Beyond Density:

Measuring Neighborhood Form in New England's Upper Connecticut River Valley

by

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Abstract

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Research evaluating the impacts of smart growth, new urbanism, and pedestrian oriented design on transportation, public health and community life is limited by weaknesses of conventional urban form measures. A review of recent literature finds standard measures, such as development density and land use, do not sufficiently differentiate basic elements of neighborhood form. This contributes to ambiguous research findings. Improved methods for operationalizing urban form as an independent variable is a critical need for the emerging field of urban design.

This dissertation explores the potential of developing simple, replicable measures that can better distinguish first order differences between neighborhoods. The complex nature of three-dimensional space and a lack of useable datasets at this scale suggested an exploratory, hypothesis generating, research approach. The project is built around detailed study of a dozen neighborhoods in the Upper Valley Region of Vermont and New Hampshire. An extensive field-based analysis of urban form identified key urban form variables and speculated on associations with perceived qualities of the neighborhood environment. Based on those findings, a GIS based,

parcel-level data set was compiled at two scales of analysis—neighborhood-wide and the more detailed realm of the street, block, lot, and building. The database was the basis for exploratory derivation and testing of simple replicable measures of neighborhood form. A field based survey tour established a perceptual baseline for a series of environmental qualities across the case studies. Correlating mean survey scores with calculated values served as a basic validity test for experimental measures.

Initial findings suggest both substantial limitations and promising areas of research related to developing quantitative measures of city form. The complexity of the built environment limited successful measures to very simple constructions based on the standard density measure of units per acre such as parcels per acre, buildings per parcel, or simple ratios such as building height to setback. Correlations of measured and perceived values offered insights into the relationship between urban form and environmental qualities. For qualities such as density, connectivity, and enclosure, the associated physical dimensions were generally clear and relatively easy to measure. Physical relationships associated with other qualities such as grain, scale, consistency and permeability, are more complex but certain classes of measures seemed to capture much of the observed variation between cases. Others, such as variability, are so complex that they seem best approached, at least initially, through use of proxy measures. Opportunities for future research include testing measures across a broader context of urban form and density and operationalizing measurement protocols within a GIS framework.

Dedication

For

James Marshall

and

Amanda Patricia,

who made the very last edit to this dissertation

(she highlighted, he deleted) and who are glad to have their father back

so he can read them bedtime stories,

and for Carolyn

who made it all possible.

List of Tables

List of Figures

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I was also fortunate to have the support and wisdom of the world's best dissertation committee—Michael Southworth, Louise Mozingo and Betty Deakin. The seeds of this project began with a 1992 term paper in Betty's transportation and land use class. Several meetings in her New Hamsphire farmhouse kitchen ten years later helped revive and re-focus the project. Louise has been a source on continuous encouragement over the years and her sharp and insightful criticism at just the right moments kept me moving forward. And finally my chair, Michael, has inspired and encouraged me, through good times and bad, with his keen intellect, insightful critique and unwavering belief in my ability to complete the project. Like all great teachers, he always seemed able to help me sort out my muddled thoughts by asking a few simple questions.

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Cities have often been likened to symphonies and poems, and the comparison seems a perfectly natural one. They are in fact objects of the same kind. The city may even be rated higher since it stands at the point where nature and artifice meet. A city is a congestion of animals whose biological history is enclosed within its boundaries, and yet every conscious and rational act on the part of these creatures helps to shape the city's eventual character. By its form as by the manner of its birth, the city has elements at once of biological procreation, organic evolution, and esthetic creation. It is both a natural object and a thing to be cultivated; individual and group; something lived and something dreamed. It is the *human invention par excellence.*

• Claude Lévi-Strauss *Tristes Tropiques*

Chapter One:

INTRODUCTION & RESEARCH SUMMARY

There has been much debate in recent years over the influence of urban form on the way we live. The discussion can be traced back nearly a half century to the seminal work of Kevin Lynch and Jane Jacobs on the relationship between city form and people. While their perspectives were quite distinct, each argued persuasively that existing planning paradigms did not adequately understand how cities really work and what makes them good places to live. Over the past several decades, this critique has expanded to include the suburbs. It has triggered a growing call to rethink how we plan and design communities in response to the dispersed, auto-dependent pattern of the post-war suburban growth—an environment that has emerged as the dominant form of American urbanism at the end of the 20th century.

This new development paradigm has gained considerable support in among architects, planners and developers. It has begun to have widespread influence on planning policy, especially in the rapidly growing regions of the Southeast, mid-Atlantic and West Coast. A common assumption of these "smart growth" or "new urbanist" proposals holds that increasing land use mix, street connections, residential densities and pedestrian scale will result in less auto-centered travel and more walking-oriented lifestyles. It is argued, in turn, that this will induce improvements in environmental quality, accessibility, public health and community life. While this paradigm is applied across all scales of development (from building to region), much of the discussion has focused on the neighborhood scale where attributes of a "walkable" urban environment can be most easily studied, observed and tested.

Testing the Claims. In the past decade, a significant body of research has begun to emerge that examines the validity of these widely promoted virtues and its role in American urban policy. An extensive literature has emerged on the extent to which urban form influences travel—specifically can it help reduce auto use and increase use of transit, bicycling and/or walking? (see Boarnet & Crane 2001, Ewing & Cervero 2001). A more recent body of literature, prompted by widespread concern for increasing obesity and sedentary lifestyles, looks at the potential influence of the built environment from the perspective of public health. There has also been renewed interest in a debate going back to 19th century social reformer movement over the potential impacts of urban form on social interaction, children, safety and public life of communities and neighborhoods.

While research debates have been lively, efforts have produced often mixed, ambiguous and/or tentative conclusions. This is understandable given the complex set of variables that underscore the relationship between human activity and the physical environment. The influences of many non-spatial factors such as demographics, life-cycle, user preferences, economic costs, etc. are difficult to sort in relationship to the complexities and multiple scales of the built environment. A review of recent research testing impacts on travel reveals that findings may also be compromised by an inability to fully operationalize urban form as an independent variable. While most agree the differences between *compact mixed-use forms* and *sprawling single-use forms* should be studied, methods for specifying key issues in robust, replicable terms are lacking.

One may argue a central issue in this research lay beyond the standard focus on sorting out the impacts of urban form variables (density, use, pattern, etc.) from those of user characteristics (income, education, class, etc.). A more fundamental challenge in this research area may be the task of conceptualizing, describing and understanding the complexities of urban form itself. In other words, work evaluating the influences of urban form needs to be informed by more robust description of what is being studied.

1.1 The Problem of Neighborhood Measurement

The goal of this project is to contribute to these research efforts by examining the potential to develop systematic and replicable measures that are capable of describing a range of physical attributes at the specific scale of the neighborhood. Neighborhood scale is important for several reasons. First, its limited scale allows investigation into the complexities of three-dimensional design (enclosure, volume, scale) while it is expansive enough to observe the dynamic relationships of land use planning (proximity, movement, territory). At the scale of neighborhood, the vertical dimension emerges as a central feature of the built environment. This is an area where there is little in the way of standard methods of measurement. Two-dimensional planning measures typically dominate physical planning practice and policies (Lynch 1981).

Secondly, it has special relevance to the particular issue of walking. Unlike other modes of travel and movement, the distance limitations of walking make it much more strongly related to the spatial scale of neighborhood (Handy et al 2002). Walking, in turn, is linked to other quality of life issues such as health and social interaction (Frank 2000, Lund 2003). Finally, the physical neighborhood has proven curiously persistent in its importance to residents despite the ever-widening social networks and mobility of modern lifestyles (Lynch 1981). It retains its importance in terms of human identity and association. More robust description of neighborhood settings should allow more effective testing of how its physical form influences the way we live.

This area of research also has implications for the larger field of urban design. At issue is advancing the substantive basis of urban design as an academic field through improved description of the built environment (Appleyard & Jacobs 1987, Moudon 1992, Southworth 2003). Urban design as a field is understandably heavily biased towards a prescriptive or normative approach—a concern for how the city should be; how it can be made better. Yet these aims are compromised by a relatively weak knowledge of what the city is and how it works. Advancing the field requires building a knowledge base to better inform debates about how to design livable places. One of the first requirements of understanding anything is to be able to measure and describe it.

It is this larger research context of building knowledge in an emerging field to which this project seeks to contribute.

1.2 Project Summary: Questions, Approaches, and Findings

There is considerable evidence that existing measurement conventions for urban form are inadequate. For all their usefulness in other respects, standard descriptive tools such as *residential density* and *land use classification* are unable to differentiate rudimentary physical characteristics of the built environment—particularly at the more detailed scale of the neighborhood. Earlier work the Seattle region found striking differences of urban form between neighborhoods that were virtually identical when measured by units per acre and land use mix (Owens 1993). A more recent project systematically documented hundreds of neighborhoods across the US and found enormous variation of environmental quality between areas of similar density and land use (Campoli & MacLean 2004). While some recent research efforts have begun to work on the development of more effective measures of urban form, many questions remain (Moudon & Hess 2000, Krizek 2001, Handy et al 2002).

Maple Street (left) and Hemlock Ridge (right): two Upper Valley neighborhoods with contrasting urban form character and the same mix of single-family and multi-family units developed at the same density over an equivalent land area.

Figure 1-1 Two Neighborhoods: Different Forms / Same Density & Land Use

1.2.1 Research Questions:

This project explores the potential of developing systematic, replicable measures of distinguishing physical attributes at the scale of the neighborhood. Thus the core research question may be re-stated as:

> **Are there simple, replicable measures of neighborhood form, beyond conventional measures of density and land use, that can more fully account for urban form variation between neighborhoods?**

At the heart of this seemingly simple question lies a basic conceptual tension between the quest for "simple, replicable, finite" measures on one hand, and the "complex, dynamic, elusive" nature of what is being measured, on the other. The three-dimensional reality of "a neighborhood" is a complex entity. A series of underlying questions that suggest this may not be as simple a task as it initially appears:

1. How can concepts such density, use & circulation be measured in more spatial terms?
2. How can the key spatial relationships linked to physical variation be teased out and identified?
3. What kinds of approaches are most suited to translating complex and variable spatial characteristics into comparable measures?
4. How can the effectiveness of any derived measure be tested for validity and replicability? (i.e. do they work?).
5. What kind of data specification is required for measures to be used for broader analysis and application? (e.g. GIS computing?)

1.2.2 Research Approach & Methods:

These are not insignificant questions. Neighborhoods are dynamic systems with many interconnected parts that change over time. Standardized urban form data, especially in the third dimension, is almost non-existent. This suggests a research design approach that is exploratory in nature, focusing on in-depth analysis of a few case studies rather than on a more broad-ranging analysis using existing large data sets.

Case Study Approach: The project is built around an in-depth analysis of a set of twelve neighborhoods in the urbanized portion of New England's Upper Connecticut River Valley encompassing parts of Hanover, NH; Lebanon, NH; Hartford, VT and Norwich, VT. An initial selection process using US Census Data and street mapping software identified a universe of 25 neighborhoods. These were winnowed down to a set of 12 using a field evaluation matrix that assessed a series of urban form variables.

This set of twelve was arrayed into three sub-sets of four neighborhoods that share similar densities and mix of uses but contrast to varying degrees in physical form.

The neighborhood, as a unit of analysis, offers a unique balance of physical dimension. It is small enough to analyze in terms of three-dimensional space (e.g. enclosure, volume, scale). It is, at the same time, large enough to possess key dynamics of two-dimensional patterns (e.g. proximity, movement, territory). The project was organized around two scales of analysis: 1) the larger scale of the **neighborhood** as a whole and 2) the more detailed scale of **street/block/building/lot**.

Multiple Methods: The research design involves a series of steps leading from the initial selection of the cases to the final testing of the derived measures. Once the neighborhood case studies were selected an extensive analysis of urban form was undertaken to identify key urban form variables and speculate on their connection to perceptual differences between neighborhoods. Based on those findings, an extensive data set was compiled at the two scales of analysis. The database was the basis for conducting a series of exploratory efforts aimed at deriving and testing simple replicable measures of neighborhood form. A field based survey tour is used to establish a baseline of perceived qualities across the case study neighborhoods. Finally measures are tested by comparing calculated values with mean survey scores. A summary of each of the major steps in included below.

Documentation of Neighborhood Form: Drawing on a review of urban design theory, the 12 neighborhoods were examined using three systematic methods of urban form analysis. Aerial and ground photography was used to capture the "whole" sense of the place as well as to provide a standardized visual reference. Extensive field observations were made to identify key issues that distinguish the form of one neighborhood from the next. Finally, systematic mapping and typological analysis provided a consistent "spatial" record for each neighborhood. This process provided a baseline record for subsequent use in analyzing urban form, derivation and internal testing of measures, and as a reference tool for external validation testing.

Analysis of Neighborhood Form: The next step involved an "analysis of variance" for neighborhood form. The case study profiles were analyzed in matrix form for first order variation across a range of neighborhood-wide urban form variables such as street pattern, block and parcel pattern, open space, vegetation, land use, building type, street type, and overall spatial quality. The matrix, in turn, provided the basis for the development of conceptual models of spatial form and structure at the scale of the neighborhood and the more detailed scale of street/block/house/lot. These models provided a sound basis for identifying potential elements to be measured and potential methods for their measurement.

The conceptual models also identified the need to develop more detailed baseline information at the detailed scale of the street & block. Preliminary field measurements were made for 73 streets within the 12 neighborhoods. First order measures of variables such as street type, cross-sectional dimensions and components, street trees, building setback, building height, building orientation, building spacing, unit type, and extent of features such as walks, porches, garages were arrayed into a second comparative matrix of neighborhood space. This matrix became the basis for selecting six detailed cases for use in deriving more three-dimensional measures of neighborhood form. The detailed study cases were further divided into three sets of matched pairs—streets that were similar density and land use but contrasting in key urban form characteristics.

Data Compilation: With a better understanding of what should be measured, the next step involved the gathering, compilation, coding and formatting a wide range of urban form data. For the neighborhood-wide analysis, existing GIS datasets from the four towns provided a beginning framework of parcel lines with linked parcel ID and area data. As the quality of data ranged widely between towns, considerable effort was required to compile a standardized dataset that included land use, block, street pattern, building type, unit type, topography and vegetation. Where possible, data was arrayed at the parcel level (about 1,000 records across 12 neighborhoods) to allow more robust analysis of spatial patterns and relationships.

Data compilation for the detailed study sets was even more challenging. There was virtually no useful pre-existing data at this more detailed scale and much of it included three-dimensional variables that lacked any standard specification protocol. However, limiting the case studies to six small areas (3 to 7 acres) with a limited number of parcels and buildings (less than 100 records) allowed assembly of a useable dataset. Building off the parcel unit data of the larger database, measurements for a variety of variables were made using a combination of field measurements, field photography, orthophotographs, GIS layers, and even as-built drawings of recent projects. While the resultant dataset was not as complete as possible, it provided a useful basis for the development of experimental measures of three-dimensional form.

Deriving & Testing Measures: Each database provided the basis for looking at potential relationships and metrics that would correlate with observed environmental character. Relationships between variables were probed using rudimentary statistics (average, sum, count, max, min, etc.) and rudimentary measures were derived using various "intensity measures" (i.e. value per unit area or unit of analysis). The process was a trial and error process where resulting values were arrayed against recorded neighborhood and street profiles asking the question: ***Do the values reasonably represent the observable variation in neighborhood form?*** Based on results, measurements were adjusted, revised, or thrown out. The process was repeated until a reasonably "good fit" was attained for a given spatial characteristic. The overall goal was a set of measures that capture physical differences between neighborhoods in as simple and efficient way as possible.

Survey of Neighborhood Qualities: A series of six neighborhood tours were conducted to establish a more substantial baseline for perceived environmental variation of neighborhood qualities across the selected cases. Survey participants evaluated nine qualities on a 1 – 5 scale during two-hour tours of six case study neighborhoods. The survey tested three basic questions: 1) could the qualities be reliably and consistently distinguished across the study neighborhoods, 2) did the findings confirm the assumption of physical differences that underlay the case study selection process, and 3) to what extent do the surveyed perceptions of differences between neighborhoods correlate with those of the researcher.

Correlating Measured and Surveyed Values: Finally the average survey scores for each quality were correlated with values calculated from experimental measures developed over the course of the project. Combination graphs allowed values of derived measures (e.g. *parcels per acre, setback to height ratio*) to be comparatively scaled with the mean survey values across all six cases for each surveyed quality. This served to test the capabilities of different measures to record first order differences between neighborhoods. Potential refinements and improvements are discussed. Prospects and limitations of findings within a broader context of urban conditions are evaluated and directions for research are suggested.

Hypotheses & Expected Findings: While exploratory research is often seen as more "hypothesis generating" than "hypothesis testing", a series of expected findings regarding the type and nature of derived measures were defined at the project's outset. They included a series of hypothesized relationships between perceived urban form qualities, the physical elements that define them, and the challenge of measuring their differences. Some of the principle challenges were methodological.

A series of research parameters were identified that were expected to be critical to success. It was expected that the process would depend on the ability to measure relationships between elements rather than simple the elements themselves. It was further expected that key metrics would be proportional and relative rather than absolute in their specification and that typological analysis would be important to measuring complex form relationships. Finally it was expected that the process would be iterative—moving back and forth between measurement values and observed variation between case studies.

A series of hypothesized relationships about key issues that would prove significant in explaining variance in neighborhood form were also developed. These are outlined at length in the expected findings discussion in Chapter Three. The key issues thought to be important included:

- Form and distribution of density and land use
- Tree cover and landscape character
- Relationship between private and public domain
- Orientation of building and lots along street
- Scale and degree of spatial enclosure
- Scale and grain of neighborhood
- Connectivity of street system
- Degree of openness of boundaries and edges
- Relationship of variation and order
- Change and adaptability over time

1.2.4 Research Findings:

The results of the research project were, in turn, sometimes promising, sometimes surprising, and occasionally disappointing. The limited geographic scope and the exploratory nature of the work tend to restrict the degree to which findings can be generalized to a broader context. Even within these limitations, the findings present considerable evidence of the potential for standardized measures to capture first order distinctions of urban form. While the final conclusions of the project in many respects raise more questions than they answer, a series of preliminary findings can be summarized as follows:

Structure of Derived Measures: The underlying structure of the standard density measure (*units per acre*) proved an adaptable model for building more effective measures through its format of *some value per standard reference unit*. Variables that can be easily expressed as numeric values (either in absolute or ordinal terms) proved critical to the construction of simple measures.

Different Scales of Analysis: There is clear distinction between the challenges of measuring neighborhood wide scale and those associated with the more detailed scale of the street and block. The detailed scales of three-dimensional space are more complex, open-ended. Studying this scale requires limiting analysis to a finite area for which dimensions could be perceived and recorded.

Lack of Key Descriptive Language and Reliable Data: There is a notable weakness and/or ambiguity of definition for key elements of urban form (especially in three-dimensional space) such as "street", "block", "verge", or "building type". There was also revelation regarding the absence of any reliable urban form data—especially at the more detailed scale of a neighborhood. Data compilation turned out to be an unexpectedly major challenge that in many way limited scope and extent of the findings. Data specification issues were complex and required trial and error explorations to determine what kind of information would be most useful.

Limits of Typology: The expectation that "typology" would provide useful proxies for complex elements (e.g. building type, street to building relationship, landscape pattern) was very limited due to the difficulty in defining types that could be clearly understood, coded, and compiled in simple, replicable terms (i.e. without an "expert" to needed to make judgment). Type classification for this kind of measurement needs to be extremely simple and easy to specify.

Difficulty in Capturing Spatial Patterns: Spatial patterns and distributions proved very challenging to capture in a simple measure—most effective method was to break down distributions within a larger area into smaller geographically or spatially specific areas (e.g. by block, street, or parcel).

Significance of Parcel as a Variable: Surprisingly, the variable of "parcel" was central to the successful derivation of successful measures correlating to observed variation in physical character. It can be understood as a kind of "genetic code" or "skeletal structure" that guides and informs all subsequent actions of urban development.

Measurement Challenges of Different Qualities: Some identified qualities such as connectivity, enclosure, or permeability proved surprisingly conducive to measuring in relatively simple terms. Others such as scale, complexity or adaptability proved more difficult to reliably measure. The more difficult qualities were, not surprisingly the ones that were subject to the broadest interpretations. Clearly defining what was being measured was a key element of deriving successful measurement. This was more difficult for certain qualities than others.

Key Differences of Neighborhood Form: While the contrast between traditional and newer era neighborhood forms was found to be strongly associated with variation in this set of neighborhoods, the work also suggests the distinction between these two development eras may neither be as clear or well understood as the literature would suggest. The findings from this study suggest the real conundrum in measurement terms, of distinguishing between them comes not so much from density levels, street patterns, or building forms as from parcel patterns and development practices. The most basic distinction of neighborhood form contrasted patterns of small-lot patterns of individual buildings with large-lot patterns with multiple buildings on each parcel. Additional research is needed to better understand these patterns.

1.3 Contributions

This project contributes to the field of urban planning and design in several ways. First, it contributes to recent research efforts to operationalize neighborhood form as independent research variable. Unlike most other work, the specification of the urban form is not done in conjunction with testing some related outcome but rather treated as a discrete research question. Secondly, the project contributes to better understanding between the quantitative representation and the perceptual understanding of the built environment. It also contributes to on-going efforts to establish a more substantive base of knowledge on the form and structure of urban space, and in particular, the residential neighborhood.

The project is also set within an understudied but important emerging regional environment—a small but steadily growing urban core within a largely rural setting. Access to the outdoors, and a health care and education-based economy make it an potentially important proto-type for emerging patterns of economic and regional development. Finally, the project explores some key issues related to the development of more sophisticated planning and zoning standards that are more oriented toward neighborhood form and character.

1.4 Organization of Dissertation

This dissertation is organized into eight chapters. The first chapter introduces the research problem and outlines research questions, approach, and findings. Chapter Two locates this research topic within the several branches of related literature. Chapter Three outlines the research methods in detail and describes the case study selection process. Chapter Four documents the study areas and analyzes the key components of urban form, approaches to measuring them and compilation of related data sets. Chapters Five and Six describes the heart of the project—the derivation of urban form measures at two scales: 1) neighborhood and 2) street/block/building/parcel. Chapter Seven describes the use of a field survey to establish broader baseline for perceived qualities. Chapter Eight concludes by correlating measured values with surveyed values and outlining final conclusions and research directions.

It once seemed reasonable to me to think that a single standard language for settlement pattern could be developed. But preparing such a description for any area proved to be very time-consuming. More important, when faced with a particular problem of analysis or design, one falls back on some other specialized language, usually a rather conventional one. Developing a standard city language may be will-o'-the-wisp, or it may simply be premature. Just now we are constrained to refining existing descriptions, or to inventing and testing partial, specialized modes for specialized problems (p. 351).

• Kevin Lynch <u>Good City Form</u>

Chapter Two:
LITERATURE REVIEW

There are several bodies of literature that provide a useful context for the question of how to conceptualize and measure the built environment. In Section 2.1, the central challenge of operationalizing urban form as a research variable is examined across a wide range of literature concerned with the influence of the built environment on human activity. Section 2.2 focuses on the issue of conceptualizing and describing urban form within the broader context of urban design and planning theory. Finally, Section 2.3 reviews several literatures related to the core question that was outlined in Chapter One—measuring neighborhood form. It covers 1) the limitations of existing measurement conventions; 2) recent work on the specific question of measuring urban form; and 3) the concept of *neighborhood* as a unit of analysis.

2.1 Neighborhood Form as a Research Variable: Environment & Behavior

Going back at least as far as Andrew Jackson Downing or Frederick Law Olmsted's 19th century associations of "good" design with a moralizing influence on society, there has been a steady stream of work concerned with linking environmental form and social behavior. A central issue in this work concerns how urban form is operationalized for the purposes of testing its impacts on travel, public health, social life, etc. The following discussion is organized around three bodies of literature concerned with the relationship between the built environment and aspects of human behavior including: a) travel behavior, b) public health and c) social & community life. It describes relevant methods and assesses key findings and limitations in the work.

2.1.1 Transportation and the Built Environment

The task of measuring and characterizing the built environment has been a major issue in studies examining the relationships of urban form and travel behavior over the past 15 years. Some of the earliest studies used simulation models of street networks to show reduced vehicle miles traveled (VMT) associated with higher street connectivity (Kulash 1990, McNally & Ryan 1993). Findings were limited by the simplification of both the urban form and trip variables. Other early studies showed a correlation between measures of aggregate density and VMT but did not account very well for population variables (Kenworthy & Newman 1989, Holzclaw 1994). Pivo and Frank (1994) introduce population controls and find that density and mixed use still make a difference. However they still rely on aggregate census-level land-use that many have argued poorly distinguishes important characteristics of the built environment.

Cervero and Kockelman (1997) attempt to address the shortcoming of census land use data by using regional *dominant land use* data. However that data's coarseness—1 hectare (2.5 acre) cells—again leave a large uncertainty regarding the specific characteristics of the built environment they are evaluating. Introducing the impact of regional accessibility on travel into her analysis, Handy (1996) advances measures of local accessibility through measures like blocks per square mile and retail uses per population unit. Other approaches were more disaggregate, using household surveys and qualitative analysis of urban form dimensions in specific neighborhoods with clearly contrasting form (Cervero & Radisch 1996)

Crane (1996) is very critical of these studies for their failure to control for "self selection" of users to specific types of neighborhoods. In a later study, he tries to address this problem by using a "consistent behavioral framework" to test the urban form variable of "street connectivity" (Crane & Crepeau, 1998). However he exposes himself to a similar criticism on the urban form side of the equation by operationalizing street connectivity as a geographic information system (GIS) measure of *grid* versus *non-grid* street network that was far too coarse and abstract to account for key differences of scale, pattern and quality that may exist within street pattern when used as an independent variable. Not surprisingly, his results are inconclusive.

Similar shortcomings can be identified in other recent studies. Kitamura and Mokhtarian (1997, 2002) make some good points about the influence of personal preference on travel and the need for multi-dimensional neighborhood measures. However their physical variables are so abstract and weakly defined that it is hard to discern any distinctive physical traits of the places they are examining. More recently Srinivasan (2002) takes on the challenge of specifying detailed urban form through a large-scale GIS based analysis of the greater Boston area. She attempts to derive transportation choice models that are "more sensitive to the fine grained spatial structure of neighborhoods." While the careful parsing of GIS data gives a continuous measure of urban form, what is seen as "fine-grained" in the world of regional GIS analysis remains very abstract and difficult to correlate with the reality of a neighborhood. In general, while there is a lot of rigorous data analysis in these studies, their explanatory value is consistently undermined by vague or coarsely defined characterization of the environment they are studying.

Developing measures of street design and street networks has emerged as a significant factor in the travel-land use puzzle (Ewing & Cervero 2001). Various measures of intersection frequencies have been used to characterize the relative connectivity of the network (Handy 1992, Southworth & Owens 1993, Cervero & Radisch 1996). Average block size (together with sidewalk continuity and accessibility) is used by Hess (1997) as a related but more easily calculated measure of street pattern and scale in his work on connectivity measures for pedestrian travel. Hess et al. (1999) apply these measures in six matched pair neighborhoods with similar residential density, land use mix, and income but contrasting street layout. They found three times the pedestrian volumes in sites with higher connectivity. Significantly, pedestrian counts in low accessibility areas were over-represented by children—that is many of the pedestrians found in these areas have didn't have the options of driving.

Krizek's (2003a) recent work probably represents the most comprehensive effort to operationalize neighborhood-scale urban form across an entire region. He derives a more sensitive index of neighborhood accessibility by arraying census and other aggregate data on density, land use and street network across a 150-meter grid covering the greater Seattle area. While his approach addresses earlier critiques of the coarseness of traffic (TAZ) area zone as a unit of analysis, he concludes the "the elusive nature of design often defies measurement and is sometimes best captured by more qualitative measures." He ends up using block size as a proxy for the complex and interrelated qualities of neighborhood-scale urban design.

While block size *might* be a reasonable proxy for the combined influence of multiple urban design variables, it is impossible to know with any certainty unless these variables can be more clearly distinguished. In a second article describing conclusions related to travel (Krizek 2003b), findings are consistent with earlier work by Handy, Cervero and Crane which found that higher accessibility is associated with decreased VMT but increased trip frequency (i.e. shorter, more frequent trips). However, no significant mode shift from auto to walking could be discerned. Not surprisingly, walking is the mode that is most sensitive to fine-scaled urban design character.

While the general influence of development density and land use mix use on travel behavior has been well established (Puskarev & Zupan, 1977), efforts to capture the more elusive variables associated with fine-scaled urban form have been difficult. Owens (1993) examines a wide range of detailed urban form variables that could affect travel choice by comparing urban form differences between two of Seattle area neighborhoods of equivalent density and land use mix. Due to potential problems of co-linearity, others have tried to capture the complex, multivariate nature of this scale with indices such as such the Pedestrian Environmental Factor used in Portland's LUTRAQ project (1000 Friends of Oregon). A major problem here is 1) the enormous time and energy required to collect this data and 2) the questionable correlations with distinct variation in neighborhoods (Cervero & Kockelman 1997, Lamont 2000). Cervero (1993) suggests design level factors might simply be too "micro" to detect any significant impact on travel.

2.1.2 Public Health and the Built Environment:

Rising concerns about America's increasingly sedentary lifestyle have led to the recent emergence of a parallel body of literature regarding the potential impact of the built environment on public health. A 1996 Surgeon General's report *Physical Activity and Health*, cites increasing levels of physical inactivity as a growing cause of mortality (Frank 2000). The September 2003 issue of the *American Journal of Public Health* and *American Journal of Health Promotion* were dedicated to the impact of the built environment on public health. Groups such as the Robert Wood Johnson Foundation have made this area a funding priority (www.activelivingbydesign.org/ 2005).

The prospects for linking urban form characteristics with levels of walking are a primary issue in this research (Jackson 2003). The hypothesis being tested is that people who walk in places where walking is part of daily life will enjoy substantial health benefits compared with those who don't (Frank & Engelke 2001). Ewing, Pendall et al.

(2003) use a "sprawl index" derived from widely available aggregate data to analyze 448 counties across the United States. They conclude "people living in counties marked by sprawling development are likely to walk less, weigh more, and have high blood pressure." While the formulation of urban form is very coarse in these studies, the findings are encouraging for research seeking to examine this link within more disaggregate, place-specific settings. Frank (2000) suggests that the same three elements of the built environment (development density, land use mix and street connectivity) identified in the transportation research will be critical to public health questions.

Handy et al. (2002) and Frank (2001) reaffirm these three elements and add a fourth element of particular importance to walking—the human-scale qualities of three-dimensional space. Frank asserts that travel modes linked to better health (e.g. walking and bicycling) are inherently more sensitive to the "micro-scale" urban form elements. This view is supported by Rapoport's (1987) theory that the slower speed of pedestrian travel (compared with auto travel) makes it a mode more sensitive to small-scale details and variation in the environment. Handy et al. (2002) label this fourth dimension as "street scale & aesthetics." Street scale describes the three-dimensional space along a street as defined by buildings or other features (e.g. trees, walls). They further distinguish aesthetics as a more intangible factor that often defies measurement but note some specific issues such as orientation of windows and relation of doorways to street as well as trees and pedestrian amenities (benches, lighting) as contributing elements. They point out that experiential issues of safety, comfort, etc. are important components of travel utility and are also closely related to the physical environment.

Handy et al. conclude that because the neighborhood scale is much more critical to walking, research using household level disaggregate data for both activity and the built environment will be critical to understand walking behavior. They go on to support a core premise of this dissertation by suggesting qualitative research methods should be used to identify key elements at this environmental scale as well as effective methods for measuring them (p.72).

Results from one early study support the influence of the neighborhood scale environment on walking and physical activity. In a small, but carefully specified study of two San Diego neighborhoods, residents in the "high walkability" neighborhood had almost 70 more minutes per week of physical activity (measured by an accelerometer) than those in the "low walkability" neighborhood after adjusting for age and education (Saelens et al. 2003). Curiously, the study used a self-reported "neighborhood walkability scale" to "measure" variation of urban form attributes such as density, mixed use and street connectivity. No visual information (i.e. photographs or maps), written descriptions, or other measures were offered as independent assessments of the two neighborhoods under study.

With no independent measure of urban form, the implied link between urban form and walking is an unsupported finding—increased physical activity can only be linked with the *perception* of sidewalk facilities. In sharp contrast to these findings, another study that *did* independently account for urban form variables found "sidewalks facilities" had *no* influence on walking activity (Hess et al. 1999). In order to draw conclusions regarding the influence of the built environment on behavior, it is necessary to first understand the actual dimensions of the environment under study.

2.1.3 Social Life and the Built Environment

A third body of literature deals with the influence of the built environment on issues such as neighboring, social interaction and community life. This is a much older literature that has its roots in the 1960's. From Claude Nicholas Ledoux's 1770's plan for Chaux to the 1960's-era Model Cities Program, planning and urban design has long believed in the potential for design to effect social change (Kostoff 1991).

During the 1960's, a body of research began to emerge that looked more closely at these relationships. This "social design" paradigm began to be challenged by people like sociologist Herbert Gans (1962 & 1963). His studies of Boston's West End and Leavittown concluded urban form does not exert as much influence on basic social behavior compared to factors such as class, ethnicity and age.

However, more site-specific study of social use and behavior did find strong links to the physical environment—although not always as envisioned by the designer. Clare Cooper Marcus' (1975) early study of the Easter Hill Village housing development found the use of the site in striking contrast to that assumed by its designers. Other important work included Appleyard (1972) on the impact of traffic on social life, Newman (1973) on relationship between urban form and crime and, most notably, Gehl (1971) and Whyte (1979) on design factors influencing street life and use of public spaces. This body of research has direct relevance to the identification of key attributes of the built environment that may influence human activity. This work will be considered more specifically in next section of this chapter.

While more recent work in the *social factors* area was not surveyed, one recent study recently published in the *Journal of the American Planning Association* is notable for what it *does* and *does not* demonstrate (Lund 2003). The study—entitled *Testing The Claims of New Urbanism: Local Access, Pedestrian Travel, and Neighboring Behavior*—sets up access to parks and/or shops as an independent variable being tested in relation to two dependent variables: walking and neighboring. The influence of age is also tested with four match pairs each including a pre-1945 and post-1995 neighborhood. Local access is varied by selecting study matched pairs with: 1) shops and park, 2) retail only, 3) shops only, and 4) neither shops nor park within walking distance. An extensive resident survey is administered to gather data on demographics, attitudes and perceptions.

Significantly, typical pedestrian environment variables are held constant—all eight have connected streets, narrow lots, sidewalks, street trees, shallow setbacks, etc.

Portland's "smart growth" policies have produced a series of new suburban neighborhoods with many traits that are similar to older city neighborhoods. This allows access to be tested more independently—often very difficult when comparing older and newer neighborhoods that vary in both design quality and access. Not surprisingly the study finds when there is someplace to walk to (especially shops) *destination* walking trips are high. When there are no nearby shops, walking trips are few. The study also found—consistent with Handy (1996) and others—that variation in local access did not significantly affect *strolling* or recreational walking after controlling for population variables.

With regard to social interaction, she finds that the more people walk, the more social interactions they had with their neighbors. Again, this is a useful confirmation of Jan Gehl's work 20 years earlier that found this connection in studies of neighborhoods in Toronto, Sydney and Denmark. Lund's findings also suggest personal attitudes and household characteristics are equally important to local access in explaining pedestrian activity and neighboring. Positive attitudes towards neighboring and families with kids are more strongly associated with walking and neighboring in many cases—an important cautionary finding for those who see design as strongly deterministic of behavior.

What is extremely troubling about the study, however, is the misrepresentation of neighborhood design significance. The study explicitly excludes any variation in the "quality of the pedestrian environment" by selecting all "compact, walkable neighborhoods." It then goes on to state that this "allowed the study to focus on accessibility to everyday amenities *without ignoring the importance of people-friendly designs*" (emphasis added). This appears to be simply a misstated association. The study can conclude nothing about design—it is not tested. The study only tests the impact of access, attitudes on walking and neighboring in neighborhoods of similar design—some new, some old.

The misconception of design is carried forward through the entire article. A review of design literature is framed around the question of whether "changing the way we design our neighborhoods—particularly their public spaces—can help revive the strong community life observed in early 20th century neighborhoods." It goes on to incorrectly interpret Appleyard's *Liveable Streets* study as linking "human-scale, people-friendly street design to increased interaction among neighbors." It did nothing of the sort—it tested the impact of traffic volume on neighboring. As in Lund's study, street design was explicitly held constant in order to test traffic as the independent variable.

Likewise a review of the land-use and transportation literature begins with the statement "neighborhood and streetscape environments also affect the frequency with which people walk in their neighborhoods." In contrast, this literature review found the variable of "streetscape" has been very difficult to operationalize and only a weak associations have been made with travel choice. Density, mix of activities and accessibility are all shown to be much more important explanatory variables. These are large scale planning variables not small-scale design ones.

Finally, one of two major conclusions supporting New Urbanism finds "*when combined with pedestrian-friendly streetscapes*, locating parks and retail shops within a neighborhood can increase pedestrian travel and neighboring" (again emphasis added). Locating parks and shops in a neighborhood was indeed shown to matter. But the study proved nothing related to "pedestrian-friendly streetscapes"—they were not tested. What about neighborhoods with wide streets and big setbacks that have shops and parks nearby? Comparing these types of neighborhoods with those in the study set could have tested the potential influence of "walkable" neighborhood design. But without varying design elements, we have no way of knowing.

While not wanting to unfairly single out this study, it does exemplify the common difficulty in sorting out measures of two-dimensional planning from three-dimensional design that persists throughout this literature. It also illustrates how an earnest desire to "prove" something (in this case that good design matters) can lead to conclusions that are not supported by the research.

2.1.4 Operationalizing Neighborhood Form: Key Findings and Limitations

The preceding discussion reveals a series of lessons related to capturing variation of neighborhood form. The goal of almost every research project discussed was to understand the influence of the built environment on human use and perception of those environments. A key theoretical and methodological issue in this work concerns operationalizing complex phenomena of the built environment. This task presents an inherent theoretical tension between the inherent wholeness of a physical place and the need disaggregate and specify its component parts in order to sort out the influence of spatial variables (e.g. connectivity, enclosure) from non-spatial variables (e.g. demographics, economics). The challenge is to being able to examine the parts without compromising the integrity of the whole. Several lessons have emerged:

Limitations and Bias of Available Data: One the biggest obstacles is the availability of good data. Many projects depend on readily available aggregate data sources on urban form such as the US Census. This tends to bias models of urban form towards dimensions such as density and land use for which data is easily available (Cervero & Kockelman 1997). Studies seeking to overcome data limitations have often required resource intensive data collection and/or a limited geographic scope. They also tend to lack rigorous theoretical models of urban form. Studies that sought to retain the integrity of the whole environment were limited in three ways: 1) potential subjectivity of case selection, 2) problems of research replicability, and 3) an inability to disentangle urban form factors.

Unit of Analysis—Density and Land Use*:* A related problem is that density and land use data sets tend to be aggregated into units (census tracts or TAZ) that cannot distinguish perceived character differences (Owens 1993, Moudon et al. 2001). The poor matching of data cell boundaries to actual development pattern can misrepresent specific land use patterns as well as mask cross-border relationships. When used in combination with disaggregate household level data this incongruity can produce an "ecological fallacy" where aggregate form data may have little relationship to a household's specific physical context. The use of more sophisticated GIS tools in some recent studies have helped captured a finer-grain of land use pattern by introducing smaller and more continuous units of analysis (Srinivasan 2002, Krizek 2003).

Capturing Street Connectivity & Scale: Another specification issue is the effective characterization of circulation patterns beyond the initially limiting binomial specification of *gridded* versus *curvilinear* (Kulash 1990). Messinger & Ewing (1995) follow Southworth & Owens (1993) in developing a more refined ordinal scale of street network type. Counting *intersection type* and *frequency* introduced more quantitative data on network connectivity (Handy 1992, Cervero & Radisch 1996). Later studies incorporate a more discrete and continuous measure of environmental scale such as *average block size* or *average length of block* based on the assumption that block size and street network connectivity are closely related (Hess et al. 1999, Krizek 2003). While measures of connectivity and block size may often be a useful proxy for walkable places, the fine-grained block pattern of downtown Houston suggests that this may not always be the case. Neighborhood form needs to be understood as a bundle of inter-related factors (Kostoff 1992, p. 287).

Under-specifying Density, Land-Use & Streets: The overwhelming tendency in these studies is to focus on a trio of two-dimensional urban form measures: 1) residential density, 2) mix of uses and 3) street network. While these are all significant factors (especially for automotive travel), their weak specification at the scale of neighborhood, block, street and building misses qualities of order, form, shape, scale, enclosure, rhythm, etc. that are inherent to any three-dimensional environment. Instead, the tendency is to simply lump all these issues into a catchall category of "design" (Cervero, Krizek, Handy, Ewing, Frank, etc.). The problem is that conceptualizing design as something that only affects the micro-scale environments tends to mask the *design dimensions* of density, land use and street networks—especially at the neighborhood scale where they really matter. They become essentially under-specified variables. Only the concept of "street scale" introduced by Handy et al. (2002) begins to recognize the need to better specify the design dimensions of these elements.

Micro-Scale Lumping: A closely related problem is the anti-theoretical lumping of all sorts of physical and perceptual factors into the elusive category of *micro-scale design*—everything from light posts to aesthetics to landscaping to sidewalk width. This is not to say these factors are not important. The problem is they tend to be specified within catchall shopping lists that seem based more on brainstorming about "what's left" rather than on any sound theoretical model of physical space. This practice also suffers from enormous data gaps and problems with time-consuming data collection in the field. The reviewed studies often array these factors into composite "pedestrian indices" to allow more systematic statistical analysis. Yet clearly these factors are important—especially at the detail-sensitive scale of walking. Ewing et al. (2005 forthcoming) are attempting to address this shortcoming by linking key environmental qualities to finite, measurable physical elements.

One obstacle to better specification of detailed design elements might be called the "eye wash" problem. Focusing on the *visual surface* of an urban scene it may actually obscure deeper structural relationships of urban form. Some recently published photo-simulations show two views of the same street—one dressed up with streetscape elements, one stripped bare (Urban Advantage 2004). The perceptual difference is astounding. The contrast clearly demonstrates the importance of the micro-scale elements on the quality of urban space. However the comparison also reinforces the simplistic belief that adding landscaping or lampposts somehow constitutes a full urban design solution. A more systematic model for underlying dimensions of urban form might better account for the full range of neighborhood space.

Urban Form Proxies for New Urbanism. Another widespread practice in this literature is the use of older neighborhoods as proxies for testing the claims of New Urbanist developments. While this may be a necessary second-best strategy due to the lack of completed examples for comparative research, it is a surprisingly unchallenged assumption. While many aspects of neo-traditional or new urban projects may appear similar to the places that inspired them, it is potentially misleading to assume they are in fact the same. They have been developed under different development standards, real estate practices, market conditions, financing constraints, and cultural contexts.

Two critical reviews by Southworth (1997 and 2003) suggest there is much that may be different between these types of neighborhoods. A careful look at the underlying structure of new urban developments reveals form qualities that may be closer to the suburban model they claim to be rejecting than to the older urban neighborhoods they claim to be emulating. As the marketing currency of labels like *new urbanism*, *neo-traditional*, or *smart growth* gain value, there is also a considerable variation in what is passed off under their names. This uncertainty underscores the need for better methods of defining and differentiating neighborhood character in more systematic and accessible ways.

The Challenge of Replicable Measures. Finally some attention must be given to the conundrum of operationalizing measures that are conceptually and methodologically simple enough to be replicable in future research. Urban form measures need to be accessible enough to be recognized and understood by researchers from allied non-design fields. This task is inherently handicapped by the complexity and dynamic character of the built environment itself and its resistance to easy representation—especially in quantitative terms.

Yet the need is clear. There is enormous variation in how urban form is measured in the reviewed work. The standard measures that do exist have relatively weak descriptive power at the neighborhood scale. These factors, combined with pressing research demands on the built environment, underscore the need for better measures. The prospect of increased computing power in GIS and other spatially based formats is promising (Dodge & Jiang 1998). But the powerful data analysis is only as good as the theoretical constructs they are based on. The complexity of the problem suggests a research approach that is exploratory and focused on discrete, particular and identifiable urban forms.

In conclusion, a common weakness found in these three literatures was a limited ability to capture the full dimension of the built environment in robust yet replicable terms. However, doing so does not appear to be an easy task. Urban form is a complex ecology of relationships that are not easily reduced to a simple set of measurable attributes or variables. Sorting out the long debate concerning the influence of urban form on human use depends on an improved ability to adequately distinguish the built environment. Comparative research demands more refined descriptors and measurements. Ultimately, better accounting of urban form variation will help us to better see, evaluate and understand the world we live in.

2.2 Theoretical Foundations for Measuring the Neighborhood

The second section of literature review takes a step back to consider the question of "measuring urban form" within a more theoretical context. How do different conceptual frameworks look at urban form? How do they define the key elements or dimensions? What are their inherent biases and assumptions? What can they tell us about methods for deriving measures or measuring itself? What are the theoretical challenges and limitations of such an endeavor?

There is no better place to begin this discussion than with the sweeping theoretical perspective of Kevin Lynch's *Good City Form* (1981). In Chapter 2, *What is the Form of a City, and How is it Made*, he asserts before one can evaluate human settlement as "good" or "bad," one must decide how to describe it in ways that different observers will confirm—not a simple task his mind:

> *The fundamental problem is to decide what the form of human settlement consists of: soley the inert physical things? or the living organisms too? the actions people engage in? the social structure? the economic system? the ecological system? the control of the space and its meaning? the way it presents itself to the senses? its daily and seasonal rhythms? its secular changes? Like any important phenomenon, the city extends out into every other phenomenon, and the choice of where to make the cut is not an easy one (p.48).*

Lynch's working definition of "settlement form" is defined by two major elements: 1) people doing things and 2) the physical spaces where they do them. His Appendix B summarizes a series of five persistent difficulties with conventional approaches for recording or measuring settlement form (p. 345-47).

The Third Dimension: Conventional modes of two-dimensional description are very poor at capturing the third dimension, which is so critical to the experience of a place at the limited scale of a neighborhood. Sections, elevations, axonometrics, bird's eye views, photographs, perspectives and 3-D projections all help but each has its limitations.

Change Over Time: They are also very poor at capturing the important dimension of time. It is hard to discern the daily rhythms of a place (so important to their quality) or longer term change of the built environment and associated activities over time. We are limited by static descriptions of dynamic environments.

Succinct Display of Information: Since city form is so complex, there is a persistent problem of what to show. Too much information can overwhelm and be unreadable. Not enough information can miss what is important to show. The challenge is to describe complex systems in succinct terms.

Missing Spatial Features: Other spatial features such as condition, ownership, flows of communication and people, and the various qualities that can only be learned from actual experience of the place are also missed by conventional measures.

Confusion of Use and Form: The inevitable association between use and form in can also be confusing. Consider the example of "church." Does it refer to a certain building type or the activity of worship? The building type can house other uses (e.g. an art gallery). Worship can happen in other kinds of buildings (e.g. in a barn).

Unlike other fields, Lynch observes that city planning has no basic language of its own. Its theoretical models often don't deal with the rich texture of city form and meaning (e.g. Alonso 1964, Weber 1964, Foley 1964, Berry 1970, Dowall 1978). "Space is abstracted in a way that impoverishes it, reducing it to a neutral container, a costly distance, or a way of recording a distribution. Most of what we feel to be the real experience has simply vanished" (p. 39). While Lynch is not optimistic a language particular to cities will emerge, if one did, he feels it would likely be a graphical one.

Nonetheless, he does assert a general description of settlement form is possible. It should account for two classes of physical things: persons acting and the physical environment associated with those actions (p.351). He further divides each class into elements related to relatively fixed locations and those related to movement.

persons staying	places of staying
persons moving	paths of moving

The diagram above adapts Lynch's schema as a two-by-two matrix (from Lynch diagram p. 351). People are either pursuing activities of working, playing, talking in bounded locales such as buildings, parks or stoops (the upper half) or they are moving along connecting facilities such as streets, paths or corridors (the lower half). This distinction correlates very nicely with Jan Gehl's (1987) two-part classification of pedestrian activities into "staying" versus "coming and going." Gehl's empirical research finds that the most fertile grounds for social interaction are in the edge spaces where these two activity classes overlap.

This crude classification provides the beginnings of a conceptual model for measuring basic differences in the urban form. Given this project's focus on the physical dimensions of the built environment, we will focus on measurements related to the right side of the matrix. However, the intertwining of physical form and human activity demands doing so without losing sight of the left side of the matrix. Lynch's work also suggests our problem is complex enough to limit initial work to a few specific and exploratory cases.

2.2.1 Three Approaches to Describing Neighborhood Form

With this foundation, one can focus on the more specific question of conceptualizing and describing neighborhood form from the perspective of urban design. As an emerging interdisciplinary field, urban design draws from a diverse set of disciplines and approaches ranging from its early 20th century roots in architecture, sociology and physical planning to more recent influences by environmental psychology, cultural geography, urban morphology, transportation planning, landscape architecture & ecology, environmental planning, economics & political science, anthropology, etc. (Lynch 1981, Appleyard & Jacobs 1987, Southworth 1990, Moudon 1992, Lang 1994, Loukaitou-Sideris & Banerjee 1998, Sternberg 2000).

The core concern of urban design remains the built environment. The following discussion will focus on concepts and observations relating to neighborhood form from three distinct urban design perspectives. The classification system is taken from the theory section of the author's own qualifying exam (1993) and owes considerable debt to

Moudon's (1992) more comprehensive "epistemological map" of urban design. The three approaches include:

Environment & Behavior: Focus on the built environment in relation to human use, behavior and perception. (Gehl, Rapoport, Appleyard, Whyte, Marcus)

Place & Image: Focus on dimensions of the built environment in relation to human experience, meaning and values. (Lynch, Alexander, Jacobs, Southworth)

Structure & Process: Focus on the evolving built environment thru analysis of the typological elements of urban morphology. (Conzen, Krier, Rossi, Moudon)

Some of the work reviewed is theory oriented; some of it is more empirical. Still other work is concerned with history or practice. As urban design is fundamentally about making better places, it tends to have what Moudon calls a normative bias—a concern for "what a city should be" as opposed to a more substantive concern for "what a city is, or how it works." While research is usually associated with the later, urban design research requires a dialog between knowledge and action; between analysis and prescription. Although there is considerable overlap between the categories, each offers a unique perspective. The overall intent is to draw insight into key dimensions of the physical neighborhood that might be measured and appropriate methods for doing so.

2.2.2 The First Approach: Environment – Behavior

This area is concerned with how human use, behavior and perception are directly affected by the built environment. It is biased toward the left side of Lynch's diagram—the arena of human action. Here, urban form (the right side) is conceptualized as perceived space. It does not have autonomous standing. This perspective looks at people acting in space, and how various components of their environment—some spatial, some perceptual—affect those actions.

Research approaches are generally empirical-inductive—inference of is drawn from direct knowledge of what is going on. It typically is not based on a strong theoretical model but rather seeks to contribute a more grounded empirical perspective. Madge (1953) notes that "direct, personal knowledge is our only means of insuring that our theories are grounded on empirical fact" (p.122). The concept of "grounded theory" argues that in some fields like the social sciences, theory is best developed through qualitative methods like observation (Strauss 1967).

Typical methods are borrowed from the social sciences: observation, surveys and interviews. The power of observation as an urban design research tool was ironically introduced to the nascent field by a journalist. Jane Jacobs (1960) used interviews and together with her own observations about the use of neighborhood space in New York and Boston to call into question the theoretical underpinnings of the urban renewal policies. While she might be considered a participant observer in a field like anthropology, her lack of a standardized method of observation could present problems of reliability and observer bias (Zeisel 1981).

Allan Jacobs (1985) argues that simply looking is a powerful tool of urban design. A keen eye can pick up a range of environmental clues about how a place is used and what might be important (Zeisel 1981). Annotated maps and field notes are key tools for field observations. William Whyte (1980), who used time-lapse photography to look at social behavior in NY urban plazas, emphasizes the importance of seeing how people actually use space as a basis for evaluating policy. Other techniques such as interviews & surveys can help gain insight into a user's feelings and perceptions. They can also record use and behavior at larger scales. Demographic and transportation research rely heavily on surveys to gain insight into broad social or travel patterns. Large samples of systematically gathered data are often well suited to more quantitative analysis.

In general, measuring *behavior* in relation to form it is not directly relevant to our central question of measuring *physical form* itself. However, the literature does offer insight into some key environmental qualities at the neighborhood scale. These empirically derived qualities are key factors affecting public life and the walking environment—a central concern of the research debate about neighborhood design. Reviewing some key sources may be useful in setting up our own work: What kinds of measurements are important? What kind of qualities should they be able to capture? How are these qualities physically manifested? How are they best distinguished?

Jan Gehl's *Life Between Buildings* (1987) provides many useful insights on the use of neighborhood-scale environments. His work comprises empirical case studies of residential streets and public spaces from Europe, Australia, and North America. His methods, drawn from many years of observation and surveys, might best be described as hypothesis-generating rather than hypothesis-testing. Overall he finds outdoor activities, especially more discretionary or "optional" ones, are highly sensitive to environmental quality. He notes a kind of multiplier effect in good environments—a whole range of secondary activities (e.g. chatting, playing, stopping, sitting) spring from an original "necessary" activity (e.g. walking to the store).

> *In streets and city spaces of poor quality, only a bare minimum of activity takes place. People hurry home. In a good environment, a completely different, broad spectrum of human activities is possible (p.13).*

Gehl contrasts four pairs of environmental factors that are critical to quality of urban spaces: 1) assemble or disperse, 2) integrate or separate, 3) invite or repel, and 4) open up or close in. A number of specific relationships operationalize these concepts. Mixing of activities within a 400 to 500 meter (1,300 to 1,600 feet) radius increases integration. Assembly is supported by closely spaced entries opening directly in public streets and spaces such as around a square or common. Entries are where the action is—long facades with few entries disperse events. At the scale of the street, widths modulating in proportion to pedestrian use help integrate activity. Cars and people are best integrated by slowing cars rather than segregating the two modes. Streets that have a strong transition zones between public and private realms (e.g. large storefront windows, sidewalk cafes, gardens, porches, stoops, etc.) open up and invite interaction. Providing good staying places with things to do at the edge invites close contact of neighbors and informal exchange with passersby.

These key relationships are confirmed by other environmental design research. Whyte (1980) finds the key design element in a downtown plaza is not within the plaza itself, but in its relationship to the adjacent street. If it opens directly to a busy street with lots of pedestrians, it is likely to be well used. If it is sunken, raised or otherwise separated, it almost always fails. Food, sun, trees, and lots of places to sit, lean or talk help too. Rapoport (1987) finds good walking environments are characterized by high levels of perceptual complexity along the path. At walking speeds, it is the complexity of building edges and associated activity that matter. The concept of *edge* is identified as a key environmental factor in many studies.

Other important work addresses the influence of environmental form on urban problems like crime and traffic. Newman (1973) finds visual connections between interior and exterior spaces creates a sense of "territoriality" that greatly improves perceived safety and attractiveness. This perception, in turn, supports use and "ownership" of outdoor space, which in turn, discourages crime—criminals don't like to be watched. Appleyard & Lintell's (1972) landmark study of impacts of traffic in San Francisco does not test physical design variable but rather traffic volumes on the perception and use of streets. The negative impacts of traffic on *livability* between otherwise similar streets is dramatic and has been confirmed in other studies. A follow-up study 25 years later by Bosselmann et al. (1999) inverts the research design to control for traffic and vary design. It conclude the physical design of the street can significantly mitigate impacts of heavy traffic thru use of a boulevard cross-section that separates local access and pedestrians from thru traffic. Again the importance of *edge* is shown. It also supports Gehl's notion of modulating street width in response to activity.

Beyond the work reviewed in the previous section, there have not been many studies of urban form and use at a neighborhood specific scale. A rich body of urban sociology studies have looked at neighborhoods as cultural and ethnic organizations (Abu-Lughod 1991). Southworth (1970) dealt in depth with children's conception and use of a neighborhood in Cambridge, MA. A number of works discuss the importance of street patterns as key organizing elements affecting both the physical and perceptual form of a neighborhood or district (Wolfe 1987, Jacobs 1993, Southworth & Ben-Joseph 1997). Hester (1975) discusses the importance of community values in shaping neighborhood space. Lynch's (1961) early image studies, studies the relationship of physical and perceptual form at the scale of a district. But it is much harder to find work probing the overall relationship between neighborhood form and how people use it.

It is, however, not hard to find work by designers that *presume* to understand the link between neighborhood form and use. Planning & urban design have a long history of belief in the power of the built environment to affect social behavior. The strong reaction to the overcrowding in 19th century cities led to theories that believed design intervention could not only solve sanitation and public health issues, but induce moral values, assimilate immigrants, foster democracy and promote social harmony (Howard 1898, Unwin 1909, Stein 1927, LeCorbusier 1929, Mumford 1938). These ideas became codified (some would say distorted) in mid-century federal policies promoting the low-density residential suburb and inner city urban renewal aimed at solving the plight of urban poverty (Wright 1981, Jackson 1985). Jacobs (1960) wryly notes the obvious anti-urban bias of the decentrist's ideas: "how could anything so bad be worth the attempt to understand it?" (p. 21).

While the failure federal urban renewal policies in the 1950's & 1960's have discredited the idea of design shaping social outcome, the unshakeable belief in the virtuous power of design lives on in the current new urbanist and smart growth movements (Katz 1996, Ewing 1999). Leading proponents Duany and Plater-Zyberk "believe a designer's decisions will permeate the lives of a residents not just visually but in the way residents live" (Lennertz 1992). It is a powerful belief that has shown widespread appeal. It is curious to note that design prototypes initially championed as models of reducing density and escaping the overcrowded city are now serving the opposite purpose (e.g. Forest Hills Garden, Perry's "neighborhood unit"). They are now held up to promote a renewed urbanism in the face of unyielding sprawl by applying the principles of "civilized townscape" to the formless expanses of the urban edge.

While history reveals no shortage of proponents claiming to understand how urban form affects use, it is only recently that research efforts have begun to rigorously test these claims. As discussed in Section 2.1, most of this work has been focused in transportation and more recently in "active living" research. Good specification of urban form, especially at the neighborhood level remains a challenge—perhaps due to the extremely time consuming and labor intensive nature of such work (Lynch 1981).

Together with Gehl's work, Jacobs early observations (1961) still offers some of the best assessments of key neighborhood scale urban form issues in relation to pedestrian use and street life. For dense city neighborhoods she rejects the segregation of planned organization in favor on key physical factors that promote diversity and mixing: active sidewalks, permeable and finely scaled street edges, small blocks, mixed uses, variation in building age and size, concentration of people, and open spaces intimately linked to surrounding uses. Perhaps the greatest contribution of this literature is a recognition that building better cities depends on city planning and design research to move beyond the abstract world of two-dimensional diagrams an into the tangible realm of three-dimensional experienced space.

2.2.3 The Second Approach: Place & Image

As opposed to the direct concern for human use and behavior in the first approach, the second approach focuses on dimensions of the built environment associated with human values and meaning. This approach might be seen in the center of Lynch's diagram, balancing concerns between form (places) and human values (people). The conception of form moves beyond a functional container for activity to a physical realm endowed with cultural meaning and association. People are important not so much as users, but as agents of human aspirations expressed in our built landscape. It is premised on an inseparable bond of form and meaning. It advocates a more integrated construct of space that merges people and place.

This area may be seen as the realm of stories and beautiful images. Its methods tend to be very qualitative, emphasizing visual and narrative formats such as stories, drawings and pictures. Except for history, it is generally considered as the least academically rigorous approach. It does not have a theoretical base that can support predictive models. It seeks to understand how a city works through the mind of the collective and the culture.

Metaphor is often an important device for conveying theoretical understanding: city as organism (Mumford 1961), city as machine (Le Corbursier 1933), city as garden (Spirn 1984), city as poem (Calvino 1972), city as monument (Haussmann's Paris, Papal Rome—see Kostof 1991). Photography and drawings are used to capture the wholeness of place. If lectures in the *Environment-Behavior* area have lots of charts and diagrams of people flows, *Place-Image* lectures might tend to focus on projected images and narrative. The idea of city and landscape as cultural narrative is explicitly discussed by cultural geographers such as Brink Jackson (1980) and Grady Clay (1973).

While there is no agreed upon syntax or concept of urban form, it is not for lack of trying. This approach is where designer's feel most at home. Polemic debates and manifestos about the correct city form are central to this literature—from Le Corbusier's (1929) tale of "the man's way and the pack-donkey's way" to Solomon's (1992) "Tod and Mindy." This approach is often biased toward the normative perspective—concerned with what the city should be rather than what it is or how it works.

The field is built around the visual image and the aesthetics of place. Numerous works over the past century illustrate this central theme—albeit while advocating for widely divergent views of aesthetic quality (Camillo Sitte 1889, Burnham 1896, Sharp 1946, Unwin 1909, Hegeman & Peets 1922, Bacon 1976, Trancik 1986, Kostoff 1991, Duany 1992, 2003). The graphic / narrative synthesis of the environmental design journal PLACES provides an excellent illustration of the integration of visual image and cultural content.

The city as a historical artifact is also a central concern. The importance of the historical narrative and the city as a cultural expression is found in many places (e.g. Reps 1964 or Kostoff 1991). A particular segment of the literature focuses on the way in which historic cultural forces have shaped the decentralization of the American city (Warner 1962, Wright 1981, Hayden 1984, Jackson 1985, Stern 1986, Weiss 1987, Fishman 1987, Stilgoe 1988, Rowe 1991, Hayden 2003 and 2004). The built landscape as a cultural phenomena is well-represented in another related branch of literature—cultural geography (Lewis 1979, Jackson 1980, Lowenthal 1985, MP Conzen 1990, Groth 1994). This body of work tends to focus not so much on the aesthetics of place but rather how the visual and built landscape is linked to everyday culture.

Not surprisingly, architecture is well represented in this area. An excellent illustration of this literature is Christopher Alexander's *A Pattern Language* (1977). It is a fascinating attempt to be systematic while remaining non-specific. It breaks down the built environment into 253 patterns that range in scale from region to building detail. Its qualitative, poetic tone allows subtle insight and makes it a widely accessible work. Yet its application to more quantitative research it limited—it is replicable in conceptual terms but hard to use within a consistent analytical framework. The problem from the researcher's perspective is that it requires judgment. While this may be good for practitioners, it is not useful for systematic measurement. In the companion volume, *A*

Timeless Way of Building (1977), Alexander becomes almost mystical in his depiction of the key quality he seeks—the "quality that can't be named."

The investigation of deep human associations with the built environment and the neighborhood is well represented in other work as well. Southworth and Southworth (1974) explored these associations in looking at the city as a learning environment. Others probed different connections such as Hiss (1990), Garreau (1991), Lyndon & Moore (1994), Morrish & Brown (1994), and Rybczynski (1995). This literature expresses the broad complexity of the American city with its celebration of urban qualities ranging from ordered and graceful to rambunctious and chaotic.

This second approach is relevant to the particular interests of this research in several ways. While it does not provide a basis for systematic investigation of urban form, it does shed considerable light on the variation of urban form qualities and offers some very strong opinions on which of them are important to making good places. This literature is very strong on capturing the "wholeness" of a specific place and the subtle ways that places distinguish themselves as memorable in the world. It's use of photography, historic maps and field sketches demonstrate the power of graphic media in conveying environmental qualities. Lessons in reading the landscape offer insight into the embedded values and meaning in the built environment.

One of the key challenges will be to look at ways of using these tools in systematic ways to build comparative baseline knowledge of the proposed study areas. A good recent example is Alex MacLean's (Campoli and MacLean 2004) database of oblique aerial photography of American neighborhoods. It has begun to build the kind of rich historical record of urban form as the popular 19th century bird's eye views that John Reps (1964) used so successfully to chronicle the development of the American city. Systematic photography as research method may offer baseline data of urban form that eludes other more conventional methods.

2.2.4 The Third Approach: Structure & Process—Urban Morphology

The last approach focuses on understanding the built environment through analysis of typological elements of urban form and their evolution over time. We now find ourselves leaning distinctly toward the right side of Lynch's diagram—toward the urban form itself. People are still important but in a more distant and indirect way. Moudon in her 1997 article *Urban Morphology*, summarizes it as the "study of human habitat." The city is not conceived as a grand plan (e.g. Burnham, Haussmann), but rather as the "accumulation and integration of many individual and small group actions" (p. 1). The human side is represented as the producer of urban form. A morphologist might say this association of form to action is what endows an otherwise inert physical form or setting with cultural meaning.

This is the realm of the map-makers & ciphers. Its primary concern with systematic description and analysis of the built environment makes it most direclty related to my research objectives. The built environment is seen as an additive process of change, built-up from base elements such as buildings, gardens, plots, streets, parks and monuments. The formal patterns and relationships are "read" for significance and association. Meaning is a function of the form and adaptation of these typological elements over time—a kind of autonomous vessel for cultural meaning.

Theory and methods are systematic and graphic. They are based on a clear structural concept of the city being defined by the assembly of core physical elements (house, lots, streets) at different levels of resolution. These scales of resolutions step from building/lot to street/block to neighborhood/district to town/city and finally region (Moudon 1997). The elements together form a kind of descriptive language. This might be classified as an empirical-descriptive-inductive approach applied to measuring patterns of urban form rather than human activity.

The field of urban morphology is quite young. Moudon (1994) describes its emergence out of three parallel but distinct schools of thought: 1) The Birmingham

School founded by MRG Conzen (1961), 2) the Versailles School in France, and 3) the Italian School founded by Saverio Muratori (1959). While it is still rather inconsistent in its focus, a body of literature is starting to emerge and the field now has its own journal: *Urban Morphology*. All these schools are grounded in the conceptual use of "type" as a way of systematically understanding and directing the making of the built environment.

Urban morphology breaks down the built environment into three key issues: form, resolution, and time. The basic form increment or cell of the city is the house/lot/related open space. These cells aggregate up into key building blocks of urban form—for Conzen it is the "plan unit", for Muratori it is the "tessuto". Both group buildings, open spaces, lots and streets into larger cohesive wholes with common attributes. Thus the city may be analyzed at different resolution levels. Finally these patterns are analyzed to understand how they are transformed over time in relation to changing cultural and economic factors. Comparative time series graphics become important ways to see these transformations.

There is a strong bias toward using rigorous description as a basis for explanation. Yet the enormous lack of good mapping information at these scales presents an enormous obstacle to this research approach. However, recent advances in the computing power of GIS are increasingly seen to hold great promise for the future (Dodge & Jiang 1998, Hess et al. 2001).

The use of typology or "type" as normative model for urban design is not a new idea. It goes at least back to Italian renaissance architects such as Alberti and Palladio. The latter's highly influential *I Quattro Libri dell' Architecttura* (1570), or *The Four Books of Architecture*, laid out an entire rulebook of proportional and pattern for buildings, streets and cities. The specific typologies of palazzo (townhouse) and villa (country house) are clearly seen in his own work in the Vicenza region.

In this country, 19th century pattern books such as Asher Benjamin's *The Country Builder's Assistant* (1797) or Andrew Jackson Downing's *Cottage Residences* (1842) were widely employed source of typological forms of the American built landscape. Thomas Hubka's *Big House, Little House, Back House, Barn* (1984) picks up this tradition by using typology as a basis for studying New England farm architecture patterns. The tradition continued into the early 20th century with "catalog bungalows" influencing residential typology and and Hegemann & Peet's *American Vitruvius* (1922) informing the civic scale of the "city beautiful".

More contemporary work uses typological description and analysis for uncovering patterns at all scales. The most extensive analysis at the neighborhood scale is Anne Vernez Moudon's (1986) study of urban transformation in San Francisco's Alamo Square. Frank & Schneeckloth's (1994) collection includes numerous uses of type in spatial analysis. Southworth & Owens (1993) look at morphology of street networks at the urban edge. Jacobs (1993) looks at urban street typologies from around the world. Others use morphology and typology to discuss the infill development in the American City (Doern 1988, Owens 1994, Miller 1998, Ellis 2003). The use of urban form typologies to guide new development is much more common in Europe (Rob Krier 1979, Rossi 1982, Leon Krier 1984).

Much of the new urbanism's sense of order is premised on historic patterns. Vincent Scully (1992) observes the major insight of the early new urbanist work was the recognition of an integrated "street-building typology" as a defining feature of American urbanism. They adopt the same nested levels of analysis from region, to neighborhood, to street, block and building (Duany 1992, Calthorpe 1994, Katz 1986, Solomon 2003, Duany et al. 2003). While the best of new urbanist design is based on typology derived from a historical tradition, in general, the connection with any kind of systematic urban form analysis (in the Conzian sense) is weak at best. Without a solid basis, projects tend to easily morph into self-referential ordering systems hung on static, nostalgic or even wholly invented concepts of traditional town.

The relevance of urban morphology to my research aims is quite direct. It provides a systematic analytic framework for representing urban form at neighborhood scale. It offers some promise of being measurable. It is also has considerable strength for comparative analysis. The systematic, rational approach provides an organizing structure for graphic analysis. It also holds some promise for looking at the tricky issue of change over time and adaptation. Typology may also prove a useful analytic tool for capturing complex interconnection of form elements that are hypothesized influences on the pedestrian environment (Handy et al. 2002).

The problem of deriving replicable measures still remains a significant challenge. It is further handicapped by the large gaps in existing data sources at the detailed scale of the neighborhood, block, street and building. Increasing use of GIS analysis at this level is promising but still distant. However, keeping this possibility in mind will help inform the type and format of data developed for this project.

By way of summary, it may be useful to think about the three approaches to urban design in relation to a three basic ways of seeing the built environment:

FUNCTION (Environment and Behavior)

IMAGE (Place & Image)

STRUCTURE (Urban Morphology)

These ways of seeing all offer important perspectives to the work at hand. The first (function) offer insights into what may be key qualities to measure in relation to pedestrian travel and social life. The second (image) offers insights into ways of capturing holistic qualities of a place. The third (structure) offers the possibility of a systematized basis for analyzing neighborhood character is specific and discrete terms. All three perspectives will help inform the project's research design as outlined in Chapter Three.

2.3 Issues of Language, Measurement and the Idea of Neighborhood

The third and last section of the literature review addresses several key areas related to the specific task of measuring urban form and the specific scale of neighborhood. Lynch (1981) asserts that "language limits thought" (p350). By this he means the limitations of the standard two-dimensional planning language limits our ability to talk and think about cities; "thus, it is difficult to compare the quality of two places, except in some gross measures such as size or average density." These descriptive shortcomings, in turn, limit our ability to conceive and understand and the city—one can't think about something that one can't describe.

The rational geometry of the land use diagram was the ideal conceptual language for a young planning profession in pursuit of the scientifically-based city (Boyer 1986). The terms of this language have encouraged thinking about the city as an detached, abstract entity where everything has a proper place and is neatly bounded (Perin 1977). It also diminishes the perception of the city as web of relationships and stories with complex and subtle qualities of scale, texture, and overlapping realms. Thus, the abstract, detached character of post-WWII growth is not surprising. Dolores Hayden's (2004) book *A Field Guide to Sprawl* develops a more descriptive slang for these patterns to assist the average person to see their environment more clearly.

In *Planning to Stay*, their lucid primer on Twin City neighborhoods, Morrish and Brown (1994) argue that the simple act of changing the descriptive words we use, will help change how residents see their neighborhood.

> *We have deliberately used new language for this book, because we are trying to help people see familiar things in a different way. We have avoided using standard "land use" terms used in typical city planning documents or descriptions you may assume you already understand. This vocabulary shift is meant to help you express some important ideas about your neighborhood more vividly and precisely, without resorting to technical terminology. (p.15)*

Another compelling portrait of how visual language can limit cognition can be found in the work of Edward Tufte (*Envisioning Information* 1990, *The Visual Display of Quantitative Information* 2001). In his brilliant short essay on Microsoft's *PowerPoint* software, he discusses how the ubiquitous, one-size-fits-all format presents information in a way that actually impoverishes thinking and ideas. It fails to convey, in substantial ways, what is really important (2004). This problem is analogous to GIS generated graphics. Standard displays of information replace thoughtful display. Rather than removing bias, the "objectivity" of a default program view can sort and display information in a highly biased way. This unintended bias is well illustrated in the geographical organization of US census data into closed polygons that do not reflect the basic structure of human settlement. Without meaning to do so, it distorts spatial distribution of population at more detailed scales. In a world of massive amounts of information, it seems ever more critical for researchers to understand how data collection and display affects research interpretation and findings.

This final literature review will cover some specific issue related to this project's efforts to develop more specific accounting of neighborhood form. It includes 1) a brief description of the history and limitations of conventional measures of urban form, 2) a review of some current work related to measurement of urban form, and 3) a discussion of *neighborhood* both as a historic idea and a unit of analysis.

2.3.1 The Limits of Conventional Measures: Density and Land Use

One only has to look as far a typical zoning code or an introductory planning text to see how fundamental the concepts of land use and development density are to a planner's understanding of the urban environment (Gallion and Eisner 1963). Use typically refers to the segregation and classification of land by type of activity—such as residential, commercial, or industrial. Density describes the intensity of urban activity over some unit area such as units/acre or persons/square mile. Combined into designated land use zones, these constructs are easily illustrated as magic-markered blobs on a land-use map (or, in today's terms, as filled polygons on a GIS map).

There is an extensive literature documenting the emergence of these concepts as the primary controls governing land development. Warner (1962) documents the rapid pre-zoning development of Boston at the end of the 19th century. Boyer (1983) outlines how rational science pushed the emergence of segregated Euclidean zoning. Kenneth Jackson (1985) documents how the rise of the automobile and related federal policies directed investment away from existing mixed-use neighborhoods in favor of low-density single use neighborhoods. Wright (1981) recounts the strong social and cultural pressures toward suburbanization in response to urban crowding and the "cult of domesticity." Weiss (1987) shows how the concepts of separation and control aligned with the interests of large real estate by stabilizing markets and limiting competition.

The problem, from an urban design perspective, is the abstract and general nature of these standardized descriptors. Simple comparisons of neighborhoods that measure as quite similar using conventional planning measures can, in fact, be dramatically different places (Owens, 1993). The descriptive weakness of these concepts can obscure significant issues of urban development. A recent study of the Puget Sound Region discovered an unrecognized pattern of suburban form by comparing census measurements of form and use with ground based knowledge from aerial photos and field reconnaissance (Moudon & Hess 2000). They discovered, contrary to popular images of suburbs, over 20% of the suburban population lives in "nucleated clusters" that were denser, and more mixed than a typical urban neighborhood in the same region.

This pattern of suburban nucleation runs completely counter to the dominant understanding of the suburbs as dispersed and segregated. This was missed by conventional measures for two reasons: 1) the coarseness of data due to the size and arbitrary boundaries of the unit of measurement (e.g. census tracts, TAZs), and 2) the type of data collected did not fully describe the actual patterns on the ground (Moudon et al. 2001). The incorporation of more sophisticated GIS measures holds considerable promise to better address poor spatial matching of data boundaries to "on the ground" land use and weak measurement of other important form characteristics (Southworth 2003, Dodge & Jiang 1998). However, the key question of what to measure in order to efficiently capture urban form still remains a debated issue for researchers (Hess et al. 2001, Southworth 2003, Talen 2003, Ewing et al. 2004).

The problem of language is further illustrated in a 1997 JAPA *Point/CounterPoint* debate between Gordon & Richardson and Ewing. Their divergent views are muddled by conflicting definitions of what constitutes *compact* versus *sprawl* development patterns. The debate is handicapped by poor specification of widely used terms as sprawl, compact development, new urbanist, smart growth, suburban, etc. Some argue poorly defined terms can result in adoption of policies whose associated public benefits are more based on speculation than fact (Furseth 1997). While a recent project works towards a nation-wide standard for measuring sprawl at the regional scale using aggregate data, problems of developing more refined and replicable measures at the neighborhood scale remain (Ewing, Pendall & Chen 2003).

An unspoken problem underlying this debate is that, strictly speaking, density and land use don't actually measure urban form very well. Development *density* measures average intensity of building type or persons over a given spatial unit. Their ability to represent spatial parameters (e.g. pattern, shape, grain) depends on a base spatial unit fine enough to differentiate the space under study. Likewise, generalized *land use* classifies activity type within a given area but provides little insight into spatial form. Better spatial measures depend on data being attached to something finer—a building or a space or a parcel. While Lynch (1981) considers this a problem, the inseparable bond between use and the built environment may provide important clues for methods of capturing these patterns of land use in more specific and precise terms.

For instance, the concept of typology (associating specific form & use) may be a useful tool to describe this relationship in much more concrete terms. While type is still a generalization of the actual form, it provides much greater descriptive power than a land use bubble. This gets at the central challenge of this project—to derive replicable, understandable, and measurable dimensions for urban form analysis.

2.3.2 Measuring Urban Form: Recent Work

There has been a growing effort to develop better descriptions and measures of the built environment and neighborhood form. A scattering of work over the past 30 years addresses questions of key qualities of urban form at the neighborhood scale (Hester 1975, Moudon 1986, Owens 1993, Morrish & Brown 1994, Southworth 1997). More recently, attention has been focused on measuring specific aspects of urban form such as Hess (1997) on connectivity, Moudon & Hess (2000) on suburban nucleation, Southworth (2003) on livability, Krizek (2003) on urban form / transportation, and Talen (2003) on urbanism. A systematic model of urban form proposed by the New Urbanist's call the "transect" has of generated a lively debate about key questions of measurement (Duany & Tallin 2001, Southworth 2003).

Other work is bringing new tools to the task. The Lincoln Institute of Land Policy's *Visualizing Density* project (Campoli & MacLean 2004) presents a compelling catalog of aerial photographs of development patterns from across the US with related density calculations. It reveals the great variety of physical form and visual character across areas with similar density. These variations are explained by differences of design but are not described with any specific measures or attributes. The project demonstrates the oblique aerial photograph (or bird's eye view) as a promising tool for capturing key visual and structural dimensions of a neighborhood in a single image.

Significant contributions are also being made in measuring street patterns—a key differentiating quality in urban form. While street pattern certainly has a great influence of development character (see Southworth and Owens 1994), the tendency has been to limit the distinction to a simple dichotomy between *grid* and *cul-de-sac* (see Crane 1996). While Hess (1997) and Krizek (2003) have developed better measures of street network connectivity, it remains fertile ground for future research.

Another promising direction in urban form research is the collecting urban form data using GIS at the parcel-level. This may potentially address many of the data specification issues discussed earlier. Moudon & Hubner (2000) and Moudon (2001) have employed a parcel-level GIS approach to measuring land supply and development capacity. This work suggests a promising new direction for a broader application of parcel level analysis to the challenges of measuring urban form—the direct concern of this project.

Finally some on-going work should also be noted. McNally (forthcoming 2005) has been developing methods for analyzing the landscape of the urban neighborhood by using Perry's "neighborhood unit" concept as a basis for comparative analysis of neighborhoods in California and Japan. Ewing, Handy et al. (forthcoming 2005) are in the midst of another promising project focused on "developing measurement methods for intangible urban design qualities" thought to have a significant influence on active living (i.e. walking, exercising, etc.) in residential neighborhoods and urban settings. The research approach focuses on rating key qualities in across a series of video clips of streets using statistical controls to ensure reliability. Associated physical elements are then measured from media.

While it shares the general aim of better specifying urban form variables at the detailed scale of street / block, the above project appears to be conceptually inverse to the research approach of this project as outlined in Chapter Three. This project begins by measuring actual physical variance in the built environment, and then tests correlations of measured values with perceived environmental qualities as opposed to vice versa. The results should prove interesting to compare.

2.3.3 The Neighborhood Unit: History of an Idea & Increment of Analysis

Finally some discussion is in order regarding the basic unit of analysis for this project—the neighborhood. The concept of neighborhood has been a powerful idea in the history of American urbanism. It has emerged as key aspect social and cultural identity (for divergent perspectives see Keller 1968, Poponoe 1977, Davis 1992). The concept of the residential neighborhood as a planning ideal has also had a major impact on the growth and form of the American city in the 20th century. An extensive discussion of this literature can be found in *The American Urban Neighborhood: 1890-1990* (Owens 1993).

Arguably the single biggest influence on the development of the neighborhood as a central idea in city planning was Clarence Perry's 1929 article in the *Regional Survey of New York and It's Environs*. In it he draws on his own experience of living in the Grovesnor Attenbury's Forest Hills Village in Queens (circa 1911) to develop his now famous concept of the "neighborhood unit" as a protected family enclave from the dangers of modern life (e.g. motor vehicles). Others such as Stein (1951) and Lewis Mumford picked up and promoted this thesis across the country (Hall 1988).

Though stripped on many of Perry's original concerns for pedestrian scale and community uses, it's organizing influence can be seen in the suburban form of every major city in the United States, and even around the world. Two key concepts have been largely retained—1) protection from automobile traffic and 2) organization around an elementary school. The linking of elementary schools and housing tracts can be most clearly seen in many older suburban patterns from the 1950's and 1960's. Curiously, despite its historic association with single use, low density, traffic-protected suburbs, Perry's ideal has been vigorously promoted by the champions of the current new urbanist movement (Duany et al. 2003).

In more recent decades expanding size requirements for school sites and arterial roadways have meant the ideal of integrating of schools and neighborhoods in many newer suburban areas survives in concept only. The resulting scale of development patterns is simply too large to support pedestrian life. Kids are driven to new mega-schools by their parents because school sites are simply too far away and too dangerous to walk to anymore. With the explosion of gated communities, planned unit developments (PUDs), and auto-scaled site planning, the reality of the neighborhood unit as a basis for city planning is highly debatable in many areas. Yet the concept remains a powerful one. A resurgence of the neighborhood-based images in the real estate industry suggests its influence is likely to continue—at least in theory.

The staying power of *neighborhood* as a conceptual building block of the American city makes it an ideal unit of analysis to look at issues of measuring urban form. It has been a central frame of reference for the past 50 years of urban design research. Jacobs (1961) uses it to framework for organizing her observations relating urban design and street life and her related critique of the city planning profession. Hester (1975) considers neighborhood as the physical realm for building community identity and political power. Lynch (1981) discusses it both as a type of urban form and a social construct. Morrish & Brown (1994) attempt to develop better language for neighborhood analysis and revitalization. Finally Patricios (2002) revisits the concept and relevance of the neighborhood unit for a new century.

The neighborhood scale provides an ideal unit of analysis for researching questions of measuring urban form. The lack of clear standards and definitions of neighborhood form continue to handicap research (Plaut & Boarnet 2003). The relative advantages and disadvantages of neighborhood as the primary unit of analysis for developing more systematic methods for measuring urban form will be outlined at length in the upcoming Chapter Three discussion.

I am no scientist. I explore the neighborhood. An infant who has just learned to hold his head up has a frank and forthright way of gazing about him in bewilderment. He hasn't the faintest clue where he is, but he aims to learn. In a couple of years, what he will have learned instead is how to fake it: he'll have the cocksure air of a squatter who has come to feel he owns the place. Some unwonted, taught pride diverts us from our original intent, which is to explore the neighborhood, to view the landscape, to discover at least where it is that we have been so startlingly set down, if we can't learn why (p. 12).

• Annie Dillard Pilgrim at Tinker Creek

Chapter Three:
RESEARCH DESIGN & CASE STUDY SELECTION

This chapter outlines the project by asking three related questions: 1) *What* is the question being studied? 2) *How* will this question be studied? 3) *Where* will this question be studied? Section 3.1, lays out the central research question related to measuring neighborhood form. It also discusses related theoretical issues, the neighborhood as a unit of analysis, and a series of key hypotheses and expected findings. Finally it summarizes the research methods associated with each of the project's five phases. A more extensive discussion of methods in relation to each phase of the project will be presented at the outset of each subsequent chapter. The balance of this chapter summarizes the first phase—case study selection. Section 3.2 summarizes the selection of twelve neighborhood cases used for developing measures of broader, neighborhood-wide patterns. Section 3.3 discusses the selection of six more detailed cases used for developing measures at the more detailed scale of the street and block.

3.1 Research Question & Methods

The core of the proposed project is rooted in the question that first sparked the author's interest in urban design research twenty years ago: Why is the built form prescribed by a typical New England town's zoning laws so often at odds with the built form of the New England town—a form widely praised in the literature for its considerable virtues? For example, John Reps (1965) admires its human scaled mix of uses and simple yet richly varied spatial character. While the answer of this question is no doubt complex, one contributing factor *may* lie in the shortcomings of the urban form descriptors that typically underlie a zoning ordinance. Conventional measures such as *units per acre* are often unable to capture rudimentary physical differences that may be critical to prescribing a "good place" in policy language. It is this narrower question of how more robust methods may be developed to capture first order dimensions of urban form that is the focus of these research efforts.

The project began with a 1992 study of Seattle neighborhoods that found existing descriptive conventions of land use mix and density unable to account for basic differences in neighborhood form—especially those related to the quality of the walking environment (Owens, 1993). The limitation of development density measures to distinguish obvious differences of urban form is more broadly illustrated in the recently completed *Visualizing Density Catalog* (Campoli & MacLean 2004). The project uses systematic oblique aerial photography to document an enormous variation of character between dozens of places with similar density and use. Finally, the literature review presented in Chapter Two finds persistent problems related to operationalizing urban form as a research variable in a recent body of work testing the relationship of urban form to transportation, public health and other areas of interest—especially at the scale of the neighborhood.

In response to these issues, this project explores the potential for developing systematic, replicable measures for describing key physical attributes and relationships at the scale of the neighborhood. The central research question asks:

> **Are there specific, replicable measures of neighborhood form, beyond conventional measures of density and land use, that can more fully account for physical variation between neighborhoods?**

3.1.1 Theoretical Challenges of the Research Question

The literature review in Chapter 2 raises several key theoretical challenges in relation to this question. One issue is replicability—a key concern of many research efforts. Can the methodology be replicated and tested in other research? In some of the work reviewed, the urban form measures were replicable but weak. They did show much descriptive power to differentiating relevant variables. In other work, descriptions were more robust but not easily repeated in other research settings. At the heart of this question lies a basic theoretical tension between the quest for *simple, replicable, finite* measures and the *complex, dynamic, elusive* nature of what is being measured. Something is bound to get lost in translation.

Prospects for overcoming this tension are brightened by the powerful conceptual fact that many aspects of environmental space are dimensionable. For example, it is easy enough to give specific dimension to a say, a building. It is so long, so high, so wide. It has a volume and a floor area. Accounting for its shape in simple terms is more difficult but by no means impossible—for example pitch and orientation of a roofline can be simply described. Modern CAD (computer aided design) software can measure an extreme level of complexity and detail but generally doesn't provide any summary descriptive measures much beyond floor area and volume. The same holds true, at least potentially, for three dimensional city forms, though the measurements become even more involved and multivariate.

It is easy to see how measuring the complexity of the built environment could be an infinitely expanding task. However, without an underlying model relating measures to environmental quality, measurement alone is not a particularly useful exercise. Yet developing these models is not a simple task. Specific qualities need to be captured in simple, replicable standard measures without falling back on narrative distinctions such as “traditional” or “suburban” or "human-scaled." While these terms may have enormous descriptive power and efficiency, their ability to influence research and public policy is ultimately limited by their non-specificity. More useful and realistic measures may dwell in the “middle ground” between the abstract two-dimensional space of a land use diagram and the infinitely variable dimensions of a real place. The challenge, then, is to generalize up to a level of abstraction where ***readily observable spatial qualities*** can be grasped and distinguished in easily replicable dimensions. While on the surface this seems like a simple problem, the specifics are somewhat more complex. Some key issues include:

Challenge of Spatial Dimension: The conventional measures of density and use have weak spatial or formal dimension. How can density and use be measured in more spatial terms? How can neighborhood space be generalized to describe basic form while avoiding the problem of unlimited variation and specificity?

Challenge of Complexity: The variations of built form at this scale are quite complex. How can key elements or relationships of variation be teased out and defined? How can factors, particularly those relevant to the “walking” environment, be discerned?

Challenge of Measurement: Dimensions of design quality are considered elusive and resistant to systematic measurement. What kind of tools and methods are best suited to capturing complexity? How can the particularly elusive three-dimensional realm be measured? What exactly is going to be measured?

Challenge of Validity: Verification of any derived measure depends on both reliability and replicability. How can the correlation between a measured value and a perceived quality be tested? Is the measure simple enough to be repeated and used elsewhere?

Challenge of Specification: One possible goal is to derive measurement concepts that can be automated with GIS or other spatial computing tools. How well can derived measures be translatable to a computable specification? What kinds of data sets are required to do so? How accessible is this data?

Based on insights drawn from the literature review, it is the premise of this project that these issues are best addressed through exploratory in-depth study of a small group of neighborhoods. While this research could have been carried out in almost any urbanized region with variety of development patterns, the particular context for this work is the urbanized core of the Upper Valley region of Vermont and New Hampshire. The research design incorporates field and graphic based methodologies intended to capture broad spatial qualities and a set of specific and replicable measures that can describe them. The remainder of this section will discuss: a) the neighborhood as a unit of analysis, b) methods employed in the five part research project, and c) the set of hypothesized expected findings.

3.1.2 Unit of Analysis: The Neighborhood

As discussed in Chapter Two, the *neighborhood unit* has been a powerful idea in 20th century urban planning. Neighborhoods are a widely recognized unit of analysis well suited to the study of various dimensions urban form. As identifiable, physically bounded areas where people live, shop and work, they are places where the intersecting concerns of urban planning and design meet. While a neighborhood can be examined as single unit, it is also comprised of interrelated component parts that can be studied in detail. Elements such as buildings, parcels, streets, blocks, and open spaces are easily identified and analyzed. These may be organized as three nested scales of a tiered analysis of neighborhood form as follows:

1. **Building & Lot:** typical conditions at the level of smallest components
2. **Street & Block:** groupings of buildings and lots and their defining streets
3. **Neighborhood:** streets and blocks assembled into an identifiable area

These allow study of neighborhood dimensions ranging from the very detailed to the very general. In this project, analyses focus on the two larger scales: the *neighborhood* as a whole and the *street and block* scale. Streets and blocks are important because they are the primary realms where neighborhoods are experienced as fully three-dimensional spaces. Buildings, lots, and gardens will be considered as components of street/block spaces but will not be studied independently.

In defining a neighborhood as streets and blocks assembled into an identifiable area, the concept of *identity* is not used in the full Lynchian sense of somewhere with a strong “sense of place” or a vivid and unique character. It is intended only to describe somewhere with enough physical definition to be circled on a map as a place distinct from its surrounding context. It might be vivid, it might be common, it might be utterly forgettable. The important issue here is that one can draw a boundary around it based on some standard criteria.

The scale of a neighborhood is also unique because it is small enough to be defined as a specific and tangible place yet large enough to be acted on by the complex functions of exchange that are the public life of a city. A neighborhood is also understood (at least ideally) as having a pedestrian scale. This is typically described as an area falling within a radius of roughly 1,000 to 1,500 feet (300 to 500 meters) or approximately a five-minute walk from center to edge. This makes it a particularly relevant unit of analysis for studying the relationship of urban form to walking.

Key advantages of neighborhood as "unit of analysis" include:

- modest scale is complex but manageable
- discrete entity that can be widely understood
- form lends itself to analysis and expression of third dimension
- a unit of analysis accessible to researcher
- good unit for comparison, i.e. it can be identified elsewhere
- encompasses the domain of home-based walking
- scale is relevant to many issues of development and planning

There are also some disadvantages. While neighborhoods are often physically discrete, they are not functionally autonomous systems. Within the highly mobile and interdependent structure of the modern metropolis, neighborhoods are part of a larger regional network. Ambiguous boundaries can make them difficult to define in consistent terms. Today's neighborhood has been shown to have rather weak spatial correlation to people's work, family, and social allegiances. And yet it remains a central and important part of people's geographic identity (Lynch 1980).

Neighborhood complexity and variability present other limitations for urban form researchers. Variation in population and use that influence how a neighborhood looks and functions can mask underlying structural and physical characteristics. Research concerned with how *form affects use* must be careful to control for these variables. As this project focuses on form only, the significance of this problem is greatly reduced. Incidental observation of use will not be used to draw connections about the influence of form on behavior, but rather to help identify key physical components of neighborhood structure.

Finally, the sheer variety of neighborhood form makes it difficult to draw a representative sample of a larger universe of neighborhoods. Not surprisingly, there is also a scarcity of standardized urban form data at the neighborhood scale. As a result, compiling urban form data can be very time consuming. And since there is no general agreement on what should be collected, there is little compatibility of any data collected between places. This is especially true for three-dimensional data. By developing more systematic measures, this project hopes to help: 1) facilitate better classification of neighborhood form variables, and 2) identify key gaps in urban form data.

Key limitations of neighborhood as unit of analysis includes:

- problem of controlling for larger issues of city and regional context
- influence of population variables (but not for this project)
- problems of generalization—the lack of a representative sample
- limited data and time consuming data collection
- difficulty of measuring third dimension

This all suggests an exploratory research design based on a limited sample of cases. Two sets of cases will be drawn from the same region. A *neighborhood* scale set will be used to derive and test measures of neighborhood wide spatial patterns and relationships. A more limited and detailed set of *street/block* cases will used to derive urban form measures at the scale of three-dimensional neighborhood space. The results of such an approach are necessarily specific and non-generalizable. It is hoped, however, the project will complement the broader goal of developing more robust means for operationalizing urban form in future research.

3.1.3 Hypotheses & Expected Findings

The exploratory nature of the research makes standard hypothesis testing using a quasi-experimental research model somewhat problematic. In this project potential findings were less certain. The relationships and outcomes that were tested were somewhat more general and speculative at the outset. Over the course of the project they were revised and sharpened in response to findings along the way. In place of specifically predicted outcomes, a series of expected findings were proposed in relation to nine characteristic qualities of urban form. Each quality was thought likely to prove a significant factor in explaining variation of neighborhood form that eludes standard land use and density measures. The following discussion summarizes each quality and speculates on key factors related to its physical manifestation and measurement in simple, replicable terms.

Spatial Form of Density and Use. One of the key findings taken from the literature review was that planning standards such as density and land use are not very good measures of urban form—especially at the scale of neighborhood and street. They measure of basic distribution (i.e. units per acre) and simple use type (i.e. retail or residential) but they capture little about the way a neighborhood is organized, scaled, and shaped as three-dimensional space. Yet density and land use do have observable spatial patterns. A key part of this project may lie in capturing these patterns through higher resolution analysis.

- Density can be given more specific spatial dimension through measures keyed to block by block, parcel by parcel, or building by building variation
- Land use can be given more discernable dimension by using typologies that associate uses with patterns of buildings or parcel configuration

The Overlap Zone: Public and Private Space. Another key concept found in the literature is the impact of the relationship between private building and public street on neighborhood character. A variety of elements affect this relationship. Building-edge elements include setback, front yards, and connection of inside to outside (e.g. entries, porches, stoops, windows). Street-side elements include street width, sidewalks, tree belts and traffic volumes. Key issues are likely to include:

- Interaction of front yard/house with the street (fences, windows, doors, etc.)
- Gradient of public vs. private space (porches, yards, sidewalks)

- Degree of street right-of-way dedicated to non-auto use

Building / Lot Orientation & Spacing Along Street. Another distinguishing characteristic of neighborhoods is the arrangement of buildings on lots, and the orientation of building and lots to the street. These relationships affect how compressed or expansive a street feels. On one end of scale are skinny buildings, on skinny lots, with gables facing the street. At other end are wide buildings on wide lots set far back from the street with gables perpendicular to the street. The relative consistency of the pattern along a block and at corners is also important.

- Proportion of lot & building width to depth
- Setback of building to street
- Relative distributions along the street/block

Scale and Degree of Enclosure. The degree to which street or neighborhood space feels enclosed is also expected to be significant in distinguishing neighborhoods. It is often discussed in relation to the concept of scale. Words like "intimate" describe one end of the scale (e.g. pedestrian walks in North Berkeley) while terms such as "vast" describe the other (e.g. Corbusier's Ville Radieuse). Vegetation (especially shade trees) and building edges are the major factors affecting sense of enclosure. Smaller scale elements such as fences and hedges also play a role. Key issues may include:

- Proportion of street width to height of building
- Spacing between buildings
- Extent, size, spacing of street trees

Scale and Neighborhood Grain. Another aspect of scale is "grain" or the basic cell size within a larger neighborhood pattern. It is related to what Muratori (1959) called "edilizia"–the smallest element of building and surrounding open space that defines the character of the built fabric. Aerial photographs clearly show how changes in grain correlate with on the ground experience. Unlike enclosure, this quality is a more about two-dimensional pattern than three-dimensional space. For example, at one end of this scale might be Beacon Hill in Boston, and the other end might be groups of large suburban estates found at the edge of most American cities. Grain can be measured in relation to both size and consistency (i.e. homogeneity versus heterogeneity).

- Relative size of parcels, blocks and buildings
- Building to parcel relationship
- Relative consistency of pattern across neighborhood

Connectivity of Streets. Street pattern is a widely cited element of neighborhood form. Because street data is widely available, (from gas station maps to USGS quads), it is one of the few elements of neighborhood form widely analyzed in academic work. However, until recently there was little in the way of connectivity standards much beyond typologies of grid versus cul-de-sac (Butler and Handy, 2003). Connectivity, or the extent to which the network is inter-connected, is one attribute that can be measured across many types of street pattern. Block size and intersections per unit of area have both been used as connectivity measures. Paths, sidewalks and trails are key elements for pedestrian and bike connectivity.

- Block size versus intersections per unit area counts
- Accounting for internal versus external connectivity

Openness of Edges & Boundaries. Boundaries and edges are what divide and distinguish a neighborhood from its context. Neighborhood borders are almost always some combination of circulation corridors such as major streets or railroads and/or physiographic elements such as streams, topography, and open space. As with streets, there can be great contrast of edge permeability. Some neighborhoods are inwardly focused and shut off from their surroundings (e.g. gated communities); others are open and permeable at their edges (e.g. part of a street grid). Permeability is a function of both building/lot orientation (e.g. facing outward or inward) and street connections (e.g. number of access points).

- Points of access into neighborhood (both streets and open space)
- Orientation of lots and buildings at the neighborhood edge

Variability and Consistency. A more elusive quality is the relationship between the variability and consistency. At one end of the spectrum is heterogeneity—a random pattern with little in the way of organizing or standardized elements. The opposite is homogeneity—a clear and unyielding order across all aspects of neighborhood form. Most neighborhoods fall somewhere in the middle with some degree of variation around some ordering framework. Sometimes the street system provides the order, sometimes the buildings do, sometimes both. Some places, such as Boston's Back Bay, have greater variation at the house/lot scale and less variation at neighborhood scale.

The degree of variation and order can range widely. Consciously planned places are typically associated with a high degree of order (e.g. master planned communities). More organic places (e.g. squatters settlements) are typically linked with high variation. But rules are sometimes invisible and variation has a way of sneaking into even the most monotonous places over time. The development process itself is plays a significant role in this quality. Some places have very organic forms that have been standardized through contemporary codes (e.g. Nantucket); others show organic transformation of originally standardized forms (e.g. Levittown). It is expected this relationship will be a difficult to reliably assess and measure.

Change and Adaptability. Finally some attention to the temporal aspect of neighborhood form—that how form changes over time. While this can have an enormous impact on the quality of a neighborhood, it also is expected to be very hard to measure in systematic terms. What are the units of measurement? Layeredness? Visible history? Sense of time? How are these qualities derived and compiled? Time sequence drawings or historic photographs can show some first order representation of change over time but comparative measurements may be difficult.

Clearly the degree of change is to some extent a direct function of age. Rome has many layers of settlement patterns. Orange County does not. Pressure for change is also directly related to the cultural and economic conditions of successive generations of users. A village in a relatively remote part of the world (e.g. Bohemia) may not change much over centuries while areas outside fast growing American cities (e.g. Santa Clara Valley) can change beyond recognition in several decades. Some places seem to adapt well to incremental change (e.g. Alamo Square in San Francisco) while others change by large scale clearing and rebuilding (e.g. Santana Row in San Jose). Development standards, ownership patterns, lot size and real estate practices all impact the pace and nature of change. Many American neighborhoods are young and patterns of change are not very clear yet. However, as land resources dwindle, political resistance to sprawl mounts, and lifestyles change, a better understanding of the dynamics of change and adaptation within existing neighborhoods will become increasingly important.

Concluding Thoughts. Many of these concepts such as grain, scale, and orientation have been extensively discussed in the urban design literature. However they are almost always defined in qualitative or narrative terms. They are routinely discussed in professional design forums with little regard for precise definitions or shared basis for meaning—often as a part of a rationale for a proposed design scheme or theory. The intent of this project is to explore to what extent some of these qualities can be captured in more systematic terms.

Some qualities are clearly easier to operationalize than others. The last two may be seen as meta-patterns that will likely be hard to capture with any static measure. Others such as street connectivity maybe more straight forward. While they range in scale, they are interrelated. Neighborhood wide patterns (e.g. grain, boundary, street pattern) are assembled from smaller scale increments (house & lot, street section). As the project proceeds, it is expected this classification will be revised and reordered. The final set of qualities that will be measured and their related physical components are bound to change. Nevertheless the above outline provides a good starting point for exploring and measuring physical differences between neighborhoods.

Hypothesized Research Parameters: Finally some hypothesized parameters were proposed in relation to the specific nature of the measurement instruments and process. Specifically they postulated that comparative measurement of neighborhood form would:

- require measuring relationships between elements rather than simply the individual elements themselves;
- result in measurement units that are expressed in relative or proportional terms rather than absolute numbers;
- require data sets that are primarily quantitative in form in order to create simple, replicable measures;
- find certain urban form characteristics will elude attempts to be captured in quantitative terms;
- need to utilize typological analysis to capture more complex aspects of three-dimensional form;
- require a "trial and error" method that works back and forth between derived measure and observed variance.

Many of these assumptions were built directly into the research methods. Their validation was largely a function to what extent they proved to be true over the course of the research project. In some cases they were, in other case they weren't. These findings will be discussed at length in the concluding chapter.

3.1.4 Summary of Research Methods

The research design comprises a five-step process leading from the initial selection of the cases to the final testing of the derived measures. Methods for selection of twelve *neighborhood* case studies and six *street/block* case studies will be described at length in Section 3.2 ***Case Study Selection*** of this chapter. The methods for each subsequent step are summarized below and discussed at length in the five subsequent chapters. Chapter Four summarizes the analysis of neighborhood form used to identify potential variables to be measured and their associated qualities; Chapter Five & Six describe the derivation and testing of experimental measures at two distinct scales; Chapter Seven details the use of a field based survey to evaluate the perceptual range of qualities across the cases; and Chapter Eight tests the correlations of measured values with the range of perceived qualities at both the neighborhood wide and street/block scale.

Analysis of Neighborhood Form (Chapter Four): Following the case study selection, a series of three methodologies were enlisted to systematically document a comparative baseline profile of neighborhood form. Each relates to the three theoretical approaches discussed in Chapter Two including *observation* (environment & behavior); *photography* (image and place); and *mapping analysis* (urban morphology). All support an analytic framework that understands the built environment as a dynamic ecology requiring first hand seeing, feeling, touching to grasp its full complexity.

The baseline profiles were used to build an *analysis of variance* matrix to comparatively array character differences for a series of urban form elements or variables across each set of case studies. Variables for the *neighborhood* set included elements such as street pattern, land use & parcel pattern, building type, etc. Variables for the *street/block* set included variables such as street cross-section, landscape character, building setback/height/width, and streetscape features. Finally patterns of physical variation were speculatively associated with a series of structural relationships and tentative environmental qualities. Associations provided direction for potential measures that might be derived in the next stages.

Deriving and Testing Measures (Chapters Five and Six): Based on insights from the urban form analyses, a series of urban form measures were derived and initially tested at each scale of neighborhood analysis. The *neighborhood-wide* measures are covered in Chapter Five; measures for the *street/block* scale are described in Chapter Six. Deriving and testing measures involved a similar process for each scale. First the data necessary to develop the measures had to be identified, specified and compiled into a master database. Wide variations in available data across analysis scales and study sites presented a variety of challenges. Basic parcel-level GIS data did allow a database to be built around individual parcel records allowing higher resolution specification of many urban form variables than is typically possible. By filling in gaps in existing data with assessor's records and field surveys, a consistent database was established for most neighborhood wide variables. Since there was virtually no pre-existing data for the detailed scale of street/block, potential measures were limited by the type and extent of data that could be manually compiled through field surveys and photographic analysis.

Each data set provided the basis for deriving experimental measures of various dimensional relationships and assessing potential correlation between the measured variation and key environmental qualities (e.g. enclosure, connectivity). The nature of these qualities were hypothesized in the initial project design and refined over the course of the urban form analysis (see previous discussion in Section 3.1.3).

Relationships between variables were probed with basic statistics. Rudimentary measures were tested using various "intensity measures" describing some *value per unit of analysis*. Resulting values were initially tested using a trial and error calibration process that arrayed calculated values against the researcher's own perception of variation between neighborhoods and asking: ***Do the values reasonably represent the observable variation in neighborhood form?*** Based on results, measurements were adjusted, revised, or thrown out. The process was repeated until a reasonably good fit was attained for a given spatial characteristic. The goal was to identify measures with some potential to capture first order physical differences between neighborhoods in as simple and efficient way as possible.

Surveying Neighborhood Qualities (Chapter Seven): The fourth step used a *Neighborhood Evaluation Survey* to establish a more substantial baseline for perceived environmental variation of neighborhood qualities across the selected cases. A relatively small sample of thirty-seven individuals evaluated nine qualities on a 1 – 5 scale during six carefully controlled two-hour survey tours. In each of the six case study neighborhoods, four qualities were assessed during a five-minute driving tour and five more during a five-minute walking tour down a single block. The sample was split between professionals with some training in an urban design-related field and laypersons with an interest but no formal training.

The survey tested three basic questions. First, were the qualities clear enough to be reliably and consistently distinguished by each survey group across the study neighborhoods. Secondly, did the range of observed variation between neighborhood confirm the assumptions of physical differences that underlay the case study selection process. And finally, how did the survey group's perceptions of differences between neighborhoods correlate with those of the researcher. The clarity of quality definitions of were probed with open-ended survey questions. Scores were compared to see how perceptions of different qualities varied across survey groups and case studies. Taken together, the results provided a broader baseline against which to test and evaluate derived measures in Chapter Eight.

Correlating Measured and Surveyed Values (Chapter Eight): Finally the distribution of average survey scores for each quality were correlated with values calculated from experimental measures across the six study cases. Combination graphs allowed the relative values of derived measures (e.g. *parcels per acre, setback to height ratio*) to be scaled on a primary axis and correlated with the mean survey values scaled to a secondary axis across all six cases for each surveyed quality. This allowed some first order testing of the capabilities of different measures to record basic distinctions in environmental qualities perceived across case study neighborhoods. The relative robustness of measures to capture variation in neighborhood form is assessed and potential refinements and improvements are discussed. Prospects and limitations of findings within a broader context of urban conditions are evaluated and directions for research are suggested.

3.2 Neighborhood Case Study Selection

The project's first task was to select the set of neighborhoods where the project would be carried out. The following section summarizes the process beginning with a description of the study's regional context. The next sub-section describes the initial identification and sorting of two dozen potential case studies by density and development pattern. The section concludes by detailing the rationale for selecting the final set of twelve neighborhoods—three sets of four matched cases. Each set is selected to cover a broad variation of urban form within a specified development density. Together they comprise a field-based laboratory for testing and comparing proposed measures of neighborhood form.

3.2.1 The Regional Context of the Upper Valley

The Upper Valley region is a surprisingly good place to study neighborhood form. While its small size limits the potential universe of cases, it has a reasonable range of neighborhood form within its urbanized core. The region is located along the Connecticut River bordering Vermont and New Hampshire about 120 miles northwest of Boston *(Figure 3-1 Location Map of the Upper Valley Study Area)*. First settled in the mid-18th century, the region has grown to encompass several dozen valley towns with a population of about 125,000. It is centered around a 19th century railroad junction and a 20th century intersection of two interstate highways. Its four town cores include Lebanon, NH (pop. 13,000); Hanover, NH (pop. 11,000); Hartford, VT (pop. 10,000); and Norwich, VT (pop. 4,000). A number of older and newer neighborhood patterns can be found within their seven distinct village and town centers.

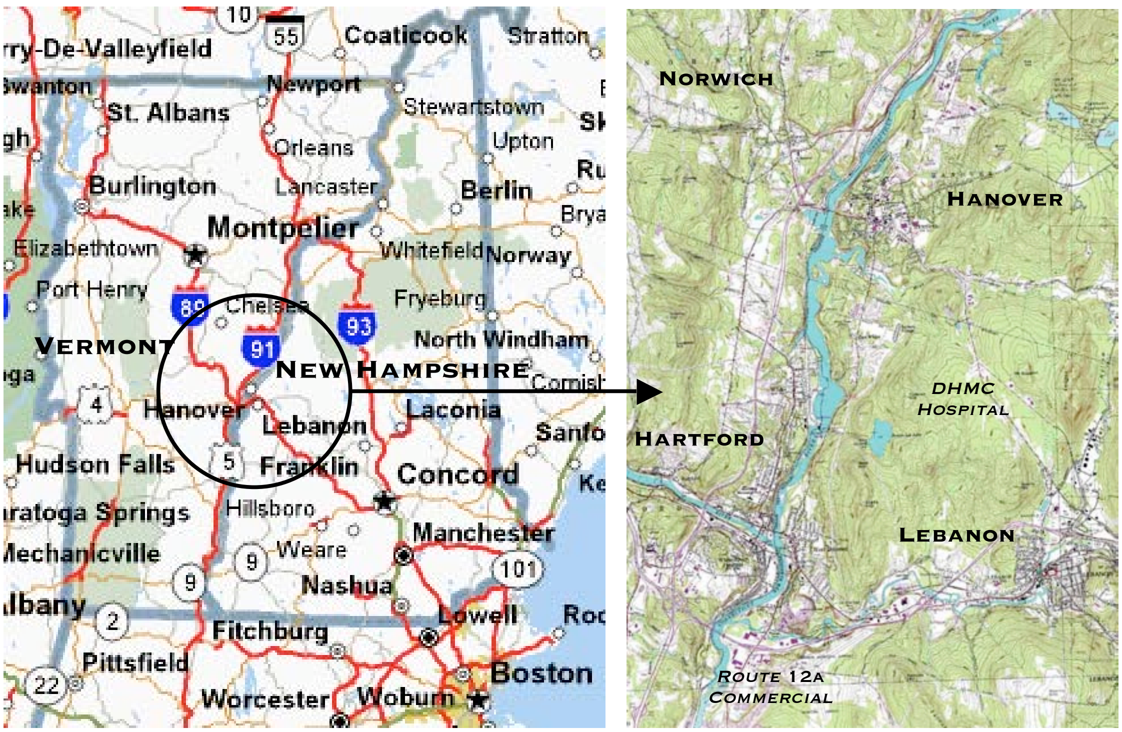


Figure 3-1 Context Map of the Upper Valley Region & Study Area

In recent years the core area has been further multi-nucleated by the growth of two new regional centers that are separate and distinct from the region's historic centers. The region's major employer, the Dartmouth-Hitchcock Medical Center (DHMC) and its associated Centerra Business Park, are sited on a new hilltop campus midway between Hanover and Lebanon. The Route 12A commercial strip, just across the across the river from Vermont, has grown into the regional retail center. Remarkably, neither of these places has a single unit of housing within walking distance.

As a result of these patterns most of the core's residential areas have comparable regional access to jobs and shopping. The exception is central Hanover where

Dartmouth College remains a major in-town employer. Despite the historic decline of rail, mill, and manufacturing jobs in the other older centers, a variety of retail shops and small businesses continue to serve these areas. Many newer areas (especially the higher density ones) share a similar, if somewhat less organized, adjacency to local retail services and small businesses. Thus a variety of in-town neighborhoods with a wide mix of traditional and post-war development patterns can be found within the core area.

3.2.2 Identifying and Sorting Potential Case Studies

Case selection began by identifying all potential study neighborhoods in the Upper Valley. The process was a variation on methods employed by Moudon and Hess (2000) to identify areas of suburban nucleation in the greater Seattle region. They used a three-step trial-and-error process including census analysis, aerial photography, and on-the-ground field checking to identify suburban clusters of higher density residential use in close proximity to retail and other services. These same steps were adapted to the Upper Valley region to locate areas of comparable residential density and land use context with contrasting attributes of physical form.

In the spring of 2004, USGS maps, a digital street atlas (Delorme Street Atlas USA), and the on-line TerraServer-USA ortho-photography database were used to locate all potential case studies within the urban core of the four towns. For the purposes of this study, potential neighborhoods were defined as any identifiable, contiguous, residential cluster that was roughly one-quarter mile in radius with some adjacency to non-residential uses such as schools, shops, and recreation. The target radius was quickly reduced to 1,000 feet (75 acres) to better fit the grain of local settlement patterns. The region's varied terrain and irregular street network tends to limit neighborhood size to 75 acres or less. Areas less than 35 acres in area or one unit per acre density were not considered viable neighborhoods for the purposes of this study.

Preliminary screening identified about 20 potential cases. Study areas were defined using observable common sense boundaries such as streets, land use pattern, and physiographic features such as waterways, wetlands, and topography. A follow-up windshield survey confirmed a reasonable range of physical character and density. Further field checking and pre-testing density using online census block maps resulted in a series of adjustments. Several boundaries were refined, one case was dropped and several others added to get a better mix of neighborhood types. In one instance a case (Norwich Village) was split into two cases to create two study areas of compatible size to other cases. *Figure 3-2* shows the full set of 24 cases. The set appeared to include at least several examples of all primary neighborhood types in the Upper Valley.

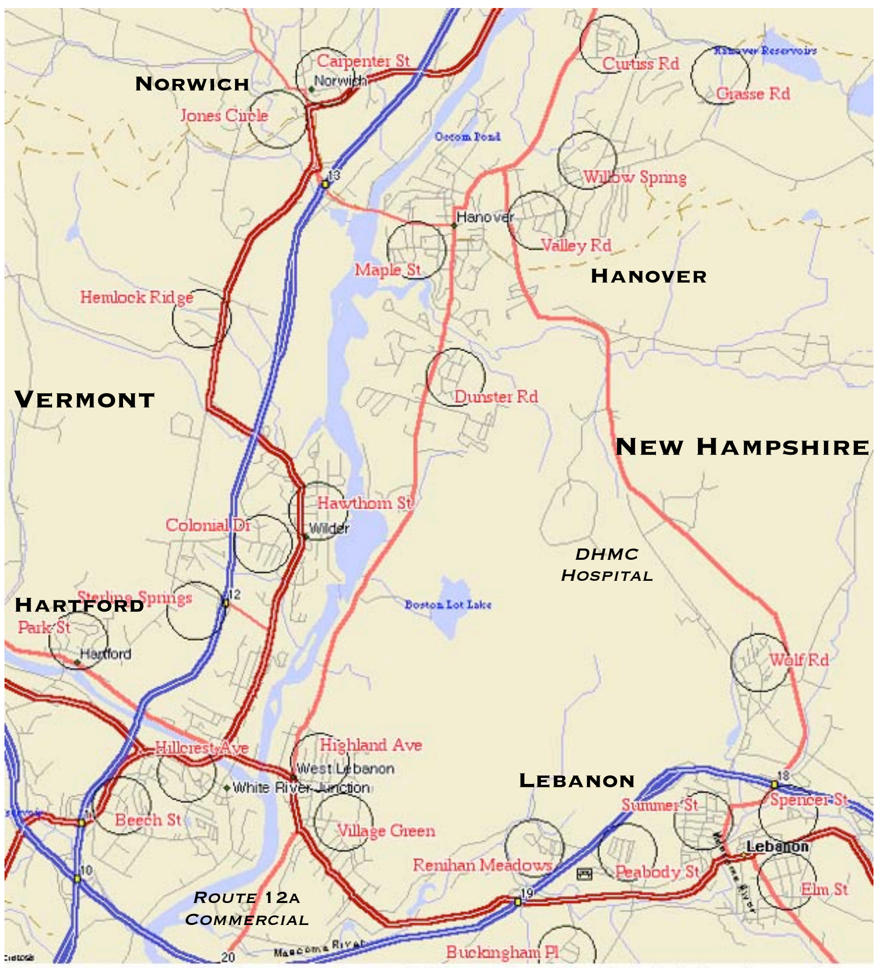


Figure 3-2 All Potential Neighborhood Cases in the Upper Valley

Calculating Density: The next step calculated and sorted the cases by residential density by the conventional measure of *units per acre*. Although the project is focused on physical form, *average household size* was also examined to ensure basic consistency of population between cases. The density calculation methodology was modeled on Campoli & MacLean (2004) which used ortho-photography, a digital atlas and census block level data to calculate number of units for physically identified blocks of residential development pattern.

An important difference is that neighborhood density, for the purposes of this study, is calculated as a *gross measure* rather than *net measure*. This means that 100% of the land area within the neighborhood boundary, including local streets, internal open space and a scattering of other non-residential uses, was included. The specific selection criteria ensured all cases included comparable degrees of non-residential uses. Once a parcel-level database was compiled for each case, a more detailed analysis of land use mix was done. The first part of Chapter Five describes this in detail. In contrast, *net density* calculations typically include only the land area of the developed parcel itself and not adjacent streets, parks, etc. As a result, gross neighborhood density is typically somewhat lower than net density calculated for similar housing patterns.

As long as the study area correlated with census blocks, the process worked quite well. The Campoli / McLean method assumes calculates density for individual blocks. Adapting this method to larger multi-block neighborhoods where blocks do not always correlate with census block boundaries presented a series of challenges. In the Upper Valley, the degree of non-correlation between census block geography and development pattern geography is amplified by highly varied, non-continuous terrain. Unlike larger, flatter urban areas where census blocks are almost agree with identifiable neighborhood blocks, nearly every neighborhood in the Upper Valley has at least one edge that is defined by topography or open space rather than a street. This results in perimeter edges of a neighborhood being included as part of enormous census blocks, often totaling several hundred acres, which extend to the next identifiable census division (e.g. distant street, water body, railroad, etc). Only a small portion of these census blocks and their associated population and housing data fall physically within the study area neighborhood.

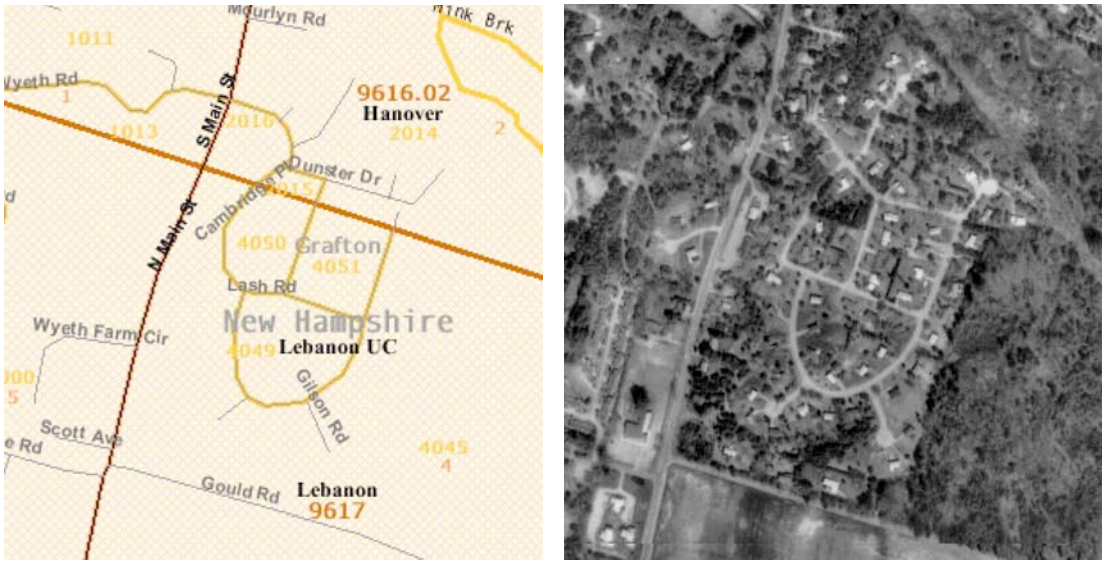


Figure 3-3 Comparing Census Block & Neighborhood Boundaries

This problem is illustrated in *Figure 3-3 Comparing Census Block & Neighborhood Boundaries.* The census boundary map on the left shows three internal census blocks (4049, 4050, 4051) just south of the Lebanon-Hanover town line. These blocks correspond exactly with the development block areas visible on the right hand ortho-photograph of the Dunster Road neighborhood. They have areas of 5.8, 3.7 and 4.2 acres respectively. However, the perimeter areas of the neighborhood just to the east, south and west of the three block cluster are part of census block 4045. This block measures a 324.3 acres—more than 6 times the area of the entire neighborhood. In GIS terms, this is because the census block polygon “fills” until it finds a “closed” perimeter. This results in a giant area of interstitial space being defined as a single census block. Because only a small fraction of the block falls within the physically defined neighborhood, land area and housing unit totals for 4045 must be interpolated using alternative methods.

The inconsistency of census blocks and neighborhood boundaries complicated calculation of accurate residential densities. Instead of simply adding the census blocks in the neighborhood, census blocks were divided into *inside* blocks (100% included) and *outside* blocks where only some fraction of total area fell within the neighborhood boundary. Since dropping outside blocks would exclude a large part of the neighborhood from the density calculation, both geography (area) and housing data had to be interpolated for each *outside* block. The number of census blocks per neighborhood varied from a low of one to a high of fifteen. In all but one of the 24 potential case study areas there was at least one (and often three or four) *outside* blocks that had to be interpolated. Depending on circumstance, several different techniques were used to interpolate values for land area and unit counts. The compilation and interpolation process is discussed at length in Appendix A. It also includes a table that breaks down all 24 neighborhoods by census block and documents sources and assumptions for interpolated values. An excerpt is shown in *Table 3-1 Census Block Interpolation*.

	NOTE 1: Data in white cells are from census blocks outside of, but adjacent to neighborhood
	NOTE 2: Data in blue cells are from census blocks partially within neighborhood (blue areas are much larger than yellow ones)
	NOTE 3: Data in yellow cells are from census blocks that are 100% internal to neighborhood
XXX	NOTE 4: Totals in BLUE type are use interpolated values from blue blocks (area, housing units, density, population)
XXX	NOTE 5: Totals in BLACK type generally use 100% values from blue blocks (occupied housing, % owner, HH, ave HH size)

Tract	BG	Block	Area (acres) (inferred)	Housing units: (inferred)	Density (units per acre)	Occupied housing units	Owner occupied units	Renter occpd x blk (% own total)	Total population: (inferred)	Total Households	Average Household size
961602	4	4008	281.15	120	0.4	119	114	5	334	119	2.81
961602	4	4010	25.54	0	0.0	0	0	0	0	0	0
1. Grasse Rd			**35.0**	**60**	**1.7**	**119**	**114**	**96%**	**168**	**119**	**2.81**
			new dev #'s from J Caulo, Dartmouth RE, 4008 (37 u / 32 ac), 4010 (23 u / 22 ac) minus 19 ac (35%) req OS								
961602	4	4000	316.00	111	0.4	108	8	100	599	108	2.36
961602	4	4001	2.15	5	2.3	5	0	5	13	5	2.60
961602	4	4006	2.68	0	0.0	0	0	0	0	0	0
961602	4	4003	164.97	38	0.2	37	30	7	110	37	2.97
961602	4	4002	14.45	63	4.4	63	7	56	198	63	1.65
961602	4	4004	2.38	9	3.8	9	7	2	31	9	3.44
961602	4	4005	3.20	11	3.4	11	10	1	44	11	4.00
2. Curtiss Rd			**33.0**	**116**	**3.5**	**120**	**54**	**45%**	**360**	**120**	**3.14**
			need confirmed counts for SF houses on outside streets in 4003, estimated 33 units on 13 acres from aerial								
961602	4	4011	1.41	2	1.4	2	2	0	8	2	4.00
961602	4	4007	237.64	198	0.8	181	138	43	381	181	2.10
961602	4	4012	26.85	47	1.8	41	38	3	86	41	2.10
961602	4	4013	1.93	9	4.7	9	6	3	18	9	2.00
961602	4	4014	3.47	16	4.6	15	8	7	29	15	1.93
3. Willow Spring			**27.0**	**165**	**6.1**	**246**	**190**	**77%**	**347**	**246**	**2.09**
			assumes 110 on 11 ac in 4007 & 30 on 10 ac in 4012--MF unit counts from V Smith (BrHlw 78/5, WilSpr 28/5, Crtyd 24/2)								

Table 3-1 Sample of Census Block Interpolation & Density Calculation

Sorting by Density: With block level area and unit totals set, calculating average neighborhood density was a simply calculated by adding up all units and dividing by total area. *Table 3-2 Potential Cases Sorted by Density* shows the range of all 24 cases.

Neighborhood	Density (u/ac)	Growth Period	Town	% Owner Occ	HH Size	Populat'n	Housing Units	Area (acres)
Low to Moderate Density: 1 to 2 units / acre (about 44,000 to 22,000 sf land per unit)								
12. Buckingham Pl	**1.2**	1970-80	LEB	92%	3.11	220	71	59.0
20. Colonial Dr	**1.3**	1960-80	HAR	81%	2.58	268	103	78.0
17. Beech St	**1.6**	1960	HAR	97%	2.30	85	37	23.0
6. Dunston Rd	**1.7**	1940-70	LEB	91%	2.91	261	90	54.0
23. Jones Circle	**1.7**	1900-70	NOR	75%	2.30	189	82	48.0
1. Grasse Rd	**1.7**	1990-00	HAN	96%	2.81	168	60	35.0
24. Carpenter St	**1.8**	1900-90	NOR	69%	2.40	218	91	52.0
4. Valley Rd	**2.0**	1930-90	HAN	56%	2.59	315	121	60.0
Moderate Density: 2 to 5 units / acre (about 22,000 to 9,000 sf of land per unit)								
16. Hillcrest Ter	**2.5**	1900-40	HAR	49%	2.34	161	70	28.0
19. Sterling Springs	**2.8**	2000	HAR	96%	2.01	220	110	40.0
21. Hawthorn St	**3.1**	1900-60	HAR	61%	2.22	317	144	47.0
18. Park/Summer St	**3.3**	1900-70	HAR	42%	2.35	202	84	25.8
15. Highland Ave	**3.5**	1900-60	LEB	57%	2.32	437	190	55.0
2. Curtiss Rd	**3.5**	1950-80	HAN	45%	3.14	360	116	33.0
22. Hemlock Ridge	**3.8**	1990	HAR	72%	2.29	334	145	38.0
5. Maple St	**3.9**	1900-50	HAN	41%	2.47	625	248	63.0
11. Peabody St	**4.2**	1960	LEB	83%	2.01	200	100	24.0
Moderate to High Density: 5 to 10 units / acre (about 9,000 to 4,500 sf land per unit)								
10. Summer St	**5.2**	1900-60	LEB	38%	2.15	823	374	72.5
7. Wolf Rd	**5.6**	1980-90	LEB	19%	1.95	642	321	57.0
9. Elm St	**5.8**	1900-40	LEB	31%	2.02	676	338	58.0
3. Willow Spring	**6.1**	1920-80	HAN	77%	2.09	347	165	27.0
8. Spencer St	**7.3**	1920-00	LEB	15%	2.00	366	183	25.0
14. Village Green	**7.7**	1920-80	LEB	44%	2.06	966	460	60.0
13. Renihan Meadw's	**8.7**	1980	LEB	12%	2.54	325	130	15.0

NOTE: Grey cells indicate numbers that need further checking of unit count numbers for first order confidence

Table 3-2 All Potential Cases Sorted by Residential Development Density

The neighborhoods fall into a fairly well distributed range of density values from about one to ten *units per acre*. Fields for *percentage owner occupied*, *household size,* and *population* provide a general assessment of demographic characteristics between potential cases. However, mix of housing type, a key variable of neighborhood form, was not so easily determined. Census data on unit type is only gathered as 1:6 sample data (sf3) that is not available at the block level. While it is available at the block group level, Upper Valley block group geography is too coarse and heterogeneous to provide a reliable predictor of neighborhood housing mix. *Tenure of household* (100% sf1 data on owner versus renter) provides a much better proxy for housing mix in many cases. Combining household tenure with field surveys allowed reasonable first order distinctions of housing unit mix by neighborhood.

Two important observations about density need to be noted. First of all, density relationships expressed as *units per acre* (u/a) are not linear. Values have more of a geometric relationship with the relative difference of whole number increments growing smaller as density rises. For example going from 1 u/a to 2 u/a is a 100% increase of density whereas going from 9 u/a to 10 u/a is only a 10% increase. Comparative classes of density should reflect equivalent distribution intervals. For this project, cases were arrayed as three general groups with the highest value about twice as dense as the lowest value within each group (i.e. lower 1 to 2; middle 2 to 5; higher 5 to 10).

Secondly, the higher end of the density range found in the Upper Valley is quite low in comparison to larger metropolitan areas where values below 10 u/a are often considered on the mid to lower end of the distribution. The literature review, however, found little in the way of conventions for comparing neighborhood density. References for density figures were found for census tracts and for development projects, but little information was specific to density calculation by neighborhood. This underscores an overall need for better base information on neighborhoods in general.

The surveyed cases were pretty well distributed with eight in the lower group, nine in the middle group and seven in the upper group. There was also some correlation between density class and estimated mix of housing types. The lower end cases were predominantly single family houses with generally higher rates (75-95%) of owner occupied units. Middle range cases were generally split between owners and renters and matched the observed mix of single family and multi-family types (although the relative mix ranged and one case, a mobile home park, had no multi-family units).

The upper end cases were dominated by multi-family units and had more renters although some exceptions were noted. Considerable variation in types of multi-family structures was also observed. Some were older homes that had been sub-divided; others were newer apartments or condominiums with a higher number of units per building.

Not surprisingly, distribution of household size correlated with density and housing type with values near two persons per household for higher density areas and approaching three persons per household for lower density areas. It was also interesting to note that the relative distribution of density between towns is largely a function of their character. All four towns had lower-density neighborhoods. However mid-range cases were restricted to the three larger towns (Hanover, Hartford and Lebanon) and almost all of the upper-density range cases were found in Lebanon—the region's only "city" with a population of 13,000.

While the project's research prospectus had called for sorting cases into four density classes, the limited range of neighborhood type suggested three was a much better fit to the local context. The region is just not a big enough to have many examples of higher density. Densities above 8 u/a are only found in very small areas that are better characterized as housing projects than neighborhoods. While it would be possible to add a lower density category below 1 u/a, these areas are typically outside the built up core and fall outside the "in-town" focus of this study.

Sorting by Physical Character. The next step was to sort potential cases by physical character. A two-day "windshield" survey of all 24 cases recorded basic variation of edge conditions, landscape character, housing density, development era, street section, setbacks, building type, and land use context. The field survey concluded that for the purposes of initial sorting of neighborhood form, development era was a very good proxy for basic variation in physical character. *Table 3-3 Potential Cases Coded by Development Period* codes all 24 cases by age or growth period within each density class. Descriptive fields for *general type* (e.g. large-lot single-family or village-lot single family / multi-family mix) and *general context* (e.g. mixed residential, village center or low density residential) were also added to the table.

Site	u/ac	Growth Period	Age Code	General Type	General Context	% Owner	HH Size	Pop	DUs	Area (acres)
Low to Moderate Density: 1 to 2 units / acre (about 44,000 to 22,000 sf land per unit)										
12 Buck Pl	**1.2**	1970-80	2	large lot SF	ldr / os	92%	3.11	220	71	59.0
20 Colonial	**1.3**	1960-80	2	large lot SF	mxr / os	81%	2.58	268	103	78.0
17 Beech St	**1.6**	1960	2	med lot SF	com / mxr	97%	2.30	85	37	23.0
06 Dunston	**1.7**	1940-70	2	med lot SF	mu / mxr / os	91%	2.91	261	90	54.0
23 Jones Cir	**1.7**	1900-70	1	mixed vill SF	village	75%	2.30	189	82	48.0
01 Grasse	**1.7**	1990-00	3	med lot SF	ldr / os	96%	2.81	168	60	35.0
24 Carp St	**1.8**	1900-90	1	vill SF & MF	village	69%	2.40	218	91	52.0
04 Valley Rd	**2.0**	1930-00	4	lg lot SF & MF	town	56%	2.59	315	121	60.0
Moderate Density: 2 to 5 units / acre (about 22,000 to 9,000 sf of land per unit)										
16 Hillcrest	**2.5**	1900-40	1	vill SF & MF	town / hill	49%	2.34	161	70	28.0
19 S Springs	**2.8**	2000	3	s-lot SF / MF	woods	96%	2.01	220	110	40.0
21 Hawthorn	**3.1**	1900-60	1	vill SF & MF	village	61%	2.22	317	144	47.0
18 Park St	**3.3**	1900-70	4	vill SF & MF	village / hill	42%	2.35	202	84	25.8
15 Highland	**3.5**	1900-60	4	vill SF & MF	village	57%	2.32	437	190	55.0
02 Curtiss	**3.5**	1950-80	2	m-lot SF & MF	mu / ldr / os	45%	3.14	360	116	33.0
22 Hemlock	**3.8**	1990	3	s-lot SF / MF	mu / ldr / os	72%	2.29	334	145	38.0
05 Maple St	**3.9**	1900-50	1	vill SF & MF	town	41%	2.47	625	248	63.0
11 Peabody	**4.2**	1960		mobile hm pk	mu / os	83%	2.01	200	100	24.0
Moderate to High Density: 5 to 10 units / acre (about 9,000 to 4,500 sf land per unit)										
10 Summer	**5.2**	1900-60	1	vill MF & SF	town	38%	2.15	823	374	72.5
07 Wolf Rd	**5.6**	1980-90	3	MH & m-lot SF	mu / ldr / os	19%	1.95	642	321	57.0
09 Elm St	**5.8**	1900-40	1	vill MF & SF	town	31%	2.02	676	338	58.0
03 Willow Sp	**6.1**	1920-80	4	MH & s-lot SF	town / os	77%	2.09	347	165	27.0
08 Spencer	**7.3**	1920-00	4	MH & m-lot SF	town / ind	15%	2.00	366	183	25.0
14 Villg Grn	**7.7**	1920-80	4	MH & vill SF	town / os	44%	2.06	966	460	60.0
13 Renihan	**8.7**	1980	3	MF	ldr / os	12%	2.54	325	130	15.0

AGE CODE:
1 = 1900-1940 Pre WWII
2 = 1950-1980 Post WWII
3 = 1980-2005 Late 20th Century
4 = Mixed Development Period

CONTEXT CODE:
ldr = low density residential
mxr = mixed residential
com = commercial, mu = mixed use
os = open space

Table 3-3 All Potential Cases Coded By Primary Development Period

Once again a reasonable distribution of development era was found across the set. Thirteen of the cases date from development before World War II (WWII) with the other eleven developing afterwards. Of the later developments, four date from primarily after 1980. In general, these cases showed a greater mix of uses and higher denser than earlier post-war areas. While some of the 13 pre-war neighborhoods such as

Elm have change little since their initial development, others such as Willow Spring and Spencer have been significantly altered.

Taken together, these patterns suggested four classes of development pattern rather than the three envisioned in the project prospectus. The first three define areas where primary development patterns fall within a specific period: 1) *1900 to 1940*; 2) *1950 to 1980* and 3) *1980 to present*. Limited development before 1900 is included the first category. A fourth *mixed period* category defines areas where growth spanned more than one development era. It is also interesting to note that except for the farming village of Norwich, all the lowest density areas developed after WWII.

3.2.3 Selection of Final Set of Neighborhoods

The final step in the case selection process pared the potential set of 24 neighborhoods down to a final set of 12 cases for in-depth study. Potential cases were arrayed into a simple selection matrix that arrays density class by development era in order to provide an overview of character variation within the potential cases. The research prospectus lays out the basic selection criteria as follows:

> *Depending on the range and distribution of neighborhoods found, representative examples of each type will be selected as a general set of neighborhoods for the next level of study. Selection will be based on the cases that most clearly contrast key physical variations (e.g. building, lot, street, block, landscape) within each density level. Matrix rows and columns will be adjusted as required. Some cells may have several examples, other cells may have none. The goal is to come up with a set of 10-12 cases that represent a range of physical form and character across several density categories (p. 37).*

The final set of cases is shown in *Table 3-4 Neighborhood Selection Matrix*. As noted earlier, age of development was used as a proxy for overall physical variation within each density level. While the matrix shows at least one example in each matrix cell, the distribution was not perfect. Some cells had three or four examples, others only one. Some minor revisions to cases were made to provide a stronger set. The weakest cell was *Post-WWII* by *Higher Density*. Its only example was *Renihan Meadows*, an isolated housing project on a twelve-acre site. In response, the rather ambiguous boundary of the *Village Green* neighborhood was redrawn to include newer development and moved to this cell. It is a much more robust case for this type.

	Low to Moderate Denstiy 1 to 2 units / acre, mostly SF	Moderate Denstiy 2 to 5 units / acre, mix SF & MF	Moderate to High Denstiy 5 to 10 units / acre, mostly MF
Pre WW II Development Pattern 1900-1930	23 Jones 1.7 mixed vill SF 24 Carpentr 1.8 vill SF & MF **25 Main 1.8 vill SF & MF**	16 Hillcrest 2.5 vill SF & MF 21 Hawthorn 3.1 vill SF & MF **05 Maple 3.9 vill SF & MF**	10 Summer 5.2 vill MF & SF **09 Elm 5.8 vill MF & SF**
Post WW II Development Pattern 1950-1980	12 Buck Pl 1.2 large lot SF 20 Colonial 1.3 large lot SF 17 Beech St 1.6 med lot SF **06 Dunster 1.7 med lot SF**	**02 Curtis 3.5 med SF & MF** 11 Peabody 4.2 mobile hm pk	13 Renihan 8.7 MF **14 Village G 6.5 MH & vill SF**
Late 20th C Development Pattern 1980-2005	**01 Camp Bk 1.7 med lot SF**	19 S Springs 2.8 s-lot SF / MF **22 Hemlock 3.8 s-lot SF / MF**	**07 Wolf Rd 5.6 MH & m-lot SF**
Mixed Period Development Pattern 1900-2005	**04 Valley 2.0 lg lot SF/MF**	18 Park 3.3 vill SF & MF **15 Highland 3.5 vill SF & MF**	**03 Willow 6.1 MH & s-lot SF** 08 Spencer 7.3 MH & m-lot SF

Table 3-4 Neighborhood Selection Matrix: Final Set of 12 Case Studies

One neighborhood from each cell was selected as to create a matched set of four cases for each density level. The process was guided by the overall goal of representing a broad range of neighborhood form across cases with a similar density. The final set of cases is shown bold type above. The selection rationale for each set of cases is described below. A location map and detailed matrix of photographs and maps comparing all twelve study cases is presented in the beginning of Chapter Four as *Figure 4-1 Neighborhood Baseline Profile.*

Lower Density Set (1 to 2 units/acre): This set is generally characterized by a pre-dominance of detached single-family housing types on larger lots. The older cells also have some mix of multi-family housing types and lots size. This set also has a high percentage of owner occupied units. Of the eight cases, six of them fall within the density window of 1.6 to 2.0. The overall goal was to find a set of contrasting development patterns among predominantly single-family neighborhoods.

Before WWII: Both cases are in Norwich village. Street patterns are organic. Unlike more regular sub-divisions, streets and lots were added incrementally. Houses vary in size and age but are mostly older with a scattering of newer houses and multi-family units mixed in. After closer field inspection, the original boundaries were altered to divide the village into north and south areas with Main Street at the center. The north area was re-named **Main Street** and selected for its more clearly defined boundary.

Post WWII: These four cases are single-family post war subdivisions. The street patterns are more regular and curvilinear. Housing types are similar although not identical. The two lowest density cases were dropped because they do not compare as well with others. Of the remaining two, **Dunster Drive** was selected because it: 1) was more comparable in area (40 to 60 acres), 2) had more variety of landscape and housing types, and 3) has a more comparable context to the others.

Late 20th Century: Only one example, **Camp Brook,** was found in this cell. For uncertain reasons recent development in the Upper Valley appears to be higher density or scattered semi-rural density. Nonetheless it is a good case for several reasons. It features elements of "neo-traditional" design with gables facing the street, front porches, downplayed garages and a central common. As with most neighborhoods, the landscape is very sparse. This serves as a nice contrast with other cases, especially Dunster Road—a similar sub-division from 30 years earlier.

Mixed Period: This cell also has only one example. While the other older cases have some mix of age, only **Valley Road** has distinct patterns from different eras. It includes: 1) college-duplexes from the 1930's, 2) post war large-lot single-family houses, and 3) a 1990's multi-family infill area—again with some neo-traditional elements (e.g. front porches). With a combined density it is equivalent to the other cases, it should provide some interesting contrasts and comparisons.

Moderate Density (2 to 5 units/acre): This category is characterized by a mix of single-family and multi-family units. Owner occupant percentages run in the 40-75% level. Every case has some mixing of lot size and housing type. But as with the lower density set, greater heterogeneity is found in the older periods than the more recent ones. The strongest density cluster was between 3.5 to 3.9 *units per acre*. The overall goal was to find a set of contrasting patterns with mixed housing types.

Before WWII: These three cases are associated with the historic centers of White River Junction, Wilder, and Hanover respectively. Multi-family units tend to be in converted houses although Maple Street has some newer apartments. Hillcrest's extreme slopes, limited size, and lower density makes it rather idiosyncratic. Of the remaining two, **Maple Street** was chosen because of: 1) a wider variety of multi-family housing, and 2) its strong landscape character--an important form variable.

Post WWII: The choice here was between Curtis Road, a classic neighborhood unit with an elementary school and a small retail center and Peabody Street, a trailer park. While an interesting outlier, the later is fundamentally different from the others and not very representative of the era. It also has no housing mix—trailers by definition are single family. **Curtis Road** was selected because it provides an excellent transition between smaller lot historic patterns and larger lot planned unit developments.

Late 20th Century: Both of these cases are "planned neighborhoods" by the area's largest residential developer, Simpson Development. They both feature a combination of small lot SF houses and MF condominium townhouses. They both have similar layouts and architecture. However, **Hemlock Ridge** was chosen because it has 1) a more comparable density, 2) a greater variety of housing types, and 3) a mixed land use context that is more comparable with the other cases for this density level. There is an elementary school, a number of small offices, and several recreational uses within walking distance of the homes.

Mixed Period: Park and Highland are part of historic villages—Hartford and West Lebanon respectively. However, they both have had significant areas of post-war era expansion. **Highland Avenue** was selected because it is a more discrete and identifiable area. The post-war additions to Park Street spread up a steep hill at a very low density making it very hard to draw a boundary around this area. Density calculations can vary radically depending on where the line is drawn.

Higher Density (2 to 5 units/acre): This category is generally characterized by multi-family units in small buildings, townhouses, and larger apartment blocks. Owner occupant percentages are mostly on the low side (20-40%). Every every case except one mixes lot sizes and housing types. Development patterns are more complex than in the other categories. Older mixed patterns have considerable diversity at the detail level but are quite consistency in overall character. Newer less mixed areas are comprised of large multi-family projects that are internally quite consistent. However the contrast from one project to the next creates a neighborhood with a rather diverse overall character. The strongest density cluster was from 5.5 to 6.5 *units per acre*. The overall goal for this level is a set of primarily multi-family areas with contrasting patterns of form and character.

Before WWII: Both Summer and Elm are neighborhoods at the center of the Lebanon, the region's largest city. Both are comprised of houses on small lots organized around a network of connected streets. Many of the single-family houses have been converted to small multi-family structures. **Elm Street** was chosen because: 1) it has a higher density that is more comparable with newer multi-family developments, and 2) its form and character comprise an excellent example of a traditional neighborhood.

Post WWII: As noted earlier, **Village Green** was added to this cell by redrawing its borders more tightly around several large 1970's-era housing projects. It comprises several contrasting multi-family housing types within comparable land use context to the other cases in this class (i.e. short walk to schools and services). In contrast, Renihan Meadows has poor correlation of density, size and location with the other cases.

Late 20th Century: As with the lower density level, there was only one example found here—**Wolf Road** in Lebanon. The development of this area is clearly related to the relocation of the Dartmouth Hitchcock Medical Center from downtown Hanover to a greenfield site in the mid-1980's. It makes a good comparative case for several reasons. Its density and mix housing is well matched with other cases but sharply contrasts in physical form and layout. It also has a rich mix of housing types and compares reasonably well with the land use context of the other selected cases.

Mixed Period: The two remaining cases here present an interesting contrast. Both are in-town areas where a small cluster of single-family houses have been transformed by large multi-family development. Brook Hollow has three 1970's condominium projects. At Spencer Street, a new apartment project (160 units in two five-story buildings) is transforming a marginal industrial area into a residential district. Despite it being more similar to Wolf and Village Green, ***Brook Hollow*** was selected because Spencer was still under construction and difficult to assess.

3.3 Street/Block Case Study Selection

A second somewhat different process guided the selection of six street/block scale case studies. These cases served as the field laboratory for developing a set of measures related to the more detailed, three-dimensional space of a single street and block. As with the neighborhood selection process, the overall goal was to derive a set of matched cases that were similar in density but varied sharply in urban form.

The original intent of the study was to study this scale through more detailed typological analysis of two matched pair neighborhoods selected from the larger set of twelve. However, several months into the project it became apparent the initial strategy was not well matched to the research goal of deriving simple and replicable measures. Specifically, the approach proved unmanageable at the neighborhood wide scale, failed to provide a sufficient range of urban form variation, and did not create the type of simple data sets needed to measure first order differences at this scale. Typologies were simply too complex and non-specific to be systematically applied to the task of simple measurement. It was decided project goals would be better served by selecting a second set of specific street and block scale cases for in-depth study and analysis.

The discussion that follows covers the four major steps in the street/block selection process. First, the basic classification of all potential streets within twelve case study neighborhoods is reviewed. This is followed by a summary of field measurements and related analysis for a smaller group of 73 streets. This set was used to identify and refine a set of key urban form variables at this scale. Next, the selection of three sets of four cases for each density level from the larger set is described. The section concludes with the rationale for selecting a final set of six cases for detailed study—a matched pair for each of the three density classes.

3.3.1 Identification & Distribution of Potential Street/Block Scale Cases

By definition, a neighborhood is a series of linked streets and blocks. Together they form a shared framework for the group of individual buildings and parcels that populate any neighborhood. This next scale of analysis looks more carefully at the base unit of this framework, the linear corridor of a single block of a single street—called a *street/block* for purposes of this study. The *street/block* is defined as including both the street proper and the adjacent buildings and landscape that define the edges of the corridor. Views along and within this shared framed framework of space comprise the primary perceptual experience by which the character of one neighborhood is distinguished from that of another.

The *street/block* selection process was very similar to the *neighborhood* selection process. The intent was to select a range of Upper Valley cases that would capture a broad but representative range of urban form across three density classes. Once again *age of development* was used as a rough proxy for physical differences to allow an initial sorting of potential cases by urban form. The twelve neighborhood case studies provided a broad and known universe from which to select. Unlike the universe of potential neighborhoods, however, the number potential of cases at this scale was far greater. Each neighborhood is made up of a half-dozen or more streets and/or shared residential parking drives. Many of these streets and drives are made up of multiple blocks or sections that can vary in character. This adds up to well over a hundred possible cases. An initial cut was made by focusing only on residential streets that were internal to the neighborhood. Perimeter streets were seen as a distinctly different type of neighborhood space and not included.

Neighborhood	Streets per N_hood	Lower Density: 1 - 2 u/a	Middle Density: 2 - 5 u/a	Higher Density: 5 -15 u/a	Pre-WWII 1900-40	Post-WWII 1950-80	Late 20th 1980-pres
1 Main Street	7	5	1	1	5	1	1
2 Dunster Drive	8	8	0	0	0	8	0
3 Camp Brook	5	5	0	0	0	0	5
4 Valley Road	10	*7*	*3*	*0*	*4*	*5*	*1*
5 Maple Street	15	6	6	3	11	4	0
6 Curtis Road	6	1	3	2	0	6	0
7 Hemlock Ridge	12	4	4	4	0	2	10
8 Highland Avenue	13	*3*	*8*	*2*	8	*5*	*0*
9 Elm Street	10	0	3	7	8	2	0
10 Village Green	7	2	1	4	1	6	0
11 Wolf Road	8	3	0	5	0	3	5
12 Willow Spring	12	*4*	*3*	*5*	*3*	*8*	*1*
Total # of Streets	113 100%	**48** 42%	**32** 28%	**33** 29%	**40** 35%	**50** 44%	**23** 20%

Note: Darker type denotes correlation of street density and age with neighborhood density and age. Italic type denotes street density and age in mixed age neighborhoods (N4, N8, N12).

Table 3-5 Distribution of Street Type (Density and Age) by Neighborhood

Distribution of Street Type: An initial inventory found a total of 113 internal streets in the twelve neighborhoods. *Table 3-5 Distribution of Street Type by Neighborhood* summarizes the distribution of this potential universe of cases sorted by neighborhood, development era (age), and rough density. Initial density values were estimated by visual comparison with overall neighborhood densities. Age was estimated through a combination of historic maps, photographs, and the researcher's own knowledge of architectural and development periods. In cases with a mix of building type or development era, the street was assigned to the most dominant category.

Given the range of neighborhoods surveyed, it is not surprising to find a well-distributed range of street type. What is more surprising is the range of street type within individual neighborhoods and sets of neighborhoods. The table shows that just because a street is located within a neighborhood with a given density and development age, it does not mean it will correlate with either. For example Main Street, a lower density pre-WW II era neighborhood, includes a higher density late 20th century street. While a few neighborhoods, such as Dunster Drive, had strong correlations between street type and neighborhood type across the board, there was considerable diversity found in many others. Not surprisingly, the most diversity is shown in the mixed age neighborhoods, such as Highland Avenue or Willow Spring.

This initial analysis also suggests that the process of deriving a good cross-sectional sample for further study would be more extensive than it was for neighborhoods—there are simply more choices. The equivalent three by four matrix of age by density used to sort out the potential pool of *neighborhood* cases would have cells with more than two dozen options rather than two or three. As a result, a more detailed analysis of basic urban form variables was necessary to guide the selection of a robust set of *street/block* case studies.

3.3.2 Analysis of Urban Form Variables

Eliminating obviously redundant or excessively idiosyncratic street/block candidates cut down the initial universe of 113 cases to 73—about 25 potential cases for each of the three density classes. However, unlike neighborhood wide variables such as streets, parcels, and land use, detailed data at the scale of street and block was almost non-existent in the region. GIS data for building footprints, street sections, or vegetative cover were either not found or at such a low resolution to be of little use at this scale. Common archival sources that are used to compile urban design data in many parts of the country such as Sanborn Insurance Maps or Beer's Atlas, were found for only one historic neighborhood in Vermont.

These data gaps resulted in an extensive field measurement effort carried out over a two-week period in the fall of 2004. Cross-sectional data was compiled for the most typical condition along each of the 73 *street/blocks* using a rolling wheel to measure street width, street verge (sidewalk/tree belt), and building setback. In addition first order differences (e.g. high, medium, low) were assessed in the field for streetscape, shade trees, front walks, porches, garages, building height, orientation & spacing, and unit type. Field notes and additional photographs were also taken.

Street	Site	General Type	Growth Era	Face to Face	Street & Curb	Setback (av) L / R	Verge Elements	Extent of Yard Trees	Walk to Street	Front Porch	Prkg/ Garge	Bldg Face	Blding Space	Unit Type SF/MF	Spat Encl H/M/L
				STREET			TRANSITION			EDGE					
Moderate Density: 2 to 5 units / acre (about 22,000 to 9,000 sf of land per unit)															
S Balch	4Vall	str_1 sw	1930-90	~130'	22' 2c	50' / 58'	grs_sw_nw tr	med	yes	most	rear	eave	m / w	MF	med
Maple W	5Mapl	str_1 sw	1910-30	~90	20' 1c	44' / 26'	gs_hdg_sw	med	some	most	rear	gable	mod	SF	m/h
Sargent	5Mapl	str_no sw	1910	~90	20' nc	34' / 34'	gv_gs_h_s_t	med	yes	most	rear	gable	mod	SF/MF	high
Read	5Mapl	str_no sw	1960	~ 90'	20' nc	30' / 40'	grass	med	some	some	mixed	eave	mod	SF	med
Prospect	5Mapl	str_1 sw	1890-40	~90'	22' 1c	28' / 40'	grass_sw	low	yes	some	rear	mixed	mod	SF	m/h
Allen	5Mapl	str_1 sw	1900-40	~100'	22' 1c	44' / 38'	grass_sw	low	yes	some	rear	mixed	mod	SF/MF	m/h
Maple E	5Mapl	str_1 sw	1850-20	~80'	22' 1c	14' / 40'	gs_fn_st_sw	low	yes	most	rear	mixed	tight	SF/MF	m/h
Pleasant	5Mapl	str_no sw	1900	~90'	13' 2c	34' / 29'	gs_fn_st_tr	med	yes	most	rear	mixed	tight	SF	high
Curtis	6Curtis	str_1 sw	1960	half ~ 55'	20' nc	45' L only	gs_mb_tr_hg	med	no	none	side	eave	mod	SF/MF	m/l
Woodmore	6Curtis	str_no sw	1960	~ 110'	20' nc	45' / 45'	gs_mb_tr	med	no	none	side	eave	mod	SF	med
Bridgeman	6Curtis	str_no sw	1960	~ 110'	20' nc	42' / 50'	grass_mbox	med	no	none	side	eave	mod	SF	med
Dresden	6Curtis	str_no sw	1960	~ 115'	20' nc	46' / 50'	gv_gs_mb_s	med	no	few	mixed	eave	mod	SF	med
Hemlock	7Heml	col_no sw	1990	~80' tree	20' nc	~30' / 30'	gs_tr_berm	high	dna	none	none	eave	dna	dna	m/h
Laurel	7Heml	str_no sw	2000	~80' av	18' nc	34' / 34' av	grass_uu	med	no	none	side	eave	tight	SF	m/h
Iris	7Heml	str_no sw	2000	~80' av	18' nc	30' / 32' av	grass_uu	med	no	none	side	eave	tight	SF	m/h
Larkspur	7Heml	str_no sw	2000	~80' av	18' nc	40' / 24' av	grass_uu	med	no	none	side	eave	tight	SF	m/h
Maple S	8High	col_2 sw	1900	~90'	22' 2c	34' / 30'	grass_sw	low	yes	most	rear	gable	mod	SF/MF	m/h
Maple N	8High	str_2 sw	1920	~90'	22' nc	36' / 38'	grass_sw	med	yes	most	rear	mixed	mod	SF	m/h
Pearl	8High	str_2 sw	1910	~90'	20' nc	36' / 32'	gs_sw_fen	med	yes	most	mixed	mixed	mod	SF/MF	m/h
Prospect	8High	str_1 sw	1900-30	~100'	20' nc	42' / 42'	grass_sw	med	yes	most	rear	mixed	mod	SF	m/h
Timothy	8High	str_no sw	1950-80	~120'	22' nc	60' / 36'	grass	low	no	few	side	eave	mod	SF	med
Mack	8High	str_2 sw	1930	~ 90'	20/26' nc	34' / 32-38'	gs_sw_fn_hg	high	yes	most	mixed	mixed	mod	SF	m/h
Dana	8High	str_2 sw	1900-30	~ 90'	20' nc	38' / 34'	grs_sw_fen	med	yes	most	rear	mixed	mod	MF/SF	m/h
Highland	12Will	str_no sw	1930	half ~ 55'	18' nc	44' R only	grass_wds	mxd	no	few	mixed	eave	mod	SF / MF	m/l
Fairview	12Will	str_no sw	1930-40	~110'	19' nc	41' / 48'	grass	med	no	few	rear	eave	mixed	SF / MF	med

Table 3-6 Sample of Street/Block Urban Form Matrix for 73 Cases

The results are shown in excerpt form in *Table 3-6 Urban Form Matrix for Potential Street/Block Cases.* The complete table with all 73 streets is shown in Appendix B. The table arrays streets as records against a series of fields summarizing measured characteristics for ease of comparative analysis. The findings were analyzed under four major elements of spatial structure at this scale including: 1) general type, 2) street cross-section, 3) street to building transition, and 4) building edge. The following discussion summarizes the key patterns and differences for each element.

General Street Type: There are fundamentally two street types to account for within this sample: 1) *Residential Street,* and 2) *Residential Parking Drive*. They suggest two basic approaches to organizing neighborhood space. The *Residential Street* is by far the most dominant in this sample—especially in the lower and middle density class. It is characterized by individual lots and buildings fronting onto a public street. The resultant lineal space is comprised of parallel edges defining a central street corridor. Within this basic type there is enormous variation of lot size, setbacks, spacing, landscape, building character, cross-section dimensions & features, etc.

The *Residential Parking Drive* is a different kind of space that is not, strictly speaking, a public street. It is a private driveway with certain street-like qualities primarily serving newer neighborhoods with large-lot, multi-family development. While both types share the basic street function of an access corridor space serving a group of private dwellings, they differ significantly in cross-section. Parking drives tend to be spatially much more complex and often less defined in both plan and section. This presents a series of measurement issues.

Traffic volumes also affect the character of street/blocks. Almost all cases are local streets or drives with low volumes. In most neighborhoods, however, a few collector streets have higher volumes. In older neighborhoods with a connected street pattern, collectors tend to be quite similar to local streets (e.g. Main, Maple). In new neighborhoods where local access is served more by private drives, collectors tend to be fronted by larger lots with dwellings oriented away from the street (e.g. Wolf, Hemlock).

Street Cross-Section: The street cross-section is defined here in the broadest sense—from building face to building face. It has two main components: 1) the width of the street proper (i.e. pavement), and 2) the setbacks from edge of pavement to building face on either side of the street. There seems to be a strong correlation of face-to-face width, setback, and land-use density. Typical ranges include:

Lower density:	FF 120′ to 150′	Setback 40′ to 60′
Middle density:	FF 80′ to 100′	Setback 30′ to 40′
Higher density:	FF 60′ to 70′	Setback 20′ to 25′

More surprising is the relative consistency of the street proper. About 80% of low and mid density streets measured between 18 and 22 feet. Higher density streets serving a greater demand for on-street parking tended to be a bit wider—between 22 to 28 feet. Not surprisingly, parking drives are considerably wider and more varied (24 to 64 feet) to accommodate large numbers of parking spaces in front of residences.

Surprisingly, a consistent lack of curbing and sidewalks is found across the entire sample. Over 80% of the lower and mid-density streets are curb-less and about 70% don't have sidewalks. Curbs and sidewalks are more prevalent (50%) in denser areas. However the traditional street cross-section with of double-sided curbs and sidewalks is only found in the Elm Street neighborhood.

Street to Building Transition: While setback *distance* and density tend to vary together, setback *character* (i.e. the front yard) varies independent of density. Variation seems linked to several factors: 1) the type of "verge" (i.e. the parallel strip of land between paving and edge of right of way), 2) landscape qualities—primarily the extent of trees, and 3) connection between the front door and street. There is extensive variation in the verge ranging from only grass to varying combinations of grass, gravel, sidewalk, trees, fences, hedges, utilities, gardens, etc. Greater diversity is linked with increasing age and lot frequency. Trees have a major impact on street character. Size and frequency varies widely from almost none to completely canopied. Front walks show a correlation with age on older, less dense streets. Walks are generally more common and varied on denser streets of any age.

Built Edge of Street: The built edge of a street may have the greatest impact on street character. A primary factor affecting this element is building orientation and height which appears to have strong correlation with street age. While "street wall" heights range from one to three stories, older streets tend to have higher, gabled edges fronting the street, while newer ones are lower and with long eave side toward the street. This pattern is reinforced by garage width and location—placement is farther back and narrower on older streets. Front porches, a transition element between public and private space, also seem to increase with street age. A higher frequency of porches on some very new neighborhoods (e.g. Camp Brook), however, suggest the pattern may be changing.

Not surprisingly building spacing tends to get narrower as density increases on streets with buildings of four units or less on small lots. As buildings get larger than four units, spacing tends to widen or hold steady as density increases. The mix of building types appears to be strongly related to the neighborhood density. Lower density cases tend to have most single-family housing and higher density cases, mostly multi-family ones. However the mix of multi-family unit types appears to be more varied on older streets compared to new ones.

3.3.3 Selecting Final Set of Twelve Streets/Blocks Cases

Selecting the final set of streets was guided by the same objectives as the neighborhood selection—identifying key physical variation within streets of similar density and land use mix. Based on the preceding analysis, a trial and error matching process was used to derive three groups of four streets displaying a dynamic range of differences within a general density level. As with neighborhoods, era of development proved to be consistently associated with variation in character. The set of selected cases is arrayed in *Table 3-7 Final Set of Street/Block Case Studies.* Key distinguishing attributes of neighborhood form are summarized below.

	Lower Density Set about 2 units / acre	Middle Density Set about 4 units / acre	Higher Density Set about 10-12 units / acre
Pre WW II 1900-1930	**N1 Main Street** N4 Dana Road	**N5 Sargent Street** N8 Mack Avenue	**N9 Green Street**
Post WW II 1950-1980	**N2 Longwood Lane**	N6 Bridgeman Road	N5 Lewin Road N12 Brook Hollow
Late 20th C 1980-2005	N3 Camp Brook	**N7 Iris Way**	**N11 Wolf Run**

NOTE: Bold type shows final three matched pairs selected for detail analysis

Table 3-7 Street/Block Selection Matrix: Final Set of 12 Cases

Lower Density Set (1 to 2 units/acre): This group consists of four streets of detached houses from different development eras. All are roughly similar with respect to building setbacks. **Main Street** in Norwich village is set apart by a wide verge, strongly defined edge of right-of-way (fences, hedges), and the only sidewalk in the set. Buildings are most varied in spacing and orientation, large trees are abundant and parking is primarily located behind houses. Traffic levels are also higher than the other three. **Dana Road**, a planned street from the 1930's, is also distinguished by large trees and parking behind. The front porches of Main Street are replaced by less prominent but well-detailed entryways. Buildings are laid out symmetrically with some gables and some eaves toward the street. The verge zone is completely undefined with yards running directly to edge of street. **Longwood Lane**, a 1960's subdivision street, has wider pavement (30 feet) than the others. It is lined with low, horizontal ranch houses that have little connection to street. Attached garages accentuate building length. Large trees, ample lawns and widely spaced buildings create a park like flow of space. **Camp Brook** is recently built neo-traditional street. Some gables and porches face the street but there are no walkway connections. In some places drainage swales separate front yards from the street. A lack of established landscaping and buried utilities creates somewhat of a stage set effect that highlights building massing.

Middle Density Set (2 to 5 units/acre): This group consists of four streets with more tightly spaced houses on small lots. **Sargent Street** is a turn-of-the-century village street with gables to street, large front porches, front walks, mature trees. Several houses are converted to multiple units. It has no curbs, a partial sidewalk and sections of irregular gravel shoulders. Lawns typically run to the pavement but fences or hedges delineates some right-of-way lines and lot divisions. **Mack Avenue,** a 1920's village street, is similar in lot and building size but has a more formal layout with double concrete sidewalks, grass verges, a line of mature street trees (Silver Maples). There are front walks and parking also generally set back behind houses. All houses appear to be single-family. **Bridgeman Road** is an L-shaped post war street of ranch houses on small lots. Building setbacks and spacing are similar to the first two cases but building height and orientation vary sharply. There are no curbs or sidewalks. Trees are ample in size though not quite as large as the first two. There are no front porches or walks and attached garages face the street. **Iris Way** is a new street of very tightly spaced hip-roofed, one-story homes. While setbacks are less than other cases, the absence of street trees creates a more open feeling. Double garages are a prominent element of the street edge. A curvilinear street alignment contrasts sharply with the others. The coordinated landscape appears to emphasize spatial flow over demarcation of lot lines.

Higher Density Set (5 to 15 units/acre): This group consists of four streets or parking drives bordered by predominantly multi-unit buildings in a variety of configurations. The contrasts between street and parking drive create the strongest contrast spatial quality among the cases. **Green Street** is distinguished from the others by tightly spaced lines of houses on both sides of a traditional village street. The streetscape has porches and sidewalks. All but a couple of houses have been converted to small, multi-family buildings. Lots are long and narrow with parking behind and on street. Tight setbacks, gables to street and few large trees create a strong building edge. **Lewin Road** is a short block of 1950's townhouses that represents a transitional condition between Green and the other cases. The attached townhouses nominally face the street with small entry stoops and an overgrown front walk. However, the primary unit access is off a broad parking alley behind the townhouses. Neither street nor alley have sidewalks. **Brook Hollow** is 1970's condominium project that is completely oriented away from the street. A line of twelve to twenty unit buildings is organized by a double-loaded, 60 foot-wide parking drive with curbs and sidewalks. In contrast to Lewin, the front of units clearly face the parking lot. Setbacks range widely from 25 to 50 feet. They all have front walks but no porches. Facades with low eave lines make the buildings relatively low for three stories. The landscape is relatively lush with good size shade trees. **Wolf Run** is 1990's townhouse project with a different type of parking drive. Each unit fronts onto a single carport instead of a parking lot. A narrow paved aisle leads to an on-grade front door. The building setbacks are much tighter than Brook Hollow with carports facing directly onto a 24-foot wide drive. Except for small planter wells there is no green space between building and drive.

3.3.4 Street / Block Measurements: Three Matched Pairs for Detailed Study

With a good cross section of cases selected, the next step was to compile the required database for deriving and testing a series of experimental urban form measures. This process is described at length in the first parts of Chapters Five and Six for each scale of analysis. However, the difficulties initially encountered while compiling *neighborhood* scale data resulted in an additional modification to the final set of *street/block* cases (see Chapter Five for complete discussion).

These difficulties made it clear that compiling the necessary data for twelve *street/block* cases was beyond the scope of the this project. There were no existing data sets to work from at this scale. Existing base mapping and aerial photography were only marginally useful. This meant data sets would need to be compiled largely by time-consuming field measurements and manual techniques. Faced with these issues, the number of street/block cases had to be further cut from twelve down to six. The intent, however, remained the same—to select a set of streets that represented a broad sample of physical variation of neighborhood space within the Upper Valley region. This final section summarizes this process.

The specific aim was to select the best pair of street-scale case studies from the original set of four discussed in the previous section. It also should be noted that while the neighborhood sets held both density and mix of housing constant, this was not possible for the street/block sets. Key variations in spatial character were found to correlate quite strongly with variation in housing mix. Thus the case studies within this sample vary by both urban form and housing mix within a given density.

Calculating Street Density: The first step in culling the final set of six was to better calculate housing density at the street/block level. The density values used in the original set of twelve streets had only been visual estimates. Parcel level density calculations made while deriving neighborhood-wide measures found density varied widely from block to block. The parcel-by-parcel database made it possible to expand the street/block density analysis to twenty four possible cases—the original twelve plus another dozen that seemed to offer some interesting potential contrasts. This provided a broader context for the final selection.

As was found with calculating neighborhood density, some adjustments to boundaries were necessary to create comparable units of analysis. For instance, most street/block cases ranged from 3 to 6 acres depending the lot size and length of the block. However in large-lot, multi-family areas it was impossible to define equivalent street blocks because parcels were often bigger than the "blocks" of development. In these areas, single developments or sub-sections of single developments were found to provide the best match in terms of comparable units of neighborhood space. This required a pro-ration of parcel area quite similar to that used in the census analysis.

Final Selection Criteria: Matched pairs were selected that had the broadest variation possible across three major components of neighborhood space: 1) character of the street proper, 2) character of the street edges, and 3) relationship between the edge and the space it defines. While a few interesting possibilities were found in the broader density screening of potential cases, for the most part the selection process reaffirmed the validity of the original twelve cases. The most notable finding was that density range in higher density set was much greater. This was because calculations focused on specific streets rather than being averaged across the whole neighborhood. The higher density cases at the street/block scale ranged from 6 to 18 *units per acre* compared with 5 to 10 *units per acre* neighborhood wide. The rationale for the final three matched pairs is summarized below. Site plans and photographs of the final three matched pair street/block cases are presented in Chapter Six.

Lower Density Set (~2 units/acre): For the lower density level, the original set was **Main**, **Dana**, **Longwood**, and **Camp Brook**. In terms of *street,* Main varies with the others in terms of sidewalk, verge, and sidewalk while Longwood varied in actual street width. In terms of *edge,* the more varied lot size and building spacing of Main contrasts with the others. The contrast of building orientation and height is greatest between Main and Longwood with Dana being a hybrid case and Camp Brook being more similar to Main. The landscape edge varies between the larger trees of Main and Dana and the absence of trees at Camp Brook with Longwood falling in between. Regarding *transition,* all have about same setbacks but Main has greater dimensional complexity than the others. Longwood and Camp Brook are the least complex. The density measures are roughly equivalent with Dana (2.5) being a bit higher than the others. Based on this analysis **Main Street** and **Longwood Lane** made the best matched pair.

Middle Density Set (~4 units/acre): At the middle density level, the original set was **Sargent**, **Mack**, **Bridgeman**, and **Iris**. In terms of *street*, all are quite similar in width but Mack has double sidewalks, Sargent has partial sidewalks and others have none. In terms of *edge*, Sargent contrasts with the others in terms of a more varied lot size and building spacing, while Iris is far more tightly dimensioned than the others. Sargent & Mack contrast with Bridgeman & Iris in building orientation with their higher, gable-ends facing the street. The coordinated low landscaping of Iris contrasts sharply with the larger trees along the other streets. In terms of *transition*, Iris (more garages, less porches) contrasts with Sargent and Mack with Bridgeman falling in between. Another difference between Iris and the others in terms of overall character—it is a master-planned street with all houses on a single lot. In terms of density, Iris and Sargent are very close (about 4.0) with Bridgeman closer to 3.0 and Mack in between. Based on this analysis, the best matched pair is **Sargent Street** and **Iris Way**.[1]

Higher Density Set (~11 units/acre): This original set for the higher density street/block set included **Green**, **Lewin**, **Wolf Run**, and **Brook Hollow**. For these areas, the very definition of *street* becomes a major distinguishing factor. Green and Lewin are traditional streets bounded by adjacent buildings and lots. However, their respective street *edges* contrast sharply in building type and spacing (free-standing houses vs. townhouses), landscape *edge* (weak vs. strong) and the building to street *transition* (close vs. set back). Wolf Run and Brook Hollow are both multi-family townhouse projects organized around parking drives. They also contrast sharply in terms of *street* layout (i.e. parking layout), *edge* conditions of building and landscape (hard versus soft) and *transition* from building to adjacent drive (carports vs. parking lot). While analysis of all four cases would be interesting, the primary contrast of street type suggests pairing either Green or Lewin with Wolf Run or Brook Hollow. Calculated street density showed Green and Wolf Run to be quite close (about 11 u/a) while Brook Hollow was higher (16 u/a) and Lewin lower (8 u/a). Based on this analysis **Green Street** and **Wolf Run** are the best match within the parameters of the selection criteria.

While this winnowing process has undoubtedly omitted any number of interesting variations of physical character, the line had to drawn somewhere. The potential variations at this scale of space are enormous. Within the context of an exploratory research striving to measure first order distinctions of urban form, these three matched pairs provide an excellent basis for this work. And even with a reduced set of cases, the challenges of data compilation and determining what can be reliably measured remain substantial.

End Notes:

Note 1: Other Potential Mid-Range Cases: *The density screening also turned up several lower density, multi-family areas (i.e. "garden townhouses") that were found to have a middle level density (e.g. Village Green, Azalea). They were missed in the original street matrix because they were assumed to part of the higher density set. Having a "street" with all multi-family units at this middle density would make a very interesting contrast with Iris (all single-family units) and Sargent (mixed single-family & multi-family units).*

A town of Roxaboxen began to grow, traced in lines of stone:
Main Street first, edged with the whitest ones, and then the houses.
Charles made his of the biggest stones.
After all he was the oldest.
At first the houses were very plain, but soon they all began to add more rooms.
The old wooden boxes could be shelves or tables or anything you wanted.
You could find pieces of pottery for dishes.
Round pieces were best (p. 7).

• Alice McLerran, <u>Roxaboxen</u>

Chapter Four:

ANALYSIS OF NEIGHBORHOOD FORM

This chapter lays the foundation for derivation of the exploratory measures described in Chapters Five and Six. The research context for the chapter is framed by one simple question: *What to Measure?* The project's original research prospectus elaborates on the nature and breadth of the challenge:

> ***What to Measure?*** *The overall research goal is to derive replicable measures that capture variation in neighborhood form that eludes conventional measures. Obviously the choices of what to measure in a neighborhood are nearly infinite--street width, block size, building set-back, tree cover, pavement area, number of rose bushes, etc. The key is to measure things or relationships that will can differentiate distinguishing qualities of neighborhood form in as efficient and effective way as possible. Considerable insight is expected to be gained through careful, systematic observation and analysis of the case study neighborhoods (p. 45).*

The chapter is organized around three related tasks: 1) documenting the case studies, 2) analyzing the patterns of physical variation, 3) linking identified patterns with a set of perceived qualities that distinguish one place from the next. Section 4.1 describes the systematic documentation of the existing form and character of all twelve case study neighborhoods using photography, field observation, and base mapping.

Detailed protocols for photography and mapping are discussed in related appendices. The documentation process is summarized in a multi-page set shown as *Figure 4-1 Neighborhood Baseline Profiles* at the end of the section.

Section 4.2 summarizes key patterns of neighborhood form drawn from two distinct analytic exercises. The first is a series of speculative findings based on initial *field observation* tours of all neighborhoods. The second uses the baseline profiles to analyze the physical differences between cases. Two matrices of urban form variation—one for neighborhood elements such as street pattern, the other for smaller scale elements such as building type—help to frame a discussion of differences across all neighborhoods. Major distinguishing patterns and relationships are identified.

Section 4.3 focuses on linking physical patterns with the qualities hypothesized to be significant factors in perceived differences between sites. Definitions of qualities are refined in response to findings. Preliminary approaches to measuring patterns and qualities are outlined for each scale of analysis—the *neighborhood* and the *street/block*. Finally, two matrices summarize the observed differences of qualities between cases and create a baseline for calibrating measures in Chapters Five and Six.

4.1 Documenting the Neighborhood

The documentation of existing urban form conditions for all twelve case study neighborhoods was carried out using three basic methods: *field photography*, *field observation*, and *base mapping*. Each documentation method loosely relates to one of the three major branches of urban form theory reviewed in Chapter Two—photography to *place & image*, observation to *environment & behavior*, and mapping to *structure & process*. This section summarizes how each was used.

Extensive aerial and ground *photography* captured the whole sense of the place as well as to provide a standardized visual reference. Related *field observations* helped to identify key issues that might distinguish the form of one neighborhood and provided a consistent protocol for the researcher to become familiar with each case. Finally, systematic *base mapping* created a consistent graphic/spatial record for each case study and a consistent reference for examining patterns of physical differences that can't be seen in photographs or field observations. Taken together, this documentation process comprised a baseline for use in analyzing urban form and deriving measures.

4.1.1 Field Photography

The first step in the documentation of the twelve case studies was systematic field photography. While many urban design research projects use photography to document existing conditions, this process was designed to be a more rigorous method of comparative analysis by scripting a consistent set of shooting protocols across all neighborhoods. Systematic procedures were followed in order to minimize the inherent bias of photographic methods (Bosselmann 1998). As it was not feasible to photograph everything, use of typical conditions and standardized points of view were required. To the extent possible, controls were followed for variables such as light quality, time of day, time of year, camera angle, and lens aperture. Because photographic data will be used as a comparative baseline for analyzing urban form, testing derived measures, and potentially correlating measured and perceived qualities, establishing a rigorous but accessible photographic record was critical to minimizing the subjective bias of composition and point of view.

Photo documentation included procedures for both oblique *aerial photography* and ground level *field photography*. Aerial photographs were made of all twelve case studies in June 2004 using the standardized conventions of Campoli and MacLean (2004). The intent was to derive an overview of neighborhood-wide patterns that would not be visible in ground level photography. Sites were photographed from several perspectives including a steep angled oblique view intended to capture as much three-dimensional information as possible. However, the ability to get up in the air before trees leafed out and difficulties in maintaining a consistent protocol ended up limiting the utility of the aerials as analysis tools. Nonetheless, the aerials remained very useful as a general overview of the comparative form and character for all cases. A detailed discussion of the aerial photography protocol is presented in Appendix C.

Keeping view clear of airplane wheels & stuts was difficult

Five minutes later light conditions dramatically changed

Figure 4-2 Comparative Aerial Photo Views: N9 Elm versus N11 Wolf

An extensive protocol was also developed for ground level field photography. The protocol was adjusted and refined based on pre-tests in May 2004. It established a standard series of twelve photo shots to create a comparative record of urban form character at three scales: 1) building and lot, 2) street and block, and 3) neighborhood. However the pre-tests quickly found that multiple four-shot sequences would be required to capture extensive street-to-street variation at the two smaller scales (i.e. building/lot and street/block) within each neighborhood. It was simply not feasible to select a single set of typical conditions in the field. Consequently the number of photos substantially exceeded initial estimates. Over three weeks in June, approximately 1500 shots were recorded across all twelve study areas—ranging between 80 and 150 per neighborhood. A second set of about 500 images documenting potential street/block study areas were shot in November. Controls for light conditions and time of day ensured as consistent a record as possible between locations. A detailed summary of the ground level photo protocol and pre-testing is also presented in Appendix C.

Building/Lot View C: Street Elevation of Sideyard (#3539)

Building/Lot View A: Street Elevation of Building (#3538)

Street/Block View B: Street Right-of-Way (#3545)

Street/Block View A: Street Centerline (#3543)

Figure 4-3 Examples of Building/Lot and Street/Block Protocols in Case N2

The ground photographs were compiled into an image database for the project. The database provided a set of comparative views for many conditions across the twelve neighborhood case studies. The database could be scanned in short order to investigate particular issues of interest over the course of the urban form analysis. High-speed image viewing software made reviewing hundreds of photographs in rapid succession possible in way not possible even a decade ago. The database proved a great aid in identifying the range of street and building typologies and other physical patterns in the *analysis of variation* that will be described at length in Section 4.2.

Case Study Profile Images: The image database also provided a pool of images from which to draw representative views for use in the *Neighborhood Baseline Profiles*. The profiles were developed as a comparative summary graphic for each case study including maps, photos, and basic description information. While the photo protocol was a very useful for inventorying a broad range of specific conditions, it was not a very effective means of conveying an overview of neighborhood character. Methodical sequences of standardized views across a street section or along a street elevation were quite redundant and uninformative as profile images.

Two alternative profile prototypes were prepared to evaluate the most efficient format for summarizing neighborhood character. A review of the alternatives showed photographs to be the most robust representational tool for conveying neighborhood character across scale (e.g. aerial neighborhood view, street corridor view, house elevation view). Map graphics on the other hand were better suited to representing discrete patterns of neighborhood elements (e.g. street, parcel, building). The review suggested a simple set of three photographs, stepping down in scale from bird's eye view to street & block to house & lot, was the most efficient way to represent each neighborhood in the profile graphics.

Finally, it was also obvious that the range of variation at the street and block scale meant this scale could only be represented in a most general fashion in the baseline profiles. While images at this stage were selected to be as representative as possible across an entire neighborhood, a longer list of supplemental images was also prepared to supplement the profile analysis in the analysis process. *Figure 4-1 Neighborhood Baseline Profiles by Density Class* presents the full set of neighborhood profiles in summary form at the end of section 4.1.4.

4.1.2 Field Observations

Systematic field observation was the second method employed to document the case study neighborhoods. While this method is most often used to gain insight into the relationship between people and their environment, in this case systematic observation is to gain insight into differences of physical form between neighborhoods. The protocol called for particular attention to be paid to the physical structure of the environment (e.g. form, dimensions, configuration) and the perceptual qualities they evoke (e.g. scale, enclosure, connectivity). Observations of human use (or traces of use such as children's toys, gardens, or porch furniture) were significant only in as far as they provided clues to elements of neighborhood form that may be important to measure.

Observation, like photography, is an inherently subjective method. A systematic approach is required to minimize bias. The original research design called for a series of separate, highly controlled observation tours in four neighborhoods to gather insights into key relationships for further study. However, as the project proceeded, it became apparent that the extensive and controlled survey protocol used for field photography essentially fulfilled this research goal—and it did so across all twelve neighborhoods instead of only four. It was decided a separate, scripted field observation tour would be more effectively incorporated into procedures for testing correlation between derived measures and perceived environmental qualities (see Chapter Seven for detailed discussion of field survey methods and protocol).

The scripted field photography protocol provided reasonably disciplined observation method across all cases. Making mental observations about the world framed by the camera lens proved inevitable. Typically each neighborhood tour was done on foot and/or bicycle and lasted a minimum of two hours. A total of about 30 hours were spent in the field. Observations were recorded for each field tour in the form of field notes and sketches. Major insights were distilled into written research notes that recorded the progress at regular intervals. A summary of key issues noted during field observation and photo tours is presented in the next section.

4.1.3 Base Mapping

Compiling base mapping for each case study was the final step in the documentation process. Mapping conveys an essentially different type of information than either of the first two methods—information more directly associated with form as opposed to character. Maps allow particular types of information to be sorted and abstractly represented in two-dimensions. While they do not offer the reality-based perspective of either photographs or field observations, maps can capture larger patterns and underlying relationships that elude the other sources. Spatial patterns that cannot be seen in the field such as parcel lines or street systems can be seen clearly on a map. Because maps are abstractions, individual elements such as land use, circulation patterns or topography can be simplified and detached from the noise of their context so they can be more easily studied.

Perhaps the greatest attribute of maps for this project is that they are *scaleable*. They are not subject to the distortions of perceptual space. Arraying spatial information at a pre-determined scale allows dimensions for all sorts of elements to be measured and compared across geographical space. The attribute of definitive scale is what makes mapped information such a useful urban form analysis tool for urban morphology, city planning, architecture, ecology, geography and any other field concerned with spatial distribution. Map like two-dimensional drawings can also represent three-dimensional space as cross-sections, elevations and various ortho-graphic projections. What maps obviously lack is the ability to convey the perceptual experience of space. However maps in combination with photographs and field observation provide an excellent baseline for measuring the neighborhood form.

Mapping of Neighborhood Case Studies (GIS): The primary mapping information for the neighborhood scale is derived from existing geographic information system (GIS) spatial databases. While 1:24,000 USGS mapping and low resolution ortho-photos were used to for initial sorting and selection of cases, more detailed spatial data for parcels, streets, hydrology, and topography was derived from existing GIS databases. The ability to array different elements of urban form (e.g. streets, buildings, parcels) as separate "layers" also permits analysis of these elements both independently and in relationship to each other. The other big advantage of GIS systems is the ability to attach non-spatial data to attribute tables linked to lines and polygons on each GIS layer or theme. In particular, the ability to attach non-spatial data such as land-use to a parcel level resolution allowed a more robust analysis of neighborhood form.

Initial investigation confirmed GIS mapping data existed for all four core towns in the Upper Valley. ESRI ArcView© software was utilized to view, sort, and analysis the GIS data. GIS graphics were exported to Adobe Illustrator© software for preparation of final report graphics. These data sets provided both the framework for base mapping and the parcel by parcel data tables that provided the basis for analyzing spatial variation and developing quantitative measures of urban form at the neighborhood and street/block scales (see detailed discussions in Chapter Five and Six). The goal was to map basic coverages for parcels, streets, buildings, land use, vegetation, and topography that could be presented at 1"= 500' scale for each study site. However the relative accessibility, breadth and quality of the GIS data varied enormously from town to town. This resulted in some considerable frustrations in acquiring and assembling consistent GIS data sets for all twelve case studies. A detailed of discussion of the GIS data issues is presented in Appendix D.

Mapping of Street/Block Case Studies: Mapping the six street/block scale case studies was even more challenging due to the low resolution of GIS data relative to the scale of a 500 foot long block. When GIS neighborhood scale maps were blown up by 500% to create a map scale appropriate to presentation at 1" = 100', the quality of the base data was far too coarse to be a reliable base map. As noted in Section 3.3, there was no available information for this scale of neighborhood space. Construction of a reliable base map thus depended on refining and expanding the GIS based framework to a reasonable resolution by other means—primarily extensive field measurements.

As part of the street/block scale case study selection process, an extensive field survey measured cross-sectional dimensions for the most typical condition for 73 street/blocks including the set of six final case studies. Street width, sidewalk and verge width, building setback, and face to face measures provided a sound dimensional framework for refining GIS base maps to a higher resolution and incorporating new field measured data. For the three Lebanon sites (Longwood Lane, Green Street and Wolf Run) higher quality ortho-photography allowed considerable refinements to existing line work by zooming into a larger scale. For Iris Way, scanned as-built maps for the Hemlock Ridge development provided an accurate plan of buildings, streets and driveways to base refinements on. For the other two sites, Sargent Street in Hanover and Main Street in Norwich, adjustments are primarily based on information measured in the field.

After refining the base maps as much as possible using existing data sources, maps printouts were marked up in the field with additional field measurements. Primary attention was paid to four areas: 1) getting a reasonably accurate building footprint layout along both sides of the street; 2) confirming the relationship of buildings to parcel and street right-of-way lines; 3) translating street section elements into plan view (paving, curb, sidewalks, fences); and 4) inventorying approximate size and location of all major trees and other landscape features. The extensive image database was a very useful reference to use in conjunction with field notes to construct the final plans. The plans provide a consistent graphic/spatial framework for the work of deriving and testing measures.

4.1.4 Neighborhood Baseline Profiles

The final base maps were incorporated into the Neighborhood Baseline Profiles assembled for each case study. They include photography, mapping and summary statistics for each area. They can be seen in summary form in the ten-page set of baseline matrices included at the end of this section as *Figure 4-1 Neighborhood Baseline Profiles by Density Class.* The profiles use photographs to convey a more holistic view of the neighborhood character and maps to convey both the overall context as well as individual plan elements (e.g. parcel, street, building). The scale for all summary neighborhood maps is 1:20,000 or approximately one inch equals 1600 feet.

The neighborhood profile matrix comparatively arrays each set of four cases within a given density level *(lower, middle, higher)* over three consecutive pages. The first *OVERVIEW* page presents basic statistics and context with comparative USGS mapping and ortho-photography overlaid with neighborhood boundaries. The second *CHARACTER* page presents a series of three photographic views describing the neighborhood at three different scales *(bird's eye, street oblique, elevation).* The final *ELEMENT* page presents comparative mapping of three framework elements *(parcels, streets, buildings)* at a consistent scale of 1:20,000 or about 1"= 1600'.

Each page also arrays cases from top to bottom by general development era: first row is *Pre-WWII*, second row is *Post WWII*, third row is *Late 20th Century*, and bottom row is *Mixed Era*. Summary information on the overview page includes: 1) development era, 2) residential land use density in *units per acre*, 3) number of dwelling units, 4) the total geographic area of the neighborhood in acres, and 5) a percentage breakdown of housing type mix by single-family and multi-family units. The first page of the summary matrix is a regional context map that locates all study sites within the landscape of the Upper Valley. The regional context map is presented on a reduced 7.5 minute USGS quad composite base at a scale of approximately 1:72,000 or 1"= 6000'.

The neighborhood profiles provided the researcher with a consistent comparative summary of all twelve neighborhood case studies for the entire duration of the project. Larger scale neighborhood-by-neighborhood versions of the profiles that arrayed a single neighborhood over three pages were used for more detailed analysis and as a comparative reference during the derivation and testing of measures.

Figure 4-1a LOCATION MAP: 12 STUDY NEIGHBORHOODS

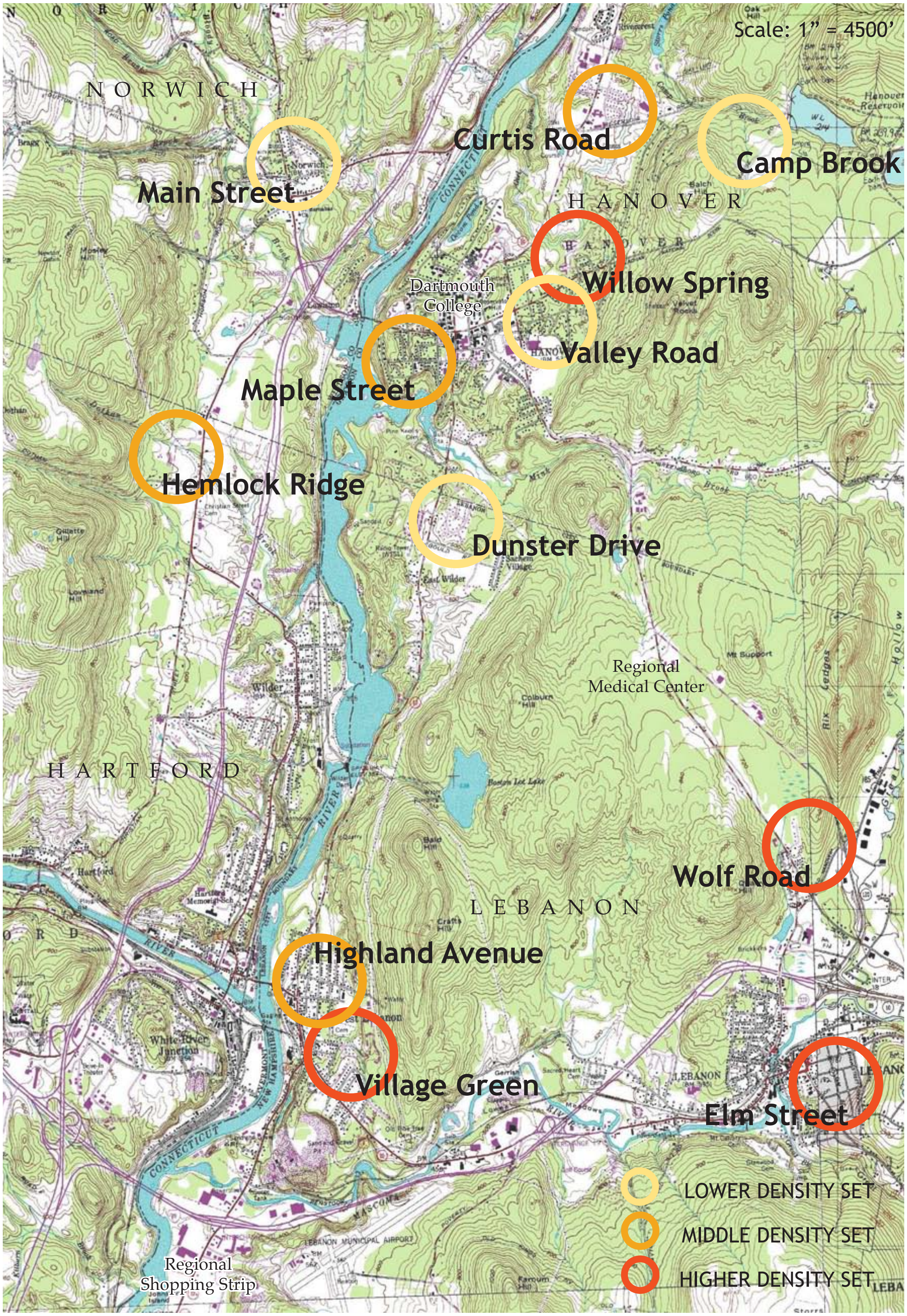


Figure 4-1b LOWER DENSITY SET: OVERVIEW

	N-hood Profile	USGS Map (1988)	Orthophoto (1992)

01. Main Street

Era: Pre WW II

Density: 1.8 units/ac

Number: 98 units

Area: 58 acres

Mix: 90% sf / 10% mf

02. Dunster Drive

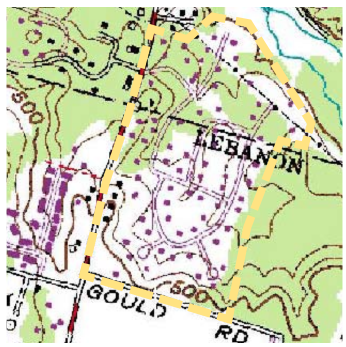
Era: Post WW II

Density: 1.4 units/ac

Number: 90 units

Area: 54 acres

Mix: 100% sf



03. Camp Brook

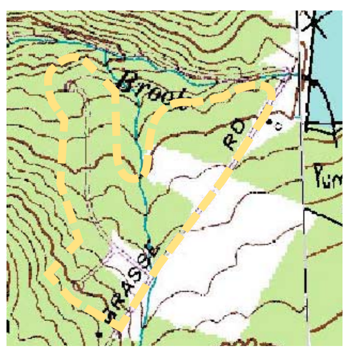
Era: Late 20th Century

Density: 1.5 units/ac

Number: 60 units

Area: 40 acres

Mix: 100% sf



04. Valley Road

Era: Mixed Era

Density: 2.1 units/ac

Number: 137 units

Area: 64 acres

Mix: 50% sf / 50% mf

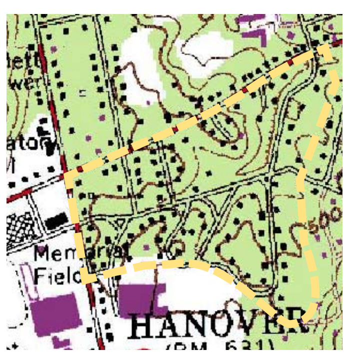


Figure 4-1c LOWER DENSITY SET: CHARACTER

Figure 4-1d LOWER DENSITY SET: ELEMENTS Scale: 1” = 1600’

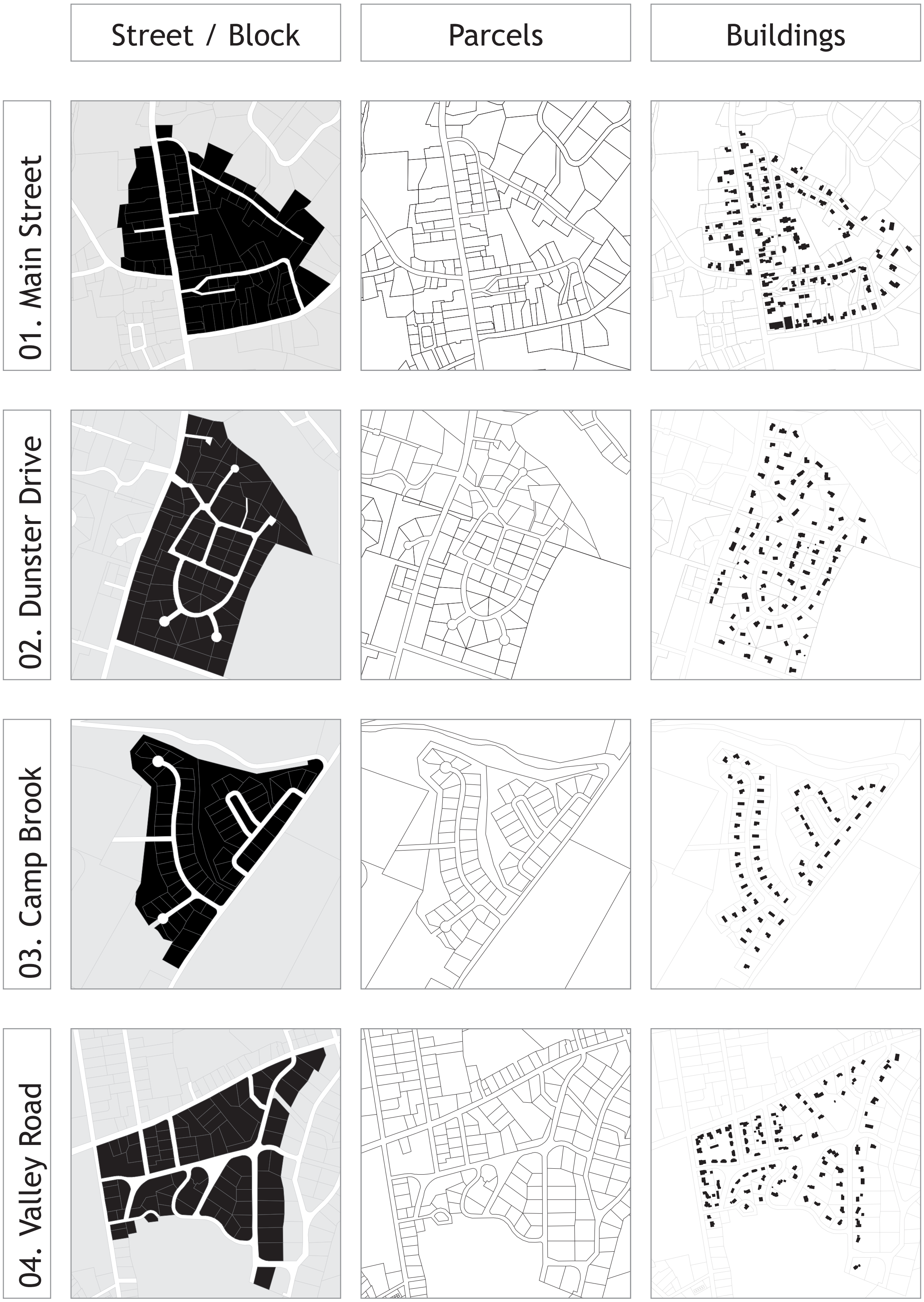


Figure 4-1e MIDDLE DENSITY SET: OVERVIEW

N-hood Profile | USGS Map (1988) | Orthophoto (1992)

05. Maple Street

Era: Pre WW II

Density: 3.9 units/ac

Number: 260 units

Area: 66 acres

Mix: 35% sf / 65% mf

06. Curtis Road

Era: Post WW II

Density: 3.9 units/ac

Number: 129 units

Area: 33 acres

Mix: 50% sf / 50% mf

07. Hemlock Ridge

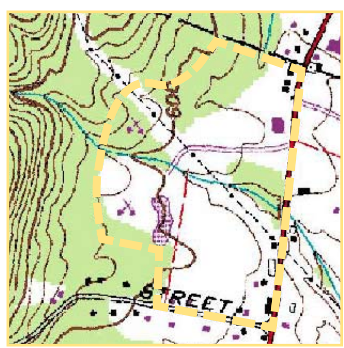
Era: Late 20th Century

Density: 3.8 units/ac

Number: 227 units

Area: 60 acres

Mix: 35% sf / 65% mf



08. Highland Ave

Era: Mixed Era

Density: 3.4 units/ac

Number: 186 units

Area: 55 acres

Mix: 65% sf / 35% mf

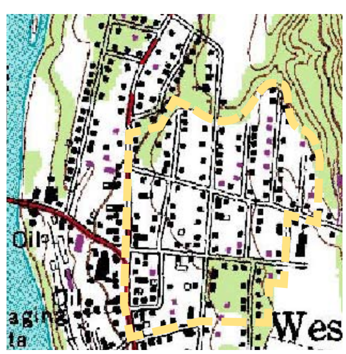


Figure 4-1f MIDDLE DENSITY SET: CHARACTER

Figure 4-1g MIDDLE DENSITY SET: ELEMENTS Scale: 1” = 1600’

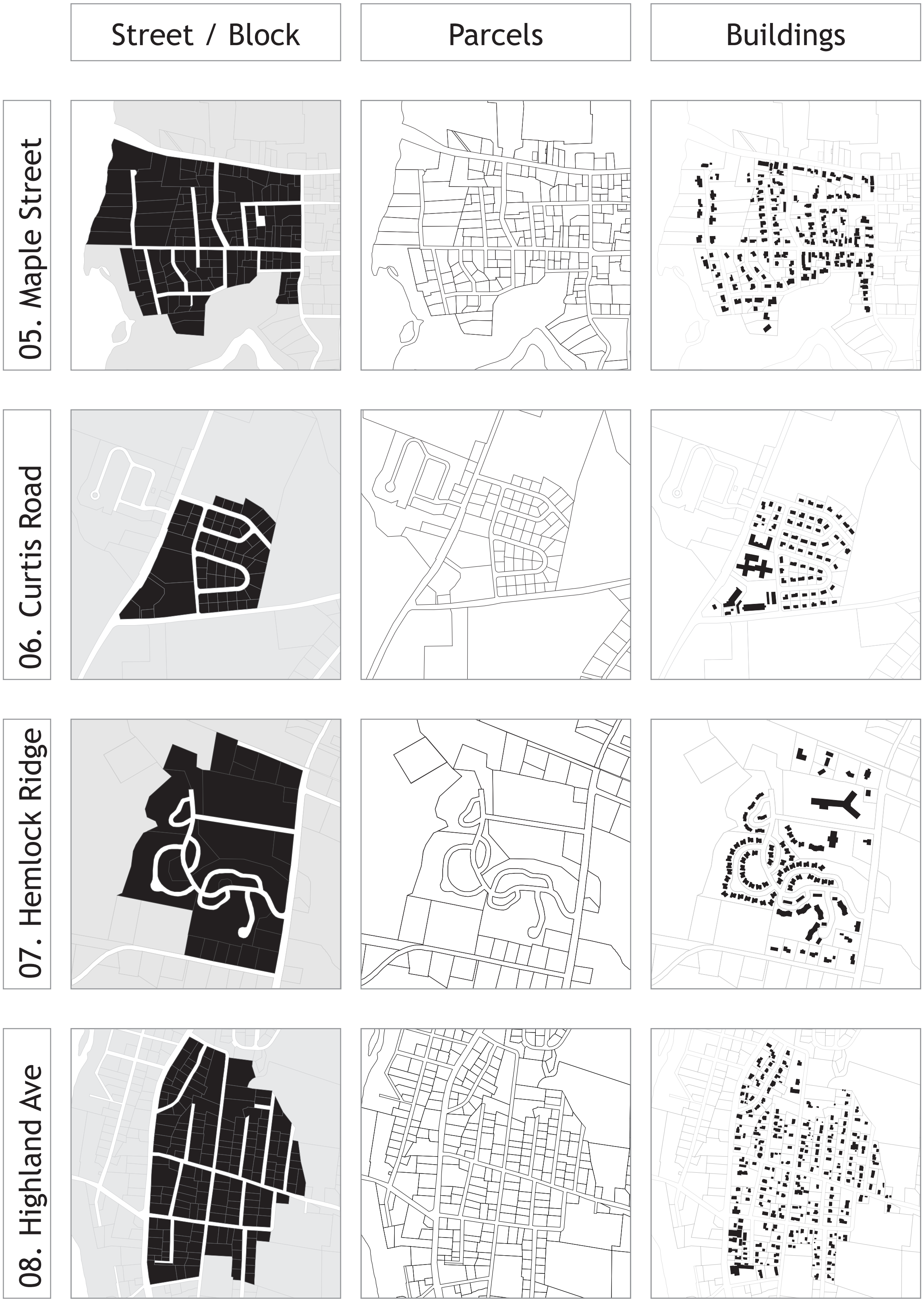


Figure 4-1h HIGHER DENSITY SET: OVERVIEW

N-hood Profile	USGS Map (1988)	Orthophoto (1992)

09. Elm Street

Era: Pre WW II

Density: 5.9 units/ac

Number: 332 units

Area: 58 acres

Mix: 20% sf / 80% mf

10. Village Green

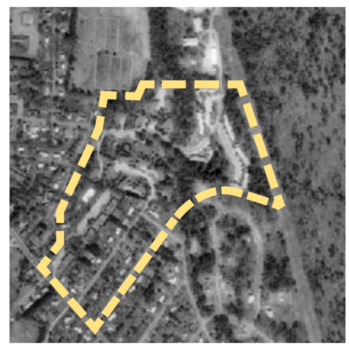
Era: Post WW II

Density: 5.1 units/ac

Number: 245 units

Area: 48 acres

Mix: 10% sf / 90% mf



11. Wolf Road

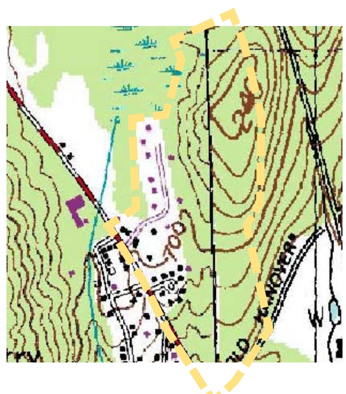
Era: Late 20th Century

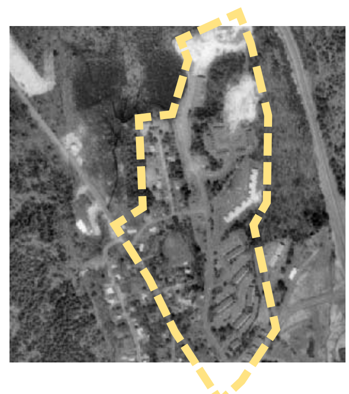
Density: 5.9 units/ac

Number: 321 units

Area: 57 acres

Mix: 10% sf / 90% mf





12. Willow Spring

Era: Mixed Era

Density: 5.5 units/ac

Number: 165 units

Area: 30 acres

Mix: 20% sf / 80% mf

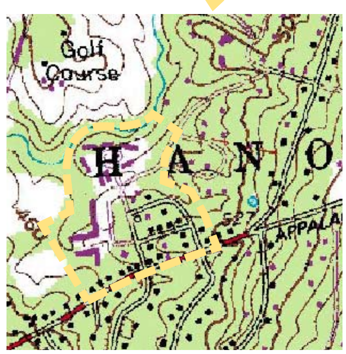


Figure 4-1i HIGHER DENSITY SET: CHARACTER

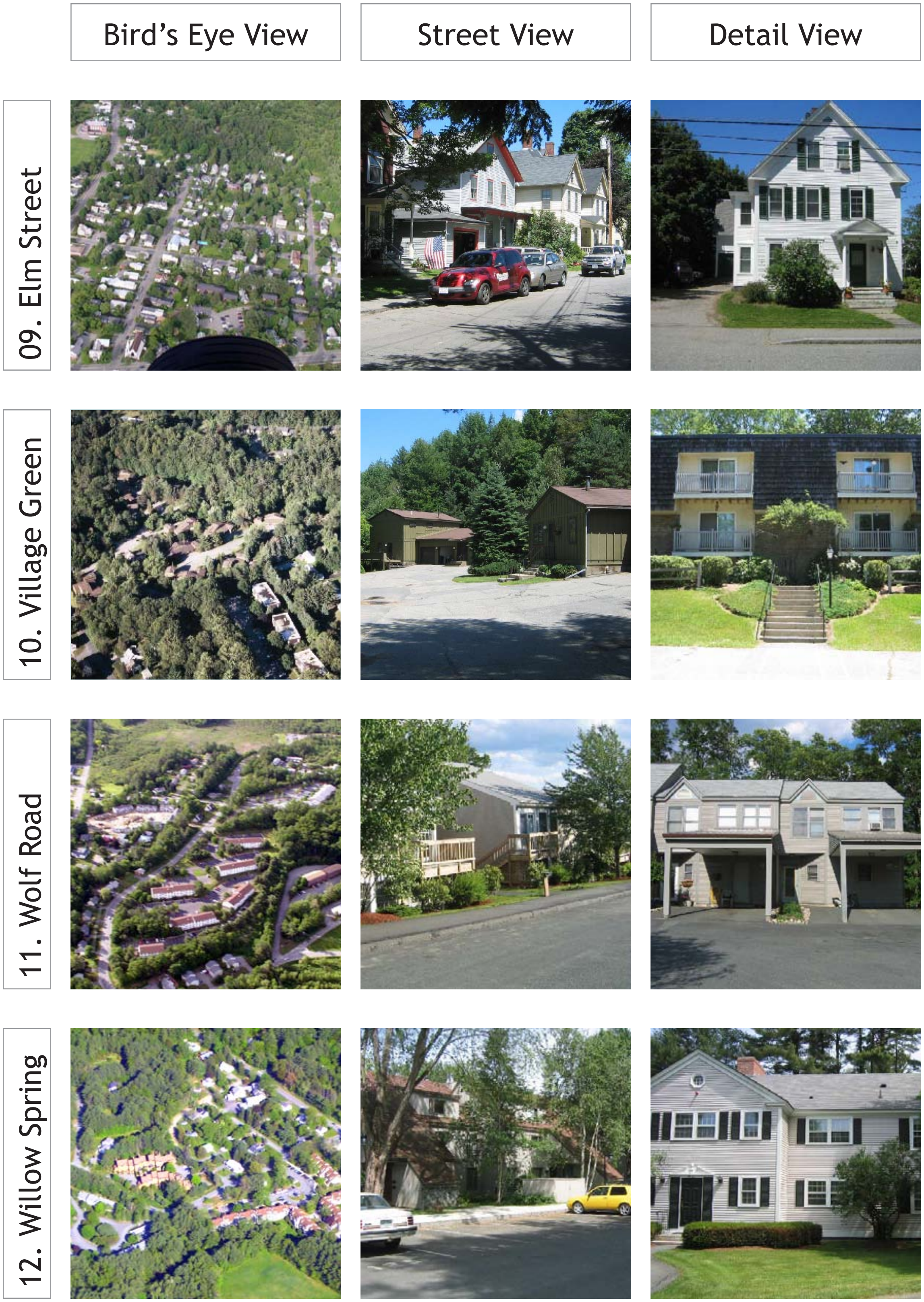


Figure 4-1j HIGHER DENSITY SET: ELEMENTS Scale: 1” = 1600’

4.2 Assessing Differences Between Neighborhoods

This next section summarizes the results of two distinct analytic exercises designed to identify key patterns and relationships that distinguish neighborhood form across the twelve case studies. In each case, the intent was to use systematic observation and analysis as a basis for speculating about physical dimensions that underlie the perceptual differences between neighborhoods and how they might be might be measured in simple replicable terms.

This *first* exercise was based on the *field observation* and photography protocol described in the previous section. It summarizes a series of first impressions about significant factors or relationships that seemed to distinguish one case from another during a series of field visits to the case study neighborhoods. The researchers observations were recorded in the form of summarized field notes.

The *second* exercise was the step-by-step analysis of physical variation between case study neighborhoods. This *analysis of variation* is based on a comparative review of a series of urban form characteristics or variables across all case study neighborhoods. A total of twelve variables were evaluated using a combination of mapping analysis, review of field photography, and the researcher's field notes and impressions. The analyzed variables included six that seemed to relate more to the neighborhood scale and six that were focused on smaller scales of street, block, building, and yard. The list was initially drawn from a much longer list presented in the research prospectus.

The field observation analysis was carried out over a three-week period in June of 2004. The analysis of variation was prepared during the months of July and August of the same year. Findings are summarized below in three sections. The first summarizes the *field observations*. The second and third summarize the *analysis of variation* by the scale of neighborhood and street/block/building/yard respectively.

4.2.1 Summary of Key Field Observations

A series of initial impressions drawn from a series of field tours are discussed below. The findings are organized around a series of findings related to difference between neighborhoods. The sub-headings of each finding highlight what was observed to be a potentially significant factor in distinguishing differences between case study neighborhoods beyond simple differences in development density. Photographic comparisons illustrate identified differences between neighborhoods in the same density class whenever possible.

Mature trees and individual taste (#3938)

Young trees in a master planned landscape (#3895)

Figure 4-4 Comparison of Landscape Character: N5 Maple vs. N7 Hemlock

Landscape Matters. The quality of landscape character, especially the trees, has an enormous impact on the spatial quality of neighborhoods *(Figure 4-4 Comparison of Landscape Character)*. In some cases this seemed a result of conscious design (e.g. Hemlock Ridge); in some cases it seemed more related to the differences of taste among individual property owners (e.g. Maple); and in still other cases it seemed to simply be function of age (e.g. Main Street versus Camp Brook). In some cases, extreme variation could be found from lot-to-lot, in other cases it was quite consistent across the entire area. Surprisingly, very little of the observed landscape character resulted from street trees planted in the public right of way. In contrast to more densely settled metro-areas, street trees were not typically a part of the street cross-section. Trees along the street seemed more a function of each landowner than a broader community effort.

Building & site orient to both sides of street corner (#3748)

Building & site orient to only one corner (#4053)

Figure 4-5 Comparison of Corner Conditions: N9 Elm vs. N11 Wolf

Corners. The treatment of corner lots and buildings also seemed to be a significant element in distinguishing places *(Figure 4-5 Comparison of Corner Conditions)*. Whether or not a building's orientation on its lot responded to a corner condition had noticeable impact on the way a street turned the corner and the continuity of the street environment. In areas with more recent development patterns, special corner conditions tend to be both less frequent and more frontally oriented (i.e. more consistent with the orientation of interior buildings of the block). In older areas, special corner conditions are more frequent and they tend to reflect a rotated orientation in which buildings relate to frontages on both streets that form the corner.

Building / site design connect to street (#3662)

Building / site design oriented to driveway (#3688)

Figure 4-6 Contrasting Building to Street Relationships: N9 Highland Ave

Building to Street Relationship. While the relationship between building and street was identified in as potentially significant in the prospectus, photographing it systematically provided considerable insight into how this relationship changes from place to place *(Figure 4-6 Relationship of Building to Street)*. Of particular note was the relative prominence of the front door and the contrasting orientation of entry walkways between case studies—in some cases walks connect door to street; in other cases they connect door to driveway. Other important components of this relationship were the contrasting treatment of front yard spaces and the type and presence of transition elements such as porches. This relationship contrasts from house to house as well as between neighborhoods. The above examples are located on the same block.

Public street with many small lots & many m-f units (#3761)

Public street with few large lots and many m-f units (#3761)

Figure 4-7 Street Frontage in Multi-family Areas: N9 Elm vs. N11 Wolf

Street Frontage in Multi-Family Areas: It was also striking how different the relationship of private parcel to public street was in newer multi-family areas compared with older multi-family areas. Larger parcel sizes in newer areas seemed to be associated with greater setbacks and less connection between buildings and the public street. Variation of street frontage conditions was observed to have a significant impact on the quality of the public street environment *(Figure 4-7 Public Street Frontages in Multi-Family Areas)*. The above examples are located within a mile of each other in Lebanon. It was speculated that deriving a measure of this difference could involve some kind of ratio between linear feet of street frontage and associated number of dwelling units or linear feet of building face or façade.

Front entry oriented to street with parking in rear (#1926)

Front entry oriented to driveway and garage (#3575)

Front entry to public street w/on-site parking in rear (#3791)

Front entry oriented to private off-street parking lot (#3761)

Figure 4-8 Transition and Arrival Spaces: N1 vs. N2 (s-f) & N9 vs. N10 (m-f)

Transition and Arrival Spaces: A related issue is the contrast of the arrival or transition space from street to dwelling in different neighborhoods. These spaces define the intersection between Lynch's (1981 p. 352) two-part distinction between stationary "adapted spaces" (in this case the dwelling unit and associated yard) and movement oriented "flow facilities" (in this case associated circulation, parking, and entry areas). This interface is a primary characteristic of neighborhood space. In some neighborhoods these spaces are pulled back from the street and oriented around driveways and garages (see right above). This pattern is often found in newer single-family areas. In other cases arrival spaces are split between pedestrian front entry and vehicle entry in the rear. The pattern is more typical in older village housing with front porches and doorways face directly onto the street and private on-site parking in the rear (see left above).

A multi-family version of this pattern is illustrated on *Figure 4-8 Comparison of Transition/Arrival Spaces* on the lower left side. In still other cases, all access and entry functions face directly onto shared off-street parking facilities as illustrated on the right hand image above. In the later case, it is not simply a case of contrasting character or dimension but of basic spatial typology Spaces defined by buildings on a public street feel fundamentally different from those defined by buildings on a parking lot. Sorting out how to define and measure these hybrid elements will be a key challenge in describing these places.


Designed variation in a master planned m-f area (#3865)


Variation in incrementally developed m-f area (#3793)

Figure 4-9 Contrasting Types of Visual Variation: N7 Hemlock vs. N9 Elm

Contrasting Perceptions/Types of Variation: A distinct contrast was also noted between places where conscious efforts had been made to create environmental qualities such as variation and visual interest and places where these qualities had derived more organically, over time. This was most clearly observed by comparing neighborhoods that were master-planned with those that were not. This difference also seemed to be a function of age and ownership. Visual variation in developments with commonly owned land is distinctly different from that in areas of individual ownership. In *Figure 4-9 Contrasting Types of Visual Variation* both photographs show visual variation but the perceived effect is quite different. It is expected that standardized measurement of these differences will be quite difficult. The key distinctions seem to lie beyond a simple accounting of what is the same versus what is different.

Small lot eight-unit building with parking behind (#7918)

Large lot twelve-unit building with parking in front (#4303)

Figure 4-10 Comparison of Parking Arrangement & Allocation: N8 vs. N12

Parking Arrangement / Allocation and Personal Outdoor Space: Two other issues that stood out during field observations relate to the relative arrangement and allocation patterns of parking and personal storage. In the newer areas, surface parking was perceived to be more dominant component of site development than in older areas—especially in multi-unit areas. In *Figure 4-10 Comparison of Parking Arrangement & Allocation*, the right hand side appears to show a higher parking allocation than the area on the left hand side. Observations also suggested an inverse relationship to the allocation of personal storage and outdoor space. Neighborhoods with less overall open space showed greater provisions for personal outdoor space in garages, porches, outbuildings, gardens, entryways, etc. In others with a greater overall sense of open space, personal outdoor spaces seemed scarce—outdoor grills, bicycles, strollers, kayaks, etc. were seemingly scattered across the landscape. Deriving comparative measures for parking allocation seem more straightforward than ones for personal outdoor space.

View Type and Spatial Structure: Finally over the course of taking 1500 photographs across the case study neighborhoods, a very interesting congruence was noted between types of views and classifications of spatial structure. The literature notes a basic theoretical division between spaces of movement (i.e. streets/paths) and the stationary spaces they serve (i.e. parcels/buildings). *Figure 4-11 Three View-Types of Neighborhood Space* shows this same distinction in neighborhood photographs and the related diagrams of compositional structure. These differences between the *staying* space of the house/lot and *moving* space of the street/drive are clearly manifest in the three basic points of view visible to any passerby (Lynch 1980, Gehl 1987).

Frontal View: 100% Edge (#3777)

Parallel View: 100% Corridor (#3780)

Oblique View: Edge & Corridor (#3778)

Figure 4-9 Three View-Types of Neighborhood Space: Shaw Street (N9)

The first view type is the *frontal view* of a building and/or side yard on a parcel. With its perpendicular angle to the street, this street elevation view is a 100% frame of the realm of the *staying*. It does not show any street except as a line a bottom of frame. In perspective terms, it is a flat image. It has a central vanishing point but there is little perspective distortion because typically a building, trees or other edge elements fills the frame. It is fundamentally a short-range view of visually solid foreground elements. Glimpses of more distant space depend on the relative openness of the landscaped voids between buildings.

The second view type is the *parallel view* down the street or sidewalk. It is taken from center of street section and encompasses a 100% view of the realm of *moving*. It is compositionally both similar and opposite from the first. This view also has a central vanishing point because it is looking down the long void of the street corridor. The buildings and yards are only visible as outside edge elements that bound the street. The greater the corridor width, the less visible the vertical edges become. These views have a deep (versus flat) spatial structure with the classic X-shaped pattern of a deep, single-point perspective. This gets slightly distorted as one moves off the centerline. The perspective depth can be altered by a foreground element (e.g. large truck or low tree canopy) or by the street curving away or terminating.

The third is the *oblique view* that is hybrid of the first two. It is taken at some angle to the street edge or elevation. Its subject is split between the two realms and illustrates the interface between the spaces of staying and moving. As an oblique view, it has a two-point perspective with one side vanishing into the building/yard edge and the other side vanishing down the street. However, due the opacity of the street edge, the visual composition is strongly biased toward the street side vanishing point. The only exception is a corner condition where the viewer can look down both vanishing lines of two perpendicular streets. This view has a characteristic > arrow shape crossing the frame from left or right or vice versa. The comparative photographs illustrate how the view composition shifts from frontal to parallel as the camera angle is swung from 90 degrees to 0 degrees with respect to street centerline.

It is possible to instantly classify these view types while flipping through images in rapid order without knowing the specific context or location of the photograph. The types are clearest in areas where buildings are close to streets. It is somewhat less clear, though still visible, in more spread out settings. These contrasting views between the street and its adjacent edges relate strongly to Lynch's two-part classification between moving and staying (p. 351). This suggests the transition zone between them may be fertile ground for exploring key differences of neighborhood form.

4.2.2 Analysis of Variation: Neighborhood Scale

The second exercise draws its findings in a more indirect method that analyzed photographs, maps, and field notes in more systematic fashion several weeks after the actual field observation tours. The analysis sought to identify and describe the range of differences found for a series of urban form variables examined across the twelve case study neighborhoods. The analysis was split into two parts—the first considered neighborhood wide patterns; the second more detailed patterns. This first sub-section covers a set of six variables or characteristics at the neighborhood scale. They include street pattern, network connectivity, block grain and pattern, open space, tree cover, and parcel pattern. It is organized around the column headings shown in *Table 4-1 Matrix of Neighborhood Form Variation*. The following sub-section 4.2.3 will discuss a similar matrix organized around six smaller scale variables. The discussions will also help clarify the shorthand field notations in the matrix cells.

Neighborhood	Growth Period	Density (u/ac)	% SF / MF units	Street Pattern	Network Connectivity	Blk Grain & Pattern	Open Space	Tree Cover	Parcel Pattern
Low to Moderate Density: 1 to 2 units / acre (about 44,000 to 22,000 sf of land per unit)									
1 Main Street	pre WWII 1850-1940	1.7	90% / 10%	radial vill w/ loops & 3 dead ends	medium: 4 external access pnts	med-low: 2 int reg blocks	edges, meadow, green	mature, dense, cntr blck	fine grain mixed size
2 Dunster Drive	post WWII 1950-1980	1.7	100% SF	linked loops & 4 cul-de-sacs	very low: 1 external access pnt	medium: 3 int irreg blocks	edges, none internal	mid age, modest, even	med grain med lots
3 Camp Brook	late 20th 1990-2000	1.7	100% SF	loops & 2 cul-de-sacs	low: 3 ext ac pts int discon	weak/low: 2 int reg blocks	edges, common, brook	young, sparse, thck edge	med grain med lots
4 Valley Road	mixed era 1930-2000	1.9	50% / 50%	curving grid w/ 3 dead ends	med-high: 4 ext access pnts	med-high: 6 int mxd blocks	edges, lawn, sm park	mature, dense, open MF	med grain mix'd size
Moderate Density: 2 to 5 units / acre (about 22,000 to 9,000 sf of land per unit)									
5 Maple Street	pre WWII 1900-1940	3.9	40% / 60%	irreg grid w/ loops & 3 dead ends	high: 6 external access pnts	med-high: 5 int reg blocks	edges, meadow, garden	mature, dense, lot lines	fine grain mixed size
6 Curtis Road	post WWII 1950-1980	3.5	50% / 50%	2 loops, 1 cul-de-sac & prkng lots	low: 2 external access pnts	medium: 3 int mxd blocks	edges, sm park	mature, dense, open MF	med grain mixed size
7 Hemlock Ridge	late 20th 1980-2000	3.8	30% / 70%	loops off loop & parking lots	low: 2 external access pnts	medium: 4 int irreg blocks	edges, pond, sm park	young, dense, thck edge	PUD dev crse grain large lots
8 Highland Ave	mixed era 1900-1980	3.4	60% / 40%	village grid w/ 4 dead ends	high: 7 external access pnts	fine/high: 7 int reg blocks	edges, ballfield, cemetary	mature, modest, even	fine grain small mixed lots
Moderate to High Density: 5 to 10 units / acre (about 9,000 to 4,500 sf of land per unit)									
9 Elm Street	pre WWII 1880-1940	5.8	25% / 75%	orthogonal village grid	very high: 9 external access pnts	fine/high: 7 int reg blocks	edges, city green	mature, modest, cntr blck	fine grain small mixed lots
10 Village Green	post WWII 1960-1980	6.0	5% / 95%	1 loop, 7 cul-de-sacs & prkng lots	med-low: 5 ext ac pts int disconct	very low: no intern blocks	edges, brook, lawn	middle, modest, even	PUD dev crse grain large lots
11 Wolf Road	late 20th 1980-2000	5.6	10% / 90%	3 cul-de-sacs & 8 off st prkg lots	low: 2 external access pnts	very low: 1 lrg irreg block	edges, lawn	middle, modest, thck edge	crse grain med & large lots
12 Willow Spring	mixed era 1920-1980	6.1	20% / 80%	grid frag w/ 5 parking lots	medium: 3 external access pnts	med-low: 2 int reg blocks	edges, lawn	middle, modest, even	crse grain med & large lots

Table 4-1 Matrix of Neighborhood Form Variation

Street Pattern: The pattern of streets is a major distinguishing element of neighborhood form. The irregular terrain of the Upper Valley makes typical distinctions between grid and cul-de-sac systems not very useful. While all neighborhoods have some degree of internal connection, only Elm comes close to a traditional grid pattern of interconnected streets and small blocks. Highland, Maple, Main and Valley are hybrids—traditional patterns modified to various degrees by topography and circumstance. Dunster, Curtis, Camp Brook, and Hemlock Ridge are characterized by patterns of loops and cul-de-sacs associated with post-war development. A final pattern finds a few public streets serving a series of dead-end drives and parking areas serving large multi-family developments (e.g. Village Green, Wolf, Willow Spring).

Network Connectivity: A second component of street pattern is the degree of interconnection with surrounding areas. Finer grained patterns (e.g. Elm) tend to have more connections; coarser patterns tend to have less. The connectivity associated with a higher number of access points can be offset by internal disconnection of the street system within the neighborhood (e.g. Camp Brook).

Block Grain & Pattern: Block pattern and grain is generally a function of street pattern. Tightly woven streets tend to make small blocks and fine grain (e.g. Highland). Widely spaced streets produce big blocks and coarse grain (e.g. Wolf). Topographic variation can again complicate the issue by limiting street connections and expanding block size without a proportional impact on neighborhood grain (e.g. Maple).

Open Space: While all neighborhoods have access to adjacent open space, the pattern and quality of the open space varies widely. Some have formally defined parks or greens (e.g. Main, Elm, Camp Brook). Others have recreation fields, playgrounds or school fields (e.g. Highland, Curtis, Valley, Dunster). In other places open space is less formal—a meadow, wooded hollow or pond open to the community (e.g. Maple, Hemlock Ridge). In some cases open space consists of large areas of lawns and wooded buffers (e.g. Wolf, Village Green, Willow Spring).

Tree Cover: Trees have a huge impact on neighborhood character in New England. Their influence seems affected by at least three factors: age, density, and distribution. In general, older neighborhoods have larger trees. Age can create a distinct contrast between otherwise similar places (e.g. Dunster versus Camp Brook). Density is the number of trees per unit area. Some places simply have more trees and less open lawns (e.g. Maple versus Highland). Distribution pattern of tree cover also varies. In some cases like Elm, trees tend to be clustered at the center of blocks. In other places like Wolf, trees form strong perimeter frames around individual developments. In still others like Curtis, they appear to be more evenly spread across the whole area. Surprisingly, formal street tree plantings are found in only a few recent neighborhoods (e.g. Hemlock Ridge, Camp Brook).

Parcel Pattern: Property lines have a major impact on neighborhood character. They set the framework of spatial division between private parcels and public streets. Parcel pattern grain is a function of at least three key dimensions—size, uniformity, and distribution. Small parcels are typically associated with more extensive street patterns. The finest grained patterns tend to be mixed in size (e.g. Elm, Highland, Main). In other cases, like Dunster and Camp Brook, grain is somewhat larger but more consistent. In Village Green, Hemlock, and Wolf, large lot sizes result in a relatively coarse grain of land division. There can also be considerable variation in parcel sizes from one part of the neighborhood to another. The gradient can be either be gradual (e.g. Maple, Valley) or sharp (e.g. Wolf, Willow Spring). In most neighborhoods the divisions between parcels are distinctly marked by landscape and building patterns. However in master planned places, such as Hemlock Ridge, they are more difficult to detect.

4.2.3 Analysis of Variation: Street/Block/Building/Yard

Issues of comparative analysis change significantly at the more detailed scale of streets, blocks, buildings, and yards *(Table 4-2 Matrix)*. The remaining variables concern smaller scale patterns within neighborhoods rather than the neighborhood as a whole. Ironically, by zooming into a smaller scale of analysis the potential universe of variation

Neighborhood	Growth Period	Density (u/ac)	% SF / MF unts	Non-res Land Use	Edge Streets	Building Types	Bldg to Street	Street Types	Public Private
Low to Moderate Density: 1 to 2 units / acre (about 44,000 to 22,000 sf of land per unit)									
1 Main Street	pre WWII 1850-1940	1.7	90% / 10%	mixed along SW edge	bldgs front street	9 total SF 1-6 MF 1,2,5	small stback frnt walks	A/NC 4,6 B/SC 4 B/NC 4	strong public st priv lots
2 Dunster Drive	post WWII 1950-1980	1.7	100% SF	mixed along west edge	bldg/prk setback street	2 total SF 5,6	med-lrge setback no walk	A/NC 6 B/DC 6 B/NC 6	modest public st priv lots
3 Camp Brook	late 20th 1990-2000	1.7	100% SF	none	bldgs back to street	2 total SF 2,6	medium setback no walk	A/NC 6	modest public st priv lots
4 Valley Road	mixed era 1930-2000	1.9	50% / 50%	mixed along west edge	bdgs front street	7 total SF 3-6 MF 2-4	mxd stbck mf walks sf no wlk	A/NC 1,2,6 A/DC 2	modest public st priv lots
Moderate Density: 2 to 5 units / acre (about 22,000 to 9,000 sf of land per unit)									
5 Maple Street	pre WWII 1900-1940	3.9	40% / 60%	mixed along east edge	bldgs front street	10 total SF 1-6 MF 1-4	small setback frnt walks	A/NC 2,6 A/SC 4 A/DC 6	strong public st priv lots
6 Curtis Road	post WWII 1950-1980	3.5	50% / 50%	mixed along west edge	bldg/prk setback street	5 total SF 4-6 MF 7,8	medium setback no walk	A/NC 2,6 B/SC 2 B/DC 2	modest public st priv lots
7 Hemlock Ridge	late 20th 1980-2000	3.8	30% / 70%	mixed along east edge	bldgs back str frnt prkg	4 total SF 5 MF 5,7,8	mf to prkg sf close to pvt drive	A/NC 6 PP/NC 4,6	semi-private str & yrd
8 Highland Ave	mixed era 1900-1980	3.4	60% / 40%	mixed along west edge	bldg/prk mxd to street	8 total SF 1,2,4-6 MF 1,3,4	mxd stbck old walks new none	A/NC 1,2 A/SC 4 A/DC 3	strong public st priv lots
Moderate to High Density: 5 to 10 units / acre (about 9,000 to 4,500 sf of land per unit)									
9 Elm Street	pre WWII 1880-1940	5.8	25% / 75%	mixed along west & north edges	bldgs front street	9 total SF 1-6 MF 1,2,4	small setback frnt walks	A/NC 2 A/SC 3,4 A/DC 3	strong public st priv lots
10 Village Green	post WWII 1960-1980	6.0	5% / 95%	adjacent to west edge	mf bdgs sep frm street	5 total SF 2,5 MF 1,5,8	distant: bldg frnts to parking	A/NC 6 PP/NC 6 P/NC 6	semi-private str & yrd
11 Wolf Road	late 20th 1980-2000	5.6	10% / 90%	mixed along south edge	mf bdgs sep frm street	7 total SF 1,5,6 MF 1,5,6,8	distant: bldg frnts to parking	A/NC 6 PP/DC 4 B/SC 4	semi-private str & yrd
12 Willow Spring	mixed era 1920-1980	6.1	20% / 80%	none	mf bdgs sep frm street	7 total SF 1,2,6 MF 2,3,6,8	distant: bldg frnts to parking	A/NC 6 PP/DC 4 PP/NC 6	semi-private str & yrd

KEY for Buildlings:

Multi-Family Building Types (MF)
1 Trad House w/ 2-4 units
2 Duplex (side by side, gar frnt or back)
3 Row Buillding 3-8 units gar/prk back
4 Apt Flats 4-8 gar/prk back
5 Row Buillding 3-8 units gar/park front
6 Apt Flats 4-8 gar/prk front
7 Row Buillding 9 plus units prk front
8 Apt/Loft/Barn Flats 9 plus units park front

Single-Family Building Types (SF)
1 One story cape/bungalow w/porch garage side or back
2 Two story trad w/ porch, gar back or side
3 One story cape/bungalow no porch, garage bk
4 Two story trad no porch, gar back or side barn
5 One story ranch/cape garage side or under
6 Two story colonial garage side or under
7 One story contemp garage front
8 Two story contemp garage front

KEY for Streets:

Local Street Section Width Types
A narrow 16-24
B medium 24-32
C wide 32-40
P parking lot single loaded 36-44
PP parking lot double loaded 56-64
/SC with single curb (one side)
/DC with double curb (both sides)
/NC with no curbs

Local Street Section Types
1 with tree strip and sidewalks both sides
2 with tree strip and sidewalk one side
3 with sidewalk both sides but no tree strip
4 with sidewalk one side but no tree strip
5 with street tree strip but no sidewalks
6 with neither sidewalks nor street trees
7 other cross-sections (eg wide sidewalk w/ tree wells)

Table 4-2 Matrix of Street, Block, Building, & Yard Variation

expands exponentially. Smaller scale patterns often have multiple variations within a single neighborhood. Thus it is possible to compare and contrast pieces of the same neighborhood as well as any number of comparisons with similar variations in other neighborhoods. The following discussion is again organized around six matrix headings including non-residential land use, edge streets, building types, building-to-street relationship, street types and public/private spatial quality.

Non-Residential Land Use: While all neighborhoods include some mix of non-residential uses at their perimeter, specific patterns show considerable contrast between cases. Mixing of non-residential uses seems closely tied to parcel grain and pattern. In neighborhoods with a finer grained lot pattern, uses such as shops, offices, and services tend to be mixed side-by-side with residential uses at the edge of the neighborhood (Main, Maple, Elm, Highland). In cases where the parcel pattern is moderate, non-residential uses are still mixed in along the edge of the neighborhood but arranged in larger, more self-contained parcels distinct from adjacent residential uses (e.g. Dunster, Curtis, Hemlock and Valley). In the coarsest grained neighborhoods, large lot sizes convey a sense of proximity with little association or mixing (e.g. Village Green, Wolf and Willow Spring). Commercial and public uses located along or just beyond neighborhood boundaries are perceived as largely distinct from them.

Edge Streets: The character of streets at the neighborhood edge also varies considerably from one site to another. The key variables seem to be: 1) building orientation and setback, and 2) parking location and distribution. In older neighborhoods (e.g. Main, Maple, Elm, Highland, Valley) buildings front onto edge streets with parking located either on-street and/or in small lots to the side or rear of buildings. In newer neighborhoods (e.g. Dunster, Curtis, Hemlock, Camp Brook, Village Green, Wolf, Willow Spring) residential buildings tend to be oriented away from edge streets (i.e. back to the street) and commercial buildings are set back from the street behind parking areas. An interesting exception to the commercial typology is Dan & Whit's General Store on Main Street where a large paved area with parking and gas pumps separates the store from the street. In this case the *complete* lack of a defined street edge results in the entire space functioning almost like a piazza where slow speed cars and pedestrians seem to mix safely in an undifferentiated paved area.

Relationship of Building to Street: Some of the same distinctions carry over to the relationship between buildings and streets inside the neighborhoods. In the older pre-war neighborhoods buildings face the street with a minimum setback. The setbacks are tightest and most consistent in the higher density cases (e.g. Elm) and more variable in the lower density cases (e.g. Main). In post-war single-family neighborhoods (e.g. Curtis, Dunster), setbacks are larger with lower density corresponding to larger setbacks. Setbacks appear to become smaller again in some late 20th century single-family neighborhoods (e.g. Hemlock Ridge, Camp Brook). In mixed era cases (e.g. Valley) building setbacks tend to vary internally by age of development.

A second contrasting element is the entry walk. In pre-war neighborhoods (e.g. Maple, Main, Elm) front walks run directly from doorway to street regardless of setback dimension. In post-war cases front walks almost always "dog-leg" to the driveway (e.g. Dunster, Curtis). Curiously, in the late-20th century cases even when houses are again much closer to the street, walks continue to connect to driveway not to the street (e.g. Camp Brook and Hemlock).

In multi-family areas of post-war neighborhoods, issues of setback and relationship to street are more blurred by an uncertainty of what constitutes the street. In pre-war multi-family neighborhoods (e.g. Elm), the buildings face a traditional street section with fixed width street and adjacent sidewalks and right-of-way lines. In post-war multi-family neighborhoods, buildings are pulled far back from the street and oriented onto internal parking driveways that serve as a kind informal private street (e.g. Village Green, Wolf, Willow Spring). These streets are typically characterized by a 20-30 foot wide travel way with double loaded perpendicular parking bays. The relationship of buildings to these street corridors is quite different—buildings orient directly onto them with small setbacks and connecting front walks. The nature of the relationship can change dramatically based on the definition of street.

Building Types: The variation of urban form between and within neighborhoods gets even much more complex at the scale of building type. The analysis defined eight potential single-family building types and nine potential multi-family types (see Table 4-2). The primary variables for the single-family types were height, porch/no porch, and garage location. The primary variables in the multi-family types were number of units, flat versus townhouse, and parking location. The variation of building type between neighborhoods can be measured in at least three ways: 1) by dominant type, 2) by variety, and 3) by distribution. The patterns of *dominant type* have been discussed with lower density cases being predominantly single-family; middle density cases mixing single-family and multi-family; and higher density cases being mostly multi-family.

Not surprisingly, the older neighborhoods (e.g. Maple, Main, Elm) had the greatest *variety* of building types at all three density levels (nine or ten types). In the more recently developed neighborhoods, housing variety seems to be more a function of density than age. Post-war low-density neighborhoods (e.g. Dunston, Camp) are the least variable with only two types of single-family structures. Middle and higher density post-war and late 20^{th} century cases with more variety have between four to seven housing types. Not surprisingly, mixed-era neighborhoods tended toward greater variety with seven or eight building types. It is also important to remember that the degree of difference between any two types varies with the particular pair in question. For instance, the difference between two single-family building types is much less than between a single-family building type and an eight-unit multi-family building type.

In general, the *distribution* pattern for all mixed type neighborhoods includes distinct clusters of single-family types and multi-family types. However older neighborhoods have a finer grained mixing of types within those clusters and more overlapping between single-family and multi-family types. Some streets have lot-by-lot variation between single-family and multi-family. In the newer neighborhoods, the distribution of types is cleaner and more consistent. This pattern appears to be closely linked to larger increments of development with many repetitive building types being laid out and built by a single developer.

Street Types: Analyzing variation of street types within and between neighborhoods is also a complex undertaking. Four basic variables were used to construct types: street width, curbing, sidewalks, and planting strips. While various combinations of these variables theoretically yield more than 100 types, only about 18 were identified in this set of cases (see Table 4-2). Even this list is somewhat generalized due to inconsistent street sections along the same street (e.g. interrupted sidewalks, inconsistent curbs, etc). As with building types, differences between types can vary from relatively minor variations to more major ones.

In general, neighborhoods seemed to have about three or four street types each—sometimes closely related, sometimes not. The distribution of types also does not seem to be as closely correlated to development era or density as elements such as street pattern, parcel pattern or building type. For instance, *street width*, is either narrow or medium width across most study sites regardless of age or density. The only wide streets are double-loaded residential parking drives. Likewise, the presence or absence of *curbs* seems quite randomly distributed with most neighborhoods having a mix of the two conditions. Double curb sections with *sidewalks* seem to be most prevalent in older neighborhoods although by no means consistently so. Sidewalks are generally quite sparse, especially in post war developments. The traditional city neighborhood cross-section with sidewalks and street tree strips are quite rare with only two examples found—one in Valley, the other in Highland. This may be due to a general abundance of trees in most neighborhoods and concerns about plowing in winter.

The greatest contrast with street types is between the private parking drives in more recent multi-family neighborhoods versus the range of standard public street types in other neighborhoods. Since they typically have no standard cross-section, the range of variation within these parking streets is very broad. They vary in almost every dimension—width, configuration, surface treatment, edge condition, etc. In general, the somewhat random distribution of street types across these cases appears to have more to do with a lack of consistent street standards rather than any clear association with density or development era.

Public / Private Spatial Territory: Of particular concern here is assessing the balance and clarity of the distinction between public and private space. While this variable does require some qualitative judgment (a problem for replicable measures), initial assessments suggest it has a significant impact on neighborhood spatial quality. The cases seem to fall into two basic categories. The first is the historic relationship between a private building and lot facing onto a public street. While the gradient of interconnection between building and street varies, all neighborhoods share the basic spatial structure of public streets serving private parcels. This structure is most clearly expressed in neighborhoods with smaller lots and buildings—eight of the twelve neighborhoods in this set.

Within the other four neighborhoods, large development parcels minimize the role of public streets in the neighborhood structure. Neighborhood space is primarily structured by a less sharply defined relationship between the shared space of the parking drive / landscape and the internal domain of the dwelling unit. There is a pervasive sense of semi-public space in these neighborhoods. Consistent landscape treatments create a more campus-like character. A notable lack of private outdoor space contrasts sharply with the heterogeneous landscape associated with individual lots. Finally, without traditional *curb-cuts* for private driveways, there is a distinct lack of separation between the roadway and parking areas—both functions tend to bleed into each other. While there tends to be a low level of spatial variation within parcels, there is strong spatial contrast between parcels. Circulation systems rarely are interconnected. Neighborhoods tend to have a weaker sense of public domain and a stronger yet less differentiated system of private common space.

4.2.4 Urban Form Variation: Summary of Key Findings

The preceding analyses identified a number of potentially important patterns that differentiate neighborhood form. But perhaps even more importantly at this early stage in the project, they provided some important insights that resulted in re-structuring the research design to better serve the range of urban form variation found across this set of neighborhoods. Specifically, the findings of the analyses resulted in re-thinking the strategy of selecting only two sets of matched pairs for detailed study and measurement. Instead, it was decided to broaden the number of cases for deriving neighborhood scale measures to include the full set of twelve cases. It was also decided to select a new, more narrowly focused set of cases for deriving measures at the more detailed scale of street, block, building and yard (the selection process was detailed in Section 3.3). The key findings that led to the revisions are summarized below.

One Size Doesn't Fit All: The analyses suggest quite strongly that there was no perfect pair of cases suited to the broad task of measuring the multiple dimensions of neighborhood form. Different pairs were found to better illustrate different urban form issues. For instance, issues of spatial territory might be best represented by Maple and Hemlock Ridge while building-to-street variation might be better seen in comparing Elm and Wolf. Likewise the impacts of differences in age of trees are best seen comparing Dunster to Camp Brook while the variation of tree coverage might be illustrated by comparing Main and Curtis.

Shades of Grey: A related finding suggested that many issues have multiple dimensions and gradients that are simply too complex to be represented by a single matched pair. A more robust understanding of the contours of variation is better served by comparing three or four specific cases rather than only two. For instance, issues of street connectivity may be best illustrated across three or four distinct sets of street patterns with different degrees of internal and external connections. Comparing a whole set of patterns may be necessary to fully represent the range of certain patterns.

Problem of Representation: The analysis of the smaller scale urban form issues found a major problem of representation. While the range of neighborhood wide patterns can be seen by comparing case study to case study, the range of possible variations expands exponentially for more detailed scales of space. A given element may have three or four distinct sub-types within each neighborhood. These sub-types can be compared both internally and in multiple variations across neighborhoods. Choosing a single representative street type or building type for an entire neighborhood could distort the actual range of conditions that is observed in the analysis.

Limits of Typology: A closely related finding concerned the limitations of typology to serve the specific dimensional baseline required for developing replicable measures. Drawing only basic distinctions, seventeen building types and eighteen different street types were identified in this limited set of cases. Even though this range suggests a rich universe of potential patterns between cases, the typologies were quite complex and would require considerable discretionary judgment to identify and compile as measurable datasets. The challenge of building a systematic, consistent database of useful measures depends on being able to use it across many different specific conditions. Using this level of typology as the basis for simple, replicable measures seems highly doubtful. Contrary to the project's initial hypotheses, this finding suggests that focusing on more particular dimensions across a greater range of cases would be a more promising approach for successful measures.

Distinct Scales of Analysis: The above findings all support the larger conclusion that there are two distinct scales of analysis within the general concept of neighborhood form: 1) overall neighborhood patterns, and 2) the more detailed realm of experienced space (i.e. the street/block scale). Each scale has it own with distinct spatial dimensions and characteristics. The challenges of measuring each scale are distinctly different. The analysis related to *neighborhood wide scale* suggested an approach that is primarily based on measuring more abstract two-dimensional patterns and distributions. In contrast, measures of *street/block scale* are more strongly related to the much more complex and three-dimensional spaces one experiences walking down a sidewalk, looking out a window, or mowing a lawn. While plan dimensions are still important, it is the vertical dimension that adds new complexity. Potential diversity of conditions at this scale suggests these issues are best examined within a more specific and detailed set of case studies.

Congruence of Form Elements: One final observation may also prove helpful in developing strategies for measurement. A comparison of the neighborhood profiles maps suggests a sharp difference from neighborhood to neighborhood in the congruity of independent urban form elements (Figure 4-1). Some neighborhoods seem to possess an underlying structural order that is expressed by each of its component elements—an example of this is Elm Street. In other cases there appears to be less of an organizing framework—an example here is Wolf Road. Here patterns of street, block, parcels, buildings, etc. are much more free-floating with little perceptible relationship between them. Some measure of relative congruity of elements may offer interesting insight into basic differences of neighborhood form.

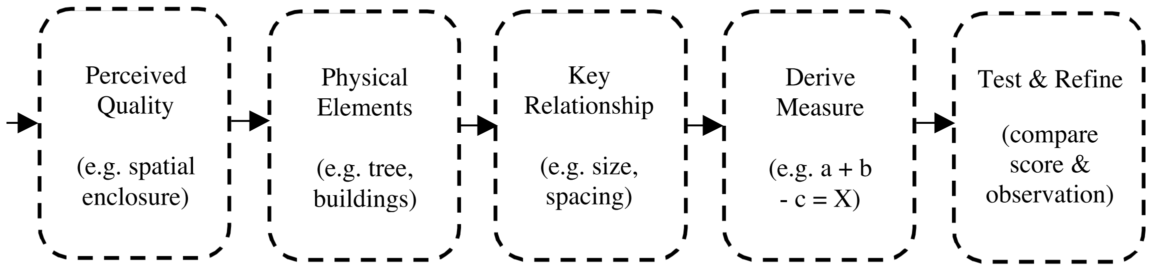
4.3 Urban Form Patterns & Neighborhood Qualities

The previous sections documented and discussed a series of pattern variations between the sets of case study neighborhoods. This last section considers these patterns in relation to measuring a broader set of perceptual qualities thought to distinguish one neighborhood from the next. It also outlines preliminary conclusions of how these qualities and patterns vary from case to case based on the preceding analysis.

The section begins with a re-consideration of the initially hypothesized set of qualities presented in Chapter Three in light of findings outlined in section 4.2. Definitions are revised and sharpened. In particular, the qualities will be related to the two identified scales of analysis. Next, some speculative connections will be drawn between observed variation of physical form and the specific environmental qualities they might influence. Key issues include how qualities are linked to specific dimensions of neighborhood form and how can these dimensions might be simply measured. Preliminary approaches to measurement will be outlined in relation to each scale of analysis. Finally, two matrices will be presented—one for each scale of analysis—that summarize the researcher's preliminary ranking of urban form qualities across all twelve neighborhoods. This evaluation forms the baseline of *observed differences* between cases used to calibrate proposed measures in Chapters Five and Six.

4.3.1 Connecting Neighborhood Qualities, Form, and Measurement

A sound conceptual framework linking: 1) the perceived neighborhood quality, 2) the physical form of the neighborhood, and 3) the process of deriving related measurements is clearly required to move forward. First the perceived quality must be defined (e.g. enclosure). Then it must be associated with some set of identifiable physical elements in the neighborhood (e.g. buildings, trees). Then the key urban form relationships that affect the perception of the quality must be identified (e.g. height, spacing). Then a measurement schema that captures this relationship must be derived (e.g. $X = a + b / c$). Finally, the measured values must be tested for correlation with values observed in the field (i.e. does X = sense of enclosure?). A conceptual diagram of this derivation process may be illustrated as follows:



The first step in this process involves tracing the linkage between two things: 1) the observed qualities that distinguish one neighborhood from another and 2) the physical elements or relationships that manifest them. The physical manifestation of some qualities (e.g. mystery, timelessness, sterility) may prove very elusive and difficult to specify. It might relate to the patina of the materials, the way light washes across a street, the lushness or absence of vegetation, or simply the cultural background and experience of the viewer. Other qualities (e.g. enclosure, scale, grain) are more concrete. Their spatial and physical dimensions are more discernable. While some variation of perception is inevitable, it is likely some general associations can be agreed on. It is these more concrete qualities that are the focus of this inquiry.

Sorting Out Qualities of Neighborhood Form: Within the context of the preceding discussion, the hypothesized list of qualities can be resorted into three groups: 1) those related to neighborhood-wide spatial patterns, 2) those related more to the detailed scale of street, block, landscape and building, and 3) those related to the fourth dimension of time. The reordered list of qualities is follows:

Overall Neighborhood Patterns & Qualities

- Spatial Form of Density and Use
- Scale and Neighborhood Grain
- Street Connectivity
- Variability & Consistency
- Boundaries and Edges

Spatial Qualities of Street/Block Scale (Three-Dimensional)

- Scale and Spatial Enclosure
- Public / Private Overlap Zone
- Orientation of Buildings and Lots along Streets
- Variation & Consistency

Dynamic, Time-related Qualities

- Change & Adaptability

For the purposes of this work, the first two groups seem to hold the most promise. Adjustments and refinements to the definitions were continually made as the project moved forward. For instance, *variation & consistency* was reassigned to be listed at both scales. Additional work described in forthcoming chapters was undertaken to better specify this quality within a more scale-specific context. Others qualities such as *change and adaptability* that seemed too complex for exploratory work were dropped.

4.3.2 Two-Dimensional Patterns, Three-Dimensional Space

The project's conception of neighborhood form has been based on the idea of nested or tiered scales from the outset. They appear, however, to have some important distinctions as units of analysis and with the kinds of neighborhood qualities each is associated with. The *neighborhood*-wide scale tends to be best described in terms of abstracted two-dimensional patterns. The *street/block* scale demands approaches more suited to describing the more three-dimensional, holistic space of an experienced place. While this distinction may seem self-evident, it suggests the need to merge two quite contrasting ways of seeing into the work of developing descriptive, replicable measures of neighborhood form.

Neighborhood Wide Patterns: This distinction appears to flow logically from nature and limits of human perception. From a five to six foot viewing height it is simply impossible to take in a three-dimensional view of an entire neighborhood at a single moment in time. Human perspective is typically limited to the immediate spaces framed by adjacent fragments of building edges and landscape. In New England, views are typically more closed and intimate in summer and more open and expansive in the winter—often including more distant elements obscured by the foliage of summer. However, as was found in experimenting with aerial photography, even bird's eye views produce largely two-dimensional information about neighborhood space. It is impossible see inside neighborhood space and overlook it at the same time.

Since the whole neighborhood can't be seen all at once, it must be experienced episodically—as a series of linked views over time. In its most simple form, it is the experience of a person moving thru the space of a neighborhood (e.g. walking, driving, biking). Perceptions become more complex as many individual trips are compiled over a longer window of time—weeks, months or years. While movies or videos can provide a reasonable facsimile of such an episodic sequence, it is not a method that is easily translated this into discrete measures.

For the purposes of this project (i.e. deriving replicable measures), a more useful method of looking at the whole neighborhood scale involves translating of three-dimensional space into two-dimensional patterns using ortho-photography and maps. These abstracted views can show overall organization, patterns, and relationships that are impossible to see as a person inside the neighborhood. Patterns of elements that can typically be depicted include streets, blocks, vegetation, building footprints, and topography.

These physical patterns, in turn, no doubt underlie and influence a wide range of perceptual qualities that distinguish different neighborhoods. For instance the size and pattern of parcels and dwelling units seem likely to be associated with qualities of neighborhood *grain, scale,* and *density*. Likewise patterns of streets and blocks are directly linked to qualities of neighborhood *connectivity* and *accessibility*. Finally, patterns of land use mix, building types and landscape are certainly associated with relative degrees of *variability* and *consistency* that define overall differences in neighborhood character. Chapter Five will look more specifically at how physical patterns most closely associated with some of these neighborhood wide qualities might be simply described and measured.

Experienced Space of the Street & Block: While human perception inherently limits neighborhood-wide patterns, it is well suited to taking in the more detailed scale of a street and block. Three-dimensional street views are critical to distinguishing one neighborhood from another. They are the perceptual windows though which neighborhoods are seen and understood. The street/block scale of neighborhood space is accessible to the researcher through field observations and eye-level photography. Rather than simply representing space as patterns, photographs and field observations can capture the holistic sense of a place.

While these methods provide an enormous amount of information for the researcher, they also have limitations. Any chosen point of view has the inherent potential for bias. Perspective distortion of photographed views also makes it them impossible to systematically scale or dimension. This makes the task of measuring from photographs difficult at best. Thus photographs and field observations need to be supplemented by scaled plans, sections, and axonometrics that convey actual dimensions in consistent, measurable terms.

At this scale, spatial qualities are not so related to discrete patterns of streets or parcels but rather are impacted by the full three-dimensional character of the street and block. An ensemble of buildings, yards, landscape, and street all work together to govern the perceptual qualities of neighborhood space. Different dimensions of their relationships are likely to be associated with different qualities. For instance, issues of relative height, spacing and width are likely to affect perception of enclosure and scale. Likewise setbacks, building design, parking and circulation will impact the relative perception of permeability and transparency. Finally, the spatial composition and character of any number of elements is likely to affect the overall sense of variability and consistency found along a particular block or street. Chapter Six will consider the challenge of measuring particular sets of physical dimensions in relation to a series of street/block scale qualities.

4.3.3 Baseline of Observed Differences Between Neighborhoods

A central part of the research design called for the exploratory measures described in Chapters Five and Six to be calibrated using observed differences between neighborhoods. The analysis in Chapter Four found the differences between case study neighborhoods to be quite complex and multi-faceted. Moreover, the relationship between different urban form dimensions and different environmental qualities is also complex and overlapping. In order to provide a more orderly basis for this calibration process, *Table 4-3 Baseline of Observed Differences: Neighborhood & Street/Block* was constructed to organize the researcher's initial evaluations of the perceptual differences between neighborhoods.

The matrix evaluates key urban form relationships under a series of eight qualities. A series of urban form elements are associated with each quality. The eight were distilled from the list in section 4.3.1. They are divided between four at the neighborhood wide scale and four at the street/block scale. Based on the work described in this chapter, the researcher evaluated the extent or degree of each quality across all twelve neighborhoods using a simple three-part ranking. These recorded distinctions formed the baseline used by the researcher to derive, calibrated, assess, and refine the exploratory measures described in detail over the next two chapters.

Neighborhood Qualities	Growth Period	Enclosure	Scale	Connectivity & Accessibility	Consistency of Character
Related Urban Form Issues		development intensity of dwelling units, buildings, & land use	size and pattern of parcels, blocks, buildings, & landscape	internal and external connections of street, path and trail networks	distribution and mix of land use, building type, & landscape
Lower Density Set					
N1 Main	pre WWII	low	medium to fine	medium	mixed
N2 Dunster	post WWII	low	medium to coarse	low	consistent
N3 Camp Brook	late 20th	low	medium	low	consistent
N4 Valley	mixed era	low	mixed	medium to high	mixed
Middle Density Set					
N5 Maple	pre WWII	medium	medium to fine	medium to high	mixed
N6 Curtis	post WWII	medium	medium	medium	inconsistent
N7 Hemlock	late 20th	medium	coarse	low	inconsistent
N8 Highland	mixed era	medium	fine	medium to high	consistent
Higher Density Set					
N9 Elm	pre WWII	high	fine	high	consistent
N10 Village Grn	post WWII	high	coarse	low	inconsistent
N11 Wolf	late 20th	high	coarse	low	inconsistent
N12 Willow	mixed era	medium to high	medium	medium	inconsistent

Street & Block Qualities	Growth Period	Enclosure	Scale	Permeability & Transparency	Visual Variability
Related Urban Form Issues		relationship of building and tree height to setback and street width	size and spacing of parcels, blocks, buildings, & landscape	interconnection of buildings, porches, yards with adjacent street	degree of visual variation in architecuture, streetscape, & landscape
Lower Density Set					
N1 Main	pre WWII	medium	medium to fine	medium	high
N2 Dunster	post WWII	low	medium to coarse	low	low
N3 Camp Brook	late 20th	medium to low	medium	medium to low	medium
N4 Valley	mixed era	mixed	mixed	mixed	medium
Middle Density Set					
N5 Maple	pre WWII	high	medium to fine	high	medium to high
N6 Curtis	post WWII	mixed	mixed	medium	low
N7 Hemlock	late 20th	medium	medium	low	medium to low
N8 Highland	mixed era	medium to high	medium	medium to high	medium to high
Higher Density Set					
N9 Elm	pre WWII	high	fine	high	high
N10 Village Grn	post WWII	Medium to low	coarse	low	low
N11 Wolf	late 20th	low	coarse	low	low
N12 Willow	mixed era	mixed	mixed	medium	mixed

Table 4-3 Baseline of Observed Differences: Neighborhood & Street/Block

The streets provide interesting views of buildings. Nothing is centered or quite lined up, but this does not produce visual confusion. Is it accidental? The overall plan seems to have been dictated by the site: A narrow, flat valley hemmed in by the sweeping curve of the Ottauquechee River on one side and a small creek on the other. The green was laid out lengthwise on the narrow peninsula between the river and the creek, allowing for many plots to have rear gardens running down to the riverbank. At each end of the green, two streets fan out at an acute angle... Woodstock grew by a set of rules—not all written down, perhaps, but nevertheless widely understood. (p. 89-90).

• Witold Rybynzski City Life: Urban Expectations in a New World

Chapter Five:

DERIVING NEIGHBORHOOD SCALE MEASURES:

The overall goal of this project is to develop a series of measures that describe physical differences between neighborhoods beyond simple residential density and land use. This is the first of two chapters that will describe the results of these efforts. This chapter will address measures of broader, neighborhood-wide patterns. Chapter Six will focus on the more detailed, three-dimensional scale of an individual block and street. The intent was not to measure specific physical differences, but rather to derive some first order correlations with perceived differences in neighborhood qualities.

Up to this point, the research has combined two converging theoretical approaches in probing how the measures might best be constructed. An initial "top-down" approach identified a series of overall neighborhood qualities (i.e. scale, grain, mix, enclosure, accessibility, etc.) and hypothesized about key elements and relationships that contribute to each. The second, more "bottom-up" approach used systematic field observation, photography, and base mapping to document actual variation in physical elements (e.g. buildings, landscape, streets) and speculate about associations of observed variation with neighborhood qualities. Both approaches seek to answer the same question: How do physical elements combine to create key differences in perceived neighborhood quality?

Overview of Method: Correlating Measured Values and Observed Differences. The next two chapters move on to address the core research question: How can these key differences be measured in simple, replicable terms? The heart of the derivation method is a back and forth process of measuring simple, discrete relationships within the data set and comparing resulting values with the researcher's observed variation of qualities between the case studies. The measures are calibrated using the researcher's own perception of the differences between the cases built up through the documentation and analysis of the twelve case study neighborhoods. A summary of the researcher's baseline rating of each quality by neighborhood is outlined in the two summary matrices presented at the end of Chapter Four *(Tables 4-3 & 4-4)*.

The measurement process is organized around a parcel-level database that compiles data for a range of different neighborhood form elements (e.g. parcels, land use, building type, street dimensions, etc.). Initial discussion explores potential patterns and spatial distributions in the data. Based on those results, key relationships between variables are probed and expressed as simple measures. The resulting values are internally tested for correlation by arraying them against observed neighborhood qualities while asking a series of questions:

- *Do the values reasonably represent observable variation in neighborhood form?*
- *Can they capture relatively subtle variations in urban form and character?*
- *Do they work equally well in different neighborhoods and conditions?*
- *How well do they relate to hypothesized environmental qualities?*
- *Are there other measures that might better express or capture these qualities?*
- *Can they be calculated with existing data or is additional collection required?*

Depending on results the measure may be refined and adjusted as required. The process is repeated in trial and error fashion until a reasonably good set of measures is found connecting urban form variables with a given spatial quality. Measures of little use are rejected. Other measures are derived in relation to other urban form variables and other environmental qualities. The overall goal is to develop a set of easily replicable measures that capture physical differences between neighborhoods in as simple and efficient way as possible.

While this method is inherently limited by subjective evaluation of the researcher, it creates a very efficient feedback loop for the complex task of deriving and testing comparative measures of urban form. To the extent possible, systematic observation, photography and mapping protocols were used to standardize perception and help minimize the subjective bias of the researcher. However, as with any qualitative evaluation, some perceptual bias in inevitable. In the final phase of the research project, a *Neighborhood Evaluation Survey* is used to test broader perceptions of key neighborhood qualities and establish a more substantial baseline of variation against which to compare and assess derived measures. This work is presented in Chapters Seven and Eight.

Chapter Outline: The matrix at the end of Chapter Four identifies three primary qualities associated with measurable neighborhood-wide patterns. They include: 1) overall *scale* and *grain*, 2) overall *connectivity*, 3) overall *variability/consistency*. Exploratory efforts to measure these neighborhood scale qualities were developed in conjunction with two distinct sets of urban form data. Section 5.1 uses data related to the underlying framework elements of parcels, blocks and streets. Section 5.2 derives measures from a series of overlying elements including land use, buildings, and, to a lesser extent, landscape. Each section begins with a discussion of the data compilation and specification issues. This is followed by an element-by-element summary of the trial and error process of calibrating derived measures with observed variation of qualities between the case studies. Section 5.3 concludes with some tentative findings regarding what worked, what didn't, and what remains to be done.

5.1 Parcels, Blocks, & Street Rights-of-Way: The Underlying Framework

Parcels and street rights-of-way are the basic organizing units of the American neighborhood. They are the invisible lines that divide up territory and provide the underlying framework guiding all subsequent development of the neighborhood. Together they comprise the entire land area of any neighborhood. In their Escher-like relationship, they represent the two-pronged model of urban form described by Lynch and others between places and paths. Parcels define the territory where the residents dwell and related activities take place (store, playfield, gas station, park, school, etc.). Street rights-of-way define the network of corridors connecting individual parcels with each other and the outside world. Parcels in turn, can be aggregated into larger units of geography commonly called blocks. Parcels, blocks and streets combine to create the spatial structure used for everything from compiling census statistics to assessing property taxes to giving directions to friends coming over for dinner.

Their abstract nature allows parcels, blocks, and rights-of-way to be more precisely measured than other neighborhood-wide elements. They don't have the inherent material complexity of buildings, streets, landscape or trees. While land division is not the only factor behind physical character, it is clearly a significant one. Parcels and street rights-of-way set the legal, territorial, and structural framework for development. In almost every instance, the first step in developing a neighborhood is drafting and filing a plat map. This map legally subdivides the land into building parcels and, in larger subdivisions, related street rights-of-way and blocks.

These attributes make parcel level data the ideal unit of analysis for measuring neighborhood form for several reasons. First of all, because parcels and street rights-of-way cover 100% of the area being analyzed, their distribution is an inherently consistent geo-spatial expression of basic neighborhood from. Secondly, because parcels are inherently abstract (i.e. geometrically described lines and polygons), they can be easily measured and analyzed in quantitative terms. Finally, as bounded cells of analysis, they provide the ideal framework for attaching all kinds of measured data related to other more tangible and concrete elements of neighborhood form such as buildings, landscape, trees, land uses, etc.

It is precisely these qualities that make parcel level data so adaptable and useful for Geographic Information System (GIS) analysis. Parcels provide a field of geographically distributed polygons to which non-spatial attributes can be attached as data tables. These keep tract of everything from 911 addresses, to land records, to assessment values, to water and gas consumption. While these initial explorations into measuring neighborhood form do not utilize GIS powered calculations, measurement protocols based on parcel-level analysis are potentially adaptable to GIS calculation in the future. This offers the potential for more extensive testing and application of any derived measures that emerge from this process.

Data Compilation & Specification Issues: The parcel level analysis for this project is based on locally available data sets. They included GIS shape files (.shp) for parcels (commonly called coverages, layers or themes) and their attached attribute tables. Data includes about 1,000 parcel records for the twelve case study neighborhoods in four towns and two states in the Upper Valley. Parcel records range from as few as about 25 (in N7 Hemlock Ridge) to as many as 150 (in N9 Elm Street) for neighborhoods averaging about 50 acres in area.

The wide-ranging quality of available GIS data was discussed in the last chapter. Related difficulties were encountered compiling a consistent set of parcel attribute tables. At a minimum, required data fields for each parcel record included: 1) parcel area in acres or square feet, 2) an identifiable street address and 3) a unique ID number to sort by. Each town's data presented its own unique set of challenges. These are described in detail in Appendix E.

ID	Area (ac)	Land Use	# Units	# Bldgs	Area (sf)	Address	Block	Owner	Map	Blk	Lot	Use
38	0.46	1	1	1	20154	8 WEST ST	2	ANDERSON,	33	80	1	Single Fam
39	0.33	1	1	1	14234	18 WEST ST	2	DURCEK, EV	22	16	1	Single Fam
40	0.29	3	3	1	12518	20 WEST ST	2	DARTMOUTH	22	17	1	DORM NL
41	0.14	2	2	1	6028	19 MAPLE ST	2	JACOBS, THA	22	18	1	TWO FAMILY
42	0.11	3	3	1	4659	9 PROSPECT ST	2	FIRSTSAFE C	22	19	1	Single Fam
43	0.11	1	1	1	4949	7 PROSPECT ST	2	SA'ADAH, M A	22	20	1	Single Fam
44	0.43	1	1	1	18782	5 PROSPECT ST	2	HARP, DOUG	22	21	1	Single Fam
45	0.31	2	2	1	13299	3 PROSPECT ST	2	GLOUCHEVIT	33	62	1	TWO FAMILY
46	0.64	3	3	1	27783	1 PROSPECT ST	2	MERRY MEAI	33	63	1	OTHR LIV F
47	1.74	4	4	1	75752	19 ALLEN ST	2	TRAZ CAPITA	33	64	1	TWO FAMILY
48	0.45	1	1	1	19589	17 ALLEN ST	2	ZAPPALA, DC	33	65	1	Single Fam
49	0.32	1	1	1	13900	15 ALLEN ST	2	BAICKER, KA	33	66	1	Single Fam
50	0.32	2	2	1	13877	13 ALLEN ST	2	SILVERMAN,	33	67	1	TWO FAMILY
51	0.36	1	1	1	15490	11 ALLEN ST	2	TRUMBULL, (	33	68	1	Single Fam
52	0.50	3	3	1	21712	3 SCHOOL ST	2	TRUMBULL, (	33	69	1	THREE FAM
53	0.17	8	0	1	7462	1 SCHOOL ST	2	FIRST CHUR(	33	70	1	RELIGIOUS
54	0.38	4	4	1	16450	14 WHEELOCK ST	2	TRUMBULL, I	33	71	1	APT 4-UNT
55	0.35	4	4	1	15246	16 WHEELOCK ST	2	CONDO ASS(	33	72	1	Condo
56	0.70	3	11	3	29868	18-22 WHEELOCK	2	CONDO ASS(	33	73	2	Condo
57	0.18	1	1	1	7704	24 WHEELOCK ST	2	PHILMCO INC	33	77	1	Single Fam
58	0.20	1	1	1	8649	26 WHEELOCK ST	2	SMALLEY, WI	33	78	1	Single Fam
59	0.40	4	5	1	17539	28 WHEELOCK ST	2	SALAZAR-KIS	33	79	1	APT 4-UNT
60	0.20	2	2	1	8916	2 PROSPECT ST	3	DARTMOUTH	33	59	1	TWO FAMILY
61	0.17	1	1	1	7426	4 PROSPECT ST	3	STALTER, AN	33	60	1	Single Fam
62	0.18	1	1	1	8028	6 PROSPECT ST	3	MITCHELL, J/	33	61	1	Single Fam
63	0.19	1	1	1	8242	8 PROSPECT ST	3	KLUG, STEPH	22	22	1	Single Fam
64	0.18	1	1	1	7832	10 PROSPECT ST	3	RIORDAN, RC	22	23	1	Single Fam
65	0.18	1	1	1	7755	13 MAPLE ST	3	BRYANT, DAI	22	24	1	Single Fam
66	0.25	2	2	1	11073	11 MAPLE ST	3	BEAUCHENE	22	26	1	TWO FAMILY
67	0.17	2	2	1	7238	9 MAPLE ST	3	O'BRIEN, TIIL	22	27	1	TWO FAMILY
68	0.29	2	2	1	12568	7 MAPLE ST	3	DEAETT, DOI	33	50	1	TWO FAMILY
69	0.29	3	3	1	12823	5 MAPLE ST	3	CLARKSON, I	33	51	1	THREE FAM
70	0.26	7	0	1	11437	1 MAPLE ST	3	CHICAGO-SC	33	52	1	OFFICE BLD
71	0.07	2	2	1	2964	13 SCHOOL ST	3	HASSE, ERIC	33	53	1	TWO FAMILY
72	0.20	7	1	2	8606	11 / 11.5 SCHOOL S	3	WILSON, JOH	33	86	1	FUNERAL HM
73	0.46	3	3	1	20151	9 SCHOOL ST	3	DART ASSOC	33	55	1	FRAT/SOROR
74	0.92	9	0	0	40050	12 ALLEN ST	3	DARTMOUTH	33	89	1	RES ACLNDV
75	0.21	1	1	1	9142	14 ALLEN ST	3	LILLEY, MARI	33	56	1	Single Fam
76	0.20	1	1	1	8609	16 ALLEN ST	3	ROBINSON, F	33	57	1	Single Fam
77	0.35	1	1	1	15111	1 ALLEN LN	3	BIRD, CAROL	33	58	1	Single Fam
78	0.27	1	1	1	11596	2 ALLEN LN	3	CAMPAGNA,	22	25	1	Single Fam

Table 5-1 Sample Parcel Level Database for Two Blocks in N5 Maple

Table 5-1 Sample Parcel Level Database shows an excerpt of the database for two blocks in the N5 Maple Street neighborhood. These provided the basic data from which measures were generated for all neighborhood-wide patterns. In the coarse of compiling a consistent database across all neighborhoods, a series of parcel specification issues also had to be resolved at the edges of some neighborhoods. Parameters had to be developed for non-residential parcels and for large parcels with land area that went beyond the defined neighborhood boundaries. These issues are also presented in detail as part of Appendix E.

5.1.1 Measuring Parcel Patterns

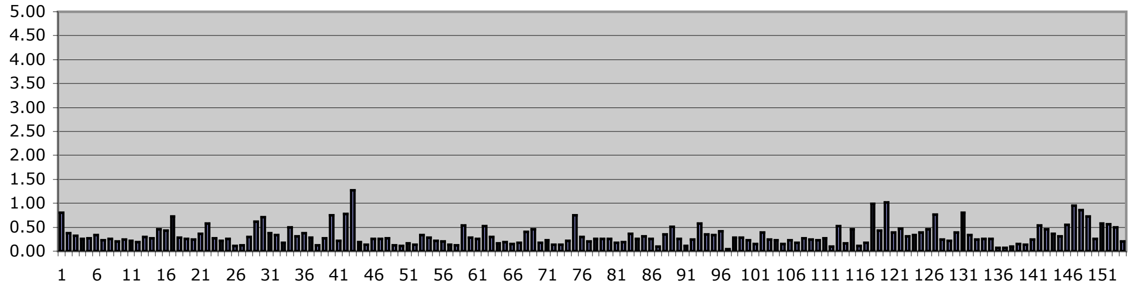
The final set of parcel maps are shown as a matrix of development era by density in *Figure 5-1 Parcel Patterns: 12 Neighborhoods*. The challenge was to convert the obvious pattern differences into measures or metrics that capture some degree of the difference. Key qualities associated with parcel patterns were expected to include: 1) relative scale or grain, and 2) degree of consistency or variability of distribution. Furthermore, because parcel patterns underlie much of the development process, there is expected to be some overlapping with related patterns of buildings, land use and landscape. These will be explored in the second half of this chapter.

The relative scale or grain of a pattern can be described as the relationship between the individual increment of whatever is being measured (e.g. parcels, buildings, trees) and the pattern as a whole. A fine-grained pattern is made up of many small increments; a coarse grain consists of fewer, larger elements. Grain can also be consistent (made up of all one size increment) or varied (made up of mixed sizes). Grain can also be distributed in various patterns across a neighborhood. Grain, as a concept of relative size, is closely related to scale. Within this project, *grain* will used for describing the scale of two-dimensional patterns while the term *scale* will be reserved for discussion of more complex three-dimensional environments.

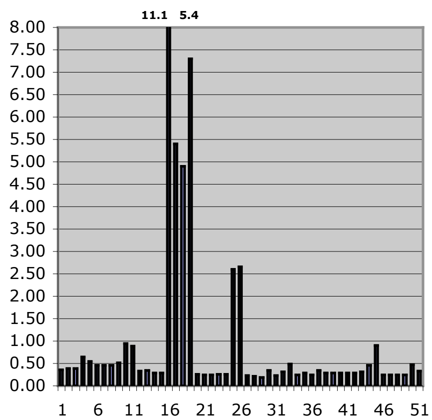
Visualizing Parcel Size and Distributions: Graphs provide a good visual comparison of parcel size and distribution by neighborhood. *Figure 5-2 Sample Distributions of Parcel Size for N9 and N11*, shows the comparative size of individual parcels for two neighborhoods as consistently scaled bar charts. Parcels are arrayed in a continuous sequence running around each successive block in counterclockwise order to show some sense of relative spatial distribution. While the base maps gives a more

Figure 5-1 Parcel Patterns: 12 Neighborhoods

spatial sense of grain and distribution, the bar chart allows viewing each parcel cell in scaleable relation to the size and location of every other parcel. A complete set of bar charts, grouped by neighborhood density, is presented in Appendix E.



9 ELM sequential distribution of parcel size in acres



11 WOLF sequential distribution of parcel size in acres

Figure 5-2 Sample Distributions of Parcel Size for N9 Elm and N11 Wolf

Some interesting relationships can be observed in the charts. In an overall sense, the proportions of the charts themselves provide a quick impression of grain. Fine-grained patterns with many small parcels are wide and short (e.g. N8 Highland); coarse-grained ones with fewer larger parcels are narrow and tall (e.g. N7 Hemlock). Others fall somewhere in between. Some neighborhoods show great variation in size (e.g. N1 Main) while others are quite consistent (e.g. N3 Camp Brook). Finally in some cases the range of parcel size is consistent across the site (e.g. N9 Elm) while others show distinct clusters of different size parcels (e.g. N11 Wolf).   These sharply contrasting patterns all appear show a rough correlation with observed differences in *grain* and *variation* /

consistency outlined in *Table 4-3*. A detailed comparative review by density level provides some additional insights into the relationship of parcel size patterns to the overall neighborhood. This analysis is presented in conjunction with the charts in Appendix E.

	area (acres)	count (number)	average (ac)	max (acres)	min (acres)	median (ac)	SDV
N1 Main	58.46	104	0.56	4.98	0.05	0.38	0.640
N2 Dunster	57.64	88	0.66	1.84	0.28	0.56	0.277
N3 Camp	41.46	68	0.61	3.32	0.25	0.47	0.503
N4 Valley	51.48	80	0.64	3.75	0.18	0.52	0.521
N5 Maple	58.01	136	0.43	2.47	0.07	0.30	0.439
N6 Curtis	28.35	67	0.42	3.38	0.18	0.27	0.546
N7 Hemlock	57.98	23	2.52	8.83	0.46	1.10	2.788
N8 Highland	44.46	137	0.32	2.27	0.09	0.27	0.228
N9 Elm	50.72	154	0.33	1.27	0.04	0.27	0.209
N10 Vill Gn	47.47	37	1.28	14.60	0.23	0.40	2.899
N11 Wolf	50.52	51	0.99	11.10	0.19	0.33	2.005
N12 Willow	41.21	52	0.79	4.91	0.12	0.56	0.863

NOTE: parcel area includes ***parcels only*** *, not street rights-of-way.*

Table 5-2 Data Characteristics of Parcel Size by Neighborhood

Measures of Parcel Size (Grain): While the visual correlation between the bar charts and neighborhood form provide useful insights, only individual lot size is actually measured. *Table 5-2 Data Characteristics of Parcel Size by Neighborhood* presents a series of basic comparative statistics for parcel size across the twelve data sets. Several of them prove quite useful. *Average* lot size provides a decent measure of overall grain. Neighborhoods with larger parcels have higher values (red), smaller parcels lower ones (green). The relationship is clearest where parcel size and distribution are consistent (e.g. N7 Hemlock and N8 Highland). As parcel sizes and distribution are more mixed, values get muddier. For instance all four lower density cases are about the same. While they have the same average grain values, the texture of the pattern changes significantly depending on whether the average is made up of similar sizes as in Camp Brook or a more variable ones as in Main Street. A second related issue is how much these character differences are rooted in parcel pattern / grain dimensions versus differences in patterns of other elements such as buildings, streets, or landscape.

Maximum and *minimum* values are useful to get a sense of the range of lot sizes but a few aberrant values can distort the actual range (e.g. N3 Camp Brook). Comparing the *median* with the *average* provides some indication of parcel mix. When the *average* is much higher than the *mean* it suggests some larger parcels in the mix (e.g. N11 Wolf). When the values are almost the same it suggests a more consistent distribution of sizes.

Standard deviation (SDV) is a useful in measuring the degree of variation of lot sizes. This suggests a stronger link to quality of *variation / consistency* rather than *grain*. Neighborhoods with low SDV tend to be ones perceived as more consistent (e.g. N2 Dunster) while cases with a higher SDV suggest a greater degree of variation between large lots and small lot areas (e.g. N10 Village Green). However relatively high SDV values seem associated with cases with more consistently large lots (e.g. Hemlock Ridge) even though they may be perceived as relatively consistent in character simply because the values have a greater range in absolute terms.

Sorting Size by Parcel Type: In order to consider measures that may be more sensitive to issues of mixed parcel size and distribution, it was useful to sort all parcels into simple categories of parcel size. Assigning simple typologies of size allows seeing the relative "strata" of parcel mix much more clearly than a continuous gradient of parcel size. There is also a strong correlation between different size classes of parcel and certain types of development categories. This helps to correlate concentrations of certain type sizes with development character. A simple *countif* formula that counts only the data cells falling within a prescribed range of values was used to tally parcel size within five size categories ranging from very small to very large. The classes are based on the range of sizes found in the cases and were defined as follows:

- **Very Small** (less than .2 acres)**:** Typically smallest village lots, always pre-zoning, but with ample space for freestanding house and yard.
- **Small** (.2 to .4 acres): Smaller lots found in both older and newer areas. Typically single family but some multi-family, especially in older areas.

- **Medium** (.4 to 1.0 acres): Typically post-war single-family sub-division lots or larger single-family or multi-family lots within older neighborhoods.
- **Large (1.0 to 4.0 acres):** Largest single family lots in both new and older neighborhoods or smaller multi-family development in newer areas.
- **Very Large (greater than 4.0 acres):** Almost always large multi-family development lots for newer master planned projects (24 to 132 units).

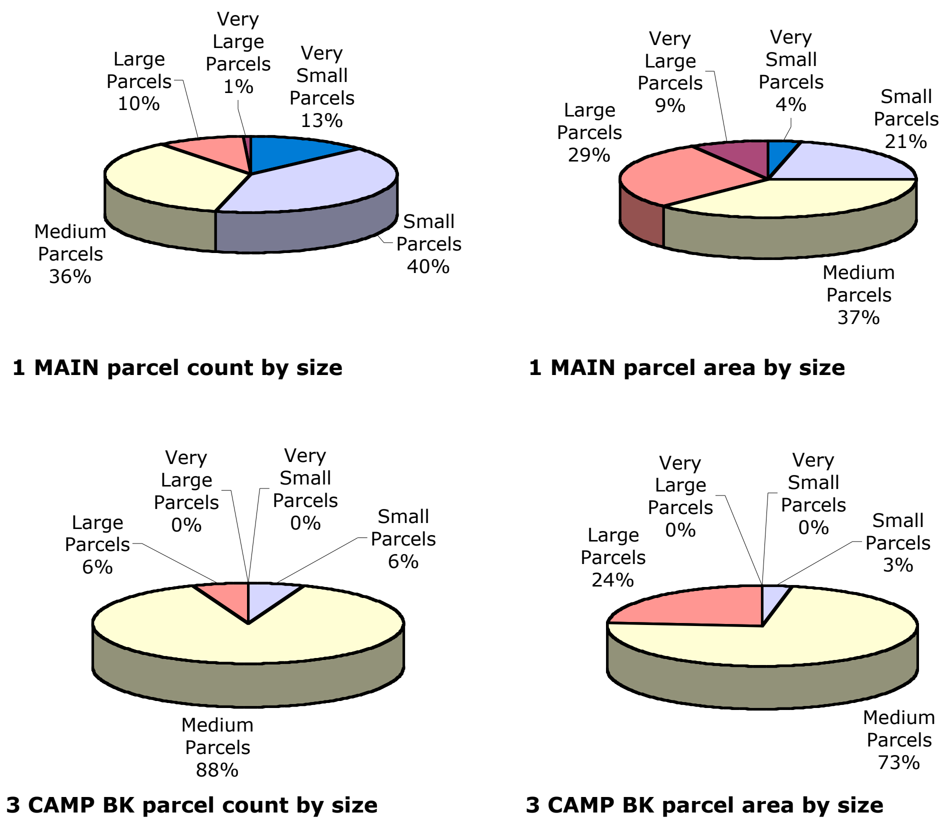


Figure 5-3 Percentage Count & Area of Parcel Type by Size: N1 & N3

Measuring Parcel Mix: The type categories allow a more robust measure of parcel size mix by calculating the share of each size type by neighborhood. *Figure 5-3 Percentage Count & Area of Parcel Type by Size* shows four pie charts for two neighborhoods that record percentages of each size type by count and by land area. The full series of twenty-four charts are included at the end of Appendix E. The results provide a quick snapshot of some of the key patterns noted in the bar charts. For example, the same progression of lot variation that was visible in the bar charts is given numerical expression in the pie charts. N1 Main shows the widest distribution of parcel types (i.e. the most variety) with percentage shares of all five categories. N2 Dunster shows a dropping out of both very large and very small, with a strong clustering toward medium parcels. N3 Camp Brook shows the least variation--it is almost entirely (88%) comprised of medium parcels.

The pie charts also show an inverse relationship between number of parcels and area of parcels in the extreme categories. For instance at N1 Main, only 1% of the parcels are *very large* but they cover 7% of the neighborhood area. Conversely, the 13 % of the parcels that are *very small* cover only 3% of the area. It can take many small lots to cover a significant part of the neighborhood while a few very large parcels can have a relatively large impact. At N10 Village Green and N11 Wolf only 8% of the parcels are *very large* but respectively comprise 63% and 58% of the total area.

While the percentage of type is useful for measuring the relative mix of parcel types, it again offers no accounting of the spatial relationships between types visible in the bar charts and the base plans. For instance, the percentage of parcel area by type of N5 Maple and N6 Curtis look very similar with about 75% small and very small and 25% medium and large. Yet the clusters of large lots are completely different in both character and use—one being a single-family area, the other being a multi-family area. Likewise, the percentages of type can't detect the higher degree of intermixing of smaller lot types in N5 Maple. Thus the percentages of parcel type might be seen as ingredients in a recipe. They tell how much of each thing goes into the bowl, but don't reveal how they are combined or what the shape and flavor of the final outcome is. A more sensitive metric may require some ability to measure dimensions of arrangement and spatial distribution.

Variation in Spatial Distribution: The spatial dimensions of a pattern are quite complex, even for something as simple as a hundred or so parcels of known size. The potential distribution variations are nearly infinite. This information is typically best expressed through a map. An astute reader of urban development maps can discern quite a bit about a place from known relationships and patterns. However, translating these subtleties into a set of easily calculated metrics is simply not a realistic goal for this study. The goal instead is to find proxies that can make some first-order distinctions—it might be thought of as an exercise in measuring pattern "shadows."

Parcel patterns come in many different varieties. They can be regimented or random. They can be clustered by type or type mix, or they can be mixed evenly across the pattern. The previous measures describe average parcel size and variation across neighborhoods. The gradient runs from places with quite consistent parcel sizes to places where sizes are quite varied. The question here is how these are mixed across space. Looking again at the base maps and the bar charts, N1 Main and N9 Elm both have a mix of sizes (more extreme in NI Main, less so in N9 Elm) that are more or less evenly distributed. N4 Valley and N12 Willow also have a mix of sizes, but they are arranged in uneven clusters that do not reflect the general mix. In N4 Valley, medium lots tend to be clustered in the east and small lots in the west. N12 Willow is even more patchy with a few very large lots in the west, a small lot group in the center, and large lots across the eastern half. Of course, if there is not much variation in type, the spatial distribution of type is, by definition, consistent (e.g. N3 Camp Brook).

Measures of Spatial Distribution: One potential way to better measure distribution was to break down patterns of parcel mix into smaller sub-pattern areas within the neighborhood. This allows comparing parcel grain and mix of different areas with the neighborhood. Two techniques for dividing the neighborhood into smaller units of analysis were tested. The first simply divided each neighborhood into four equal quadrants as a two by two grid. The lot type mix was counted and measured for each quadrant. While this provided systematic comparison between neighborhoods, it proved quite difficult to actually calculate using available methods. First of all, hand counting and coding lot size by this new spatial division was extremely time-consuming. While this may be a relatively simple procedure using GIS, doing so was beyond the the scope of this study. Secondly, establishing control criteria for subdividing the study areas and assigning overlapping parcels introduced another level of data specification and complexity into the protocol. Finally, and perhaps most importantly, the quadrants often did not capture the visible variations in the pattern. Just like the neighborhood as a whole, a quadrant could contain clustered areas or parts of clusters that obscured plainly visible differences of pattern.

A second method was more successful. This entailed parsing size data by pre-existing divisions of neighborhood blocks. Parcel data was already coded by block so it was much easier to compile and analyze local distributions. Furthermore, blocks are a basic structuring element of the physical neighborhood. Observed variation in neighborhood character, both on maps and in the field, was much clearer between blocks than between arbitrary quadrants. While streets may have an even closer relationship to observed character variation than blocks (i.e. two sides of a street are seen together while opposite sides of a block are not), coding parcels by blocks was much easier. And while the number of blocks varies between neighborhoods, this in itself represents a rough measure of neighborhood grain and scale.

The second technique was tested on two neighborhoods of similar density but contrasting spatial distributions of parcel size. In the N9 Elm neighborhood, all eight blocks seemed to have a similar mix of lot sizes compared to the neighborhood as a whole. Two charts were generated to illustrate the relative consistency of the parcel mix by block. *Figure 5-4 Parcel Type % by Block* is a 100% stacked bar chart that shows the relative percentage of parcel types for all eight blocks. They all share a mix of *very small*, *small* and *medium* parcels. Though ratios vary from block to block, they generally correlate with overall ratios shown in the pie chart. *Figure 5-5 Area of Parcel Type by Block* shows the land area in acres for each parcel type across all eight blocks as a three-dimensional bar chart. It gives a good visual sense of variation within an overall consistent mix of parcel types from block to block.

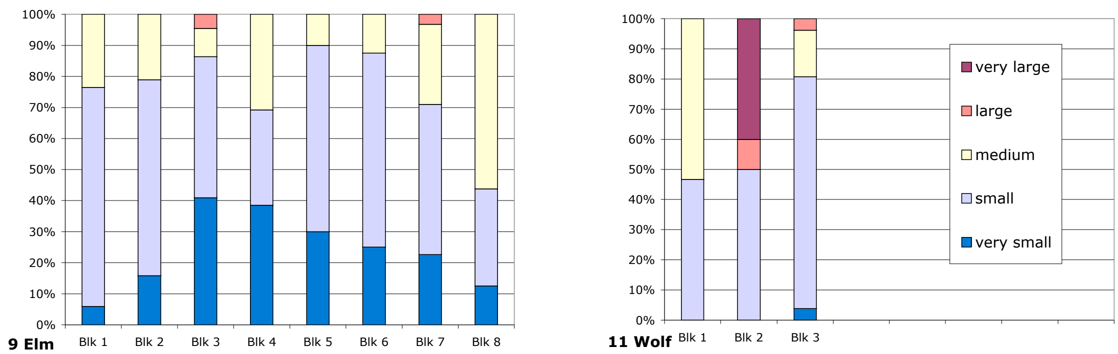


Figure 5-4 Percentage of Parcel Type by Block: N9 Elm & N11 Wolf

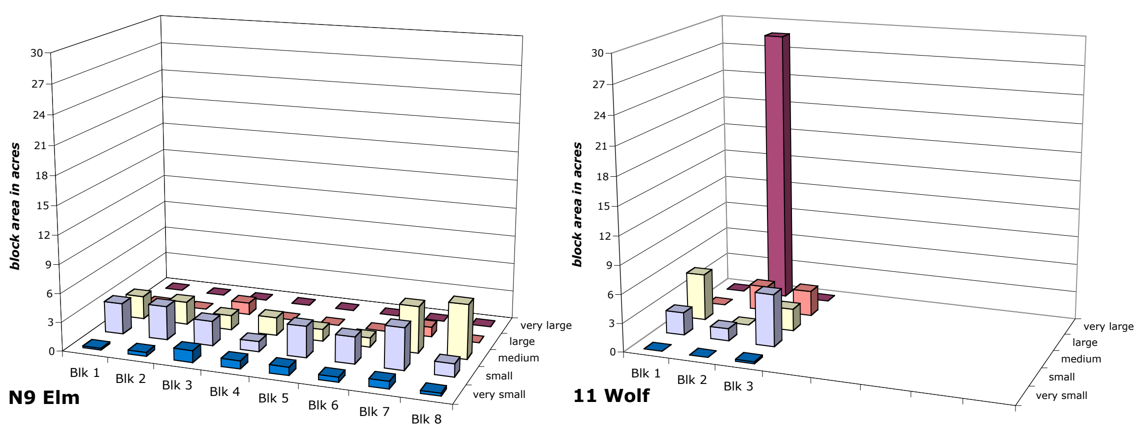


Figure 5-5 Area of Parcel Type by Block: N9 Elm & N11 Wolf

A very different relationship between overall parcel mix and block-by-block parcel mix is seen in the Wolf Road neighborhood. The parcel mix on the individual blocks varies between each other as well as with the neighborhood as a whole. The stacked bar chart shows the variation of type mix across the three blocks Block 1 & 3 are almost entirely *small* and *medium* lots. Block 2 is half *large* and *very large* lots and one half small lots. The contrasting patterns between blocks are even more strikingly illustrated in the three-dimensional bar chart showing the total land area assigned to each parcel type for each block. As opposed to the graduated values across the Elm blocks, values for Wolf blocks range widely and abruptly by block. Four *very large* lots comprise nearly 90% of Block 2 while the other two have no *very large* lots at all. This reflects the highly segregated character of large multi-family projects to the east and small single-family areas to the west.

While the ratios of percentage shares can be constructed to measure the contrasting mix of types between neighborhoods, finding a measure that captures the range of internal variation (i.e. from block to block) seems a bit trickier. A neighborhood value would require combining many sets of parcel type ratios. While the charts illustrate the range of parcel pattern variation, they do not calculate a representative numeric value. One approach may be to calculate a simple standard deviation (SDV) across the average lot size for each block. The values calculated for the two test neighborhoods seem to reflect the extremes of type distribution. The SDV value of .06 for *average lot size* across *Elm* blocks is quite small in contrast the SDV value of 1.62 for *average lot size* calculated for *Wolf* blocks.

Combining Elements & Measures: These initial results suggest some significant correlation between simple parcel statistics and perceived qualities of neighborhoods. Average parcel size seemed to be a good measure of neighborhood grain. The results also suggest some areas where correlations aren't as clear, such as spatial distribution and the quality of overall consistency and variation. The demonstrated potential of combining parcel pattern and block pattern in the last analysis suggests the interaction of elements may be more useful than simply looking at elements in isolation—looking for key relationships between them appears to be a promising direction for deriving even better results. Measures related to other elements (e.g. streets, buildings, land use, landscape) may also prove more efficient proxies for these and other neighborhood qualities. The next sections will consider elements measured individually as well in combination with each other.

5.1.2 Rethinking Density: Finding the Common Denominator

The considerable challenges of translating obvious differences in parcel patterns into simple, replicable measures resulted in a new level of respect for the conventional density measure of *units per acre*. While it may miss many significant aspects of neighborhood form, the simplicity with which it can be calculated across a great variety of circumstances make it a powerful and elegant first order measure. These first round explorations served as a reminder that the overall research goal was not to measure every possible detail of spatial form but rather to derive simple, efficient ways to explain basic differences in neighborhood form.

One of the most powerful features of the *unit per acre* measure is the ability to describe a broad range of physical conditions in comparable terms by using a known common denominator—in this case a single acre. This suggests a useful lesson for other measures. One of the seeming limitations of the basic measure *average parcel size* was that it produced a series of values without a comparative reference point—just a series of fractional parcel sizes. A closer examination shows, however, that average size is in fact a ratio of *area* divided by *count*—in this case the entire area of a neighborhood in acres divided by number of parcels in it. The fractional value is area—the numerator. The reference unit is a single parcel—the denominator. It can be expressed as a kind of intensity measure as *acres per parcel*.

Inverting Terms: The problem is that a *parcel* isn't the same kind of standardized reference point that an *acre* is. It didn't take long to realize that the same proportional relationships would show up if the ratio was inversed with parcels as the numerator and acres as the denominator. The same measure can be re-expressed as *parcels per acre*. The fractional value of parcel is now the numerator. The reference unit of area—in this case a single acre—is the denominator. Thus the same proportional measures between neighborhoods can be re-stated in reference to a known reference unit by a simple inversion of terms.

As a test case, the block-by-block *average parcel size* values for N9 Elm and N11 Wolf that were used to look at spatial distribution of parcel patterns was re-expressed as *parcels per acre* for both block and neighborhood:

N9 ELM:	**Block**	**Average Size**	**Parcels / Acre**
	N9 B1	0.35	2.89
	N9 B2	0.33	3.00
	N9 B3	0.30	3.32
	N9 B4	0.29	3.42
	N9 B5	0.27	3.71
	N9 B6	0.27	3.70
	N9 B7	0.36	2.81
	N9 B8	0.46	2.18
	Overall	**0.33**	**3.04**

WOLF:	**Block**	**Average Size**	**Parcels / Acre**
	NH11 B1	0.49	2.06
	NH11 B2	3.26	0.31
	NH11 B3	0.41	2.44
	Overall	**0.99**	**1.01**

The significance of this re-expression is that the value becomes a more comparable index because it is expressed as a kind of density. It measures the intensity of something (in this case a parcel) over a constant unit of measurement (in this case a single acre). Instead of envisioning a comparison of lot sizes (e.g. .33 acres versus 3.26 acres), the common denominator of an acre creates a consistent framework for comparative analysis (e.g. 3.0 parcels per acre versus .31 parcels per acre). The former value (for N9 Elm) expresses a higher density of parcels than the latter (for N11 Wolf). It feels more like an indexed measure. The simple inversion of terms to create a common denominator may prove useful in developing measures for other elements of neighborhood form such as streets, land use and building type.

Rethinking Density: A related idea reconsiders the place of *units per acre* in the research design. Instead of focusing only on new measures that lie beyond this standard density measure, what about using it in new ways that might be more sensitive to spatial patterns? For example, the problem of capturing the varying patterns of parcel mix that were masked by average parcel size could easily be restated as average density masking variations of density within a neighborhood. Analyzing density patterns block by block would certainly provide a more robust picture of the neighborhood form than simply looking at a neighborhood-wide value.

Consider the two examples from above—two neighborhoods with the same overall density, overall size, and overall unit mix. In the case of N9 Elm the density of individual blocks would likely be fairly consistent with the overall density. There would likely be some gradient of density that drops off as blocks get farther from downtown. In the case of N11 Wolf, block densities are likely to be more variable from block-to-block and with a far greater range to either side of average density. And rather than gradient based on distance from a neighborhood center, higher values are likely to be clumped around multi-family housing blocks and lower ones around single-family blocks. Comparing these internal density distributions allows simple density to be a much more effective measure for differentiating neighborhood form—even ones with the same overall development density.

5.1.3 Measuring Block Patterns

Neighborhood blocks aggregate complex parcel patterns into much simpler patterns. Data on block size is widely available through the US census. It has been used in some recent studies as a relatively successful proxy of both street connectivity and general urban design scale at a regional scale (Krizek 2003a, 2003b). As noted in the previous section, blocks also provide a good framework for looking at internal distribution patterns of more detailed urban form elements (e.g. parcels, land use, buildings, landscape) within a neighborhood. However, as discussed in Chapter Two, without being able to specify the more detailed elements of urban form it is impossible to understand the relationship block size with more specific urban form qualities (i.e. scale, enclosure, etc.).

The other general problem within the context of this study is the poor congruence between census block geography and neighborhood geography in places like the Upper Valley (discussed at length in Chapter Three). This makes use of pre-existing block data of limited value in small urban regions without a continuous urban fabric. However, once a parcel-level database is in place, deriving some simple block measures is quite straightforward and seemed likely to provide a quick proxy for both connectivity and grain. In general, smaller average block size would be expected to correlate with finer grain and higher connectivity. This expectation is based on the assumption that smaller block sizes are associated with smaller parcels and a denser network of streets.

The four neighborhood block patterns shown in *Figure 5-6 Comparative Block Patterns* serve to illustrate both the basis for these expectations and the confounding issues that could potentially undermine the usefulness of block measures within the context of this study. While these four cases were chosen to illustrate the basic range of issues, a full set of smaller scale maps are presented as Figure 5-8 in the next section.

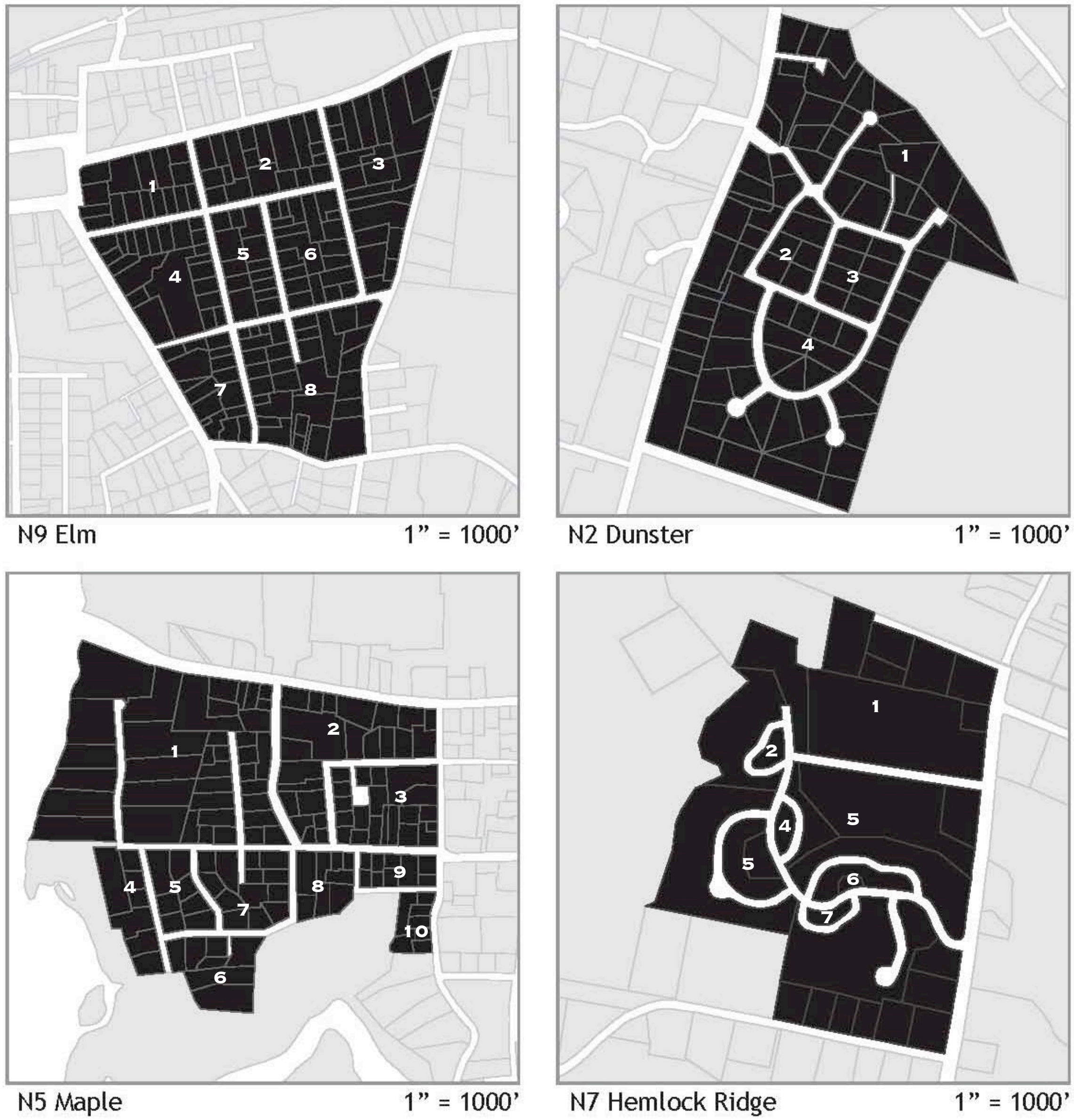


Figure 5-6 Comparative Block Patterns in Four Neighborhoods

The examples above illustrate the wide variety of block sizes, shapes, and patterns in the Upper Valley. Of the twelve neighborhoods, only N9 Elm fits the prototypical urban design pattern comprised of blocks defined by streets around their entire perimeter. Due to the highly varied terrain, all other neighborhoods have at least one edge defined by a parcel line marking a change from developed area to open space (see Chapter Three for detailed discussion). More typically, neighborhoods are comprised of some combination of street-defined inside blocks and open space-defined exterior blocks.

The range of this mix varies widely from case to case. N2 Dunster and N7 Hemlock illustrate the common condition in many newer neighborhoods where limited access to adjoining streets or parcels results in a one very large perimeter block (#1 in both these examples) and a number of smaller interior blocks. In other cases, perimeter blocks are not always larger. N5 Maple has one larger perimeter block (#1) and a series of smaller ones (#4, 6, 8, 10) that result from the street or trail right-of-ways connecting through to the edge of open space beyond in four different locations. However, very different edge conditions make these small outside blocks very different in character from similar sized inside blocks—for example inside block 7 or 9 compared with outside block 6 or 10.

There is also the same issue faced when comparing parcel patterns—how to account for widely different distribution patterns that can be masked by similar average size numbers. For example N7 Hemlock and N9 Elm both have roughly the average block size with about the same number of blocks over the same total area. But the very different internal distributions underlying those average values create a very different block pattern. In N9 Elm, block size range is modest ranging from a low of about 4 acres to a high of about 11 acres with the majority around 5 or 6 acres. In contrast, N7 Hemlock the smallest block is less than a half-acre and the largest nearly forty acres. There is no strong size pattern evident. Average block size can mask underlying differences.

This results in fundamental questions about the comparability of the block patterns for the purposes of measurement. Not only are there questionable differences between different types of blocks, a series of tricky data specification issues, such as how to define boundaries on non-street edges, make the prospects for replicable datasets uncertain. However, even with these problems, there still appears to be some useful general correlations between block patterns and neighborhood character—especially in relation to grain and connectivity. The advantage of readily available census datasets for a widely accepted increment of neighborhood form make block patterns a potentially powerful first order measure worth investigating within the limitations of this set of cases.

Measures of Average Block Size. The simplest measure of grain is the average size of the base unit—in this case the neighborhood block. Figures 5-7 and 5-8 show inverse expressions of the same relationship—one as an average number, the other as a ratio of blocks per unit area. In this case 50 acres was chosen as an area increment that was relative to the size of a typical neighborhood in this set.

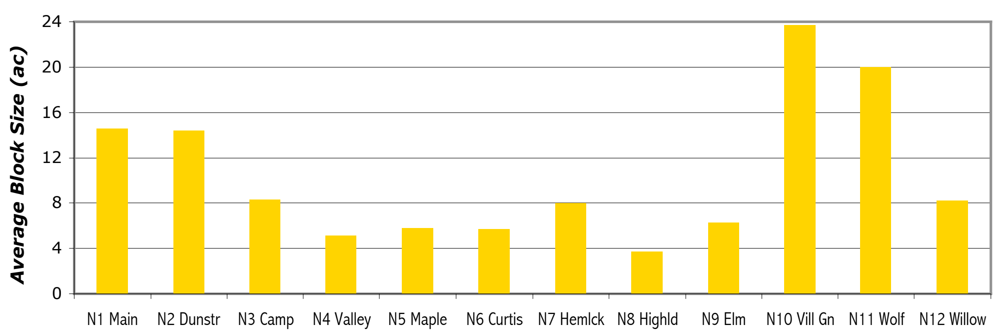


Figure 5-7 Average Block Size (acres) by Neighborhood

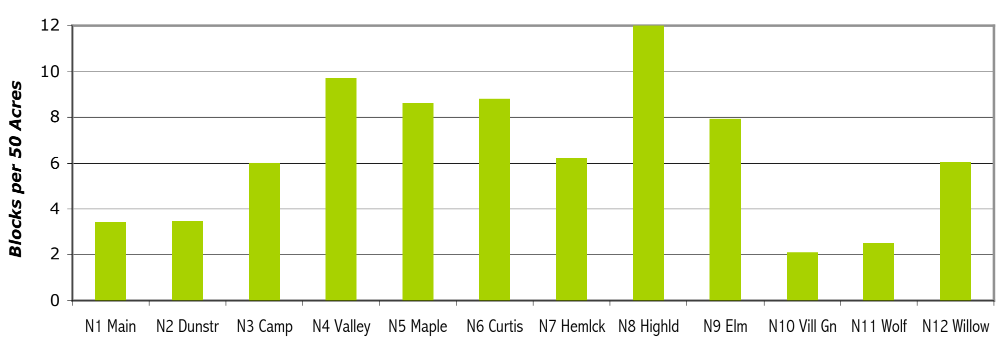


Figure 5-8 Ratio of Blocks per 50 Acres by Neighborhood

The advantage of the latter measure is that is allows the higher measured value to be correlated with finer grain and higher connectivity. It also expresses the measure relative to some known constant rather than simply a number. Comparing the scores across the neighborhood shows some mixed results, with greater success in capturing observed grain than connectivity. In a very general sense, smaller block size or larger blocks per 50 acres correspond with grain. The older, finer-grained areas score higher in the green bars (e.g. N8 Highland) and newer, coarser-grained ones lower (e.g. N10 Village Green). However, looking more carefully within density sets finds several incongruities between scores and observed character. In the lower density set, N4 Valley shows a much higher score than N1 Elm despite having a similar village character and a much greater extent of large lot post-war tract development. Correlations in the middle density set seem better though N6 Curtis and N7 Hemlock seem somewhat over valued compared to the finer grained N5 Maple. Correlations in the upper density set seem reasonable based on initial assessments of grain.

The measure is somewhat less useful as a measure of connectivity. While the overall direction of the relationships seem correct, there are a number of mis-matches. N2 Dunster, a very low connectivity case with only one way in and out, is scored equivalent to N1 Main a village neighborhood that is pretty well connected to its surroundings (though without strong internal connections). Likewise, N9 Elm, clearly the best example of high connectivity, scores in the upper middle range, lower than a number of neighborhoods that clearly have a less connected network. It is also relatively close to N7 Hemlock, which has very limited network connectivity *(see Figure 5-6)*. N3 Camp Brook also seems to score higher than it should given its very limited street connectivity although a higher degree connection to surrounding open space and trails may partially justify a higher score.

These initial results suggest, despite idiosyncrasies of block pattern, average block size provides a rough measure of neighborhood quality. The scores also show variation in block grain having little relation to density. The measure is easy to calculate, though difficult to specify reliably within this context. A number of questionable correlations suggest other measures may be better suited to describing variation across this particular set of neighborhoods. These also suggest that other block-based measures such as average block length would be even more difficult to specify for the irregular block structure found in this set. They may hold more promise in larger metropolitan areas with more consistent patterns of urbanization.

5.1.4 Measuring Street Patterns

If parcel and block patterns represent the *staying* side of neighborhood space, street patterns represent the *moving* side. While the majority of neighborhood area is comprised of parcels, there would be no access to individual parcels without some kind of street network. Street patterns are important for at least three reasons: 1) as a system of public rights-of-way; 2) as a network of paths around which other elements are organized; and 3) as the "windows" through which neighborhoods are perceived as a place. This section will address streets in relation to the first two issues—public domain and path network. Streets as corridors of spatial perception will be reserved for the more detailed scale of analysis in Chapter Six.

Measuring Streets as Public Domain: Parcels and street rights-of-way (ROW) comprise 100% of neighborhood area. However, the relative relationship between them varies quite significantly from neighborhood to neighborhood. In some cases street rights-of-way are a relatively thin part of neighborhood structure. In other cases, they are the primary organizing structure of neighborhood space. A matrix of base maps showing measured street rights-of-way and adjacent block structure arrayed by density and age of development can be seen in *Figure 5-9 Street ROW & Block Patterns*.

The overall range of these differences can be measured as a simple ratio of the land area of private parcels to the land area of public streets. It can also be perhaps more simply expressed as a percentage of street ROW area in relation to neighborhood area. Both these measures are shown in *Table 5-3 Relationship of Street ROW to Neighborhood Area*. Specification of the street right-of-way data was very straightforward. Overall street length was multiplied by ROW width for each block of each neighborhood. Only internal streets were counted. Boundary streets and private drives or parking areas were not included.

	parcel area (ac)	n-hood area (ac)	street area (ac)	street count	% parcel area	% street ROW	str : par ratio
N1 Main	58.46	65.25	6.80	6	90%	10%	0.12
N2 Dunster	57.64	63.25	5.61	8	91%	9%	0.10
N3 Camp	41.46	47.09	5.62	4	88%	12%	0.14
N4 Valley	51.48	60.75	9.27	9	85%	15%	0.18
N5 Maple	58.01	66.21	8.20	14	88%	12%	0.14
N6 Curtis	28.35	32.82	4.48	4	86%	14%	0.16
N7 Hemlock	57.98	62.07	4.09	3	93%	7%	0.07
N8 Highland	44.46	52.22	7.76	10	85%	15%	0.17
N9 Elm	50.72	57.88	7.16	6	88%	12%	0.14
N10 Vill Gn	47.47	50.94	3.47	4	93%	7%	0.07
N11 Wolf	50.52	54.56	4.04	4	93%	7%	0.08
N12 Willow	41.21	46.75	5.54	8	88%	12%	0.13

Table 5-3 Relationship of Street Right-of-Way to Neighborhood Area

Compared with some other parts of the country, the proportion of street area in Upper Valley neighborhoods appears to be relatively low. The highest ratio within the twelve study neighborhoods is .18 or about 15% of total land area as streets. The relatively dense street grids of cities such as New York and San Francisco streets can account for more than 25% of the land area. The lower percentages in this region may be related to generally lower regional residential densities. Larger lots require a less fine-grained street pattern. However street area is also likely to be a function of development type.

Even within this relatively low range, there are significant differences in street area coverage in the Upper Valley cases that impact neighborhood character. At the low end of the range, streets are about 7% of total area. These include N7 Hemlock, N10 Village Green, and N11 Wolf—the three neighborhoods with the most large-block, large-lot multi-family development. The high end is about twice that at 15%. It includes N4 Valley and N9 Highland—both areas with small blocks and lots. In general, right-of-way width does not seem to be much of a factor as width does not vary much across the twelve cases. In older neighborhoods right-of-ways are typically 40 feet wide while newer ones are more likely to be 50 feet. Paving width, which would have a more direct impact on perceived character, also does not appear to be a factor. Streets are consistently 18-22 feet wide across all neighborhoods. As can be seen in the base maps in *Figure 5-9*, differences in street area is primarily a function of some neighborhoods having significantly more lineal feet of street than others.

The extent of the street network seems to be somewhat related to size of parcels. All things being equal, simple geometry dictates that larger lots require less street area per square foot of parcel than smaller lots do. For example N2 Dunster with 90% medium and large single family lots only requires about two-thirds as much street area as N8 Highland with 80% small and very small, primarily single-family, lots. Another factor is efficiency of street layout. N4 Valley's relatively high percentage (15%) seems in part due to several single loaded streets and sweeping curvilinear geometries. Street layout will be considered in more detail in the street network discussion.

By far the greatest factor affecting the extent of street area is proportion of large and very large parcels. The three neighborhoods dominated by large and very large parcels (i.e. parcels above 1 acre) have less than half as much total street area as those comprised of mostly medium, small, and very small lots. The larger parcels in Hemlock, Village Green and Wolf are not associated with large-lot single-family areas but rather with areas of large-lot multi-family land use. This factor is primarily responsible for the relatively high correlation of % of overall street area and observed differences of neighborhood form and character.

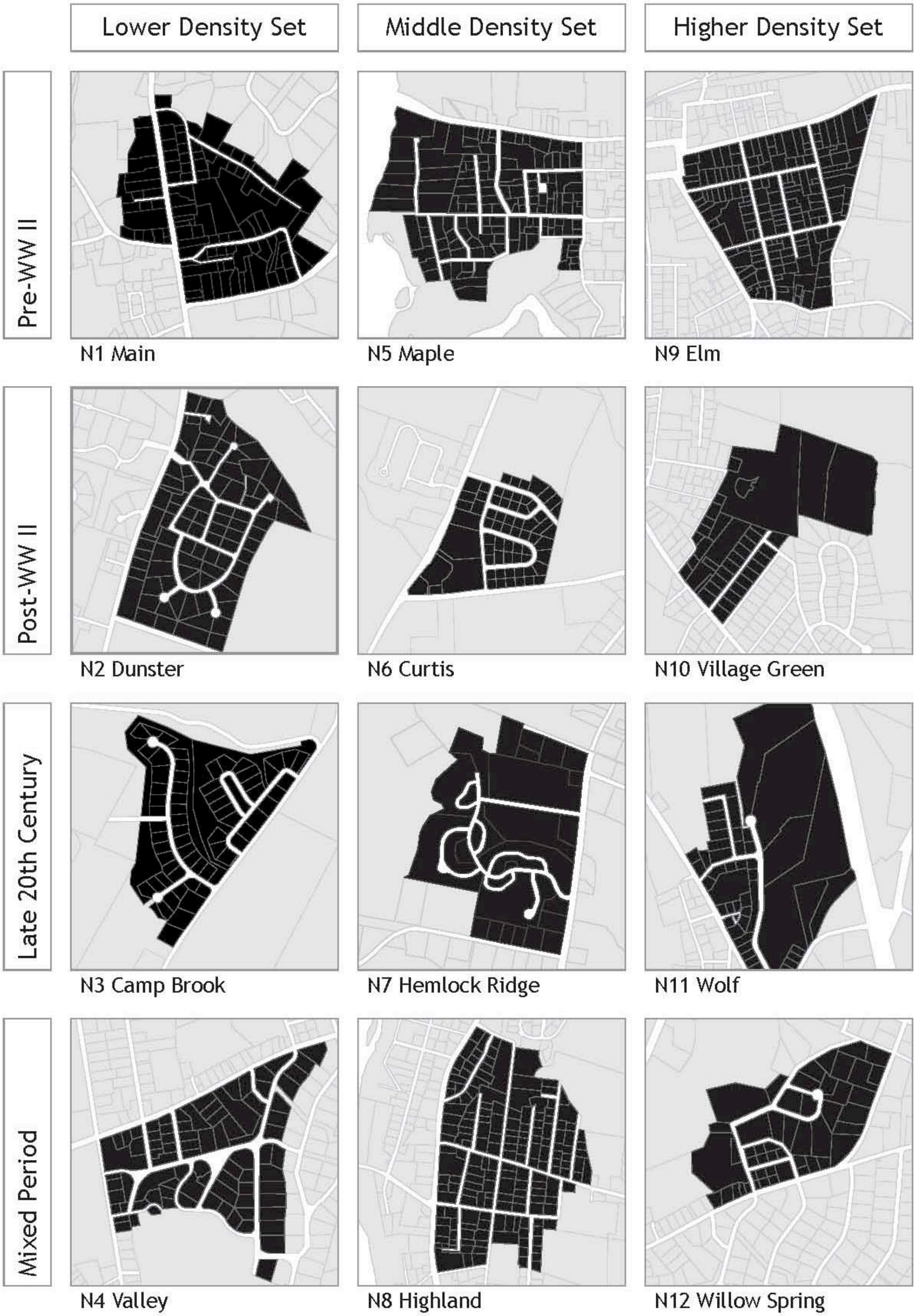
Typically these larger multi-family parcels have their own internal circulation systems of driveways and parking lots that minimize the amount of public street infrastructure. This circulation pattern alters the traditional relationship of dwelling unit to street and seem strongly associated with differences in neighborhood character. It not only affects street patterns, but also patterns of land use, blocks, building typologies, open space and vegetation. These issues will be discussed further in upcoming sections.

Finally, the relationship of street area to parcel area also seems potentially linked with the perceived quality of public space. Neighborhoods with a more extensive street network may be associated with a more active street life while those with less public streets may feel more private and secluded. However there are some complicating factors. Public space can also take the form of parks or open space that can contribute to the public domain. Another issue is that not all streets are public rights-of-way. Private streets and driveways in larger multi-family areas often function as shared community space for local residents although they remain part of the private domain. This issue will be further discussed in the next chapter.

Measuring Streets as Connecting Frameworks. The pattern and interconnection of this street network also has a significant relationship to the perceived differences between neighborhoods—particularly the quality of connectivity. The concept of *connectivity* has been widely discussed in the transportation / land use literature over recent years as a critical dimension of street networks (Butler, Handy, and Paterson 2003). Connectivity refers to the directness of links and the density of connections in path or road network (Victoria Transport Policy Institute 2005). A well-connected street network has many short links, numerous intersections, and minimal dead-ends (cul-de-sacs). As connectivity increases, travel distances decrease and route options increase, allowing more direct travel between destinations.

A series of measures have been discussed in the literature of the past ten years. Given that this is one of the few urban form measures that has been given considerable attention, it will not explored in great detail in this study. However several measures will be tested to gauge the utility of some basic measures for this set of neighborhoods. In particular, efforts will be focused on distinguishing between a neighborhood's internal and external connectivity. Internal connectivity refers to the interconnection of

Figure 5-9 Str ROW/Block Patterns: 12 Neighborhoods 1” = 1600’



the network within the borders of a neighborhood. External connectivity refers to the connections of the neighborhood's streets to the surrounding street network and land area. The range of these relationships in all twelve cases can be seen in the base maps of street right-of-way and block pattern in *Figure 5-9 Street ROW & Block Patterns*.

Measuring Internal Connectivity. The most basic measure of street connectivity is the density of street intersections. More intersections per unit area offer a greater number of route choices within the neighborhood. Not all intersections, however, are created equal. Four-way intersections offer more choices than three-way intersections. More importantly, intersections with non-closed ended streets offer greater accessibility that those with dead-end or single loop streets. There are also some issues of specifying intersections. Are offset street crossings counted as one or two intersections? Are private streets and drives counted or not?

For this initial exercise two types of intersection counts were made. The first counted all intersections within the neighborhood. The second counted only intersections with non-close ended streets—intersections that led to other route choices in the network rather than back to same ones. As previously, the measure is expressed as a count per 50 acres to provides some tangible relationship of the value to the size of a typical neighborhood.

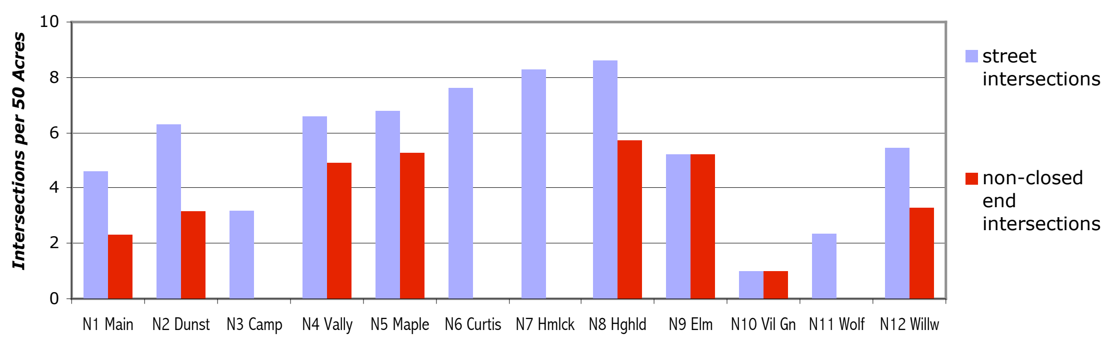


Figure 5-10 Street Intersections per 50 Acres by Neighborhood

The above graphs comparatively arrays the two counts with *all* intersections on the left side and only *non-closed end* intersections on the right. Again the values show little if any correlation to development density with intersection density varying across both density class and the entire set. There is less variation among the *all intersection* measure with only two large lot multi-family cases, N10 Village Green and N11 Wolf, showing very low accessibility. It is important to note that if private drives serving multiple units were counted, these cases would show values more equivalent to the others. It is also important to note that in the case of N7 Hemlock, all the loop drives were counted because they were included in the town's GIS system database even though they are technically private streets (see diagrams in Figure 5-9). Another issue is N9 Elm Street, the case with the greatest perceived connectivity, does not score as high as many other cases.

The only *non-close ended* streets measure shows a much stronger variation between cases that seems to better correlate with perceived differences in internal neighborhood accessibility. The more traditional block and street networks show much higher values than newer patterns of loops and cul-de-sacs where route choices are more limited. It is interesting to note that N9 Elm, the only true grid network, now scores near the top. It is the only case where the value remains the same for both measures. It is also interesting to note that the cases with only loop and cul-de-sac internal streets (i.e. N3, N6, N7, N11) drop completely off the chart. These results suggest some combination measure that gives some greater weighted value to non-close ended streets might prove an even more representative measurement on internal neighborhood connectivity.

Measuring External Connectivity. A second set of measurements examined the relative impacts of number of external access points on values of neighborhood connectivity. The more points of connection to its surroundings, the higher the connectivity value for given neighborhood. Again there are a series of specification issues. Do connections to major streets count more than to minor streets? How are minor connections to dead end streets with no connections to the internal network counted? Do connections in multiple directions count more than connections in only one or two? Do restricted access points (i.e. one way or emergency access only) count the same as unrestricted access points? Perhaps most importantly, how can bike and pedestrian-only access points be included in measures of external connectivity?

Two relatively simple measures were developed for this initial exercise. The first includes only functioning street connections to the outside street network. The second adds in all public trail and path connections. Measures are again expressed as ratios of counts per 50 acres for comparative purposes.

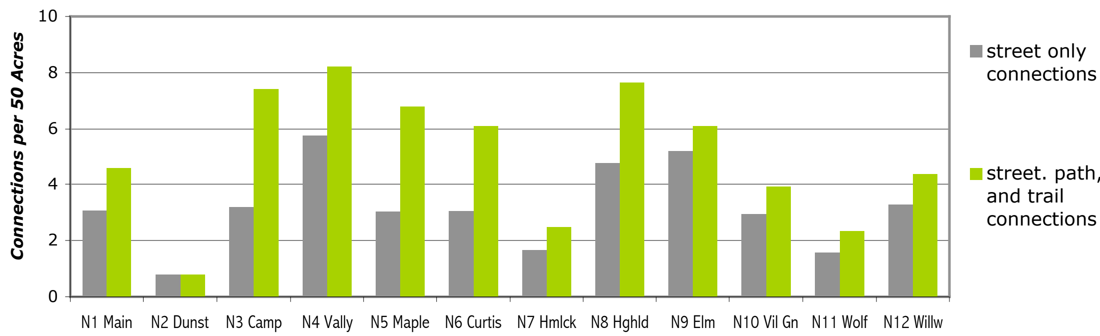


Figure 5-11 External Access Points per 50 Acres by Neighborhood

The results show a fairly robust range of connection values across all neighborhoods that seem both independent of density and fairly well correlated with initial perceptions of differences in street networks between neighborhoods. The left hand bars show street only connections. The more traditional connected street patterns score higher (e.g. N4, N8, N9) while the more isolated development patterns score lower (e.g. N2, N7, N11). While N9 Elm scores near the top, some weighting for connections in all four directions could help account for its stronger network connections.

The bars on the right represent values with trail and path connections added. In general the same relative order in between neighborhoods is maintained though some neighborhoods such as N3 Camp Brook and N5 Maple show a sharper rise. In the case of Elm, the only neighborhood 100% bounded by streets, trail and path connections are less. To some extent the preferred measure of external connectivity largely depends on the relative values placed on the different types of travel modes served. Clearly vehicular accessibility is primarily a function of street connections while more local pedestrian, bicycle, and recreational accessibility is strongly linked to trails and paths as well as streets (see Figure 5-12).

Street / sidewalk connection to downtown at east end (#3545)

Trail connection to conservation lands at west end (#5299)

Figure 5-12 Street versus Trail Connection at Either End of N5 Maple Street

As with internal connections, the extent of the network being connected into also makes a difference—a trail connection could link to an isolated playing field or to a entire regional trail network. Likewise different types of street connections can be more or less conducive to use by pedestrians and bicycles. More sophisticated weighting of these factors could be incorporated into revised external connectivity measures. But again the more factors being considered the more complicated and less easily replicable the measure becomes.

Finally, some observations can be made between the two sets of connectivity measures—one internal, the other external. In general both sets of values reflect the same relative differences between neighborhoods though the measure of only c*lose-ended intersections* drew stronger distinctions than the *all intersection* version. This suggests there is some basic congruence between internal and external connections.

There were, however, some interesting exceptions that suggest this is not always the case. In N2 Dunster, a relatively connected internal system ranked in the mid to upper range in the first measures while its single point of access resulted in a very low score in the second case. Likewise, both N3 Camp Brook and N10 Village Green, which have very weak internal connections but more frequent external connections, score low in the first set and higher in the second set. These exceptions suggest both dimensions are important to capturing a fuller sense of neighborhood connectivity. While both measures seem to capture basic first order differences between neighborhoods, it may be possible to derive a composite measure that factors in both measures of internal and external connectivity.

There may also be some other measures not considered here that would be useful to try, such as close-end streets as percentage of all streets, average length of closed-end streets, or average intersection spacing. Average block size, probably a close proxy for intersection spacing has already been discussed. It will, however, be useful to first compare the measures that were tested with a broader baseline of perceived variation between neighborhoods. This will be presented as part of the *Neighborhood Evaluation Surveys* discussion in Chapter Seven.

5.2 Land Use, Buildings and Landscape: Overlying Elements

The second half of this chapter focuses on neighborhood-wide patterns of land-use, buildings and landscape. These are elements that lay on top of the invisible framework of property division. They are visible surface that give a neighborhood tangible dimension, color, texture and life. *Land use* describes the general function associated with each parcel in the neighborhood. *Buildings* are the primary structures associated with various land uses. In a neighborhood these are primarily dwelling units in residential building types. *Landscape* is used in a broad sense to include the many elements that comprise the outdoor realm of a neighborhood—including trees, lawns, gardens, streets, drives, walks, patios, fences, walls, outbuildings, etc. In the matrix at the end of Chapter Four, contrasting patterns of these elements were perceived to be particularly associated with qualities of *variation and consistency* across the case study neighborhoods.

Measuring land uses, buildings and landscape elements is potentially a much more difficult task. Unlike the precise, scalable dimensions, parcel lines and rights-of-way, this set of elements is more characterized by the real world complexities and the associated variation and detail of composition. Tools of typology and classification are required to translate these inherent complexities into to a measurable data set. While much of the richness of individual variation is lost in the process, type classification can help highlight distinguishing relationships that allow differences to be more easily seen and analyzed. In order to construct simple, replicable data, each of these elements must first be sorted into basic types that can be consistently understood and identified. The next section describes the process and limitations of specifying and compiling these data sets from available sources and field observations.

Data Compilation: The data sets for land use and building type were built on top of the database set up for the parcel analysis. This framework included about 1,000 records linked to individual parcels within the twelve study neighborhoods. The parcel records were also arrayed by geographic proximity for both parcel and block *(see Table 5-1)*. As *land use* and *building* data are typically attached to unique parcels numbers in municipal GIS files, this new data could be simply added as new fields to the existing project database.

The data compilation issues related to measuring *landscape* elements was more challenging. By its nature, landscape is a complex and multi-variate aspect of neighborhood form. While neighborhood-wide data could be measured for walks, drives, trees, fences, walls, outbuildings and other smaller scale elements, they were not included in existing GIS data sets and were difficult to pick up off ortho-photography. Vegetation layers are more common in GIS sets, but only one of the towns had this data and it was very poor quality at the neighborhood scale.

In the end, the limited scope of the project did not allow for the extensive data gathering required to measure even the simplest of landscape character distinctions such as vegetation type and coverage. The treatment of landscape at the neighborhood scale is limited to a discussion of general measurement issues and approaches. Some specific landscape measures are developed at the more detailed scale of the street and block where the limited analysis area allowed field compilation of some basic landscape data on tree size and location. This work is described in Chapter Six.

As with parcels, the ease of compiling land use, building and vegetation data varied widely from town to town. Once again Lebanon's data was the easiest to work with. Data compilation for the other three towns presented a series of challenges. These issues are described in detail in Appendix F. Once these were resolved, reasonably accurate parcel-by-parcel data was compiled for land use, building type and dwelling units for all twelve neighborhoods.

Another benefit to parcel level data was the ability to easily update and refine overall residential densities. Initial calculations of neighborhood density were based on block level parcel data supplemented by some field verification. Some significant limitations to this method included the need to interpolate both housing counts and area for perimeter census blocks that did not match neighborhood boundaries. Parcel-by-parcel area totals and unit counts not only allowed more accurate neighborhood-wide densities to be calculated, but also permitted measurement of internal density variations within a neighborhood.

Counting dwelling units was very straightforward for the one, two and three unit land use categories where there is typically only one building on a parcel. However, counting dwelling units was tricky for more intensive land use categories because these land use classifications were expressed as ranges and often have more than one building per parcel. Thus several parcels classified as eight or more units included 100 or more units in several buildings. Several methods were used to tally and verify unit counts in multi-family areas.[2]

Using more accurate parcel-by-parcel unit counts, initial density totals were re-calculated and refined. By and large, the initial estimates were pretty accurate. In two or three neighborhoods, interpolation errors on some of the larger blocks resulted in some small variation in density levels. However, in one case, Willow Spring, the revised density level made it less comparable with the other three neighborhoods in the higher density set.[3] The real value of the higher resolution density data was the ability to calculate accurate densities for small areas within a neighborhood. This was extremely useful in matching densities for the more detailed Street/Block case studies that will be the subject of Chapter Six.

Data Specification: Once that data was compiled, a series of specification issues needed to be resolved in order to classify and code both land use and building data. Unlike parcel size, there were a wide range of potential land use and building type classification systems that could be used to organize the data. Each town had its own variation on classification. While there were some similarities, terms varied and there were some internal inconsistencies that had to be addressed. For instance, Lebanon records coded residential land use by range of units (e.g single family, two unit, eight or more units) unless the parcel has condominium ownership. In that case the parcel land was simply classified as *condominium.*[4]

Using the existing classifications as a starting point, a simple typology classification was established for both land use and building type. The goal was to create a system that was simple enough to use existing data but complex enough to create enough variance in the data to pick up observable variation in neighborhood-wide land use. Since the research was focused on neighborhoods, the most detailed distinctions were made for residential land uses. Non-residential categories covered only basic distinctions. Land use fields for all 1,000 parcels were assigned a simple 1 to 9 numeric code that could be used to derive quantitative measures. A more detailed discussion of the land use coding is included in Appendix F. The nine land use classes included:

1) Residential Single-Family
2) Residential Two-Unit
3) Residential Three-Unit
4) Residential Four-to-Seven Unit
5) Residential Eight-plus Unit
6) Retail or Restaurant
7) Office, Service or other Business
8) Public or Institutional
9) Open Space & Recreational

One last specification issue was whether the residential land use types were defined by type of the building or total number of units on a given parcel. This was only an issue on parcels with more than one building. After some consideration, it was determined that for the purposes of distinguishing urban form characteristics, coding by the primary type of residential building would be most useful.[5]

Classifying Building Type: There is an extensive literature outlining multiple approaches to the classification of building typologies. However, most of this work is too complex and context specific to be of much use for specifying the simple, replicable distinctions required for first order measures. For this project, residential building type is simply defined by the same basic categories used for land use type—number of units per building. Due to the limited type and number of non-residential buildings in the study areas, only residential buildings were counted and classified.

Despite the absence of specific form and character attributes in this classification system, field observations suggest units per building is an excellent delineator of first order distinctions related to neighborhood character. Single unit dwellings are detached structures with a distinct relationship to street and yard. Two and three unit buildings are usually quite similar in massing and siting but have more complex issues of parking, entry, and yard. Four to seven unit buildings tend to be hybrid types that can either take on a *house* character, a *row house* character or an *apartment house* character depending on specific context. Buildings with eight or more units almost always were found in the context of a housing project and comprised of stacked flats with common entries, yards, and parking areas. Number of units also correlates very strongly with overall scale and size of buildings. Detailed consideration of building massing, scale, and composition is included in the Street/Block analysis in Chapter Six.

Classifying building type was simple for the first three categories—one, two and three-unit buildings. With almost always only one building per lot, it was typically the same as the land use. On rare occasions when a parcel contained more than one building, they were counted as two buildings of that type on a single lot. Compiling building type counts for the four-to-seven and eight-plus categories was more difficult because: 1) the number of units in a building was less certain, and 2) there was often more than one building on a parcel. Field notes and sketches were useful for determining how "x" number of units were distributed into "y" number of buildings.

For the most part, building type matched land use type. For instance, 24 dwelling units on a four-to-seven unit land use parcel was usually made up of either four six-unit buildings or six four-unit buildings. In occasional cases, where building types were mixed on a single parcel the building and land use types were simply assigned as a group to the dominant type. For instance, a Hemlock Ridge parcel with 19 units in five three-unit buildings and one four-unit building was coded as *residential three-unit* land use with six *three-unit* buildings. The unit count field still counts all 19 units. Only in two exceptional cases where the variety of building types on a parcel was judged to be a significant factor in understanding neighborhood character were building types broken out and counted in separate totals.[6]

There were only a couple of other special conditions for treatment of mixed-use buildings (e.g. an apartment above an office) and group homes.[7] Despite these exceptions, a pretty accurate dataset for land use, unit counts, and building counts was compiled using easily replicated methods. Photographs and field checks helped confirm unit counts and resolve any unique conditions.

5.2.1 Measuring Land Use Patterns

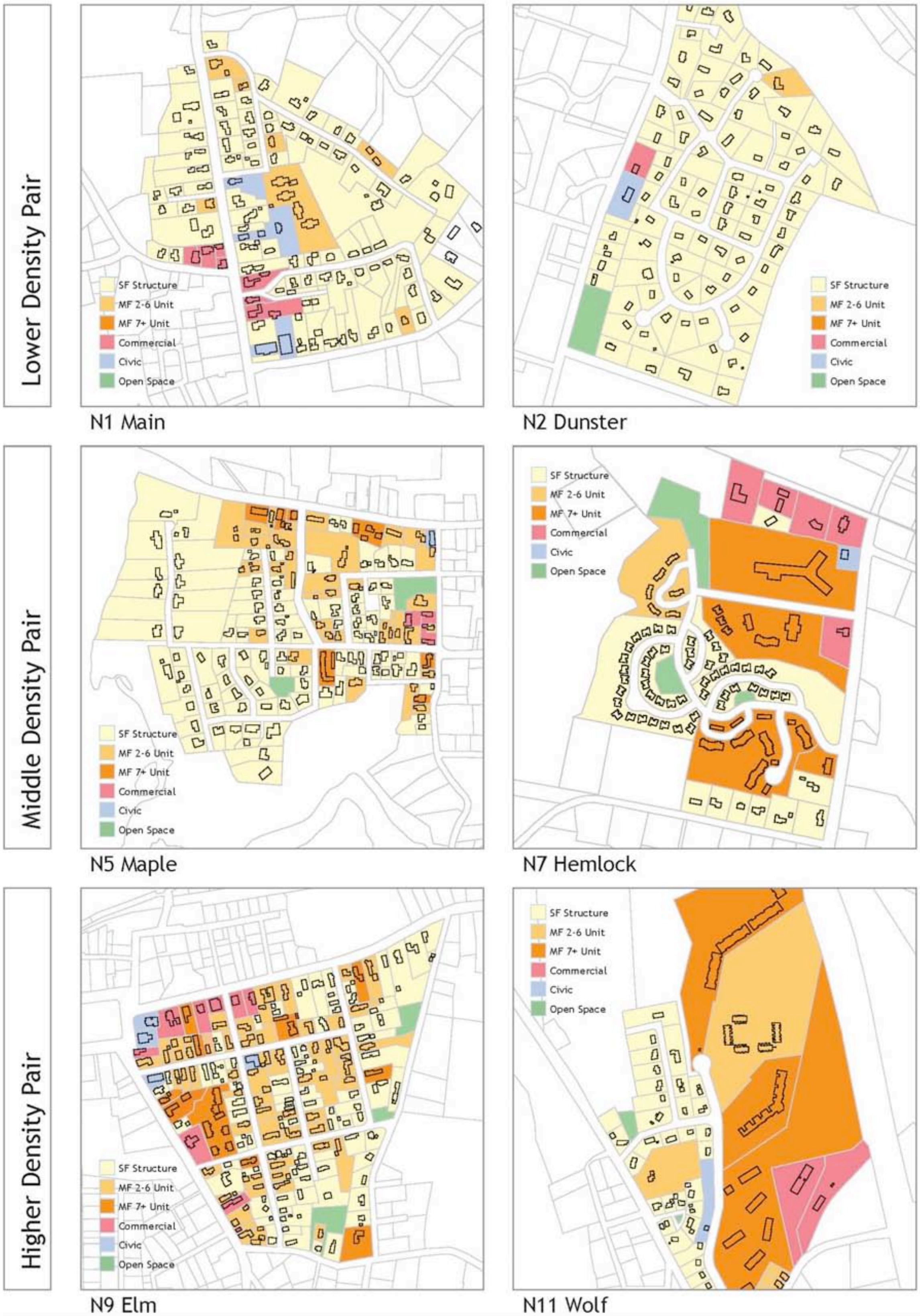
With the original parcel area database now expanded with fields for blocks, land use, dwelling counts and building types, a much broader array of metrics could be explored, tested and evaluated. The resulting data set was a useful tool for examining the inter-relationships of several elements of neighborhood form. One of the important lessons from the first set of experimental measures was to examine approaches for measuring spatial distributions of residential density and land use rather than simply looking for alternative measures. This requires a level of specification that is missing in the standard neighborhood measure of *units per acre*. This ratio provides no information about the variety and distribution of the residential parcels, land uses, buildings that make up many neighborhoods.

Consider a hypothetical example of three neighborhoods: one with a single 100-unit building on a twenty acre lot; a second with ten 10-unit buildings on two acre lots; a third with 100 single-family houses on 1/5th acre lots. By conventional measures they are all the same—five units per acre of residential land use. Yet clearly, they would be very different places.

A set of more real world examples are provided by comparative land use maps of six of the twelve case study neighborhoods—including a matched pair for each density level. As can be seen in *Figure 5-13 Comparative Land Use Patterns for Six Neighborhoods*, once parcels have been classified by land use type, it becomes much easier to see patterns of spatial variation between them.

Figure 5-13 Land Use Patterns for Six Neighborhoods

1" = 1000'



The differences in land use pattern are most clearly illustrated in the higher density pair at the bottom of the page. In N11 Wolf, similar land uses are segregated into large single-parcel clumps. In N9 Elm, various land use classes are intermixed on smaller parcels and show a more gradual gradient of change across the neighborhood. In the middle density set this distinction is also quite clear though the older N5 Maple is somewhat more segregated than N9 Elm and N7 Hemlock has a somewhat more mixed pattern of uses that is found in N11 Wolf. The predominance of single-family land-uses at the lower density case makes the contrast somewhat less vivid than at higher densities though the more heterogeneous pattern of the N1 Main neighborhood can still be clearly seen in relationship to N2 Dunster. The challenge is to capture these readily observable differences in simple, replicable terms.

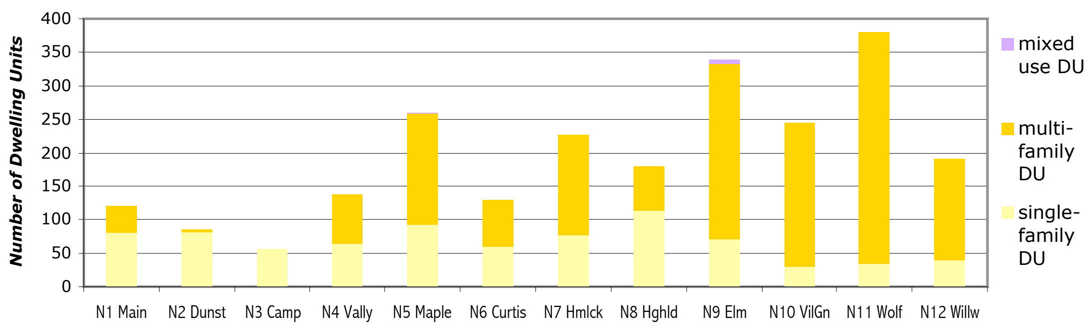


Figure 5-14 Distribution of SF vs. MF Dwelling Units by Neighborhood

Single-Family vs. Multi-Family Dwelling Units: One of the simplest distinctions of neighborhood land use pattern is the mix of single-family and multi-family units. *Figure 5-14* illustrates how each density set has a similar mix of housing units. The lowest density group (N1-N4) has primarily single-family units. Though N1 & N4 have some multi-family parcels mixed in, their overall density (about 2 units per acre) is still comparable with the others. In the middle density group (N5-N8) both single-family and multi-family units are a significant part of the overall mix. In the higher density group (N9-N12), the mix is skewed heavily toward multi-family units.

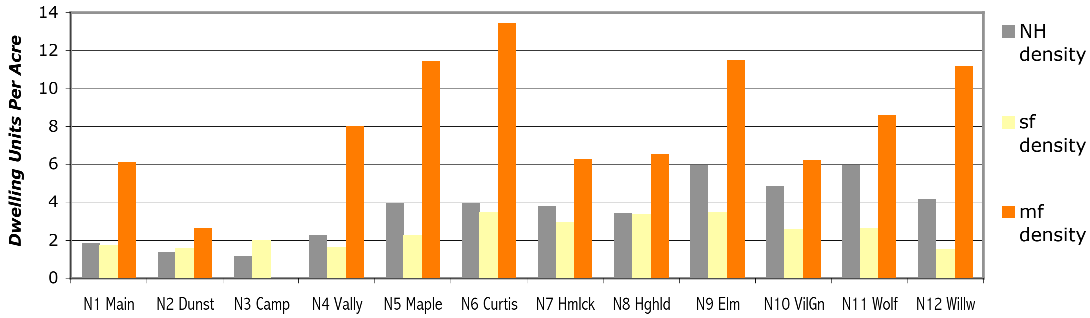


Figure 5-15 Density of Single-Family vs. Multi-Family Units

Density of Single-Family vs. Multi-Family: As each set of four cases was selected to illustrate as much contrast in character as possible within similar ranges of density and use, overall density values do not, of course, correlate with observed neighborhood form. The graph in *Figure 5-15* begins to disaggregate the measure of residential density by comparing overall neighborhood density (gray bars) with density of single-family units (yellow bars) and multi-family units (orange bars). The gray bars show the stepped density levels for the three sets of four neighborhoods. These measures begin to show some differences in sub-components, especially multi-family density, within the density sets. The higher spikes of multi-family densities seem to correlate roughly with larger lots and larger buildings although not always. N7 and N8 show nearly identical values despite being sharply contrasting in character. Not surprisingly, single-family densities are more or less steady although the middle and higher density set show more variation than the lower density set. The overall variation in multi-family densities suggest this may an area worth exploring in more depth.

An Alternative Density Measure: Units per Parcel: Some other exploratory measures show stronger correlations with the general character differences found in Chapter Four. *Figure 5-16 Single-Family vs. Multi-Family Land Use by Area & Count* shows other aspects of the relationship between single-family and multi-family land use. In the upper graph measuring land use type by land area, the single-family share goes up across all neighborhoods when measured by land area rather than dwelling units. This makes sense since single-family parcels are generally less dense and use more land per unit than a multi-family parcel. The proportion of single-family to multi-family remains roughly comparable across each density set.

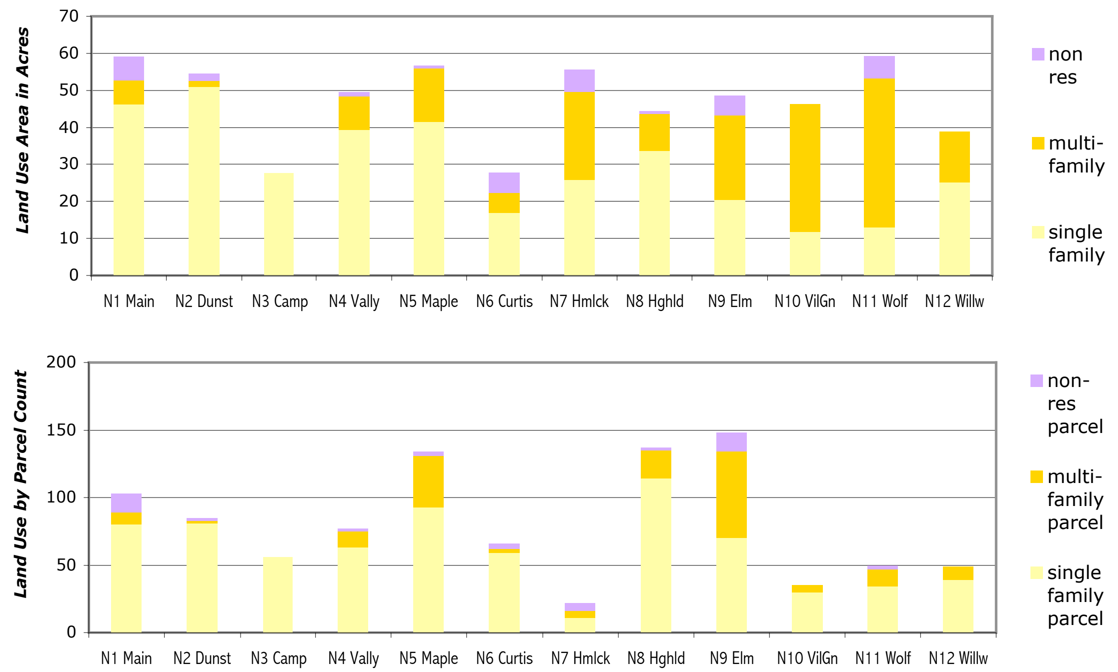


Figure 5-16 Single-Family vs. Multi-Family Land Use by Area & Count

As shown in the lower graph, however, when housing mix is measured by parcel count rather than units or land area some relationships come into sharper focus. There is significant internal variation in the upper two density groups with respect to multi-family land uses. The number of multi-family parcels is far less in relation to the number of multi-family units in N6 and N7 and N10-N12 than in the other three neighborhoods. Not surprisingly these smaller values correlate very strongly with neighborhoods that tend to have a strong mix of large multi-family projects on large lots, rather than smaller ones on multiple smaller lots. For example, N5 Maple distributes about 160 multi-family units across approximately 40 parcels while N7 Hemlock Ridge fits nearly the same number of units on only 5 parcels. In the higher density set, N9 Elm (N9) spreads some 260 multi-family units over about 60 parcels while N11 Wolf Road clusters about 340 mf units on only 13 parcels. The contrast with N10 Village Green is even greater with over 200 mf units on only 5 parcels.

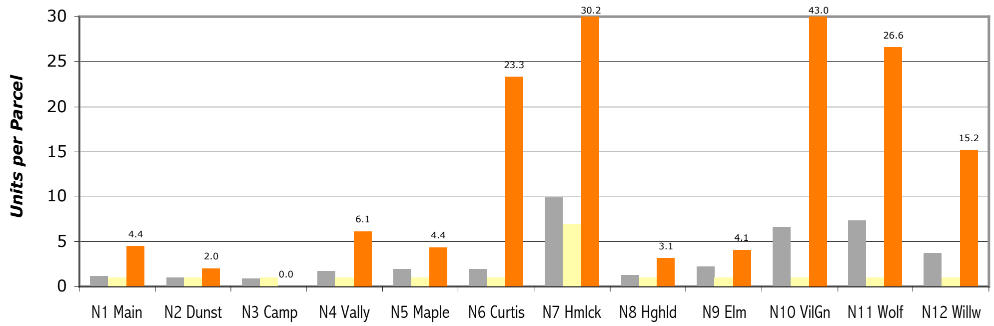


Figure 5-17 Residential Unit Type (SF vs. MF) per Parcel

By inverting the terms of the last graph, the values may be re-expressed as an alternative density measure of *units per parcel*. *Figure 5-17* converts the above quantities into comparable measures that can record the contrast between a small lot multi-family pattern and a large lot multi-family pattern. The orange bars show the small lot multi-family neighborhoods including N5 Maple, N8 Highland and N9 Elm with values of 4.4, 3.1 and 4.4 respectively. In contrast, the large lot multi-family cases N6 Curtis, N7 Hemlock, N10 Village Green and N11 Wolf score 23, 30, 43 and 27. As can be seen in *Figure 5-18*, the differences are sharp and clear within the same density set.

Small-lot multi-family character in N9 Elm (#1323)

Large-lot multi-family character in N10 Village Green (#5132)

Figure 5-18 Small & Large Lot Multi-Family Patterns in Higher Density Areas

Even within these distributions there appears to be some sensitivity to more subtle observed character differences. For instance N8 Highland, with the most consistent house-on-a-village-lot character, scores lower than similar neighborhoods with some larger apartment buildings mixed in. N12 Willow, which is split between older small lot and newer large lot multi-family parcels, had a middle range score of 15. N10 Village Green, where every multi-family site was a large complex, scored higher than similar cases with a few smaller lot multi-family areas mixed in. The low scores for the three lower density set neighborhoods with multi-family units also reflect the generally small lot multi-family character of those patterns.

Not surprisingly, the same measure is not nearly so successful for measuring single -family land use character. Because single-family houses are almost always one unit on one lot, the ratio of units to parcels is typically 1:1. The yellow bars on *Figure 5-17* show units per parcel values for 11 of the 12 neighborhoods as 1.0. However, the one exception is quite significant. In Hemlock Ridge (N7) four parcels are developed with multiple single-family homes. The rather unusual arrangement combines the ownership form of a condominium with the single-family house form. The unit per parcel value for single-family dwelling units in this neighborhood is 6.9.

Individual lot single-family character in N8 Highland (#3690)

Common lot single-family character in N7 Hemlock (#3900)

Figure 5-19 Comparative Views of Moderate Density Single-Family Areas

The sharp difference in value does seem to correlate with some noticeable character differences. As shown in *Figure 5-19,* while the area on the right has many similarities to a standard single-family tract development, there are also distinct differences. The houses are clearly single family in form. They have attached garages and front lawns. However, the land in common ownership case is missing some of the territorial markers of individual ownership. A uniform, park-like landscape flows around the houses. Each house has the same color scheme and site plan. Plant materials and maintenance are identical. Expressions of individuality are limited to front door decorations.

In general, the *units per parcel* measure appears to be a promising proxy for some important dimensions of neighborhood quality—especially related to *grain* and *variation* of land use patterns in neighborhoods with significant shares of multi-family housing. Field observations showed a strong difference between areas with fewer, larger, multi-building parcels and those more, smaller single building parcels. The larger parcels areas have a coarser parcel grain with more internally consistent building grouping, but greater variation contrast between parcels. The smaller parcel one-building-on-one-lot areas tend to have more variation from building to building, but tend to have a more consistent character between parcels. This distinction eludes the simple measures of parcel size and mix. The *units per parcel* measure appears to be a potentially good measure of the consistency of overall neighborhood character—that is the degree to which a neighborhood feels divided or broken up into distinct areas versus having a more consistent character as one moves from one part to another.

Parcels per Acre: A second alternative density measure recorded similar differences by creating a ratio of *parcel* to *land area* rather than *unit* to *parcel*. This is essentially the same as the average parcel size measure discussed in Section 5.1 only now inversed and presented as an expression of intensity. The gray bars in *Figure 5-20 Residential Parcel Type (SF vs. MF) per Acre* shows somewhat muddied correlations with character when measured across all land use types. Neighborhoods with consistently small lots such as N8 and N9 score higher than those with a mix of larger and smaller lots score lower such as N7, N10 and N11. However the distinctions are not that clear—especially across the middle set. For instance N5 Maple and N6 Curtis, which contrast sharply in character, show identical values of 2.2 parcels per acre.

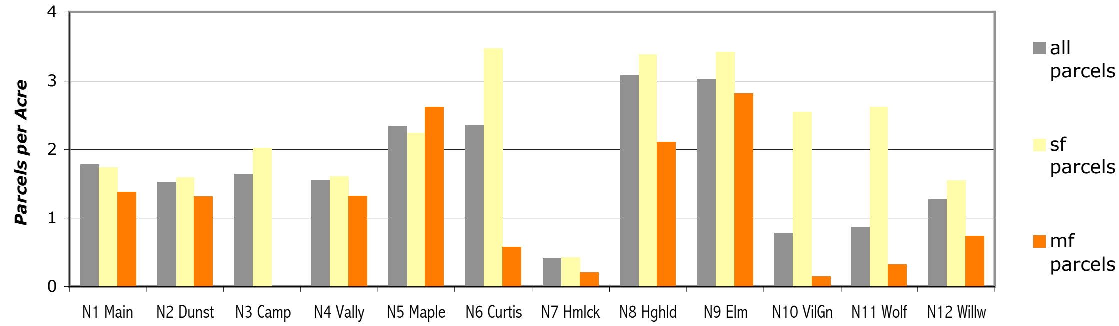


Figure 5-20 Residential Parcel Type (SF vs. MF) per Acre

When the measure is broken down by specific land use type the correlations become clearer. The orange bars show *parcels per acre* for all multi-family land use types. The resulting values show the same strong contrasts between large lot multi-family neighborhoods and small lot multi-family neighborhoods shown by the *units per parcel* measure—only now expressed in reciprocal form. The smaller lot cases such as N5 Maple and N9 Elm are now expressed as higher values (2.4 and 2.6) while the large lot cases such as N7 Hemlock and N11 Wolf are the low ones (0.6 and 0.3).

Another interesting result is the relatively lower multi-family values in the lower density set compared with other small lot neighborhoods. N1, N2 & N4 show values of 1.4, 1.3 & 1.3 respectively. This shows the average multi-family parcel size in the higher density, small-lot multi-family neighborhoods, such as N5 and N9, is significantly larger—it jumps from about 15,000 to 30,000 s.f. The measure also seems to pick up the hybrid N12 neighborhood) with a intermediate value of about .7—placing it half way between the big lot and small lots clusters.

Unlike the previous *units per parcel* value, the *parcel per acre* measure also seems to be sensitive to variations of single-family land use. Because the number of parcels and number of units are the same for single-family land use, this measure is actually identical to the standard *units per acre* measure. The small lot higher density cases (N8, N9) have the highest single-family *parcel per acre* values (above 3) while the large lot higher density neighborhoods (N10, N11) score somewhat lower (around 2). In this case density *is* a strong proxy for observed character differences—see below Figure 5-21.

Small lot single-family character in N9 Elm (#3690)

Larger lot single-family character in N11 Wolf (#3900)

Figure 5-21 Comparative Views Single-Family Areas in Higher Density Cases

N5 Maple and N6 Curtis Road don't fit as clearly into this pattern. Maple Street, a small lot multi-family case, has a *lower* single-family value than Curtis Road, a large lot multi-family area. This is because Maple Street, an older village neighborhood, has a cluster of larger single-family lots while Curtis Road has a pattern of unusually small single-family lots for a 1960's era neighborhood.

Perhaps the most striking pattern shown by this measure is the relationship between single-family and multi-family land uses across neighborhoods. In the older neighborhoods, the values for single-family land use and multi-family land use are relatively comparable—all three bars are about the same height. In the newer neighborhoods, the values for single-family and multi-family are extremely divergent. The different heights of the yellow and the orange bars show *parcels per acre* values that are *6 to 25 times higher* for single-family areas than for multi-family areas. This seems to reflect the emergence of more specialized site planning approaches for different housing types in the post-war era.

There are several interesting exceptions to this distinction of newer and older development patterns. N2 Dunster Drive, a lower density post-war neighborhood, shows similar values for single-family and multi-family parcel densities. This is simply explained by the fact that the multi-family area consists of one duplex on a street of single-family parcels. Values are also similar for N7 Hemlock Ridge, a recently built neighborhood with a mix of single-family and multi-family land uses. Here the similar scores result from both single-family and multi-family areas being developed on similar sized large parcels.

Measuring Non-Residential Land Use: While most of the analysis focused on variations of types and patterns of residential land use, some consideration was also given to non-residential land use patterns. In general, neighborhoods were selected to have a similar adjacency to non-residential uses such as schools, churches and small businesses and comparable access to open space uses. Because non-residential uses are typically transitional land uses at a neighborhood's perimeter, the degree to which particular parcels get included or excluded from the database was somewhat uneven. Consider the example of N8 Highland and N9 Elm—perhaps the most extreme case. Both are village neighborhoods of very similar character adjacent to a downtown cluster of businesses, schools and civic uses. Due to the local idiosyncrasies, one ended up with eighteen non-residential parcels while the other had just two.[8] The same goes for open space. N8 had no open space parcels while N9 had four despite having less open space resources.[9] While general land use mix is quite comparable between cases, what was included in the database varies from case to case and provides a pretty uneven sample of overall non-residential character.

What may be more useful to consider than the amount of non-residential use is the relative relationship between residential and non-residential uses in a neighborhood. How do these land use types fit together? What is their relative scale? How are they connected to adjacent uses? These relationships can be clearly seen in land use maps in *Figure 5-13*. The question is whether the differences between them can be specified, measured, and compared. While many of these questions may be better addressed with a more detailed examination of edges, the *parcels per acre* measure illustrates some initial differences of non-residential patterns.

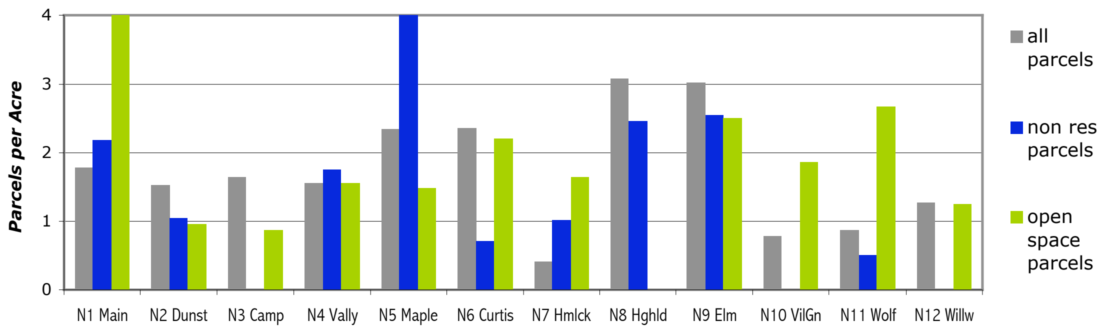


Figure 5-22 Parcels per Acre for Non-Residential Land Use

Figure 5-22 shows some first order distinctions of *scale* and *grain*. Though the sample is quite small, the results are pretty consistent with observed character. The older, smaller lot neighborhoods (N1, N5, N8, N9) all have the highest values (2.0 and up) of *parcels per acre* for non-residential uses excluding open space. This indicates a small average lot size—typically less than 20,000 sf. This is consistent with areas where small lots are used interchangeably for residential or non-residential uses. In fact, many of the non-residential land uses in these neighborhoods were almost certainly converted from original single-family homes as illustrated in Figure 5-23 below.

Office use in old house on small lot in N1 Main (#4479)

Office use in new building on large lot in N2 Dunster (#3597)

Figure 5-23 Contrasting Parcel Sizes of Non-Residential Uses in N1 and N2

In the newer, larger lot neighborhoods including (N2, N6, N7, N11), the values for non-open space, non-residential land uses all score between 0.5 and 1.0—indicating a fairly large average lot size ranging from 1 to 2 acres. This is consistent with the observed differences between uses in these neighborhoods where non-residential uses are clearly distinct from residential uses.

Measuring *parcel per acre* values for open space land uses was less successful. The range of values seems to have more to do with whether the sample includes a small vacant lot or a larger internal open space parcels. In N1 Main Street a few vacant lots pushed the value up. In N3 Camp Brook several large designated open space parcels pushed the value down even though it has a much stronger open space character. Depending on the particular delineation of parcels, this value may or may not reflect the grain of open space in a neighborhood. The extremely small sample size of open space parcels makes a very unreliable measure.

5.2.2 Measuring Building Patterns

Building type is closely related to land use as an element of neighborhood form. While definition of building type can vary widely from function (single family) to architectural form (row house) to cultural associations (shotgun house), the focus of this analysis will be on the type of use. While closely related to land use class, there are some important differences. First and foremost, the unit of analysis is the structure not the parcel. For the lower three categories with one building on one parcel this is not a significant distinction. At the upper categories of 4-to-7 and 8 plus units, where parcels in new neighborhoods often have more than one building, it becomes more important to distinguish character differences. Since building form and arrangement is probably the single largest factor shaping neighborhood space and character, it is important to distinguish when and where land use type and building type diverge.

A second key difference between land use type and building type is that land use type is an assignment of use category that has no inherent physical form. Building use, on the other hand, has strong associations with physical character. The five unit-based type categories have strong associations of scale, massing, and siting. A sixth type was added to capture all structures that mix housing and non-residential uses—see Appendix F for further discussion of building type classification. The three-dimensional form of buildings will be more specifically addressed in Chapter Six.

Figure 5-24 Comparing Parcel and Building Patterns in Two Neighborhoods

Building Patterns: Mapping building footprints with no classification of type provides insights into neighborhood form that can be picked up on parcel, street, or land use maps. The building footprints on the right side of *Figure 5-24 Comparing Parcel and*

Building Patterns illustrates the actual physical shape of the built objects that comprise a neighborhood. The two cases also show a sharp divergence in the degree of congruence between building, street, and parcel patterns. In small lot neighborhoods such as N9 Elm, the pattern of building footprints strongly mirrors the underlying parcel and street right-of-ways. Looking at only the building map, one can clearly discern the associated street network and the parcel pattern (shown on the left hand map) due to the strong relationship between all three elements.

In large lot neighborhoods, such as N11 Wolf, the relationship of buildings to other elements is more independent. Looking at only the right hand map, it is nearly impossible to discern the associated street and parcel patterns shown on the left map. This pattern is characterized by multiple buildings on single parcels that are organized around separate and unrelated systems of private drives. In these neighborhoods specifying the various sub-elements becomes more important for understanding overall form and character.

As shown on *Figure 5-25 Building Patterns in Six Neighborhoods*, lower density neighborhoods tend to show less variation in building patterns than those with higher densities and more variety of building types. Comparing the left hand set of cases with the right hand ones, one can discern more building-to-building *variability* but greater *consistency* of scale and shape across the entire neighborhood. The greater variety in shape is most likely due to the more incremental development history of the older neighborhoods. The greater consistency of scale and shape is likely due more to the uniform pattern of small lot sizes—especially for the multi-family cases. Deriving some measure of these distinctions is an important challenge of this project.

When building footprints are classified by type, an even greater amount of information is revealed. Just as with land use, coding buildings by use-type provides a richer database for analysis. It becomes much easier to both see the variation of spatial patterns between different building types as well as to devise and test measures that

Figure 5-25 Building Patterns in Six Neighborhoods

1" = 1000'

potentially capture the observed differences between them. Since the land use classification is linked to residential building type, patterns of building types can be easily seen in the colored footprints shown in *Figure 5-13*.

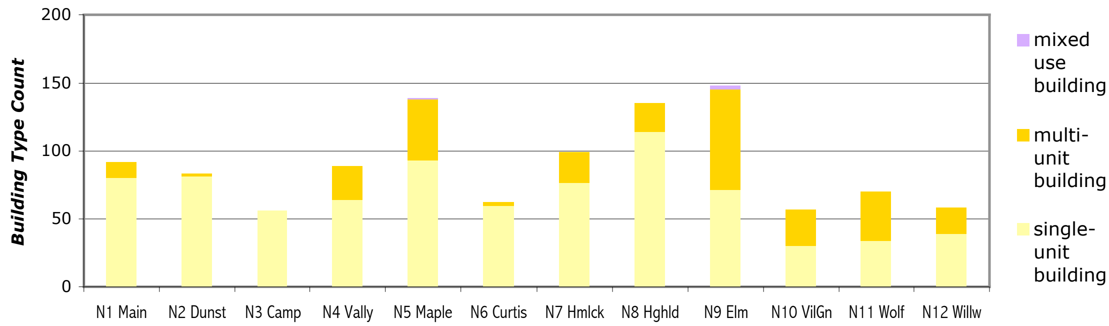


Figure 5-26 Distribution of Building Type by Neighborhood

Single-Unit vs. Multi-Unit Building Types: A breakdown of building type between single-unit and multi-unit buildings across neighborhoods is shown above in *Figure 5-26*. Total building counts per neighborhood range between 50 and 150. However without factoring in differences in neighborhood size and building size it is difficult to get comparative sense of building density. Likewise, there is considerable variation in both single-unit and multi-unit building counts between neighborhoods. Again without factoring in land area or some other common denominator, it is difficult to get any clear sense of comparative value.

Comparing the yellow bars (single unit) above with those in *Figure 5-14 Distribution of Dwelling Units*, finds with identical values—one building equals one dwelling unit. In contrast, the widely varying values of the gold bars between the two graphs shows the relationship between multi-family units and multi-unit buildings to be much more complex. While by definition, there will always be more units than buildings in multi-family areas; the magnitude of this difference varies widely between cases. How might this variation be measured from place to place?

A second perspective is offered by comparing building type counts in *Figure 5-26* with parcel type counts in *Figure 5-16 Land Use by Area and Count*. Again values for single-unit buildings correlate exactly with single-family parcels—one house for every lot (the exception is N7 Hemlock with many single-unit buildings on one lot). However, the relationship of multi-unit building types to multi-family parcels is quite varied. In N9 Elm the number of buildings and parcels is pretty close; in N10 Village Green they are quite disparate. This is a function of areas with many parcels that have more than one building on them. This relationship can be measured by crossing multi-unit building counts with multi-family parcel counts by neighborhood.

Finally, the relation of building type to a third variable, land area, in can be seen by comparing building type counts with the parcel area in the same two graphs. Unlike either unit or parcel count, the difference between single-unit buildings and single-family land area shows some modest variation. This is not surprising as the land area of a single-family lot typically varies from place to place. However, for multi-family buildings, there is even stronger variation between values of building type and land area as shown in the gold bars at the top of the columns. It can also be noted in *Figure 5-16*, that when the parcel count values are proportionally lower the proportional value for land area is sharply higher. This suggests a potentially interesting pattern—the more buildings on a parcel, the lower the density of *buildings per acre*. Based on the above observations, a series of comparative measures were derived as ratios of building type to dwelling units, parcel type, and land area.

Dwelling Units per Building: The relationship of building type and dwelling unit for both single-family and multi-family buildings across all neighborhoods is shown in *Figure 5-26* below. Since the number of units is always greater than or equal to the number of buildings, it made more sense to express the measure with building number as the denominator (e.g. four units per building is more understandable than 0.25 buildings per unit). Again, the light pink bars representing single-family dwelling units show a consistent value of one (one unit in one house) for all neighborhoods. However the height of the dark pink bars showing number of units per multi-family buildings vary widely across neighborhoods. The variation correlates pretty well with an important dimension of observed character—building size.

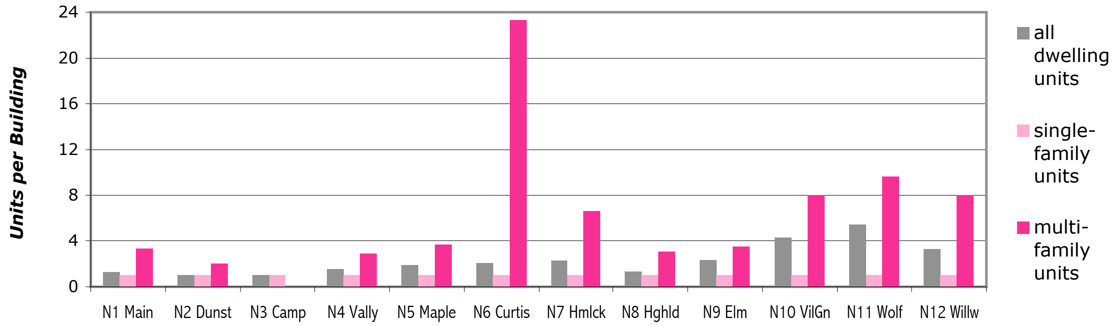


Figure 5-26 Dwelling Unit Type per Building by Neighborhood

In the middle and upper set, the newer neighborhoods (N6, N7, N10, N11) have about twice the number of units per building on average than the older neighborhoods (N5, N8, N9). This difference in building *scale* or *grain* was clearly perceptible in the field. Much like the scale contrast between green houses and red hotels on a Monopoly board, one can sense that the building pieces are simply bigger in some neighborhoods.

Row of small multi-unit buildings in N5 Maple (#5167)

Large multi-unit building in N6 Curtis (#3507)

Figure 5-27 Contrasting Scale of Multi-Unit Building Types

Values for the smaller scale buildings in older neighborhoods range from two to four *units per building* while those in new neighborhoods vary from six to ten *units per building*. In the case of N6 Curtis there is sharp spike—almost all of the multi-family units in that neighborhood are concentrated in a couple of large buildings. In general, *units per building* appears to be a useful measure of neighborhood *grain* and *scale*.

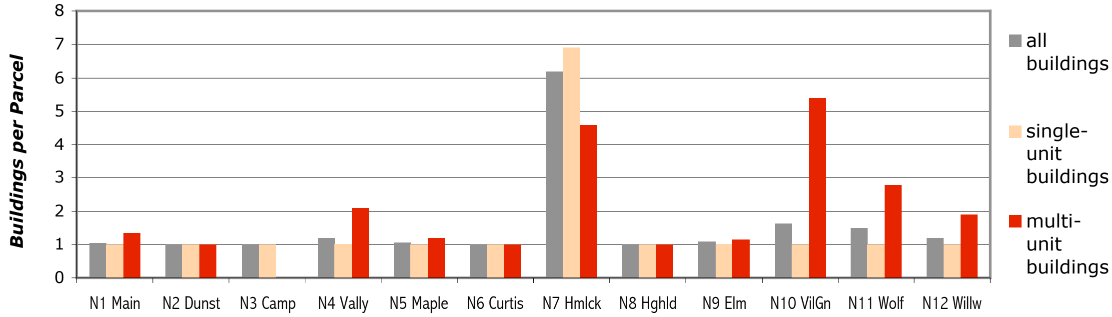
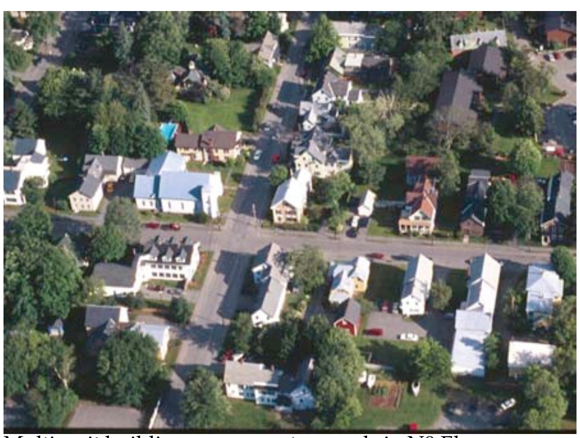


Figure 5-28 Building Type per Parcel by Neighborhood

Buildings per Parcel: Another promising measure of the residential fabric is shown above in *Figure 5-2—buildings per parcel.* Single-unit buildings (the middle bar) again score one with the exception of N7 Hemlock which measures nearly seven *buildings per parcel*—a difference in value that reflects its contrasting character with other single-family areas. Values for multi-unit buildings again show a strong correlation with observed differences between neighborhoods in the two upper density sets. The height of the right bars clearly distinguish the pattern of single multi-unit buildings on single parcels in older neighborhoods with patterns in newer neighborhoods such as N7, N10, and N11 that average three to five multi-unit buildings per parcel—see below.



Multi-unit buildings on separate parcels in N9 Elm

Six multi-unit buildings on one parcel in N11 Wolf

Figure 5-29 Contrasting Numbers of Multi-Unit Buildings per Parcel

Surprisingly N6 Curtis, a newer neighborhood that scores similar to the newer set by measures of *units per building* and *units per parcel,* scores the same as older neighborhoods. Its large multi-unit buildings all have their own lots—possibly due to the residual influence of the pre-war parcelization along this neighborhood's main street. Also surprising is the moderately high value for N4 Valley, a neighborhood with mostly older multi-units buildings that appear to be on separate lots. The high score is largely explained by a Dartmouth College redevelopment that combined older buildings on twelve separate parcels into a single redevelopment parcel with 37 units in 12 buildings. The measure picked up a more subtle aspect of neighborhood character not apparent in casual observation. This is a difference that can be seen in neighborhood-based university housing in other places as well.[10]

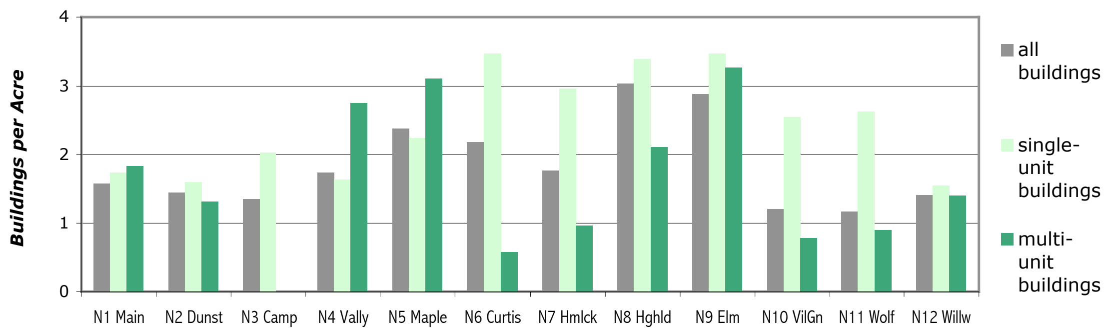


Figure 5-30 Building Type per Acre by Neighborhood

Buildings per Acre: A third building-related measure, *buildings per acre*, is shown in *Figure 5-30*. This re-expresses the traditional *units per acre* measure of neighborhood form by using buildings rather than dwelling units in the numerator. The resulting values are quite interesting. What is most surprising is that the *lowest* overall densities of *buildings per acre* are found in three of the four *highest* density neighborhoods as measured by *units per acre*—quite remarkable. The gray bars on the left representing densities of all buildings show values between 1.2 and 1.4 buildings per acre for N10, N11, and N12. These values are actually lower than those for the four *lowest* density neighborhoods—N1 through N4—that show density values ranging from 1.4 to 1.7 *building per acre.* In other words, neighborhoods that are three times as dense when compared by *units per acre*, are actually less dense when compared by *buildings per acre.* There are simply relatively fewer buildings in these places.

This relationship can be clearly seen in the comparative aerial views in *Figure 5-30*. Each view shows an approximate five-acre area with similar *unit per acre* density. The one on the left has more than twenty buildings (or more than four *buildings per acre*); the one on the right has about six buildings (or a little more than one *building per acre*). Contrasting qualities of *scale*, *grain* and *consistency* are clearly visible. Buildings are larger, more repetitive and setback farther from the street in the right hand view. This suggests *buildings per acre* may be a very good measure of these qualities—at least in this set of neighborhoods. It also suggests that the quality of *density* itself can vary considerably depending how it is measured.

The values for only single-unit *buildings per acre* densities are also quite interesting. Because one building equals one unit, the results mirror the single-family *units per acre* values shown *Figure 5-15.* While single-family densities step up with overall density in the lower and middle sets, they diverge in the upper set with densities rising in N9 Elm and dropping for the three new neighborhoods. These three higher density neighborhoods have relatively lower density single-family development patterns. This reinforces the perception that both density levels and urban form are more internally varied across these neighborhoods.

The values for multi-unit *buildings per acre* in *Figure 12* show much greater variation than those for single-unit buildings. They again reinforce the scores from several other measures that show distinct differences in multi-family areas in older small lot neighborhoods and newer large lot ones. The four older neighborhoods (N4, N5, N8, N9) have multi-family densities in the range of two to three *buildings per acre*, while the newer ones (N6, N7, N10, N11) are all below one *building per acre*. Again, these values correlate quite well with field observations of larger, more spread out buildings in these newer cases. It is also interesting to note that most of the multi-family units in the two older neighborhoods with the highest density of multi-unit *buildings per acre* were actually converted from small lot single-family houses in the 1960's and 1970's.

One final pattern worth noting is the different relationships *between* single-unit and multi-unit values within neighborhoods. In the older neighborhoods, single-unit and multi-unit density values for both *buildings per parcel* and the *buildings per acre* are quite close to each other—the height of all three bars are about the same. In contrast, values for single-unit and multi-unit densities diverge sharply in neighborhoods such as N11 Wolf Road for both measures. This suggests important differences in the relative scale, composition and inter-relationship of the two basic building types that make up these neighborhoods. In the older, small-lot neighborhood, both types are closely related—and even interchangeable—in density, scale, and pattern. This stands in sharp contrast to newer large lot neighborhoods where these two types tend to be completely independent of each other in almost every respect. Again, these distinctions seem important to understanding basic differences in neighborhood character.

Sub-Categories of Multi-Family Land Use and Buildings: While most of the analysis in this section focuses on the relationship of single-family and multi-family land use and buildings, some initial explorations of finer grain parcel level data was also carried out. As many of the key distinctions noted seemed to lay within multi-family areas, it made sense to look at whether the further sub-division of multi-family building and land use types could lead to even better correlations of neighborhood differences.

Distributions of the four multi-family categories (two unit, three unit, four to seven unit and eight plus unit) were studied by dwelling unit type, parcel type, land use area, and building type. The analysis concluded that the distinctions made using this finer grain data reinforce the general distinctions found using many of the other measures. It was less clear whether measures based on this finer grain data would significantly increase the ability to distinguish land-use related elements of neighborhood character. A fuller discussion of this analysis and associated graphs are presented as Appendix G. This may be an interesting area for future research.

5.2.3 Measuring Landscape Patterns

Finally, the last major element of neighborhood form, landscape, will be briefly considered. As noted earlier, landscape patterns at the neighborhood scale are infinitely complex with little existing data available in any consistent format. For these reasons the analysis of landscape pattern is limited to a general discussion of basic characteristics and measurement issues.

In New England, the dominant landscape characteristic is tree coverage. The most basic measurement would start by distinguishing areas covered by trees from those that are not. Trees are by far the largest physical elements in these neighborhoods. Mature trees can reach height of between fifty and seventy five feet—considerably taller than surrounding houses. The degree of tree cover is thus a major factor affecting neighborhood character. As can be seen in the aerial views of *Figure 5-31 Landscape Patterns*, tree coverage patterns vary significantly between the case studies.

Unlike most other elements of neighborhood form, landscape and tree data is not easily compiled at the parcel level. First of all, the data simply doesn't exist and surveying them by hand is an extremely labor intensive task. While new Global Positioning System (GPS) technology would help, it remains beyond the scope of this project. Secondly, field observations suggest that neighborhood tree patterns often are organized along parcel lines. This makes them very difficult to assign to parcels. Thirdly, trees are natural elements whose patterns largely transcend parcel lines across a neighborhood. Their interconnected canopies make tree patterns quite complex and difficult to characterize. These patterns are readily visible in the aerial views in Figure 5-31. The most feasible neighborhood-wide measure would begin with only tree lines.

For these reasons, specific measurement of tree patterns was not attempted at the neighborhood scale for this project. A series of measures were developed for tree patterns at the more detailed scale of the street and block, where data collection was more feasible. These measures are reported as part of Chapter Six.

Figure 5-31 Landscape Patterns in Six Neighborhoods

5.3 Correlating Measured Values and Neighborhood-wide Perceptual Qualities

The focus of this chapter has been on developing a set of simple metrics to discern first order differences between neighborhoods. A number of measures were identified that showed significant correlation with observed differences among the twelve case studies. In particular, a set of measures modeled on the simple construction of the conventional density measure *dwelling units per acre* proved quite successful. Expressing measured values as simple ratios of some *measured element per standard unit* created a set of measures that were easy to calculate, easy to compare, and surprisingly sensitive to various pattern and form dimensions. Some of the more successful ratios included:

- Parcels / acre
- Intersections / acre (50)
- Blocks / acre (50)
- Units / parcel
- Units / building
- Buildings / parcel
- Buildings / acre

The use of parcel level data for parcel size, land use, dwelling unit, and buildings allowed many options for looking at the interaction of different relationships and elements. Deriving simple typologies for various elements helped to further break down the components of neighborhood form and isolate key relationships. Of particular value was the ability to analysis contrasting patterns of single-family and multi-family development from case to case. The greatest degree of variation in form was found in the upper two sets of cases that mixed single-family and multi-family uses. A general distinction was found between the neighborhoods with smaller lot patterns and those with larger lot patterns. The most difficult challenge was to represent patterns of spatial distribution. Breaking down analysis units into smaller geographic units such as blocks or land use areas offered some promising potential.

The process of deriving and testing measures was guided by a continuous effort to correlate calculated values back to the observed variation in neighborhood form summarized at the end of Chapter Four. Differences were considered in relationship to a series of qualities hypothesized to be key aspects of neighborhood form. Examples of these qualities include *grain, scale, order, consistency, connectivity* and *adaptability*. A number of the measures were found to be helpful in describing the range of observed differences related to many of these qualities. Others such as those attempted for order and adaptability were not successful. Before moving onto the next chapter, some preliminary connections can be made between these qualities and related measures.

Grain and Scale: In general observed differences of *scale* and *grain* were successfully correlated with a number of measures—perhaps because these qualities are so strongly related to the easily measurable dimension of *relative size*. The number of *parcels per acre* proved strong measure of average grain and scale between cases. The relative mix of neighborhood grain could be seen in the *% distribution of parcel types*. The convention measure *units per acre* was actually pretty good measure of scale for single-family areas. The relationship of one unit to one building to one lot resulted in similar single-family values be associated with several other measures—although with some interesting exception in certain cases. Pattern variations for multi-family areas were far greater. A series of measures including *units per parcel*, *units per building* and *buildings per parcel* were particularly useful in differentiating issues of grain and scale for buildings, parcels and land use for these areas. In general measures linked finer grain of small lot neighborhoods with patterns of smaller buildings and higher densities in multi-family areas across this set of case studies.

Consistency and Variation: Internal spatial patterns and distributions were more difficult to discern. When *variation* of type (e.g. dwelling unit, parcel size, building type) was relatively uniform, the patterns were relatively consistent and easy to measure. However as types become more mixed, especially in the upper density sets, patterns of internal variation were more likely to be masked. Comparative analysis of single-family and multi-family types using three measures, *parcels per acre, buildings per parcel,* and *buildings per acre* were especially helpful in discerning internal distributions. Resulting values suggest newer large lot areas tended to have much more contrasting and differentiated internal patterns while smaller lot areas tended to be associated more internal *consistency* of character. These values generally correlated with observed variation between cases. Other measures used block-by-block comparisons to assess relative character differences in between parts of study neighborhoods.

Connectivity: The degree of *connectivity* is much more straightforward issue. It is directly linked to the degree of interconnection within neighborhood street, path and trail networks. It needs to be considered as both from connections within the neighborhood and connections in and out of the neighborhood. *Average block size*, which has proven a relatively good first order measure in other studies, was problematic measure within this particular set of cases due to difficulty of in consistently specifying the unit of *block*. Other measures were more successful. *Intersections per acre* proved a good of measure of internal connectivity after some adjustment to differentiate close-ended from open-ended streets was made. *Number of external access points per acre* was also a good measure of external connectivity for both street and trail networks. In both cases increasing the area unit from one acre to fifty acres created a number that was more intuitively associated with a single neighborhood.

Order and Arrangement: These qualities were very difficult to capture with any simple measures. Some initial efforts to capture ordering characteristics such as orthogonality proved unfeasible. Spatial order seemed to be best described in terms of overall typological patterns. It was noted that the relative congruence of certain patterns associated with the smaller lot cases suggested a greater degree of order within certain neighborhoods. Such congruence seemed to break down in larger lot neighborhoods. The use of certain measures as proxies for pattern typologies seemed to be a promising area for further research. An even broader sample of cases would benefit such efforts.

Adaptability: While serious efforts were not made measure this quality, it is an important element of neighborhood character that deserves a brief discussion nonetheless. Though no data was collected on change over time for these case studies, field observations offered some considerable sense of relative differences between cases as well as patterns that appear to be associated with them. In a number of the older small lot neighborhoods there was considerable evidence that land use type had changed incrementally over time to adapt to changing needs (e.g. a single-family house being converted to multiple units or a non-residential use). There was less evidence of similar adaptability in newer large lot areas although the relatively young age of these cases makes them difficult to fully assess. However, gathering parcel level data on changes in land use, building and even landscape is seems quite feasible. It is a promising area for future research.

Validity Testing of Derived Measures: Up to this point, the correlations between measured values and observed qualities have been primarily based on the researcher's own analysis of the physical differences between neighborhoods. Chapter Six covers the development of a second set of measures linked with observed qualities at the more detailed scale of street & block. Chapter Seven will discuss the use of a *Neighborhood Evaluation Survey* to evaluate how these qualities are perceived by a broader population sample in a series of controlled field tours. Finally, Chapter Eight tests how well the derived measures correlate with survey qualities by comparing calculated values with average survey scores.

End Notes:

Note 1 Compiling Hanover Land Use: *The process was slowed by a couple of days by the discovery that the Hanover database was mysteriously missing about 50 parcels for no apparent reason. After working with the town assessor's office, it was discovered that, due to some glitch in their database, including the data field "accessory buildings and special features" in the query resulted in omission of any records (ie parcels) where this field was blank. A second query was done. The omitted parcels were found and plugged into the project spreadsheet.*

Note 2 Methods of Deriving Multi family area Unit Counts: *For multi-family condominium projects, unit counts were calculated by adding up individual condo records within the master parcel record and then confirming them in the field. For multi-family rental units, it was more difficult. For newer neighborhoods, these land use types tend to be larger projects. For the largest ones in Lebanon and Hanover, detailed notes that almost always had number and type of units were reviewed in the assessor's office. For Hemlock Ridge in Hartford, unit counts were calculated from the as-built drawings from the developer. In other cases, such as Main Street or Village Green counts were made in the field by using mailboxes or utility meters or maps on signs to assist visitors find units or in one case interviewing the postman as he delivered mail. In the older neighborhoods, the most efficient way was simply to count in the field. Only Maple and Elm had a significant amount of parcels in the higher intensity land use classes. Careful counting of meters and or mailboxes determined unit counts. In several cases, small errors were also discovered in the assessor's records.*

Note 3 Willow Springs Density Revision: *Over the course of compiling neighborhood data, the initial neighborhood area of N12 Willow Springs (22 acres) was determined to be even smaller than initially estimated (27 acres) and perhaps too poorly defined to comprise a viable neighborhood. When an alternative boundary was defined to include a more comparable neighborhood area, the calculated density fell from about 6.8 to 4.1 units per acre—more comparable to the middle density set than the high one. In unit mix, however, it remains more comparable to the higher set (80% mf). Calculations were run for both alternatives and it is viewed as a "hybrid" neighborhood for analysis purposes.*

Note 4 Condominium as Land Use Type: *Some modifications were required to account for the land use category of "condominium". This was a category used in most of the databases. From a tax assessor's point of view, knowing the type of ownership is a worthwhile distinction. They typically are given a parcel number even though they don't typically occupy their own piece of land. However, from an urban form perspective it is not a very useful distinction. Although in common real estate jargon a "condo" usually refers to a suburban or resort style townhouse, condominium is in fact a type of ownership can take any physical form—from a single family detached house, to an industrial loft, to a duplex or row house. Thus for this study all the condominium land uses were re-classified to the land use category more closely allied to their particular physical form.*

Note 5 Coding Parcel Level Land Use by Building Type vs. Total Units: *For instance, at Hemlock Ridge one parcel had 27 single family homes on it (they were condominium ownership) each with their own driveway, garage and yard (though not precisely delineated). Clearly, as a land use type, it is closer in character to a group of single-family homes than to an 27 unit apartment building. The relationship between building types, number of units, number of buildings and parcel size will be one to the key set of metrics that will be explored in this section.*

Note 6 Coding Building Type on Certain Mixed Type Parcels: *For example on Valley Rd, 1-5 Park Street was a Dartmouth College redevelopment of an entire block that arrayed 37 units within 12 new and old buildings on a single combined parcel. It included 1 single-family house, 4 duplexes, 2 three unit buildings, 3 four unit buildings and 2 five unit buildings. While breaking out building type required a two little "tables within a table" in the land use spreadsheet, a more sophisticated database could probably have allowed for automatic tracking of multiple types within a single parcel.*

Note 7 Treatment of Special Conditions in Building Type Assignments: *In four instances, residential units were located in buildings that were primarily non-residential uses (e.g. an apartment above a lawyers office or rental house attached to a funeral parlor). The parcels were assigned as a non-residential land use, the units were counted in the unit count, and the buildings classified as a "mixed use" type. In several other instances, there were "group houses" that functioned and looked used more like multi-family structures than single family homes. They were simply assigned a "3 unit" use and building type in all cases. Despite these exceptions, a pretty accurate count of overall land use assignments, unit counts and building counts was compiled using straight-forward methods that could be easily replicated. Photographs and field checks helped confirm unit counts and standardized methods helped resolve any unique conditions.*

Note 8 Variation of Non-Residential Parcels in the Database: *It just so happened the pattern of blocks in one neighborhood had a number of businesses at the edge of the primarily residential blocks. While the other had a block pattern that isolated most of the adjacent nr uses just across an alley street on a separate primarily non-residential block. In this case it was a close call on whether or not to include that block. However, in order to treat the definition of boundaries in as consistent way as possible, the block was left out. And overall the included parcels in either case were only a relatively minor part of the mixed us context of the neighborhood.*

Note 9 Unevenness in Accounting for Open Space Parcels: *Elm's open space parcel were mainly comprised of a couple vacant or split lots. While Highland had a school yard, a cemetery, two church yards, and a stream ravine immediately adjacent, none of them fell within the neighborhood boundary. So the number of open space parcels included in the analysis may not be a very good measure of related open space character of the neighborhood.*

Note 10 Subtle Character Differences of University Housing: *A very similar subtle difference in character was noted during a spring trip to Cambridge, MA. The residential character of the neighborhood housing that was owned and renovated by Harvard was distinct from surrounding privately owned parcels. The parcels were often interconnected walkways that allowed free passage between them. They did not have the same sense of private yard as adjoining houses and apartment blocks. There was a more public quality to the landscape even though the building types were identical to surroundings.*

Close study of these town plans leads inescapably to the conclusion that the very real visual distinction of the New England village stems less from the merits of their two-dimensional plans than from the combination of buildings and plant materials that developed by semi-accident many years after their layout. Perhaps this merely proves that simple plans often adapt best to changing circumstance. So while the plans were simple but varied, it is the third dimension of the villages that are cherished. The scale, the materials, the architectural designs inherited from abroad but modified to meet the new environment—all combined with a village layout to produce a total quality of community that has yet to be equaled in America except in isolated towns of outstanding character (p. 128).

• John Reps The Making of Urban America

Chapter Six:

DERIVING STREET / BLOCK SCALE MEASURES:

A second set of exploratory measures address the more detailed scale of the street and block. In contrast to the broad two-dimensional patterns of the whole neighborhood, this discussion concerns the three-dimensional realm of experienced space—the world of walking around the block and driving down the street. While the elements of neighborhood form remain the same (buildings, trees, streets, blocks, lots, etc), the analysis must now take into to account a new third, vertical dimension. The inherent spatial complexities of this scale create a series of difficulties related to measuring the key relationships underlying neighborhood space.

The derivation method used in the last chapter is again followed for this series of measures. It comprises a trial and error process that identifies simple, discrete relationships within the associated data set and compares resulting values with observed variation between the case studies. The measures are calibrated using the researcher's own perception of the differences between the cases built up through the documentation and analysis of the twelve case study neighborhoods. A summary of the researcher's baseline rating for qualities relating to the street/block scale is presented in Table 4-4 at the end of Chapter Four.

The measurement process is again organized around an expanded parcel-level database that includes a range of street/block dimensions such as street width, setbacks, building height, and tree cover. For each set of measures an initial discussion explores potential patterns and spatial distributions in the data. Based on those results, key relationships between variables are probed and expressed as simple measures. The resulting values are tested against observed differences between neighborhoods to see how well they capture the key qualities of neighborhood form. Measures are refined and adjusted until a reasonably good set of measures is found connecting urban form variables with a given spatial quality.


The lineal spatial void of a street corridor (#3545)


The transition zone & the enclosing edges (#5299)

Figure 6-1 Components of a Street/Block: A Corridor and its Defining Edges

Blocks & Street / Edges & Voids: The universe of analysis for this chapter is the common domain of a neighborhood; the shared spaces through which residents and visitors experience and understand the neighborhood. While this experience can be constructed episodically as a series of linked spaces over time, this analysis will focus on measuring a single unit of identifiable space. For neighborhoods, the dominant unit of space is almost always the street corridor and adjacent edges and transition spaces through which people access their dwelling units—see Figure 6-1. In the absence of any accepted specific term describing this realm of neighborhood space, the hybrid term *street/block* will be used for this analysis.[1]

As with any space, neighborhood space is essentially a negative phenomenon. It is a void. Its form depends on the positive elements that define its edges. Much as a room is cannot be a room without walls, the dimensions and character of neighborhood space are defined by its edges. In this case the *void* is comprised of the street right-of-way and drives, yards, walks, entry of abutting parcels. The *edge* includes buildings, trees, walls, fences, and ground surfaces that define the boundaries of a discrete space. The increment of block limits the space in a longitudinal direction. The intent of this project is to measure only first order characteristics of three-dimensional space—the basics of the *street/block* and its defining edges.

Like any three-dimensional space, the *street/block* can also be described in terms of x, y and z dimensions. The two horizontal dimensions are almost never equal. One is longitudinal and runs along the centerline of the street.[2] The other is short and runs across the street—commonly represented as the *cross-section*. This results in two ends of the space being open and its two sides being closed. Not unlike a river or a hallway, this lineal geometry is strongly associated with movement. The third vertical dimension consists of the parallel block edges that contain and define the street. Modeling and measuring the relationships between these three dimensions is the nexus of research efforts at the street/block scale.

As with the previous chapter, the analysis of urban form will be built around a set of case studies. As described in Chapter Three, cases were selected from a universe of over one hundred street/blocks within the twelve neighborhoods. The final set included three matched pairs with similar densities but contrasting urban form. Each case was defined as a perceptible block of neighborhood space and represented a general type of street character.

Chapter Outline: The matrix at the end of Chapter Four identifies four primary qualities associated with measurable neighborhood-wide patterns. They include: 1) *enclosure*, 2) *scale*, 3) *permeability,* and 4) visual *variability*. The chapter begins with a summary of the compilation and specification issues related to compiling a consistent database for deriving measures. The heart of the chapter presents a series of exploratory measures. Unlike the previous chapter, these discussions will not be organized around individual elements but rather around the three major sub-components of street/block space: 1) the ground plane organization, 2) the enclosing vertical planes, and 3) the transition zone between them. This structure serves to emphasize the relationships between elements rather than separate patterns. Each discussion begins with a summary of related measurement issues and then moves on to describe a specific set of measures. The chapter closes with an evaluation of how well various measures captured first order differences between neighborhoods at the street/block scale.

6.1 Data Compilation & Specification

The complexity and limitations of street/scale does not lend itself to analysis by readily sorted classes of elements. As discussed in Chapter Four, there is almost no limit to the combination of elements that could be measured within this realm. The lack of existing databases at this more detailed scale further compounds the challenges of measurement. While this chapter is concerned with the same basic elements of urban form as the last one, the challenges of data compilation and specification are distinctly different.

There are at least three principal data challenges for street/block scale. First of all, the resolution typically found at this level of available data is too coarse for any but the crudest of comparative measures. Whether a building is twenty feet or forty feet from the street has enormous implications for spatial character. But in even in the best of existing GIS data sets, street edges at this scale wander aimlessly and building footprints look like children's drawings. Secondly, while it is conceptually an integral part of GIS databases, useful vertical data is non-existent in existing data sets. This dimension is a critical to measuring this scale. Finally, there is a menagerie of details such as architectural features, plants, fences, walls, hedges, utilities, signs, light posts, walkways, etc. that affect the quality of neighborhood space. While the extent to which this level of data can be incorporated into this analysis is extremely limited, certain key elements could be useful to include.

6.1.1 Building Data Sets

In the two-dimensional analysis, compiling data on street networks, blocks and parcels, tree coverage, land use distributions, building footprints was largely done by converting existing GIS datasets and assessor's records into a useable parcel scale data set. The lack of available data at the street/block scale presented a different set of challenges. While the existing database served as a useful organizing framework, an extensive effort was required to compile even the most basic data fields for the street/block scale analysis.

Compiling newly collected data within the same parcel-based framework established for the neighborhood-wide analysis was beneficial for several reasons. First, the parcel is generally a viable unit of analysis at the scale of an individual block and street (with certain exceptions that will be discussed shortly). Secondly, it provides a readymade structure that can efficiently integrate three-dimensional data onto pre-existing two-dimensional data sets and be easily expanded for future analysis. Finally it facilitates the same kind of simple descriptive measures used in the neighborhood-wide analysis. Simple relationships such as parcels per unit of street or ratios of height to width can be specified and measured. It also allows simple analysis of spatial distributions for irregular elements, such as trees, rather than measuring lump sum totals. A sample of the two-dimensional database expanded for three-dimensional data is shown in *Table 6-1 Sample Database for Two Street/Block Cases*.

ID	Area (ac)	LU	Units	Bldg	Blk	Address	Face-Face	St ROW	Str Wth	Str Vrg L	Str Vrg R	Blg S1	Blg S2	Blg H1	Blg H2	Lot Wth	Blg W1	Blg W2	Yrd Wth	Tree Gr	Tree F1	Tree F2	Tree S1	Tree S2
MAIN STREET			1.7	density			118	60	22	19	19	48	73	24	12	131	33	9.64	88	60+	30-60	15-30	30-60	15-30
14	0.70	1	1	1	1	371 MAIN		60	22	19	19	45		12		90	36		54			2	3	
15	0.70	1	1	1	1	377 MAIN		60	22	19	19	45		26		115	24		91		1	4	3	2
16	0.70	1	1	1	1	383 MAIN		60	22	19	19	45		22		120	38		82	1		1	1	
17	1.30	1	1	1	1	395 MAIN		60	22	19	19	45		32		290	30		260		2	13	8	2
18	0.44	1	1	1	1	409 MAIN		60	22	19	19	40	70	28	12	110	24	24	62		1	3	1	
27	0.74	2	2	1	2	410 MAIN		60	22	19	19	50		32		140	40		100	1	2		1	
28	0.50	1	1	1	2	400 MAIN		60	22	19	19	50		26		150	26		124	1	1	2	1	5
29	0.38	1	1	1	2	394 MAIN		60	22	19	19	50	75	28	10	110	30	30	50			3		2
30	0.37	1	1	1	2	386 MAIN		60	22	19	19	55	75	26	12	110	24	40	46		3		2	1
31	0.40	1	1	1	2	380 MAIN		60	22	19	19	50		12		110	70		40		1	1	1	
32	0.34	1	1	1	2	1 HAZEN		60	22	19	19	55	70	24	12	100	24	12	64		1	2	2	
par ac	6.57	11	12	11								100	max	45	max	1445	366	106	973	3	12	31	23	12
str ac	0.64					block 700 feet long						45%		54%		100%	25%	7%	67%					
tot ac	7.21																							
LONGWOOD LANE			1.8	density			149	40	30	5	5	59	65	15	10	123	50	1.88	70					
76	0.46	1	1	1	4	27 LASH RD		40	30	5	5	70		16		120	28		92		1	3	3	
77	0.49	1	1	1	4	3 LONGWOOD LN		40	30	5	5	65		18		120	50		70		2	1	1	1
78	0.49	1	1	1	4	5 LONGWOOD LN		40	30	5	5	65		18		120	50		70		1	2		2
79	0.47	1	1	1	4	9 DUNSTER DR		40	30	5	5	60		22		110	24		86	1	1		3	2
41	0.56	1	1	1	2	11 DUNSTER DR		40	30	5	5	50		18		120	70		50		1			
42	0.49	1	1	1	2	10 LONGWOOD LN		40	30	5	5	55		10		120	60		60			2		
43	0.47	1	1	1	2	6 LONGWOOD LN		40	30	5	5	55		10		130	60		70		1	1		3
44	0.46	1	1	1	2	2 LONGWOOD LN		40	30	5	5	55	65	10	10	140	60	15	65			5		2
par ac	3.89	8	8	8								100	max	45	max	980	402	15	563	1	7	14	7	10
str ac	0.46					block 500 feet long						59%		34%		100%	41%	2%	57%					
tot ac	4.35																							

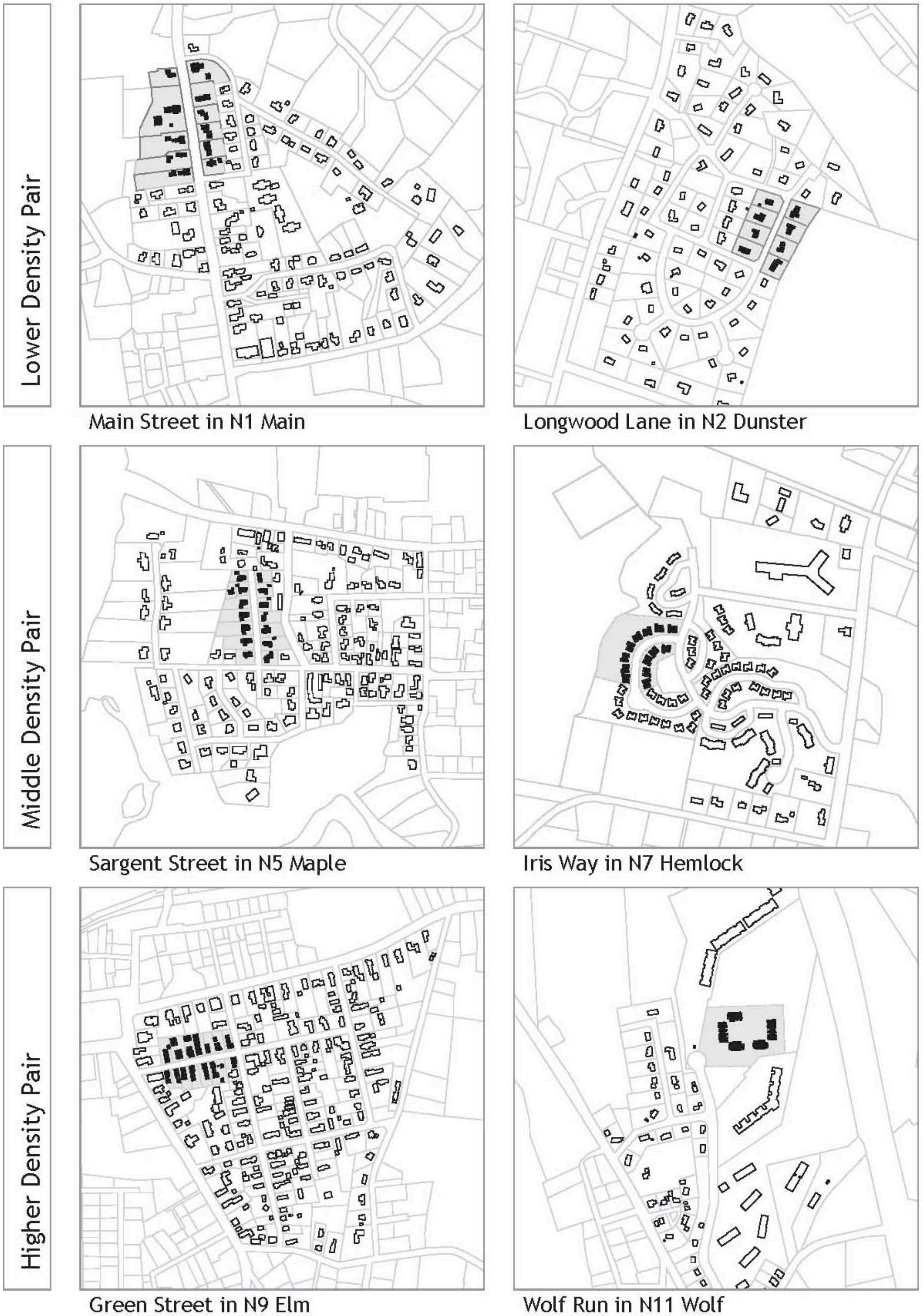
Table 6-1 Sample Parcel-Level Database for Two Street/Block Cases

Parcel Based Framework: Data sets for each of the six case study areas were developed by expanding existing parcel based databases with a series of new data fields for key dimensions at this scale. Basic parcel dimensions were compiled using existing GIS datasets. Additional fields were compiled from a variety of sources including ortho-photography, *as-built* drawings of individual developments, field photography, field measurements and field notes. Specific methods depended on the particular data field (e.g. tree locations, building height, right-of-way width). The particular compilation and specification issues are described in upcoming sections.

The number of parcel records varied from case to case depending on size of parcels and length of the block. *Figure 6-2 Context Map: Six Street / Block Study Areas* shows the parcel patterns in the context of each neighborhood. Study area sizes varied a bit by density class. The lower density areas ranged from four to seven acres, middle density cases from three to five acres, and higher density cases from two to four acres. In general, the limited number of records per study area suggested focusing on the relationships between elements rather than on patterns of individual elements.

Figure 6-2 Context Map: Six Street/Block Study Areas

1” = 1000’



The use of a parcel-based framework was somewhat complicated by two cases, Iris Way and Wolf Run, where the entire street/block area was only a fragment of a single larger parcel. Since a single record for a case study would obviously limit the resolution of the urban form data, individual buildings were used to define a proxy parcel pattern for these areas. Since the other cases were comprised of a one lot to one building pattern, using the building as the unit of analysis in these cases made some comparative sense. The use of proxy parcels for Iris Way and Wolf Run also allowed building related yard, tree, and landscape variables to be given spatial distribution. While this adjustment worked to create a more comparable data set, the inherent differences between single-building and multi-building parcels remain a critical issue of neighborhood character.

Using the building/parcel increment, the number of records for the case studies ranged as follows:

Main Street in N1:	11 building/parcels
Longwood Lane in N2:	08 building/parcels
Sargent Street in N5:	14 building/parcels
Iris Way in N7:	13 buildings (w/ proxy parcels)
Green St in N9:	14 building/parcels
Wolf Run in N11:	05 buildings (w/ proxy parcels)

Building Data Sets: After much deliberation about what type of data *could be* collected for each of the cases, it was decided to concentrate on types of data that were a) likely to be most useful in differentiating neighborhood qualities and b) relatively easy to compile and measure with available methods. The more focused analysis in this chapter called for data categories based on the physical structure of the space itself rather than individual elements. Categories were drawn from the basic three sub-components of street / block space: 1) the organizing horizontal plan, 2) the enclosing vertical edges, and 3) the transition zone between them. As the overall goal was first order measurement, data collection focused on key dimensions of spatial structure rather than assorted elements and details that overlay it. The key elements of each category was defined as follows:

- **Plan Dimensions:** Basic horizontal or ground plan elements including street section, building setbacks & locations, and landscape footprints.
- **Edge Dimensions:** Basic vertical elements of street elevation including spacing and height of buildings, yards, and landscape.
- **Transition Dimensions:** Basic elements of transition from built edge to street, including drives, parking, garages, fences, walkways, porches, and entries.

6.1.2 Plan Dimensions: Street Section & Setbacks

Basic street section dimensions were taken from the field survey of 73 neighborhood streets done in conjunction with the initial case study selection process. Since street width and street right-of-way dimensions are generally consistent, the initial survey provided a reasonably accurate measurement for each parcel record. However since full cross-sectional dimensions were only recorded for a single typical condition point on the block, additional measurements were required to gather building footprint and setback information for all seventy or so parcels in the six study areas.

Dimensions for building footprints and setbacks were compiled using available GIS data, ortho-photography, field surveys and, in one case, as-built, site plans. As with the two-dimensional data, the quality and extent varied from town to town. In Lebanon, basic 1"=100' plan maps with building footprints were made for Longwood N2, Green N9, and Wolf Run N11 using the GIS data set and recent (2002) high quality color ortho-photography. However, even with the best of available GIS data, the graphic registration between data layers was sometimes off by a factor of thirty to forty feet. These measurements were refined and corrected using ortho-photography and cross-sectional measurements taken in the field. This allowed relative positioning of building footprints with respect to determined setback and spacing dimensions for each building on the block. As shown in *Figure 6-3*, building setback dimensions were made from the wall plane of the main building envelope to the paved edge of the street. In some cases, this required adjustments when field checking found that porches or other covered structure were included in footprints taken from the ortho-photographs.


45-foot setback: street edge to building face in N3 (#3469)


32-foot setback: street edge to building face in N8 (#3671)

Figure 6-3 Setback Dimensions measured from Street Edge to Building Face

In Hanover (N5 Sargent), Norwich (N1 Elm), and Hartford (N7 Iris), GIS layers for buildings, street and landscape were either missing or so incomplete as to be useless. There were, however, reasonably accurate parcel layers and ortho-photography. In the Norwich and Hanover cases, older (1996), lower resolution photography with parcel lines was used to construct building footprint layers for each study site. The resulting base maps were field checked to verify accuracy and to revise dimensions as required. In the case of more recently developed N7 Iris Way, ortho-photographs only showed the site under construction. As shown in *Figure 6-4*, roads but not buildings could be seen. Data gaps for building locations and parcel lines were filled by photo copying, scanning and digitally tracing as-built site plans acquired from the project developer.

Finally, it is important to note the elements that were not included in the initial data set. While many of them appeared to impact spatial character, the limited scope of this first order assessment precluded their measurement. Elements included outbuildings (garages, barns, storage sheds, gazeboes, etc.), other non-enclosed structures (porches, decks, trellises, gazeboes, etc.), and a variety of site elements (driveways, walks, hedges, fences, gardens, etc.). Data for a select group of these elements was compiled separately as part of transition zone measurements.

Figure 6-4 Ortho-photograph (1996) with Iris Way in N7 Under Construction

6.1.3 Edge Dimensions: Building Height and Trees

Several issues made street edge dimensions more difficult to compile. The previous section provided basic plan dimensions but no data on building and tree height. The street-by-street case study selection survey made only the most general assessments of height (e.g. tall vs. short). Existing GIS data and ortho-photography provided little help either. General foliage lines could be seen on the higher quality Lebanon ortho-photography, but tree locations were hard to make out because images were taken before foliage was out. It was impossible to detect anything but specimen conifers with any accuracy. Only a most basic sense of relative tree and building height could be discerned from shadows. It could not be reliably scaled. Thus, gathering data for these dimensions relied entirely on field surveys and measurements.

For tree location, each site was field surveyed in the field using base maps with building footprints, streets and parcel lines. Tree locations were marked using relative visual measurement—locations were approximated from relative positioning to buildings, lot lines and edge of street. This proved an expedient method for reasonably accurate mapping of trunk locations. Relative canopy spreads were more difficult to record accurately. Tree height was used as a proxy for spread. Though differences between broadleaf and conifers were recorded, breaking them out within the database was not useful for measuring first order differences. Since the database is constructed on the increment of parcel, accounting for individual tree location was not practical or useful. Instead, parcel-based take-offs divided mapped trees on each parcel into two classes: 1) those in the front set-back zone (i.e. between buildings and street) and 2) those behind front setback (i.e. between buildings).

Trees were further classified by a second set of criteria related to height. A sample of tree heights was measured along each block using a hand held clinometer—a standard forester's survey tool used to gauge tree height. These known tree heights together with building heights provided a reference scale for comparative visual measurement of tree height. Based on this method, each tree was assigned to one of three size types: 1) medium 20 – 40 feet, 2) large 40 - 60 feet, and 3) extra large (XL) above 60 feet. Only about one-half dozen trees were found in the extra large classification, but the field was retained because they had such a significant impact on neighborhood character. Due to the minimal number of data points, the XL class was not sorted by front or side location. Trees or shrubs less than 20 feet high were not counted. While there was also considerable variation of tree shape and character, these basic type categories were deemed adequate for gauging first order differences.

For building height, a similar measurement protocol was followed. Using a 30-foot tape measure and a clinometer, several key vertical dimensions were determined for a representative sample of buildings on each street. Since floor-to-floor dimensions for residential building types on the same block were relatively consistent, it was fairly easily to extrapolate a building height for each structure accurately to within about two feet. Building height measurements were made in the vertical plane of the building face facing the street. A second height measurement was made for any secondary wing or ell that was set back more than ten feet from the front face.

Line of street trees in perspective create a visual edge (#3720)

A more oblique view shows wide spacing of trees (#3718)

Figure 6-5 The Impact of Visual Perspective on Perceived Enclosure

Measuring the vertical plane meant narrower buildings with gable ends facing streets have a proportionally greater measured value compared with wider but lower structures with eave lines facing the street. This seemed consistent with the perceived impact of *height* versus *width* on spatial enclosure. Field observations noted that the effect of visual perspective and the linear nature of street spaces tended to make *height* and *setback* relatively more important than *width* in determining perception of spatial enclosure. Views down a street tend to foreshorten edge elements and create a strong sense of edge even when elements are widely spaced. *Figure 6-5 Impact of Visual Perspective on Perceived Enclosure* shows how a row of street trunks can create a strong visual wall when viewed in perspective even though they have a very small relative width when measured in elevation.

6.1.4 Transition Elements: Walks, Garages, Porches, Entries

There are many elements that affect the spatial quality of the transition zone between the built edge and the street it defines. The underlying dimensional characteristics of building setback, height and width, and the basic element of trees have already been accounted for in the other measurements. A whole range of other factors such as porches, doorways, walks, driveways, windows, garages, gardens, fences, landscaping, etc. all contribute to character differences of the building-to-street relationship across the case studies. The challenge was to sort out which elements and relationships would best measure these differences in simple terms.

Large prominent garage and minimal entry porch (#3610)

Recessed garage and more prominent entry porch (#3718)

Figure 6-6 The Impact of Porches and Garages on the Transition Zone

For the purposes of this exploratory project, data compilation was limited to two elements that were identified as significant factors in the analysis of neighborhood form—front porches and garages. As *Figure 6-6* shows the presence or absence of these two elements can have a striking impact on the quality of the transition spaces. Field tours of all six case studies recorded basic dimensions for both elements along the street/block edge. Measurements were recorded on the same 1" to 100' base maps used to compile tree data and to verify setback dimensions. Width of both primary and secondary porches and/or garages was recorded. Other dimensions such as the height, depth and setback were also noted if they were significantly different from the typical condition—for instance a two-story porch or a garage that was pushed back or pulled forward—to allow a weighting factor to be incorporated into related measures.

6.2 Measuring Street / Block Relationships

With a basic database for street/block scale in place, a series of preliminary urban form measures were developed to capture key relationships through simple quantitative analysis. As with the neighborhood wide analysis, derived measures were compared with observed variation in neighborhood space and evaluated for fit. A single block of a street or a housing development is much easier to perceive as a tangible unit of analysis than an entire neighborhood. As shown below in *Figure 6-7*, it can be seen and experienced from a single point of view as a spatial whole with visible dimensions and physicality. As such, the relationship between physical form and perceptual form is more direct and easier to assess at the street/block scale.

The entire domain of a street/block unit can be perceived from a single point of view (#5244)

Figure 6-7 The Street/Block: A Perceptible Unit of Space

These first set of experimental measures address only the basic aspects of street/block space. The work is organized around the same three major sub-components that structure the data sets: 1) the ground plane, 2) the enclosing vertical edges (divided into discussions of cross-section, street elevation, and trees), and 3) the transition zone between built edge and street. This approach serves to emphasize the relationships between elements rather than isolate them as discrete patterns. The open-ended structure of the database allows new dimensions and new case studies to be added over the course of future research.

6.2.2 Measuring the Ground Plane: Elements of the Plan

As discussed early in Chapter Five, the division of land into parcels and streets comprise the basic framework of neighborhood space. The street is the shared corridor through which visitors and residents move as they come and go from individual parcels. It is this connecting function that makes streets fundamentally lineal elements. In theory, their length is almost infinite—a continuous system of rights-of-way connects together virtually every street in the continental United States. While for the purposes of analysis, the length of case study streets is restricted to single block, the street's inherent longitudinal bias remains. As such, the key dimensions of any street is cross-sectional. This is where the primary variation in dimension and character occurs.

Figure 6-8 Diagram of a Typical Street Cross-Section

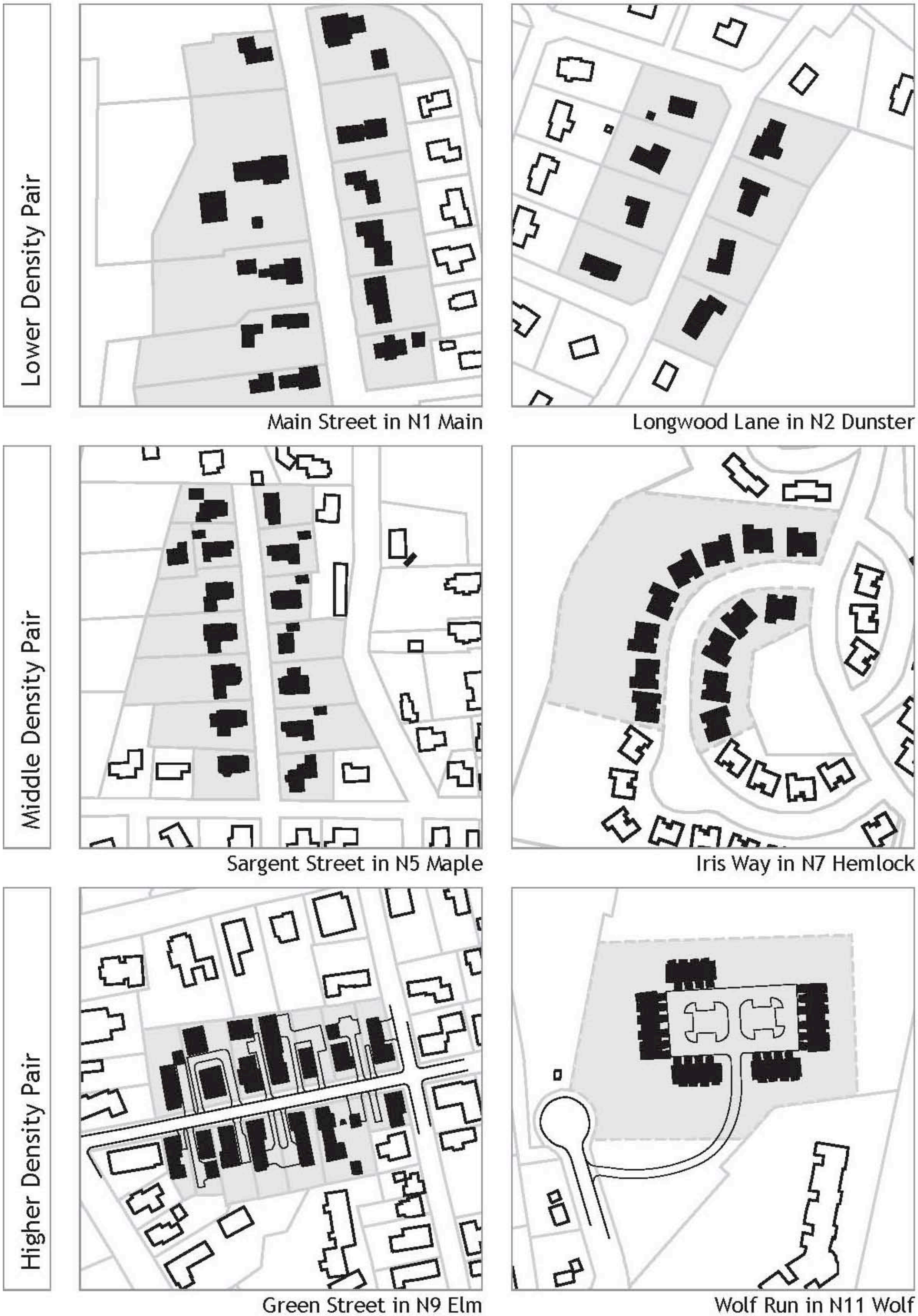
Dimensions of Street Section: As shown *Figure 6-8* above, a typical neighborhood street has at least three key cross-sectional dimensions. The fullest width of the street corridor defined by the *building face to building face* dimension. A second measure, the street *right-of-way* (ROW) width, measures the legal corridor reserved for public use and travel—it also defines the front property line of adjoining parcels. A third measure, *width of pavement*, describes the street more specifically as a paved surface for vehicular travel. Two other key dimensions describe sub-sets of the cross-section. The *verge* width measures the strip of land between the edge of pavement and the right-of-way line on both sides of the street. It typically includes any planting strips or adjacent sidewalks. Finally, the *setback* dimension covers the distance from either the right-of-way line or the edge of paving line to the face of adjacent buildings.

Figure 6-10 Detail Plan of Six Street/Block Study Areas shows the basic framework of street right-of-way and building footprints for all six cases. *Figure 6-9* below shows typical width of the street corridor in the six study areas. The values correlate fairly well with housing densities. Greater width is linked with lower density and larger setbacks; narrower width with the higher density and smaller setbacks. Of course this is only an average dimension drawn from average building setbacks of both sides of the street. As such. this dimension doesn't fully account for spatial variation along a block.

Figure 6-9 Street Cross-Section: Average Fact to Face Dimension

While it provides a reasonable overview of general scale, this measure does little to explain character variation between streets at the same density level. It confirms the earlier finding from the case study selection process; standard density is actually a pretty good general measure of street *scale*. The lower the density, the farther apart the

Figure 6-10 Detail Plan of Six Street/Block Study Areas 1" = 300'



buildings are, the higher the density, the closer together they get. Across all 73 streets that were measured in the selection process, face-to-face dimensions ranged from about 110 to 150 feet for lower set; from 80 to 100 feet for the middle set; and from 60 to 80 feet for the higher set. Thus, the small detailed study sample is fairly representative of Upper Valley streets. It should be noted in newer multi-family areas where street corridors are less clearly defined, face-to-face values sometimes fluctuate to the point of not being useful. This issue will be discussed in upcoming sections.

The next set of measures deal more with the street proper. Due to the lack of a street edge layer (versus street right-of-way) in most GIS data sets, mapping the actual paved street, driveways, and parking areas was not feasible for most of the study areas. It was possible to digitally trace paving patterns off high quality ortho-photography for only the highest density pair—Green St N9 and Wolf Run N11. *Figure 6-11* below compares right-of-way dimension, street width and verge width across all six study areas. While these are average values based on parcel level data sets, there is no change between the individual parcel values and the average value. As with most American streets, the cross-sectional dimensions are consistent along any given block.

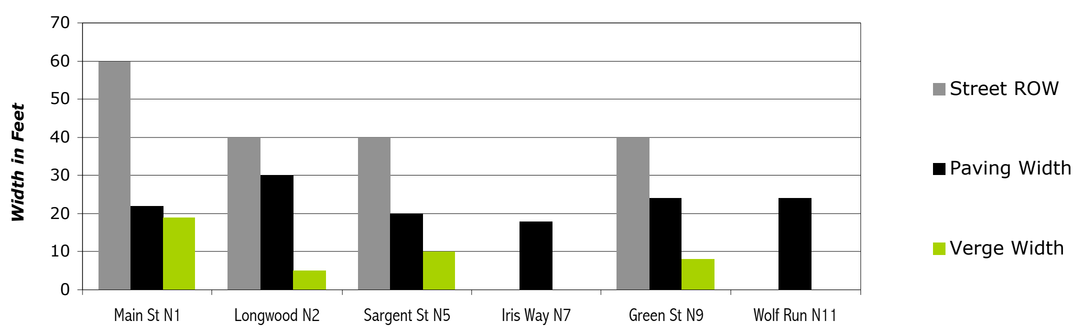


Figure 6-11 Street Cross-Section: Width of ROW, Paving, and Verge

Street *paving width* in the Upper Valley is relatively consistent in value—even across density categories. The black bars show paving width for all six case study streets. They are representative of the larger set. Paving width of four of the six cases falls within the most common range of 20 to 24 feet. Longwood N2 (30 feet) and Iris N7

(18 feet) fall toward either end of the distribution range. Even within this relatively narrow distribution, street width values seem to have a correlation with differences in observed character. As illustrated in *Figure 6-12* below, the scale of 30-foot-wide Longwood (S2) feels significantly larger than 18-foot-wide Iris (S4)—although other factors such as setback are likely to also affect perception of *scale*.

The 30 foot paving width of Longwood Land N2 (#3543)

The 18 foot paving width of Iris Way in N7 (#3887)

Figure 6-12 Comparing Street Width Extremes: Longwood N2 vs. Iris N7

Right-of-way width is also fairly constant across the Upper Valley sample. Most streets tend to be 40 feet wide, although 50 feet widths are found on some newer streets. A 40-foot right-of-way leaves a 10-foot verge on either side of a 20-foot wide street. Sargent N5 represents this typical condition on the *Figure 6-11* graph. As paving width widens, verge width narrows (e.g. Longwood S2). However, as illustrated in *Figure 6-13* above, when there are no sidewalks or elements to mark the right-of-way, the verge zone blends into the front lawns of adjacent houses.

The verge zone becomes visible only when there is some marking of the right-of-way line—see *Figure 6-13*. When a sidewalk runs along the right-of-way line the verge is visually defined by a change in materials in the ground plane. Vertical elements such as a fence or hedge can also mark the verge and ROW in a variety of ways that affect the quality of street/block space. For the verge to read clearly as linear space, the right-of-way needs to be marked continuously in some fashion (e.g. fence, sidewalk). Lines of street trees can also mark the verge—not a commonly found in the Upper Valley.

Verge/ROW line blend into yards on Longwood N2 (#3544)

Sidewalk & trees mark verge zone on Bank St in N9 (#3749)

Verge/ROW line marked by picket fence on Main N1 (#4493)

Verge/ ROW line marked by hedge on Sargent N5 (#4942)

Figure 6-13 Variations on Spatial Definition of Street Verge & ROW Line

Of the study set, only Main Street N1 has a well-delineated verge zone—marked by in alternating fashion by fences, hedges and street trees. This pattern creates a more complex cross-section that differentiates public street from private yard.

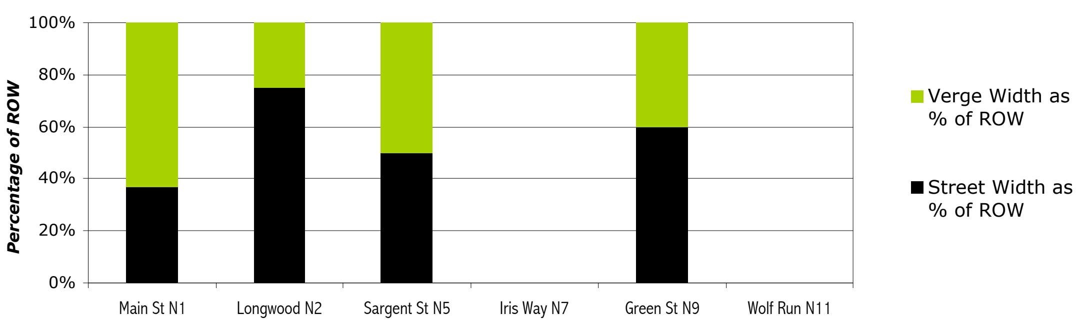


Figure 6-14 Pavement and Verge Width as Percentage of ROW

As shown in *Figure 6-14* above, one approach to measuring the extent of verge within the street section is percentage of right-of-way width. While this is potentially a very useful measure of the proportion of open space within a right-of-way, the general lack of street right-of-way demarcation on Upper Valley streets limits its utility in this context. Green space within the right-of-way cannot be visually distinguished from that of adjacent lawns. A relationship that seemed significant in plan view turned out only marginally useful when applied in the field. In a more urban context, where right-of-way lines are more strongly marked, this ratio would be likely have a much stronger correlation to differences in street character. The relationship of green space to paving within a street right-of-way can also be re-expressed as a more comparative ratio of *verge width per foot of paving* as shown in *Figure 6-15* below.

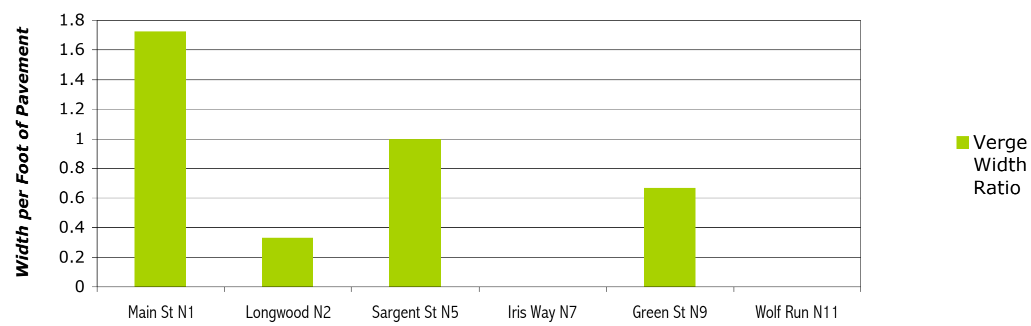


Figure 6-15 Street Cross-Section: Verge Width per Foot of Pavement

Perhaps the most significant cross-section ratio in *Figure 15* are the ones that aren't there. There is no right-of-way value for either Iris Way N7 or Wolf Run N11 because they do not share the street right-of-way system that traditionally organizes neighborhood space. They are private ways accessing multiple buildings on a single privately owned parcel. The street zone is simply defined by the paved surface.

This has several implications for differentiating the character of neighborhood space. First of all, privately held spaces feel differently than public ones in subtle ways. They are quite simply more private. On a public street right-of-way, though neighbors may wonder about a stranger, he or she has a legal right to pass. On a private drive, a stranger is technically trespassing. While this territorial distinction may not be obvious in casual observation, there is a palpable difference in the perceptual quality.

Iris N5 has many detached homes on a common lot (#3877)

Sign marking of private territory on Iris Way N7 (#3898)

Variable street geometry on Wolf Run N11 (#4039)

Mixing parking lot and street on adjacent Ivy N11 (#4067)

Figure 6-16 Private Streets serving Multiple Buildings on a Single Parcel

Secondly there is no right-of-way to delineate public travel from private access and parking. Functions of circulation and parking become more mixed—especially in multi-family areas as shown above in *Figure 16*. The resulting variations in street geometry are almost limitless. Widths change, parking bays branch off, landscape islands protrude. In some projects the street function is simply absorbed into a parking lot. Since private streets are not subject to the public street standards, there is little to encourage much in the way of consistency in their design. Deriving simple metrics to describe them is quite difficult. For example, specifying a standard protocol for measuring something as simple as a street can be quite a complex task.

Finally, within the twenty or so private drives surveyed in the 73 street sample, the relationship of street to building was found to be highly variable. In some cases, buildings are only located along one side of the drive corridor. In other cases, there is no discernable geometric relationship between the drive and the buildings it serves. Thus it is not only the geometrics of the paved street that varies but the shape and character of the enclosed space as well. Spatial character tends to be much more free form and difficult to pin down. Unlike the simple parallel geometry of a standard street, these spaces are very difficult to measure in standardized terms.

6.2.3 Measuring Enclosing Edges: Cross-Section

The vertical dimension plays a primary role in the human environment. The human body is a vertical element in a horizontal world. Planting a vertical pole in the ground is thought to be among the earliest markings of symbolic space. From the earliest settlements, vertical edges such as walls or structures have defined and enclosed the spaces of human habitation. Spatial enclosure is inseparable from the history of architecture and urban development. Within this context, it is not surprising the spatial identity of a residential neighborhood depends to a great degree on the delineation and enclosure of space by vertical edges.

Composite view of the mix of houses and trees that make up the street elevation along street/block Sargent N5 (#4927-4929)

Figure 6-17 Street Elevations are Primarily Defined by Buildings and Trees

As shown in the composite photo in *Figure 6-17*, the major elements of street enclosure are buildings and trees. The principal space that they enclose is the street—the basic building block of neighborhood space. In the case of a typical neighborhood street, there are at least three sets of dimensions that influence its spatial character. The first set delineate the *parcels* that front onto it; the second set describe the ensemble of the *buildings* that line it, and the third set locate the size and shape of *trees* that grow along it. Dimensioning these elements and the relationships between them provides a solid foundation for drawing first order character distinctions between neighborhood streets & blocks.

Parcels: Parcel lines literally lay the groundwork for three-dimensional space by creating a framework for development. The primary parcel dimension affecting street definition is width or frontage. Parcel frontage is the side of the parcel adjoining the street right-of-way. The frontage lines delineate the boundary between the public and private space. Parcel frontages also segment the length of a block into discernable units that govern the spatial rhythm and order of the street. Frontage dimensions can be wide or narrow; they can be similar or varied. Parcel width also dictates the relative spatial separation between neighbors.

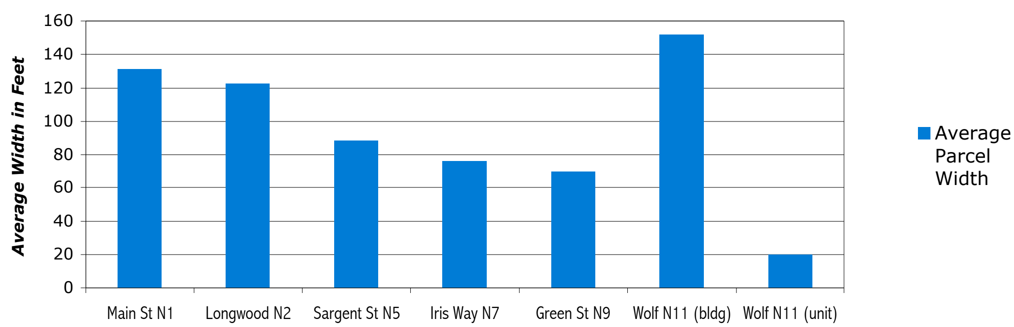


Figure 6-18 Street Edge: Average Parcel Width

Figure 6-18 shows the average values for all the parcels fronting on the six case study blocks. For cases Iris Way N7 and Wolf Run N11, frontage width is interpolated from centerlines between buildings. Not surprisingly, the average width tends to go down as density goes up—smaller lots correlate with higher densities. However, this relationship breaks down when there is more than one unit on a parcel. On Green N9, lots are only slightly narrower despite being 50% more dense than the middle density pair. The limitations of this measure shows even more strongly for Wolf Run which has more than one unit per building *and* more than one building per parcel. Two calculations for proxy parcel width were made—the left is based on building spacing (152'), the right is based on width of a townhouse unit (20'). If actual parcel frontage were used, the blue bar would literally be off the chart (several hundred feet) but in this case there is no parallel relationship because in this case the street / block space is *inside* the parcel as opposed to *fronting onto it*. While all these dimensions can be perceived in the field, none are comparative in format to the other five streets.

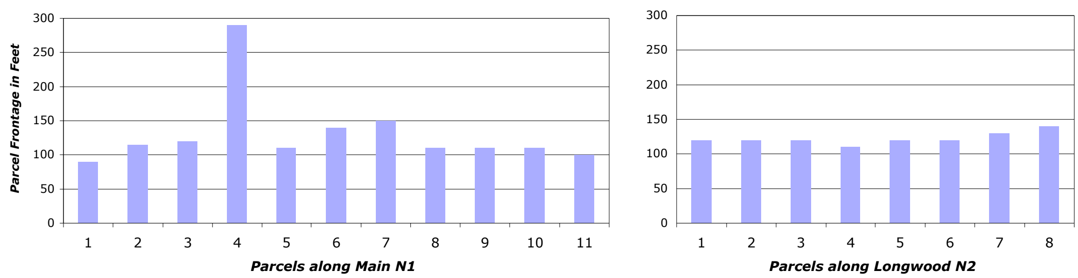


Figure 6-19 Distributions of Parcel Frontage: Main N1 vs. Longwood N2

Average values also describe nothing about the relative *distribution* of individual values. For example, Main N1 and Longwood N2, have similar average frontage values—Main is 131 feet, Longwood is 123 feet. As was found for neighborhood parcel patterns, this similarity masks the great range of frontage values along Main Street. The contrasts in frontage distribution can only be seen when data is arrayed as individual widths are shown in *Figures 6-19.* The more consistent width of parcel frontage on Longwood N2 can reflect the more consistent rhythm of the street.

Building Setback, Height, & Width: Things began to get more interesting when adjacent buildings were considered. Buildings, unlike parcels, are three-dimensional and solid. They are a primary shaper of neighborhood spatial character. The building edge has three principle dimensions: 1) setback, 2) height and 3) width. The *setback* modulates the cross-sectional scale of the street. Building *height* modulates vertical scale. Finally building *width* in relation to parcel width modulates elevation scale along the street.

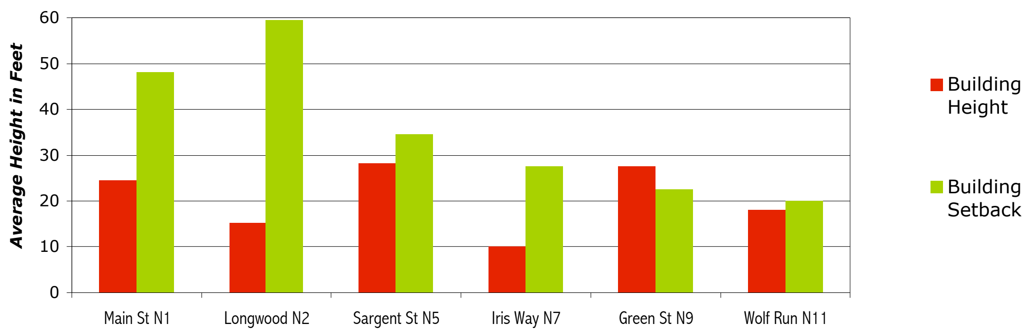
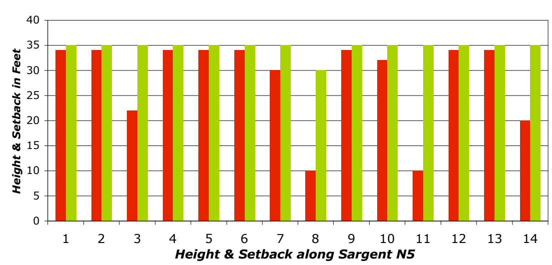


Figure 6-20 Street Edge: Average Building Height and Setback

Figure 6-20 shows the key cross-sectional relationship between height and width. This relationship has long been understood in the field of urban design to be a key ratio affecting sense of street *enclosure* and *scale*. Both values show considerable variation across the set. While setback seems to vary pretty much *with* density level (similar to face to face dimension), the building height tends to vary *within* density level. Building height tends to be greater on older blocks with gables facing the street—Main N1, Sargent N5, and Green N9. Lower values are associated with newer blocks of more horizontal buildings with eaves facing to the street.



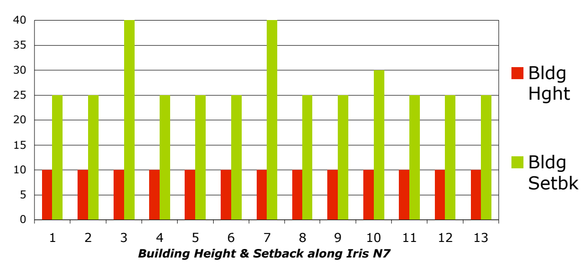


Figure 6-21 Distribution of Building Height & Setback: Sargent N5 vs Iris N7

As with frontage width, parcel-by-parcel distribution shows the complexities of internal variation underlying the averages. On the left hand graph *Figure 6-21* Sargent N5 the red bars show fairly consistent heights with several sharp exceptions, while the green bars reflect very consistent setback values. On the right graph, Iris Way shows an inverse distribution pattern with identical height and pretty consistent setbacks with several sharp exceptions. As illustrated in Figure 6-22 these variations in distribution patterns can be clearly seen in the field. The challenge is to convert the relationships found in the distribution patterns into a simple measure of the obvious differences they show in the perceived scale, enclosure and character of the two cases.

Greater building height along Sargent = ratio 0.86 (#1242)

Lower height & tighter setbacks on Iris = ratio 0.36 (#1247)

Figure 6-22 Height to Setback Relationships in Sargent N5 vs. Iris N7

When height to setback is expressed as ratio of height-to-setback as shown in the values of the black bars in *Figure 12,* they strongly mirror perceived variation in character—especially the relative sense of *enclosure* on a street. The ratio can be also be restated in *per unit* terms as *building height per foot of setback*. Values below 1.0 correlate with edge-of-street to top-of-building angles that are less than 45 degrees; values above 1.0 represent angles greater than 45 degrees and a greater sense of enclosure.

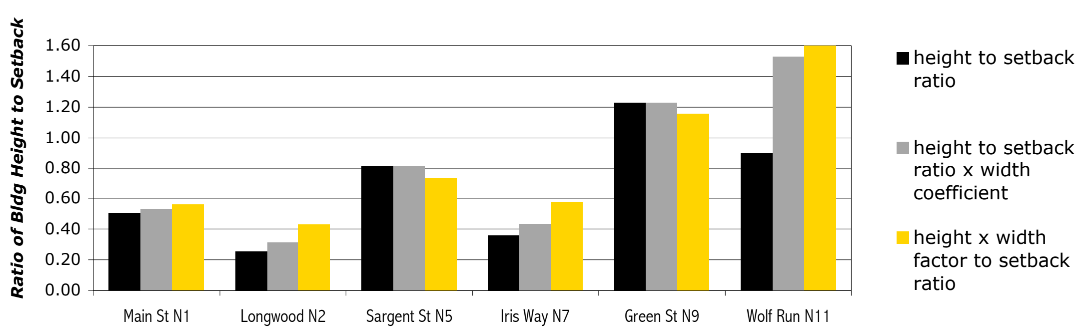
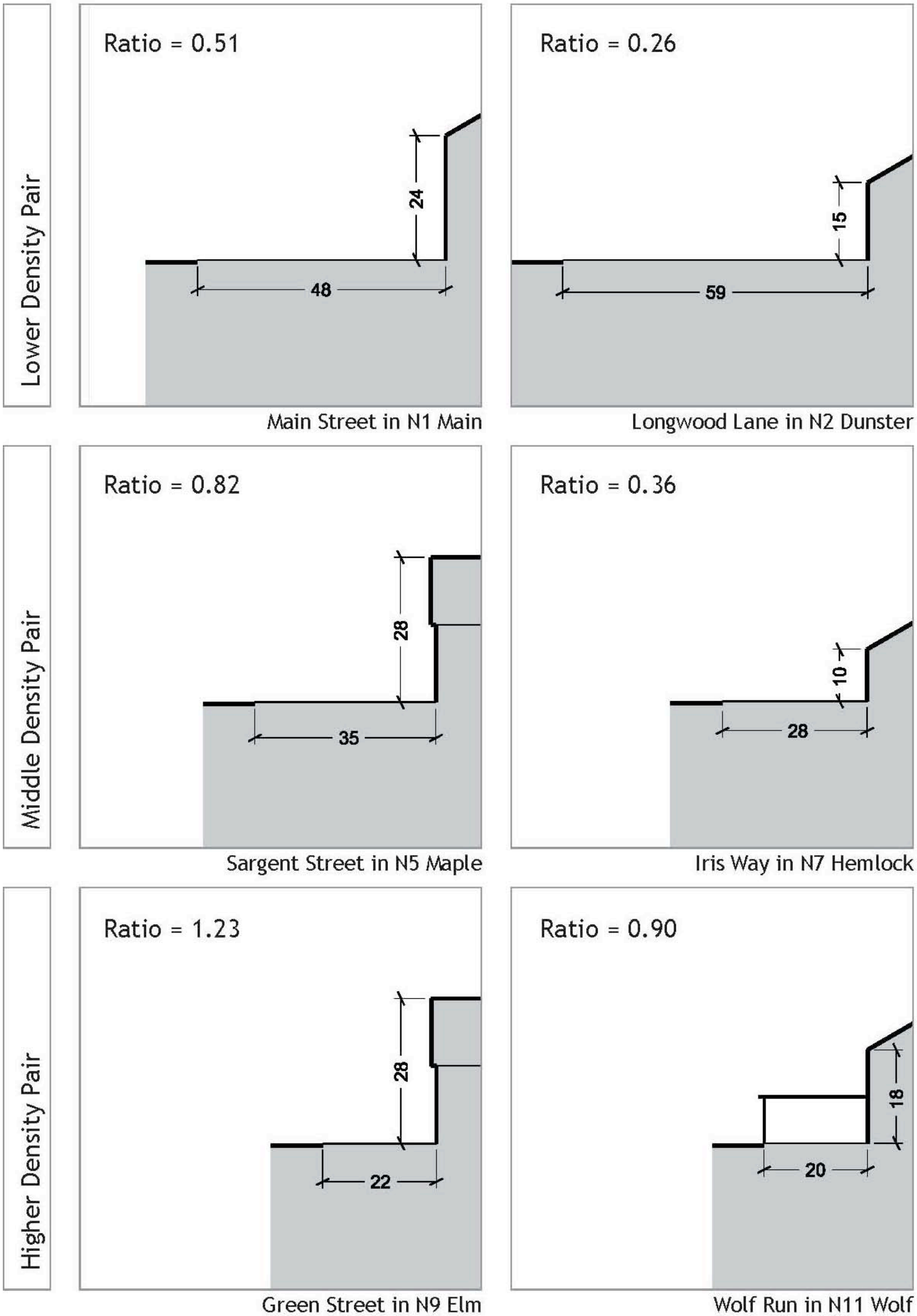


Figure 6-23 Street Edge: Height to Setback Ratio

The ratio works pretty well as a first order enclosure measure. *Figure 6-24* shows the proportional height and setback values in sectional drawings for all six street/block cases. These same relationships are shown as comparative photo images in *Figure 6-22*

Figure 6-24 Height to Setback Ratio: Six Street/Block Cases



Height is 50% of setback along Main = ratio 0.51 (#4497)

Big setbacks / low houses on Longwood = ratio 0.36 (#1308)

Tall buildings & tight setbacks on Green = ratio 1.23 (#1323)

Nearly equal height & setback at Wolf = ratio .90 (#1314)

Figure 6-25 Height to Setback: Main N1 vs Longwood N2 & Green N9 vs Wolf N11

and *Figure 6-25*. At the lower density level, shorter buildings and deeper setbacks correlate with a relatively weaker sense of *enclosure* on Longwood N2 compared with Main N1. In the middle set, lower buildings offset narrower setbacks on Iris N7 to produce a lower value than Sargent N5. The same relationship is seen in the higher density pair although less of a difference in average height make the ratio value for Wolf N11 proportionally closer to Green N9. The values reflect the observable differences in the matched photographs above.

A potential problem of compatibility arises in the case of Wolf N11 because the building edge is only defined on one side of the street. The lack of a symmetrical cross-section may limit its comparative value to the other cases. The measure could be adjusted to allow calculation of an asymmetrical condition by factoring a value for a non-building edge based on trees, etc. A blended value of enclosure could be derived by adding values for each side together and dividing by two. This might be an appropriate approach for any street with different setbacks and/or building heights on each side.

A further complication is presented by conditions where buildings are not simple box-like structures. In two cases, Main N1 and Sargent N5, building ells or wings create a more complex spatial geometry along the street edge *(see Figure 6-22)*. While data was gathered on secondary height and setback, it was difficult to determine how best to factor it into the measure and whether it would increase its effectiveness in capturing first order differences of *enclosure*. After some fiddling, the secondary height and setback data was dropped from consideration. These dimensions may prove more significant for some type of complexity related metric.

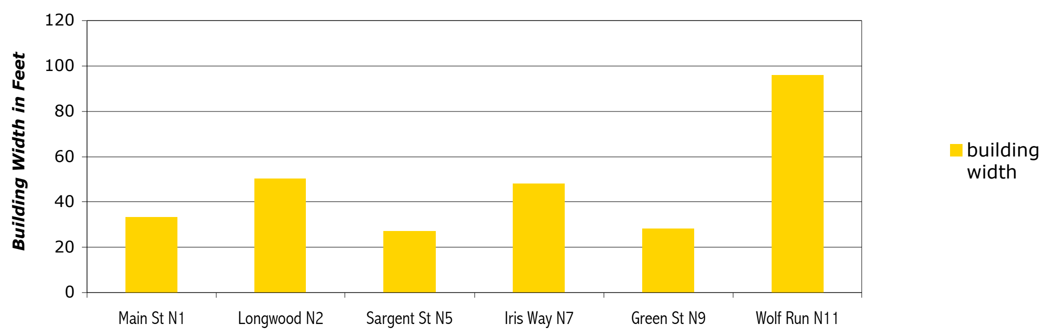


Figure 6-26 Street Edge: Average Building Width

Some accounting for the influence of building *width* on enclosure seemed to be a potentially more useful issue to consider in conjunction with the *height to setback* measure. Relative width of buildings by study area is shown in *Figure 6-26* above. They are essentially inverse to the building heights in *Figure 6-20*—wider ones are lower and taller ones are narrower. As noted earlier, width was hypothesized to have less impact on enclosure due to foreshortening of street edge elements seen in perspective. Nonetheless it seemed reasonable to give it some weight in the calculation.

Two options were tried. The first *height to setback* ratio was weighted using a *width coefficient*. This was calculated by assigning a value of 1.0 to the narrowest building width and adding 0.1 for every ten feet of width beyond that. The values shown in *Figure 6-23* calculate modest increases for Longwood N2 and Iris N7 and a disproportional increase for Wolf N11. The second option replaced *height* in the *height to setback* ratio with a *height to width* factor calculated multiplying height by width-divided-by-thirty. The resulting values shows an even stronger influence of width on ratio values—especially for Wolf N11 where a value 2.88 is literally off the chart.

Focusing on First Order Measures: This exercise raised a larger question about how far to take the internal derivation and testing process. How much fine-tuning should be done to metrics that seem to work pretty well already? Common sense suggests not much. By design, initial calibration of measures has been based only on the researcher's perception of variation between cases. However, until these baseline perceptions are corroborated through the external survey process, they remain limited by potential bias. In lieu of a more reliable baseline, excessive tinkering makes little sense. At this initial stage of the research, looking for simple correlations with basic differences between places seemed like the best approach to calibrating measures.

6.2.4 Measuring Enclosing Edges: Street Elevation

Up to this point measuring the vertical street edge has primarily focused on the street/block cross-section. The longitudinal section or street elevation is a second major component of street/block space that is also integral to neighborhood space. The street elevation defines the street corridor and influences associated spatial density, continuity, and rhythm. Unlike the cross-section, which is fundamentally a void, the street/block elevation is visually more or less a solid edge—especially when viewed obliquely (see related discussion in section 4.2).

As with the street/block cross-section, the street/block elevation has three basic dimensions: 1) parcel or lot width, 2) building width, and 3) side yard width.[3] As illustrated in *Figure 6-28*, the lot width creates a basic interval or division of space. This interval is marked in positive terms by the sequence of buildings and negative terms by sequence of gaps between the buildings—called side yards in this discussion. In many cases the interval is also marked in positive terms by a fence, hedge, or tree line running along the boundary between parcels.

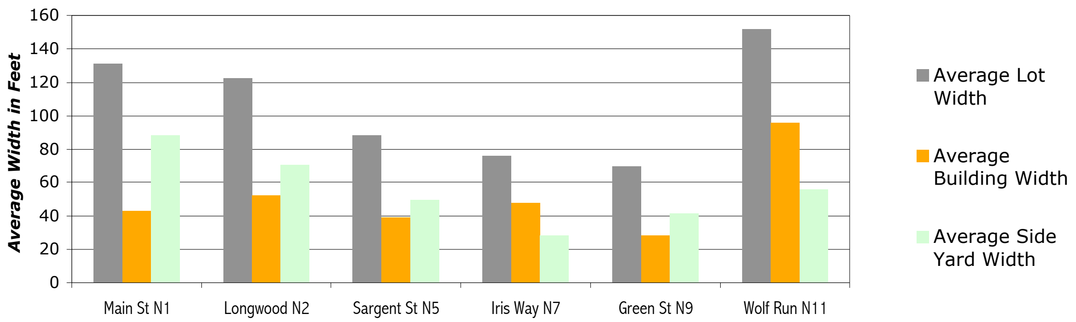


Figure 6-27 Street Elevation: Average Lot, Building, & Side Yard Width

The relative values for these three dimensions for the six case studies are shown in *Figure 6-27.* The relationships between them correlate pretty well with basic differences in physical form. With the exception of Wolf N11, *lot width* varies directly with density. Not surprisingly, the space between buildings or *sideyard* width (the right hand bars) also steps with density—the wider the lots, the lower the density. However, *building* width values (the center bars) do not. With the exception of Wolf N11, it remains rather steady *across* density.

Gap between houses filled with trees on Main N1 An open gap between houses on Longwood Lane N2

Figure 6-28 Examples of Side Yard: The Space Between Buildings

The conundrum of the large-lot multi-family case appears again in the case of Wolf N11. The highest values of both *lot* and *building* are associated with the larger width of multi-family buildings—on the order of two to three times wider than the house-like scale of the other five streets. While *side yard width* is more consistent with other cases, it is important to remember that lot width is only a proxy dimension used to create a comparable measure of building in relation to adjacent open space.[4] Actual width of the Wolf Run parcel would be literally off the chart—in the range of 200 to 400 feet depending how it was measured.

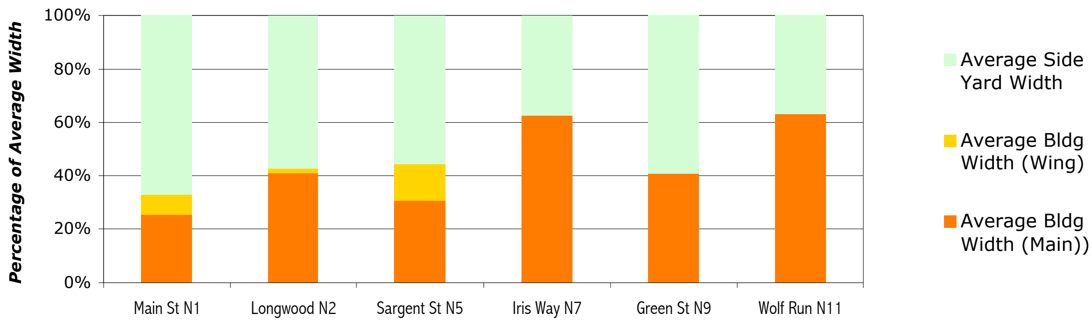


Figure 6-29 Street Elevation: Average Building vs. Side Yard Width

If parcel width is the interval of the street elevation, the relationship of building to yard may be seen as a sub-interval adding a second layer of spatial complexity. *Figure 6-29* arrays the proportional relationship between building and side yard as a percentage of average parcel frontage. This chart shows an interesting correlation—the relative

Example of wider side yard in Sargent N5 case study

Buildings more tightly spaced but same density in Iris N7

Figure 6-30 Comparative Views of Side Yard Space: Sargent N5 vs. Iris N7

proportion of *sideyard* (the top segment) to *building* (the lower segment) seems more a function of age than density. The older cases (N1, N5, N9) have less building and more yard space while the newer ones (N2, N7, N11) have more building and less yard space. This correlates with the perception that, after controlling for density, the newer cases seem more crowded and filled-in than the older ones. This could be a significant factor when comparing perceived density with measured density.

Another interesting observation is that two very different streets, Longwood N2 and Green N9, show identical 60-to-40 relationships of yard-to-building. This finding underscores the importance of also using parcel width, setback and building height in assessing differences in street elevation. This chart also breaks out *main* versus *wing* components of building width, in order to get a sense of how secondary width may modulate the reading of primary width. It is only a factor in N1 and N3 and appears to be too subtle a distinction to be significant at this level.

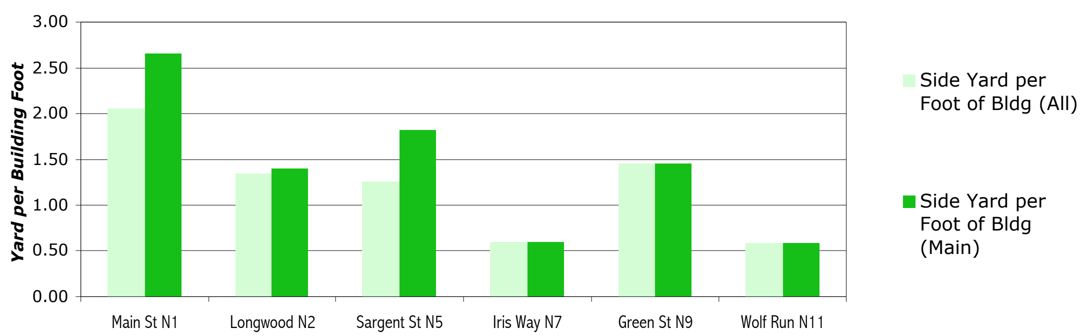


Figure 6-31 Street Elevation: Side Yard Width per Building Foot

The next two charts illustrate two attempts to give measured value to these relationships. *Figure 6-31* measures open space as a ratio of *feet of side yard width per foot of building width*. Values higher than 1.0 have more open space between buildings; values less than 1.0 have more building than side yard across an average parcel. The same contrast of newer versus older development era is expressed here as a more comparative ratio. Within each pair matched by density, relative open space between buildings is greater in older neighborhood patterns than in newer ones. This distinction is even more pronounced when only the primary building width is included—shown by the right hand bars on the graph. This measure may have some relationship to perception of *scale* although it is not clear why. A more interesting correlation may be with the perception of *density*. Though the research design conceived density as a control measure, these results suggest density perception may significantly diverge from measured density. This question will be picked up in Chapter Seven.

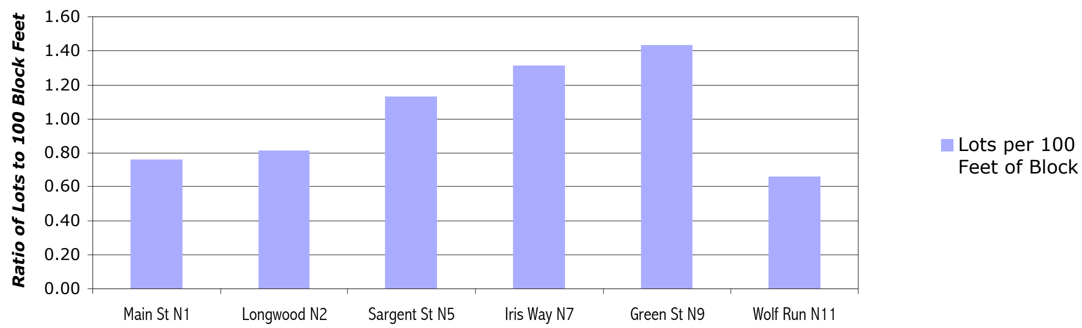


Figure 6-32 Street Elevation: Lots per 100 Feet of Block Length

Figure 6-32 looks at the question of relative scale by measuring the interval of lot in relation to block length. It expresses the rhythm of parcels as a frequency of *lot count per 100 feet of block frontage*. Values greater than 1.0 have a higher frequency or a finer grain; those lower than 1.0 have a lower frequency or coarser grain—they are more spread out. Here the relationship to perception of *scale* is much clearer. The measure is similar to the *parcel per acre* metric used to measure neighborhood grain in Chapter Five—only here the unit is linear not area. The measure correlates fairly well with general perception of *scale* across the study cases outlined at the end of Chapter Four. Smaller yards closer together seem associated with a more intimate scale of space across these cases. These values also reflect the change of *scale* associated with the larger buildings and parcels that are associated with the Wolf Run N11 case.

It is again worth noting the preceding analysis is based on average numbers. As such, it holds the potential to mask internal spatial variation that an average value doesn't account for. An analysis of the individual distribution of the three key variables shows this to be less of a problem at the street/block scale than it was at the neighborhood scale. While there is a certain amount of internal variation from parcel to parcel it did not appear likely to have any perceptible impact on the spatial qualities of the six street/block cases. This is likely related to the tendency of block scale development to be more or less consistent in parcel and housing types. In Chapter Five, these same patterns were seen to vary quite sharply at the neighborhood scale.

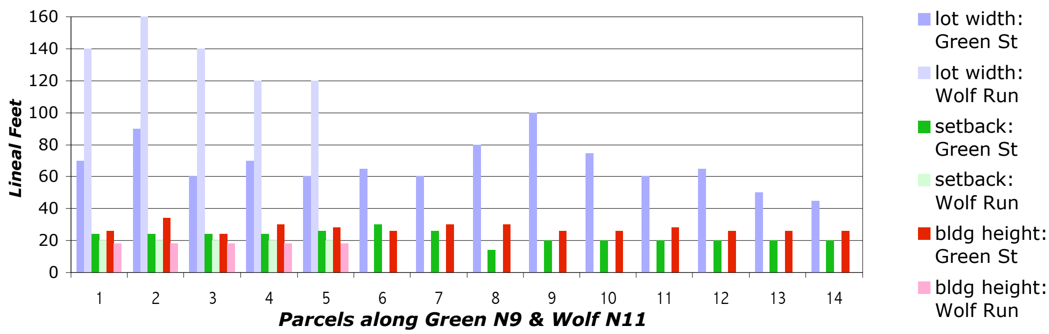


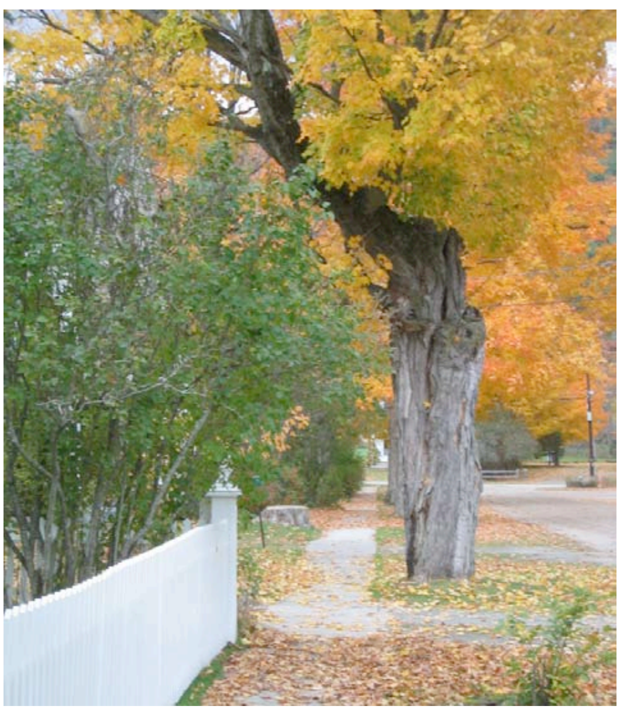
Figure 6-33 Distribution of Frontage, Setback & Height: Green N9 vs Wolf N11

Figure 6-33 shows one of the internal distribution graphs that were done for each matched pair. It compares parcel-by-parcel distributions of three key dimensions of neighborhood space: 1) parcel width, 2) setback and 3) building height. Each dimension is color coded—blue for lot width, green for setback, and red for building height. The values for the older cases (e.g. Green N9) are shown in darker tones, the newer cases (e.g. Wolf N11) are the lighter tones. While the graphs were a bit hard to read, they do offer a broad visual comparison of values for key dimensions on a parcel-by-parcel basis across matched pairs. The distribution of values confirms that variation at the parcel level does not range significantly from street/block averages for this set of cases. This suggests they are places that are relatively consistent in character.

The question remains: to what extent do any of these measures correlate with the perceptual qualities of the street as a whole? Frontage width, yard width, building height are all key variables of the street/block edge. The character of the street edge is closely tied to the character of neighborhood space. Some connections to qualities of scale and density were noted. The street section measures also showed some strong correlations to the sense of *enclosure*. While at this point these remain relatively fuzzy correlations, some first order success can be reported. The potential for other elements and dimensions to contribute to first order measurement of neighborhood space—in particular trees and those related to street-to-building transition—will be considered in the final sections of this chapter.

6.2.5 Measuring Enclosing Edges: Street Trees

In contrast to the geometric qualities of streets, parcels and buildings, the landscape, especially large trees, contribute a more organic element to neighborhood form. Trees have a particularly strong presence in New England towns that are almost always built in cleared areas within in the native forestland. Shade trees in New England also introduce in major element of seasonal transformation with dense, green foliage in the summer turning to brilliant colors in the fall that in turn give way to the ghostly silhouettes of winter.



Newbury, Vermont Streetscape

Figure 6-34 Autumn Color in an Upper Valley Neighborhood

Accounting for trees presents a different type of measurement challenge. They lack the easily measured orthogonal dimensions of streets, parcels and buildings. On the other hand, they are typologically quite consistent in shape and volume. They all share a central trunk supporting a three-dimensional canopy. Primary variation occurs in size and shape of broadleaf versus evergreen trees. Trees are dynamic elements of neighborhood form. They change over seasons and from year to year. They self-seed in untended corners. Trees are also planted for shade, privacy and pleasure. Over less than 50 years trees can completely transform a New England neighborhood.

The goal of this project was to measure a snapshot of tree patterns across the case studies in 2005. Efforts were focused on two basic dimensions—location and size. The first concerned their relative location within the street/block corridor. Trees adjacent to the street have the greatest impact on spatial character. The second distinction was size. Only trees above 20 feet were counted. Trees larger than about 40 feet begin to define a distinct space beneath their canopies—spatially more like ceilings than objects in a room. On occasion, really large specimen trees ranging above 60 feet become more visually dominant than the surrounding buildings.

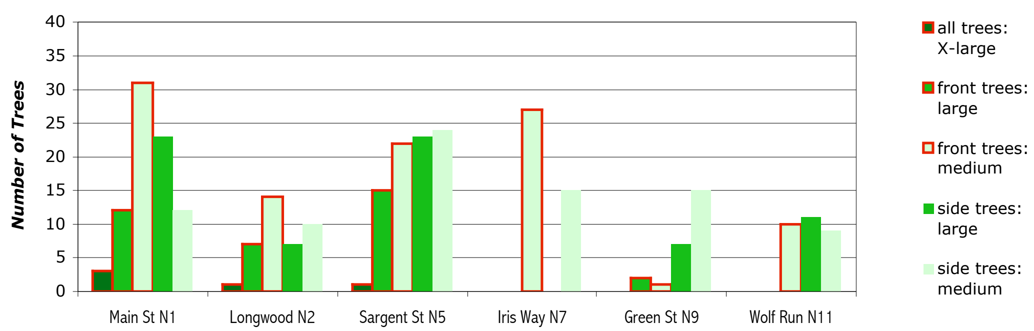


Figure 6-35 Raw Tree Counts by Tree Size and Location

Figure 6-35 shows all the trees sorted by size and by location for each street/block. Location is divided between trees in front of the building line (the outlined columns) and behind the building line. Size is divided into small-medium 20 to 40 feet (light green columns), large 40 to 60 feet (green columns); and extra large 60 plus feet (short bars on left). The initial impression of the graph is that some areas simply have many more trees than others. For example, Maple N5 has close to 100 trees while Elm

N9 has only 25. Other areas have roughly comparable numbers but are distributed differently both by size and location. For example Longwood N2 and Iris N7 both have around 40 trees but with very different distributions. These are summary counts over different sized areas, however, so comparative analysis is limited.

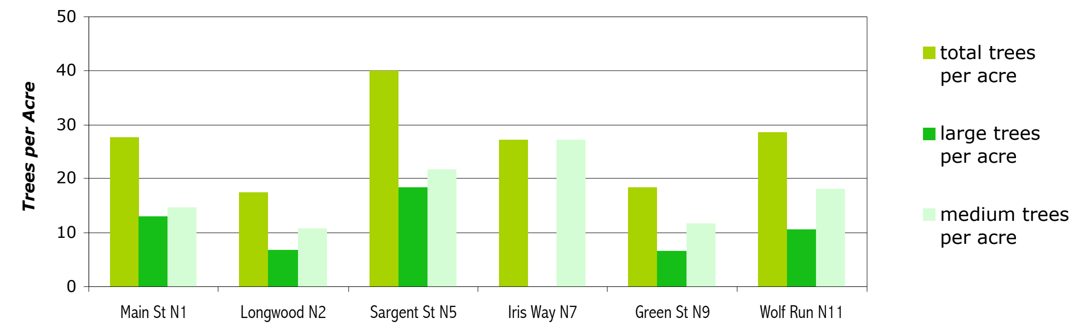


Figure 6-36 Trees per Acre: Large & Medium Trees in Both Zones

Better measures of relative character differences required better accounting of the range and density of tree sizes between study areas. Just as with single-family and multi-family land use types, some measurement of basic tree type distribution and density is required. *Figure 6-36* shows *average tree density per acre* broken down by large and medium size across both front and side zones. The results show relative densities for each size tree but still fall short of capturing obvious differences in tree character.


Many large and small trees in front zone of Main N1


Wolf N11: same density but only small trees in front zone

Figure 6-37 Similar Tree Type Densities but Different Landscape Character

Two pairs of low and high density cases—Longwood N2 / Green N8 and Main N1 /Wolf N11—show nearly identical density distributions by type. However, as

Figure 6-37 shows, they are sharply contrasting in landscape character. A large share of the trees in the lower density cases is in the front zone, while only a few trees are in the front zone of the higher density cases. The values don't convey that trees closer to the street have a greater impact on spatial character.

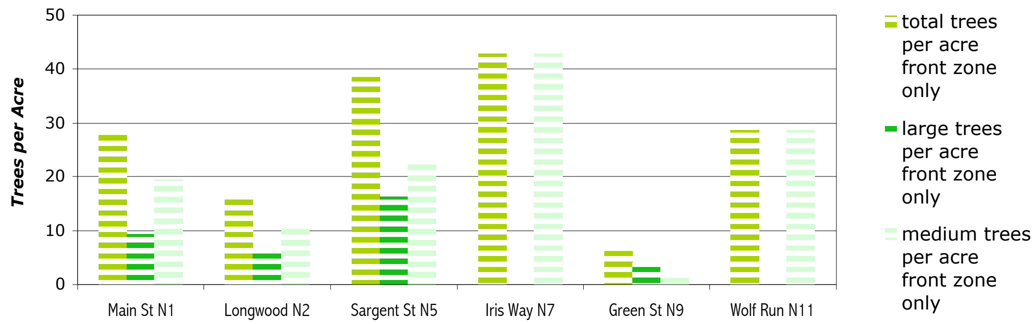


Figure 6-38 Trees per Acre: Large & Medium Trees in Front Zone Only

Figure 6-38 re-calculates tree density for only the front zone between the building line and the edge of pavement. This is a classic case of making some things better ends up making other things worse. Values for the previously discussed pairs now better reflect their relative differences. But the relative values between Sargent N5 and Iris N7 are now out of whack because of a failure to account for the differences in tree size. By this measure, Iris Way (shown on the right below) has a higher value for total front yard

Large trees near street affect street quality of Sargent N5

All small trees along Iris Way in N7 create sharp constrast

Figure 6-39 Impact of Large vs Small Trees in Front Zone of Street

trees per acre than Sargent Street (shown on the left) does. What the measure misses is the relative impact size has on perceived character of the street. Sargent N5 has about 15 large trees per acre in the front zone while Iris N7 has none. Clearly they are not equivalent in character. Some adjustments needed to be made to the measurement protocol to ensure that larger trees and trees closer to the street have a greater value than smaller trees and trees farther away from the street.

In response, a third approach was devised that assigned each category of tree a coefficient to weight its value. *Figure 6-40* shows re-calculated density for weighted tree counts for both the entire area and for only the front zone. Larger trees closer to the street received the highest coefficient (2 in this example) while smallest trees farther from the street got the lowest coefficient (.5 in this test). The resulting values are a much better fit with the overall variation in the tree-related character between case study streets. While values for the two alternatives are close in most cases, field observations suggest the all zone measure may be a somewhat better fit than the front only values.

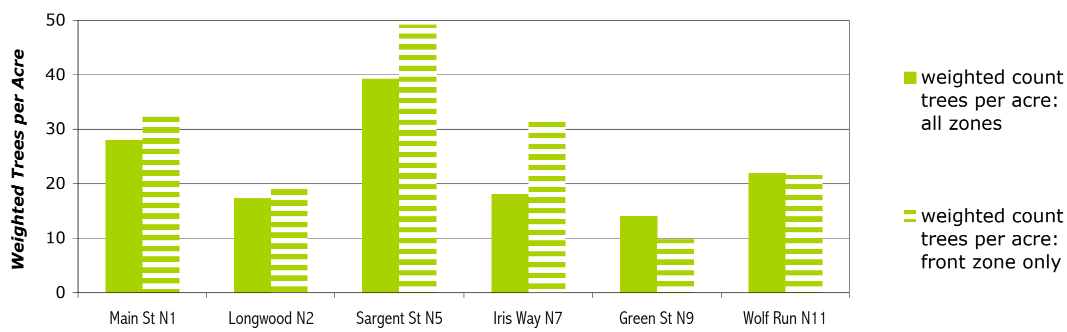


Figure 6-40 Weighted Counts of Large & Medium Trees per Acre

This assessment may vary depending on which qualities are being evaluated. Clearly trees have a major impact on sense of *enclosure*. The front only score gives N7 a disproportionately higher value for enclosure relative to cases such as N2 with large trees in front yards. Tree character is also likely to impact sense of *scale* and *variability*. The details of foliage and blossoms on small front yard trees may result in the front yard only measure being more stronger associated with differences in these qualities—again see *Figure 6-39*. The perception of different environmental qualities across this set of case studies will be considered at length in Chapter Seven.

6.2.6 Measuring Transition Spaces: Relationship of Building and Street

The last section describes attempts to measure the perceptual differences of the transition zone between the street corridor and the building edges that define it. The primary relationship of interest is that between building and street. The primary perceptual quality of interest is *permeability*—how open and connected are the buildings to the adjoining space of the street? In some ways this was an exercise in trying to measure the obvious. The differences between two neighboring houses on Sargent N5 are self-evident (see *Figure 6-41* below). On the left a large front porch, architectural detail, open windows, a broad entry walk, and flowers all convey a sense of perceptual connection to a passerby. In the right hand example the absence of many of these characteristics conveys a sense of privacy and separation from the adjacent street.

A house on that opens the adjacent street (#3545)

A neighboring house feels closed off from the street (#5299)

Figure 6-41 Building to Street: Side by Side Comparison on Sargent N5

The issue at hand is how can these differences be simply measured. As discussed in the data compilation section, there are any number of factors that affect this relationship and thus many choices as to what could be measured. Because these factors tend to be things that are not simply reduced to a measured value such as building height or street width, the problem of data specification becomes much more complex. In order to make the task more manageable, two variables—porch and garage—were chosen for preliminary study. As illustrated in *Figure 6-41* below, field observations found these both to be significant factors affecting the perceptual quality of the street/block space. Prominence of front porches was generally associated with a greater degree of connection between house and street; prominence of garages was generally associated with a lesser degree of connection. They both have the advantage of being widely understood features of a residential neighborhood and they both range quite widely in form and character across the study set.

A typical front porch commonly found in older streets

A typical double garage commonly found on newer streets

Figure 6-42 Key Building to Street Variables: Porches & Garages

Approaches to Measurement: The initial approach called for simply totaling the lineal feet of each element along each block and dividing by the number of buildings to come up with an *average lineal foot of the element per building* along the street. *Building* rather than *parcel* used as the reference unit in the ratio because 1) it is more directly associated with the two elements, and 2) it avoided the thorny specification issue related to some cases having more than one building on a parcel. It was soon discovered that the lineal foot approach was not as simple as first envisioned. Both elements come in many shapes and sizes. The impact of these variations on perceptual space was clearly not simply a function of lineal feet. For instance, a front porch that is three feet deep is perceived differently from one that is eight feet deep. Likewise an eight-foot wide garage next to the street has a different impact than one set at the rear of the lot.

Two responses were considered. The first would have narrowed the definition of each element to only comparable typologies—for instance, eight-foot deep porches projecting from the front of a house. While this would make for simple data collection, it would exclude many porch variations such as recessed entry porches or narrow porches or two story porches from consideration. The measure would be blind to their relative influence by reducing the variable specification to a black and white distinction of *yes* or *no*—a standard garage would be included, a carport would not.

The alternative was to count all related structures and assign a weighting factor to adjust the score up or down from a standard baseline. This approach was similar like the protocol adopted for the measurement of trees—the weighting factor allowed measurement of more subtle shades of gray. This approach requires more involved data specification process but creates a more dynamic measurement protocol that can be adjusted and refined with experience. Though this approach had its own potential for bias due to the judgment required to weight to various conditions, it was adopted because of its general flexibility and inclusiveness.

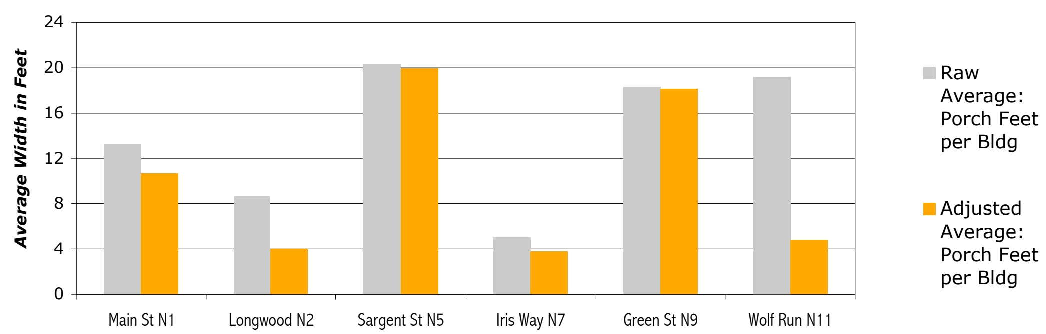
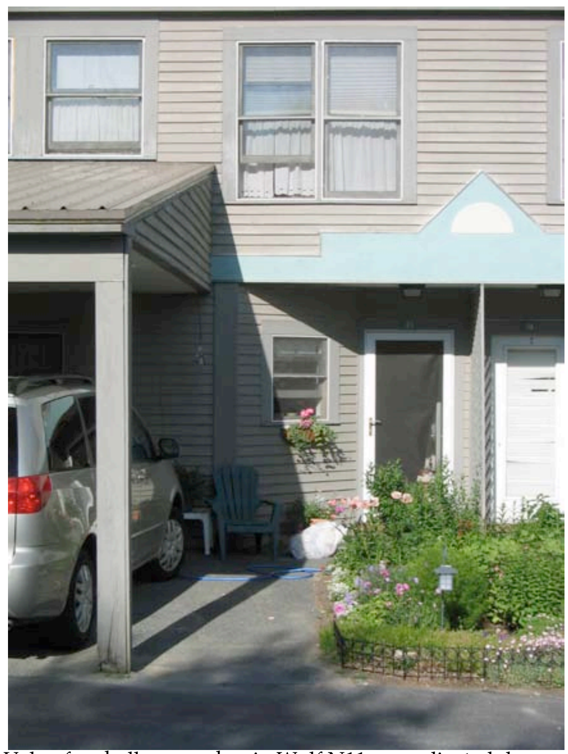


Figure 6-43 Raw vs. Adjusted: Average Porch Feet per Building

Measuring Average Porch Feet Per Building: The preliminary results of these efforts are presented in *Figure 6-43*. It arrays the raw measure of average lineal feet of porch against the adjusted measure for all six case studies. From a baseline of a six-to-eight-foot-wide, open, one-story porch (e.g. as shown in *Figure 6-42*), scores were adjusted down for factors such as shallowness, recessed position, side location, glazing or screening and adjusted up for factors like double-height or extra depth. For two of the older street/block cases with traditional porches—Sargent N5 and Green N5—the raw and adjusted scores were very close. For two others, they were pretty close. Main N1 was adjusted down for a number of side porches and glassed-in porches. A factor of 0.75 was applied to Iris N7 for their recessed position (see *Figure 6-44*) although the minimal porch width would score low in either case.

Value for a double porch in Green N9 was adjusted up.



Value for shallow porches in Wolf N11 was adjusted down.

Figure 6-44 Building to Street: Adjustments of Measured Porch Values

In two cases the difference was significant. In Longwood N2, measuring lineal feet of long narrow decorative entry porches on standard ranch houses seemed to overstate their impact relative to more traditional porches. In the case of Wolf N11, a high frequency of very minimal entry alcoves created a very high raw number and was adjusted down by a factor of 0.25 to better correlate the perceived impact of the these porch elements compared with the baseline type—see right side of Figure 6-44. While the factor was a rough guess, this variation clearly needs to be less than a full value but more than no value. It will be easy to revise the weighting coefficient based on more experience and a broader baseline of perceived differences between places. The left side of Figure 6-44 shows a double-height porch assigned a factor of 1.5 due its prominence. The adjusted values appear to correlate quite closely with initial assessments of *building-to-street* relationship summarized at the end of Chapter Four.

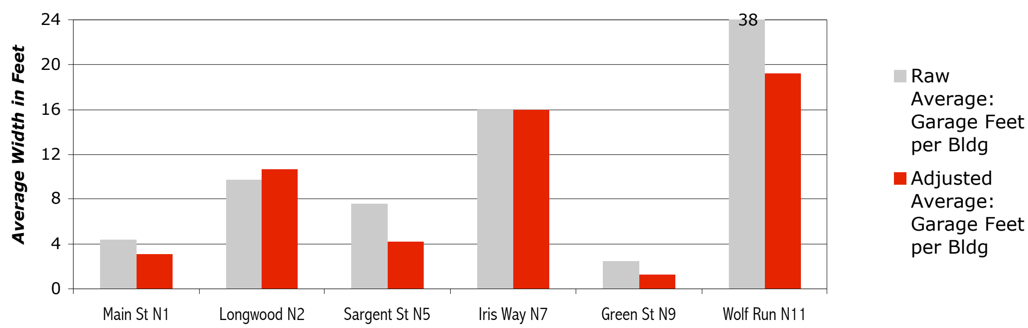


Figure 6-45 Raw vs. Adjusted: Average Garage Feet per Building

Measuring Average Garage Feet Per Building: The same approach was applied to measuring impacts of garages on the perceived qualities of the street/block environment. Adjustments were made up or down from the baseline of a garage in the same plane as the primary structure—see *Figure 6-42*. The farther back from the street, the lower the score. Carports were also adjusted downward. Garages projecting toward the street were adjusted up—though only a few of these conditions were found in Longwood N2. With exception of Sargent N5 and Wolf N11, both the raw and adjusted scores were fairly comparable in *Figure 6-45*. Iris N7, with many double-wide garages, scored high.   Green N9, with almost no garages, scored low either way.

The two exceptions are illustrated in *Figure 6-46*. In Sargent N5 most of the garages are at the rear of the lots and have little impact on the streetscape. They were adjusted down. In the case of Wolf N11, a high frequency of carports drove the raw score literally off the chart. While this case was perceived to be in the high end of the range of garage impacts, the raw score overstated the value with respect to the other cases. It was adjusted down using a coefficient of 0.50 to create a value more in line with perceived character relative to the other cases.

Value for rear garages in Sargent N5 were adjusted up.

Values for typical carports in Wolf N11 were adjusted up.

Figure 6-46 Building to Street: Adjustments of Measured Garage Values

As with the first measure, the weighted values for *average feet of garage width per building* appears to correlate quite with general differences observed between neighborhoods. Not surprisingly, there is almost a direct inverse relationship between the two scores. Cases that tended to score high on the porch measure, tended to score low on the garage measure and vice versa. There is clearly a strong association with age of development with pre-war cases scoring high on porches and post-war patterns scoring high on garages. There is also some indication that the differences become greater as density and mix of housing type goes up. This is consistent with other findings that the most extreme differences in the study set are shown between large lot multi-family areas and small lot multi-family areas.

Other Building-to-Street Measures: This measure appears to correlate well with initial associations of the quality of *permeability,* and to a less direct degree *scale* and *variability*. There are also a number of other factors such as front walks, entryways, driveway configuration, façade character, and front yards that are also likely to affect the quality of the building-to-street relationship. It appears likely that there may be some considerable congruence between these factors as well, but measuring them will present a series of specification challenges for future research.

6.3 Correlating Measured Values with Perceived Street / Block Qualities

This chapter focused on simple metrics that can discern first order differences of environmental qualities at the more detailed scale of street & block. The more limited number of parcel records per case and the greater number of variables to consider, resulted in measures being focused on comparing relationships between elements rather than comparing patterns of discrete elements. As was found at the neighborhood wide scale, expressing calculated values as simple ratios of some *measured element per standard unit* created a set of measures that were easy to calculate, easy to compare, and relatively sensitive to variation of spatial form and character. While measuring certain qualities was easier than others, some successful correlations between measured and observed qualities were made.

In the *street plan* discussion there was not an extremely wide range of variation. There were also certain limitations posed by the single parcel cases in larger multi-family areas. However several useful measures were discussed. They included:

- Street Width
- Verge Width per foot of Pavement.

While the range of values for simple street width was quite small, what variation there was seemed to have a strong correlation to the relative sense of street/block scale. The verge width measure was a very good way to measure relative extent of open space within right-of-way that can influence sense of scale, complexity and enclosure. Again the limited range of conditions did not allow the measure to be fully tested.

There was considerably more success in looking at measures of the *street edge*—in cross-section, in elevation, and with respect to influence of trees. In general, the use of case width averages did not have the same problem of masking internal variation of data points because there generally was not much internal variation from street/block to street/block. Street edge elements along a single block tend to have similar dimensions from parcel to parcel because they are usually similar in type (i.e. building type, lot type, setback, landscape, site plan, etc.). Some of the more successful measures included:

- Height to Setback ratio (height per foot of setback)
- Yard to Building ratio (side yard per foot of building width)
- Lots per 100 feet of Street

The *height to setback* ratio proved to be an excellent match with observed sense of enclosure (assuming constant street width—which there was in most cases). Some adjustments to include a width factor had mixed success. The *yard to building* ratio was more generally correlated with observed scale, however other factors also came into place. There also was a very interesting potential correlation with perceived (rather than measured) density. Relative *lot width*, like street width, is a simple but reliable measure of scale and may also have some bearing on complexity and enclosure.

Deriving first order measures of differences in *tree character* and density also proved quite successful. Measures were based on parcel-by-parcel distributions of simple binary coded classes (e.g. larger versus smaller, closer versus farther away). After some efforts to account for the varying influence of tree size and location, some successful correlations were found by using weighted coefficients to calibrate calculated values with observed character. Two variations of the same measure proved useful:

- Trees per Acre: All Zones (weighted values)
- Trees per Acre: Front Yard (weighted values)

While the range of values were not greatly divergent, there was some evidence that the success of these versions was a function of the quality being measured. The *all zones* measure tended to give greater weight to large trees and seemed to be a better comparative measure of enclosure. The *front yard* measure, on the other hand, appeared to be a better measure of quality of scale and perhaps variability. As with all measures, findings are limited by the small sample size they were tested across.

Finally, two measures related to the relationship between building and street were tested. Although a range of issues were identified as potentially significant factors affecting this relationship, the initial measurement exploration focused on only two—front porch and garages. A similar weighted measurement approach to that used in the tree section was adopted. A series of simple field measures were made recording basic extent of both elements in all six cases. The base measure was lineal feet of porch and garage per building. Raw measurements were adjusted up or down to account for varying impacts on the street environment. The two resulting measures included:

- Adjusted Porch-Feet per Building (weighted values)
- Adjusted Garage-Feet per Building (weighted values)

While raw values worked pretty well in most cases, in certain cases adjusted values allowed unusual or non-standard conditions to be included in the calculation. The resulting scores seemed to correlate well with variation in qualities of permeability and transparency. They also appeared to be potential useful in measuring qualities of variability and complexity.

It was also apparent that observed variation for certain environmental qualities was more difficult to assess than for others. For example, enclosure seemed pretty straightforward. While others, such as scale, complexity and variability, seemed more difficult to assess in simple terms. Since calibration of the measures is based on observed ranges of character, the less certain the observations are, the fuzzier the measures are apt to be. The external survey of neighborhood qualities described in the next chapter will help provide a more stable baseline of perceived variation against which to test measures. The survey will include evaluations of a series of environmental qualities such as enclosure, scale, density, permeability and variability.

End Notes:

Note 1 Defining the Term Street / Block: *There is no accepted term to define the spatial domain under discussion. Street commonly refers to the corridor of movement and its associated paving, curbs, sidewalks and right-of-way. Block typically refers to the area of development defined by four perimeter edges—most often they are streets. The space we are interested comes at the intersection of these two realms—it is neither and both. (show diagram of figure ground of streets and blocks and then zoom into one street block—just two lines—unidentifiable).*

In popular language the terms are used interchangeably: "We are having a block party." "I live on Maple Street." "I live on the 1200 block of Pine Street. "Let's go to the street festival." But a specific descriptive term of this domain does not exist—it is a combination of each. One does cannot exist without the other. The term neighborhood space suggests a more integrated idea but is quite vague. Neighborhood space, as the common or shared territory also includes parks, recreation fields, vacant lots, corners, bus stops, and whole networks of streets and open spaces. The concern here is to define a specific increment of space—the shared outdoor access corridors serving a discrete group of individual dwellings. The two-part name used to describe this domain (street/block) reflects the two main elements that define it—the horizontal plane of the street (including streetscape elements within it) and the two vertical street elevations or block faces that enclose it (including buildings, and landscape).

Note 2 Street / Block Spaces as Longitudinal: *There are exceptions to this rule. Example include where cross-sectional dimensions are widened as "places" and geometric conditions at terminus of dead end or cul-de-sac streets. However they will not be addressed in this discussion of first order distinctions.*

Note 3 Calculation of Yard Width Dimension: *Yard width is calculated as difference between parcel width and building width. In fact, in the field this dimension is split between yard on either side of the building. Building spacing equals the sum of the two adjacent halves of yard width for two adjacent parcels.*

Note 4 Buildings and Adjacent Open Space: *The concept of "building and adjacent open space" that is used to define "proxy" parcels within large multi-family parcels for the purposes of comparative evaluation, is consistent with the way Urban Morphologists define the elemental unit of measurement within their classification system—a building and its related open space—see Chapter 2 for detailed discussion.*

Different people see and interpret what they see in different ways, depending on a host of variables. Some of these are situational—buildings tend to look less good on a cloudy day than on a sunny day—and others have to do with the observer's focus—development or preservation, for example. Probably the most important variables are the values observers bring with them and everything that makes up their personal experience. People do not observe with a blank mind; they come with certain expectations, based on their values and past experiences. Also there may be differences in people's judgment about actual physical attributes of an environment... So regardless of the purposes of observation, or its scale, mode, or process, the experiences and values we bring to the task color what we see. We cannot observe with objectivity (p. 11).

• Allan Jacobs Looking at Cities

Chapter Seven:

SURVEYING PERCEPTIONS OF MEASURED QUALITIES

The last two chapters have reported some success in deriving first order measures of neighborhood form. Up to this point, the calibration and testing of the measures has thus been an internal process that depends on the researcher's own perception of differences between case studies.[1] Some questions remain about the extent to which these measures, and the perceptual baseline used to derive them, can be validated outside the study design. The final two chapters each describe a related validation issue tested within the scope of this study. Chapter Seven looks at the reliability of the perceptions of neighborhood form used to derive the measures. Chapter Eight examines the correlation of resulting measured values with a broader baseline of perceived differences in neighborhood form.

Assessing the reliability range of the perception of environmental qualities is the focus of the final major task of the research design—the development and execution of the field-based *Neighborhood Evaluation Survey.* The survey protocol asked a small group of volunteer survey participants to independently evaluate a series of neighborhood qualities during a two-hour walking and driving tour of six case study neighborhoods and six related street & block case studies. Survey respondents were divided into two classes: 1) *professionals* in urban design and planning related fields and 2) *lay persons* with an interest in the subject but no formal training.

Chapter Outline: The survey of neighborhood qualities is the focus of the final chapter of this dissertation. Section 7.1 presents the basic research objectives of the external validation process and its relationship to establishing a broader perceptional baseline and correlation of baseline values with measured values. Section 7.2 describes the design of the survey including the definitions of tested qualities, selection of the survey sample, development of the survey instrument, pre-testing the survey protocol, and administration of the final survey in six survey tours. Section 7.3 summarizes the results of the survey. A series of simple descriptive and distribution statistics will characterize the range and reliability of the responses for a series of qualities across the six cases at both scales of analysis. It will also compare surveyed scores of the researcher with the other two groups and draw conclusions about the findings.

7.1 External Validation Testing

The project design depends heavily on the researcher's use of systematic observation, mapping and photography combined with professional experience to gauge variation of neighborhood form. Thus the validity of research findings are inherently limited by the extent to which the perceptions of a single individual may differ from those established by a broader sample.

The researcher’s assessment of neighborhood form was a central part of at least three major parts of the research design. First, the *initial case study selection* was premised on a basic ability to distinguish differences between a set of neighborhoods that measured the same in terms of conventional standards such as density and mix of uses. Secondly, the *identification of key neighborhood qualities* that are measurable depended on distilling the observed differences between each case into a set of defined qualities of neighborhood form. The identity of these qualities was hypothesized at the outset and actively revised and refined throughout the research process. Finally, the researcher's perception of differences between cases was the baseline used for *internal testing and calibration* of the experimental measures.

Reliability of Perceptions: A series of obvious questions concern the reliability of these perceptions. Are these perceptions valid? Are they shared by a larger audience? Does the distribution of measured values correspond to a perceived variation recognized by the broader field of urban design and planning? Does the perception of neighborhood form qualities vary depending on who is observing and under what conditions?

For example, in deriving and calibrating a measure for *street enclosure*, the researcher depended on evaluating variation in street enclosure from one neighborhood to the next based on field observations, photographs, and maps. Since the measures are tested and calibrated by comparing the calculated value with perceived value, the validity of the perceived value is directly related to the validity of the measure itself. Thus it is important to gain some understanding of how widely shared these perceptual distinctions are.

The neighborhood survey offers a kind of external validity test for the perceptual assessment of neighborhood qualities in a least three ways. First of all, asking a range of participants to evaluate a series of nine qualities across six cases, will produce some understanding of whether the quality itself can be clearly distinguished between neighborhoods by a wider group of professionals and citizens. Secondly, the neighborhood survey allows evaluations of the researcher to be compared with those of the wider group in order to gain some general understanding of the extent to which the researcher's perceptions may vary from a broader norm. Finally, for those tested qualities that are found to be more or less consistently distinguished between neighborhoods by the larger group of observers, a more substantial baseline for the refinement and calibration of measures will be established.

Correlating Perceived and Measured Qualities: If the broader baseline seems to agree with the internal baseline used in the derivation process, the validity of the associated measure is confirmed and substantiated within that broader sample. If, on the other hand, the broader evaluation shows significant deviation from the original baseline, the validity of the measure is brought into question. The measure may be able to be adjusted and refined to better fit the broader revised baseline. Alternatively the measure may simply be determined to be of limited use to distinguishing the particular quality.

It may also be possible that the perception of some qualities can simply not be clearly or consistently distinguished by the surveyed sample of participants. Without any clear patterns associated with a perceived quality, it obviously becomes difficult to say much about correlations between perceived values and measured values. This may be the result of several factors. First of all, the quality could have simply been poorly defined in the survey—the participants simply confused about what they were looking for. Secondly, the ability of the surveyor to accurately assess a given quality may depend on a certain level of training or experience. Finally, the quality may simply be very difficult to clearly assess the complex world of the built environment. Based on the experience described in the last two chapters, it was also expected that certain qualities in certain neighborhoods would prove more difficult to assess in certain kinds of neighborhoods than in others.

The Control Variable—Density: A closer examination of *density* within the neighborhood survey provides a tool for better understanding any discrepancies between the perception and measurement of neighborhood qualities. Up to this point, density has been used as a control variable of urban form. The case studies were selected to control for density in order to better isolate the influence of other neighborhood form variables. However, density is also a neighborhood form quality with a well-established measure: *units per acre.* Thus, by including *density* as one of the evaluated qualities (i.e. a research variable) in the survey, it serves as a kind of comparative baseline for the relationship of perceived versus measured qualities. Comparing correlations between perceived density and measured density helps provide a context within which to discuss the same relationship with respect to other qualities.

7.2 Survey Design: Qualities, Sample, Instrument, Protocol, & Implementation

The *Neighborhood Evaluation Survey* is a very simple validation test designed to assess key questions of reliability and correlation. In order to establish a broader baseline against which to test both the researcher's perceptions and correlations of measures, the survey protocol asks volunteer testers to evaluate a series of pre-defined environmental qualities during controlled field tours of six case study neighborhoods. The qualities are divided into two groups. The first group of qualities corresponds to measured qualities at the neighborhood wide scale; the second group to measured qualities at the street/block scale. Comparing measured scores with surveyed scores tests how well the measures correlate with a broader baseline of perceived variation of neighborhood form.

Each quality is scored on a simple 1 to 5 ordinal scale within the universe of "all in-town neighborhoods in the Upper Valley." No information is provided about the associated measured . Participants were told to score each quality as objectively as possible based on what they see, not whether they like or dislike the particular quality or neighborhood. Surveyors were divided into two groups, those with professional training in design and planning and those without. The entire survey took about two and a half hours to complete. It was broken up into a fifteen-minute introduction, a two-hour driving and walking tour and a fifteen-minute conclusion.

Field-Based versus Photography-Based Survey: Since the subject of the surveys is perception of the built environment, it depends heavily on good representation of the complex three-dimensional world of experienced space. The initial survey design called for using two survey techniques to test perceptions of environmental qualities: 1) a field-based survey tour by a very small group (three or four individuals), and 2) a much larger mail back or internet survey using photographs or videos clips to represent the case studies. However, because of the inherent bias of photographic point of view and presentation (discussed in Chapters Two, Three, and Four), it was decided the direct field-based observations under a controlled protocol was the preferred method. All of the tested qualities are either associated with a scale that is too large to be photographed in a single view (i.e. neighborhood wide) or involve inherently three-dimensional qualities that are difficult to represent in a two-dimensional photograph. Furthermore, because early pre-testing showed the tested qualities to be initially quite difficult to understand, especially for non-professionals, the need to explicitly define them in consistent and clear terms for each group was considered a critical part of the survey protocol.

Because the case studies were all in relative geographic proximity (they all fall within a three mile radius), a field-based tour was feasible. While this required a considerable commitment of time by both the researcher and the participants, the advantages of direct observation outweighed the limitations of a somewhat smaller sample size. A very interesting future research project could easily compare results of a photographic based survey with the field survey results to study how and to what extent the inherent bias of photography affects environmental perception.

The section will summarize the main components for the survey design and implementation. Section 7.2.1 describes the process of distilling and defining the qualities to be tested. Section 7.2.2 summarizes the recruitment and selection of the survey participants. Sections 7.2.3 and 7.2.4 outline the design of the survey instrument and the development of the tour protocol and related revisions resulting from several pre-tests. Section 7.2.5 reports on the administration of the survey instrument over the course of six different field based tours during May and June of 2005.

7.2.1 Defining Neighborhood Qualities to Be Tested

The eight qualities that were tested were distilled directly from the trial and error process of the research project itself. As described at the start of Chapter Five, the process of defining measured qualities combined a top-down and ground-up approach. At the outset, a series of qualities were hypothesized as important components of overall neighborhood form—these are summarized in Section 3.1.4 *Expected Findings*. The connection between these qualities and measurable patterns found in the case studies were the subject of an extensive analysis of physical variation between neighborhoods. This ground-up process is described at the outset at follows:

> "The overall research goal is to derive simple, replicable measures that capture variation in neighborhood form that eludes conventional measures. Obviously the choices of what to measure in a neighborhood are nearly infinite--street width, block size, building set-back, tree cover, pavement area, number of rose bushes, etc. The key is to measure things or relationships that will be able to distinguish overall variation in neighborhood form and character in as efficient and effective way as possible. Considerable insight is expected to be gained by careful, systematic observation and analysis of the case study neighborhoods. The project is intended to be hypothesis generating--certain patterns and insights are bound to fall out of intensive study." *Research Prospectus, p. 44, May 2004*

Based on this analysis the qualities were refined, re-ordered and re-presented in Section 4.3.1 *Connecting Qualities and Measurement*. In Chapters Five and Six, the list of qualities continued to be refined and pared down based on the extent to which they could be connected to a series of specific, exploratory neighborhood measures.

Based on this work, a final set of measurable qualities was defined for inclusion in the neighborhood survey. While the initially hypothesized set provided a pretty good starting point, the final set was considerably revised and transformed by the research process. Some qualities such as c*hange & adaptability* or *spatial order* were dropped because they were simply too difficult to simply measure. Others, such as *openness of boundaries & edges*, seemed important but were dropped because there was insufficient data to calculate and were somewhat peripheral to the primary focus. Still others such as *building/lot orientation & spacing* were concluded to be physical patterns rather than discrete qualities. They were absorbed into measures of related qualities such as enclosure, scale and variability.

For the most part, however, the original set proved a solid foundation from which to draw the final set. All of the final eight qualities were derived, in one form or another, from the initially hypothesized list. At least one preliminary metric was developed to measure each quality during the derivation process. The final qualities include ***density, grain, connectivity, consistency, scale, enclosure, permeability***, and ***variability.*** They are divided into two sets. Each is defined with respect to one of the two scales of analysis: 1) the neighborhood as a whole, and 2) the more detailed scale of the street & block. The first set of qualities was evaluated during a five minute driving tour through each neighborhood. The second set of qualities was evaluated during a five-minute walk down a single block (about 500 feet) in each neighborhood.

The working definitions for each set of qualities are presented below in *Figure 7-1 Defining Neighborhood Wide Qualities* and in *Figure 7-2 Defining Street/Block Qualities.* Density, as the control quality, is evaluated at both scales. Each quality includes a written definition and defines the range of the survey scale (e.g. big versu. small). Pre-testing the survey resulted in the addition of a series of questions for surveyors to ask themselves in the field.[2] These questions helped provide a more tangible approach to evaluating sometimes abstract or unfamiliar concepts for the survey sample.

Figure 7-1: Definitions of Neighborhood Wide Qualities (1-4):

1. *Consistency* describes how consistent or similar a neighborhood's form and character is from one part to another. A consistent neighborhood has a sense of continuity and similarity as you move through it; one with less consistency feels more broken up into distinct and separate parts. *(range: consistent versus inconsistent)*

> *Does the neighborhood feel relatively similar as you move through it?*
> *Or does it feel divided into different and discrete parts?*

2. *Connectivity* is the degree of interconnection of the neighborhood's circulation system (streets, drives, sidewalks, paths) both internally and with its surroundings. Places of high connectivity have many route choices for getting around; areas of low connectivity offer more limited choices. *(range: high versus low)*

> *Do you see lots of route choices for moving around through the neighborhood?*
> *Or not so many? How many ways are there in and out of the neighborhood?*

3. *Grain* refers to the pattern of structural "cells" that make up a neighborhood. It is typically a function of parcel size and related buildings and landscape. A fine grain would be perceived as many, smaller spatial cells, a coarse grain would have larger cells and a more generously spaced structure. *(range: fine versus coarse)*

> *Can you see or sense the division of land in the neighborhood?*
> *How big are these divisions? How do they relate to landscape & buildings?*

4. *Density* refers to the relative intensity of residential land use across the neighborhood. In higher density areas the arrangement of dwelling units and buildings feels denser and more compact; lower density areas of residential development feel more spacious and spread out. *(range: high versus low)*

> *In relative terms, how many dwelling units are in the neighborhood?*
> *A lot of units? Not so many? How intensively are they arranged on the land?*

Figure 7-2: Definitions of Street/Block Qualities (5-9):

5. *Enclosure* is the degree of spatial containment of the street corridor. It is a function of the size and arrangement of edge elements of the street (buildings, trees, fences, etc) in proportion to the street itself. Vertical edges on a tight street create a strong sense of enclosure; weak enclosure is associated with more open, less defined spaces. *(range: strong versus weak)*

> *Do you feel a sense of enclosure as you walk along the street?*
> *How high are the buildings & trees? How close are they to the street?*

6. *Permeability* is the degree of interconnection between the street and the edges that define it. A street edge with buildings and yards that open to and invite interaction with the street tend to be highly permeable; edges that are perceived as closed or cut off from the street have low permeability. *(range: high versus low)*

> *What kind of relationship do you sense between the buildings and the street?*
> *Does it feel open and inviting? Or is it more private and walled off?*

7. *Scale ref*ers to the relative size and proportion of the environment in relation to the observer. Scale is influenced by both spatial edges and elements within the space. In smaller or more human scaled spaces the observer feels relatively more in-scale; while more larger or grandly scaled spaces tend to evoke a sense of being somewhat diminished. *(range: large versus small)*

> *Does the street feel comfortable to walk along? Does the space feel relatively large and expansive? Or does it feel more intimate and human-scaled?*

8. Variability is the relative compositional variation of the street. It is a function of the texture and character of defining edges (i.e. details of buildings, yards, and street). Highly variable spaces are composed of many complex and articulated parts; spaces with low variability have a more uniform and repetitive character. *(range: diverse versus uniform)*

> *Is there a lot of visual interest along the street? Are there a variety of details that catch your eye? Or does it seem more uniform and repetitive?*

9. Density is the same as for the neighborhood wide scale only now considered within a much smaller area. On higher density streets the arrangement of dwelling units and buildings feels denser and more compact; on lower density streets development feels more spacious and spread out. *(range: high versus low)*

> *In relative terms, how many dwelling units are there along the street? A lot of units? Not so many? How intensively are they arranged along the street?*

While density is obviously the same between the two sets, several other sets of qualities are related across scales. *Grain* and *scale* are both a function of relative size. *Consistency* and *variability* are both a function of degree of similarity versus dissimilarity. Connectivity and permeability both are a function of degree of interconnection. Only the three-dimensional measure of *enclosure* seems to be uniquely suited to the street/block scale. Enclosure at the scale of neighborhood may be a function of a larger relationship to the surrounding terrain—for example a neighborhood in a steeply sided valley versus a neighborhood on an open prairie. Further efforts to clarify these qualities for participants are described in the pre-test section of Section 7.2.3.

7.2.2 Recruitment of Survey Participants (Sample)

The sampling strategy for the validation survey, like the research itself, evolved over time as the key research issues became clarified and better defined. Initially, it was hypothesized that the spatial complexity of the issues being measured would require survey evaluators to have professional or academic training in urban design or related fields. An analogy might be the requirement of some kind of specialized medical training to successfully read an x-ray or MRI image. Due to the extremely limited pool of locally qualified persons, the time commitment involved, and the lack of resources to pay a stipend, there was no practical way to ensure a random sample. Early on in the process, four local professionals spanning the fields of architecture, planning, and landscape architecture were recruited as participants in the planned field-based survey components. A complimentary photo-based email survey was envisioned for distribution to a larger national sample of professionals and academics.

As the research progressed, it was discovered that the most successful first order measures of neighborhood form were related to very simple, clear relationships—for example street enclosure measured as a simple ratio of building height to setback. Early field-based pre-tests concluded that with sufficient explanation, many of these basic concepts might be clear enough to be evaluated by a broader pool of surveyors. This finding, together with the concerns for the inherent bias of a photo-based survey described earlier, resulted in a revised sampling strategy focusing on recruiting a much larger local sample for the field-based survey tours.

Implementing Revised Sample Strategy: Even with a larger potential pool to draw from, the substantial commitment of time (approximately three hours including travel time) inherently biased the survey pool toward people with an interest in neighborhood planning and design issues. This is, of course, a limitation of any survey technique that relies on volunteer participation including mail-back surveys—response rates are always affected by the interest of the individual in the surveyed subject. Accepting this limitation, the revised sampling strategy focused on drawing volunteers from pre-existing groups that combined a known interest in survey issues (i.e. neighborhood qualities) with a reasonable representation of the larger community (i.e. age, gender, occupation, etc). Of particular interest was balancing the type of neighborhood lived in by respondents as much as possible. The process of self-selection is known to be an important factor in predicting preferences related to residential environments.

The obvious starting point for participant recruitment was local citizen based planning boards, committees, and groups. Given the practical limitation of six participants per survey tour, a goal of recruiting an additional twenty participants would make a total of twenty-four surveyors for four survey tours.[3] Several groups were identified for recruitment efforts including a town planning board, a citizen committee working on plans for a suburban growth area, and a regional organization promoting citizen involvement in civic affairs.[4] To increase the diversity of the selection pool, an additional group was added to the pool that was known to have no particular interest in these issues but to represent a broad cross-section of residential location and have a potentially high response rate.[5]

Response Rate & Final Sample: In total, about 60 email invitations to participate were sent out to pre-existing email distribution lists. For the largest group (about 25), a follow-up presentation was made at one of their regular meetings. Almost forty people indicated an interest in participating, but due to scheduling conflicts only about 33 were able to participate. This was still a better than hoped for response rate of over 50%. Together with the original four volunteers, this raised the total sample size to 37—not large enough for extensive statistical analysis, but certainly adequate to test first order reliability of responses and correlations with measured values. This number divided nicely into six survey tours—the one bicycle-based tour included seven surveyors.[6] Several unsolicited requests to participate in the survey via word-of-mouth reports from tour participants suggest a potential for using a "snowball" sampling strategy to expand the sample size for future research.[7]

The resulting sample population is reasonably well distributed across key survey variables. While the targeted groups were primarily citizen-based, some mix of professional expertise was represented within each group. As a result, the total survey population was reasonably split between professionals with relevant training (17) and citizens with an interest but no training (20). The sample, while small in size, also is reasonably well balanced on key variables such as age, gender, and place of residence. Ethnicity matched the regional population—predominantly Caucasian. A more extensive discussion of sample characteristics and related differences in survey responses will be presented in the Section 7.3 *Survey Results*.

7.2.3 Design of the Survey Instrument

The design of the survey instrument was very straightforward. The intent was to ask each evaluator to assess a series of eight qualities, across six study sites, on a simple gradient scale. Seven of the qualities, three at the neighborhood-wide scale and four at the street/block scale, were directly related to specific measures of neighborhood form developed over the previous 12 months. The eighth quality *(density)* was a control variable evaluated at both scales. The surveyed sites corresponded to six of the twelve case study sites used to derive the measures. They were chosen to comprise three matched pairs of neighborhoods—similar in density but broadly varied with respect to other urban form characteristics.

Defining & Assessing Individual Qualities: The survey instrument was designed to assess one quality per page as shown in *Figure 7-3: Sample Survey Evaluation Page.* Each page is titled with the quality name (e.g. *Enclosure of the Street*) and a sub-title indicating whether it belongs to the driving / neighborhood-wide segment or the walking / street & block segment. At the top of each page are series of questions intended to guide the evaluator in assessing that particular quality in the field. The body of each page lists the six study sites each with its own 1 to 5 scoring scale labeled with descriptive terms at each end of the range (e.g. *weak enclosure* & *strong enclosure*). Each of the six street / block scale cases is referenced to its associated neighborhood to help keep evaluators oriented as they move between different sites and scoring sheets. Following the list of six scoring bars, two questions probe key issues about the second

Figure 7-3: Sample Survey Evaluation Page:

Walking Segment / Street - Block Scale

ENCLOSURE of the Street

Do you feel a sense of enclosure as you walk along the street?
How high are the buildings & trees? How close are they to the street?

Sargent Street (Maple)

	1	2	3	4	5	
weak enclosure						strong enclosure

Iris Way (Hemlock)

	1	2	3	4	5	
weak enclosure						strong enclosure

Main Street (Main)

	1	2	3	4	5	
weak enclosure						strong enclosure

Longwood Lane (Dunster)

	1	2	3	4	5	
weak enclosure						strong enclosure

Wolf Run (Wolf)

	1	2	3	4	5	
weak enclosure						strong enclosure

Green Street (Elm)

	1	2	3	4	5	
weak enclosure						strong enclosure

In relation to this quality, please circle the response that best fits your experience:

How clear was this concept?

(a) very clear
(b) moderately clear
(c) not very clear

How difficult was it to evaluate?

(a) a piece of cake
(b) moderately difficult
(c) it was really hard to judge

Enclosure is the degree of spatial containment of the street corridor. It is a function of the size and arrangement of edge elements of street (buildings, trees, fences, etc) in proportion to the street itself. Vertical edges on a tight street create a strong sense of enclosure; weak enclosure is associated with more open, less defined spaces.

asks how difficult it was to evaluate in the field survey. Finally, at the bottom of the page, a full written definition of the quality is provided in a highlighted box. Both the questions at the top and the definitions at the bottom are repeated from materials sent to each evaluator prior to the survey and in the verbal introduction given at the start of each survey tour.

Overall Differences and Livability: In addition to the nine pages of individual qualities, two summary pages at the end probe a pair of important overall issues: 1) the basis for case selection, and 2) preferences of the evaluators. Instructions for these pages are only given at the end of the tour. The first summary page tests perception of the overall differences between cases that guided the case study selection process. It asks evaluators to rate the degree of difference between seven matched pairs of neighborhoods. Each pair is rated on a scale of 1 to 4 as: (1) very similar, (2) somewhat similar, (3) somewhat different, or (4) very different. The first three matched pairs hold density constant and vary by development type. The second three pairs hold development type constant and vary by density. The last pair varies by both density and development type. Two final questions ask evaluators to circle which two of the six cases are most alike and which two are most different. The underlying research premise holds that significant and perceptible differences of character remain between neighborhoods of similar density.

The final page of the survey asks evaluators to switch gears from objective evaluation to subjective preference. It asks each neighborhood to be ranked on a 1 to 5 scale in terms of *livability*. While the definition of what constitutes livability is left for each individual to decide based on his or her own judgment of "what make a good place to live," field questions to guide responses are listed in the same format as the measured qualities at the top of the page. They specifically ask the evaluator to consider if the neighborhood is comfortable, attractive, interesting, and accessible. These questions are significant for three reasons: 1) pre-tests showed evaluators had a strong desire to express their personal opinion, 2) it provides some record of personal preferences that may bias a surveyor's response, and 3) it offers some first glimpses of potential relationships between measured qualities of neighborhood form and relative attractiveness for residents—at least for this very limited sample.

Finally a series of three open-ended questions at the bottom of the page probe the relative difficulty of evaluating these qualities in the neighborhoods by asking: 1) if certain *qualities* were more difficult to evaluate than others, and 2) if certain *neighborhoods* were more difficult to evaluate than others. A final question asks if there were any other qualities of neighborhood character that they thought might be important to evaluate.

7.2.4 Pre-Testing Survey Protocol

In concept, the survey protocol was also quite straightforward. Surveys were administered to groups of six evaluators in discrete two and a half hour field tours of the six case study neighborhoods. Each neighborhood tour was divided into a driving segment and a walking segment—each with its own set of associated qualities to evaluate. The protocol pays special attention to creating as consistent an experience as possible between neighborhoods and between tours. A series of pre-tests were used to develop and refine the protocol and to trouble shoot any potential problems. A number of adjustments were made in consultation with the researcher's dissertation chair in early May 2005.

Pre-Test Number 1: The first pre-test focused on the route and timing of the tour. Following a sketched out tour route, a sequential windshield tour was made between all six tour neighborhoods. Based on this test, it was determined the minimum time required to complete the entire tour was about two hours. This seemed near the limit of a reasonable time commitment for volunteer evaluators. As can be seen in *Figure 4-1a Location Map of Twelve Study Neighborhoods,* the four northern sites are clustered within about five-minute drive of each other. They include *Main* in Norwich, *Hemlock* in Hartford, *Maple* in Hanover, and *Dunster* in Lebanon. The last two, *Wolf* and *Elm*, are located within five minutes of each other but about ten minutes away from the other four near downtown Lebanon. After accounting for travel time between cases, this left about 90 minutes of actual survey time—or roughly fifteen minutes per neighborhood.

The allotted fifteen minutes for each neighborhood was divided between three components: 1) a five minute driving tour to evaluate four neighborhood wide qualities; 2) a five minute walking tour to evaluate five street/block qualities; and 3) another five minutes for filling out the scoring sheets. Specific routes within each neighborhood were mapped out with a goal of seeing the neighborhood by the most efficient route. A representative entry and exit point to each neighborhood was identified. A stop location for each walking tour was designated. Directions identifying each turn and street name, the route between neighborhoods, and associated time intervals were drafted.

Pre-Test Number 2: About a week later, a full-length pre-test was done following the complete route with a single volunteer completing the full survey. An interval stopwatch was used to time each tour component as well as overall time. This test resulted in a number of adjustments to the protocol. First, traveling at the target speed of 10 to 15 miles per hour, the driving tour was too long (about 7 minutes) in most cases. Repetitive legs along the neighborhood edges intended to provide a fuller view of context were shortened. Several internal street segments that were similar in character to other segments were made optional. The overall intent was not to cover 100% of each site, but rather to present a reasonable representation of the overall neighborhood.

Secondly, scoring the neighborhood wide qualities was best done while the vehicle wasn't moving. The logical point for this to occur was the starting point of the walking tour. The protocol called for scoring to be done in the field immediately following each tour segment. However, if the walking tour street fell in the middle of the driving tour, only partial observations of the neighborhood could be used. In response, the internal routes in several cases were re-routed so that the walking tour fell at the very end of the driving tour. This allowed evaluators to complete their neighborhood wide evaluations before starting the walking tours.

The walking tour was less complicated. The administrator pointed out the block to be walked and then moved the vehicle to the end point of the walking tour—about 500 feet away. This provided ample time for evaluators to both observe and fill out the associated scoring sheets on clipboards as they walked down the block. Evaluators were asked not to begin scoring until they had walked at least half of the block.

In general, the survey instrument worked pretty well. The biggest problem was keeping track of which of the eleven pages were associated with which part of the tour. Confusion was minimized by printing each group on different colored paper and stapling them together as sets—white for the driving tours, yellow for the walking tours, and pink for the summary pages. This also proved a great advantage keeping the nearly 500 survey sheets organized during the data entry process. Several adjustments were made to the quality definitions to reduce confusion of terms and remove potential for bias.[9]

The initial draft of the survey instrument used a 1 to 7 gradient scale. It seemed to offer a suitable range of ranking that could be scored relatively quickly although some trouble was found in debating between intermediary values such as 2 and 3. It also became quickly apparent that provision should be made for changing scores. The first few neighborhoods were difficult to score in relation to the other cases that had not yet been seen. A scoring procedure that simply allowed crossing out initial scores and circling a new one was adopted. This allowed some view of how scoring was adjusted in response to more information. The alternative of waiting to score all neighborhoods until the end of the tour was thought to be less desirable due to the high likelihood of evaluators getting confused trying to sort out nine different qualities across six different neighborhoods from memory.

Pre-Test Number 3: In mid-May a third and final pre-test was done with two volunteers who were completely unfamiliar with the project and who had no training in urban design or related fields. The tour route and sequence worked well. The major problem was in clearly defining what qualities were being evaluated. While both had read the definitions, they had several questions. The first related to an uncertainty about "what to look for." They both wanted some examples that would illustrate the concept. The challenge was do so in a way that would not bias ranking by suggesting there was a "correct" answer. The second major question concerned the relative scale. What was it relative too? While project introduction instructed them to use the "local range of neighborhood form not New York City versus rural Kansas" there was a need for more specific known examples that would provide a better frame of reference for evaluating the places they were seeing. Finally, there was a general problem conceptualizing the neighborhood wide qualities because they could not be "seen" in one view. They require a certain level of abstract spatial thinking that can assemble a sequence of moving views into a composite pattern of grain, connection, character and density.

Several adjustments to the protocol were made in response to these problems. First of all a series of "field questions" to actively guide the evaluator in the field were drafted and added to the survey instrument (see Section 7.2.1 and 7.2.3). Secondly, the introduction was re-written as spoken script that would be used to introduce each tour (the full text is included as Appendix H). In the script, several local references were added as examples beyond the extremes of the scoring scale in order to provide a clearer frame of reference. Finally, a stable of relevant examples were identified that would be known to participants but not directly relevant to the local cases. These were available "on demand" to respond to the evaluator's questions about specific qualities. For instance, in response to questions about *grain*, the administrator could contrast the pattern of Provincetown or Boston's Beacon Hill with the pattern of a suburban office park such as Centerra or the Route 128 corridor.[11]

Two Scoring Issues: Reviewing the pre-test scores raised two more possible problems with the survey protocol. First, the scores, especially for the neighborhood patterns, did not seem to vary as much as might be expected. This could have simply been a function of being confused about the qualities in question. However, another possible explanation was that they simply did not see the same basic differences between the case study neighborhoods that the researcher saw. In order to further probe this potential a new summary page was added to the survey that asks participants to rank overall differences between a series of matched pair neighborhoods—this page is described in detail in Section 7.2.3.

A second scoring pattern was noted relative to the positioning of scores on the 1 to 7 gradient scale. The two sets of scores tended to share a similar relative relationship. For example, both ranked *connectivity* in case A as lower than *connectivity* of case B. However the actual scores often seemed to be located in different regions of the scale. In the same example Evaluator #1 might have scored case A as 1 and case B as 3, where Evaluator #2 might have scored case A as 3 and case B as 5. In relative terms they are the same, in absolute terms they are very different. Again this might be explained by a poorly defined frame of reference. It also could be the scale was too broad for them to work within. The fact that scores tended to be limited in range suggests it may be the latter. Given the general difficulties in grasping the concepts, it was decided to narrow the scoring scale to 1 to 5 in order to make a simpler set of choices.

Once three or four neighborhoods had been completed, and they had been able to ask some clarifying questions, both pre-testers reported being much more comfortable with their evaluations. They also both seemed to thoroughly enjoy the process. One noted at the end of the pre-test tour "this is so much fun, I could do it all day." The researcher found this endorsement of great use in recruiting survey participants.

7.2.5 Survey Implementation

Once the survey instrument and protocol were set, the survey was implemented. Six survey tours were run between mid-May and mid-June of 2005. Survey tour groups and schedules were arranged via e-mail from the pool of volunteer surveyors who had responded to earlier recruitment efforts. Communication with several older participants without ready access to e-mail was done via phone and by US mail. While availability of participants was the primary factor in setting up tour times, some attempt was made to vary time of day to minimize any associated bias. Sufficient flexibility in evaluator schedules allowed a reasonable time of day distribution among the six tours. As shown in *Table 7-1 Log of Tour Dates, Time of Day, and Sequence*, there were three morning tours, two late afternoon tours and one early evening tour.

Table 7-1 Log of Tour Dates, Time of Day, and Sequence

Survey Tour Schedule:			Order of Tour Neighborhoods:					
	DATE	TIME	1ST	2ND	3RD	4TH	5TH	6TH
Tour A	20-May	3-5 pm	Duns	Wolf	Elm	Maple	Heml	Main
Tour B	25-May	4-6 pm	Maple	Heml	Main	Duns	Wolf	Elm
Tour C	2-Jun	10-noon	Maple	Heml	Main	Duns	Wolf	Elm
Tour D	14-Jun	9-11 am	Duns	Wolf	Elm	Main	Heml	Maple
Tour E	16-Jun	7-9 pm	Main	Heml	Maple	Duns	Wolf	Elm
Tour F	17-Jun	10-noon	Duns	Wolf	Elm	Main	Heml	Maple

The sequence of tour neighborhoods was also varied to the extent possible to minimize any bias related to scoring certain neighborhoods first or last. While pragmatics of routing and meeting places didn't allow a completely randomized order, the tours were rotated between three different starting and ending neighborhoods and four different tour orders. Meeting places were chosen as convenient, neutral, parking areas at the edge of the first neighborhood surveyed in that tour.[12]

Other than tour time and order, only one other element was changed from tour to tour. A preliminary review of scoring from the first tour suggested it would be interesting to alternate specific street/block cases in two neighborhoods. In the Wolf Rd. neighborhood, the *enclosure* scores for Wolf Run were surprisingly high in some evaluations. This appeared to be related to the difficulty of addressing the typically one-sided street sections found in large lot, multi-family areas. This was discussed at length in Chapter Six as an important but confounding issue. Wolf Run is one of these cases. However, initial observations suggested the abundance of trees on the non-building side was strongly influencing scores. In order to try and separate the influence of trees and buildings on this quality, an alternative case, Ivy Place was used in three of the six tours. Ivy Place has similarly scaled buildings but no trees on the non-built side. The rotation order is shown in the blue type in *Table 7-2 Alternative Street/Blocks*.

Table 7-2 Alternative Street/Blocks for Main N1 and Wolf N11

Key to Alternative Street/Block Cases in Two Neigbhorhoods:		
	MAIN St Neighborhood	WOLF ROAD Neighborhood
Tour A	Main Street	Wolf Run
Tour B	Main Street	Ivy Place
Tour C	Elm Street	Ivy Place
Tour D	Elm Street	Ivy Place
Tour E	Elm Street	Wolf Run
Tour F	Main Street	Wolf Run

Townhouses with individual entries Wolf Run N11 (#1314)

Stacked flats with shared entries & parking Ivy N11 (#4067)

Figure 7-4 Contrasting Multi-Family Building Edge: Wolf N11 vs. Ivy N11

As illustrated in the *Figure 7-4 Wolf Run versus Ivy Way*, this pair of cases also offered another useful comparison between two common types of street/building edge found in these large lot multi-family areas: 1) buildings of individual townhouses (Wolf Run) and 2) buildings of stacked flats with common entries (Ivy Run). Both cases are very similar in the control variables of density, land use mix, and size. They are also located next to each other so their physical context and setting is almost identical. While the sample size for each case is cut in half, it was expected that the contrasting scoring could provide some insights into this confounding measurement issue.

A second alternative street/block was added to the Main Street neighborhood in Norwich village. The Main Street street/block case (not to be confused with the larger Main Street neighborhood) was chosen in part to look at how the variable of a wider street right-of-way and higher traffic volumes may affect perception. Again, a review of the initial scores suggested they were affecting scores when compared with other older village streets. However, because the densities were different it is hard to sort out the relative influence on these different qualities.

Main N1 has sidewalk, more traffic and wider ROW (#4502)

Elm N1 is narrower with no sidewalk and less traffic (#4452)

Figure 7-5 Contrasting Street Width & Traffic: Main N1 vs Elm N1

It was decided that alternating Main Street with Elm Street could be helpful in sorting out some of these variables. Elm Street is another Norwich village street with similar density and physical dimensions of the built edge (i.e. setback, style and spacing of houses) to Main Street. The primary difference is less traffic, no sidewalk, and a narrower right-of-way. Given the overall lack of regional variation in right-of-way width, this seemed like a useful pair of cases to compare within the same neighborhood. By mixing and matching the tour routes, all four possible combinations were included (i.e. neither alternative, one alternative, the other alternative, both alternatives). This helped to minimize scoring bias of from any one group.

Finally, in order to create a more direct baseline for comparing the perceptions of the researcher with that of a larger sample population, the survey was self-administered following the full protocol on two separate occasions. The first time was during the pre-test period. Scores were recorded and filed along with other pre-test results. They were not consulted over the course of administering the six field tours. At the very end of the process, six weeks after the first pre-test was done, the researcher again went through the full evaluation process as part of the Tour F. By this time, the familiarity with the tour protocol allowed the researcher to make evaluations and administer the survey at the same time. Evaluations were done without the knowledge of the tour group while they were out of the vehicle on the walking tour so as not to change the tour experience for the six Tour F evaluators. Scores were compiled separately for use in later comparisons. The researcher had no specific recollections of how the survey had been scored six weeks earlier.

Conducting the Survey: Other than the changes described above, the six survey tours were done strictly by the protocol that had been established over the pre-test period. While the pre-tests resulted in many refinements and improvements to the survey protocol, the basic survey design remained essentially unchanged from the field survey proposed in the research prospectus thirteen months earlier. The overall goal was to evaluate a series of neighborhood form qualities using the most objective and value-neutral process as possible outside a controlled laboratory setting. The protocol emphasized consistency at each step of the process. The survey protocol used for all six tours is summarized below.

Several days in advance of each scheduled survey tour, a group e-mail message was sent to each participant confirming the date and meeting time of the tour and attaching two supporting .pdf documents. The first was the *Survey Protocol and Consent Letter* required by the University of California, Berkeley's *Committee for the Protection of Human Subjects* required as part of the approval of the this research project.[8] The letter outlined on University of California letterhead the overall research project and the rights and responsibilities of both researcher and participant. A signed copy of the letter was collected from each evaluator at the beginning of each tour. The second document, the survey script, outlined the specific protocol and defined neighborhood qualities and field guide questions in the same manner as the survey form. Participants were asked to review the definitions before coming if possible.

At the start of each tour, the survey script was read to each group. The script emphasizes that they are not being asked to make evaluations of "good" versus "bad" but rather to simply assess the qualities as objectively as possible based on what they see during the field tour. In a world where people are saturated with market and opinion surveys asking their personal preferences, this concept sometimes had to be repeated in several ways. Surveyors were encouraged to think of themselves as botanists doing plant identifications—observing form and counting flower parts without expressing preference for one plant over another.

The script also explained how the evaluation process would change somewhat between scales. The neighborhood-wide evaluations required blending together a sequence of views into a composite image and were likely to be more difficult. The street/block scale evaluations were based on what they could see within a single block. The script also explained that the frame of reference for the survey was "all in-town neighborhoods in the Upper Valley" and advised that the first neighborhood would be especially hard to score without the benefit of seeing the other cases. It was suggested they make a tentative score if they really weren't sure and that it was perfectly fine to go back and change earlier scores after seeing the full range of case study neighborhoods.

A standard seven-seat mini-van was used for the survey tours. This allowed six evaluators and a driver/administrator to be comfortably transported. The only unsolicited commentary by the administrator described the location of the case study boundaries and reviewed the names of the qualities being evaluated for each tour segment. Clarifying questions about the qualities were sometimes discussed during the drive between neighborhoods. Evaluators were asked not to discuss or compare scores among themselves. They were assured there were no right or wrong answers. They were also advised not to over think their answers. It was emphasized that the success of the research depended on understanding how they saw each quality during the tour.

During each tour interval times were recorded at each neighborhood on the tour route sheet to ensure the number of minutes spent in each case study was comparable both between neighborhoods and between tours. Though relative "chattiness" of groups created some variation in tour length, the overall time intervals were very close across tours. Occasionally a group needed to be reminded that the tour was on a schedule and hurried along a bit.[13] For each tour the same route was followed for both driving and walking except as noted above. It became clear after the first tour that the tightness of the schedule would preclude using any of the optional driving segments and they were dropped from the route protocol.

After the last neighborhood was completed, the last two summary sheets were explained and completed before heading back to the starting point. These both generally were found to be quite easy to complete although occasionally the names of different neighborhoods had to be clarified by the administrator.[14] This generally took about ten minutes. The tour then returned back to the starting point. The participants were thanked for their help and the completed forms were collected. The next day a follow-up email was sent to each tour group member thanking them for their time and asking for any "day after" thoughts they may have on tour related issues. About 1/4 of the sample responded with useful feedback and/or questions.

7.3 Survey Results

The analysis of the *Neighborhood Evaluation Survey* begins by tabulating the evaluators' scoring of nine different urban form qualities across the six case studies visited on each field tour. Qualities 1 through 4 concern overall neighborhood patterns. Qualities 5 through 9 survey characteristics at the more detailed scale of a single block and street. Results also broken down between two primary groups of evaluators. The "professional" group is made up of persons with some formal training and experience in urban design and allied fields. The "lay person" group consists of people with an interest in the issues but no formal training. Comparing the two groups scores is useful for understanding how clearly different qualities can be "seen" by people with different aptitude and training in visual/spatial thinking.

The primary research goal of the survey is to test the extent to which each of the qualities can be understood and consistently reported across this small initial sample of thirty-seven individuals. As such, the analysis focuses largely on the distributions of the scores by looking at comparative histograms and basic descriptive statistics for each quality across the six study sites. The relationship of interest is the correlation between scores of individuals both across the entire sample and broken down by the two classes of evaluators. The small sample mandates particular attention to the magnitude or "size" of the relationship between individual scores for a given quality—that is how strongly they are in agreement. While sample size clearly limits the ability to generalize to a larger population, the stronger the magnitude between scores, the greater the reliability of the relationship. Being able to literally see the full array of data is one advantage of the relatively small sample and a relatively simple research question.

While many other interesting questions could be hypothesized about relationships between different quality types and neighborhood types, these are not the aim of this project. Other interesting questions might examine neighborhood form variables in relationship to various kinds of human activities, preferences, and ecological processes. These are also outside the bounds of this analysis. The goal of this project is simply to develop more robust descriptive measures of existing conditions. In doing so the project contributes to a more substantial basis for future work by helping to better define and operationalize "urban form" as research variable.

Presentation of Scoring Distributions: The scores are presented in discussion sections organized around each of the nine qualities. Each section begins with a large column chart comparing mean values for the entire sample *(all)* with mean values for the professional *(pro)* and lay *(lay)* groups. Columns are color-coded for visual comparison with blue for *all*, orange for *pro*, and green for *lay*. In general, if there is more than a difference of .5 in the mean score between sub-groups (5% to either side of the overall mean), it suggests there *may* be differences in the way the groups are seeing the quality. If the difference of the sub-means is greater than 1.0 it suggests a *high likelihood* there is something going on between the groups. This only occurs in seven out of fifty-four cases. However, as will be seen in the analysis of individual histograms, congruence of mean values doesn't necessarily correlate with clearly reported values across both groups. To the extent these charts are shown to be reliable assessments of qualities between neighborhoods, they will provide the basis for comparative analysis with the derived measured values in Section 8.2.

The presentation of mean scoring values for the street/block scale is somewhat complicated by addition of alternative street case studies for the Main (N1) and Wolf (N11) neighborhoods. This results the sample being split between two case studies for the first and last neighborhood on the summary tables. In these instances, the scores are split between streets rather than survey groups due to limited sample size. Means for the entire sample are still shown in blue (average of both streets). However, chart colors change for the sub-samples with lavender showing the mean for the first set of alternatives (Main St. and Wolf Run) and yellow showing the mean for the second set (Elm St. and Ivy Court).

Detailed Distributions by Case Study: Within each quality, a series of histogram tables and graphs present the detailed scoring frequencies for individual cases. While room does not allow a full discussion of scoring distributions for every case by every quality, sufficient examples are given to illustrate a number of fairly strong patterns found within certain qualities, certain neighborhoods, and particular to each class of surveyors. The titles of histogram tables and charts are color-coded using the conventions for distinguishing between sample groups: blue for *all*, orange for *pro*, green for *lay*. The same conventions are also used for the alternative streets for Q5 to Q9.

Frequency graphs array data in a continuous gradient of patterns. Some exhibit stronger agreement of values—they are shown in periwinkle blue. Distributions with less clear patterns are shown in coral red. Sometimes the distinction between "clear" vs. "not clear" is very apparent, other cases are more borderline. In general the distribution graphs seem to fall into one of four general shape categories:

1. *Clear and Sharp:* Qualities that are consistently scored. Almost everyone scores in a narrow range. Widespread agreement (tall, spiky graph).
2. *Clear but Broader:* Scoring has a single peak but distribution is bit wider. Still clear but across a broader range of scoring (lower, flatter peak on graph).
3. *Double Peak:* Scoring values cluster around two places on scale. Suggests contrasting interpretations (two discernable frequency peaks on graph).
4. *Scattered:* Simply no discernable pattern. Scores are scattered across the scale. Suggests poorly defined or hard to judge (ragged, low, graph values).

Overall, the scoring frequencies are fairly consistent across most neighborhoods and qualities. Patterns of a few qualities are very clear across all groups in most neighborhoods (e.g. density). In other cases, the professional group reports a clearer range of values while the lay group is more spread out (e.g. permeability). For a few more difficult ones, the professionals still are relatively clear while the lay group is much less certain (e.g. scale or consistency in certain neighborhoods). On rare occasions, both groups have pretty clear scores that are slightly shifted from each other. Some neighborhoods simply seem to be harder to judge (e.g. Hemlock N7). As expected, the professional sample generally draws sharper, more consistent distinctions between neighborhoods. This makes sense since given their greater familiarity with urban design concepts, experience in evaluating the built environment, and training in abstract visual/spatial thinking.

Other Issues: Finally the survey analysis looks at several broader questions. First it tests the underlying assumptions of differences in character that guided the original case study selection process. Secondly, it tests the underlying perceptions of the researcher used to develop and calibrate measures by comparing the researcher's independently reported survey scores with those of the survey sample. Finally, it reports on value-based *Livability* ratings across all six neighborhoods by the three sample groups. At least among this very limited sample, results suggests some very interesting implications for non-density, form-based measures in future assessment of neighborhood environmental quality.

7.3.1 Overall Differences Between Case Study Neighborhoods

The first results test a key underlying research assumption: whether or not the case studies exhibit broad variation of physical patterns after controlling for density. This test was developed in response to the rather weak variation of comparative scores between neighborhoods observed in early pre-testing. While this was likely related to confusion about definitions or frame of reference scale, it could also have indicated evaluators simply did not see the basic differences between neighborhoods that was the basis for their selection. In order to test this, at the end of the survey, evaluators were asked to rate the overall differences in neighborhood form between seven pairs of neighborhoods. Matched pairs were varied by type holding density constant, and by density holding type constant. Evaluators had no prior knowledge of selection criteria and the pairings were scrambled to obscure the underlying patterns.

Table 7-3 shows clearly shows the differences between neighborhoods are widely shared by a larger sample of opinion. In evaluating overall differences between three matched pairs of neighborhoods of similar density, surveyors were nearly unanimously perceived them as highly contrasted. The cases were viewed as quite different places with average values for all three pairs close to the maximum score of four.

Table 7-3 Overall Variation: Same Density / Different Development Era

	Pre WWII	Post WW II	Mean Score	VERY SIMILAR	SOMEWHAT SIMILAR	SOMEWHAT DIFFERENT	VERY DIFFERENT
Lower Density	N1 Main	N2 Dunster	3.4				
Middle Density	N5 Maple	N7 Hemlock	4.0				
Higher Density	N9 Elm	N11 Wolf	3.9				

Note: mean scores are based on a scale of 1 (very similar) to 4 (very different).

The research premise is further confirmed by ranking of neighborhood pairs that contrasted in density but similar in development type. As shown in Table 7-4, perception of differences is not nearly as strong in these pairings with mean values falling in the middle ranges between "somewhat similar" (score of 2) and "somewhat different" (score of 3). Density has a weaker influence on perception of physical variation than other dimensions of the neighborhood form.

Table 7-4 Overall Variation: Same Development Era / Different Density

	Lower Density	Higher Density	Mean Score	VERY SIMILAR	SOMEWHAT SIMILAR	SOMEWHAT DIFFERENT	VERY DIFFERENT
Pre WWII	N1 Main	N5 Maple	2.0				
Post WW II	N2 Dunster	N7 Hemlock	3.1				
Pre WWII	N5 Maple	N9 Elm	1.9				
Post WW II	N7 Hemlock	N11 Wolf	2.6				

Note: mean scores are based on a scale of 1 (very similar) to 4 (very different).

This relationship was further corroborated by responses to a question that asked evaluators to circle the two neighborhoods that were "most alike." Since the six cases constitute a two by three matrix in which cells vary either by type or density, all possible pairs must vary by either type or density. In 36 of 37 responses, the "most alike" pairs varied in density not in type. In only one case did the pair vary by type and not density (Main and Dunster). These results present strong support for the underlying research assumption that there are many factors other than density that contribute to perceived variation between neighborhoods. They show significant and perceptible differences of character remain between neighborhoods of similar density.

These findings raise serious questions about the use of density as the primary variable of neighborhood form in many research models. It suggests, at least in part, that the popularity of density as a form variable may be more related to how easily it can be measured (i.e. operationalized), than to its significance as a variable. This is not to suggest density is not important. Rather it suggests that a fuller understanding of the influence of urban form on a variety of research questions may need to account for other dimensions that are not so easily specified. The balance of this chapter discusses the potential of seven other dimensions of urban form—three at the neighborhood scale and four at the street/block scale—to be defined and captured in simple replicable terms.

7.3.2 Neighborhood Scale Qualities

Four neighborhood scale qualities were evaluated across the six study sites in six different survey tours. Surveyors were unaware that the study sites were comprised of three sets of matched pairs similar in density but contrasting in form. The study neighborhoods include N1 Main and N2 Dunster at the lower density; N5 Maple and N7 Hemlock Ridge at the middle density level; and N9 Elm and N11 Wolf at the higher density level. The cases were selected from the larger set of twelve cases discussed at length in Chapter Three. The sequence of neighborhoods was changed for each tour.

Each quality was rated on a scale of 1 to 5 over the course of a carefully controlled five-minute driving tour in each neighborhood. Because the entire site cannot be seen from one point at this scale, assessments require the evaluator to integrate a series of successive views into a composite mental image of the whole. Pre-tests suggested this kind of abstract thinking might be more difficult for the lay participants. The results show that this is not necessarily the case—it appears to be more of a problem in some neighborhoods than in others. The set of four qualities included the three test qualities of *consistency* (Q1), *connectivity* (Q2), *grain* (Q3), plus the control quality of *density* (Q4). Each of the test qualities corresponds to one or more measures of neighborhood form derived over the course of the research project.

Ratings of qualities are analyzed in two primary ways: 1) variation between scoring of different cases as measured by mean value, and 2) internal consistency within each case measured by standard deviation (SDV). Table 7-5 arrays the average (arithmetic mean) scoring value for each quality across all six neighborhoods. In general, the average scores show considerable variation of perceived character between neighborhoods for the four surveyed qualities.

Table 7-5 Average Survey Scores for Qualities Across Six Neighborhoods

Quality	N1 Main	N2 Dunster	N5 Maple	N7 Hemlock	N9 Elm	N11 Wolf
Q1 Consistency All	3.1	4.5	3.3	3.7	4.2	1.8
Q1 Consistency Pro	2.9	4.4	3.5	2.8	4.6	1.2
Q1 Consistency Lay	3.2	4.6	3.2	4.6	4.0	2.2
Q2 Connectivity All	3.1	2.8	4.0	2.9	4.6	1.4
Q2 Connectivity Pro	2.9	2.1	4.1	2.4	4.9	1.2
Q2 Connectivity Lay	3.3	3.3	4.0	3.3	4.3	1.5
Q3 Grain All	3.1	2.4	3.8	3.0	4.1	2.0
Q3 Grain Pro	3.2	2.1	4.2	2.2	4.4	1.3
Q3 Grain Lay	3.1	2.8	3.6	3.8	3.9	2.7
Q4 Density All	2.7	2.1	3.7	3.8	4.2	4.2
Q4 Density Pro	2.5	1.6	3.9	3.5	4.3	4.1
Q4 Density Lay	2.9	2.6	3.5	4.1	4.1	4.4

Note: Scoring is based on a 1 to 5 interval scale with 3 being the neutral assessment

When broken out by professional versus lay person sub-sample, the mean value remains pretty consistent across all six neighborhoods for most qualities. This suggests an overall consistency in how qualities are "seen" between groups. In a few instances, however, values diverge. For example in Q1 *consistency* in Hemlock, the difference of means is almost a full scoring interval of 1.0. This may indicate some difference of perception and/or understanding between groups. The overall variation between sample groups will be discussed in more detail for each quality.

A key research question is how internally consistent or reliable the scored values are within the sample. Strong agreement suggests the quality is readily "seen" and differentiated across this set of cases. More divergent scores suggest either the quality was not well specified or it is simply hard to judge consistently across settings or by groups. Table 7-6 arrays the standard deviation (SDV) for each quality.

Table 7-6 Standard Deviation (SDV) of Scores Across Six Neighborhoods

Quality	N1 Main	N2 Dunster	N5 Maple	N7 Hemlock	N9 Elm	N11 Wolf
Q1 Consistency All	0.89	0.56	0.91	1.47	0.83	1.09
Q1 Consistency Pro	0.75	0.51	0.80	1.60	0.62	0.56
Q1 Consistency Lay	1.01	0.60	1.01	0.60	0.89	1.24
Q2 Connectivity All	0.80	1.14	0.64	0.97	0.73	0.55
Q2 Connectivity Pro	0.78	0.86	0.49	0.62	0.24	0.44
Q2 Connectivity Lay	0.79	1.08	0.76	1.03	0.85	0.61
Q3 Grain All	0.82	0.96	0.80	1.28	0.82	1.34
Q3 Grain Pro	0.88	0.66	0.73	0.95	0.80	0.59
Q3 Grain Lay	0.79	1.07	0.76	1.07	0.79	1.50
Q4 Density All	0.66	0.92	0.71	0.78	0.78	0.76
Q4 Density Pro	0.80	0.79	0.70	0.72	0.77	0.75
Q4 Density Lay	0.49	0.83	0.69	0.76	0.79	0.75

Note: Scoring is based on a 1 to 5 interval scale with 3 being the neutral assessment

In general the overall scoring is relatively consistent (SDV from .7 to 1.0) for many of the qualities. Slightly higher values (1.0 to 1.3 SDV) show somewhat less consistency but show a recognizable trend. In some cases scoring is very consistent (less than .7 SDV)—for example 0.55 for Q2 *connectivity* at N11 Wolf Road. These values indicate all surveyors are seeing the same thing. In other cases, the SDV for the overall sample is quite inconsistent (greater than 1.3 SDV)—for example 1.47 for Q1 *consistency* at Hemlock. This suggests some disagreement or confusion among evaluators and may be related to the large variation of means seen in Table 7-5.

When SDV values are split out by sub-group, the pro sample is almost always lower indicating a more consistent scoring for that group. Again, one notable exception is found for *consistency* in N7 Hemlock. The specific patterns underlying these values will be discussed in more detail by looking at the comparative internal frequency distributions for several study sites for each of the four surveyed qualities.

Q1: CONSISTENCY

The quality of *consistency* is defined by the degree of change in urban form that is perceived as one moves from one part of the neighborhood to another. A consistent neighborhood (score of 5) feels similar throughout while an inconsistent neighborhood (score of 1) feels divided into distinct and contrasting parts. Figure 7-6 shows the comparative means of the three survey populations across all six study sites.

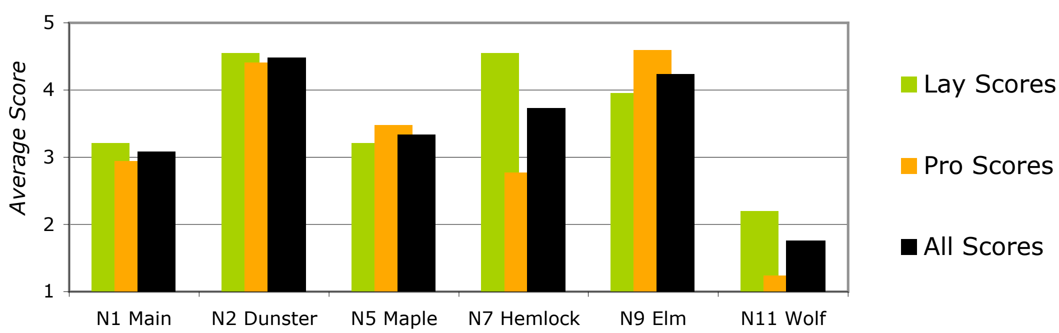


Figure 7-6 CONSISTENCY (Q1): Mean Scores by N_hood

The comparative means show several interesting patterns. First of all, the overall mean (i.e. the blue columns) shows a fairly broad variation of this quality across the case studies and across matched pairs. N2 and N9 were rated strongly consistent with scores over four. N11 was rated strongly inconsistent with a mean below two. The others fell a bit to the consistent side of neutral with N7 being closer to four. This matches the assumption of form variation beyond density in the case selection.

A second pattern finds that for four of the cases, the professional and lay person means (i.e. the orange and green columns respectively) are very close the overall mean.

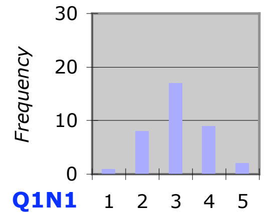
This suggests both groups were seeing similar relationships. However, just because the means correlate does not necessarily prove that the qualities are being clearly seen across the both samples. For example, assume a total sample of twelve with six lay and six pro. Three scores of "1" and three scores of "5" in one group together with six scores of "3" in the other would result in all three samples having an identical mean of "3" though they clearly are seeing very different things. A clearer understanding the strength of relationships underlying the mean, requires more detailed look at the internal scoring distributions of each group using histograms.

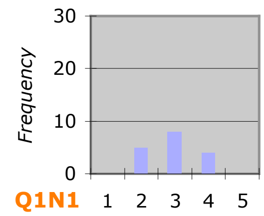
In contrast, there is a significant difference of sub-sample means for the last two neighborhoods—N11 Wolf and N7 Hemlock. The contrast is most strong in N7 where the difference of means between the *pro* and *lay* sample is 1.8. This finding suggests a difference between how each group is evaluating or "seeing" the quality in these cases. However once again this does not necessarily mean one group is seeing it more clearly than the other. They could both seeing different things equally clearly or both could be equally confused in their scoring. Understanding the correlations of scoring within each group requires a closer look at the frequency distributions. As will prove the case for all qualities, the means provide a good overview of the relative assessments, but more conclusive findings regarding scoring the quality *consistency* will depend on a more detailed analysis.

Table 7-7 is a histogram for *consistency* scores in the N1 Main Street neighborhood in Norwich village. It is a two-part graphic. The table on the left shows distribution of 1-5 scores by count and percentage for the entire sample *(all)* and count for the professional sub-sample *(pro)*. The two graphs on the right show these same two distributions with score value on the X-axis and scoring frequency on the Y-axis. These allow the two distribution patterns to be visually understood and compared. The color-coded Q1N1 title identifies the quality, neighborhood and sample of the graph.

Table 7-7 CONSISTENCY Q1 Histogram for N1: Overall vs. Professional Only

Mean	*3.1*		*2.9*
SDV	*0.89*		*0.75*
Score	*All Freq*	*All %*	*Pro Freq*
1	1	3%	0
2	8	22%	5
3	17	46%	8
4	9	24%	4
5	2	5%	0
	37	100%	17



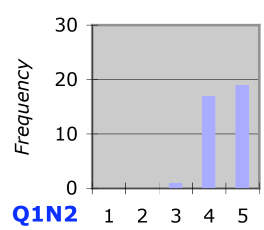


The relationships are pretty clear. The overall distribution is well-shaped but a bit broad. Ninety-two percent (92%) of the sample rated between two and four with exactly half of those assessing the middle value of three. The *pro* sub-sample distribution is almost identical in shape and distribution. By default, the *lay* distribution can be assumed to be similar as well. It should be noted that three outliers are all in the *lay* category. This was expected and fits the anecdotal evidence that several of the lay evaluators were very uncertain of what they were doing at times (see Note 12).

In this instance, there seems to be a fairly consistent evaluation of N1 as a place of middle-of-the-road *consistency* with some ranging up or down one score from the center. All groups seem to be seeing the same thing. This also seems to fit the village character where considerable variety of housing type, age, lot size, street pattern, etc exists within a traditional, mixed village fabric. The number of variables makes it difficult to assess exactly but it clearly is neither extremely consistent nor inconsistent.

Table 7-8 CONSISTENCY Q1 Histogram for N2: Overall vs. Lay Person Only

Mean	*4.5*		*4.6*
SDV	*0.56*		*0.60*
Score	*All Freq*	*All %*	*Lay Freq*
1	0	0%	0
2	0	0%	0
3	1	3%	1
4	17	46%	7
5	19	51%	12
	37	100%	20



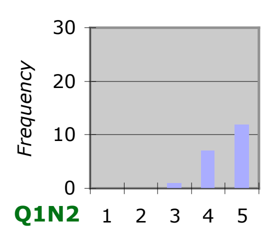
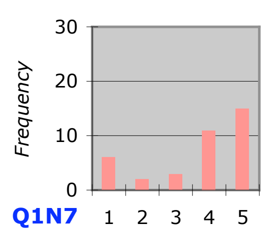


Table 7-8 shows the same set of relationships for the N2 Dunster Drive neighborhood just south of downtown Hanover—only this time the overall sample distribution is compared with the lay sub-sample rather than the professional sub-sample. The patterns in this neighborhood are even sharper than in N1 Main. Ninety-seven percent (97%) of the evaluators (i.e. 36 of 37) rank it either a four or a five—strongly consistent. Again the overall sample is pretty well mirrored in the sub-sample. A slight shift toward five is noted (12 of 19 total) with the pro sample shifting slightly toward four (10 of 17). However, given the overall research goal of making first-order distinctions of form, this case is very clear. Again, this is not surprising finding. The neighborhood is primarily a 1960's and 70's single-family tract with similar lot sizes and housing types with some variety of landscape character—a very straight-forward assessment setting.

Assessments of *consistency* for the N5 Maple and N9 Elm neighborhood are quite similar to those of N1 and N2. In Figure 7-6 shows these similarities are quite clear in the summary means. N5 is an older neighborhood with some variety of lots and buildings but not as much as N1. N9 is also older neighborhood but with more formal town character including a regular grid of streets and more consistent lot patterns. While not as consistent as a tract development, it was scored as relatively consistent. Due to limitations of space, detailed histograms will only be presented for cases where they are especially illuminating.

Table 7-9 CONSISTENCY Q1 Histogram for N7: Overall vs. Professional Only

Mean	3.7		2.8
SDV	1.47		1.60
Score	All Freq	All %	Pro Freq
1	6	16%	6
2	2	5%	2
3	3	8%	2
4	11	30%	4
5	15	41%	3
	37	100%	17



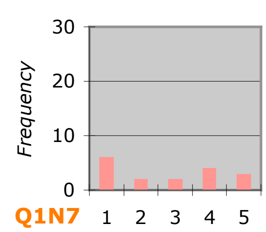


Table 7-9 shows the scoring distributions were considerably cloudier for N7 Hemlock Ridge. The overall distribution is an example of a "double peak" frequency. Values show some clustering at opposite ends of the scale. In this case, as in most cases, the difference in clearly linked to the different perceptions of the *lay* versus *pro* sample.

Each group is seeing something different. The interesting twist here is that it is the *pro* sample rather than the *lay* sample that shows ambiguity of scoring ranging across all five categories from very inconsistent to very consistent and an SDV of 1.60. In contrast, simple subtraction shows the lay sample was quite clear about what they were seeing with 95% (19 of 20) reporting either a four or five and an SDV of .60.

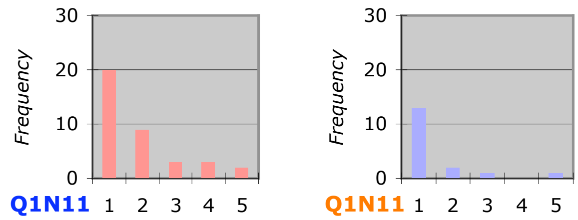
Over the course of the survey tours, the reason for this divergence became quite clear. The concept of *consistency* was intended to capture the large-scale structural differences of neighborhood space (i.e. building type, land use, street pattern). A related but distinct issue is the assessment of visual consistency and design character (i.e. architectural & landscape details) that is evaluated at the street/block under the quality of *variability*. These distinctions were discussed at length and definitions re-worked during the survey design but the results suggest more work needs to be done.

N7 Hemlock is largely a master-planned community with distinct and contrasting pods of development (i.e. single-family, garden apartments, townhouses, senior housing, and large apartment blocks). However the over-riding consistency of the neighborhood-wide landscape design and appears to be strong enough to obscure the basic structural differences of land use and building for most evaluators (see comparative photos in *Figure 4.1f Middle Density Set: Character)*. The distributions show the *lay* sample seeing a "consistent" place while the pro sample was sharply divided. When the definition of *consistency* became clearer to one pro surveyor over the course of the survey, she exclaimed "oh, now I understand" and went back and changed her score from five to one for N7 Hemlock. The researcher's own score changed from a one in the pre-test to a three during the last tour in response to the confounding issue of landscape. This suggests the *consistency* definition needs to be further clarified.

In the case of N11 Wolf, the results in Table 7-10 show the opposite pattern between sub-samples. As a large-lot multi-family neighborhood the underlying pattern

Table 7-10 CONSISTENCY Q1 Histogram for N11: Overall vs. Pro Only

Mean	1.8		1.2
SDV	1.09		0.56
Score	All Freq	All %	Pro Freq
1	20	54%	13
2	9	24%	2
3	3	8%	1
4	3	8%	0
5	2	5%	1
	37	100%	17



is quite similar to N7. However the lack of any coordinated landscape treatment makes the contrasting pods of development much easier to see and evaluate. Here 78% of the *all* sample and nearly 90% (15 of 17) of the *pro* sample scored a one or two—they clearly saw a very inconsistent neighborhood. This time is was the *lay* sample that was not so sure—70% rated one or two but the other 30% were less sure. Anecdotal comments suggest they simply saw "a bunch of developments" that seemed the same.

Q2: CONNECTIVITY

The quality of *connectivity* is defined by the degree of interconnection of a neighborhood's circulation system (i.e. streets, sidewalks, etc.), both internally and with its surroundings. In neighborhoods of high connectivity (score 5) the street network offers many route choices and access points. Areas of low connectivity (score 1) have limited access and route choices. Figure 7-7 shows the comparative scoring means of the three sample populations across all six study sites.

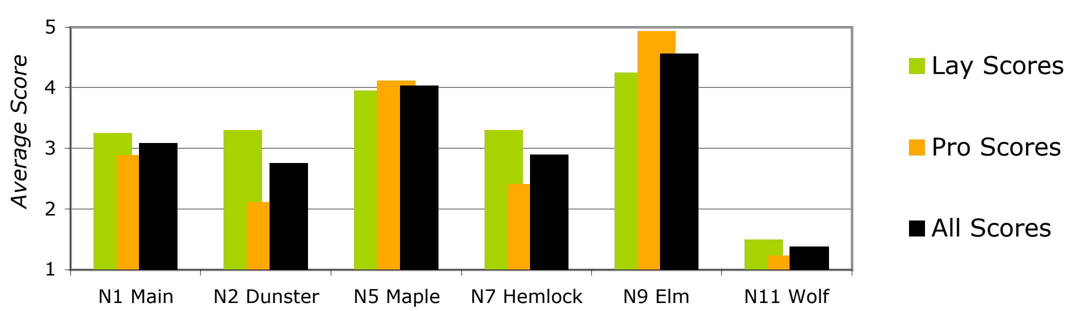


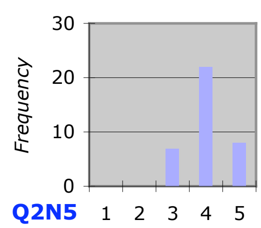
Figure 7-7 CONNECTIVITY (Q2): Mean Scores by N_hood

The comparative means graph suggests some variations on the patterns seen in the previous quality. Once again, the strong variation of the overall average score confirms there are considerable differences between both matched pairs and across all cases as well. Within the lowest density pair (N1 & N2), the difference is smallest. Within the middle density pair (N5 & N7) the differences become more pronounced. The difference of over three intervals (4.6 to 1.4) between the highest density pair (N9 & N11) is almost as broad a difference as the scale allows. These differences generally correlate with expected variation.

Comparing the means of the sub-sample groups finds strong agreement in three cases (N1, N5, N11), weaker agreement in two others (N7 & N9) and a significant difference (1.2) in N2 Dunster. As this quality is somewhat easier to conceptualize and assess, examination of the relative distributions offer considerable insight into some key differences between groups. These are again best revealed in frequency distributions.

Table 7-11 CONNECTIVITY Q2 Histogram for N5: Overall vs. Lay Person Only

Mean	*4.0*		*4.0*
SDV	*0.64*		*0.76*
Score	*All Freq*	*All %*	*Lay Freq*
1	0	0%	0
2	0	0%	0
3	7	19%	6
4	22	59%	9
5	8	22%	5
	37	100%	20



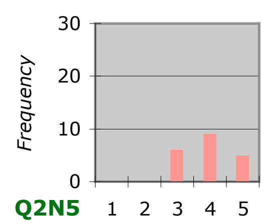
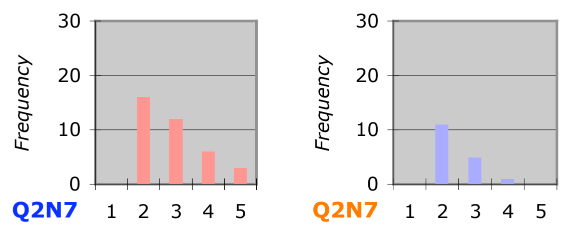


Table 7-11 shows the scoring distributions for N5 Maple. The overall distribution is quite clear and sharp with about 60% of scores right at four and the other 40% split just one interval to either side. The neighborhood is seen a pretty well connected with about 40% feeling it might be stronger or weaker than the rest. However, the right-hand histogram shows almost all of this uncertainty belongs to the *lay* group. Taken alone, they are almost evenly split between values of three, four and five. In contrast, this means the *pro* scores are actually that much more sharply in agreement with 13 of 17 giving this neighborhood a score of four. This is a pattern that is seen repeatedly in the data. Even in cases where the overall sample seems clear, the *pro* sample is relatively more sharply focused in its scoring while the *lay* sample tends to be somewhat more tenuous and inconsistent. This is a pattern that makes sense given the professional's greater degree of experience and training in the field and the relative unfamiliarity of the concepts to many of the non-professionals.

The scoring distributions (not shown) of the other two neighborhoods with equivalent mean values are very similar to N5 Maple—only shifted lower on the scale. N1 Main's distributions are cleanly focused around three and N11 Wolf's scores are sharply focused around the lowest value of one. There is also the same tendency shown for the *pro* scores to be more in agreement.

Table 7-12 CONNECTIVITY Q2 Histogram for N7: Overall vs. Pro Only

Mean	*2.9*		*2.4*
SDV	*0.97*		*0.62*
Score	*All Freq*	*All %*	*Pro Freq*
1	0	0%	0
2	16	43%	11
3	12	32%	5
4	6	16%	1
5	3	8%	0
	37	100%	17

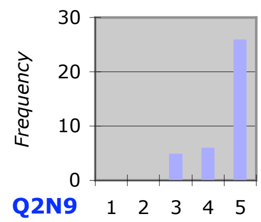


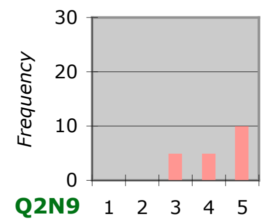
In N7 Hemlock, a moderate difference of means (.9) between *pro* and *lay* hints at underlying differences between groups. In Figure 7-12 the overall distributions are not as clearly focused as the previous cases with values trending toward two but ranging out to five. However, the pro sample again is more sharply focused (16 of 17 at two or three) which means conversely the lay sample is more widely spread with values spread from two to five. It is hard to know how this neighborhood of closed loops off a spine road might be judged as highly connected but some evaluators found it to be so.

The Elm Street (N9) neighborhood shows this pattern of more consistent evaluations by the *pro* group even more clearly. This traditional in-town neighborhood is the poster child of *connectivity* in the Upper Valley. It is the only neighborhood that is organized around a clear grid of streets with sidewalks on both sides and multiple connections in all directions to its surroundings. Like N7, a moderate difference of

Table 7-13 CONNECTIVITY Q2 Histogram for N9: Overall vs. Lay Only

Mean	4.6		4.3
SDV	0.73		0.85
Score	All Freq	All %	Lay Freq
1	0	0%	0
2	0	0%	0
3	5	14%	5
4	6	16%	5
5	26	70%	10
	37	100%	20

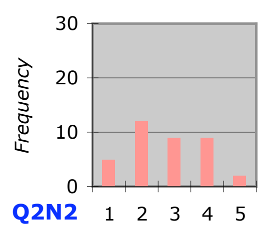


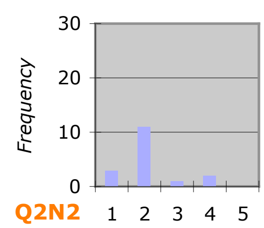


means (.7) hints at underlying distribution issues. Not surprisingly, Table 7-13 shows overall scoring strongly biased (70%) toward the maximum value of five. Within the *lay* only sample, however, only 10 of 20 scores a five, with the others choosing more moderate values. In the *pro* group there is no uncertainty—16 of 17 score five. Connectivity is so black and white in this case, the only plausible explanation seems that as a group, the lay sample found the underlying concept to be somewhat confusing or unclear.

Table 7-14 CONNECTIVITY Q2 Histogram for N2: Overall vs. Pro Only

Mean	1.4		1.2
SDV	0.55		0.44
Score	All Freq	All %	Pro Freq
1	5	14%	3
2	12	32%	11
3	9	24%	1
4	9	24%	2
5	2	5%	0
	37	100%	17





Finally, the larger difference of mean (1.2) for the N2 Dunster neighborhood corresponds with another striking difference between the groups. The street pattern in this single-family tract neighborhood includes a series of cul-de-sacs branching off a few internal blocks with only a single way in and out. Yet, as shown in Figure 7-14, the overall scoring is surprisingly spread out across the board. In contrast, the pro sample is clearly at the low end with nearly two-thirds of the surveyors choosing the score of two.

It is suspected that some of the inconsistency may be due to the fact that the definition requires balancing external and internal patterns of connection. Field conversations suggested this was sometimes overlooked—especially by the lay group.

Taken together, the preceding analysis helps to sharpen one other overall pattern in the scoring relationship that will also be seen in other qualities—the tendency for the lay group to see less pronounced overall distinctions between neighborhoods. Looking back at Figure 7-7, it is clear that the pro group finds higher highs and lower lows at the extreme ends of the scale. Thus not only do they score more consistently, but also draw sharper overall distinctions between neighborhoods. This fits with the lay group being somewhat less clear about what they are looking for. The more tentative a judgment, the more likely it is to score in the "safer ground" of middle range values.

Q3: GRAIN

The quality of *grain* is defined by the relative scale of structural cells or spatial divisions that underlie a neighborhood. Fine-grained neighborhoods (score 5) are divided into many smaller increments of space. Coarse-grained neighborhoods (score 1) are characterized by larger, more generous spatial divisions. Figure 7-8 shows the comparative mean values of the three groups across the six study sites.

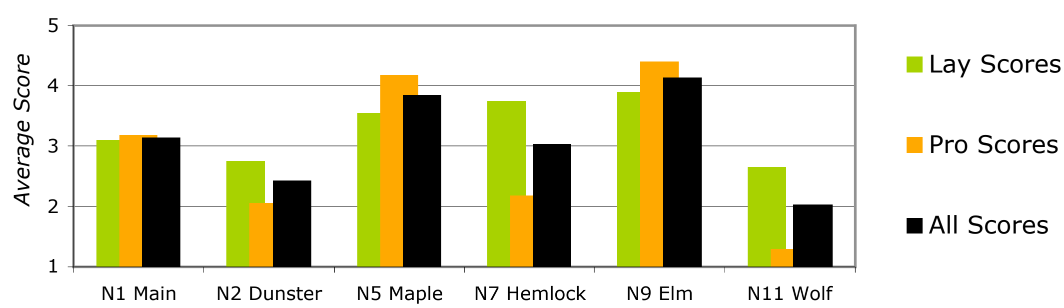


Figure 7-8 GRAIN (Q3): Mean Scores by Neighborhood

The big patterns discussed in the preceding sections are again visible in the comparative means between groups by neighborhood. First of all, while the variation between neighborhoods is generally quite strong, there a more pronounced distinction drawn by the pro group—in other words the mean values represented by the orange columns are always located farther from the neutral value of three. For example, N5 and N9 Elm both are fine grained (about four) when judged by the overall average. However, the pro average in both cases are *more* fine-grained than the lay average (the green columns). Likewise, the overall averages for N2 Dunster and N11 Elm both trend toward the coarse side of the scale (i.e. toward two), however the *pro* averages are significantly *more* coarse (i.e. lower) than the *lay* averages.

In the case of the last two neighborhoods (N1 & N7), the overall averages are almost exactly neutral (i.e. three). Thus there is no directional bias to trend towards. In the case of N1 Main, the close clustering of all three means suggests everyone is seeing, on average, a very middle-grained neighborhood. In contrast, the overall neutral assessment of *grain* in N7 Hemlock is sharply disputed in opposite directions by the *pro* and *lay* average scores. The graph shows an identical relationship of means for N11 Wolf only now shifted one interval lower on the scale—high green, low orange, middle blue. The relationships will all be further clarified by the frequency distributions.

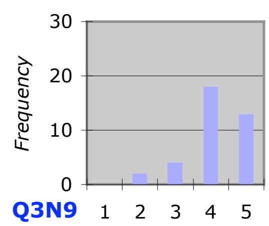
The second strong pattern seen in the Figure 7-8 is the distinct variation of scored values for neighborhoods of similar density. In the lower density pair, N1 is higher and N2 is lower; in the middle density set N5 is higher and N7 is lower; and in the higher density set N9 is higher and N11 is lower. The overall distinction is significant for both the first two sets (.7 and .8 respectively) and quite dramatic (2.1) in the last pair. Again the distinctions are more sharply drawn (1.1, 2.0, and 3.1 respectively) by the *pro* sample across all three matched pairs. These values further support the finding that the *pro* group is more confident and decisive in their evaluations than the *lay* group. The variations are still detected by the *lay* group, just not as strongly. Again studying the distribution tables will further illuminate these patterns.

Finally there is the question of internal distribution. How much internal agreement underlies the scoring averages? Within each group is everyone seeing values close to the mean or is the mean masking a considerable disagreement within the group? These questions are, of course, can only be answered by looking at the individual frequency distributions or histograms for each group.

In the four neighborhoods (N1, N2, N5 and N9) where the pro and lay averages where fairly close (i.e. the green and orange columns in Figure 7-8), the group distributions follow a very similar pattern. As was found for the first two qualities, a generally clear overall distribution masks diverging tendencies within the sub-samples. The pro group scores tend to be more tightly focused and sharply drawn and the lay scores are more spread and moderate.

Table 7-15 GRAIN Q3 Histogram for N9: Overall vs. Professional Only

Mean	*4.1*		*4.4*
SDV	*0.82*		*0.80*
Score	*All Freq*	*All %*	*Pro Freq*
1	0	0%	0
2	2	5%	1
3	4	11%	0
4	18	49%	7
5	13	35%	9
	37	100%	17



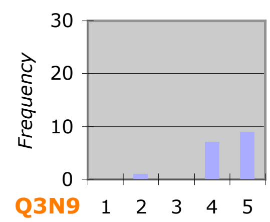
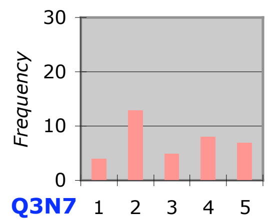


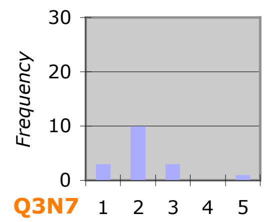
Table 7-15 illustrates this pattern in the Elm Street N9—a traditional small lot neighborhood. This case is strongest Upper Valley example of what most professionals and academics would identify as a "fine-grained" urban fabric. The distribution graph shows 84% of the overall sample with ranking either a four or five. Within the pro group agreement is even both stronger (16 of 17 or 94%) and more pronounced—a more choose the extreme value of five. The mixing of some relatively larger lots and buildings make the debate between four and five a reasonable one.

Take away the *pro* scores and the *lay* distributions are more tentative. There is a tendency toward moderately fine but scoring is spread from two to five. Once again the *pro* sample sees the quality more sharply than the *lay* sample. The one professional who scored it a two (moderately coarse), demonstrates that even within the *pro* group some differences of understanding and judgment are possible.

Table 7-16 GRAIN Q3 Histogram for N7: Overall vs. Professional Only

Mean	*3.0*		*2.2*
SDV	*1.28*		*0.95*
Score	*All Freq*	*All %*	*Pro Freq*
1	4	11%	3
2	13	35%	10
3	5	14%	3
4	8	22%	0
5	7	19%	1
	37	100%	17

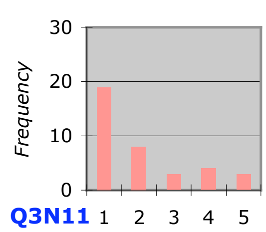


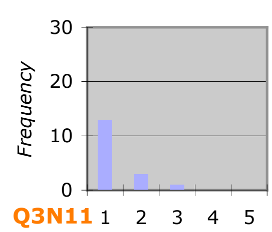


The two remaining neighborhoods, N7 and N11, a much larger difference of means (1.6 and 1.4 respectively) between *pro* and *lay* again suggests some underlying differences between groups. In Figure 7-16 the overall distributions are a good example of a scattered or unfocused distribution although a slight focus is visible around two (35%). Here is a case where a random looking overall distribution masks a significant underlying agreement within the pro sample. The right graph shows a pretty strong agreement around two—somewhat coarsely grained. It is not as tightly focused as some of the other cases (10 of 17 with 3 to either side) but it certainly is clear. Conversely the lay sample is widely spread with values spread from two to five. As was the case with *consistency* at Hemlock Ridge, the unifying influence of the master-planned landscape may make it somewhat confounding for an untrained eye to pick up the "pod" edges within this large-lot neighborhood. Several anecdotal comments suggested that *grain* was simply hard to "see" in such a unified landscape.

Table 7-17 GRAIN Q3 Histogram for N11: Overall vs. Lay Person Only

Mean	*2.0*		*1.3*
SDV	*1.34*		*0.59*
Score	*All Freq*	*All %*	*Pro Freq*
1	19	51%	13
2	8	22%	3
3	3	8%	1
4	4	11%	0
5	3	8%	0
	37	100%	17





As was the case for consistency, the distribution graphs for N11 Wolf suggest its less coordinated landscape character makes the large lot divisions more distinctive for most observers. The left graph on Table 7-17 shows 73% of surveyors scored it as somewhat coarse or very coarse—although there is still some disagreement visible. Given the patterns seen thus far, it is not surprising to find only one member of the *pro* sample among the 13 who did not find it coarsely grained. Consistent with the pattern of tight and pronounced values in the *pro* group, 13 of 17 rated it one—very coarse.

Q4: DENSITY

The quality of *density* is defined as relative intensity of residential land use (i.e. dwelling units) across a neighborhood. In higher density neighborhoods (score 5) buildings and dwelling are more intensively arranged on the land. Lower density neighborhoods (score 1) feel less intense and more spread out. Figure 7-9 shows the comparative mean values of the three groups across the six study sites.

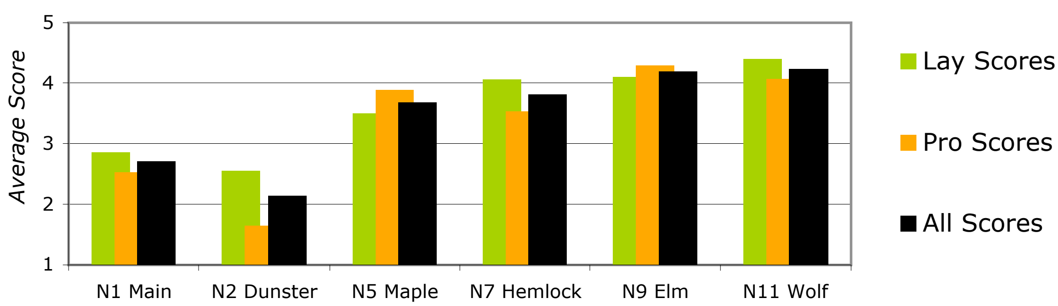


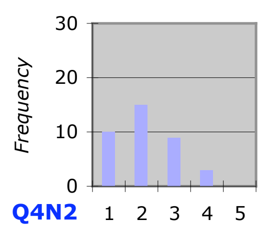
Figure 7-9 DENSITY (Q4): Mean Scores by Neighborhood

Density, of course, is the one neighborhood quality being assessed for which a well-known and understood measure already exists. For residential neighborhoods the measure is typically calculated as units per acre.[15] The measure generally seemed familiar to the *lay* sample as well as the *pro*. This familiarity may help explain why *density* is the only quality where a general parity of scoring was found between the groups. A number of patterns observed in previous analyses were either not as strong or absent in these scores. The above graph shows a strong correlation of average scores for every case but N2 Dunster with a modest 0.9 difference. This suggests some congruence between sub-sample observations. Moreover, the pattern of greater contrast of extreme values in the pro sample is seen in the lower range but not at the upper one. Finally, the sharp divergences within the internal distributions for each group that has been so clear in prior data sets is largely missing for this quality.

In general, the average values show a variation between neighborhoods that generally capture the correct relative density relationships but does not reflect the full amplitude of the differences in measured values. The lower set, especially N1 Main, is perceived to be a bit denser in relationship to the others. Likewise, the very small difference between the middle and upper density sets understates the actual measured differences. The relationships between perceived and measured values will be discussed at length in Section 8.2 of the final chapter.

Table 7-18 DENSITY Q4 Histogram for N2: Overall vs. Professional Only

Mean	*2.1*		*1.6*
SDV	*0.92*		*0.79*
Score	*All Freq*	*All %*	*Pro Freq*
1	10	27%	9
2	15	41%	5
3	9	24%	3
4	3	8%	0
5	0	0%	0
	37	100%	17



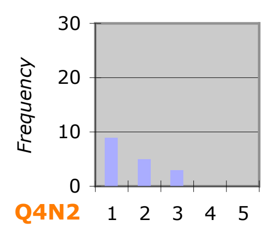
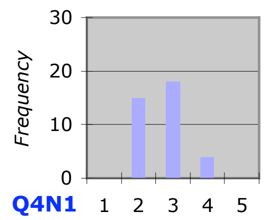
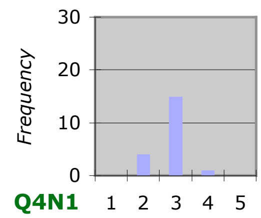


Table 7-18 shows the distributions for N2 Dunster, the only case with a significant difference of means and the only case where the internal distributions are similar to previously noted patterns. The overall distribution is fairly clear but also quite broad. The right graph shows the pro distribution. Although it is typically more focused and shifted to toward one end of the scale, it is still a bit broad. However, unlike previous patterns, the *lay* sample (not graphed) has almost an identical shape only shifted one interval higher on the scale. Though the reason why the *pro* group scores reflect a more accurate assessment of relative density are unclear, it may be related to single-family tract development being a well-known “low density” housing type to most professionals.

Table 7-19 DENSITY Q4 Histogram for N1: Overall vs. Lay Person Only

Mean	*2.7*		*2.9*
SDV	*0.66*		*0.49*
Score	*All Freq*	*All %*	*Lay Freq*
1	0	0%	0
2	15	41%	4
3	18	49%	15
4	4	11%	1
5	0	0%	0
	37	100%	17

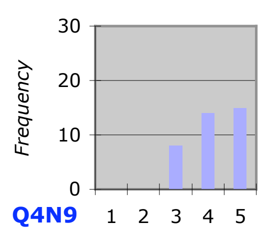




A somewhat different pattern is shown in Table 7-19 for the village N1 Main neighborhood. Here the overall distribution shows a pretty strong focus around the low to moderate density, the right hand graph shows the *lay* sample rather than the *pro* sample as more focused with 75% of respondents scoring three. While the pro average is similar to the *lay*, its scoring distribution (not shown) is somewhat less focused. Curiously, both groups overstate its density relative to other cases. This may be related to a broad associations of village neighborhoods with that of higher density living.

Table 7-20 DENSITY Q4 Histogram for N9: Overall vs. Professional Only

Mean	*4.2*		*4.3*
SDV	*0.78*		*0.77*
Score	*All Freq*	*All %*	*Pro Freq*
1	0	0%	0
2	0	0%	0
3	8	22%	3
4	14	38%	6
5	15	41%	8
	37	100%	17



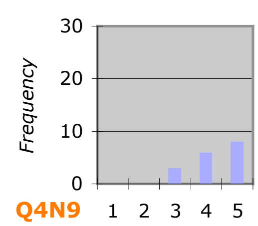
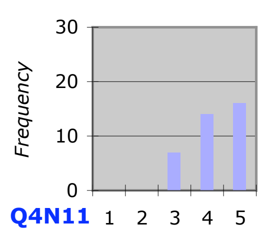
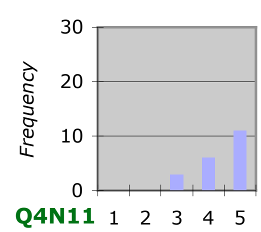


Table 7-21 DENSITY Q4 Histogram for N11: Overall vs. Lay Person Only

Mean	*4.2*		*4.4*
SDV	*0.76*		*0.75*
Score	*All Freq*	*All %*	*Lay Freq*
1	0	0%	0
2	0	0%	0
3	7	19%	3
4	14	38%	6
5	16	43%	11
	37	100%	20





Tables 7-20 and 7-21 provide an excellent comparative illustration of how similar the distributions are within the remaining four neighborhoods. They show the higher density matched pair, N9 Elm and N11 Wolf. The left graph shows a fairly clear but somewhat broad scoring bias toward the higher density end of the scale. The overall distribution values are almost identical in distribution with both having 38% with a score of four and 41% / 43% with five. The sub-sample distributions are quite similar as well. What is even more interesting, however, is that in the case of N9 it is the *pro* distribution that is slightly sharper and more sharply trending toward the extreme value of five while in N11 it is the lay distribution. While the differences are probably too small to be significant, it is interesting that the *lay* group seems slightly less clear in the traditional N9 neighborhood while the pro class seems less certain about the newer N11 neighborhood.

While graphs for N5 Maple and N7 Hemlock are not shown, the patterns are quite similar to those above. The overall distributions are also almost identical. They are focused around a value of four (57% / 54%) and have a very similar breadth. The sub-samples vary slightly but both share a similar breadth.

Overall, the density scores seem to differ from the others in two significant ways. First, the overall distributions tend to be rather similar in shape—clear but a bit broad. Secondly the sub-sample distributions also have a very similar shape and most significantly, show very little variation between them. Unlike the other qualities, the *pro* scores did not exhibit a sharply focused scoring pattern. This suggests that *density* is a quality that is either more widely understood or simpler for a non-professional to evaluate—or maybe both. At the same time, the lack of focus in the professional scores suggests it may be more difficult to evaluate as precisely they had with the other three qualities. The quality of *density* will be further examined as the last of the five street/block scale qualities that will be discussed next.

7.3.3 Street/Block Scale Qualities

A second set of five street/block scale qualities were evaluated across eight detailed study areas within the six case-study neighborhoods. Like the neighborhoods as a whole, the street/block scale study areas were arrayed as pairs matched by density but differing in urban form characteristics. As with the previous evaluations, surveyors had no knowledge of underlying case study selection criteria other than the fact they were a series of sites being studied with respect to their urban form qualities.

In general, one street/block scale study site was selected within each study neighborhood. Each site consisted of a single block of a single street that was more or less representative of the neighborhood as a whole. The lower density matched pair was *Main Street* in N1 Main versus *Longwood Lane* in N2 Dunster. The middle density matched pair was *Sargent Street* in N5 Maple versus *Iris Way* in N7 Hemlock. The upper density matched pair was *Green Street* in N9 Elm versus *Wolf Run* in N11 Wolf. For the low and middle density pairs the detailed study area density was very close to that of the neighborhood (about 2 units per acre and 4 units per acre respectively). For the upper density pair, the detailed study area density was almost twice that of the neighborhood (roughly 12 units per acre compared with 6 units per acre for the neighborhood as a whole).

As described in Section 7.2, several potentially confounding issues were noted in the first survey scores for N1's Main Street and N11's Wolf Run. An alternative street/block case was added in both neighborhoods to test the influence of these confounding issues. The alternative to N1 's *Main Street* (A) was *Elm Street* (B)—not to be confused with the N9 neighborhood of the same name. The alternative to N11's *Wolf Run* (A) was *Ivy Court* (B).

This resulted in a total of eight street/block cases and two additional matched pairs within the lower and upper lower density neighborhoods:

- **N1 *Elm Street*** versus N2 *Longwood Lane*: Elm had same type and density as Main but varied in traffic level and street right-of-way width.
- N9 *Green Street* versus **N11 *Ivy Court***: Ivy had same type and density as Wolf Run but varied in unit type, parking configuration, and layout of trees.

The survey analyzes scores for all eight street/block scale case studies: three lower density (*Main* or *Elm* in N1 and *Longwood* in N2); two middle density (*Sargent* in N5 and *Iris* in N7); and three in the upper level (*Green* in N9 and *Wolf* or *Ivy* in N11).

As shown in Table 7.2, various combinations of the alternative streets were assigned to each tour to minimize potential bias of any one tour group on overall scoring. One of the alternatives (A or B) was included in three of the six tours. As a result, the sample of surveyor's for the four alternative streets is only half the sample (18 or 19) of the other four cases (37). Thus sub-sample analyzed within N1 and N11 is not *pro* versus *lay* but alternative *A* versus alternative *B*. While some note was taken about the comparative scoring between the pro and lay evaluators within each of the alternative cases, it is difficult to infer too much due to the much smaller sample size between these two groups compared with the other cases.

Each quality was rated on a scale of 1 to 5 over the course of a carefully controlled five-minute walking tour along each street/block. Surveyors scored each over the course of about an approximate 500-foot walk. The sequence of surveyed sites was shifted up between each tour in conjunction with mixing of associated neighborhoods. While pre-tests suggested the direct evaluation of a single place would be easier than the neighborhood scale evaluations for the lay person, the results did not seem to bear this out. Some street/block scale qualities proved difficult for the lay population to grasp, others seemed to be less so. The set of five qualities included in the four test qualities of enclosure (Q5), *permeability* (Q6), *scale* (Q7), *variability* (Q8) plus the control quality of *density* (Q9). Each of the test qualities corresponds to one or more measures of street/block form derived over the course of the research project.

The overall scores are compared in two primary ways: 1) scoring variation between cases as measured by mean value, and 2) internal consistency of scores for each case as measured by standard deviation (SDV). Table 7-22 arrays the average (arithmetic mean) scoring value for each quality across all eight cases. In general, the average scores for all five qualities show considerable variation in the perceived character between the street/blocks study sites. To what extent patterns of perceived variation correlate with the measured differences of neighborhood form will be the focus of the Section 8.2.

Table 7-22 Average Survey Scores for Qualities Across Street/Block Cases

Quality	N1 Main St	N1 Elm St	N2 Longwood	N5 Sargent St	N7 Iris Way	N9 Green St	N11 Wolf Run	N11 Ivy Court
Q5 Enclosure All	2.4	3.5	1.8	4.1	3.1	4.2	3.6	2.3
Q5 Enclosure Pro			1.5	4.4	2.9	4.5		
Q5 Enclosure Lay			2.1	3.8	3.3	3.9		
Q6 Permeability All	3.2	3.4	3.1	4.4	2.7	4.2	2.6	2.1
Q6 Permeability Pro			2.2	4.6	2.2	4.5		
Q6 Permeability Lay			3.8	4.2	3.2	3.9		
Q7 Scale All	2.6	3.6	2.6	4.2	3.8	4.1	2.9	2.0
Q7 Scale Pro			2.1	4.5	3.9	4.7		
Q7 Scale Lay			3.1	4.0	3.8	3.6		
Q8 Variability All	4.0	4.2	2.2	3.9	1.4	4.0	1.3	1.6
Q8 Variability Pro			2.1	4.4	1.2	4.4		
Q8 Variability Lay			2.3	3.6	1.5	3.7		
Q9 Density All	2.2	2.8	2.0	3.6	3.6	4.0	4.6	3.7
Q9 Density Pro			1.6	3.6	3.5	4.1		
Q9 Density Lay			2.4	3.6	3.6	3.9		

Note: Scoring is based on a 1 to 5 interval scale with 3 being the neutral assessment

When broken out by professional versus lay person sub-sample, the mean value remains close to the overall value for most qualities. This suggests a certain level of consistency in how the qualities are "seen" across groups. There are some exceptions. For example scores for Q6 *permeability* at Longwood clearly diverge. The difference of means between samples is greater than a full scoring interval of 1.0. This may indicate some difference of perception and/or understanding between groups. Both the overall variation of means between cases and the variation between sample groups will be discussed in more detail for each quality.

As with the neighborhood scale discussion, a key research question is how internally consistent or reliable the scored values are for each quality. Strong agreement would suggest the quality was being reliably "seen" and differentiated across this set of cases. More divergent scores suggest either the quality was not well specified or it is simply hard to judge consistently in certain settings or by certain groups. Table 7-23 arrays the standard deviation (SDV) value for each quality across all eight cases.

Table 7-23 Standard Deviation (SDV) of Scores Across Street/Block Cases

Quality	N1 Main St	N1 Elm St	N2 Longwood	N5 Sargent St	N7 Iris Way	N9 Green St	N11 Wolf Run	N11 Ivy Court
Q5 Enclosure All	0.86	0.61	0.82	0.80	1.21	0.90	1.26	1.53
Q5 Enclosure Pro			0.72	0.62	0.99	0.51		
Q5 Enclosure Lay			0.83	0.83	1.37	1.04		
Q6 Permeability All	0.94	0.76	1.20	0.69	1.05	1.04	1.50	1.13
Q6 Permeability Pro			0.73	0.61	0.81	1.01		
Q6 Permeability Lay			1.01	0.70	1.04	1.02		
Q7 Scale All	1.09	0.68	1.26	0.75	1.09	0.97	1.24	1.03
Q7 Scale Pro			0.93	0.62	0.93	0.47		
Q7 Scale Lay			1.36	0.76	1.24	0.99		
Q8 Variability All	0.77	0.60	0.93	0.94	0.83	1.04	0.58	0.92
Q8 Variability Pro			0.75	0.61	0.56	0.93		
Q8 Variability Lay			1.07	1.05	1.00	1.04		
Q9 Density All	0.86	0.79	0.83	0.87	0.88	0.76	0.76	1.19
Q9 Density Pro			0.62	0.80	0.80	0.86		
Q9 Density Lay			0.82	0.94	0.96	0.66		

Note: Scoring is based on a 1 to 5 interval scale with 3 being the neutral assessment

In general the overall scoring is relatively consistent for many of the qualities with SDV values from .7 to 1.0. Slightly higher values (1.0 to 1.3 SDV) show somewhat less consistency but show a recognizable trend. In some cases scoring is very consistent (less than .7 SDV)—for example 0.61 for Q5 enclosure at N1 Elm Street. These values indicate all surveyors are seeing more or less the same thing.

In other cases, the SDV for the overall sample is quite inconsistent (greater than 1.3 SDV)—for example 1.53 for Q5 enclosure in Ivy Court. This indicates some disagreement or confusion among evaluators in this instance. When the SDV is broken down by sub-group, in almost every case lower values for the pro sample indicate a more consistent scoring for that group while higher values in the lay group indicates less consistent scoring. This parallels the same pattern found in the scoring for neighborhood wide qualities. The specific patterns underlying these values will be discussed by looking at the comparative internal frequency distributions for several study sites for each of the five surveyed qualities.

Q5: ENCLOSURE

The quality of *enclosure* is defined by the degree of spatial containment perceived as one moves along the street/block corridor. Streets with strong enclosure (score 5) tend to be relatively narrow with well-defined vertical edges (e.g. buildings, trees, etc.) along both sides. Streets with weak enclosure (score 1) tend to be wider with edges that are less defined and more open. Figure 7-5 shows the comparative means of enclosure scores for the three survey populations across all eight study sites.

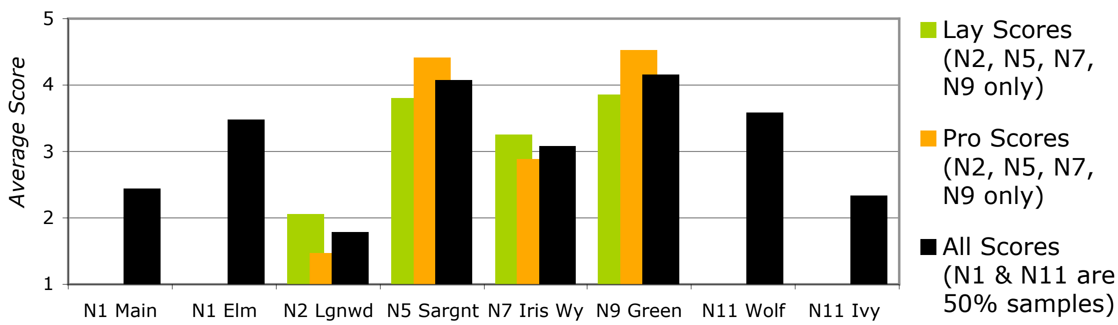


Figure 7-10 ENCLOSURE (Q5): Mean Scores by Street/Block

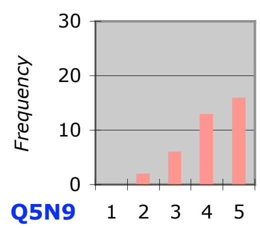
The comparative means show several interesting patterns. First of all, the overall mean (i.e. the black columns) shows a fairly broad variation of this quality across the case studies. Sargent and Green were rated strongly enclosed with scores over four, Longwood was rated as weak with a mean below two. The other five fell to either side of neutral between two and four. Variation is also found within density sets with the greatest contrasts between Elm (3.5) and Longwood (1.8) at the lower level and Green (4.2) and Ivy (2.3) at the higher level. As with neighborhood scale evaluations, scores confirm the assumption of form variation beyond density across these case studies.

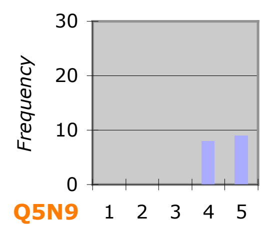
A second pattern finds that for all four cases where mean scores are broken out between professional and lay person groups, (i.e. the orange and green columns respectively), the values are pretty close to the overall mean. This suggests both groups were seeing similar relationships. However, as previously seen, just because the means correlate does not necessarily prove that the qualities are being seen with equal consistency across both samples. A clearer understanding of the strength of agreement underlying the mean, is measured by the standard deviation from the mean across each sample, both by quality and by survey group.

Table 7-20 shows SDV for N2 Longwood, N5 Sargent, and N9 Green to be relatively consistent (between about .8 and .9). However, when split out between pro and lay groups the pro group tends to show greater consistency (i.e. less deviation from the mean) while the lay group shows a somewhat broader range. This relationship is illustrated more visually in the *enclosure* histogram table and graph for N9 Green Street shown in Table 7-24.

Table 7-24 ENCLOSURE Q5 Histogram for N9 Green St: All vs. Pro Only

Mean	*4.2*		*4.5*
SDV	*0.90*		*0.51*
Score	*All Freq*	*All %*	*Pro Freq*
1	0	0%	0
2	2	5%	0
3	6	16%	0
4	13	35%	8
5	16	43%	9
	37	100%	17

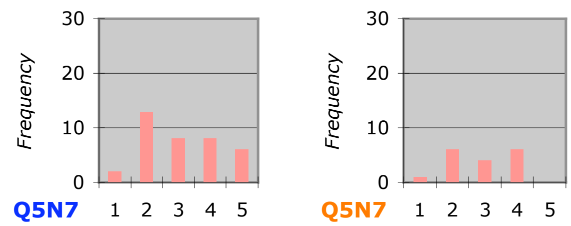




The overall distribution shows a clear though rather broad trend. About 80% of the sample rated Green Street as leaning toward strongly enclosed with scores of four or five (SDV 0.90). However the *pro* sub-sample distribution is unanimous on this count with all seventeen scoring either four or five and a low 0.51 SDV. In contrast, the *lay* distribution is wider (i.e. less certain) with a 1.04 SDV. As Green Street is a narrow street with tightly spaced buildings close to the street, it seems likely that the two lay respondents who scored a "two" either did not understand the definition or were seeing something differently. Going back and looking at the data set reveals they were both part of the tour in which this neighborhood was surveyed last and in near darkness. Under low light conditions a clear sense of enclosure may simply have been harder to differentiate or perhaps surveyors were rushing a bit to complete the last form.

Table 7-25 ENCLOSURE Q5 Histogram for N7 Iris Way: All vs. Pro Only

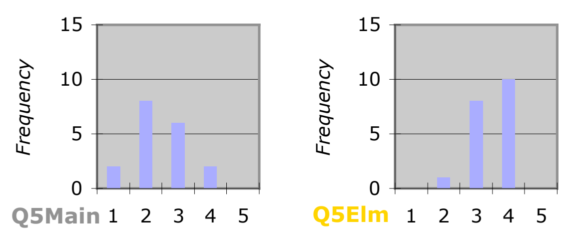
Mean	*3.1*		*2.9*
SDV	*1.21*		*0.99*
Score	*All Freq*	*All %*	*Pro Freq*
1	2	5%	1
2	13	35%	6
3	8	22%	4
4	8	22%	6
5	6	16%	0
	37	100%	17



In the case of Iris Way, the higher SDV of 1.21 suggests there is some real divergence in the way *enclosure* was evaluated on this street both across the whole sample and by sub-samples. Table 7-25 shows the overall distribution to be scattered across the whole scale. The *pro* group shows some loose agreement around a neutral value (SDV 0.99) but the lay group is clearly conflicted (SDV 1.37) with 8 of 20 rating weak enclosure and 8 of 20 rating strong enclosure. This uncertainty is likely related to the confounding physical dimensions of the street. On one hand, tight setbacks and building spacing suggest strong enclosure. One the other hand, low building heights and an absence of substantial trees suggest weak enclosure. The scores appear to reflect this ambiguity. A definition that more clearly specifies how to consider this quality may help to produce more consistent scoring.

Table 7-26 ENCLOSURE Q5 Histogram for N1: Main St and Elm St

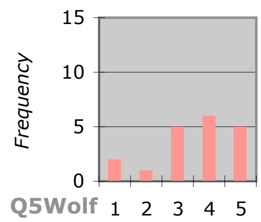
Mean	*2.4*		*3.5*
SDV	*0.86*		*0.61*
Score	*Main Freq*	*Score*	*Elm Freq*
1	2	1	0
2	8	2	1
3	6	3	8
4	2	4	10
5	0	5	0
	18		19

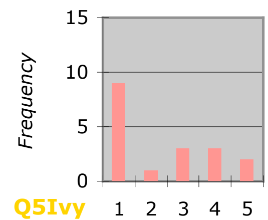


A comparison of scoring between the two N1 alternative streets confirms the initial speculation that sense of enclosure would be directly affected by street right-way-width on Norwich village streets that were otherwise quite similar in dimension and character. On average, the surveyed block of Main Street scores significantly lower than nearby Elm Street with mean of 2.4 versus 3.5 respectively. The scoring consistency on Main was not as high on Elm (0.86 vs. 0.61), suggesting while in general agreement on both, surveyors were a bit less certain in scoring Main Street. This suggests the countervailing factors of the wider street/greater traffic and the large trees/well-defined street edges on Main Street were somewhat harder for evaluators to reconcile.

Table 7-27 ENCLOSURE Q5 Histogram for N11: Wolf Run and Ivy Court

Mean	3.6		2.3
SDV	1.26		1.53
Score	Wolf Freq	Score	Ivy Freq
1	2	1	9
2	1	2	1
3	5	3	3
4	6	4	3
5	5	5	2
	19		18





As expected, in the case of the two N11 street alternatives, Wolf Run and Ivy Court, scoring is considerably less consistent, though still distinct, with means of 3.6 versus 2.3 respectively. Both are examples of the "one-sided" condition that proved somewhat confounding in the process of deriving measurement schemas. The left graph in Table 7-27 shows a general clustering of scores for Wolf Run towards stronger enclosure although scores span the whole scale. There was no doubt some uncertainty in how to judge the impact of the small trees clustered on the non-building edge.

For Ivy Court (the right graph) the scoring was at once more consistent and more varied. Half of the respondents looked at the strong street wall on one side and the flat, open treeless parking lot on the other saw very weak enclosure (i.e. score of one). However, the other half was widely divergent with scores ranging from two to five. While the sub-samples are small, sub-distributions (not shown) reflect a familiar pattern that seems to explain the divergence. Across the pro scores on Ivy, 6 of 9 agreed on "one" (very weak) and all but one saw the enclosure as weak. In contrast, the lay scores were very inconsistent with three at "one", three at "four" and the rest scattered.

Clearly they were more confused about how to judge this quality. The one pro score of "five" shows even professionals sometimes bring divergent judgments, although the clear lack of enclosure in this case suggests it may be more likely the result of a simple scoring error (i.e. mixing up the ends of the scale or marking the score on the wrong line).

Q6: PERMEABILITY

The quality of *permeability* is defined by the degree of interconnection between the street and the edges that define it. On street/blocks with high permeability (score 5) the buildings and spaces along a street tend be open to and invite interaction with the adjoining street. Streets and blocks with low permeability (score 1) building edges and associated activities are separated and closed off from the adjacent street. Figure 7-11 shows the comparative means of the three samples across all eight study sites.

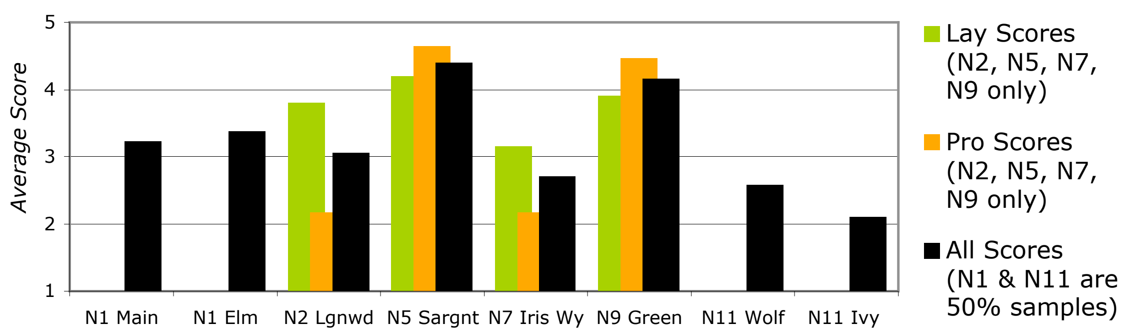


Figure 7-11 PERMEABILITY (Q6): Mean Scores by Str/Blk

The comparative means graph illustrates some variations on the patterns associated with the previous quality—enclosure. Once again the strong variation of overall average scores confirms considerable differences were perceived across all cases. There is also distinct differences within the middle and higher density set with a difference of 1.7 between N5 Sargent and Iris and a difference of 2.1 separating the three higher density cases (Green, Wolf Run and Ivy Court). However, unlike the previous case, average values for the lower density set (Main, Elm and Longwood) are quite similar. They all hover just over the midpoint (3.2, 3.4, and 3.1).

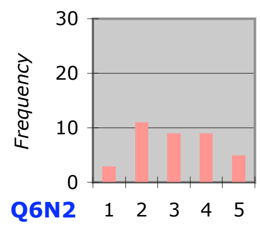
Comparing the means of the sub-sample groups suggests that the apparent consistency in these lower level scores is to some extent a function of inconsistent scoring between sub-samples. On Longwood there is sharp disagreement shown by average scores of the *pro* group (2.2) and *lay* group (3.8). There is also significant disagreement between the two groups on Iris Way with *pro* at 2.2 and *lay* at 3.2. However, the close average values between the two groups at Sargent and Green suggest the entire sample is viewing these cases consistently. This is confirmed by close standard deviation values for these cases shown in Table 7-23. Generally, the comparative means again show the professional group drawing more decisive distinctions between cases than the lay group with higher highs and lower lows.

Finally, some observations can be made about the two sets of alternative streets. The similar average scores and low SDV of Main and Elm suggest they are being judged consistently as places with similar *permeability*. In contrast, the high SDV values for Wolf and Ivy suggest the difference in average scores may be partially due to an uncertainty of scoring rather than a clear observed difference between the two cases. A closer examination of the internal scoring distributions may offer more concrete insight into these differences between groups and cases.

Table 7-28 confirms the sharp differences in scoring between the two sub-samples on Longwood. While the overall distribution shown on the left graph reflects a very modest trend toward the middle of the scale, the variation in scoring is still quite broad. In contrast, the pro group shows considerably stronger agreement around an assessment of somewhat low permeability. Conversely, the lay sample is spread widely from somewhat low to very high permeability. As an unfamiliar concept, it was not as clearly or consistently understood by the latter group in this setting of post-war split-level ranch houses set well back from the street. Written comments on the scoring sheet next to a "four" score such as "many cars in driveway" or "large lawns look inviting" suggest rather creative interpretations of *permeability*.

Table 7-28 PERMEABILITY Q6 Histogram for N2 Longwood: All vs. Pro Only

Mean	*3.8*		*2.2*
SDV	*1.20*		*0.73*
Score	*All Freq*	*All %*	*Pro Freq*
1	3	8%	3
2	11	30%	8
3	9	24%	6
4	9	24%	0
5	5	14%	0
	37	100%	17



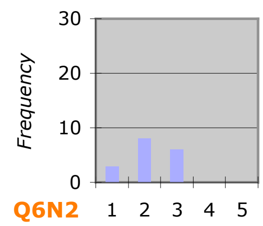
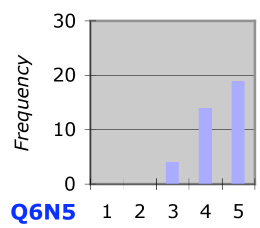
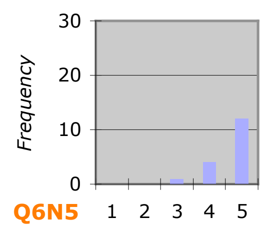


Table 7-29 PERMEABILITY Q6 Histogram for N5 Sargent St: All vs. Pro

Mean	*3.8*		*2.2*
SDV	*0.69*		*0.61*
Score	*All Freq*	*All %*	*Pro Freq*
1	0	0%	0
2	0	0%	0
3	4	11%	1
4	14	38%	4
5	19	51%	12
	37	100%	17



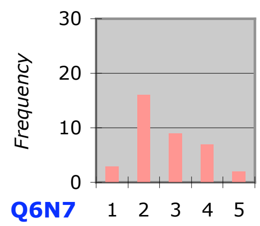


In contrast, the traditional streetscape of N7 Sargent with its large front porches, narrow setbacks, front walks and understated garages seemed to facilitate a clearer and more consistent assessment of high permeability. Mean scores among the groups were very close (4.2 to 4.6) and SDV values were very low (0.61 to 0.70). However, even within these close ranges, there remains a clear pattern of the pro group being more decisive (i.e. drawing sharper distinctions) and more consistent in their assessment.

An almost identical pattern was found on N9 Green Street, a denser street of somewhat similar character (not shown). Of particular note in this case is the impact of a single "outlier" on the SDV values. For the pro sample, 11 of 17 evaluators score the street at the maximum "five" and 16 of 17 are either "four" or "five." However the last one scored a "one" which bumped the SDV to 1.01. Dropping this score lowers the SDV by more than half to 0.47. Curiously, it was the same evaluator who made a sharply divergent assessment of Q5 enclosure for Ivy Court. This suggests either an individual with contrarian views or someone who simply may not have been paying close attention. In both cases however, the sample size is large enough to ensure the occasional odd outlier does not excessively distort overall findings.

Table 7-30 PERMEABILITY Q6 Histogram for N7 Iris Way: All vs. Lay Only

Mean	*2.7*		*3.2*
SDV	*1.05*		*1.04*
Score	*All Freq*	*All %*	*Lay Freq*
1	3	8%	0
2	16	43%	7
3	9	24%	5
4	7	19%	6
5	2	5%	2
	37	100%	20



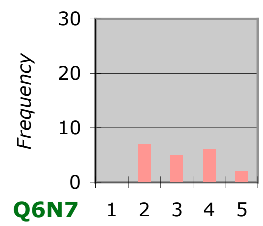
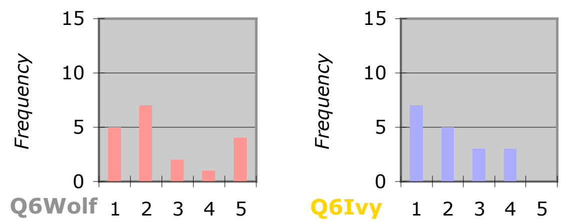


Table 7-30 shows the frequency histograms for N7 Iris Way, the other case where there was a significant difference between overall and sub-group scoring. In contrast to N2 Longwood, the overall scoring is somewhat more clustered (43% at two) though still quite widespread (SDV 1.05). In this case, the right graph shows the lay scoring being weakly consistent though shifted toward a more neutral center. Again the pro scoring (not shown) is more sharply drawn with a mean of 2.2 (low permeability) and an SDV of 0.84. Houses with wide blank garage doors and recessed entries very close to the street may have been confusing for some lay evaluators. Written comments such as "nice landscaping" also simply suggest unexpected interpretations of permeability.

Finally, the examination of the alternative street pairs in N1 and N11 reveal some interesting patterns. The relatively consistent mean values and low SDV for N1 Main and Elm (not shown) confirm the initial assessment that street width has little effect on permeability on a traditional village street. However, the N11 alternatives reveal some fascinating issues that may affect assessment in newer, higher density settings. On the left graph of Table 7-31, the double peak histogram for Wolf Run suggests potentially countervailing interpretations of permeability. Some seemed to see the high frequency of street-edge carports filled with the traces of human activity (toys, bikes, kayaks, BBQs, etc.) as a kind of front porch connecting the house to the street. Others seemed to view the carports and obscured entries as barriers between the house and street. This split in assessment seems to run across both sub-samples.

Table 7-31 PERMEABILITY Q6 Histogram for N11: Wolf Run vs. Ivy Court

Mean	*2.6*		*2.1*
SDV	*1.50*		*1.13*
Score	*Wolf Freq*	*Score*	*Ivy Freq*
1	5	1	7
2	7	2	5
3	2	3	3
4	1	4	3
5	4	5	0
	19		18



The nearby alternative N11 Ivy Court seemed to be more consistently assessed. As shown on the right graph, scores express a clear but still broad trend toward low permeability. Here the common entries to multi-unit buildings limit a sense of connection between building and street. And unlike Wolf Run, the pro scores were more consistent and pronounced with 8 of 10 either a one or two. The less consistent scoring for this set of streets seems to be associated with newer, large lot neighborhoods. Based on the relatively more difficult issues associated with measuring these types of neighborhoods in previous sections, this is not a surprising finding.

Q7: SCALE

The quality of *scale* is defined by the relative size and proportion of the environment in relation to the observer. On smaller-scaled streets (score 5), dimensions are smaller and spaces tend to feel more intimate and comfortable. On larger-scaled streets (score 1), dimensions are greater and spaces tend to feel more generous and expansive. Figure 7-12 shows the comparative mean values of the three sample populations across all eight street/block study sites.

The comparative mean scores for scale are closely related to those for enclosure with several interesting exceptions. This is not surprising as both are qualities strongly linked to relative distance and size with stronger enclosure associated with smaller or finer scale in most cases. The overall means show a fairly broad variation with Sargent and Green rated smallest in scale with scores over four. The lower end of the scale is less represented, with only Ivy reaching as low as two. The other five fall in between. Variation is also found within the density sets with the exception of the middle set where Sargent (4.2) and Iris Way (3.8) are rather close. Both of these cases also have relatively close sub-sample means (.5 or less). Both cases are relatively consistently scored although agreement on Sargent is stronger with an SDV of 0.75 versus a broader 1.09 on Iris. Both cases also show the dominant pattern of the pro group scoring more

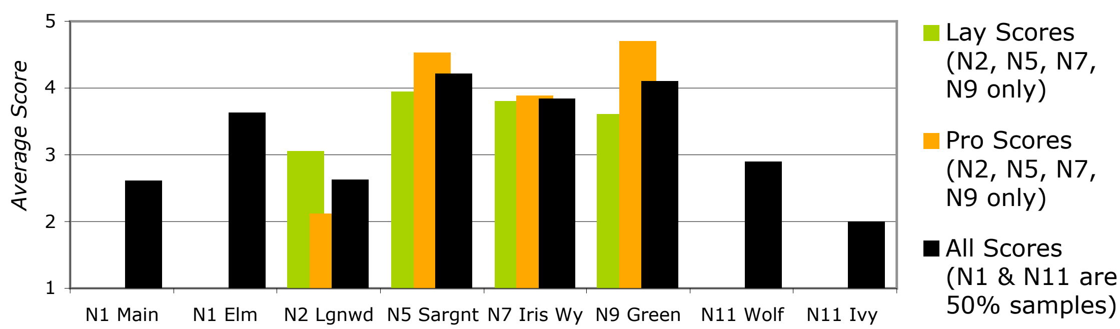


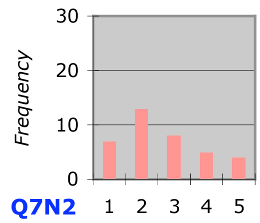
Figure 7-12 SCALE (Q7): Mean Scores by Street/Block

consistently and drawing sharper distinctions.

In two cases, Longwood and Green, the difference between professional and lay person scores exceeds a full scoring interval (1.0 and 1.1 respectively) suggesting some greater differences in what each group was seeing. In both of these cases the average lay score hovers near neutral (3.1 and 3.6) while the pro scores are more pronounced in both directions (2.1 and 4.7 respectively). The pro group is seeing a much greater distinction between the two places. The comparative SDV values in Table 7-23 also show the pro group in much stronger agreement than the lay group—the lay standard deviation is about a half interval more (0.5) in both cases. This suggests scale may be a somewhat foggier concept for the lay population. These relationships can be more clearly seen in the comparative frequency distribution graphs in Table 7-32 and Table 7-33.

Table 7-32 SCALE Q7 Histogram for N2 Longwood Lane: All vs. Lay Only

Mean	2.6		3.1
SDV	1.26		1.36
Score	All Freq	All %	Lay Freq
1	7	19%	2
2	13	35%	7
3	8	22%	3
4	5	14%	4
5	4	11%	4
	37	100%	20



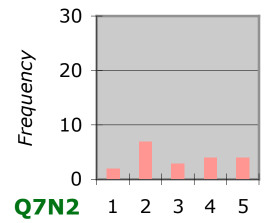
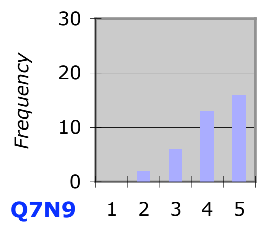
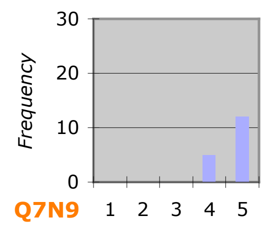


Table 7-33 SCALE Q7 Histogram for N9 Green Street: All vs. Pro Only

Mean	4.1		4.7
SDV	0.97		0.47
Score	All Freq	All %	Pro Freq
1	0	0%	0
2	2	5%	0
3	6	16%	0
4	13	35%	5
5	16	43%	12
	37	100%	17



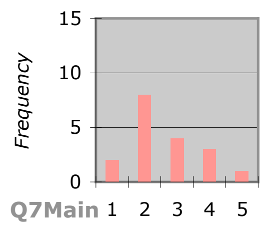


The left two graphs illustrate the overall scoring pattern for scale on Longwood Lane (a 1960's single-family street) and Green Street (a 1900's village street). Both show relatively clear, though fairly broad, scoring trends toward different parts of the scale. The two right graphs show the lay (above) and the pro (below) distributions for their respective cases. On Longwood, the lay pattern flattens to almost no discernable relationship and the mean moves to neutral (3.1) while the pro group (not shown) clusters around the assessment of "large scale" (2.1). In contrast, the pro pattern on Elm sharpens significantly and the mean value moves out toward the end of the scale (4.7) while the lay group (not shown) widens and drifts toward the center (3.6).

This comparison illustrates the overall pattern seen throughout the survey of pro scores being more tightly clustered and more sharply differentiated indicating a strong consensus in their evaluations. The broader and more neutral patterns of the lay group suggest a tentativeness arising from less certainty. The comparison also illustrates how some neighborhoods are simply harder to evaluate than others. In this case, Longwood Lane proves more elusive with higher standard deviations shown for both groups. This may be the result of sorting out the confounding contrast of small houses on large lots—relatively larger distances between things suggests a larger scale, while relatively smaller structures suggests a smaller scale. On Green Street, the pattern of small structures on small lots is more internally consistent.

Table 7-34 SCALE Q7 Histogram for N1: Main Street vs. Elm Street

Mean	*2.6*		*3.6*
SDV	*1.09*		*0.68*
Score	*Main Freq*	*Score*	*Elm Freq*
1	2	1	0
2	8	2	1
3	4	3	6
4	3	4	11
5	1	5	1
	18		19



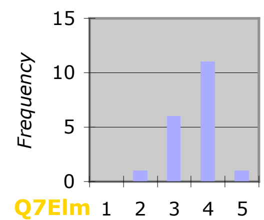
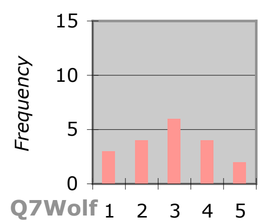
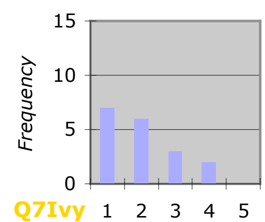


Table 7-35 SCALE Q7 Histogram for N11: Wolf Run vs. Ivy Court

Mean	*2.9*		*2.0*
SDV	*1.24*		*1.03*
Score	*Wolf Freq*	*Score*	*Ivy Freq*
1	3	1	7
2	4	2	6
3	6	3	3
4	4	4	2
5	2	5	0
	19		18





A comparison of scoring between the two sets of alternative streets illustrates some important patterns in evaluating different types of streets. In both instances (N1 & N11) an alternative case was added in response to some observed ambiguity of scoring during the first survey tour. This relative ambiguity can be seen by comparing the left and right graphs in Table 7-34 and Table 7-35. The left side (Main Street and Wolf Run) represent the original street/block scale case in each neighborhood. In both cases there is a broad scoring range and relatively weak agreement (especially for Wolf) with standard deviations of 1.09 and 1.24 respectively. The right graphs show considerable improvement of consistency in both cases with Elm showing very sharp agreement (STD 0.68) towards small scale and Ivy showing much stronger agreement (1.03) relative to Wolf but still rather broad compared with Elm.

In the case of the N1 set, the key difference appears to be street width and/or traffic as all other dimensions are the same. Just as in Longwood, the need to reconcile the broader dimensions of Main Street with the finer scale of the village landscape and houses resulted in a broader range of scoring and an average value closer to neutral (2.6). In the case of the N11 set, the key difference appears to be the amount of trees and the degree of articulation of dwelling units. Likewise on Wolf Run the need to balance the presence of trees on the non-building edge and the articulation of individual town house units with the overall large size of the buildings and spaces resulted in a broader range of scoring and a neutral average score of 2.9. The lack of any trees to mitigate the large scale parking lot and the more institutional scale of the multi-family structures made is a clearer assessment for most evaluators, with scores clearly trending toward large scale with a mean of 2.0.

These two sets illustrate a much more general emerging pattern in the scoring—the more traditional structure of streets and neighborhoods dating from the first half of the 20th century appear to be simply easier to score—that is they are scored more consistently. Comparing the standard deviations between the top and bottom cases finds the Norwich Village streets to be more consistently scored (i.e. lower SDV) than the newer Wolf Road area streets—whether comparing more ambiguous cases (left) or less ambiguous cases (right). This same pattern can be seen in the comparisons of N2 Longwood (post-war tract street) and N9 Green (pre-war village street) shown in Table 32 & Table 33.

This is a fascinating finding that seems to run contrary to the popular notion of older streets as "more complex" and newer "cookie cutter" development as simple and uniform. It seems to confirm the influence of a strong underlying order in the older neighborhoods and streets that makes them conceptually more consistent. This underlying structure seems likely to be related to the strong congruency between major elements of neighborhood form observed and discussed in earlier chapters. This pattern appears to have the effect of making more complex places actually easier to understand and evaluate for both professional and lay groups.

Q8: VARIABILITY

The quality of *variability* is defined as relative visual interest and compositional variation along a street/block. On blocks with high variability (score 5) the street edges are composed of many complex and articulated parts. On blocks with low variability (score 1) the street edges are more uniform and repetitive. Figure 7-13 shows the comparative mean values of the three sample populations across all eight street/block study sites.

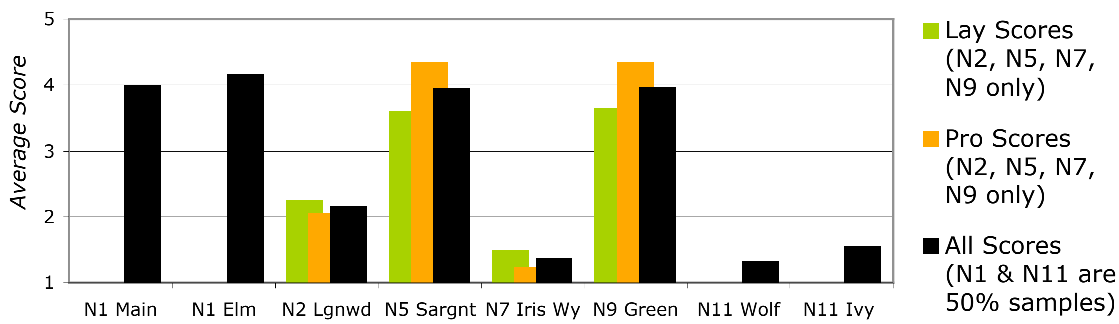


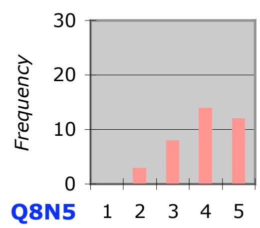
Figure 7-13 VARIABILITY (Q8): Mean Scores by Street/Blk

More than any other quality, the comparative mean scores for *variability* illustrate a striking contrast between the environmental character of newer and older neighborhoods and streets that was discussed in the previous section. Across all densities, the four pre-war street/blocks are scored at or above four—solidly higher variability. In contrast, the four post-war street/blocks are all at two or below—solidly low variability. Unlike all other surveyed qualities, there is a striking lack of a middle range for variability—not one of the eight neighborhoods are assessed as close the neutral value of three. In all other cases, at least one and usually several of the cases fell into a middle range. This finding confirms the popular understanding of older neighborhoods as being visually more complex.

Figure 7-13 also shows this distinction is clearly drawn by both the pro and lay sub-samples. While the typical pattern of the pro sample drawing more pronounced distinction remains (i.e. higher highs, lower lows), the lay sample remains unusually sharp in their distinctions between places. While the average values may be more distinct, Table 7-23 shows the internal scoring distribution of the lay group remains relatively less clear. SDV values hover around one full interval for all four cases—about the same as for other qualities. There is much stronger agreement in the pro group with SDV's ranging from about 0.6 to 0.9. This suggests the concept of *variability*, while easier to distinguish between places for the lay group, was still relatively cloudier. Again, comparative histograms help illustrate these relationships more clearly.

Table 7-36 VARIABILITY Q8 Histogram for N5 Sargent St: All vs. Pro Only

Mean	*3.9*		*4.4*
SDV	*0.94*		*0.61*
Score	*All Freq*	*All %*	*Pro Freq*
1	0	0%	0
2	3	8%	0
3	8	22%	1
4	14	38%	9
5	12	32%	7
	37	100%	17



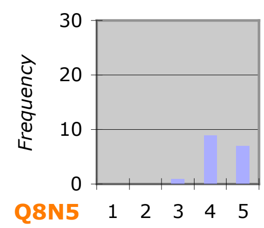
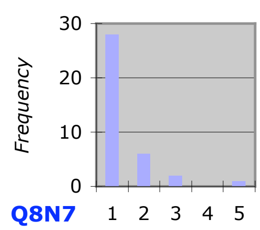


Table 7-37 VARIABILITY Q8 Histogram for N7 Iris Way: All vs. Lay Only

Mean	*1.4*		*1.5*
SDV	*0.83*		*1.00*
Score	*All Freq*	*All %*	*Lay Freq*
1	28	76%	14
2	6	16%	4
3	2	5%	1
4	0	0%	0
5	1	3%	1
	37	100%	20



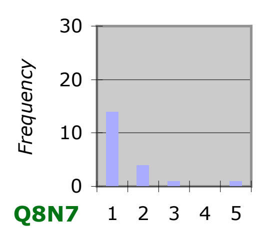


Table 7-36 and Table 7-37 show the matched pair of streets for the middle density level—Sargent Street in the N5 Maple neighborhood and Iris Way in the N7 Hemlock Ridge neighborhood. This pair was considered a strong example of how streets can be similar in many dimensions and yet quite contrasting in form. Sargent Street is a early 20th century neighborhood street with very similar houses that are rich in detail and have been modified to some degree over the years. Iris Way is a late 20th century neighborhood street of very similar newer houses that share the same appearance and color and have not been modified beyond front door decorations and flower beds. The divergent scores in the above table seem to bear this distinction out.

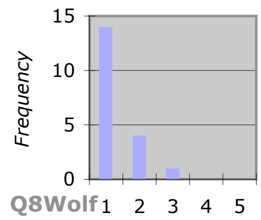
The overall scores for Sargent (upper left graph) shows a pretty clear (SDV 0.94) tendency toward high *variability* (mean 3.9). The distribution, however, is still somewhat broad scoring—perhaps due to the need to weigh the repeating house typology against the considerable variation in architecture and landscape. As with previous cases, the pro group (upper right graph) seems able to draw more consistent (SDV 0.61) and sharper (mean 4.4) distinctions.

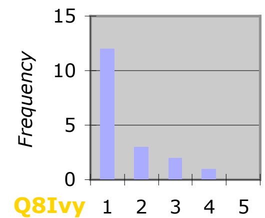
The lower graphs for Iris show an even more pronounced pattern. The overall graph on the left shows a very clear trend toward low *variability* with an average score of 1.4 and a standard deviation of 0.83. While the pro group (not shown; mean 1.2, SDV 0.56) is again sharper, the lay group shows a slightly more consistent scoring than it did on Sargent (1.00 vs. 1.05). Perhaps more significantly, the graph on the lower right shows how a large part of the inconsistency is attributable to a couple of outliers. Nearly 75% of the lay group scored Iris a "one" (very low variability). Dropping only the single "five" score lowers the lay SDV to a very clear 0.58. Thus in this case, the lay group appears to be in almost equally strong agreement as the pro group.

The clarity of assessments for *variability* also stands out across the case study as well. Unlike the other qualities, there is no clear drop-off of scoring agreement in newer streets compared with older streets. In three of four cases, the newer case of the matched pairs is scored slightly more consistently than the older ones. This may be due to the simple fact that an absence of variability leaves less room for discretionary scoring—uniformity or sameness is inherently singular. In contrast, any degree of variety seems to leave more room for discretionary judgment. Thus it is not surprising the scoring on Sargent is more divergent than on Iris Way.

Table 7-38 VARIABILITY Q8 Histogram for N11: Wolf Road vs. Ivy Court

Mean	1.3		1.6
SDV	0.58		0.92
Score	Wolf Freq	Score	Ivy Freq
1	14	1	12
2	4	2	3
3	1	3	2
4	0	4	1
5	0	5	0
	19		18





This dynamic is well illustrated by the very similar and consistent scores between Wolf and Ivy (shown in Table 7-38) and the somewhat more divergent scores on Green Street (not shown). The newer, repetitive building and site forms of the N11 street/blocks appear to be simply easier to consistently assess (SDV 0.58 & 0.93) than the more varied and heterogeneous forms of the older Green Street (SDV 1.04). However, even in the case of Ivy, a very repetitive, multi-family housing complex with seven identical 10-unit buildings, a somewhat broad scoring range suggests someone will always find variety in even the most uniform of settings.

Q9: DENSITY

The quality of *density* is defined identically as it was before except in this case it is referenced to the scale of a street/block rather than to the whole neighborhood. On higher density streets (score 5) buildings and dwellings are more intensively arranged on the land. Lower density streets (score 1) feel less intense and more spread out. Figure 7-14 shows the comparative mean values of the three sample populations across all eight street/block study sites.

As previously noted, the quality of *density*, is the one surveyed quality that is already widely known to evaluators and the only one with a well-established measure. This familiarity may help explain why *density* is the only quality without sharp distinctions between groups. In three of four cases, the pro and lay averages are very close—only Longwood shows a significant (0.8) difference. This case is in the same neighborhood (N2) that showed a difference in neighborhood wide density scoring for reasons that are no doubt similar (see Figure 7-9 and related discussion).

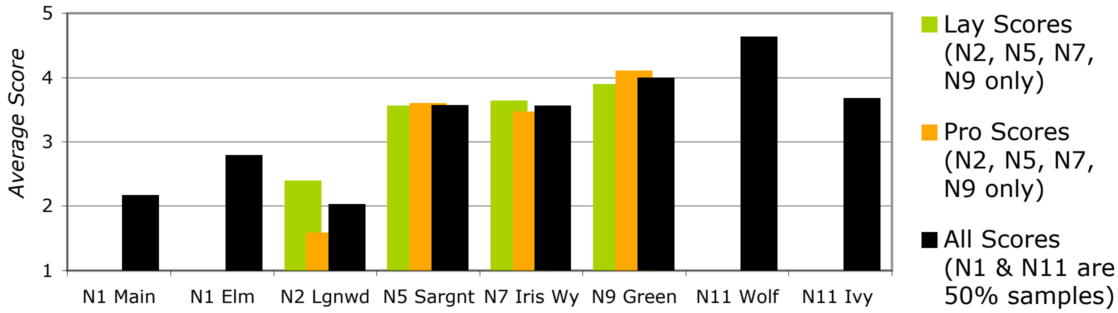


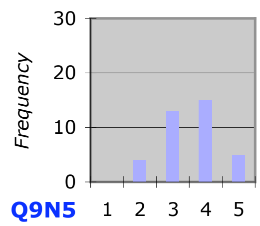
Figure 7-14 DENSITY (Q9): Mean Scores by Street/Block

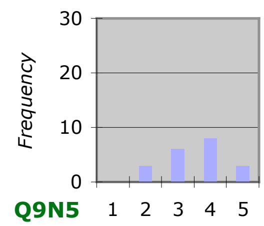
In general, the average values show a variation between neighborhoods that captures the correct relative density relationships between density levels for most cases. In several cases in the upper and lower density sets, the relative density of certain cases seems to be amplified or diminished. In the lower density case, the density of Elm is relatively higher than the other two lower density cases. In the upper density set both Green and Ivy seem to be relatively lower than Wolf (which more correctly reflects the with overall density differences between cases). Earlier analysis suggests the relatively diminished distinction between Elm, Sargent, and Green may have to do with the relative “sameness” of their traditional development form that seems to mask considerable differences in density. Sargent is twice as dense as Elm and only one-third as dense as Green—a total six fold difference from low to high. And yet evaluators tended to see them as relatively similar in moderate to high density (means of 2.8, 3.6, 4.0 respectively).

As was the case with neighborhood density, the relative closeness of mean values between survey groups correlates with a general closeness of scoring distributions between the two groups. Table 7-23 shows the standard deviations between the pro and lay groups to be very close. All show pretty strong agreement with SDV values ranging between about 0.6 and 0.9. Unlike the other qualities, the pro evaluations of density are not significantly more consistency than lay evaluations. In three of four cases the pro scores are a bit stronger, while in the other case (Green) the lay scores are actually a bit more consistent.

Table 7-39 DENSITY Q9 Histogram for N7 Iris Way: All vs. Pro Only

Mean	*3.6*		*3.6*
SDV	*0.87*		*0.94*
Score	*All Freq*	*All %*	*Lay Freq*
1	0	0%	0
2	4	11%	3
3	13	36%	6
4	14	39%	8
5	5	14%	3
	37	100%	20



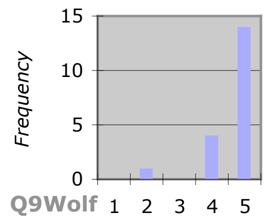


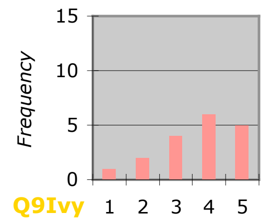
The case of Sargent Street provides a typical illustration of the strong correlation between the overall distributions and the sub-sample distributions for density scoring. In this case all three have an identical mean of 3.6. Table 7-39 shows the distribution patterns between the entire sample and the lay sample to be very similar as well. The standard deviations between all, lay and pro are 0.87, 0.94 and 0.80 respectively. The histograms for the other three cases with sub-sample tallies are remarkably similar as well. This suggests that the obvious conclusion that the more widely a quality is known and understood, the more consistently it will be seen across the entire population. It further suggests that the more consistent scoring of the other qualities may be linked to better training and more experience of the evaluators.

Finally, there is the somewhat deviant case of Ivy Court to consider. As shown in Table 7-23, Ivy is the only one of the 16 samples calculated where the standard deviation from the mean was more than one interval (1.19). Table 7-38 above shows the sharp contrast of distribution between Ivy and the other N11 case of Wolf Run. While almost 100% of Wolf Run evaluator's saw it as somewhat high or very high density, the assessments of Ivy are considerably more scattered. While there is a modest trend towards somewhat high density, scores are spread across the entire scale.

Table 7-40 DENSITY Q9 Histogram for N11: Wolf Road vs. Ivy Court

Mean	4.6		3.7
SDV	0.79		1.19
Score	Wolf Freq	Score	Ivy Freq
1	0	1	1
2	1	2	2
3	0	3	4
4	4	4	6
5	14	5	5
	19		18





This pattern may in part be explained by the fact that all the units along this parking drive are concentrated in a string of large multi-family buildings with a large adjacent parking area. This make it quite difficult to gauge the relative land area associated with the units or even the number of units themselves. The sense of expansive surrounding open areas may certainly have created the impression of a relatively low intensity of residential units per unit of land area. Others may have reacted more directly to the clearly higher density building typologies.

Once again, less consistent scoring seems to be associated with study sites that have confounding issues. One element may influence an assessment in one direction, while another influences the opposite direction. Common sense suggests that the more experience one has in balancing these conflicting dimensions of urban form, the more consistent the scoring is likely to be.

7.4 Summary of Key Survey Findings

Taken together, the analysis of evaluator's scoring of eight environmental qualities across six neighborhoods and eight street/blocks reveals several key findings. They include: 1) broad physical variation beyond density across cases, 2) generally consistent assessment across all most qualities and most cases, 3) professional's evaluations almost always showed stronger agreement and drew sharper distinctions than lay person evaluations, 4) in general older neighborhoods were more consistently scored than newer ones, and 5) certain neighborhoods and certain qualities appeared to be more difficult to evaluate than others. A brief discussion of each finding follows:

Broad Variation of Neighborhood Form: The wide variation of mean scores between cases across each quality confirms the underlying basis for case study selection—that there is considerable and readily observable variation of neighborhood form beyond basic differences of density. The comparative array of average scores (Table 7-1 & 7-20) and the comparative graphs of mean scores for each quality show clearly contrasting patterns both by case and by quality. While there are some observable relationships between a few qualities (e.g. *enclosure* and *scale*), for the most part each quality seems to have a distinct pattern of variation. While evaluators perceived differences between density levels, they were generally not as pronounced as differences found across other qualities. This finding supports the overall research goal of developing measures of neighborhood form that can distinguish urban form differences that elude standard measures of density and land use.

Table 7-41 Overall Consistency of Field Scoring

standard deviation range:		*sdv < .7*	*sdv .7-1.0*	*sdv 1.0-1.3*	*sdv > 1.3*	
Survey Group		**very clear agreement**	**clear agreement**	**fuzzy agreement**	**no agreement**	**total # of cases**
Overall Sample	count:	9	35	16	4	64
	% share:	14%	55%	25%	6%	100%

Consistent Evaluations of Surveyed Qualities: In general the field scoring for most surveyed qualities was quite consistent across the overall sample population in most cases. As shown in Table 7-41, about 70% of the time (44 of 64) the overall scoring evaluations showed relatively consistent or better agreement with a standard deviation of less than one full scoring interval. An extensive analysis of frequency distributions suggested scoring samples with an SDV of less than 1.0 were associated with qualities that were pretty well understood and observable by most evaluators. Scores with an SDV of less than 0.7 were considered to be very clear—almost everyone was seeing the same thing. About 14% (9 of 64) of the overall evaluations fell into this category. Of the twenty cases where SDV was greater than one, sixteen fell between 1.0 and 1.3—less consistent but still exhibiting a recognizable trend and shape. The remaining four were greater than 1.3. Distribution frequencies either showed no discernable trend or a bifurcated trend. This indicates considerable uncertainty among the evaluators trying to score these qualities.

Table 7-42 Consistency of Field Scoring by Sub-Sample Group

standard deviation range:		*sdv < .7*	*sdv .7-1.0*	*sdv 1.0-1.3*	*sdv > 1.3*	
Survey Group		**very clear agreement**	**clear agreement**	**fuzzy agreement**	**no agreement**	**total # of cases**
Professional	count:	18	24	1	1	44
	% share:	41%	55%	2%	2%	100%
Lay Person	count:	7	19	15	3	44
	% share:	16%	43%	34%	7%	100%

Note: The total number of cases is reduced due to the split sample for N1 & N11 Street/Block alternatives

Sharper, More Consistent Scoring by Pro Group: In general, the consistency of the scoring was much higher among the professional sub-sample. Table 7-42 shows that across the 44 cases for which sub-sample scores were broken out, over 95% of the time pro scores were quite consistent with standard deviations of less than one. In over 40% of the cases the agreement was very strong (less than 0.7 SDV). There was only one case (Q1 *consistency* in N7 Hemlock) where scoring was clearly *not* consistent. The comparison of mean values also showed this group tended to find a greater degree of contrast between the cases—in other words, they saw more pronounced differences between the study cases. This suggests a familiarity with the general concepts, training in spatial/visual thinking and professional experience all contributed to more consistent and sharply drawn evaluations of the tested qualities.

In contrast, the lay person evaluators were significantly less confident in their scoring. Only in about 60% of cases were their scores in general agreement (26 of 44), and, in only seven of these cases (11%), was there evidence of really strong agreement.

Surprisingly, five of these were associated with scoring neighborhood scale qualities where evaluations were initially suspected to be most difficult for the untrained lay surveyors. However, in many other cases, the concepts were either not clearly understood or somewhat difficult to judge for this group. About a third of the time the evaluations were quite broadly distributed and only showed a very tentative pattern of agreement. This uncertainty also resulted in average scores tending to stay closer to neutral and show less variation between cases. But only in three instances (*grain* in N11 Wolf, *enclosure* in N7 Iris Way, and *scale* in N2 Longwood) was scoring scattered enough to show no discernable pattern (SDV of 1.3 or greater). The overall success of their evaluations suggests that with some additional training and familiarity, this group would be able to assess neighborhood qualities much more consistently.

Older Neighborhoods are More Consistently Evaluated: One very interesting pattern was that older neighborhoods that are typically thought to be "more complex" were almost always more consistently scored compared with newer, more visually repetitive neighborhoods. Table 7-43 shows the average standard variation values, broken down by pre-1950 (italics) and post-1950 (red type). Whether measuring neighborhood-wide qualities or more detailed street/block qualities, in every case the scoring for the older neighborhoods shows a lower standard deviation than any of the new neighborhoods. For each set of qualities the overall SDV is about 0.2 lower for the older cases—0.76 vs. 0.90 for the neighborhood qualities and 0.81 vs. 1.03 for the street/block qualities.

Table 7-43 Scoring Consistency by Age of Neighborhood Case Study

Neighborhood Qualities	*N1 Main*	N2 Dunster	*N5 Maple*	N7 Hemlock	*N9 Elm*	N11 Wolf
AVERAGE SDV	0.83	0.86	0.68	0.97	0.78	0.88

Street/Block Qualities	*N1 Main St*	*N1 Elm St*	N2 Longwood	*N5 Sargent*	N7 Iris Way	*N9 Green St*	N11 Wolf Run	N11 Ivy Court
AVERAGE SDV	0.90	0.69	0.92	0.77	0.98	0.88	1.07	1.16

Note: The study areas in italic type date from before 1950, the areas shown in red type date from after 1950.

These findings suggest there may be a significant set of underlying formal relationships in the older cases that create a more intelligible framework for evaluating neighborhood qualities. Observations of the greater congruence between elements of small lot older neighborhoods in the previous chapters offer further evidence of a discernable underlying order. Even in the older street/block case of N1 Main Street which was thought to be quite ambiguous, scores slightly more consistent than N2 Longwood—a similarly dense, post-war street of tract homes that was thought to be about the simplest street/block composition possible.

As expected, based on the difficulties encountered in deriving measures for them, the single-sided multi-family street types (i.e. Wolf Run and Ivy Court in N11) were, on average, the least consistently scored. They are the only cases with an average SDV of over one. This appears in large part, due to several confounding dimensional characteristics that are associated with this street/block type. These findings also show that contrary to initial expectations, the evaluations of the neighborhood-wide qualities proved, on average, to be slightly less difficult than the street/block scale qualities.

Table 7-44 Scoring Consistency (SDV) of Sample Groups across All Qualities

Survey Group	Q1 Consistency	Q2 Connectivity	Q3 Grain	Q4 Density (nh)	Q5 Enclosure	Q5 Permeab'ty	Q7 Scale	Q8 Variability	Q9 Density (sb)
Overall Sample	0.96	0.80	1.00	0.77	1.00	1.04	1.01	0.83	0.87
Professional Group	0.81	0.57	0.77	0.75	0.71	0.79	0.74	0.71	0.77
Lay Person Group	0.89	0.85	1.00	0.72	1.02	0.94	1.09	1.04	0.84

Note: Scoring consistency is expressed as average standard deviation from the mean (SDV) for each sample group's scores across all cases

Some Qualities are More Difficult to Evaluate in Certain Cases: Generally speaking, all the qualities seem to be pretty well understood and consistently scored by most evaluators. As shown in Table 7-44, there didn't seem to be any one quality that stood out as difficult to score across the board. The *pro* sample was particularly consistent across all qualities with SDVs narrowly ranging between 0.7 and 0.8 with an average of 0.73. The quality of *density*, as the most familiar concept, was not surprisingly the most consistently scored of all qualities for the *lay* sample.

In ranking the clarity and difficulty of each quality on a scale of 1 to 3, all qualities except *grain* for the *lay* group were rated between "very clear" (1) and "moderately clear" (2) for definition and between "a piece of cake" (1) and "moderately difficult" (2) for application. Not surprisingly, the *pro* group had relatively greater clarity and found all qualities relatively easier to judge than the *lay* group in all cases. *Grain* was ranked relatively less clear and more difficult by the lay group (2.4 and 2.3 respectively). However, while it had the highest average standard deviation of the neighborhood wide qualities (1.0), it was not significantly higher compared with other three neighborhood qualities (0.89, 0.85 to 0.72) and actually less than the average *lay* SDV for three of the five street/block qualities. Lower SDV suggests *grain* was a more familiar and less difficult concept for the pro group.

Table 7-45 Count of Number of Times Quality Named as "Difficult"

Count of "Difficult"	Q1 Consistency	Q2 Connectivity	Q3 Grain	Q4/Q9 Density	Q5 Enclosure	Q5 Permeab'ty	Q7 Scale	Q8 Variability
# of times named	5	3	7	3	2	5	1	0

A final question asked evaluators if any quality stood out as more difficult than the others. Not surprisingly Figure 7-45 shows grain being named as difficult most frequently (7 times). All qualities except *variability* were named at least once. Three answered "none" and eight didn't answer. This suggests a relative parity among qualities in terms of clarity though certain individuals found certain qualities more difficult. Curiously, although only one named *scale*, this was the quality with greatest range of variance in scoring for the *lay* sample (1.09) as shown in Table 7-44. This suggests that it was a familiar concept that may have been somewhat difficult to assess uniformly in the field.

There were certain places where certain qualities were found to be confusing by one of the survey groups (SDV greater than 1.3). For instance, Q1 *consistency* was a problem for the pro group in N7 Hemlock. For the lay group, it was *grain* in N11 Wolf, *enclosure* in N7 Iris Way, and *scale* in N2 Longwood that seemed to cause the most confusion. Evaluating the neighborhoods and street/blocks associated with the two large lot, multi-family case studies, N7 Hemlock Ridge and N11 Wolf Road, were more difficult for certain qualities (e.g. enclosure, permeability) but not any more so for other qualities. In all these cases, the detailed discussion of scoring distributions identified some type of confounding relationship that seemed likely to explain the greater divergence of scoring in each case (for example the opposing influence of coordinated landscaping and contrasting housing types on *consistency* at Hemlock Ridge or the effect of large distances and small structures on perceived *scale* along Longwood Lane).

Some Qualities are Easier to Evaluate in Certain Cases: Not surprisingly, in certain other instances, qualities seem exceptionally clear to evaluators. For instance across the pro group, *connectivity* in N9 Elm (the grid of streets) and *variability* on N7 Iris Way (identical houses) were exceptionally clear (SDV 0.24 and 0.56 respectively). For lay evaluators *density* in N1 Main (SDV 0.49) was clear. Cases that appeared to be proto-typical examples of certain qualities were scored consistently by all groups. For example *permeability* on N7 Sargent Street (lots of front porches, SDV 0.69, 0.61, 0.70) and *consistency* in N2 Dunster (post-war tract, SDV 0.56, 0.51, 0.60) were scored consistently high. In contrast *connectivity* in N11 Wolf (lots of dead end multi-family pods, SDV 0.55, 0.44, 0.61) was scored consistently low. In general, the quality of neighborhood *density* was the most consistently scored across all three groups (SDV 0.77, 0.75, 0.72) indicating that by and large, surveyors had a pretty good grasp of what they were looking at.

In summary, the preceding analysis confirms the survey results will provide a solid basis of comparison with the measured values for all eight identified qualities. Specifically, the *analysis of means* shows a broad range of variation in each quality across the case study areas. The *analysis of standard deviation* shows a relative consistency in scoring that indicates perceptions of differences in qualities are shared broadly among the sample population. In other words, people were seeing the same things; the same key relationships from case to case. The last question to be answered before moving on to comparing surveyed and measured values is the degree of agreement between the perceptions of the sample population and those of the researcher.

7.5 Comparing Perceptions of Researcher and Sample Population

The extent to which the pattern of urban form variation found in the survey and the pattern of urban form variation perceived by the researcher is a critical issue to address before comparing surveyed and measured values. Since it was primarily the researcher's own subjective evaluations of what distinguishes one case study from another that was used to derive and calibrate the measures, it is important to know if those evaluations are shared by a broader audience before comparing the results. In other words, it is important to know if the observed qualities and the measured qualities are more or less based on the same view of the world.

In order to test this, the researcher made two independent survey tours using the same protocol as everyone else. The first one was done in the pre-test period in early May; the second one was done in conjunction with the last survey tour in mid-June. The results were not viewed until all the data was tabulated by the researcher during the third week in June. While the researcher had no specific recollection of how any neighborhoods were scored by the derived measures, some a priori knowledge of general measured distinctions was unavoidable because they were calibrated by his assessments. In other words the researcher knew that the gridded street network in N9 Elm Street was likely to score high on any connectivity measure. The only measurement that was explicitly known by the researcher prior to the survey tour was *density*. However, to the extent possible, the same instructions were followed that were given the survey tour evaluators—score density based on *observed perceptions in the field* rather than trying to calculate or guess at its actual measured value.

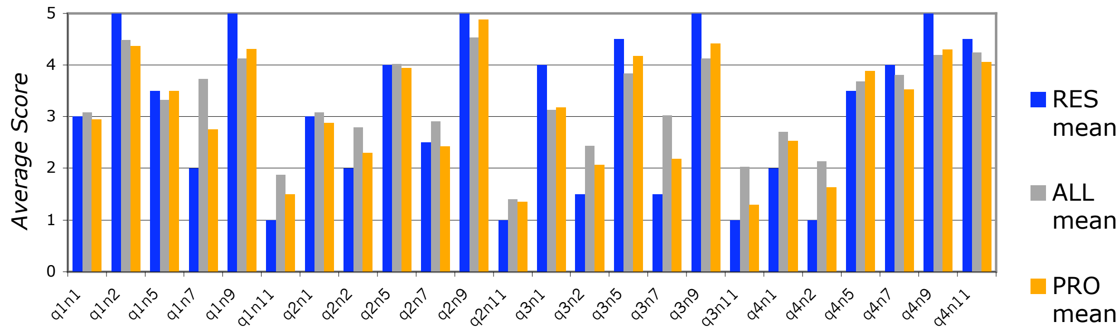


Figure 7-15 Neighborhood Mean: Researcher vs. Sample

The above graph in Figure 7-15 shows the comparative mean scores between the researcher (RES-blue), the overall sample (ALL-grey) and the professional sub-sample (PRO-orange) for four neighborhood scale qualities across all six case studies—a total of 24 separate evaluations. The pro sample is included as it was suspected that as a professional in urban design, the researcher's scores were likely to be more closely related to the professional perceptions than to a more general population. By and large, the graphed values show this to be true. In all but five of the cases the *res* mean is closer the *pro* score than to the overall mean—and in each of these five instances the difference between the *pro* and *all* mean is negligible (q1n2, q2n11, q4n5, q4n7, q4n11). In general the *res* scores follows the same pattern observed in the *pro* sample—the distinctions between neighborhoods are stronger than found in the overall population.

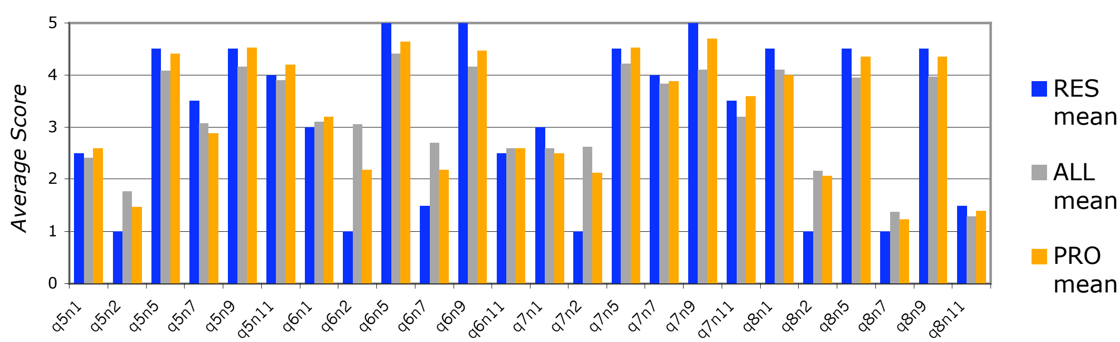


Figure 7-16 Street/Block Mean: Researcher vs. Sample

Figure 7-16 shows the researcher's mean scores (represented again by the blue columns on left) compared the overall and pro means for the four street/block scale qualities. Street/block *density* (Q9) is not included because it so redundant with the scores for neighborhood wide *density* (Q4). A very similar pattern is found. In all but four cases the *res* scores are more closely correlated with the *pro* averages rather than the overall averages—and in all four cases the differences of means are tiny (e.g. q6n1). As with the first set of qualities, distinctions between cases are more sharply drawn (i.e. higher highs, lower lows) compared with the overall averages. In the several cases were the *res* average was a 1.0 or a 5.0 strongly, the lack of any range in average values assured the scores would be more extreme than a larger population.

While standard deviations don't mean much across a sample of two, it is very interesting to note that scoring between the first and second "res" tours changed in over 40% the cases (in 23 of 54 evaluations). This suggests that: a) the researcher's own perceptions are subject to some change based on different tour conditions and an evolving understanding of the qualities, and b) he didn't peek at his first set of scores. In all but two cases, the scores only moved one interval on the scale. The standard deviation for moving from 1 to 2 or from 4 to 5 is 0.71—nearly identical to the standard deviation found in the pro sample as a whole (0.73). These cases can be seen by the cases showing "one-half" mean values (e.g. 2.5 or 4.5). In the two other cases, scores jumped two intervals. One occurred in the same evaluation of *consistency* in N7 that had confounded the *pro* sample as a whole. The other was *connectivity* in N1 Main where the second time around the researcher saw the streets were not nearly as connected as one might initially assume in a traditional village setting.

In summary, the above findings confirm that the perceptual "lens" of the researcher is quite similar to perceptual sensibilities of larger class of observers with similar professional background and training. While the tested sample remains quite small (seventeen professionals), the close correlation of their evaluations both within the pro sample and in relation to the researcher, suggests two important conclusions. First, the perceptual "measuring stick" that guided the development of measurement tools in

Chapters Five and Six appear to share a common "scale" with design and planning professions. In other words the researcher and the professional sample are seeing the basic distinctions in the built environment. Secondly, it suggests that the specific qualities that were tested in the field surveys are ones that are broadly recognizable and identifiable—even by the sub-set persons with little if any familiarity with concepts of urban design or spatial analysis. This suggests a potential for a wider audience to understand the environmental qualities being tested and measured.

7.6 Testing LIVABILTY: Sample Bias & Future Research Directions

One last question remains concerning possible influence of a biased population sample. In concept, the preferences of the evaluators should have little or no impact on the objective scoring of a specified physical quality. The fact that someone's favorite color is blue, should not affect their ability to distinguish blue from yellow. If that same person is to evaluate the mix of colors in a series of swatches ranging from yellow to blue, it is conceivable this preference may cause them to see "blue" sooner than someone whose favorite color is green. While there is inherently a preference bias in any population, it is always useful to identify it and consider any impact it may have.

At the end of each survey tour each participant was asked rate the *livability* of each neighborhood using the same 1 to 5 scale from low to high. They had no knowledge they would be asked this question prior to the end of the tour. They were asked to make their assessments based on their own personal preferences:

> The previous set of evaluated qualities was intended to be judged in as "objective" manner as possible—in other words without introducing any personal judgment as to what may be "good" or "bad" in a neighborhood setting. In contrast, please evaluate this last quality using your own values and judgment of what you think makes a "good place to live."

Not surprisingly, Table 7-12 shows some neighborhoods were viewed as more livable than others were. What is perhaps more surprising is how closely matched the preferences are between groups. Once again, a greater degree distinction drawn by the professional group compared with the layperson group. This suggests that they have stronger feelings about what makes for a "good" versus a "bad" neighborhood. And once again, the researcher's preferences are closer to the pro group than the lay group.

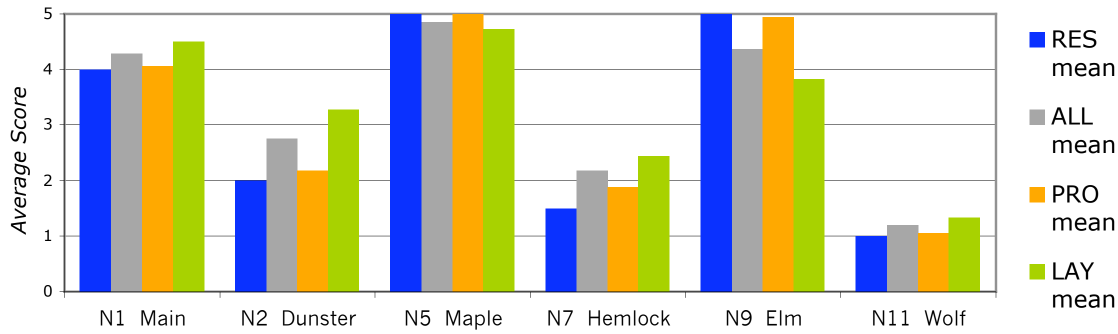


Figure 7-17 Livability Mean: Researcher vs. Survey Groups

However, what is absolutely clear is that the relative differences perceived between neighborhoods are the same across all samples—just less pronounced in the lay sample. To what extent these preferences may introduce bias into the scoring is not clear. In theory, high connectivity is high connectivity whether or not you happen to "like" the neighborhood it exists in. What is clear is that there is surprising agreement between the survey groups of what they found to comprise a livable place.

Table 7-46 Standard Deviation of Average Scores for LIVABILITY by Group

Quality	N1 Main	N2 Dunster	N5 Maple	N7 Hemlock	N9 Elm	N11 Wolf
Q10 Livability All	0.89	1.01	0.49	0.82	0.94	0.63
Q10 Livability Pro	0.75	0.81	0.00	0.78	0.24	0.24
Q10 Livability Lay	0.99	0.89	0.67	0.78	1.04	0.84

Note: Scoring is based on a 1 to 5 interval scale with 3 being the neutral assessment

The relatively tight standard deviation values shown in Table 7-46 for average scores across groups and neighborhoods also suggest these preferences, both positive or negative, are shared consistently throughout the survey population. Nearly everyone rated N5 Maple high and nearly everyone rated N11 low. To what extent these preferences may be shared by a larger population would require a much larger sample to determine. Likewise to what extent a different pattern of neighborhood form might be associated with perceptions of greater or lesser livability would require accounting for a whole range of non-spatial variables that were not part of this research. In fact, the purpose of this research is to provide a more consistent specification for urban form variables whose influence on a variety of factors (e.g. travel, social life, market preferences, land value, etc.) might be tested in future research.

Nonetheless, the findings show some very interesting patterns and relationships that run counter to some long held notions of residential preference. First of all it is very clear that density is not the primary variable affecting ranking of livability as is so often assumed by local planning boards. Within each density set there is a clear difference in ranking that is clearly being influenced by something other than density. The influence of other qualities of neighborhood form and character are clearly at work. In this particular case, the major distinction is the bundle of characteristics associated with older small lot neighborhoods versus newer large lot neighborhoods. These impacts seem ripe to be tested in future research.

These influences clearly extend between density levels as well. All groups clearly rank N9 Elm higher than N2 Dunster despite the fact it is more than three times as dense. And perhaps even more surprising, is that even after the controlling for age of development the influence of density still appears to be negligible at best in many cases. Comparing the two new neighborhoods, the low and middle density set, finds that N7 Hemlock is perceived as only marginally less livable than N2 Dunster despite being more than twice as dense. And comparing the two older neighborhoods across those same levels finds that N5 Maple is actually rated significantly higher than N1 Main although it is also more than twice as dense. While these findings are clearly limited by a very small non-random sample surveying a limited set of neighborhoods, they raise a series of intriguing questions that could be probed in future research efforts.

End Notes:

Note 1 Establishing the Survey Baseline: *An astute observer might ask why the project didn't start with the survey in order to establish a broader baseline at the outset and thus avoid the problem of the calibrating measures by less objective baseline of researcher's own perception? The answer, of course, is that one can't ask evaluate what doesn't yet exist. A key part of the research design focused on deriving and defining key qualities that could be measured. While a set of initially hypothesized qualities were offered (Section 3.1.4), they were quite tentative and lacked the type of clear definition needed to specify survey variables. This initial list was significantly modified, refined and clarified through the research process. While some initial sense for how a broader audience might distinguish differences between this initial list may have been useful, a survey seemed much more useful at the end of the project to test the measures after the qualities had been more clearly defined.*

Note 2 Directed Field Questions: *The pre-tests found the more conversational form of directed questions much more useful than carefully worded definitions in helping the non-professional class of evaluators to grasp the concept of what was being evaluated. Much like helping students on a school field trip think about what they are seeing, defining qualities via directed questions seemed to give evaluators a more tangible grasp of what they were supposed to judge without offering any opinion how a particular case might be rated. Can you sense this or that? How much or little to you see? How does it make you feel? Does it seem more this way or more that way?*

Note 3 Survey Tour Size: *The standard family mini-van used for the survey tours set a practical limit of six evaluators per survey tour (one driver/administrator and six participants). The small size also facilitated easy inclusion of the entire group in discussing important questions and answers about the survey protocol and definitions.*

Note 4 The Recruited Groups: *Groups were selected to recruit volunteers from using word of mouth networks and contacts in the local area. They included the Hanover Planning Board, the Lyme Road Citizen Planning Committee, and Vital Communities—a regional non-profit organization. Because the first two groups had been appointed through a public selection process, they were already pre-screened to represent a cross-section of views within the larger community. The third group, with its multi-town focus, helped provide a greater geographical range in the sample.*

Note 5 The Additional Group: *The last recruiting target was a group of men (including the researcher) who bicycle or ski together on Thursday evenings. While all are males between 30 and 60, members range from several Upper Valley towns with about half who live "in-town" and half who live in outlying locations. The pre-arranged meeting time and the 15-mile tour length made a high participation rate likely.*

Note 6 The Seventh Participant: *Because Tour E was done on bicycle, it was no problem to accommodate an additional participant. The survey followed the exact same route and protocol as the standard tour except bicycle segments replaced driving segments. The survey administrator led participants in a pace car to ensure the correct route was followed. A brief stops was made at the entry to each neighborhood to point out boundaries. At the start of the walking tour, clipboards were handed out with scoring sheets for scoring both neighborhood and street/block segments. Evaluators then walked designated block, filled out the associated forms, and rode off to the next neighborhood. Slightly longer times traveling between neighborhood resulted in an additional half hour in total tour length. The last neighborhood (Elm) was* *surveyed in twilight. This made some qualities a bit harder to assess although street lighting helped compensate somewhat for limited daylight.*

Note 7 Word-of-Mouth or Snowball Sampling: *The interest was clearly a function of how much participants seemed to enjoy the tours. Many found them very educational. Some said that the concepts and vocabulary would be useful to their work on town boards and for thinking about planning and growth issues. One even suggested presenting generalized findings in a local newspaper series or at various public forums. Of particular interest was the degree to which neighborhoods of the same density could vary so much in character (the matched density pairs were revealed only after the survey was completed).*

Note 8 CPHS Approval: *The approval of the research design and survey protocol by the University's Office for the Protection of Human Subjects was granted in a letter dated July 20, 2004. It stipulates that the researcher is responsible of upholding a set of University standards intended to protect the projects research subjects.*

Note 9 Adjustments to Quality Definitions: *For instance, at the neighborhood scale the quality of variation was renamed consistency to reduce confusion with the street scale quality of variability. Although all three terms deal with the same conceptual issue (the relative degree of sameness or variation) the neighborhood scale version referred specifically to variation in large scale underlying patterns of land use and layout while the street scale version referred to more detailed visual variation in street elevation. Another example was the quality of human scale was changed to simply scale in order to remove any association of goodness or bias toward a high rating of that quality.*

Note 10 On-Demand Examples to Illustrate Qualities: *A series of examples were identified for "on demand" use in response to evaluators questions about the surveyed qualities. Examples were selected that would be illustrate the range of conditions associated with the quality using examples known to tour participants but not specific to the Upper Valley cases. Specified examples by quality included:*

1. *Consistency: Contrast repetitive tracts developments such Levittown with more hodgepodge patterns such as Route 101 in Nashua or Taft's Corner in Williston.*
2. *Connectivity: Contrast grid pattern of Manhattan with suburban areas of unconnected cul-de-sacs.*
3. *Grain: Contrasted small lot / building pattern of Beacon Hill in Boston with large lot / building pattern of a Route 128 business park.*
4. *Enclosure: Contrast a locally known commercial alley (Allen Street) with an rural road through an open landscape.*
5. *Permeability: Contrasted walled off enclaves of Middle-Eastern residential districts with open-air stalls and shops of Middle-Eastern market districts.*
6. *Scale: Contrasted narrow streets and intimate patterns of old-town Montreal with the wide streets and large buildings of downtown Montreal.*
7. *Variability: Contrast the visual variety of shop windows, entries and architectural details on NYC's 5th Avenue with the repetitive façades of the corporate towers along 6th Avenue.*
8. *Density: The concept of residential density was generally well understood. A pair of local examples (Rip Road versus Emerson Gardens) was given in the introductory script to illustrate the frame of reference.*

Note 11 The Early Evening Tour: *The one early evening tour was a bicycle-based tour. The specifics of this tour are discussed in Note 6.*

Note 12 Objective Presentation of Case Studies: *Since the researcher lived in one the neighborhoods (Maple), selecting a neutral starting point was particularly important. Although a few of the evaluators knew where the researcher lived, most did not. This information was not disclosed or discussed during the tour. Every effort was made to present each case in as value neutral way as possible.*

Note 13 Comparative Time Intervals: *There was a casual correlation noted between the need to keep a group moving and the number of local politicians in the group. Tour C with two selectboard members was among the most talkative of the groups—lots of babies to stop and kiss.*

Note 14 Uncertainty of Several Lay Evaluators: *Written notes and anecdotal comments of the three of the senior citizen participants indicated considerable and sometimes quite amusing uncertainty about "what to look for." They were however extremely attentive to trying to understand the concepts and took their scoring quite seriously. But comments such the one from participant (D4) saying she thought she may have reversed the scale on some of the measures suggested there was some level of confusion. In reviewing the scores, her scores in particular (but by no means exclusively) appeared to be out of line with more typical scoring values.*

Note 15 Existing Measures of Density: *While typically measured as units per acre, there are several other accepted conventions of measurement. Floor area ratios (total floor area per square foot of land) are used for measuring mixed use or non-residential settings. Population density over larger areas is often measured as people per acre or per square mile.*

It may be that we have become so feckless as a people that we no longer care about how things work, but only what kind of quick, easy outer impression they give. If so there is little hope for our cities. But I do not think this is so. Specifically in the case of planning for cities, it is clear that a large number of good and earnest people do care deeply about building and renewing. Planners, architects of city design, and those they have led along with them in their beliefs are not consciously disdainful of the importance of knowing how things work. On the contrary, they have gone to great pains to learn what the saints and sages of modern orthodox planning have said about how cities ***ought*** *to work and what* ***ought*** *to be good for people and businesses in them. They take this with such devotion that when contradictory reality intrudes, threatening to shatter their dearly won learning, they must shrug reality aside (p. 11).*

• Jane Jacobs The Death and Life of Great American Cities

Chapter Eight:
CORRELATIONS AND CONCLUSIONS

The majority of this dissertation has been focused on identifying key dimensions of neighborhood form and deriving a series of first order measures that can distinguish form related qualities between places. The obvious question at the end of this project is: how well do the measures work?

The task of this final chapter is to evaluate the relative worthiness of the derived measures and summarize key findings, limitations and areas for future research. The discussion begins by asking a set of questions related to the assessing the utility of the derived measures:

- Do they measure anything useful?
- Can they distinguish urban form differences that elude standard measures of urban density?
- To what extent can measured values be independently correlated with perceptual qualities of neighborhood form?

- Can they distinguish the same range of values perceived by a group of surveyors in the field?
- Do some measures work better than others?
- Are there certain types of conditions that are more difficult to measure than others?
- Can they be applied to a wider range of neighborhood types and densities?
- How might their performance be tested within a broader context?

Insight into many of these questions was drawn from a very simple process that compared measured values with surveyed values. The process correlated the relative differences between case studies as calculated by the derived measures with the relative differences between the same case studies assessed during the *Neighborhood Evaluation Survey* tours. In short, it allowed a basic assessment of how well measured differences correlate with observed differences. Were the measures sufficiently robust to "see" the same set of relative relationships perceived by someone in the field?

Prior to making this comparison, an analysis of survey results in the last chapter answered three pre-requisite questions. First, did the surveyors observe the same range of neighborhood form variation beyond simple density that was the basis for the original case selection? This was primarily evaluated by looking at the comparative range and values of the *average scores* across the case studies. The broad range of values found in the analysis confirmed this to be true.

Secondly, did the surveyors understand and evaluate the eight tested qualities in a consistent and reliable way? This was important for ensuring the mean survey values represented a set of coherent observations rather than simply averaging a random set of responses. This was primarily evaluated by looking at the *standard deviation* from the mean for each set of surveyed scores. The analysis found a generally consistent scoring across the sample—people were generally seeing the same relationships. However, the evaluations of the professional sub-sample were found to be significantly more consistent with an average SDV of about 0.7 across all responses. Based on this finding the mean scoring values of the professional sample was adopted as the baseline assessment against which to compare measured values.

Finally, it was important to validate the baseline perceptions of the researcher to calibrate the measures during the derivation process. Were the researcher's own perceptions of what was different between places shared by others? This was tested by *comparing the average scores* of two survey tours by the researcher with those of the larger survey sample. Results found a strong correlation between the researcher's evaluations and the survey sample—especially within the professional sub-sample.

With some assurance that the tested qualities were reliably seen and evaluated during the survey, it was possible to move forward with the correlation exercise. Each quality was compared with a series of first order measures designed to capture the key relationships thought to be associated with them. As with the other phases of the project, several specification issues needed to be resolved before proceeding.

8.1 Specification Issues: Comparative Units and Scales

The major specification issue in comparing the measured values and surveyed values was the problem of comparable units and scales. The measures are expressed in whatever unit the field data was measured in. In cases where several alternative measures were derived, each one had its own unit of measurement and associated scale. For instance, the measure of density is typically expressed as units per acre. But it could also be expressed as units per square kilometer or building area per square foot of site.

The survey values, on the other hand, were not expressed in real world field-measured units. They were expressed in the ordinal units of a simple relative ranking scale from one to five. Without a common unit of measurement, comparison of the respective data is a bit of challenge. While the relative differences between measured and surveyed values can be generally seen by comparing various types of graphs of each value on a single page, the visual distance between them makes effective comparisons awkward. Arraying them comparatively on a single graphic was seen as a much preferred presentation format. However, doing so required some way of resolving the different vertical scales associated with each.

Using Combination Charts: This was solved by using a "combination chart" in which columns representing the *measured values* in each neighborhood were plotted on the left-hand Y axis (primary) and a line representing *surveyed scores* across the same set of neighborhoods was plotted on the right-hand Y axis (secondary). In this way, each set of values could be expressed in separate units of measurement. The key to accurately visualizing the correlation between the two sets of values was in establishing a consistent frame of reference for each Y-axis.

In the case of this research project, the frame of reference or universe of analysis is "all in-town neighborhoods in the Upper Valley." For all survey scores, a value of "five" represented the upper end of the range of values for any given quality within this universe and a value of "one" represented the lower end. For the measured values, the range of values was empirically derived based on the range of measurements made across all neighborhoods in the study set. So while the vertical scale for the surveyed values remains constant across all comparisons (i.e. 1 to 5), the vertical scale of the measured values is unique in each comparison. But as long at the two extremes of the measured value scale (e.g. units per acre) corresponds with the extreme values found within the Upper Valley set of neighborhoods, the ***relative*** or ***proportional*** relationships between measured and surveyed values are expressed in a comparable scale.

This concept can be illustrated with the familiar case of *density*. Here the range of measured density across the universe of Upper Valley neighborhoods is known to vary between about one and eight *units per acre*.[1] Thus, the vertical scale for the left-hand Y axis would be specified for this range. The right hand vertical scale would be the familiar 1 to 5 survey scale.[2] By graphing measured values as columns (units per acre) and surveyed values as a line of connected points, each of the values can be readily distinguished and referenced to its respective scale. Patterns of relative agreement or disagreement can be easily observed and discussed.

Standardizing Case Study Sets: Another specification issue related to establishing consistent X-axis categories. The case study set is needed to be standardized between the measures and the survey data in order to establish a consistent analytic categories. The derivation of neighborhood scale measures, incorporated the full set of twelve case study neighborhoods. Since the survey only evaluated six of those, the data base for the measures needed to be re-sorted with respect to the six survey sets. A different adjustment was required for the street/block scale comparisons. In this case while there were only six cases used in the derivation of measures, a total of eight cases were evaluated in the survey. For the purposes of the comparative analysis, the original set of six was returned to, and the two alternative cases (Elm Street in N1 Main and Ivy Court in N11 Wolf) were dropped.

Professional Sub-Sample for Survey Baseline: Finally, as noted earlier, the professional sub-sample was selected as the survey baseline for the comparative analysis. It was shown to contain the most consistent scoring and thus is assumed to represent the most reliable evaluation of a given quality in a given setting. The professional sub-sample also drew the sharpest distinctions of the physical differences between qualities. Their obvious training and experience in visual spatial analysis allowed them to evaluate differences with more confidence than the more general survey sample. It should be noted that due to the restricted sample size, the mean survey values for the two remaining alternative streets (Main Street in N1 Main and Wolf Run in N11 Wolf) includes both professionals and laypersons.

8.2 Correlating Measured Values and Surveyed Values for Eight Qualities

The following analysis compares one or more of the derived measures with the average scoring values (from *pro* sample) for eight urban form qualities surveyed across six case studies. The analysis begins by comparing the control measure density with the surveyed *density*. Since the density measure of *units per acre* is already well accepted, it was instructive to consider its correlation with perceived density across the set of neighborhoods. Of course any field-based survey value is bound to have some degree of perceptual variation due to a whole range of factors. The goal was not to find a perfect fit but rather to see if the measure discerns the same relative distinctions seen by an observer in the field. Density provided a useful baseline for evaluating the relationship between measured and perceived values.

Following *density*, the other three neighborhood wide qualities were compared to a series of measures described in Chapter Five. They included measures identified as potentially relevant to the quality in question. In some cases, only one measure was tested, in other cases several measures were tested. The neighborhood-scale qualities include Q1 *consistency*, Q2 *connectivity*, and Q3 *grain*. Next, the four street/block scale qualities were correlated with a series of measures described in Chapter Six. Again the number and type of measures varied with the quality. The four qualities include Q5 *enclosure*, Q6 *permeability*, Q7 *scale*, and Q8 *variability*. The last street/block quality, Q9 *density*, was considered redundant and not evaluated in this exercise. Survey results showed that it is highly associated with neighborhood wide density.

Associations of Measures and Qualities: Measures found to have relatively strong correlations were considered successful within the context of the study. However, weak or inconsistent correlations didn't necessarily mean the measure wasn't useful. It only meant that, taken alone, the measure did not seem to capture the quality in question. It may end up working better for some other quality or in combination with some other measure. Some measures were tested in relation to several qualities.

Over the course of the derivation process, several patterns of associations between qualities and measures were noted. In some cases certain measures seemed to be strongly associated with a certain quality. In other cases, measures seemed potentially associated with several qualities but none in a very direct way.   Likewise, certain qualities seemed likely to be strongly associated with specific physical patterns (e.g connectivity with street pattern). Others were more elusive, and seemingly influenced by a whole complex array of factors that were difficult to represent in a single simple measure (e.g. variability as a function of many things). In these cases, the use of proxy measures may help to distinguish the observed range of variation.

Finally, this exercise is seen as exploratory. In all cases the small sample size and limited universe of neighborhoods prohibits any finite conclusions about worthiness of measures. Rather the intent is to identify some key relationships and directions that may hold promise for additional detailed investigation. Some qualities may best be captured by more complex measures that take into account a variety of physical variables. The feedback from this comparative exercise is expected to help suggest areas for revisions and give direction for future research.

The Control Case: DENSITY (Q4/Q9)

In *Figure 8-1*, the *perceptual* baseline for density derived from the field survey (shown by the connected squares and referenced to the right hand scale) is arrayed against the *measured* baseline for density using the standard *units per acre* measure (shown by the columns and referenced to left hand scale). As might be expected, the correlations are pretty good but by no means perfect. Others have suggested a range of factors may influence the how density is perceived from one place to another (Rapoport 1975, Michelson 1977, Bosselmann 1998, Campoli & McLean 2003).

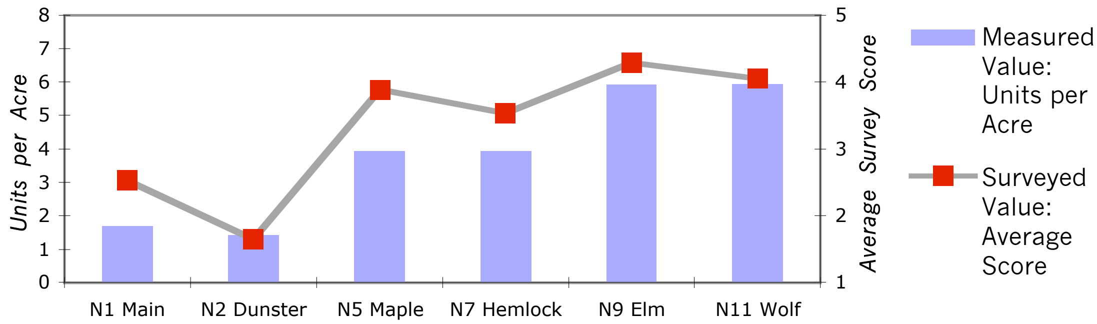


Figure 8-1 Q4/Q9 DENSITY: Units per Acre vs. Survey Score

The columns clearly show the stepped density levels of the three matched pair case study neighborhoods—N1 & N2 lower, N5 & N7 middle, and N9 & N11 higher. In general terms, surveyed density steps with measured density. The measure successfully represents the basic range of first order relationships observed in the field. There is also some variation between the two—especially at the lower density level. As noted in section 7.3, the traditional village characteristics of N1 Main seemed associated with a relatively higher perceived density than the traditional single-family sub-division of N2 Dunster. Likewise, the middle and higher density levels were perceived as relatively closer than they their measured difference suggests. This may have been due to the visible mix of housing types in both matched pairs and the assumption of equivalency between neighborhoods that have many of the same physical patterns—whether traditional small-lot, incrementally developed neighborhoods (N5 & N9) or newer large-lot, master planned ones (N7 & N11). Within this sample, the higher degree of observed open space appears to have resulted in a slightly lower assessment of perceived density in the more recently developed pair.

Curiously, the mean scores for the *overall* sample is actually a better fit than the *pro* sample for measured values *within* each matched pair as illustrated by *Figure 8-2.* The lines between each matched pair are closer to level in all three pairs. The tendency of the lay sample to see newer patterns as denser than the pro sample did result in the overall average being a slightly better fit. In general terms, both fit quite well.

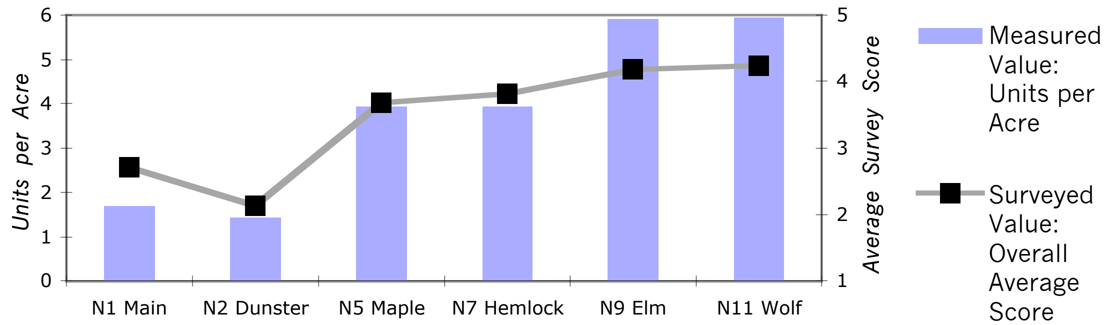


Figure 8-2 Q4/Q9 DENSITY: Units per Acre vs. Survey Score (100% Sample)

The critical role of the reference scales also illustrated in *Figure 8-2*. The scale range on the left-hand axis is changed from 0-to-8 to 0-to-6 *units per acre*. This may better represent the range of density within the survey set itself—arguably a better basis for creating a comparable scale. The column values are exactly the same—only the upper limit of the left hand scale is changed. When viewed in this frame of reference, the perception of density in the upper pair of cases appears to be dampened relative to measure density. In contrast, *Figure 8-1* shows perception of density in the middle density pair to be amplified relative to measured density. The relative relationships remain identical but the frame of reference within which they are viewed has some impact on how they are interpreted.

Neighborhood Consistency (Q1)

Values for two of the experimental measures derived in Chapter Five are presented in comparison with average survey values for *consistency* in *Figure 8-3* and *Figure 8-4.* Both were found to have a significant ability to distinguish between underlying patterns of urban form in the twelve-neighborhood study. They were both noted to be particularly strong in distinguishing the differences between neighborhoods that included multi-family housing within their land mix. Both also seemed to be somewhat related to the quality of *consistency*.

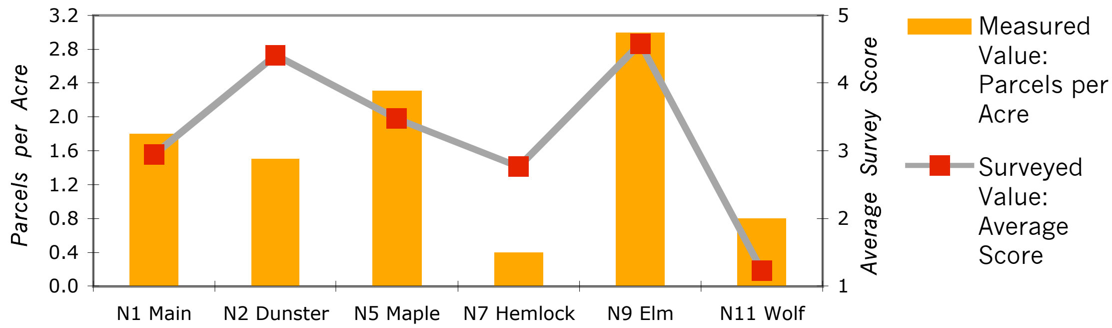


Figure 8-3 Q1 CONSISTENCY: Parcels per Acre vs. Survey Score

Figure 8-3 tests the measure of *parcels per acre*. This is an inverse measure of *average parcel size*. There are some notable correlations—particularly in the two higher density pairs that have a significant mix of multi-family parcels. Only N7 Hemlock falls short. In this case, most of the single-family homes in this neighborhood are located on large common condominium parcels. Thus the *average lot size* is higher and *parcels per acre* is lower than it would more typically be. Secondly, consistency in N7 Hemlock was the only one out of 64 evaluations where the pro and overall scores had SDVs above 1.3 (no discernable trend). This was largely thought to be a result of the confusing contrast between uniformity in site planning (high consistency) and highly segregated housing mix (low consistency). The reliability of the average score was not very strong.

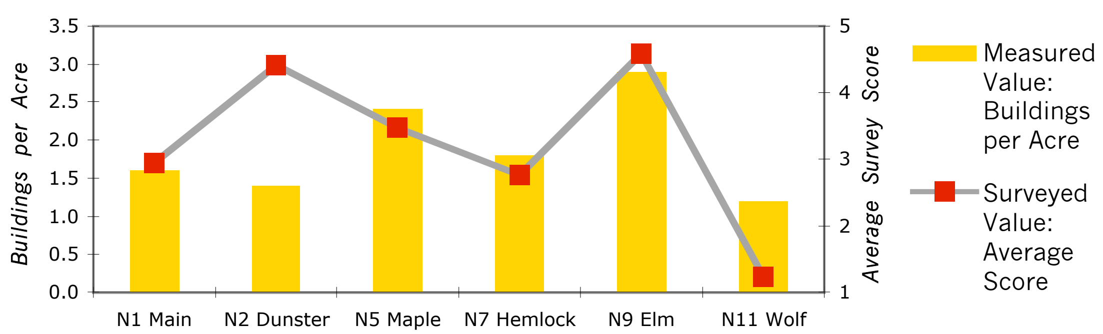


Figure 8-4 Q1 CONSISTENCY: Buildings per Acre vs. Survey Score

The common lot issue in N7 Hemlock is solved by a second measure, *buildings per acre*—shown in *Figure 8-4*. Because the unit of measurement is buildings not parcels, the frequency of houses is similar to other single-family areas. While the fit is better for

N7, it is slightly worse for N11. In both instances the measured values for N11 is slightly higher than the survey value. This is largely due to the mix of smaller single-family houses at its periphery. While this nominally adds to the sense of inconsistency (it is quite clearly inconsistent in any case), the smaller single-family lots and more frequent single unit buildings inflate the measured value somewhat in each case. Using either measure for only multi-family land use (i.e. *multi-family parcels per acre* or *multi-family buildings per acre*) creates a much stronger correlation for N11 (0.3 *par/ac* and 0.9 *bldg/ac* respectively). However, doing so amplifies the differences in other cases.

Finally, neither measure seems to work that well for the lower density set. Both are designed to pick up variation in the relative differences in buildings and lots and how they relate to different mixes of housing types. However, when lot size and building size are held constant, (as they are in most single-family lower density neighborhoods) they are not very good at distinguishing remaining differences. Both calculate very similar values for N1 & N2. However, in this pair, there is significant remaining differences that go unaccounted for. N1 Main is a mixed village that is relatively inconsistent when compared with the N2 Dunster a highly consistent 1960's tract neighborhood. This suggests some modification to the measure needs to be made to pick up these differences OR the quality itself needs to be defined more narrowly to focus on underlying building and parcel distributions. In any case, these measures seem most effective for distinguishing differences of *consistency* between mixed neighborhoods—an important distinction based on earlier analyses.

Neighborhood Connectivity (Q2)

The quality of *connectivity* has been fairly well discussed in recent years in relation to land use / transportation research. Variations for two measures discussed in Chapter Five are shown in *Figure 8-5* and *Figure 8-6.* Both were found to have a significant ability to distinguish between underlying patterns of urban form in the twelve-neighborhood study. In particular, distinguishing the influence of open-ended and close-ended streets was found important in distinguishing the perceived differences between some neighborhoods. Both measures use a base area measure of 50 acres in order to create a ratio that is more intuitively scaled to a real neighborhood.

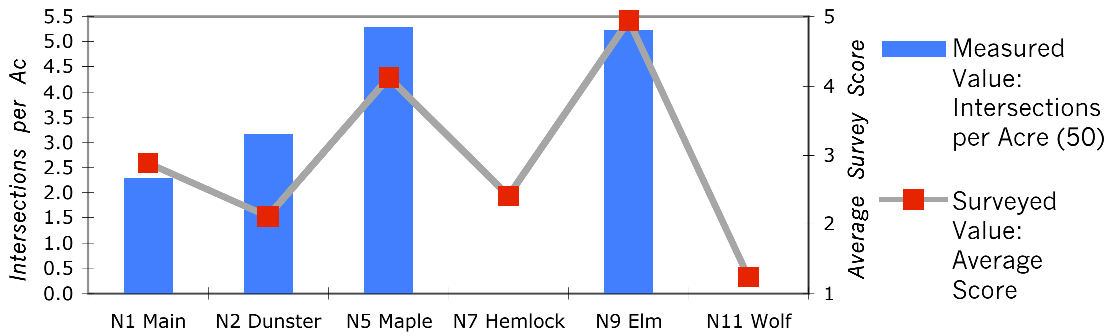


Figure 8-5 Q2 CONNNECTIVITY: Intersections per Acre (50) vs. Survey Score

The first measure shown in the graph above is intersections per acre. Two versions were tried. The first included all street intersections while the second included only open-ended intersections—that is intersections with streets that have no closed loops or cul-de-sacs. The latter measure seemed to work best in most cases as close-ended streets don't lead anywhere and therefore are less likely to be associated with increased connectivity. The obvious absence of a measure for N7 Hemlock and N11 Wolf is notable. Both are unconnected large lot multi-family areas with many close-ended loops and cul-de-sacs. Yet both measured very high (8.3 and 5.5 respectively) when all intersections were included. While the high number of close-ended intersections did not affect sense of connectivity in N11, it did somewhat in N7. This may be due to the many loops and curving streets in this master-planned community creating the experience of a somewhat connected place even if they all return to the same spine road.

Also notable is the somewhat lower survey score for N2 Dunster. This is thought to be largely related to the measure not including any accounting in relative differences of external connectivity of the neighborhood street network to the surroundings. This relationship is the focus of the second measure, number of *access points per acre*—again using a 50-acre base—shown below in *Figure 8-6*. This measure shows strong correlation with perceived differences in *connectivity*. Limited access points in the three newer neighborhoods all correspond with lower survey scores.

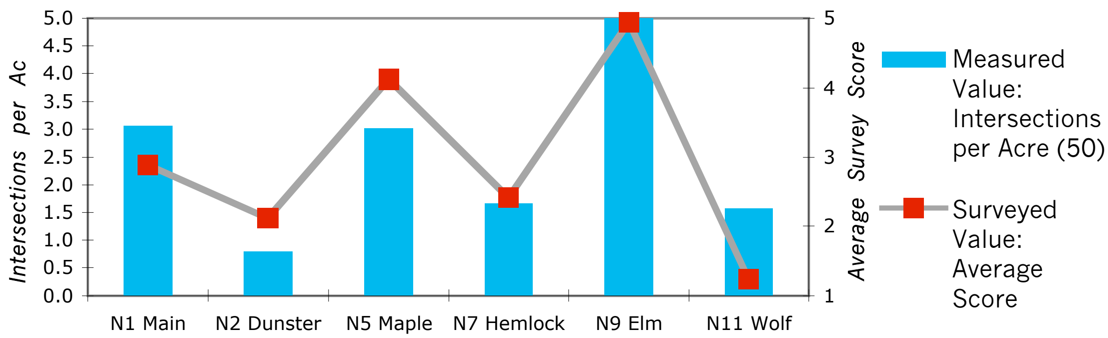


Figure 8-6 Q2 CONNNECTIVITY: Access Points per Acre (50) vs. Survey Score

In this case N2 Dunster measures somewhat lower than the perceived value—no doubt due to the influence of its somewhat more connected internal circulation pattern. Maple is also a bit lower than perceived—it feels grid like but topography somewhat limits external connections. N9 Elm, the traditional in-town grid, scores highest by all measures. In general both measures show considerable utility—the possibility of blending the two into a single index measure could potentially help level out scores in counterveiling circumstances such as N2 Dunster.

Neighborhood Grain (Q3)

During the process of testing and deriving measures, a number of different measures seemed to hold some promise for representing differences in the general characteristic of neighborhood wide *scale* and *grain*. They included *units per acre*, *parcels per acre*, *units per parcel*, *buildings per acre*, *units per building*, and *buildings per parcel*. While all of these were looked at in relationship to the survey scores for *grain*, only *parcels per acre* seemed to have a consistently reasonable fit across all cases. While some of the others such as *units per parcel* and *units per building* exhibited inverse relationships that could be translated to correlate properly, all of them except *parcels per acre* seemed to work best in neighborhoods with a mix of housing types.

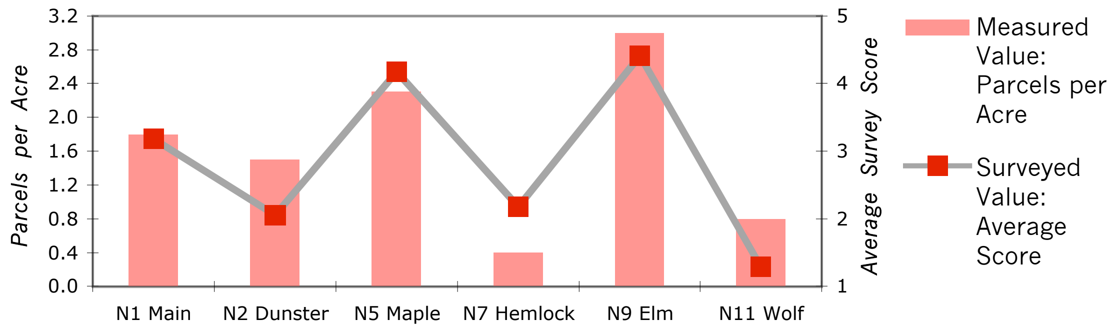


Figure 8-7 Q3 GRAIN: Parcels per Acre vs. Survey Score

The clear relationship between *parcels per acre* and *grain* shown in *Figure 8-7* is no doubt based in the strong influence of parcel patterns on neighborhood *grain*. While other factors are suspected to influence the perception of *grain*, they generally seem to vary with parcel size in most cases. Bigger buildings, bigger streets, bigger spaces generally correlate with larger parcels. This is not to say that other factors such as building size and circulation don't exert some independent influence. In all three cases where *parcels per acre* produces less exact fit, some breakdown of this general association is apparent. In the case of N2 Dunster, the relatively higher (i.e. finer) perceived value of *grain* may be related to the smaller scale of single-family buildings in relationship to relatively larger lots. In N7 Hemlock, once again, the lack of smaller parcels associated with detached houses results in measured grain being lower (i.e. coarser) than it would otherwise have been. And finally in N11 Wolf the mixing in of a line of smaller lot single-family houses at the neighborhood edge results in a higher number of *parcels per acre* than would otherwise be the case.

These patterns seem to support a tentative conclusion drawn from the analysis of survey results—when there is a strong congruence between elements of neighborhood form, their urban form qualities are easier to assess. This association may well apply to measurement as well—neighborhoods with more congruence of elements seem to be easier to consistently measure. Congruence is typically strongest in traditionally structured small-lot neighborhoods. In all three of the above cases, the weaker correlations are all associated with the newer, less congruous neighborhoods.

Street & Block Enclosure (Q5)

The correlations now move on to the more detailed scale of a single street and block within each study neighborhood. Each case was chosen to be more or less representative of the neighborhood as a whole while varying as much as possible with its matched pair—a case similar in density but contrasting in urban form. The first street/block scale quality is *enclosure*. Unlike some more complex qualities such as *consistency* or *scale,* the basic elements affecting *enclosure* are relatively simple. They include the street width, the height and setback of adjacent structures and the size and location of landscape elements—primarily trees in this context. Measures related to all three of these factors were derived. A version of each was tested in relation to the perceived sense of enclosure recorded for each street/block case study.

Figure 8-8 Q5 ENCLOSURE: Bldg Face-to-Face Width Ratio vs. Survey Score

The first measure focused on the relationship of street width to *enclosure*. As noted earlier, the relative lack of variation in street width proper and street right-of-way width suggested is would not be a very robust measure. After trying several different versions, the best street width fit was the *face-to-face width* that measures the breadth of the entire street corridor from building face to building face. Because *enclosure* logically rises as street width narrows, the measured value had to be inverted (by dividing by 100) to create a ratio with the proper relationship to the average survey score. *Figure 8-8* arrays this ration in comparison with the data line representing surveyed ratings of enclosure across all six cases. As expected, the correlations are mixed. A general trend of rising ratios (i.e. narrowing width) corresponding to greater enclosure can be seen but much of the variation between matched pairs is lost. It over-estimates enclosure on N7 and N11 and underestimates it on Sargent. Clearly there is a need to account for the differences of vertical as well as the horizontal dimensions.

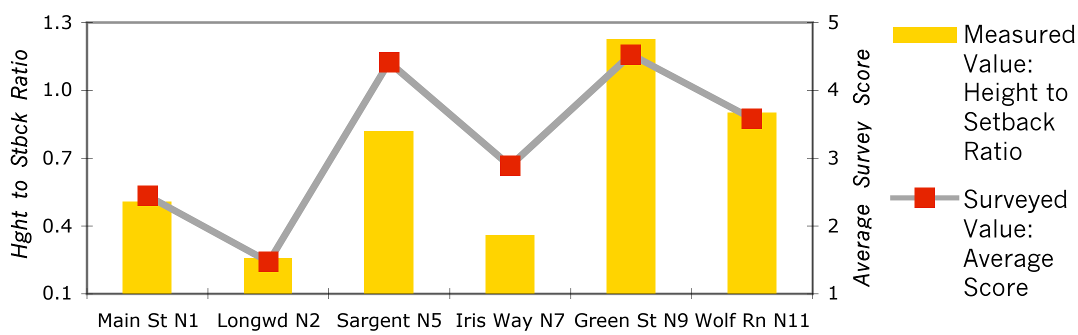


Figure 8-9 Q5 ENCLOSURE: Bldg Height-to-Setback Ratio vs. Survey Score

A second measure focuses on the relationship of building height to building setback along the street edge. As street width is relatively constant across all cases, this was expected to prove a much more robust measure of street enclosure across this set of cases. The basic measure is very simple. It divides the height of the principal building face along the street by the depth of the principal setback to create a simple ratio. It could also be expressed in more concrete terms as *height of building per foot of setback*. Several different variations of this measure (described at length in Chapter Six) experimented with "spacing coefficients" in order to account for the influence of horizontal spacing between buildings. However in the end, the original simple ratio was judged to be the most straightforward and robust measure.

As shown in *Figure 8-9*, the *height to setback ratio* provides a much stronger fit with the perceived variation of *enclosure* across these six street/blocks. Correlations are all quite strong in relational terms and except for the middle set, in absolute terms as well. This time both Sargent and Iris are under-estimated but the others all look good. However, several caveats must be noted. First of all N1 Main Street is the only case with wider street right-of-way (60 feet vs. 40 feet). If the street width was comparable, the surveyed sense of enclosure would certainly go up but the measured value would not—in other word, it would also be under-estimated. This was confirmed in surveys of the alternative N1 street (Elm) with about the same tree density and height to setback ratio but a narrower right-of-way. The mean survey score jumps to 3.5, somewhere in between N5 Sargent and N7 Iris Way.

Secondly, the measure does not account for the fact that the N11 Wolf Run is a one-sided street. The ratio is calculated based only on measurements on the built side. Clearly if this measure accounted for the lack of building on the other side, measured *enclosure* would be reduced. This again was tested on the alternative N11 street (Ivy Court). The absence of any enclosure on one side on a street reduced scores of enclosure from 3.6 to 2.3. These caveats suggest that the measure, while strong, still fails to account for some factors. There is a potential shortfall of measured values compared with perceived values of enclosure not only for N5 and N7 but for N1 and N11 as well. This shortfall confirms the hypothesis that the sense of enclosure is more than simply a function of building, street, and setback dimensions—the landscape also plays a significant role. In every one of the above cases, the influence of trees seems likely to account for any gaps between measured enclosure and surveyed enclosure.

The strong influence of trees on sense of enclosure is well illustrated by *Figure 8-10* on the next page. This arrays a measure of tree density (weighted *trees per acre*) along the street with the surveyed sense of enclosure. Total trees were inventoried and weighted to account for differences in size and location. Here relative correlations are also good (except Green St.) but show a somewhat different amplitude from the *height to setback* measure. The higher-than-survey value for *tree density* on N5 Sargent suggests trees are accounting for the lower-than-survey value when measured only by buildings in *Figure 8-9*. The same pattern on N1 Main suggests that trees *would* make up the gap if street right-of-way were constant. On N2 Longwood trees don't seem making up for shortfalls of other measures—the surveyed value is quite low. Perhaps this suggests trees alone cannot create enclosure or alternatively, the measure may simply be over-stating their influence in this setting.

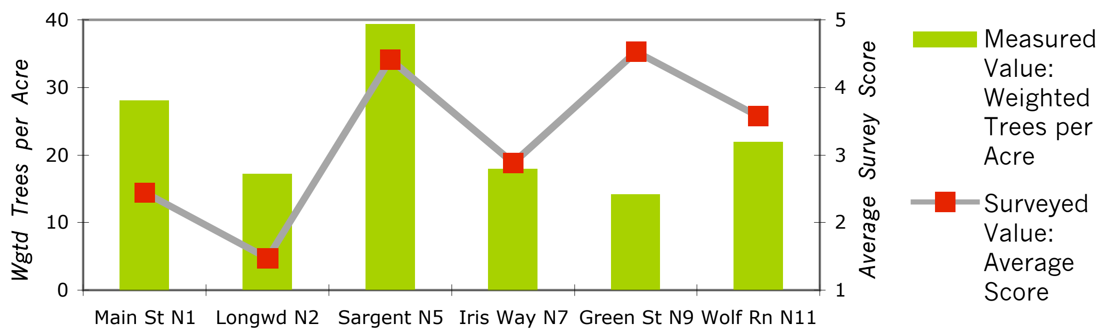


Figure 8-10 Q5 ENCLOSURE: Weighted Trees per Acre vs. Survey Score

Comparing *tree density* in *Figure 8-10*, suggests trees are an important component of *enclosure* ratings as well. For N5 Iris Way, the tree density is well matched with perceived enclosure. In contrast to Sargent Street, this suggests the shortfall in the *height to setback* measure is accounted for by a high *face to face ratio* (*Figure 8-8*) not *tree density.* Conversely on N11 Green, the dramatic understatement of tree density relative to surveyed value suggests that other factors are more dominant. While a slight over-statement in *height to setback* measure may be a factor, it also suggests that if buildings and streets are tight enough, a sense of enclosure can be achieved without a high *tree density*. Finally, in the case of N11 Wolf Run, the relatively high tree density appears to partially make up for the one-sided street condition. Taken together, these findings suggest some kind of hybrid measure in which *height to setback ratio* is somehow modified by both *street width* and *tree density* may be an even more robust and versatile measure of *enclosure*.

Street & Block Permeability (Q6)

The discussion in Chapter Six identified a whole range of factors that could influence the quality of the building to street relationship—the primary relationship thought to affect the perception of *permeability* of a street/block edge. From these, two widely recognized factors—front porches and garages—were chosen as the basis of exploratory measures of *permeability*. The two best versions of these measures are presented below as *Figure 8-11* and *Figure 8-12*. Both were found to have significant association with perceived variations of *permeability* between the six cases as reported in the survey scores. In both cases the originally derived measures were based on *average width per building* and both needed to be adjusted with a weighting to account for conditions that fell outside of the typical baseline condition. For instance values were adjusted down for an unusually shallow porch or deeply setback garage.

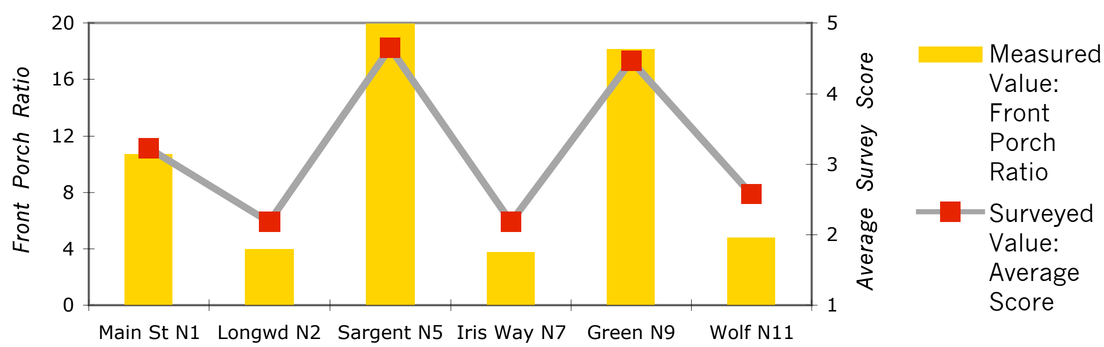


Figure 8-11 Q6 PERMEABILITY: Adjusted Front Porch Ratio vs. Survey Score

The *adjusted front porch ratio* measure shown above is calculated as a *weighted average width of porch in feet per building*. While there are clearly many other factors that are associated with a sense of *permeability*, the prominence of front porches shows very strong correlations with survey scores. The relative relationship between cases is almost perfect—if the scale were adjusted it would even be closer. The weighting factor can be adjusted to account for misfitting relationships, however this measure was developed without any knowledge of what the survey baseline would be. One of the strongest patterns in the reported values is associated with age of development. Front porches are quite common in the three pre-WWII neighborhoods and have a strong sense of pedestrian scale. Porches are much less common in the post-war neighborhoods. It would be interesting to test this measure against perceptions in some of the new urbanist developments that advocate the return of the front porch as a neighborhood design feature.

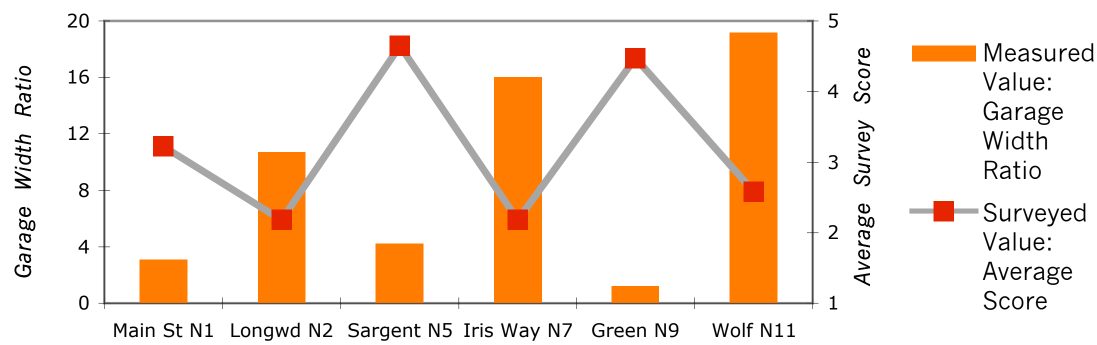


Figure 8-12 Q6 PERMEABILITY: Adjusted Garage Ratio vs. Survey Score

The above graph compares an *adjusted garage width ratio* (i.e. *weighted average garage width in feet per building*) arrayed against survey results for *permeability*. What is notable about this measure is that it maintains the exact same relative relationship between cases in a directly inverse proportion. In other words, the higher the value the lower the perceived sense of *enclosure* was reported. This is not surprising given the strong associations of blank wall surfaces with a low sense of interaction between building and street but the symmetry of the relationship is nonetheless quite notable. Again, it would be interesting to test both these measures in neighborhoods that mix porches and garages in different ways. For this limited set of cases, both measures proved robust for measuring permeability across this set of cases.

Street & Block Scale (Q7)

The quality of scale proved to be quite elusive to measure simply. Although it is a very simple and widely understood concept, the perception of scale is affected by almost every aspect of the built environment. This is supported by the survey results which show scale to be well understood but fairly broadly distributed in scoring—people seemed to give different weight to different factors. As such, there were a number of measures that seemed likely to have some association with scale but no one measure that would capture it directly.

In the derivation process, there were significant similarities noted between the factors related to *enclosure* and *scale*. This was confirmed by a strong congruence of survey scores in most cases. Measures associated with street width, building edge, and landscape were all considered promising. There are also some important differences between *enclosure* and *scale*. First, since distance is a critical issue in *scale*, *setback* as well as *height to setback ratio* is important. A broad street lined by tall buildings might have similar sense of *enclosure* to a narrower street with proportionally lower buildings but the *scale* of the two places would be very different. Secondly the *size of building* is more important. A row of many small buildings versus a single long building could have the same impact on *enclosure* but a very different sense of *scale*. Finally, in terms of landscape, the trees and elements closer to the street may be more important to a sense of *scale* than the overall tree density along a street. Based on these observations, a series of measures were compared with the average ranking of across the six sites.

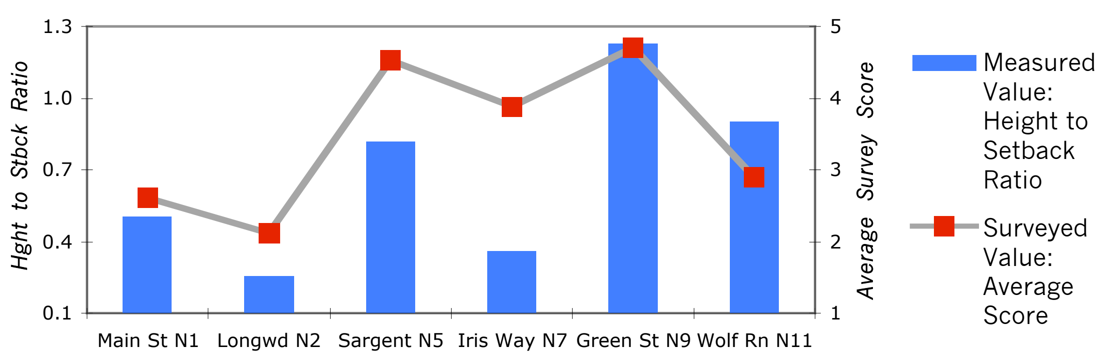


Figure 8-13 Q7 SCALE: Bldg Height-to-Setback Ratio vs. Survey Score

Comparing *Figure 8-13* (scale) with *Figure 8-9* (enclosure) shows the respective survey rankings in relationship to the same measure—*height to setback ratio*. With respect to the surveyed values, the three traditional streets (Main, Sargent, Green) are all quite close (within a 0.2 scoring interval), while the three newer streets (Longwood, Iris, Wolf) show much greater divergence (0.6 to 1.0). This reinforces the theory of congruence in the structure of the traditional street. The direction of variation is also notable. On the two streets with smaller single-family structures (Longwood, Iris Way) values for *scale* rose (i.e. finer scale) relative to *enclosure*. On the street with larger multi-family structures values dropped (i.e. coarser scale).

For reasons outlined above, the *height to setback* is not as strong for scale as it was for enclosure. All four of the lower density cases are under-valued. In particular, the small setbacks along Iris Way are way under accounted due to low building height. In contrast Wolf Run, with it's much larger building mass, is over-valued. After trying out several measures with some potential to better account for key scale dimensions of size and distance, the one that seemed to work best was *relative lot width*. While this seemed initially surprising, previous analysis has shown a strong relationship between lot size and other elements of neighborhood form. For instance, *parcels per acre* was closely correlated to neighborhood wide *grain* (a close relative of scale) due in large part to lot dimensions setting a "framework scale" for development pattern.

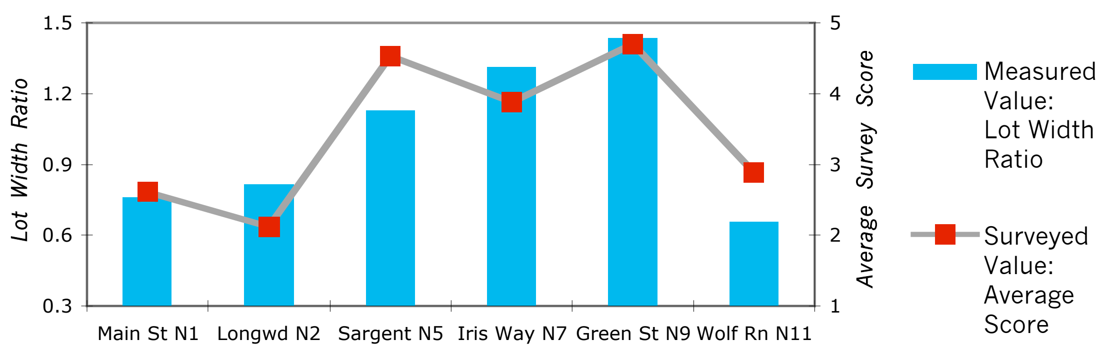


Figure 8-14 Q7 SCALE: Lot-Width Ratio vs. Survey Score

Average lot width is shown in *Figure 8-14* to be a much better measure for scale as rated across these six case studies. Average lot width is expressed as a *lot width ratio* calculated as *the number of lots per 100 feet of street* along a given block. This provides a more dynamic and tangible expression of the density of lots along a street frontage rather than simply presenting an average number. The results show much stronger correlations with perceived scale than the first measure. While scale is certainly a function of more than lot width, the measure appears to be a pretty good proxy for other factors such as building size and setback. However, Sargent Street and Wolf Run still appear to be a bit under-specified and Longwood a bit over-specified.

There are two other factors that the analysis in Chapter Six suggests may be important to consider. The first is *tree density*—a well known scaling element in street design. The second relates to the wide range of design details that are also known to affect sense of *scale*. The former will be looked at using a modified tree density measure, the latter will be discussed at length in relationship to the last quality—*variability*.

Figure 8-15 Q7 SCALE: Weighted Street Trees per Acre vs. Survey Score

The measure of *tree density* shown in *Figure 8-15* was modified to be more sensitive to the distance factor that seems so important *scale* (i.e. things close to the observer have a relatively greater impact on scale). Thus rather than including all trees on a street block as was done for enclosure, only trees between the street edge and the building line are included. While these aren't street trees in the traditional sense, the term *street tree density* is used to distinguish the sub-set of trees closer to the street. The correlations are again quite good with the notable exception of Green Street. In this case, it must be assumed there are enough other scaling factors (i.e. tight dimensions, building massing, architectural details, etc.) to create a strong sense of human scale without a high tree density. The other two measures suggest this is the case. Likewise the relative over-representation of scale by tree density on RMain and Longwood appears to be balanced by the greater street widths and setbacks associated with lower score for scale (i.e coarser scale).

The complexity of assessing scale suggests that it may be best measured by a combination of measures or by some kind of composite measure that integrates several factors. Understanding how the individual dimension impact scale, is critical to ensure the influences of each variable are properly accounted for. In the course of this project, , it was found that trying to account for multiple variables in a single measure often created a more ambiguous and less robust measure.

Street & Block Variability (Q8)

Of all the surveyed qualities, only *variability* proved too elusive to derive a simple metric to measure it. Like *scale*, *variability* is a function of almost everything in the physical environment. But unlike *scale*, which is based in dimensional certainty of size and distance, *variability* is based on basic distinction of type—a distinction that is much more difficult to specify as a measureable variable. It depends on drawing basic distinctions between what is different and what is the same. The more things are the same, the lower the *variability*. The more things are different, the higher the *variability*.

The first quality of *consistency* is conceptually a close relation. It involved evaluating large underlying distinctions of *what is similar* vs. *what is different* at the scale of a neighborhood. While it couldn't directly be measured, a number of proxy measures were derived that correlated pretty well with surveyed rankings of relative *consistency* or sameness. *Variability* requires essentially the same distinction only evaluated within the context to of a single street/block. It is also defined much more specifically to address the quality of visual variety and interest as opposed to more underlying relationships. However, because visual variety is affected by nearly everything in the environment, associating it with specific physical patterns would have involved data compilation effort that was way beyond the scope of this project. Potentially every visually prominent element in the physical environment would need to be typed and counted. Measuring variability was seen as a topic for future research in Chapter Six.

Nonetheless because terms like "rich visual variety" or "cookie cutter uniformity" are such widely used concepts in describing differences between places, it was considered an important quality to understand. Despite not having any specific associated measure, it was included in the survey in order to develop a more empirically derived baseline across the six surveyed case studies. Somewhat surprisingly, this most complex of qualities to measure, proved one of the easiest to evaluate for both groups. It seemed to be based on a notion that people clearly understood—is it uniform and repetitive or is there some variety and interest?

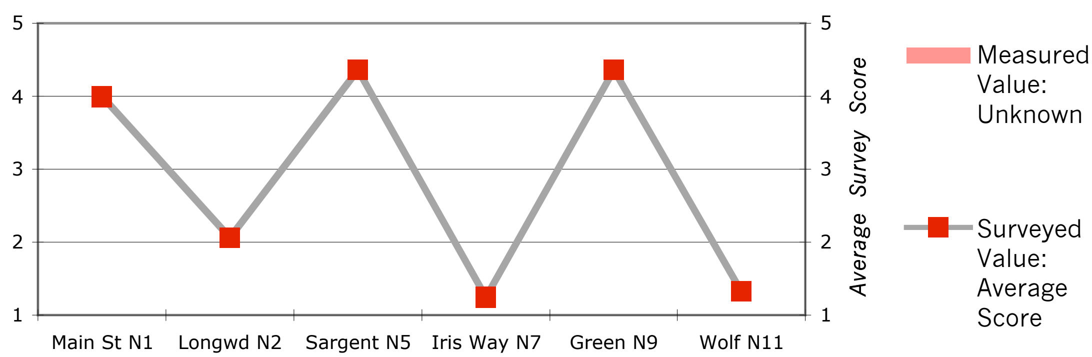


Figure 8-16 Q8 VARIABILTY: Mean Survey Score Only

As illustrated in *Figure 8-16*, not only were evaluators consistent in their scoring, they drew the sharpest of distinctions between case studies for this quality as well. There seemed to be very little middle ground, especially among the middle and upper density set. Curiously, once the values were comparatively graphed, it did not take long to recognize a basic correlation in the survey results. It seemed almost perfectly matched to the basic type distinction that was used in selecting the original case studies—development era. Over the process of selecting cases that would vary broadly in physical form within similar densities, the basic age of development seemed to be a useful proxy for general variation of urban form.

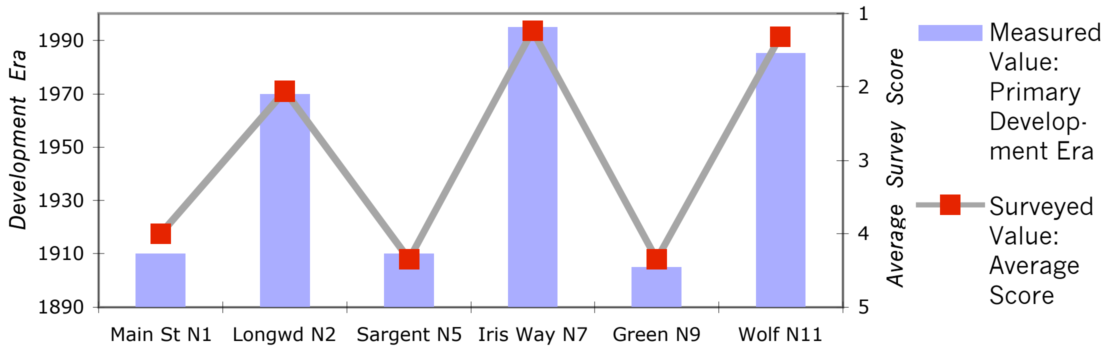


Figure 8-17 Q8 VARIABILTY: Primary Development Era vs. Survey Score

Figure 8-17 shows a remarkably good fit to the decade of primary development (the left hand scale is inverted to properly correlate date and survey value). The older neighborhoods are consistently rated as having high variability (closer to five), the newer neighborhoods are consistently low in variability (closer to one). Obviously because the older neighborhoods (particularly Main and Maple) have been developed somewhat incrementally, this is by no means a precise measure. This correlation makes quite a bit of intuitive sense within this set of cases. Older neighborhoods were developed more incrementally on small lots with considerable modification over the years. Newer ones tended to be the products of modern planning standards and development practices that emphasize consistency and mass-produced building practices. However, it seems unlikely that it would hold up so cleanly over a wider sample of cases, although it would be very interesting to test in future research.

In the end, age of development is not a physical measure—it is only a date of origin. It does appear to be a very good proxy indicator for a whole range of physical characteristics that underlie the simple assessments of the surveyors. It provides an excellent starting point for future research efforts focused on determining: 1) what these differences are, 2) how they are manifest as elements of neighborhood form, and 3) what kind of measures might best describe them.

8.3 Summary of Conclusions and Future Research

The comparisons between measured and perceived differences across the six surveyed sites identified a series of simple metrics that were able to make first order distinctions of neighborhood form. As such, the findings largely support the success of the project in deriving a series of measures that can distinguish differences in neighborhood form that elude conventional measures such as density and use. However, the significance of this success lay not so much in the specific descriptive power or utility of the metrics themselves, as in the insights they may provide into the key relationships that underlay neighborhood form and how they might be better described and accounted for in urban design practice and research.

The findings are very preliminary in nature. The goal of the comparisons was not to find exact fits with observed qualities but rather to examine basic correlations and speculate on what they might suggest about developing more robust and replicable methods for describing, specifying and measuring various dimensions of neighborhood form. Often the measures that did not work very well were as instructive as the ones that did.

Of particular interest, were the insights the survey results and correlations provided into the relationship between urban form and environmental qualities. The analysis made it clear that not all qualities are created equal. In some cases, such as *density*, *connectivity*, and *enclosure*, the associated physical dimensions were quite clear. Deriving first order measures of them was relatively easy. In other cases such as *grain*, *scale*, *consistency* and *permeability*, the physical relationships are more complex but certain measures or sets of measures seemed to capture much of the observed variation between cases. Other instances, such as *variability*, are so complex that they are best approached, at least initially, by broader terms that look to proxies and patterns that might suggest more specific avenues for future exploration.

In general it was interesting to note that the more broadly the quality was represented in various elements of urban form, the more difficult it was to identify specific relationships or measures that could independently describe it. Robust description seemed to often require a collective effort between two or more measures to capture the full variation of the quality across the range of case study conditions. One promising area for future research is to look more carefully into both the prospects and pitfalls of trying to develop some kind of hybrid or combined measure in these cases.

However, particular attention needs to be given to maintaining the essential simplicity and replicability inherent to any good measure. Over the process, a new respect was found for the elegance and utility of a measure as simple as units per acre. While the ultimate descriptive power of simple density may be limited, its intuitive nature and rudimentary structure has made it one of the most powerful measures in the practice of urban planning and development.

Directions for Future Research: The breadth of any conclusions are inherently restricted by the very limited scope of the case studies and the survey sample. Conclusions are by their nature speculative and tentative. However, the success of the initial findings suggest some future research directions. The most obvious is to expand the scope of the measurement efforts to test and refine preliminary conclusions within a broader context. An obvious place to start is in a more urban region where a greater range of urban form and density can be found. It would also be interesting to look at to what extent the basic concepts may be applicable to other regions and other countries. The elemental nature of the distinctions suggest applying them within a broader context is bound to produce new insights and problems.

A second area might address expanding the survey efforts to establish a better baseline of how urban form qualities are perceived and understood across larger sample population and across a wider range of physical settings and densities. A larger sample would allow more robust statistical analysis of results and help confirm or dispute the very strong patterns that were noted across the limited survey sample.

Finally, the use of parcel level data in the research suggests a strong potential for applying the power of GIS analysis to future analysis. Translating the basic parameters developed in this exploratory research into GIS specified variables would allow a much more widespread analysis of key questions and patterns of urban form structure. However, doing so will require overcoming a major obstacle identified in this research project—the almost complete lack of detailed urban form data in existing sources. Hopefully advances in data compilation through use of ortho-photography and digital mapping will help address this notable gap.

End Notes:

Note 1 Scales of Density in Upper Valley: *The eight units per acre was approximately the upper end of density found in the initial review of all all neighborhoodhoods. However in most cases these upper ends were straining the definition of neighborhood (too small, more projects than neighborhoods). The upper level in the final set of neighborhood was more like six units per acre. The differences between these two is compared in the density discussion.*

Note 2 Survey Scale: *Because the lowest possible value on the 1 to 5 scale is one not zero, the lowest level of the scale is a one. The law of averages does not permit any value below one, and almost guarantees that average scores will always be greater than one.*

REFERENCES

Alexander, Christopher et al. 1977. *A Pattern Language: Towns, Buildings, Construction*. New York: Oxford University Press.

Alexander, Christopher et al. 1977. *A Timeless Way of Building*. New York: Oxford University Press.

Alonso, William. 1964. *Location and Land Use.* Cambridge: Harvard University Press.

Appleyard, Donald. 1981. *Livable Streets*. Berkeley: University of California Press.

Appleyard, Donald and Allan Jacobs. 1987. "Towards an Urban Design Manifesto" *Journal of the American Planning Association* 53(1): 112–120.

Ashihara, Yoshinobu. 1983. *The Aesthetic Townscape.* Cambridge: MIT Press.

Bacon, Edmund. 1976. *Design of Cities*. New York: Penguin.

Barzun, Jacques. 1985. *The Modern Researcher, Fourth Edition.* San Diego, CA: Harcourt Brace.

Bookchin, Murray. 1970. *Ecology and Revolutionary Thought.* New York: Times Change Press.

Boyer, Christine. 1983. *Dreaming the Rational City: The Myth of American City Planning*. Cambridge: MIT Press.

Calthorpe, Peter. 1991. "The Post-Suburban Metropolis" *Whole Earth Review* (73): 44–51.

Calvino, Italo. 1974. *Invisible Cities*. New York: Harcourt.

Castells, Manuel. 1993. "The Space of Flows." Lecture. University of California, Berkeley.

Cervero, Robert and Kara Kockelman. 1997. "Travel Demand and the 3Ds: Density, Diversity, and Design." *Transportation Research-D,* 2(3): 199–219.

Clay, Grady. 1973. *Close-Up: How to Read the American City.* Chicago: University of Chicago Press.

Conzen, M.R.G. 1960. *Alwick, Northumberland: A Study in Town-Plan Analysis.* Publication #27. London: Institute of British Geographers.

Crane, Randall. 1998. "Does Neighborhood Design Influence Travel? A Behavioral Analysis of Travel Diary and GIS Data." *Transportation Research-D,* 3(4): 225–238.

Cullen, Gordon. 1961. *The Concise Townscape*. New York: Van Nostrand Reinhold.

Davis, Mike. 1992. *City of Quartz.* New York: Random House.

Doern, Daniel. 1988. *A Pattern Book of Boston Houses*. Boston: City of Boston Public Facilities Department.

Dowall, David. 1978. "Theories of Urban Form and Land Use: A Review." IURD Working Paper #295. University of California, Berkeley.

Duany, Andres and Elizabeth Plater-Zyberk. 1992. *Towns and Town-Making Principles.* New York: Rizzoli.

Duany, Andres, Elizabeth Plater-Zyberk, and Robert Alminana. 2003. *The New Civic Art*. New York: Rizzoli.

Edel, Matthew, Elliot Sclar, and Daniel Luria. 1984. *Shaky Palaces: Homeownership and Social Mobility in Boston's Suburbanization*. New York: Columbia University Press.

Ewing, Reid, Rolf Pendall, and Don Chen. 2002. *Measuring Sprawl and its Impact.* Technical Report. Washington, DC: Smart Growth America.

Fishman, Robert. 1987. *Bourgeois Utopias: The Rise and Fall of Suburbia*. New York: Basic Books.

Forman, Richard and Michel Godron. 1986. *Landscape Ecology.* New York: John Wiley.

Gallion, Arthur and Simon Eisner. 1950. *The Urban Pattern: City Planning and Design*. New York: Van Nostrand Reinhold.

Gans, Herbert. 1962. *The Urban Villagers.* New York: Free Press.

Gans, Herbert. 1967. *The Levittowners: Ways of Life and Politics in a New Suburban Community.* New York, Pantheon Books

Garreau, Joel. 1991. *Edge City: Life on the New Frontier*. New York: Doubleday.

Geddes, Patrick. 1968. *Cities in Evolution.* London: Ernest Benn.

Gehl, Jan. 1987. *Life Between Buildings: Using Public Space*. New York: Van Nostrand Reinhold. (First Danish version, 1971).

Greenbie, Barrie. 1981. *Spaces: Dimensions of the Human Landscape*. New Haven, CT: Yale University Press.

Groth, Paul, ed. 1990. *Vision, Culture, and Landscape*. Working Papers for the Berkeley Symposium on Cultural Landscape Interpretations. Berkeley: University of California Press.

Groth, Paul. 1994. *Living Downtown: The History of Residential Hotels in the United States*. Berkeley: University of California Press.

Hall, Peter. 1988. *Cities of Tomorrow: An Intellectual History of Urban Planning and Design in the Twentieth Century*. London: Basil Blackwell.

Handy, Susan. 1992. "Regional Versus Local Accessibility: Neo-Traditional Development and Its Implications for Non-Work Travel." *Built Environment* 18(4): 253–267.

Handy, Susan et al. 2002. "How the Built Environment Affects Physical Activity." *American Journal of Preventive Medicine,* 23(2S): 64–73.

Hayden, Delores. 1984. *Redesigning the American Dream: The Future of Housing, Work, and Family Life.* New York: Norton.

Hayden, Delores. 2003. *Building Suburbia: Green Fields and Urban Growth, 1820–2000.* New York: Pantheon.

Hayden, Delores. 2004. *A Field Guide to Sprawl.* New York: Norton.

Hegemann, Werner, and Elbert Peets. 1988(1922). *Civic Art.* New York: Princeton Architectural Press.

Hester, Randolph. 1975. *Neighborhood Space*. Stroudsburg, PA: Dowden, Hutchinson, and Ross.

Hillier, Bill and Julienne Hanson. 1984. *The Social Logic of Space.* Cambridge: Cambridge University Press.

Hiss, Tony. 1990. *The Experience of Place*. New York: Knopf.

Hough, Michael. 1984. *City Form and Natural Process: Towards a New Vernacular Architecture*. London: Routledge.

Hudson, Barclay. 1979. "Comparison of Current Planning Theories: Counterpoints and Contradictions." *Journal of the American Planning Association* 45(4): 387–398.

Jackson, J.B. 1980. *The Necessity for Ruins and Other Topics*. Amherst: University of Massachusetts Press.

Jackson, Kenneth. 1985. *Crabgrass Frontier: The Suburbanization of the United States*. New York: Oxford University Press.

Jacobs, Allan. 1985. *Looking at Cities.* Cambridge: Harvard University Press.

Jacobs, Jane. 1960. *The Death and Life of Great American Cities*. New York: Random House.

Keller, Suzanne. 1968. *The Urban Neighborhood.* New York: Random House.

Kepes, Gyorgy. 1944. *Language of Vision.* Chicago: P. Theobald.

Kostof, Spiro. 1991. *The City Shaped: Urban Patterns and Meanings Through History*. Boston: Bulfinch Press/Little, Brown.

Krier, Leon. 1984. *Houses, Palaces, Cities*. London: AD.

Krier, Rob. 1979. *Urban Space.* New York: Rizzoli.

Krizek, Kevin. 2003. "Operationalizing Neighborhood Accessibility for Land Use-Travel Behavior Research and Regional Modeling." *Journal of Planning Education and Research*, 22: 270–287.

Kwalter, Michael. 1989. "Legislating Aesthetics: The Role of Zoning in Designing Cities." In *Zoning and the American Dream*, C. Haar and J. Kayden, eds. (pp. 187–220). Chicago: APA.

Le Corbusier, Charles-Edouard. Frederick Etchells (trans). 1929 (1987). *The City of Tomorrow and Its Planning*. New York: Dover Press.

Le Corbusier, Charles-Edouard. 1931 (1986). *Towards a New Architecture*. New York: Dover Press.

Le Corbusier, Charles-Edouard. 1933 (1964). *The Radiant City*. New York: Orion Press.

Lewis, Pierce. 1979. "Axioms for Reading the Landscape." In *The Interpretation of Ordinary Landscapes*, D.L. Meinig, ed. (pp. 11–32). New York: Oxford University Press.

Lindholm, C. 1959. "The Science of Muddling Through." *Public Administration Review,* 19(Spring): 79–88.

Lowenthal, David. 1985. *The Past is a Foreign Country*. Cambridge: Cambridge University Press.

Lynch, Kevin. 1960. *Image of the City*. Cambridge: MIT Press.

Lynch, Kevin. 1981. *Good City Form*. Cambridge: MIT Press.

Lyndon, Donlyn and Charles Moore. 1994. *Chambers for a Memory Palace*. Cambridge: MIT Press.

Loux, Jeff. 1984. "Tinkering, Tailoring, Soldiering, Spying: An Overview of Theoretical Approaches to Environmental Planning." Ph.D. Qualifying Exam, University of California, Berkeley.

Lowe, Marcia. 1991. *Shaping Cities*. Washington, DC: World Watch Institute.

Madge, John. 1953. *The Tools of Social Science.* New York: Anchor Books.

Marans, Robert. 1987. "Survey Research." In *Methods in Environment and Behavior Research.* New York: Van Nostrand.

Marcus, Clare Cooper. 1975. *Easter Hill Village: Some Social Implications of Design*. New York: Free Press.

Marcus, Clare Cooper and Carolyn Francis. 1990. *People Places: Design Guidelines for Urban Open Space*. New York: Van Nostrand Reinhold.

Marcus, Clare Cooper and Wendy Sarkissian. 1986. *Housing as if People Mattered: Site Design Guidelines for Medium-Density Housing*. Berkeley: University of California Press.

Martin, Leslie and Lionel March. 1972. *Urban Space and Structures*. Cambridge: Cambridge University Press.

McHarg, Ian. 1969. *Design with Nature.* New York: Doubleday.

McNally, Marsha. 2005(forthcoming). *Investigating the Neighborhood Landscape: A Field Guide for Knowing and Planning Change in Your Neighborhood*. Berkeley, CA: Department of Landscape Architecture and Environmental Planning.

Morris, A.E.J. 1972. *History of Urban Form: Prehistory to Renaissance.* New York: Wiley.

Morrish, William and Catherine Brown. 1994. *Planning to Stay: Learning to See the Physical Features of Your Neighborhood.* Minneapolis, MN: Milkweed Press / Design Center for the American Urban Landscape.

Mumford, Lewis. 1961. *The City in History: Its Orgins, Its Transformations and Its Prospects*. New York: Harcourt, Brace and World.

Muratori, Saverio. 1959. *Studi per una operante storia urbana di Venezia*. Rome: Istituto Poligraphic dello Stato.

Nash, Roderick. *Wilderness and the American Mind*. New Haven, CT: Yale University Press.

Naveh, Z. 1982. "Landscape Ecology as an Emerging Branch of Human Ecosystem Science." *Advances in Ecological Research,* 12: 189–237.

Newman, Peter and Jeffery Kenworthy. 1989. "Gasoline Consumption and Cities." *Journal of the American Planning Association,* 55(1): 24–37.

Norberg-Schulz, Christian. 1980. *Genius Loci: Towards a Phenomenology of Architecture.* London: Academic Editions.

Owens, Peter. 1993a. "*The American Urban Neighborhood: 1890–1990.*" Ph.D. Qualifying Exam, Section III. Berkeley: University of California, Department of Landscape Architecture and Environmental Planning.

Owens, Peter. 1993b. "Neighborhood Form and Pedestrian Life: Taking a Closer Look." *Landscape and Urban Planning,* 26: 115–135.

Owens, Peter. 1994. "The Art of Accommodation: Designing Infill and Building Cities." *On the Ground: Journal of Community, Design and Environment,* 1(1): 10–12.

Patton, Michael. 1980. *Qualitative Evaluation Methods*. Beverley Hills, CA: Sage.

Perin, Constance. 1977. *Everything in its Place: Social Order and Land Use in America*. Princeton, NJ: Princeton University Press.

Perry, Clarence. 1929. "The Neighborhood Unit: A Scheme of Arrangement for the Family-Life Community." *Regional Survey of New York and Its Environs*. New York: Regional Planning Association.

Plaut, Pnina and Marlon Boarnet. 2003. "New Urbanism and the Value of Neighborhood Design." *Journal of Architectural and Planning Research,* 20(3): 254–265.

Poponoe, David. 1977. *The Suburban Environment: Sweden and the United States.* Chicago: University of Chicago Press.

Randle, William. 1989. "Professors, Reformers, Bureaucrats, and Cronies: The Players in *Euclid v. Ambler*." In *Zoning and the American Dream*, C. Haar and J. Kayden, eds. (pp 31–33). Chicago: APA.

Rapoport, Amos. 1977. *Human Aspects of Urban Form: Towards a Man–Environment Approach to Form and Design.* New York: Plenum.

Reps, John. 1964. *The Making of Urban America: A History of City Planning in the United States.* Princeton, NJ: Princeton University Press.

Rossi, Aldo. 1982. *The Architecture of the City.* Cambridge: MIT Press. (First Italian version, 1966).

Rowe, Peter. 1991. *Making a Middle Landscape.* Cambridge: MIT University Press.

Rybczynski, Witold. 1995. *City Life: Urban Expectations in a New World*. New York: Scribner.

Schlereth, Thomas, ed. 1982. *Material Culture Studies in America.* Nashville, TN: American Association for State and Local History.

Scott, Mel. 1969. *American City Planning since 1890*. Berkeley: University of California Press.

Sennett, Richard. *The Uses of Disorder: Personal Identity and City Life*. London: Allen Lane.

Sitte, Camillo. 1889(1965). *City Planning According to Artistic Principles*. New York: Random House.

Soja, Edward, ed. 1989. *Postmodern Geographies: The Reassertion of Space in Critical Social Theory*. London: Verso.

Solomon, Daniel. 1992. *Rebuilding*. New York: Princeton Architectural Press.

Sorkin, Michael, ed. 1992. *Variations on a Theme Park: The New American City and the End of Public Space*. New York: Noonday Press.

Southworth, Michael. 1997. "Walkable Suburbs: An Evaluation of Neotraditional Communities at the Urban Edge." *Journal of the American Planning Association,* 63(1): 28–44.

Southworth, Michael. 2003a. "Measuring the Livable City." *Built Environment*, 29(4): 343–354.

Southworth, Michael. 2003b. "New Urbanism and the American Metropolis." *Built Environment*, 29(3): 210–226.

Southworth, Michael and Peter Owens. 1993. "The Evolving Metropolis: Studies of Community, Neighborhood, and Street Form at the Urban Edge." *Journal of the American Planning Association,* 59(3): 271–287.

Southworth, Michael and Susan Southworth. 1974. "The Educative City." In *Alternative Learning Environments*, G. Coates, ed. Stroudsburg, PA: Dwoden, Hutchinson, and Ross.

Spirn, Anne Whiston. 1984. *The Granite Garden: Urban Nature and Human Design.* New York: Basic Books / Harper.

Stein, Clarence. 1951. *Towards New Towns for America*. Chicago: Public Administration Service / University Press of Liverpool.

Stern, Robert. 1986. *Pride of Place: Building the American Dream*. New York: Houghton Mifflin.

Stilgoe, John. 1988. *Borderland: Origin of the American Suburb, 1820–1939*. New Haven, CT: Yale University Press.

Stone, Christopher. 1968. *Should Trees Have Legal Standing: Toward Legal Rights for Natural Objects.* Los Altos, CA: Kaufman.

Tufte, Edward. 2003. *The Cognitive Style of PowerPoint.* Cheshire, CT: Graphics Press.

Twiss, Robert and Michael Heyman. "Nine Approaches to Environmental Planning." In *Land Use: Planning, Politics, and Policy*, R. Cowart, ed. Berkeley: University of California Extension Publications.

Unwin, Raymond. 1909. *Town Planning in Practice.* London: T. Fischer Unwin.

Vance, James. 1990. *The Continuing City: Urban Morphology in Western Civilization.* Baltimore, MD: Johns Hopkins Press.

Vernez Moudon, Anne. 1986. *Built for Change: Neighborhood Architecture in San Francisco.* Cambridge: MIT Press.

Vernez Moudon, Anne Vernez, ed. 1987. *Public Streets for Public Use*. New York: Van Nostrand Reinhold.

Vernez Moudon, Anne. 1992. "A Catholic Approach to What Urban Designers Should Know." *Journal of Planning Literature* 6(4): 331–349.

Vernez Moudon, Anne. 1994. "Getting to Know the Built Landscape: Typomorphology." In *Ordering Space: Types in Architecture and Design,* Karen Franck and L.H. Schneekloth, eds. (pp. 289–311). New York: Van Nostrand Reinhold.

Vernez Moudon, Anne. 1997. "Urban Morphology as an Emerging Interdisciplinary Field." *Journal of Urban Morphology* 1(1): 3–10.

Warner, Sam Bass. 1962. *Streetcar Suburbs: The Process of Growth in Boston, 1870–1900*. Cambridge: Harvard University Press.

Webber, Melvin. 1963. "Order and Diversity: Community without Propinquity". In *Cities and Space: The Future Use of Urban Land,* Lowdon Wingo, ed. Baltimore, MD: John Hopkins Press.

Webber, Melvin et al. 1964. *Explorations into Urban Structure.* Philadelphia: University of Pennsylvania Press.

Weiss, Marc. 1987. *The Rise of the Community Builders: The American Real Estate Industry and Urban Land Planning*. New York: Columbia University Press.

Wentworth, James and Lloyd Bookout, eds. 1988. *Density by Design*. Washington DC: Urban Land Institute.

Whyte, William. 1956. *Organizational Man*. New York: Simon and Schuster.

Whyte, William. 1980. *Social Life of Small Urban Spaces.* New York: The Conservation Foundation. This initial work was republished in an expanded 1988 version as *City: Rediscovering the Center.* New York: Doubleday.

Wingo, Lowdon, ed. 1963. *Cities and Space: The Future Use of Urban Land.* Baltimore, MD: John Hopkins Press.

Wright, Gwendolyn. 1981. *Building the Dream: A Social History of Housing in America.* Cambridge: MIT Press.

Zeisel, John. 1982. *Inquiry by Design.* Monterey, CA: Brooks Cole.

Appendix A: Research Notes on Census Block Interpolation Methods

Calculating Neighborhood Density: The week of May 24th, I focused on downloading census data and in order to calculate density. As notes in my May 21st email, the data problems associated with census block boundaries and sometimes poor correlation of mapping data with actual on the ground conditions, made this a more difficult process than I had envisioned. The number of assumptions and decisions I had to make about where to draw boundaries and how to interpolate or fill in for missing info, made me think one could do a whole dissertation on ONLY developing a methodology for calculating density. It become increasingly clear that not only does the standard measure of "residential density" ignore a whole range of neighborhood character, but that good, consistent methods for measuring "residential density" itself at the neighborhood scale do not exist. (Note: the density calculation methodology of Campoli & MacLean, 2004, that I was using as a model only looked at housing density on a block by block level that corresponded with census block boundaries. Looking at density at the neighborhood level adds a whole other level of complication).

Using both American Factfinder Census reference mapping interface (supplemented by downloaded .pdf's of block areas boundaries when on-line map labeling was illegible), a list of census blocks for each neighborhood was compiled. Data for each of these blocks (about 175 in total) was downloaded using detailed table link under for sf1 (100%) census data. Area for each census block was derived by selecting "show geographic identifiers" from under "options" menu from data output (prior to downloading). Thanks to Rolf Pendall for helping me figure this out. Once data is downloaded as Excel spreadsheet, unneeded fields were deleted, desired fields were organized and areas were converted from square kilometers to acres.

The attached file **5_27_uv_all_rawdensity_sf1.pdf** is a spreadsheet showing the raw density calculations and assumptions for each of the 24 sites. Because, of the inability to reconcile census block boundaries with actual on the ground neighborhood boundaries (issues discussed at length in May 21st email), almost every case required some interpolation of area and population data for census blocks that went beyond the limits of a given neighborhood. In only one case (Summer St) was I able to use 100% area and housing unit data from all neighborhood census blocks. In two other's (Wolf Rd and Beech St), I could use 100% of housing count but had to adjust block area for one block. In general, older neighborhoods have more census blocks than newer ones simply because a more connected street pattern results in a high concentration of closed polygons (ie blocks) per unit area.

However, the developed domain of most neighborhoods was made up of a number of 100% blocks and parts of one or two other other blocks. In order to be comparing apples and apples in terms of residential density, only areas that were predominantly residential and their associated streets and open space were included within the neighborhood area used for calculating density number. However, in most cases, some incidental non-residential uses (perhaps a day care, a small business or a small park) did end up being included in the calculation. Some care was taken to exclude these areas if they appeared to be larger than 10% of a census block.

This resulted in a three classes of census block data in the spreadsheet. The census blocks shown in yellow are the "inside" blocks which are 100% in study area and their full area and housing counts are included. The ones in blue are "outside" blocks that are only partially in neighborhood. These are generally much larger in size and almost always comprise the outside portions of neighborhood. The white blocks are adjacent but not included blocks that provide some useful information.

Interpolation was required for both geography (area) and housing data for the blue blocks. Generally, the orthophotos (developed area) and USGS maps (contours) was used to establish the overall boundaries. Overall size was calculated using a digital street atlas tool. The area in the blue blocks was measured. This was double-checked by subtracting known yellow block areas (from census) from overall size. It was determined that drawing boundaries using centerline of roads was important to be consistent census polygons. Drawing "edge of street" boundaries resulted in errors of 10% to 15% when compared to census polygons.

Once the area had been established, the number of housing units in the blue or partial blocks had to be estimated. Methods for doing so ranged depending on situation. In most cases, using orthophotos, a count could be made of structures in the included portion of blue blocks. These were double checked by multiplying the calculated block level density (units/acre) for an internal or yellow block with a similar pattern by the number of included acres in the blue blocks. In one or two cases it was easier to do the opposite: count the number of units in the unincluded area of the the blue block. In cases with more recent multi-family structures in distinct projects, it was necessary to go to town planning officials or the developers themselves to get the unit counts for these areas. This was required for entire area for four neighborhoods too new to be seen on mid-1990 orthophotos. Notes on unit and area derivations for blue blocks and overall neighborhood are shown under red total lines for each neighborhood.

Number of units and area in acres for interpolated blocks were then added to same for 100% (yellow blocks) to get a total area, unit count and density for each neighborhood. A estimated population for each neighborhood was derived by multiplying unit total by average HH size. These totals are all shown in blue typeface as interpolated values.

Demographics were calculated for other key demographics (owner vs renter and average HH size) that have a strong link to neighborhood character. As these values are not part of actual density caluculation, only 100% census block data was used to derive them rather than attempt to interpolate for partial blocks.   Blue blocks were were either included or excluded depending on whether they seemed overall more related or less related to internal blocks. Since these values are not interpolated they are shown in black type. The total value in " # of renter-occupied HH's" is actually "% owner-occupied HH) calculated from totals of two columns to left. The number of households matched exactly the number of occupied housing units for all census blocks.

A few study areas values still need more thorough checking to confirm unit numbers and areas.   Since this was going to be time-consuming, I put these off to the next round. They are marked in grey background.

NOTE: REFERENECED SPREADSHEET FOLLOWS ON NEXT THREE PAGES

TRACT	BG	BLCK	AREALAND	H003001	DENSITY	H004001	H004002	H004003	P001001	P015001	P017001
Tract	BG	Block	Area (acres) (inferred)	Housing units: (inferred)	Density (units per acre)	Occupied housing units	Owner occupied units	Renter occpd x blk (% own total)	Total population: (inferred)	Total Households	Average Household size

NOTE 1: Data in white cells are from census blocks outside of, but adjacent to neighborhood
NOTE 2: Data in blue cells are from census blocks partially within neighborhood (blue areas are much larger than yellow ones)
NOTE 3: Data in yellow cells are from census blocks that are 100% internal to neighborhood
XXX NOTE 4: Totals in BLUE text are use interpolated values from blue blocks (area, housing units, density, population)
XXX NOTE 5: Totals in BLACK text generally use 100% values from blue blocks (occupied housing, % owner, HH, ave HH size)

961602	4	4008	281.15	120	0.4	119	114	5	334	119	2.81
961602	4	4010	25.54	0	0.0	0	0	0	0	0	0
1. Grasse Rd			35.0	60	**1.7**	119	114	96%	168	119	2.81
			new dev #'s from J Caulo, Dartmouth RE, 4008 (37 u / 32 ac), 4010 (23 u / 22 ac) minus 19 ac (35%) req OS								
961602	4	4000	316.00	111	0.4	108	8	100	599	108	2.36
961602	4	4001	2.15	5	2.3	5	0	5	13	5	2.60
961602	4	4006	2.68	0	0.0	0	0	0	0	0	0
961602	4	4003	164.97	38	0.2	37	30	7	110	37	2.97
961602	4	4002	14.45	63	4.4	63	7	56	198	63	1.65
961602	4	4004	2.38	9	3.8	9	7	2	31	9	3.44
961602	4	4005	3.20	11	3.4	11	10	1	44	11	4.00
2. Curtiss Rd			33.0	116	**3.5**	120	54	45%	360	120	3.14
			need confirmed counts for SF houses on outside streets in 4003, estimated 33 units on 13 acres from aerial								
961602	4	4011	1.41	2	1.4	2	2	0	8	2	4.00
961602	4	4007	237.64	198	0.8	181	138	43	381	181	2.10
961602	4	4012	26.85	47	1.8	41	38	3	86	41	2.10
961602	4	4013	1.93	9	4.7	9	6	3	18	9	2.00
961602	4	4014	3.47	16	4.6	15	8	7	29	15	1.93
3. Willow Spring			27.0	165	**6.1**	246	190	77%	347	246	2.09
			assumes 110 on 11 ac in 4007 & 30 on 10 ac in 4012--MF unit (130 80%) counts from Vicki S (BH 78/5, WScir 28/5, WScrt 24/2)								
961602	3	3003	19.31	23	1.2	23	23	0	54	23	2.35
961602	3	3004	12.11	11	0.9	9	8	1	26	9	2.89
961602	3	3013	8.71	14	1.6	13	13	0	31	13	2.38
961602	3	3000	504.79	165	0.3	160	108	52	394	160	2.46
961602	3	3005	16.27	19	1.2	19	9	10	61	19	3.21
961602	3	3006	3.81	13	3.4	11	5	6	23	11	2.09
961602	3	3007	5.31	15	2.8	15	0	15	38	15	2.53
961602	3	3008	3.47	20	5.8	19	0	19	52	19	2.58
961602	3	3009	0.30	0	0.0	0	0	0	0	0	0
961602	3	3010	2.12	8	3.8	8	0	8	20	8	2.50
961602	3	3011	3.76	4	1.1	4	4	0	17	4	4.25
961602	3	3012	8.38	12	1.4	12	12	0	37	12	3.08
4. Valley Rd			56.0	106	**1.9**	248	138	56%	276	248	2.59
			ortho count of about 15 SF houses in 3000, 3004, 3013 on 12 ac (12+ 44=56 total) (52 u mf/54 u sf)								
961602	1	1000	4.13	14	3.4	14	0	14	44	14	3.14
961602	1	1006	6.36	5	0.8	5	0	5	16	5	3.20
961602	1	1008	6.84	40	5.9	39	19	20	75	39	1.92
961602	1	1009	7.65	4	0.5	4	2	2	12	4	3.00
961602	1	1002	83.73	151	1.8	146	62	84	310	146	2.12
961602	1	1001	10.28	53	5.2	53	14	39	159	53	3.00
961602	1	1003	2.79	7	2.5	6	6	0	14	6	2.33
961602	1	1004	5.83	11	1.9	9	6	3	20	9	2.22
961602	1	1005	5.83	22	3.8	21	9	12	75	21	2.57
961602	1	1007	2.77	15	5.4	14	6	8	36	14	2.57
5. Maple St			63.0	248	**3.94**	249	103	41%	620	249	2.47
			new unit on Weatherby (1004), 1002 estimate 140 units on 35 acres (-11 houses off lower School)--ortho count 95-100 sf units								
961700	4	4046	2.92	0	0.0	0	0	0	0	0	0
961700	4	4047	4.91	0	0.0	0	0	0	0	0	0
961700	4	4045	324.30	169	0.5	161	29	132	376	161	2.34
961602	2	2014	40.60	36	0.9	36	32	4	86	36	2.39
961602	2	2015	0.72	1	1.4	1	1	0	1	1	1.00
961602	2	2016	2.57	4	1.6	4	4	0	7	4	1.75
961700	4	4049	5.78	9	1.6	9	8	1	28	9	3.11
961700	4	4050	3.68	4	1.1	4	4	0	12	4	3.00
961700	4	4051	4.21	4	1.0	4	3	1	16	4	4.00
6. Dunston Rd			54.0	90	**1.7**	22	20	91%	261	22	2.91
			confirm outside counts: assumes 54 total site w/ 36 u in 2014 and 32 in 4045, (check sachem loops)								
961700	3	3014	45.79	8	0.2	5	5	0	107	5	2.20
961700	3	3015	269.04	294	1.1	287	42	245	537	287	1.87
961700	3	3012	19.33	27	1.4	27	19	8	76	27	2.81
961700	3	3013	0.08	0	0.0	0	0	0	0	0	0
7. Wolf Rd			57.0	321	**5.6**	314	61	19%	642	314	1.95
			assume 57 acre site covers built up MF area of 3015, includes 100% of units in 3015 (assume 10 sf + 20 sf 3012=30 sf 10%)								

961700	1	1005	34.37	24	0.7	23	11	12	45	23	1.96
961700	1	1008	50.45	69	1.4	65	24	41	151	65	2.32
961700	1	1009	1.86	0	0.0	0	0	0	0	0	0
961700	1	1010	1.32	3	2.3	3	2	1	4	3	1.33
8. Spencer St			25.0	183	**7.3**						

need to verify: assumes 15 ac. for 160 MF units under constr and existing 10u / 3ac in 1008 and 10u / 5ac in 1005

961800	2	2001	152.46	42	0.3	41	35	6	105	41	2.56
961800	2	2002	11.86	37	3.1	36	12	24	88	36	2.44
961800	2	2003	6.55	36	5.5	35	15	20	64	35	1.83
961800	2	2004	6.91	42	6.1	39	4	35	74	39	1.90
961800	2	2005	9.73	71	7.3	71	11	60	124	71	1.75
961800	2	2006	4.50	32	7.1	32	12	20	68	32	2.13
961800	2	2007	5.90	39	6.6	34	16	18	79	34	2.32
961800	2	2008	12.68	53	4.2	50	20	30	106	50	2.12
961800	2	2009	5.77	29	5.0	29	11	18	54	29	1.86
9. Elm St			58.0	338	**5.8**	326	101	31%	676	326	2.02

best defined in terms of census blocks, assumes 36 units on 6 acres in 2002 (check Forest too)

961800	4	4006	8.46	32	3.8	30	28	2	70	30	2.33
961800	4	4007	4.66	23	4.9	22	11	11	51	22	2.32
961800	4	4008	6.68	30	4.5	28	8	20	53	28	1.89
961800	4	4009	0.47	0	0.0	0	0	0	0	0	0
961800	4	4010	6.22	42	6.7	40	11	29	69	40	1.73
961800	4	4011	0.50	0	0.0	0	0	0	0	0	0
961800	4	4012	4.29	17	4.0	17	13	4	38	17	2.24
961800	4	4013	3.99	16	4.0	16	7	9	34	16	2.13
961800	4	4014	3.08	15	4.9	15	9	6	34	15	2.27
961800	4	4015	5.42	52	9.6	51	12	39	153	51	2.02
961800	4	4016	0.88	6	6.8	6	4	2	13	6	2.17
961800	4	4017	2.76	14	5.1	14	8	6	25	14	1.79
961800	4	4018	5.80	23	4.0	23	13	10	52	23	2.26
961800	4	4019	2.18	26	12.0	25	5	20	43	25	1.72
961800	4	4020	1.20	1	0.8	1	0	1	4	1	4
961800	4	4021	5.51	40	7.3	40	0	40	53	40	1.33
961800	4	4022	5.37	0	0.0	0	0	0	3	0	0
961800	4	4023	2.71	18	6.6	17	5	12	38	17	2.24
961800	4	4024	2.29	19	8.3	19	6	13	49	19	2.58
10. Summer St			72.5	374	**5.2**	364	140	38%	823	364	2.15

100% defined by yellow blocks, patchwork grid pattern & mix of house types but all within small block system

961800	4	4003	192.96	211	1.1	204	169	35	492	204	2.01
11. Peabody St			24.0	100	**4.2**	204	169	83%	200	204	2.01

need to verify: assumes site around edge of park and 100 trailer homes from aerial

961800	5	5039	298.93	59	0.2	59	54	5	195	59	3.31
961800	5	5037	4.96	10	2.0	10	10	0	26	10	2.60
961800	5	5038	3.13	9	2.9	9	6	3	20	9	2.22
961800	5	5040	3.27	17	5.2	17	17	0	54	17	3.18
12. Buckingham Pl			59.0	71	**1.2**	95	87	92%	220	95	3.11

verify with site area & unit #'s with City: assumes 35 units in 5039 and 59 total acres

961700	4	4010	1.10	0	0.0	0	0	0	0	0	0
961700	4	4011	2.38	0	0.0	0	0	0	0	0	0
961700	4	4012	1.32	0	0.0	0	0	0	0	0	0
961700	4	4013	72.07	10	0.1	10	8	2	26	10	2.60
961700	4	4014	2.17	65	29.9	63	7	56	155	63	2.46
961700	4	4015	1.28	64	50.1	63	8	55	165	63	2.62
13. Renihan Meadw's			15.0	130	**8.7**	126	15	12%	325	126	2.54

difficult boundary (need to verify): assume 15 acre site squared street & one added unit on OPTC Rd

961700	4	4032	4.79	16	3.3	16	11	5	46	16	2.88
961700	4	4033	10.90	86	7.9	81	13	68	134	81	1.65
961700	4	4035	4.73	10	2.1	10	9	1	20	10	2.00
961700	4	4036	8.72	18	2.1	18	18	0	43	18	2.39
961700	4	4037	5.06	14	2.8	13	11	2	28	13	2.15
961700	4	4038	11.68	44	3.8	44	13	31	92	44	2.09
961700	4	4020	976.97	460	0.5	443	187	256	958	443	2.16
961700	4	4034	22.93	112	4.9	108	73	35	198	108	1.83
14. Village Green			40.0	240	**6.0**	551	260	47%	504	551	2.06

assumes 100u Pine & Beech Tree, 28u Vill Green on 18 ac in 4020. Also 36u VGr, 40u Westwood, 36 misc in 4034 (40ac tot)

961700	4	4027	4.12	12	2.9	12	12	0	28	12	2.33
961700	4	4031	7.65	42	5.5	35	4	31	75	35	2.14
961700	4	4020	976.97	460	0.5	443	187	256	958	443	2.16
961700	4	4023	3.25	8	2.5	8	8	0	28	8	3.50
961700	4	4024	3.99	14	3.5	13	8	5	31	13	2.38
961700	4	4025	4.46	19	4.3	17	11	6	41	17	2.41
961700	4	4026	13.55	35	2.6	34	30	4	94	34	2.76
961700	4	4028	4.22	12	2.8	12	3	9	31	12	2.58
961700	4	4029	2.83	16	5.7	15	0	15	19	15	1.27
961700	4	4030	5.69	25	4.4	23	9	14	45	23	1.96
15. Highland Ave			56.0	190	**3.4**	122	69	57%	437	122	2.32

37.99 129 confirmed outside street counts for 4020: assume about 61 units/18 ac & total area of 56 ac from City orthophoto

965600	3	3011	80.02	150	1.9	143	67	76	395	143	2.76
965600	3	3023	62.64	162	2.6	157	73	84	306	157	1.95
965600	3	3009	25.23	29	1.1	29	17	12	73	29	2.52
965600	3	3010	7.64	29	3.8	28	17	11	63	28	2.25
16. Hillcrest Ter			28.0	70	**2.5**	357	174	49%	161	357	2.34

need to unit count for outside edges of 3011, 3023 & 3009 area: estimate 40 units on 20 acres--topo makes tough

965600	3	3014	38.53	37	1.0	37	36	1	85	37	2.30
17. Beech St			23.0	37	**1.6**	37	36	97%	85	37	2.30

confirm area (drop commerical): estimate 23 acres from ortho (includes church)

965500	1	1017	1482.90	274	0.2	266	196	70	686	266	2.58
965500	1	1028	203.03	71	0.3	70	46	24	152	70	2.17
965500	1	1029	18.39	35	1.9	33	22	11	94	33	2.85
965500	1	1030	5.71	27	4.7	26	6	20	52	26	2.00
965500	1	1033	1.74	22	12.6	22	6	16	44	22	2.00
18. Park/Summer St			25.8	84	**3.3**	81	34	42%	202	81	2.35

need to decide boundaries and counts for 1017, 1028 &1029 (difficult topo and no clear pattern): assume proxy of 1017

965500	1	1028	203.03	71	0.3	70	46	24	152	70	2.17
965500	1	1023	0.52	0	0.0	0	0	0	0	0	0
965500	1	1024	13.03	33	2.5	28	27	1	45	28	1.61
965500	1	1025	0.80	0	0.0	0	0	0	0	0	0
965500	1	1026	0.76	0	0.0	0	0	0	0	0	0
965500	1	1027	1.19	6	5.0	6	6	0	8	6	1.33
965500	1	1036	1.50	0	0.0	0	0	0	0	0	0
965500	1	1037	4.68	8	1.7	8	7	1	18	8	2.25
965500	1	1038	1.61	13	8.1	13	13	0	22	13	1.69
19. Sterling Springs			40.0	110	**2.8**	55	53	96%	220	55	2.01

confirms #'s (Simpson) for 1028, assumed totals: 40 acres and 110 units (- 21 for Maple/Christian St)

965600	5	5000	45.43	89	2.0	88	42	46	198	88	2.25
965600	5	5005	80.10	133	1.7	130	96	34	345	130	2.65
965600	5	5008	21.99	31	1.4	30	26	4	74	30	2.47
965600	5	5009	44.51	48	1.1	47	45	2	115	47	2.45
20. Colonial Dr			78.0	103	**1.3**	207	167	81%	268	207	2.58

unit counts outside streets 5000 (18) & 5005 (35), 5008 (2) from ortho and total area 78 acres

965600	1	1005	17.85	28	1.6	28	24	4	68	28	2.43
965600	1	1007	9.39	20	2.1	19	16	3	46	19	2.42
965600	1	1011	78.95	94	1.2	90	61	29	194	90	2.16
965600	1	1003	4.64	24	5.2	24	8	16	53	24	2.21
965600	1	1004	8.99	20	2.2	20	19	1	45	20	2.25
965600	1	1008	7.43	27	3.6	26	11	15	66	26	2.54
965600	1	1017	4.07	12	2.9	12	6	6	23	12	1.92
965600	1	1018	4.40	15	3.4	14	13	1	31	14	2.21
965600	1	1019	3.84	8	2.1	8	5	3	19	8	2.38
965600	1	1020	4.06	18	4.4	15	10	5	28	15	1.87
21. Hawthorn St			47.0	144	**3.1**	119	72	61%	317	119	2.22

unit counts outside streets 1005 (5) & 1007 (6), 1011 (9) from ortho and total area 47 acres

965500	1	1002	46.90	0	0.0	0	0	0	0	0	0
965500	1	1003	111.86	21	0.2	21	15	6	28	21	1.33
965500	1	1004	286.58	99	0.3	85	55	30	136	85	1.60
965500	1	1005	2.60	9	3.5	9	8	1	13	9	1.44
965500	1	1006	0.56	3	5.4	2	2	0	4	2	2.00
965500	1	1007	9.45	12	1.3	11	11	0	14	11	1.27
965500	1	1008	6.18	0	0.0	0	0	0	0	0	0
965500	1	1009	3.33	4	1.2	4	3	1	5	4	1.25
965500	1	1010	0.59	0	0.0	0	0	0	0	0	0
965500	1	1011	0.80	0	0.0	0	0	0	0	0	0
965500	1	1012	1.38	7	5.1	6	6	0	10	6	1.67
22. Hemlock Ridge			38.0	145	**3.8**	138	100	72%	334	138	2.29

confirm #'s (Simpson & elderly) for 1003 &1004, assumed totals: 38 acres and 145 units (subtracted 10 for Jericho St)

965000	2	2038	12.28	11	0.9	10	8	2	27	10	2.70
965000	2	2039	41.50	25	0.6	24	19	5	55	24	2.29
965000	2	2040	38.50	36	0.9	36	26	10	76	36	2.11
965000	2	2041	0.53	2	3.7	2	1	1	4	2	2.00
965000	2	2042	34.39	12	0.3	11	8	3	26	11	2.36
23. Jones Circle			48.0	82	**1.7**	83	62	75%	189	83	2.30

includes all units (except-4 at top of 2038) and total area 48 acres from ortho w/o flood plain (42 w/o comm)

965000	1	1045	172.47	119	0.7	111	76	35	260	111	2.34
965000	1	1062	113.44	16	0.1	16	7	9	40	16	2.50
965000	1	1063	13.89	24	1.7	22	17	5	58	22	2.64
965000	1	1065	4.69	13	2.8	13	11	2	31	13	2.38
24. Carpenter St			52.0	91	**1.8**	162	111	69%	218	162	2.40

outside street counts for 1045 (50) & 1062 (4) from orthos, 52 acres (46 w/o comm/civic)

NOTE 6: Grey cells indicate numbers that need further checking for first order confidence

Appendix B: Urban Form Matrix for 73 Potential Street/Block Cases

Street	Site	General Type	Growth Era	Face to Face	Street & Curb	Setback (av) L / R	Verge Elements	Extent of Yard Trees	Walk to Street	Front Porch	Prkg/ Garge	Bldg Face	Blding Space	Unit Type SF/MF	Spat Encl H/M/L
					STREET			TRANSITION				EDGE			
Low to Moderate Density: 1 to 2 units / acre (about 44,000 to 22,000 sf land per unit)															
Main	1Main	col_1 sw	1850-20	~120'	22' nc	42' / 52'	gv_gs_sw_fn	med	yes	most	rear	mixed	mixed	SF/MF	m/h
Carpenter	1Main	str_no sw	1910-70	~ 90	16' nc	34' / 38'	gs_hdg_mbx	med	some	some	mixed	mixed	mod	SF	med
Hazen	1Main	str_no sw	1910-50	~100'	18' nc	34' / 46'	grass_mbox	med	some	most	rear	mixed	mod	SF	med
Cliff	1Main	str_no sw	1920-50	~ 110'	14' nc	60' / 36'	grass_mbox	low	no	some	rear	mixed	wide	SF	low
Claflin Cir	2Duns	str_no sw	1970	~ 120'	20' nc	42' / 52'	grass_mbx	med	no	few	side	eave	wide	SF	low
Dunster	2Duns	str_no sw	1960	~ 130'	20' nc	56' / 52'	grass_mbx	med	no	none	side	eave	wide	SF	m/l
Longwood	2Duns	str_no sw	1970	~ 150'	30' 2c	55' / 65'	grass_mbx	low	no	none	side	eave	wide	SF	low
Lash	2Duns	str_no sw	1970	~ 130'	30' 2c	50' / 48'	grass_mbx	low	no	none	side	eave	wide	SF	low
Gilson	2Duns	str_no sw	1970	~ 150'	30' nc	70' / 50'	grass_mbx	low	no	none	side	eave	wide	SF	low
Gil Circ	2Duns	str_no sw	1970	~ 140'	30' nc	55' / 55'	grass_mbx	med	no	none	side	eave	wide	SF	low
Cambridge	2Duns	str_no sw	1970	~ 160'	30' 2c	70' / 60'	grass_mbx	med	no	none	side	eave	wide	SF	m/l
Beacon	2Duns	str_no sw	1970	~ 140'	26' 2c	68' / 46'	grass_mbx	med	no	none	side	eave	wide	SF	m/l
McDonald	3Camp	str_no sw	1990	~ 130'	18' nc	60' / 54'	gs_mb_uu	med	no	some	rear	gable	wide	SF	m/l
Morrison	3Camp	str_no sw	1990	~ 130'	18' nc	56' / 52'	gs_mb_uu	med	no	some	rear	gable	wide	SF	m/l
Camp Bk	3Camp	str_no sw	2000	~ 115'	20' nc	42' / 52'	gs_mb_uu_tr	low	no	some	mixed	mixed	m / w	SF	med
Common	3Camp	str_no sw	2000	half ~ 60'	20' nc	48' L only	gs_mb_uu_tr	low	no	some	mixed	mixed	m / w	SF	m/h
Valley	4Vall	col_no sw	1930	~130'	20' nc	58' / 58'	grass_tree	some	some	most	rear	eave	wide	SF/MF	med
Dana	4Vall	str_no sw	1930-40	~120'	20' nc	44' /52'	grs_tr_hdg	high	some	none	mixed	eave	wide	SF	med
Tyler	4Vall	str_no sw	1930-40	~100'	20' nc	35' / 45'	grs_tr_wds	high	no	few	mixed	eave	wide	SF	low
Chase	4Vall	str_no sw	1960	half ~ 60'	20' nc	50' L only	grass_wds	med	no	none	side	eave	wide	SF	low
Conant	4Vall	str_no sw	1970	~ 120'	20' nc	50' / 50'	grass	med	no	none	side	eave	wide	SF	low
Weatherby	5Mapl	str_no sw	1960	~ 100'	20' nc	40' / 40'	grass	low	some	few	mixed	eave	wide	SF	m/l
River Ridg	5Mapl	str_no sw	1930	~110'	20' nc	50' / 40'	grs_woods	med	most	none	rear	eave	wide	SF	m/l
Downing	5Mapl	str_no sw	1930	~90'	26' nc	34' / 28'	grs_wds_stw	med	yes	none	mixed	eave	mod	SF	m/h
Bassy	11Wolf	str_no sw	1970	NEED	TO	MEASURE	grass_mb	low	no	none	side	eave	wide	SF	low
Moderate Density: 2 to 5 units / acre (about 22,000 to 9,000 sf of land per unit)															
S Balch	4Vall	str_1 sw	1930-90	~130'	22' 2c	50' / 58'	grs_sw_nw tr	med	yes	most	rear	eave	m / w	MF	med
Maple W	5Mapl	str_1 sw	1910-30	~90	20' 1c	44' / 26'	gs_hdg_sw	med	some	most	rear	gable	mod	SF	m/h
Sargent	5Mapl	str_no sw	1910	~90	20' nc	34' / 34'	gv_gs_h_s_t	med	yes	most	rear	gable	mod	SF/MF	high
Read	5Mapl	str_no sw	1960	~ 90'	20' nc	30' / 40'	grass	med	some	some	mixed	eave	mod	SF	med
Prospect	5Mapl	str_1 sw	1890-40	~90'	22' 1c	28' / 40'	grass_sw	low	yes	some	rear	mixed	mod	SF	m/h
Allen	5Mapl	str_1 sw	1900-40	~100'	22' 1c	44' / 38'	grass_sw	low	yes	some	rear	mixed	mod	SF/MF	m/h
Maple E	5Mapl	str_1 sw	1850-20	~80'	22' 1c	14' / 40'	gs_fn_st_sw	low	yes	most	rear	mixed	tight	SF/MF	m/h
Pleasant	5Mapl	str_no sw	1900	~90'	13' 2c	34' / 29'	gs_fn_st_tr	med	yes	most	rear	mixed	tight	SF	high
Curtis	6Curtis	str_1 sw	1960	half ~ 55'	20' nc	45' L only	gs_mb_tr_hg	med	no	none	side	eave	mod	SF/MF	m/l
Woodmore	6Curtis	str_no sw	1960	~ 110'	20' nc	45' / 45'	gs_mb_tr	med	no	none	side	eave	mod	SF	med
Bridgeman	6Curtis	str_no sw	1960	~ 110'	20' nc	42' / 50'	grass_mbox	med	no	none	side	eave	mod	SF	med
Dresden	6Curtis	str_no sw	1960	~ 115'	20' nc	46' / 50'	gv_gs_mb_s	med	no	few	mixed	eave	mod	SF	med
Hemlock	7Heml	col_no sw	1990	~80' tree	20' nc	~30' / 30'	gs_tr_berm	high	dna	none	none	eave	dna	dna	m/h
Laurel	7Heml	str_no sw	2000	~80' av	18' nc	34' / 34' av	grass_uu	med	no	none	side	eave	tight	SF	m/h
Iris	7Heml	str_no sw	2000	~80' av	18' nc	30' / 32' av	grass_uu	med	no	none	side	eave	tight	SF	m/h
Larkspur	7Heml	str_no sw	2000	~80' av	18' nc	40' / 24' av	grass_uu	med	no	none	side	eave	tight	SF	m/h
Maple S	8High	col_2 sw	1900	~90'	22' 2c	34' / 30'	grass_sw	low	yes	most	rear	gable	mod	SF/MF	m/h
Maple N	8High	str_2 sw	1920	~90'	22' nc	36' / 38'	grass_sw	med	yes	most	rear	mixed	mod	SF	m/h
Pearl	8High	str_2 sw	1910	~90'	20' nc	36' / 32'	gs_sw_fen	med	yes	most	mixed	mixed	mod	SF/MF	m/h
Prospect	8High	str_1 sw	1900-30	~100'	20' nc	42' / 42'	grass_sw	med	yes	most	rear	mixed	mod	SF	m/h
Timothy	8High	str_no sw	1950-80	~120'	22' nc	60' / 36'	grass	low	no	few	side	eave	mod	SF	med
Mack	8High	str_2 sw	1930	~ 90'	20/26' nc	34' / 32-38'	gs_sw_fn_hg	high	yes	most	mixed	mixed	mod	SF	m/h
Dana	8High	str_2 sw	1900-30	~ 90'	20' nc	38' / 34'	grs_sw_fen	med	yes	most	rear	mixed	mod	MF/SF	m/h
Highland	12Will	str_no sw	1930	half ~ 55'	18' nc	44' R only	grass_wds	mxd	no	few	mixed	eave	mod	SF / MF	m/l
Fairview	12Will	str_no sw	1930-40	~110'	19' nc	41' / 48'	grass	med	no	few	rear	eave	mixed	SF / MF	med

Street	Site	General Type	Growth Era	Face to Face	Street & Curb	Setback (av) L / R	Verge Elements	Extent of Yard Trees	Walk to Street	Front Porch	Prkg/ Garge	Bldg Face	Blding Space	Unit Type SF/MF	Spat Encl H/M/L
				STREET			TRANSITION			EDGE					
Moderate to High Density: 5 to 15 units / acre (about 9,000 to 4,500 sf land per unit)															
Senior	1Main	drv_no sw	1980	half ~ 50'	52' nc	22' R only	grass	low	yes	none	front	mixed	mod	MF	low
West	5Mapl	col_no sw	1850-20	~120'	26' nc	45' / 45'	gvl_grs_wds	med	no	most	rear	mixed	mod	SF/MF	m/h
Lewin	5Mapl	str_no sw	1940	half ~ 35'	32'a/20'st	12'r / 32'f	grass	med	yes/yes	no	mixed	eave	tight	MF	med
School	5Mapl	str_no sw	1950-00	half =mxd	40'a/20'st	10'r / mxd f	grass	low	some	no	mixed	eave	tight	MF	m/l
Juniper	7Heml	drv_no sw	1990	~45-90'	26-60' nc	18-32' R	gs_sh_path	low	yes	none	front	eave	mod	MF	med
Azalea	7Heml	drv_no sw	2000	~80' av	36' nc	20-24' R/L	gs_sh_path	low	no	none	front	eave	mod	MF	m/l
Green	9Elm	str_2 sw	1890-20	~65'	24' 2c	24' / 20'	sw_grs_hdg	low	yes	most	rear	gable	tight	SF / MF	high
Elm	9Elm	str_2 sw	1890-20	~60	27' 2c	18' / 17'	sw_grs_fen	med	yes	some	rear	gable	tight	SF / MF	high
Union	9Elm	str_2 sw	1890-20	~70'	24' nc	22' / 22'	sw_grs_tr	low	yes	most	rear	gable	tight	SF / MF	high
Shaw	9Elm	str_2 sw	1900-30	~65'	24' 2c	26' / 16'	sw_grs_fen	med	yes	some	rear	gable	tight	SF / MF	m/h
Kimball	9Elm	str_2 sw	1910-40	~70'	22' nc	22' / 27'	sw_grs_fen	med	yes	none	rear	gable	tight	SF / MF	m/h
Sem Hill	10VGr	drv_no sw	1970	half ~ 70'	64' nc	36' R only	grass_uu	med	yes	none	front	eave	wide	MF	low
Village Grn	10VGr	drv_no sw	1970	50'	10-80' nc	4-20' R/L	grass_uu	med	yes	none	front	eave	wide	MF	med
Wolf	11Wolf	col_1 sw	1970	half ~ 55'	24' 2c	40' L only	gs_sw_mb	med	no	none	side	eave	wide	SF/MF	low
Boulders	11Wolf	drv_p sw	1990	half ~ 55'	24-60' 1c	16-26' R	gr_gv_pa_uu	med	yes	none	front	eave	mod	MF	low
Ivy Place	11Wolf	drv_1 sw	1990	half ~ 55'	62' 2c	20-26' R	grass_sw_uu	med	yes	some	front	eave	tight	MF	med
Wolf Run	11Wolf	drv_no sw	1990	half ~ 35'	28' nc	20' R only	shurbs_uu	low	no	none	front	eave	tight	MF	med
Stone Far	11Wolf	drv_1 sw	1990	half ~ 30'	22' 2c	20' R only	grass_sw_uu	low	yes	some	front	eave	tight	MF	med
Verona	12Will	col_no sw	1930-90	~ 80 wds	22' nc	~15'-30'	mxd wds_by	mxd	no	none	side	eave	wide	SF / MF	low
Brook Holl	12Will	drv_1 sw	1970	half ~ 45'	58' 2c	24'-48' L	grs_lghts_sw	med	yes	none	front	eave	mixed	MF	m/h
Willow 1	12Will	drv_no sw	1970	half ~ 60'	52(32) nc	50' L only	grass	med	yes	none	side	eave	mod	MF	m/h
Willow 2	12Will	drv_no sw	1970	~ 70' av	18' nc	15-35' L/R	grass	m/l	yes	none	front	eave	mod	MF	med
Willow 3	12Will	drv_no sw	1970	~ 40 wds	32' nc	~5 -10'	grass_wds	mxd	yes	none	none	eave	dna	MF	low
73 total streets in data set															

PRIMARY GROWTH

1900-1940	(green)
1950-1980	(blue)
1980-2010	(pink)

Appendix C: Field Photography Protocols

About 2,000 digital photographic images were compiled to create a project image database containing comparative views of many conditions across the case study neighborhoods. The database could be scanned in short order to examine for particular issues over the course of analyzing urban from. The database was compiled using a standardized protocol to create as consistent and comparable set of images as possible. The detailed protocol is described below.

Aerial Photography: Using the standardized conventions of Campoli and MacLean (2004), each site was flown in early June 2004. The goal was to fly in early May after the grass has greened up but before trees have leafed out in order optimize information about land use and building forms. However, the logistics of getting up in the air proved challenging. Between weather delays and plane availability it took almost a month to meet the research goal of a late afternoon on a clear day when the light conditions maximize contrast and clarity. Unfortunately by the time of the early June 2004 flight, the trees had leafed out enough that much of the detail of built environment was obscured in some neighborhoods. However, the trees in full leaf also illustrated the enormous impact of foliage on the comparative quality from one neighborhood to another.

Photos were shot with two cameras: a digital Canon (zoomed to 80 mm) and 35mm slides with a SLR Nikon with 55 mm lens. The goal was to get two types of shots for each neighborhood with both cameras. The first was an overview of the entire neighborhood in its context. The second was a steep angled oblique shot showing as much street and building detail as possible. The detailed view was somewhat contrained by airspace restrictions that prevented flying at the target elevation of 1000 feet above ground. Shots were all taken from approximately 1500 feet above the ground.

While there were perfect light conditions, the results were not as consistent as initially envisioned in the research design. Getting the light from the right angle, with the airplane at right tilt, at the right moment to frame the target area was not easy and involved somewhat of a learning curve. Some shots came out better than others. There was the constant challenge of keeping the wheel and wing out of the frame. While a decent set of photographs were made for all sites, the quality was not good as it could have been for some sites (*Figure x Thumbnail Aerial Photos for All Sites*). For both reasons of quality and view limited by leaf foliage, the utility of the aerial set was not as high for comparative analysis as envisioned. *Figure x Detailed Aerial Views of Two Neighborhoods* shows how limiting the view of neighborhoods with high foliage can be. Some of the shots came out very well. While the possibility of a second flight in November (after foliage, before snow) was considered, subsequent analysis showed these views to be less useful in the actual work of deriving metrics than initially hypothesized. Nonetheless, the existing set of aerials remained very useful to as a general overview of the comparative form and character of all cases within their landscape context.

Ground Photography: The protocol for ground photography detailed about a dozen shots from standardized points of view in order to capture a baseline range of urban form in the twelve case study neighborhoods. Each viewpoint was intended to illustrate the same typical “form components” across neighborhoods such as building elevation, space between buildings, front yards/setbacks, street cross-sections, oblique street edge, local open space, edge condition, use transition, entry points, etc. The views were broken down by the three "nested scales" of analysis identified in the Section 3.1.2 in the preceding chapter.

The intent was to capture the "most typical condition" for each view. By limiting the views to the most typical condition for each view, the intent was to develop a single highly accessible photo data set that would allow the cases to be quickly compared and contrasted during analysis of urban form and testing of derived measures. While there area obviously limits to what a two aerials and a dozen ground photographs can show. The purpose here is to provide a manageable photographic baseline for the general set of neighborhoods. The following framework, broken down by level of analysis, guided the field work. *Figure 4-3 Examples of Field Photo Protocol* in Chapter Four illustrates four of the typical views.

Building & Lot:

a. Elevation (frontal view from street)
b. Front yard cross-section (from building to street)
c. Side yard / lot line (space between buildings)
d. Oblique building view (showing context of adjoining lots)

Street & Block:

a. Street Centerline (cross-section @ mid-block)
b. Curb/sidewalk or edge of street (cross-section @ mid-block)
c. Oblique street view (showing relationship of buildings to street)
d. Oblique view of street intersection (showing corner of block)

Neighborhood:

a. Front edge or boundary (oblique view of main entry points)
b. Open space elements (oblique view of principal open spaces if any)
c. Land Use transitions (oblique view of changes in land use if any)
d. Edge conditions (oblique view of transition to adjacent areas)

In pre-testing the above protocol in several neighborhoods it quickly became apparent that some adjustments were required. First of all, while the protocol worked pretty well for capturing the range of spatial issues that were hypothesized as significant, assessing the "most typical condition" during a short time in the field proved quite infeasible. They were multiple issues to consider that could not be resolved without a considered analysis of the range of existing conditions. In other words, its was impossible to assess what is representative until one has seen and thought about the full range of the conditions being represented. Secondly, it also became apparent that in some neighborhoods, there were going to be more than one typical condition, especially at the smallest scale of house and lot.

As a result, the ground level photo documentation process was more extensive than initially thought. Over three weeks in June approximately 1500 shots were taken across all case study sites. Shots per For each neighborhood somewhere in the range of 75 to 150 shots were taken across multiple streets and blocks in order to assemble a reasonable cross-section of the range of urban form conditions that existed across each site. While the twelve shot protocol generally guided the framing and sequence of field photography, even within this specific protocol there was still a broad possible range of angles and framing variations. With experience, the photo protocol became more highly specified and regularized. Fortunately digital photo technology has removed many of the long standing cost and logistical barriers for compiling large image databases (i.e. film supplies, processing, printing, storing, organizing, reproducing, etc).

The project was fortunate to have several extended stretches of clear weather between in mid-June when nearly all of the basic ground photography work was completed. A major concern was controlling for light conditions. To the extent possible photographs were taken only on clear days. Photography was restricted to the mornings (before 11 am) and later in the afternoon (after 3 pm) in order to avoid flat midday lighting. Mid-day light almost always resulted in "white sky" conditions that reduced contrast and legibility of images. Backlit conditions were also avoided whenever possible. On occasion, this required returning to site a second time during another time of day to get consistent images of important views.

Appendix D: Town by Town Summary of GIS Data Issues

The relative accessibility, breadth and quality of the GIS data varied enormously from town to town. This resulted in considerable frustration in compiling consistent GIS data sets for the twelve neighborhood case studies. A detailed of discussion of the GIS data issues is presented below:

Lebanon Case Studies: The city of Lebanon is home to five of the twelve neighborhoods; Dunster Drive, Highland Avenue, Elm Street, Village Green, and Wolf Road. The had the highest quality and most accessible data. It was based on recent (2003) high quality color ortho-photography and had all the key coverages for this analysis: parcels, roads, buildings, topography, vegetation, and land use. While some of the coverages (particularly vegetation) were a bit sketchy, it provided an excellent level of base mapping especially when compared with other towns. They have an on-line interface that allowed downloading of graphics and attribute files. The Lebanon Planning Office provided all coverages (shape files) and the geo-referenced digital ortho photos neatly organized on a CD within two weeks of my request.

Hanover Case Studies: The town of Hanover is home to five more neighborhoods: Camp Brook, Valley Road, Maple Street, Curtis Road, and Willow Spring. The town-wide GIS data is about 15 years old and poorly organized. While access was easily secured, it took some time to find out what was useable. It appeared to be based on low resolution the black and white ortho-photography from the early 1990's. Only the parcel coverage was updated for the entire town. Coverages for land-use and vegetation and roads were far too general to be of any use. Topography was mediocre but good enough for project purposes. Buildings did not exist. A much more detailed GIS dataset from Dartmouth College was successfully integrated into the data set. This provided high quality building, road, tree, sidewalk and driveway coverages for two neighborhoods, parts of two others but completely missed the the fifth one. Missing information was filled in by hand digitizing off digital ortho-photography from the late 1990's from the Vermont Mapping Program. Reasonable data for streets and buildings could be taken off the ortho-photographics. However, vegetation was so difficult to see only the most first order patterns of tree coverage were mapped. The fifth neighborhood (Camp Brook) was too new (2000) to be on the photos. Through contacts at the Dartmouth College, a CAD file for this area with parcels, roads, and buildings was acquired from local site engineers and imported into the data set. The site has almost no vegetation except the forested borders surrounding the developed area.

Hartford & Norwich Case Studies: The last neighborhoods, Main Street and Hemlock Ridge are in the Vermont towns of Norwich and Hartford respectively. Baseline parcel and topography coverage for both sites were acquired though the local regional planning commission office in Woodstock. In Norwich, more coverages were available for the village area (Main Street) but securing it was another matter. After three months of repeated requests and promises the data was finally acquired. However the street coverages turned out to be nothing but the parcel lines and the building coverage was corrupted to the point of not being useful. As with the Hanover, the missing data for streets, buildings and vegetation was filled in as well as possible.

The problem for Hemlock Ridge in Hartford was similar to Camp Brook in Hanover—the development was only partially constructed in the mid-1990's when the ortho-photography was taken. Road layouts were visible but not buildings. In addition, the detailed parcel data for most of the neighborhood was missing from GIS parcel coverage for some reasons that were not clear. While not digital files existed for the project, 1"=60' "as-built" site plans with building locations and parcel lines were made available by the site developer. After photo-reducing and scanning the maps, these parcel and building layers were converted into a reasonably consistent digital format. As with Main Street, missing information for the perimeter of the neighborhood was filled in as well as possible from available ortho-photography.

Appendix E: Parcel Data Compilation & Parcel Distribution Graphs

The relative accessibility and quality of GIS related parcel attribute tables also varied enormously from town to town. This resulted in a time consuming process of trying to generate a consistent set of parcel level data for all twelve-neighborhood case studies. A detailed of discussion of the town-by-town parcel data issues and a series of related data specification issues are presented below. At the end of this Appendix, a complete set of the parcel size distribution graphs and parcel type pie charts described in section 5.1 are presented in sets of four by density class.

Town by Town Parcel Data: In *Lebanon*, the tables were well organized and up to date and included physical address, area and parcel number. It also included many other useful data fields such as land use coding, building information, and mailing address that allowed a quick determination of whether a property was owner -occupied or rented. The only glitch was that some condominium projects were linked to GIS coverages and others were not. This meant a second step of having to review city property assessment records in order to derive unit counts.

In *Hanover*, there was one set of GIS parcel data that had area but not address, and a second set (from an earlier year) that has address but not area (apparently the result of parcel coverage being constructed as lines not polygons). But since they shared a common ID number, the problem was solved by exporting out two tables for each neighborhood, sorting by parcel ID, and merging into one table.

In *Hartford*, the parcel attribute table had both address and areas but was so outdated that it was missing many of the new parcels that make up 75% of the Hemlock

Ridge neighborhood. Solving this required gathering sub-division maps from the developer and backing them out of existing parcel information. This was not too difficult as parcels were few and large (three to ten acres). An additional simple conversion calculation was required to create consistent units of measurement—Vermont uses a metric based mapping standard while New Hampshire uses square feet.

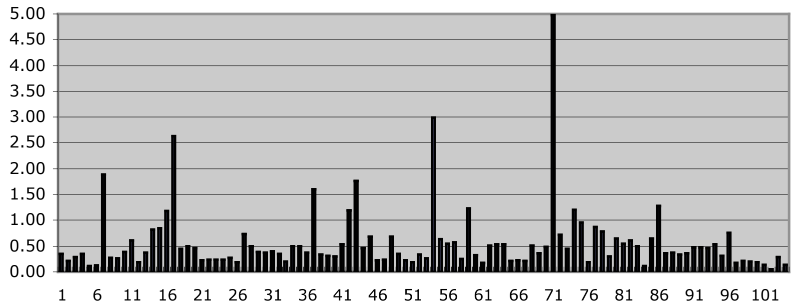
A fourth type of challenge in deriving consistent parcel attribute tables was found in *Norwich*. The age of the parcel data was not an issue since there was no recent land sub-division in the Main Street neighborhood. The problem was that parcel tables had fields for area and owner name but not for street address (only a general "village" designation). However, an existing 911 database with street addresses was linked to dots on a GIS layer that corresponded to parcel location. While they didn't share a common parcel ID as in Hanover, addresses were added by selecting each 911 dot and hand entering the address into the associated record in the parcel table for the 100 or so parcels in the neighborhood.

Once the necessary data was acquired from each town, additional sorting was required. Even though all GIS data is geo-spatial based, the associated tables are not easily organized in relationship to actual spatial proximity. Adjacent parcels are usually in the same general area of attribute tables but are organized by generic parcel numbers that are not tied to geographic sequence. Creating a data set that could be easily sorted and viewed by neighborhood geography required an additional step. Using parcel base maps and some field checking for reference, each parcel record was arrayed in counterclockwise order around the perimeter of its block starting at the northeast corner (counterclockwise seemed to correspond better with existing parcel ID numbering). Blocks of parcels were arrayed by the same protocol. Each parcel was the given a block number and a sequential ID number that allowed the database to be sorted and viewed by block and parcel proximity.

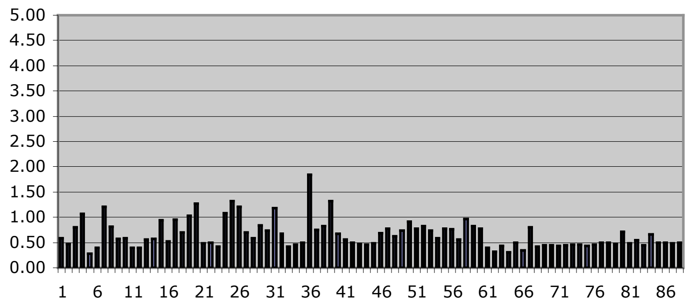
Parcel Specification Issues: General neighborhood boundaries were established during the case study selection process in the late spring 2004. Physical elements such as street and land use patterns, hydrology, topography were combined with census data to select three sets of four neighborhoods with comparable development densities. However, there were a few problems reconciling the a few individual parcels within the established neighborhood boundaries. Some additional specification parameters were required for determining how to assign certain parcels within the universe of all parcels that comprised the neighborhood.

All of the questionable conditions occurred along neighborhood edges. On the built up edges, non-residential parcels where included only if they were part of a block that was primarily part of the residential fabric of the neighborhood. For instance residential blocks with a bank, church or office were part all but three neighborhoods, while adjacent primarily commercial blocks were not. Along the non-developed outer edges, the goal was to include parcels that were perceptually a part of the identified neighborhood. Undeveloped open space parcels such as wetlands, steep slopes, cliffs, and floodplains were not included. Neither were large public or institutional uses such as schools or recreation fields. Open space parcels that were internal to the neighborhood were included.

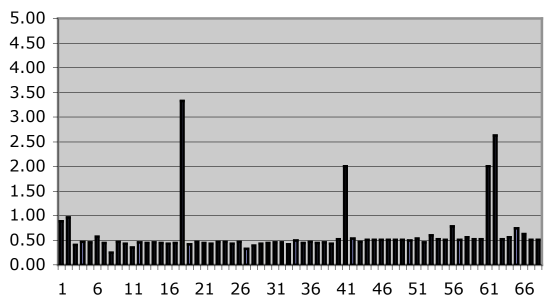
While these guidelines resolved 99% of the cases, an occasional parcel was found that included a neighborhood-related land use in one corner of a much larger parcel that was primarily made up of undeveloped lands beyond the neighborhood. Including the full parcel would misrepresent both the neighborhood boundary and density. In such instances, the parcel was divided into a *homestead portion* and an adjacent undeveloped *open space portion* using the distinction commonly made by town property assessors for tax purposes. Homestead lot was defined by developed area—the buildings and adjacent open space (i.e. lawns, gardens, yard).



1 MAIN distribution of parcel size (acres)



2 DUNSTER distribution of parcel size (acres)



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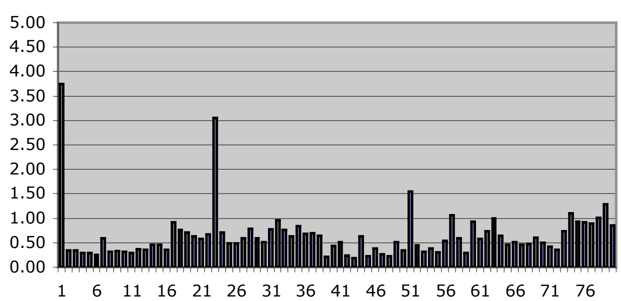
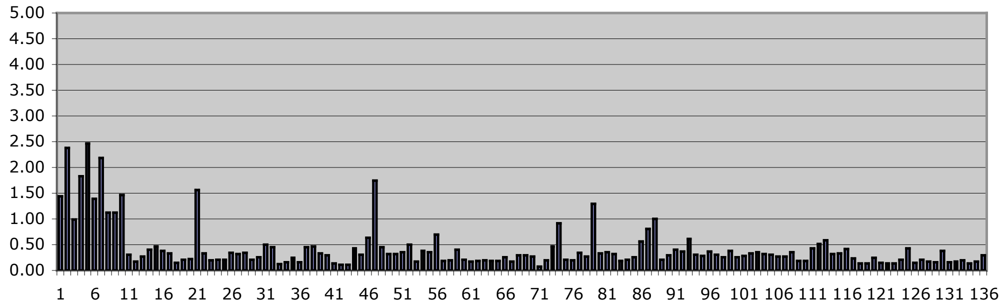


4 VALLEY distribution of parcel size (acres)



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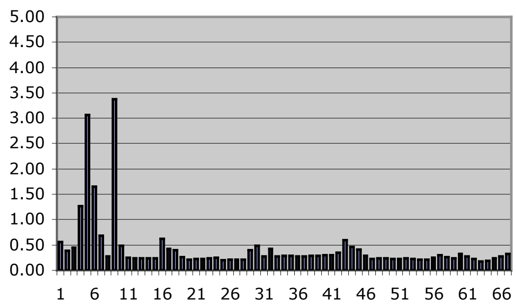
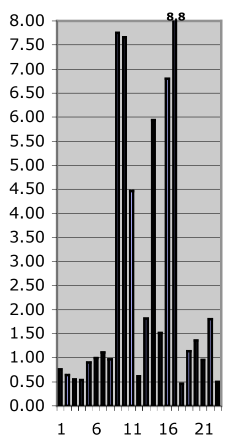
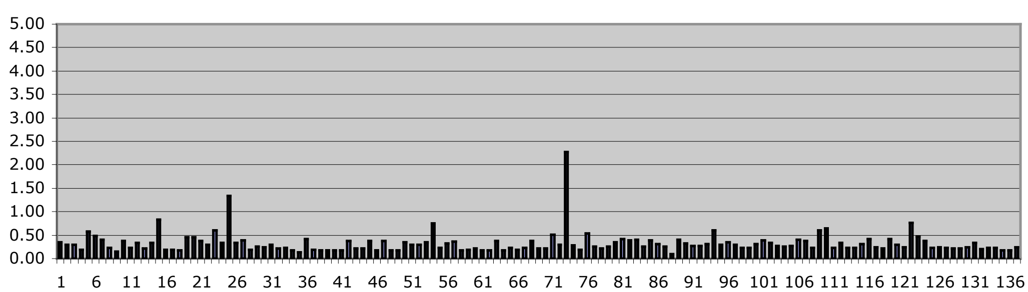


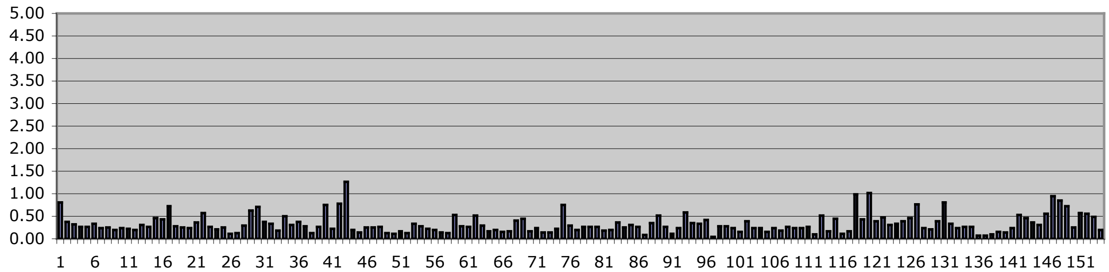
6 CURTIS distribution of parcel size (ac)



7 HEMLOCK distribution of parcel size (ac)



8 HIGHLAND distribution of parcel size (ac)



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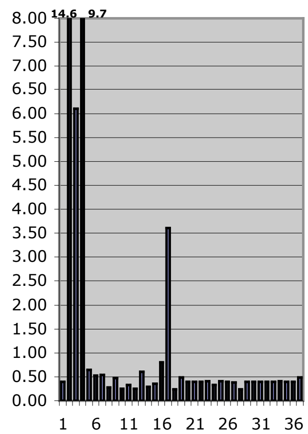

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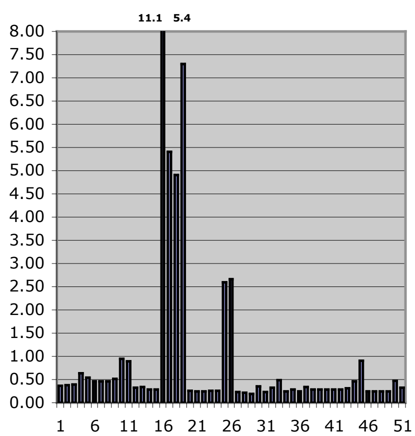
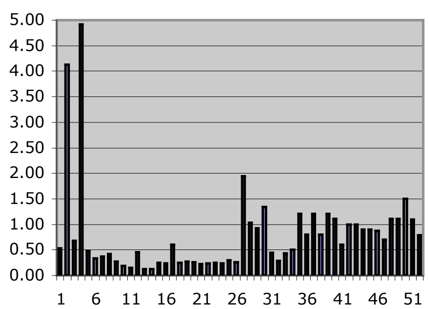


11 WOLF distribution of parcel size (ac)



12 WILLOW distribution of parcel size (ac)

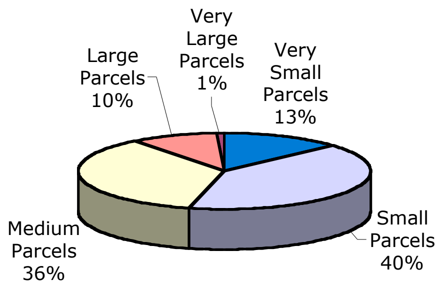
Parcel Size Distribution Charts: A close examination of the parcel size distribution graphs discussed in section 5.1 provides some interesting insights into the underlying relationships between patterns of parcel size and neighborhood character. The discussion is organized around bar charts for the three sets of four neighborhoods presented in the preceding pages.

Lower Density Set: The clearest relationship between parcel size and character occurs at the lower density level because lots represent a single family home. Main Street, the oldest and most varied in character of this set, shows the widest range of lot sizes well distributed across the site. Dunster Drive, a 1960's and 1970's subdivision, shows larger lots with less variation of size and distribution. The more variation on the left reflects the quirkier, less regular character of the Hanover side. In Camp Brook, a recent open space sub-division, consistent lot sizes match consistent character. The open space parcels are seen as spikes but the different character of its two phases cannot be discerned. Finally, the more mixed and irregular parcel size and distribution of Valley reflects it more mixed history across all three development eras.

Middle Density Set: The limitations of correlating parcel size distribution and overall character begin to show up as the land use type becomes more mixed. Maple and Curtis show similar clusters of large lots on the left and smaller lots on the right—the more consistent size in the later reflecting its post war sub-division character. And while both have a similar mix of multi-family and non-residential land uses, the parcel pattern is quite misleading in predicting overall character. Maple's large lots are large single-family homes, while Curtis's house multi-family and retail/office uses. A second limitation can be seen by comparing Curtis and Hemlock, both cases with large lot multi-family areas. The higher proportion of larger lots to small lots suggest at Hemlock suggest a lower mix of single-family houses. This again is misleading as four of the largest lots are developed with single-family detached houses with a condominium ownership structure. Again character cannot be discerned by lot size alone.

Higher Density Set: In cases where a majority of the units are known to be multi-family, a stronger correlation between parcel size and development character seem apparent. Elm's consistently small but quite varied lot size distribution reflects the physical character of older neighborhood with multi-family land uses small buildings on small lots. At Village Green and Wolf a sharply different pattern with four or five very large parcels juxtaposed against a regular group of smaller lots correlates with a prevalence of more recent multi-family projects in both neighborhoods. However, without other information, it is more difficult to discern the considerable range of character across these multi-family areas.

Parcel Type Distribution Pie Charts: Section 5.1 describes how parcel type categories allow a more robust measure of parcel size mix by calculating the share of each size type by neighborhood. The full series of twenty-four pie charts that are discussed in that section are shown in the following three pages. They record percentages of each size type by count and by land area. Each page shows a set of four neighborhoods matched by development density. The results provide a quick snapshot of some of the key patterns noted in the bar charts.



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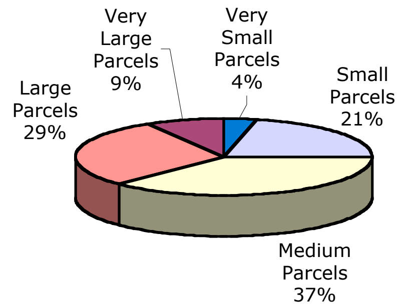
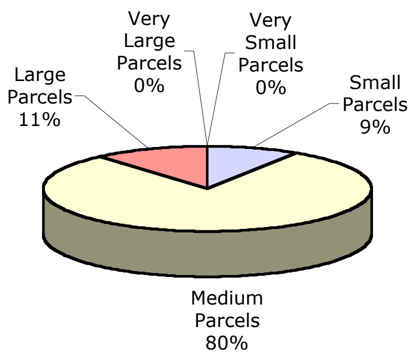


1 MAIN parcel area by size



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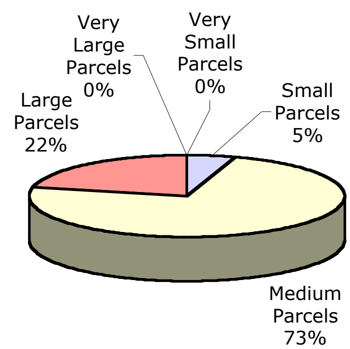

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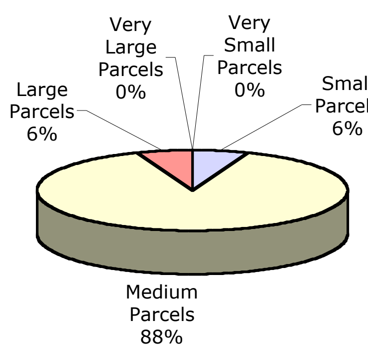

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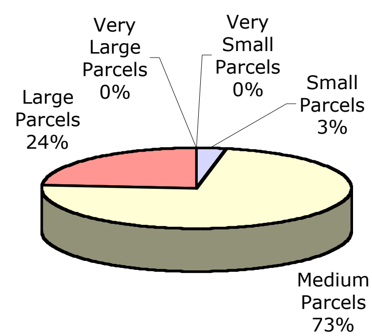

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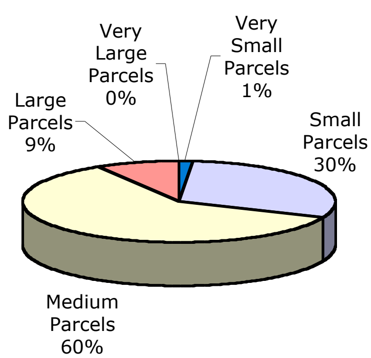

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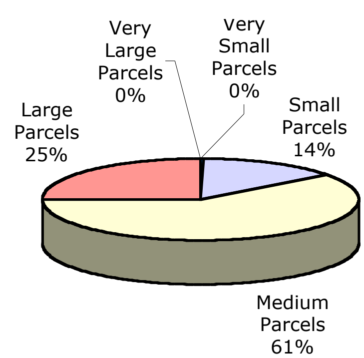
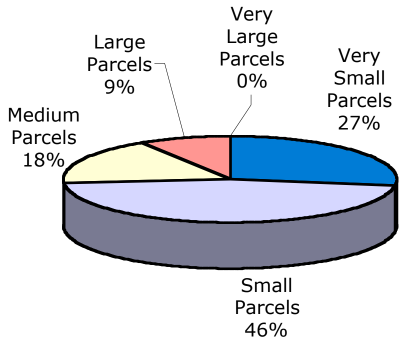


4 VALLEY parcel area by size



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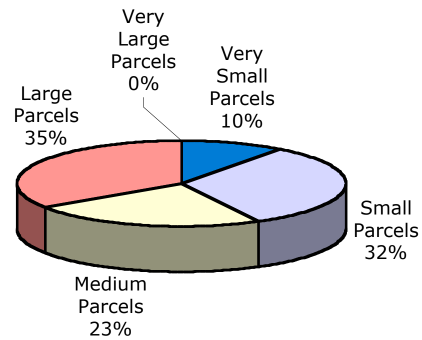

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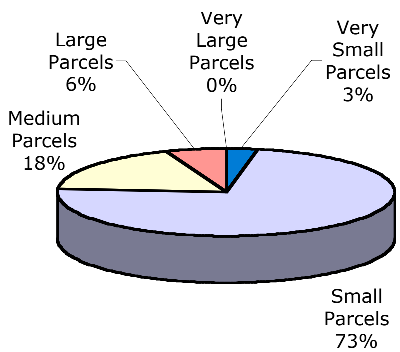

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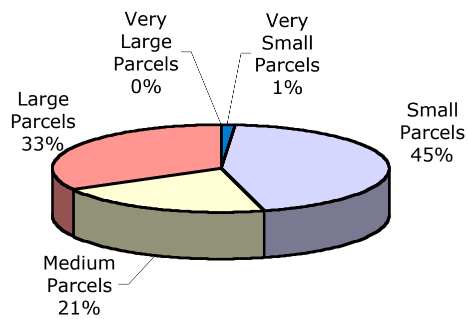

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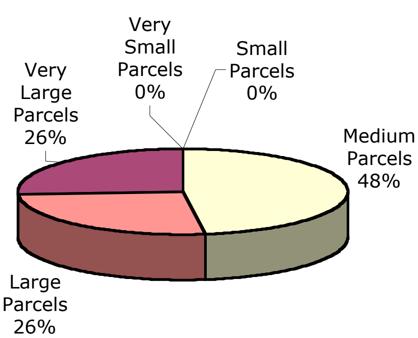
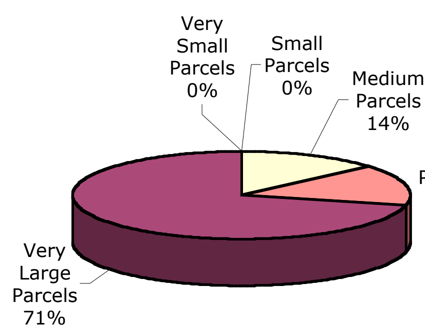


7 HEMLOCK parcel count by size



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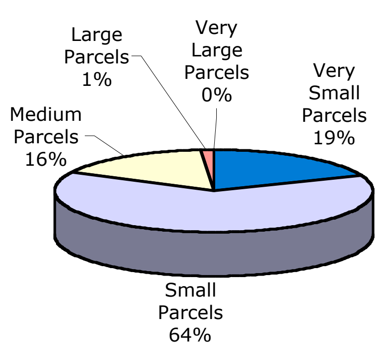

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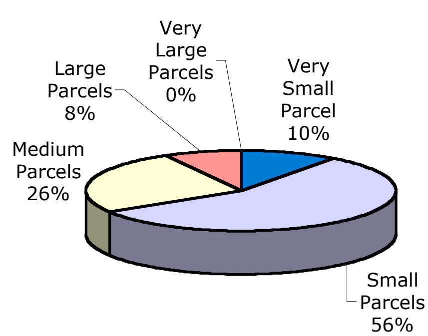

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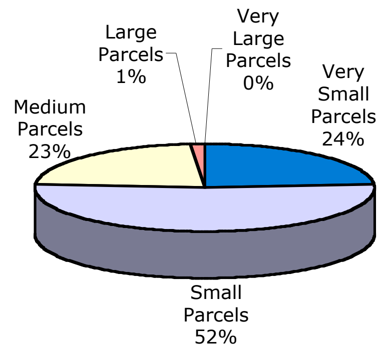

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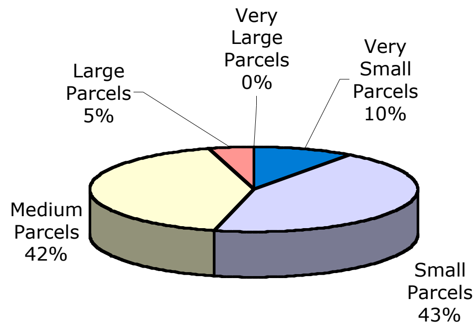

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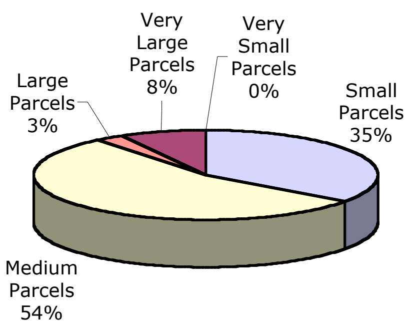
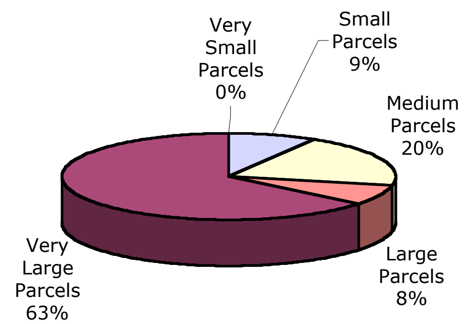


10 VILL GN parcel count by size



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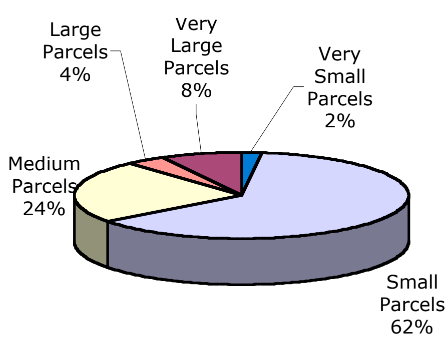
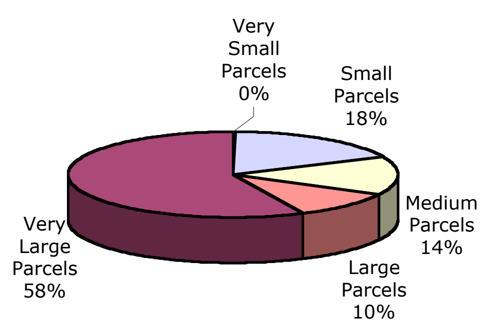


11 WOLF parcel count by size



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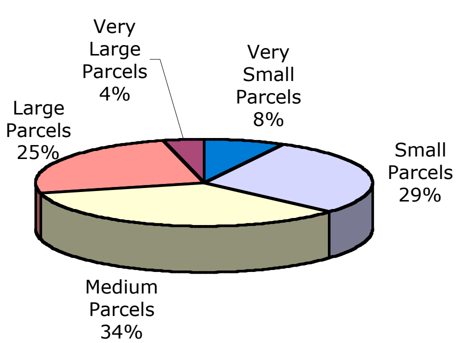

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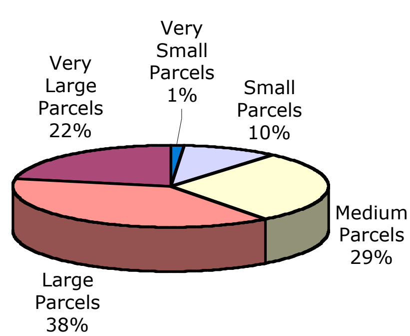

12 WILLOW parcel area by size

Appendix F: Compiling and Classifying Land Use and Building Data

As with the GIS data in general, the availability of land use, building, and dwelling unit data varied enormously from town to town. This resulted in considerable challenges for in compiling consistent GIS data sets for the twelve neighborhood case studies. A detailed of discussion of the related data issues is presented below. They include: 1) a summary of town by town issues related to compiling parcel based land use data, 2) a discussion land use classification and coding, 3) a summary of building type classification for the project.

Compiling Land Use and Building Data: Compiling data for the five Lebanon neighborhoods was the easiest. GIS based land use data was available on-line and included coverage layers for building footprints and tree lines. Attached attribute tables included pretty good data on land use. In contrast, Hanover GIS datasets lacked all three—parcel level land use, tree line and building footprint coverages. However town assessor's records did have parcel by parcel land use and some building unit data. It was purchased on a CD, sorted by parcel number and merged with the project database with a few minor hitches (see note 1). Partial building footprint data was imported from Dartmouth GIS databases with the remaining areas compiled by hand from existing ortho-photography. Tree coverage was very hard make out and was approximated to the extent possible using existing photography.

The challenges of assembling consistent data sets across town and state boundaries continued for land use data and building data for the last two neighborhoods across the river in Vermont (Hemlock Ridge in Hartford and Main Street in Norwich). Neither GIS dataset had attached land use data. For Hemlock Ridge, the Hartford assessor's office responded to a phone inquiry and simply sent the grand list with land use by email. However, because the property taxes for the six major parcels in this master planned neighborhood are billed to a single entity (a condominium association), they had neither land use and building information was not broken out by parcel. Land use, unit counts, and building types were compiled by hand off as-built drawings and confirmed in the field. Additional information regarding 38 units under construction was gathered from the town planning office and added to database.

Gathering data for Norwich continued to be a frustrating exercise. GIS data had no useable land use or building coverages. When initial attempts to get land use data from town lister (again a part-time position in a small Vermont town) were unsuccessful, an alternative method was employed. With a print out of the parcel addresses and a parcel map, a street by street bicycle survey of the entire neighborhood was made on a beautiful late winter afternoon. Land use, dwelling units and building counts were made for all 104 parcels and entered by hand into the database. Both Hartford and Norwich had the same limitations for trees as Hanover. Coverages were approximated to the extent possible using existing ortho-photography.

Classifying Land Use Type: As neighborhoods are primarily residential it was important to establish land use types that went beyond a simple distinction between single family and multi-family. Lebanon and Hanover land use records than included ten of the twelve cases were was already classified into five general categories (single family, two unit, three unit, four to seven unit, and eight or more units) it made sense to stick with them. Field observations suggested there was enough variation in their comparative spatial distributions to illustrate some significant differences of character

While non-residential uses are a decided minority of neighborhood land uses they were considered as a significant element case study selection. It was hypothesized that the relationship between residential and non-residential uses would prove a significant factor in explaining differences between places with the same density and mix of uses. Three very basic non-residential categories where defined: 1) general retail, shop, or restaurant uses; 2) less intensive uses such as offices, services, and other businesses and 3) public or institutional uses such as libraries, churches and schools. A fourth type was established for open spaces uses such as small parks or playgrounds, vacant lots that were located inside the neighborhood boundary. Land use fields for all 1,000 parcels were assigned a simple 1 to 9 numeric code that could be used to derive quantitative measures:

1) Residential Single-Family
2) Residential Two-Unit
3) Residential Three-Unit
4) Residential Four to Seven Unit
5) Residential Eight or more Units
6) Retail or Restaurant
7) Office, Service or other Business
8) Public or Institutional
9) Open Space & Recreational

Classifying Building Types: For the purposes of this study, the focus will be on residential building types only. Residential buildings are the primary building types in a neighborhood and they have the influence on neighborhood form. Commercial and civic building types, while potentially important elements of neighborhood character, are pretty consistent at the scale of overall land use. They do have a strong set of associated forms with designated use. For example a retail building can take many forms whereas the form of a single-family buildings is very consistent. Thus assigning meaningful but simple non-residential typologies becomes a much more difficult task. Building types also not include outbuildings or accessory buildings. While field observations suggest these are a significant contributing factor in neighborhood character, the data compilation issues were determined to be overly burdensome for the scope of exploratory research project.

The five residential land use types are defined from the previously the described land use types. They are based on a generally observed range of buildings types. While they do not differentiate between urban design types such as row houses, flats, cottages, duplexes, lofts, high-rise, garden apartments, ranch houses, connected house to barn, etc., they do have strong associations of scale, massing, and siting (see discussion in beginning of section 5.1). A sixth type was added to capture all mixed use structures where residential units are somehow combined with other uses under the same roof (e.g. upper story flats over ground floor retail). There are only four examples mixed use buildings found among the more than one thousand parcels surveyed across all neighborhoods. The six types include:

1) Single Family Structure: a single detached dwelling unit

2) Two Unit Structure: a building with two units

3) Three Unit Structure: a building with three units

4) Four to Seven Unit Structure: a building with 4-7 units

5) Eight + Unit Structure: a building with 8 or more units

6) Mixed Use Residential: a building mixing dwelling units with other uses

Appendix G: Sub-Categories of Multi-Family Land Use and Building Types

Most of the analysis done in section 5.2 was based on simple distinction between single-family and multi-family land use and building types. Data on four sub-components of multi-family land use and buildings was also compiled. The relationship between the four categories is discussed below. *Figures A thru D* show the distribution mix of the four of multi-family categories by dwelling unit type, parcel type, land use area, and building type. The four multi-family categories include 1) two unit, 2) three unit, 3) four to seven units, and 4) eight plus units.

Figure A Multi-family Mix by Dwelling Units shows the mix of multi-family family uses varying according to some of the same patterns noted in earlier measures. The older, smaller lot neighborhoods (N1, N4, N5, N8, N9) tend to have a much more heterogeneous mix of all for classes. The bars are comprised of relatively comparable bands of color from dark orange to pale yellow representing a broad range of building types. In the newer, larger lot neighborhoods (N6, N7, N10, N11, N12) the bars of multi-family units are primarily dark orange showing a very high concentration of units in the eight plus category. This is totally consistent with other measures showing a pattern of fewer, larger buildings on fewer larger parcels.

The concentration of eight plus unit category in the new neighborhoods is not as clear in *Figure B Multi-family Mix by Parcel Count* due the proportional bias small lots carry in this measure. For example while duplexes make up only 5% of the unit mix in N11 Wolf Road, they account for 2/3's of the multi-family parcels. However comparing Figure A and B shows the dramatic difference of number of parcels associated with number of units between cases. The majority of the units for cases N6, N7, N10, N11,

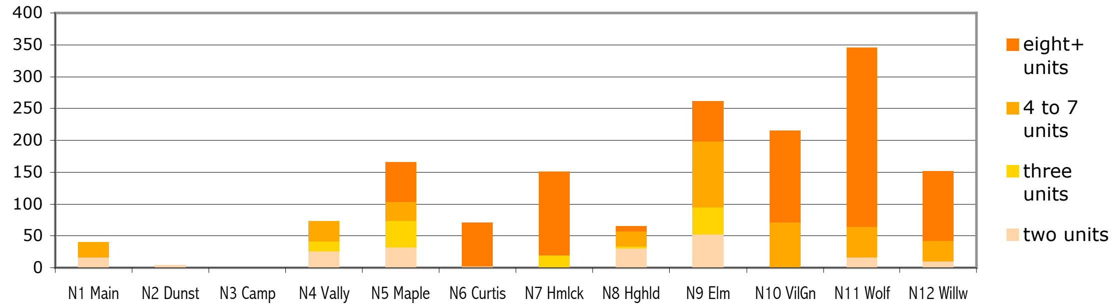

FIGURE A: Multi-family Mix by Dwelling Units

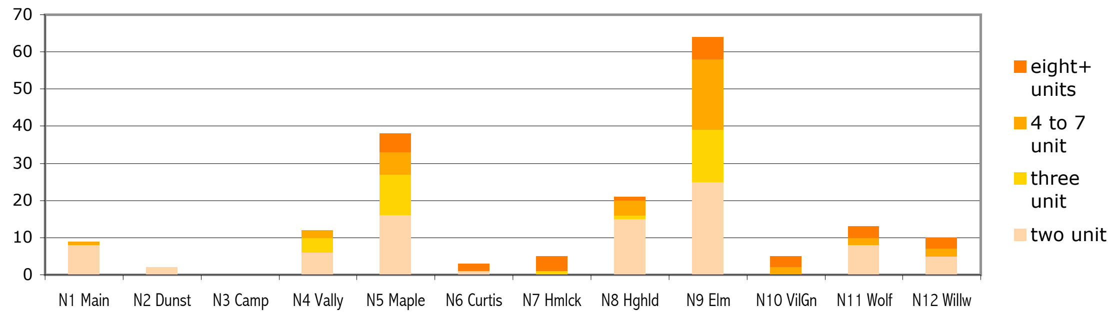

FIGURE B: Multi-family Mix by Parcel Count

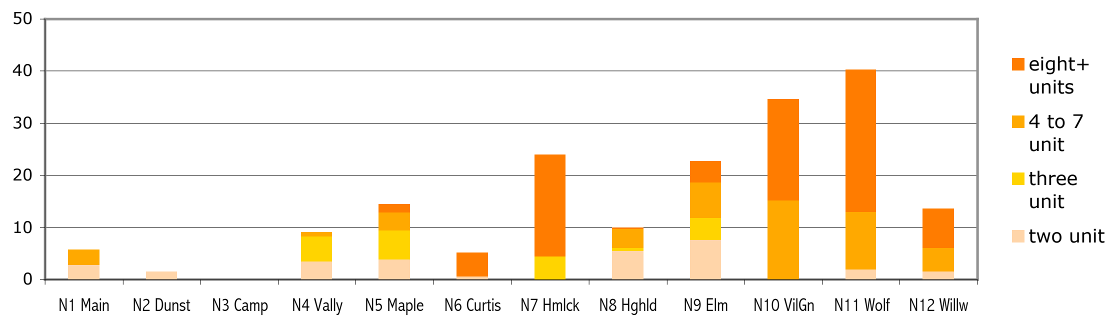

FIGURE C: Multi-family Mix by by Area (acres)

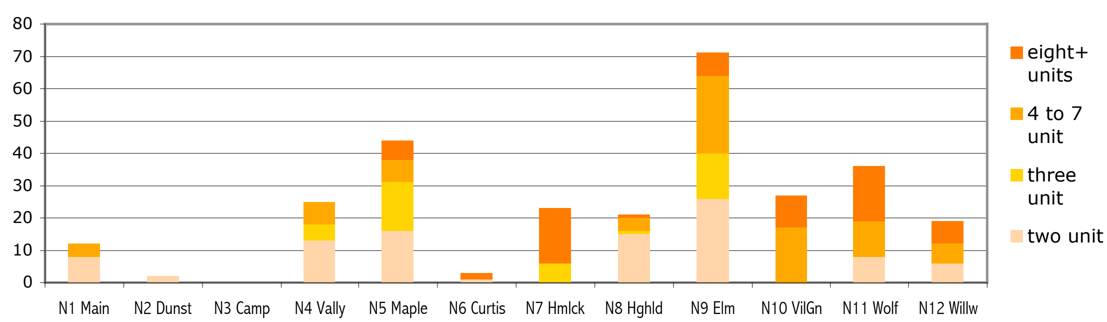

FIGURE D: Multi-family Mix by Building Type

and N12 are contained in just a few large parcels as shown by the tiny band of dark orange in Figure B. Whereas N1, N4, N5, N8, N9 spread a greater mix of units out over many more parcels.

The dominance of the eight plus categories in certain cases becomes clear again in *Figure C Multi-family Mix by Land Area.* The much larger land area values for big multi-family parcels is a much better proxy for unit type distribution. Comparing land area values of N5 and N7 or N9 and N10 with unit counts in *Figure A*, shows the previously noted pattern of areas with large multi-family buildings taking up relatively more land per unit (i.e. are less dense) than those areas with more numerous smaller multi-family buildings. In other words, cases with higher concentrations of the dark orange *eight-plus* class tend to use relatively more land per unit.

Finally, *Figure D Multi-family Mix by Building Type* also shows the same pattern of variation but again tends bias the small end of the mix though not as extremely as parcel count. A two unit building simply has less units than an eight unit building—four buildings are required to get eight units in one case where only one building is required in the other. What stands out is simply the greater number of buildings that make up the multi-family component of cases that mix the type of multi-family units as compared with the relatively few number of buildings that make up neighborhoods comprised of larger building types.

It appears the distinctions offered by this finer grain of data reinforce the distinctions found in many of the other measures. It is less certain whether measures based on this finer grain data would significantly increasing the ability to distinguish land-use related elements of neighborhood character. This may be an interesting question for future research.

Appendix H: Field Survey Script for Reviewing Environmental Qualities

Thank you all for agreeing to be evaluators for the NEIGHBORHOOD EVALUATION SURVEY. The survey asks you to carefully observe and score a series of environmental qualities in six local neighborhoods. I'd like to take about 5 minutes to review the qualities so everyone is working from a common understanding.

Scoring is based on a relative scale from 1 to 5. The frame of reference for this survey is all "in-town neighborhoods" in the Upper Valley. Don't use the NYC or rural Kansas as your extreme values; use the existing range of local development patterns. Local examples beyond the high end might include downtown White River Jct. or the new Emerson Gardens area behind Lebanon City Hall. Examples off the low end might be the Rip Road / Meadow Lane area in Hanover or the Hawk Pine area in Norwich. The 1 to 5 scale for surveyed neighborhoods falls somewhere in between these extremes.

The qualities are divided into two groups. The first four concerns the ***neighborhood as a whole***. These are a bit difficult to judge because the entire neighborhood cannot be seen in a single moment or view. Thus your evaluations have to be based on cumulative observations made as we drive through the neighborhood. Just like watching movie, you will have knit together the "frames" of your successive views of different parts of the neighborhood in order to "see" the place as a whole.

The four ***driving tour*** qualities: consistency, connectivity, grain, & density.

Consistency describes how consistent or similar a neighborhood's form and character is from one part to another. A consistent neighborhood has a sense of continuity and similarity as you move through it; one with less consistency feels more broken up into distinct and separate parts.

Does the neighborhood feel relatively similar as you move through it?
Or does it feel divided into different and unrelated parts?

Connectivity is the degree of interconnection of the neighborhood's circulation system (streets, drives, sidewalks, paths) both internally and with its surroundings. Places of high connectivity have many route choices for getting around; areas of low connectivity offer more limited choices.

Do you see lots of route choices for moving around the neighborhood?
Or not so many? How many ways are there in and out of the neighborhood?

Grain refers to the pattern of structural "cells" that make up a neighborhood. It is typically a function of parcel size and related buildings and landscape. A fine grain would be perceived as many, smaller spatial cells, a coarse grain would have larger cells and a more generously spaced structure.

Can you see or sense the division of land in the neighborhood?
How big are these divisions? Do they relate to landscape & buildings?

Density refers the relative intensity of residential land use across the neighborhood. In higher density areas the arrangement of dwelling units and buildings feels denser and more compact; lower density areas of residential development feel more spacious and spread out.

In relative terms, how many dwelling units are in the neighborhood?
A lot of units? Not so many? How intensively are they arranged on the land?

The second set of qualities concern the more detailed scale of *a* ***single street/block.*** Unlike the neighborhood, the street/block can be perceived as a discrete space. Your evaluations will be made as you walk down six pre-selected streets, one in each neighborhood. This will provide a series of viewpoints of a single space—just as you might view a room from several corners.

The five ***walking tour*** qualities: enclosure, permeability, scale, variability & density.

Enclosure is the degree of spatial containment of the street corridor. It is a function of the size and arrangement of edge elements of street (buildings, trees, fences, etc) in proportion to the street itself. Vertical edges on a tight street create a strong sense of enclosure; weak enclosure is associated with more open, less defined spaces.

Do you feel a sense of enclosure as you walk along the street?
How high are the buildings & trees? How close are they to the street?

Permeability is the degree of interconnection between the street and the edges that define it. A street edge with buildings and yards that open to and invite interaction with the street tend to be highly permeable; edges that are perceived as closed or cut off from the street have low permeability.

What kind of relationship do you sense between the buildings and the street?
Does it feel open and inviting? Or is it more private and walled off?

Scale refers to the relative size and proportion of the environment in relation to the observer. Scale is influenced by both spatial edges and elements within the space. In smaller or more human scaled spaces the observer feels relatively larger; while large or more grandly scaled spaces tend to evoke the sense of being smaller.

Does the street feel comfortable to walk along? Do you feel in-scale with the surroundings? Does the space feel large or more intimate?

Variability is the relative compositional variation of the street. It is a function of the texture and character of the defining edges (the details of buildings, yards, and street). Highly variable spaces are composed of many complex and articulated parts; spaces with low variability are have a more uniform and repetitive character.

Is there a lot of visual interest along the street? Are there a variety of details that catch your eye? Or does it seem more uniform and repetitive?

Density is the same as before only now considered within a much smaller area. On higher density streets the arrangement of dwelling units and buildings feels denser and more compact; on lower density streets development feels more spacious and spread out.

In relative terms, how many dwelling units are there along the street?
A lot of units? Not so many? How intensively are they arranged along the street?

You'll have two sets of scoring sheets; white ones for driving, the yellow ones for walking. Scoring is done following each tour segment. On the walking tour, please don't score until you are at least half way down the block. We are interested in your "in the field" perceptions. We don't want you to "over-think" your scores. You will, however, be able to go back and adjust early scores after seeing the full range of the study sites. Just put an X thru the old score and circle the new one.

Remember there are no right or wrong answers. The survey is not designed to evaluate or presume whether any of these qualities are "good" versus "bad." The intent is to assess them as objectively as possible based on your experience. We really want to know "how *you* see it." Are there any questions? If not, then let's get started.