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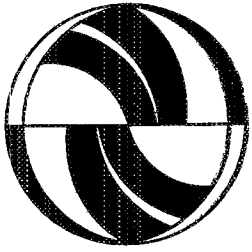
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**Pilot Study of Solano and Sonoma Counties
Land Use and Development Policy
Alternatives**

John D. Landis
Ming Zhao

Working Paper
UCTC No. 245

**The University of California
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**Pilot Study of Solano and Sonoma Counties
Land Use and Development Policy Alternatives**

**John D. Landis
Ming Zhao**

**Institute of Urban and Regional Development
University of California at Berkeley
Berkeley, CA 94720**

*Working Paper
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I. INTRODUCTION

Purpose

The purpose of this report is to evaluate the usefulness of the California Urban Futures (CUF) Model for analyzing realistic land use policy and planning alternatives at the sub-regional or county level.¹ Following previous meetings of the ABAG Regional Planning Committee and consultations with local officials and planners, two Bay Area Counties were selected for further study: Solano and Sonoma.

This report is organized into four sections. This section explains the logic and limitations of the CUF Model. Part II presents the results of four sets of land use policy simulations for Solano County. Part III presents CUF Model results for six Sonoma County Scenarios. Part IV builds on the experiences gained analyzing land use policy initiatives in Sonoma and Solano counties to evaluate the overall usefulness of the CUF Model for sub-regional planning.

How the CUF Model Works

The California Urban Futures Model breaks new ground in a number of areas. It is the first urban simulation model designed to test the spatial results of locally articulated development policies—to determine how local land use regulations affect the location, density, and pattern of new development. Historically, communities throughout the Bay Area have adopted land use plans and policies in near-perfect isolation—without considering how those policies might affect the county or region. Properly applied, the CUF model can be used to evaluate the cumulative impacts of land development policies adopted by individual cities.

A second innovation is that the CUF Model recognizes the importance of land developers and homebuilders as central actors in determining the pattern, location, and density of new development. As such, it incorporates the profit-calculations of private land developers into the growth allocation process.

Third, the CUF Model explicitly considers growth "spillovers." Spillover occurs when projected population growth is displaced from one location to another—usually as a result of local development policies. Spillovers can be intra-jurisdictional (that is, occur within a single community), or inter-jurisdictional (occur across jurisdictions).

Fourth, the CUF Model is the first urban planning model to incorporate a Geographic Information System to assemble, manage, display and make available millions of pieces of information describing land development potential. The information (or attributes) included in CUF model runs for Solano and Sonoma Counties, is summarized in Table 1.

Finally, the CUF Model is both easy to use and visual. Once set up, the process of testing different policies involves checking off different development options on an easy-to-use form (Figure 1). New policy scenarios can be simulated in a matter of minutes, and the results of those simulations can be presented in map form at almost any level of detail.

Table 1: Solano and Sonoma County Data Layers

Layer	Source	Data Categories	
		Sonoma County	Solano County
1 City Boundaries	U.S. Census Bureau and local cities	Cloverdale, Cotati, Healdsburg, Petaluma, Rohnert Park, Santa Rosa, Sebastopol, Sonoma, Windsor	Benicia, Dixon, Fairfield, Suisun City, Vacaville, Vallejo
2 Sphere-of-Influence Boundaries	LAFCOs and local cities	Cloverdale, Cotati, Healdsburg, Petaluma, Rohnert Park, Santa Rosa, Sebastopol, Sonoma, Windsor	Benicia, Dixon, Fairfield, Suisun City, Vacaville, Vallejo
3 Wetlands	U.S. Geological Service	Bay wetlands, non-bay wetlands	Bay wetlands, non-bay wetlands
4 Slope (100m x 100m cell)	U.S. Geological Service	0% slope, 1-2%; 3-5%; 6-8%; 9-10%; 11-15%; 19-24%; 25%+	0% slope, 1-2%; 3-5%; 6-8%; 9-10%; 11-15%; 19-24%; 25%+
5 Agricultural Land Type	California Farmland Mapping Project (1986)	Forest, grazing, locally-important, prime, state-important, unique, other	Forest, grazing, locally-important, prime, state-important, unique, other
6 General Plan Use Category	County and city general plans	Commercial Diverse Agriculture Grazing High Density Residential Industrial-Office Locally Extensive Agriculture Locally Intensive Agriculture Low Density Residential Moderate Density Residential Openspace Rural Residential Rural Resource Development Urban Residential	Agriculture Commercial Extensive Agriculture High Density Residential Industrial and Office Intensive Agriculture Low Density Residential Moderate Density Residential Open Space Public Special Planned Area Watershed
7 Current Land Use (100m x 100m cell)	ABAG (1990)	Commercial, Industrial, Mixed-Use, Mobile Home, Public, Recreation, Low-, Moderate-, and High-Density Residential, Vacant	
8 Major Highways and Roads	U.S. Census Bureau Tiger Files	Interstates, state highways, major and minor arterials	Interstates, state highways, major and minor arterials
9 Site distance to nearest city boundary		Measured using GIS	
10 "Infill" Percentage	U.S. Census Bureau	Calculated using 1980-90 population growth and density by 1990 census tract	
11 Market Housing Density	TRW-Redi transaction files	Calculated using the median lotsize for new homes built between 1985 and 1990	
12 Typical New Home Price	TRW-Redi transaction files	Calculated using the median sales prices for new homes built between 1985 and 1990	
13 New Home Production Cost	Calculated on the basis of fee and service standard data collected from cities; market size and quality levels; using distance to urban services; estimates of typical delay times, and site specific-slope and yield information		

Figure 1: California Urban Futures Model: Example of Growth Allocation Scenario Form

Enter the Name of this Scenario: _____

A. *Select a population projection:*

ABAG	Local	CUF
------	-------	-----

B. *Choose a transit scenario:*

Without transit
With transit

C. *Allow development in wetlands?*

No	Yes
----	-----

D. *Residential infill options:*

Historic
Market
User Defined

E. *Slope restriction on hillside development?*

None	Full
------	------

F. *Residential development can be assigned to the following farmland types:*

Grazing
Locally Important
Prime
State Important
Unique
Other

G. *Residential development can be assigned to the following General Plan categories:*

Agriculture
Land Extensive Agriculture
Land Intensive Agriculture
Diversified Agriculture
Rural Resource
Public
Commercial
Openspace
Industrial and Office
Hi-density Residential
Mod-density Residential
Lo-density Residential
Urban Residential

H. *Where do population spillovers go?*

Unincorporated Areas
All Areas

I. *Choose a residential density for development in cities:*

Market
Historic
Compact City
General Plan

J. *Choose a residential density for development in unincorporated areas:*

Market
Historic
Compact City
General Plan

Do you want to have a report of results?

Yes	No
-----	----

Do you want to view the resulting map?

Yes	No
-----	----

Running the CUF Model is a four-step procedure (Figure 2):

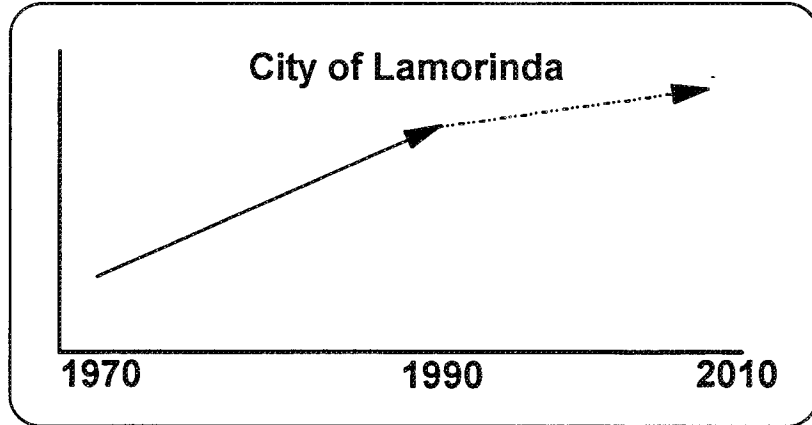
1. Develop/identify population growth forecasts by city sphere of influence.
2. Identify potentially developable sites by combining map-based information on environmental characteristics, existing land uses, current general plan designations, and access to urban services.
3. Calculate the profitability of developing each site in residential use as the difference between the price of the typical new home in each city, and the site-specific cost of producing housing.
4. Allocate forecast population growth (by sphere-of-influence; Step 1) to individual sites (Step 2) based on estimated profitability (Step 3) consistent with alternative policy scenarios.

Infill Development

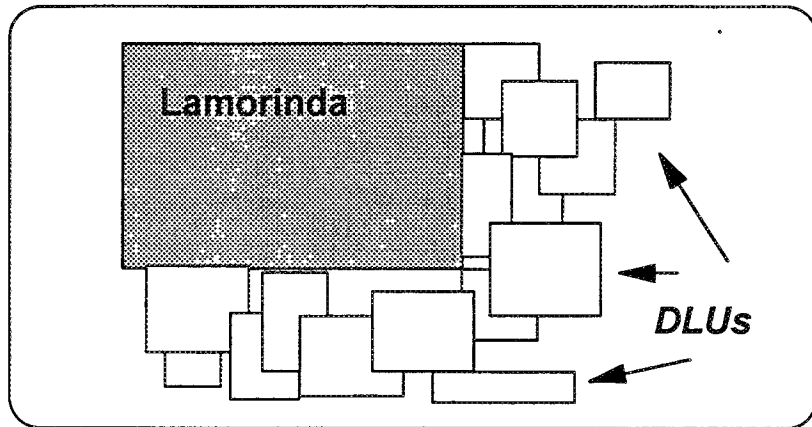
The CUF Model does not allocate "infill" development to individual sites. Infill consists of small-scale, lot-by-lot development within city boundaries. Historically, most infill development has taken the form of redevelopment and/or a use change of an existing developed parcel. The CUF Model allocates a specific share of a city's projected population growth to infill according to: (1) historical trends —specifically, the share of each city's population growth that occurred as infill between 1980 and 1990; and (2) each city's ability to accommodate infill development. One of the key assumptions underlying this work is that none of the cities in either Solano County or Sonoma County will run out of adequate infill opportunities by the year 2010.

Figure 2: How the CUF Model Works

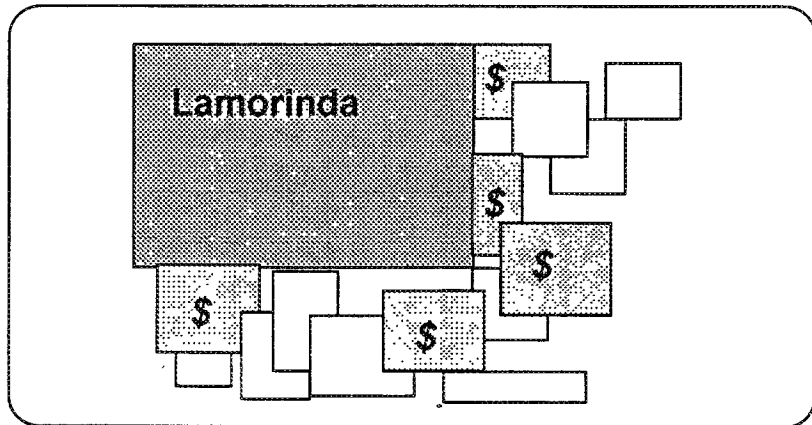
1. Project city residential growth as a function of past trends, state growth, and local growth policies



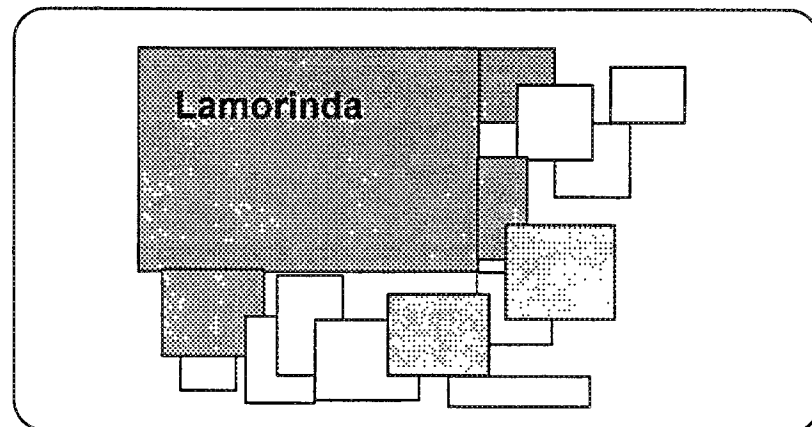
2. Geometrically combine information from different layers to create map and database of Developable Land Units (DLUs)



3. Allocate projected residential growth to most profitable DLUs consistent with policies being simulated



4. Annex/ Incorporate DLUs as appropriate



II. SOLANO COUNTY

ABAG Population Projections

According to *Projections '92*, the population of Solano County is expected to grow by 210,683 persons by the year 2010. The majority of the county's growth will be focused in three cities, Fairfield (+68,127), Vacaville (+44,571), and Vallejo (+29,830). Benicia and Suisun City, two smaller cities of residential character, are projected to add 18,306 and 13,926 new residents, respectively, by the year 2010. Solano County's other two incorporated cities, Rio Vista and Dixon, are each projected to grow by less than 10,000 new residents.

Solano County Policy Scenarios

Like most California communities, Solano County and its constituent cities are somewhat schizophrenic on the subject of growth. Solano residents and officials want job growth and economic development, but are concerned over the impacts of growth on the natural and historical environment.

In recent years, Solano County has witnessed the widespread conversion of agricultural land to urban uses. To slow the rate of farmland conversion, Solano County residents enacted Measure A in 1990. Measure A does two things. First, it prohibits urbanization of unincorporated county lands outside existing city spheres-of-influence.² Second, and more significantly, it limits the density of new development on county lands designated in the county general plan as being used for either "intensive-agriculture" or "extensive agriculture."³ Because such lands cannot be intensively developed, the effect of Measure A has been to make them less attractive to large-scale subdividers and homebuilders. Unless it is re-enacted, Measure A will expire in 1995. *How would development patterns in Solano County change in response to the lifting of Measure A?*

Solano County is similar to other developing California communities in another respect: under current zoning, the supply of vacant land reserved for future commercial and service growth far exceeds the likely demand. The supply of land designated for housing, by contrast, tends to lag demand. *How would development patterns in Solano County change if some sites currently reserved for commercial uses were made available for housing development?*

The four policy scenarios developed Solano County explore these possibilities (Table 2):

1. *Solano Scenario One* assumes that current general plan land use designations will remain in place, and that Measure A (limiting the density of development on extensive and intensive agricultural lands to 40 acres and 80 acres per dwelling unit, respectively, is re-enacted in 1995. *This scenario serves as the "status quo" scenario.*
2. *Solano Scenario Two* assumes that current general plan land use designations will remain in place, but that Measure A expires in 1995. *This would open many lands in agricultural use to urban development.* Whether particular sites would then be developed would depend on their profitability in residential use.

Table 2: Summary of Solano County Land Use and Development Scenarios for 2010

	Land Development Prohibitions		Growth Allocation Densities		Spill-over growth allocated to:
	Environmental Characteristics	General Plan/Zoning Prohibitions	Urban Areas	Agricultural Areas (Measure A)	
Current GP and Measure A Remain	Wetlands, Slopes > 15%	Public uses, commercially-zoned, office and industrial, openspace, watershed	General Plan based	Limited by Measure A	anywhere in Solano County
Current GP Remains/ Measure A Expires	Wetlands, Slopes > 15%	Public uses, commercially-zoned, office and industrial, openspace, watershed	General Plan based	General plan based	anywhere in Solano County
Current GP and Measure A Both Expire	Wetlands, Slopes > 15%	Public uses, openspace	Market-based	Market-based	anywhere in Solano County
Measure A without Current GP	Wetlands, Slopes > 15%	Public uses, openspace	Market-based	Limited by Measure A	anywhere in Solano County

3. *Solano Scenario Three* assumes that current general plan land use designations can be changed, and that Measure A expires in 1995. *The effect of this change would be to open many agricultural parcels to urban development, as well as allow residential development on commercially designated and agricultural sites.* As above, whether a particular site is actually developed would depend on its potential profitability in residential use.
4. *Solano Scenario Four* assumes that current general plan designations can be changed, but that Measure A remains in place. *This would allow residential development on commercially designated and agricultural sites (within city spheres-of-influence), but limit the density of development on intensive and extensive agricultural sites.*

Growth Spillovers

By reducing supplies of land available for development (or by reducing the profitability of development), land use policies re-allocate growth from site to site. When growth is re-allocated between communities, we call it "spillover." Overly restrictive land use policies may cause development to spillover from county to county, or even from region to region. None of the four policy scenarios considered above displace development from Solano County; in all four cases, there is more than adequate developable land in Solano County to accommodate projected population growth.

Under Scenarios Two and Three (in which Measure A is allowed to expire in 1995), each Solano County city is able to accommodate its projected level of growth within its current sphere-of-influence. Growth is not displaced from one community to another.

The same cannot be said for Scenarios One and Four — in which Measure A is assumed to remain in effect through 2010. Because Benicia and Suisun City both contain large amounts of farmland which would be precluded from urban development under Measure A, both cities would become large growth exporters (Table 3). Benicia would export 12,032 residents to other parts of the county, while Suisun City would export 6,620 residents. Most of this displaced growth would spillover into Vallejo, which would see an additional increase in population (above its own level) of 16,386. Dixon is the other Solano county city which would be a large net importer of growth under Scenario One. The same pattern, albeit at a reduced level, is also evident under Scenario Four (Measure A remains in effect/Current general plan limits are released): Benicia and Suisun City would export growth to Vallejo.

Patterns of Land Development

A picture, as the saying goes, is worth a thousand words. In addition to simulating the total amount of development likely to occur for a given policy scenario, the CUF model also simulates the pattern of development. Figures 3 through 6 illustrate the pattern of projected development in Solano County under each policy scenario. Existing urban development is indicated in grey. New development is indicated in purple; the darker the shade of purple, the higher the density.

Under Scenario One (Figure 3: Measure A and current general plans remain in place) new, lower-density single-family residential development (defined as fewer than 6 persons per acre) will be focused:

Table 3: Summary of Solano County Year 2010 Growth Projections, Infill Levels and Allocations by City and Scenario

City	Projected Population Growth 1990-2010		
	ABAG Growth Forecast (Projections '92)	Population assigned to "Infill"	Population to be allocated
Benicia	18,306	3,662	14,644
Dixon	7,204	1,441	5,763
Fairfield	68,127	27,251	40,876
Rio Vista	8,825	8,825	0
Suisun City	13,926	2,786	11,140
Vacaville	44,571	22,286	22,285
Vallejo	29,830	22,373	7,457
Unincorporated	10,149	0	10,149
Total	200,938	88,624	112,314

City	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Allocated Population	Spill-over (+: exporter -: importer)	Allocated Population	Spill-over (+: exporter -: importer)	Allocated Population	Spill-over (+: exporter -: importer)	Allocated Population	Spill-over (+: exporter -: importer)
Benicia	2,612	12,032	14,644	0	14,644	0	11,435	3,209
Dixon	7,402	-1,639	5,763	0	5,763	0	5,763	0
Fairfield	41,078	-202	40,876	0	40,876	0	40,876	0
Rio Vista	0	0	0	0	0	0	0	0
Suisun City	4,520	6,620	11,140	0	11,140	0	7,245	3,895
Vacaville	22,710	-425	22,285	0	22,285	0	22,285	0
Vallejo	23,843	-16,386	7,457	0	7,457	0	14,561	-7,104
Unincorporated	10,149	0	10,149	0	10,149	0	10,149	0
Total	112,314	0	112,314	0	112,314	0	112,314	0

Source: Association of Bay Area Governments, Projections '92

Residential Development in Solano County

projected for 2010 under the scenario:
General Plan and Measure A

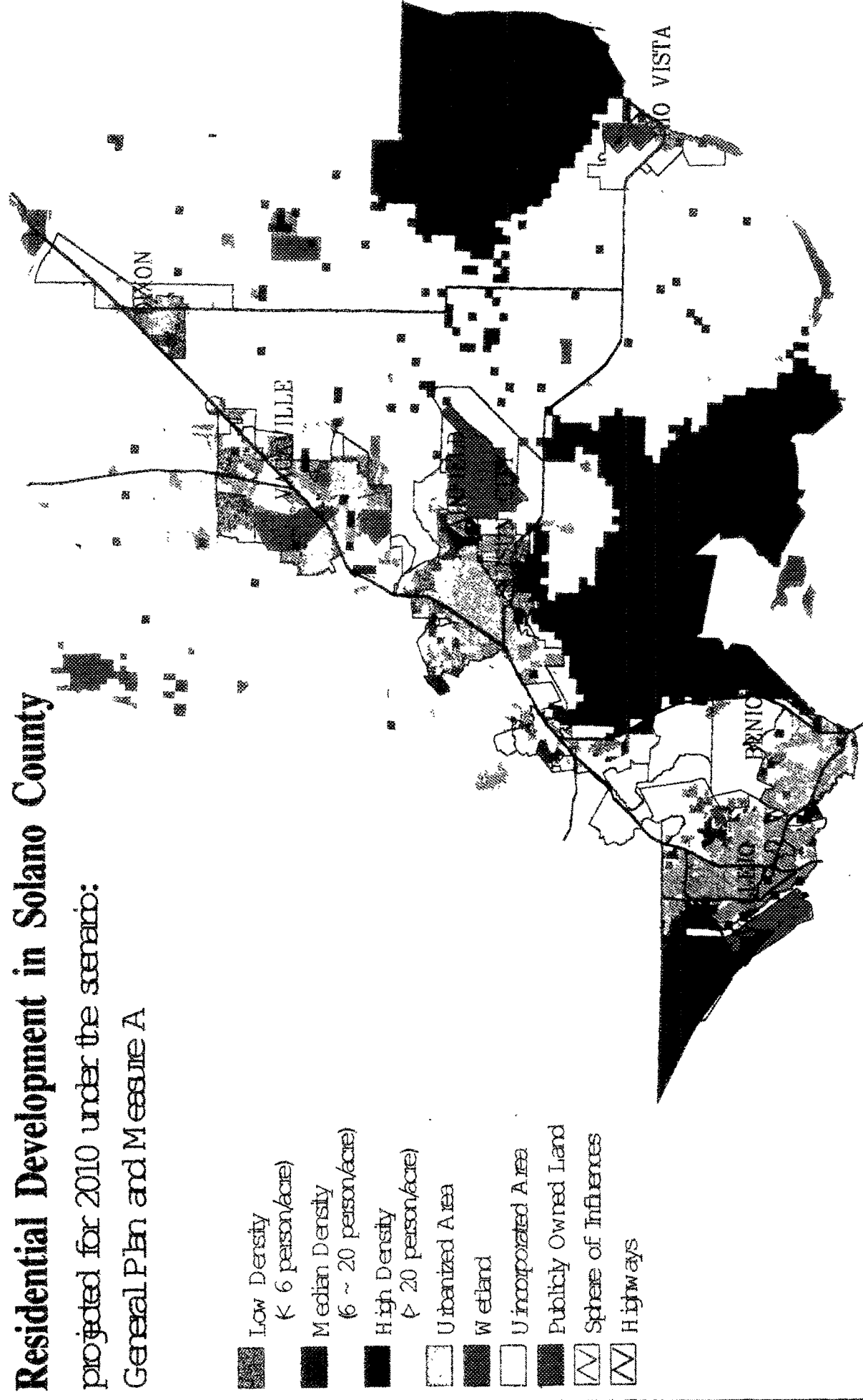


Figure 3: Solano Scenario One

Residential Development in Solano County

projected for 2010 under the scenario:
General Plan without Measure A

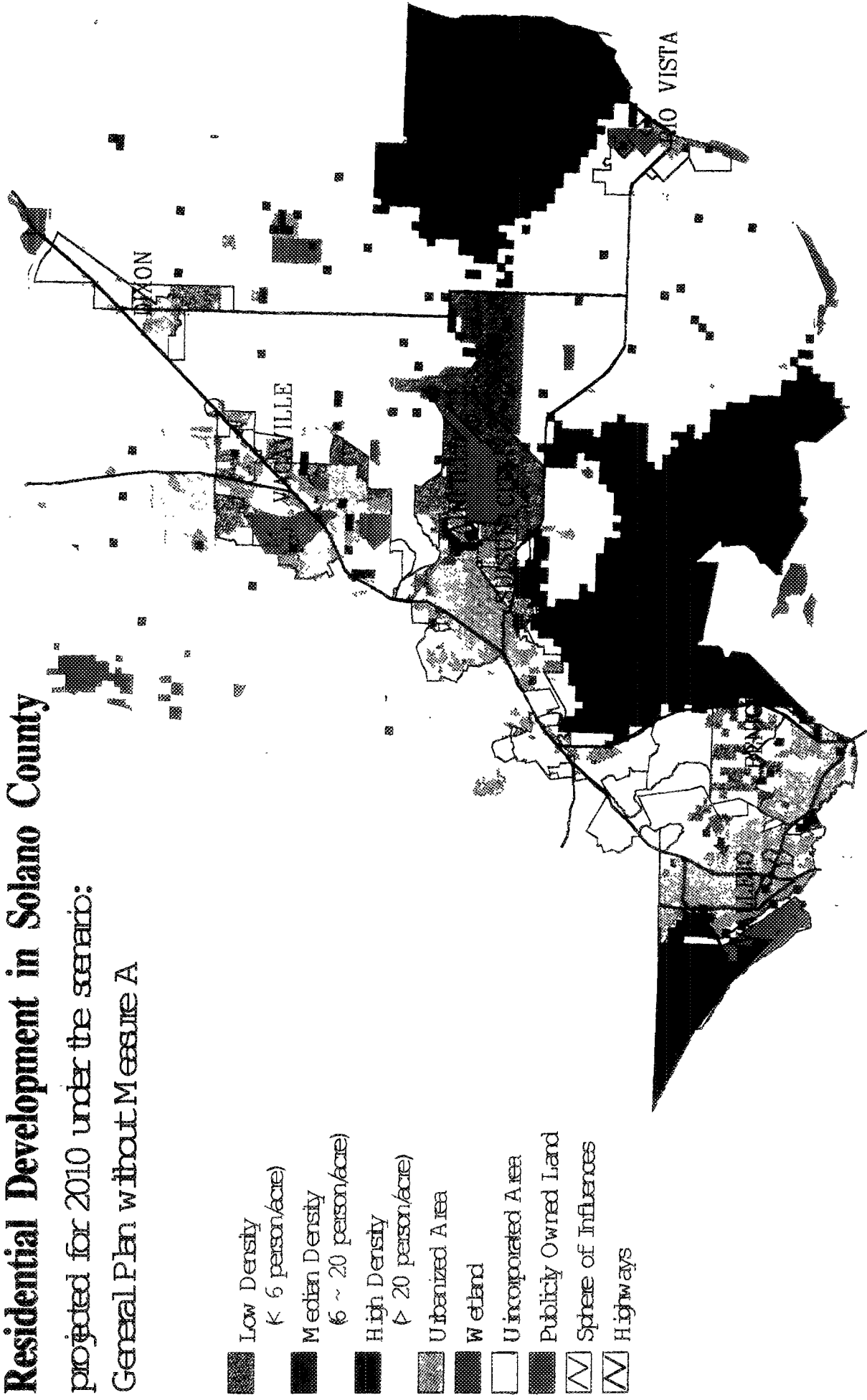


Figure 4: Solano Scenario Two

Residential Development in Solano County

projected for 2010 under the scenario:
 No General Plan, No Measure A

- Low Density (< 6 person/acre)
- Median Density (6 ~ 20 person/acre)
- High Density (> 20 person/acre)
- Urbanized Area
- Wetland
- Unincorporated Area
- Publicly Owned Land
- Sphere of Influences
- Highways

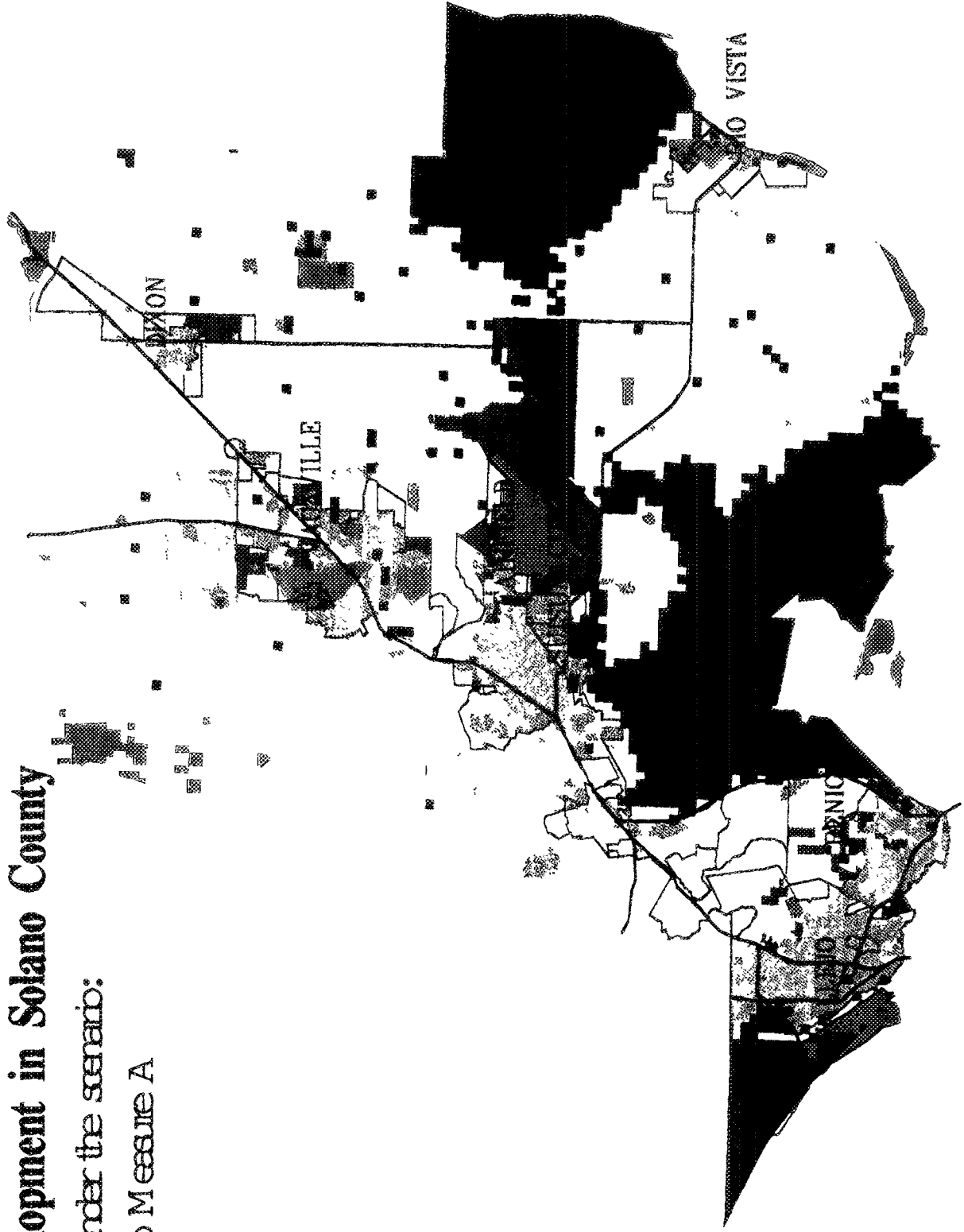


Figure 5: Solano Scenario Three

Residential Development in Solano County

projected for 2010 under the scenario:
Measure A without General Plan

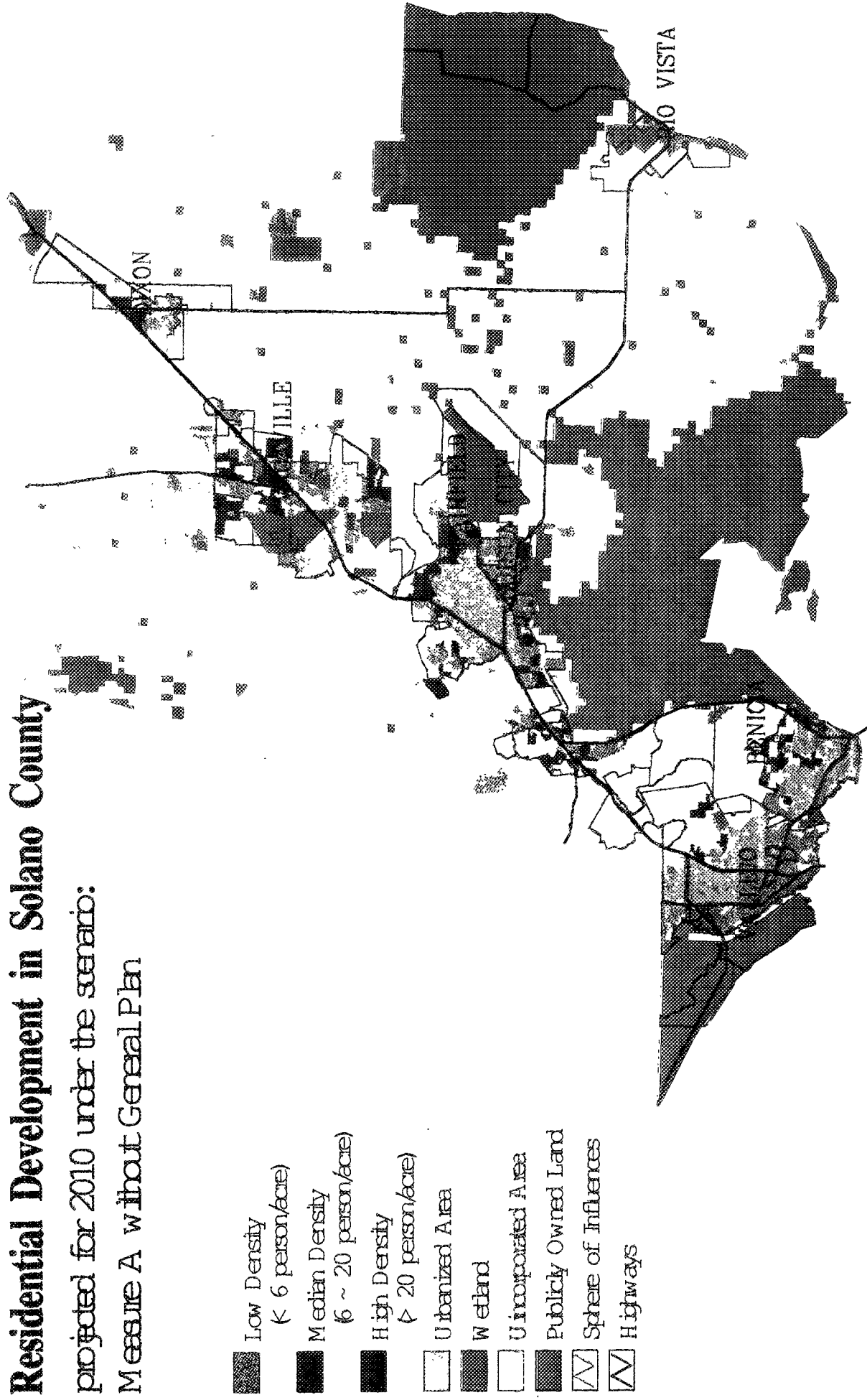


Figure 6: Solano Scenario Four

(1) along the northern edge of Fairfield, east of I-80; (2) along the eastern and northern edges of Vacaville; and (3) along Dixon's northwestern edge south of I-80. Somewhat higher-density single-family subdivisions would be concentrated: (1) along the eastern edge of Vallejo; and (2) in the West Fairfield-Cordelia Junction area. Although most of the residential development anticipated under Scenario One would not be far from I-80, very little new development would actually front on the interstate.

Except in Vacaville, the pattern of development under Scenario Two (Figure 4: Measure A expires but current general plans remain in place) would be very different from that under Scenario One. Specifically, new single-family residential development would be concentrated in eastern Fairfield instead of northern Fairfield and southeastern Dixon instead of northwestern Dixon. New residential development would also be scattered among the hills and valley north of Benicia. Eastern Vallejo would remain relatively undeveloped. The pattern of new residential development under Scenario Three (Figure 5: Measure A expires/current general plan limits are released) would be very similar to that under Scenario Two.

Land Conversion by Type

What types of lands would be developed under each scenario? Tables 4 and 5 list land consumption and gross development density under each scenario according to current general plan designation. Three types of land use types are listed: (1) those sites designated for residential development; (2) those sites designated as currently being in agricultural use; and (3) those sites designated for commercial use, or as unrestricted openspace. The following sections discuss land conversion by general plan type for each Solano city.

Benicia: Under Scenario One (Current general plans and Measure A remain in place), 399 acres of land currently designated for residential use would be developed. An additional 2,960 acres of agriculturally designated land would be developed, albeit at the very low densities (one unit per 20 acres) required by Measure A. Under Scenario Two (Measure A expires, but current general plans remain in place), 294 acres of residentially designated land and 2,400 acres of agriculturally designated land would be developed. Under Scenario Three (Measure A expires, and current general plan use restrictions are lifted), a substantial amount of new residential development would shift from agriculturally designated parcels, to parcels currently reserved for commercial uses. Under Scenario Three, the total amount of additional acreage required for development would fall to 1,665. Results for Scenario Four (Measure A remains in place; however, current general plan use restrictions are lifted) generally parallel those for Scenario One, but with one exception: more than 800 acres of land currently reserved for commercial uses would be residentially developed.

Dixon: Under Scenario One (Current general plans and Measure A remain in place), 1,091 acres of land currently designated for residential use would be developed. An additional 4,007 acres of agriculturally designated land would be developed, albeit at the very low densities (one unit per 20 acres) required by Measure A. Under Scenarios Two and Three (Measure A expires), new development would shift from sites designated for residential uses to sites currently zoned for agricultural use. Under Scenario Four (Measure A remains in place; however, current general plan use restrictions are lifted), 268 acres of land designated for residential uses would be developed, 1,013 acres of land designated for agricultural use would be developed, and 259 acres of land currently designated for commercial uses would be developed.

Table 4: Solano County Land Consumption by City and Scenario: 2010

<u>Area and Scenario</u>	<u>Allocated Pop. Growth**</u>	<u>Land Consumption (Acres) by Current GP Designation</u>			
		<u>Residential</u>	<u>Agricultural</u>	<u>Other</u>	<u>Total</u>
Benicia					
1 Current GP and Measure A Remain	2,612	399	2,962 *	0	3,361
2 Current GP Remains/Measure A Expires	14,644	294	2,408	0	2,702
3 Current GP and Measure A Both Expire	14,644	235	765	665	1,665
4 Measure A without Current GP	11,435	399	2,962 *	810	4,171
Dixon					
1 Current GP and Measure A Remain	7,402	1,091	4,007 *	0	5,098
2 Current GP Remains/Measure A Expires	5,763	0	1,013	0	1,013
3 Current GP and Measure A Both Expire	5,763	0	1,013	0	1,013
4 Measure A without Current GP	5,763	268	1,013 *	259	1,540
Fairfield					
1 Current GP and Measure A Remain	41,078	3,029	5,232 *	495	8,755
2 Current GP Remains/Measure A Expires	40,876	1,118	4,290	307	5,715
3 Current GP and Measure A Both Expire	40,876	178	3,280	31	3,489
4 Measure A without Current GP	40,876	1,837	4,284 *	1,668	7,789
Suisun City					
1 Current GP and Measure A Remain	4,520	403	2,336 *	0	2,740
2 Current GP Remains/Measure A Expires	11,140	0	2,336	0	2,336
3 Current GP and Measure A Both Expire	11,140	0	2,336	0	2,336
4 Measure A without Current GP	7,245	403	2,336 *	216	2,955
Vacaville					
1 Current GP and Measure A Remain	22,710	3,611	1,500 *	0	5,111
2 Current GP Remains/Measure A Expires	22,285	3,028	614	0	3,642
3 Current GP and Measure A Both Expire	22,285	1,326	0	452	1,778
4 Measure A without Current GP	22,285	1,770	0	843	2,614
Vallejo					
1 Current GP and Measure A Remain	23,843	957	1,955	0	2,913
2 Current GP Remains/Measure A Expires	7,457	295	421	0	716
3 Current GP and Measure A Both Expire	7,457	146	296	122	564
4 Measure A without Current GP	7,457	146	296	122	564
Unincorporated					
1 Current GP and Measure A Remain	10,149	367	54,830 *	333	55,530
2 Current GP Remains/Measure A Expires	10,149	0	7,856	0	7,856
3 Current GP and Measure A Both Expire	10,149	0	7,856	0	7,856
4 Measure A without Current GP	10,149	367	54,830 *	33	55,230
Solano County Total					
1 Current GP and Measure A Remain	112,314	9,858	72,823 *	828	83,509
2 Current GP Remains/Measure A Expires	112,314	4,734	18,940	307	23,981
3 Current GP and Measure A Both Expire	112,314	1,885	15,546	1,270	18,701
4 Measure A without Current GP	105,210	5,191	65,721 *	3,952	74,863

Notes

* Acreage is developed at extremely low densities consistent with Measure A

** Excludes population growth allocated to infill

Table 5: Solano County Housing Unit Density of New Development by City and Scenario: 2010

Area and Scenario	Allocated Pop. Growth*	Gross Density (Units/Acre) by Current GP Designation		
		Residential	Agricultural	Other
Benicia				
1 Current GP and Measure A Remain	2,612	2.4	0.01	no development
2 Current GP Remains/Measure A Expires	14,644	2.2	2.02	no development
3 Current GP and Measure A Both Expire	14,644	3.5	3.54	3.0
4 Measure A without Current GP	11,435	3.5	0.01	3.5
Dixon				
1 Current GP and Measure A Remain	7,402	2.1	0.02	no dev.
2 Current GP Remains/Measure A Expires	5,763	no development	1.87	no development
3 Current GP and Measure A Both Expire	5,763	no development	1.87	no development
4 Measure A without Current GP	5,763	2.8	0.02	4.4
Fairfield				
1 Current GP and Measure A Remain	41,078	3.7	0.01	5.84
2 Current GP Remains/Measure A Expires	40,876	3.1	2.02	6.06
3 Current GP and Measure A Both Expire	40,876	4.0	4.01	4.01
4 Measure A without Current GP	40,876	4.0	0.01	3.93
Suisun City				
1 Current GP and Measure A Remain	4,520	3.2	0.01	no development
2 Current GP Remains/Measure A Expires	11,140	no development	1.41	no development
3 Current GP and Measure A Both Expire	11,140	no development	1.41	no development
4 Measure A without Current GP	7,245	3.4	0.01	3.4
Vacaville				
1 Current GP and Measure A Remain	22,710	2.2	0.02	no development
2 Current GP Remains/Measure A Expires	22,285	2.2	2.09	no development
3 Current GP and Measure A Both Expire	22,285	4.5	no dev.	4.3
4 Measure A without Current GP	22,285	3.8	no dev.	4.4
Vallejo				
1 Current GP and Measure A Remain	23,843	6.6	1.06	no development
2 Current GP Remains/Measure A Expires	7,457	5.9	2.07	no development
3 Current GP and Measure A Both Expire	7,457	4.4	4.73	4.7
4 Measure A without Current GP	7,457	4.4	4.73	4.7
Unincorporated				
1 Current GP and Measure A Remain	10,149	2.0	0.02	5.36
2 Current GP Remains/Measure A Expires	10,149	no development	0.45	no development
3 Current GP and Measure A Both Expire	10,149	no development	0.45	no development
4 Measure A without Current GP	10,149	4.2	0.33	3.03

Notes

** Excludes population growth allocated to infill

Fairfield: Under all four scenarios, Fairfield will be focus of Solano County growth. Under Scenario One (Measure A and current general plan designations remain in place), an additional 3,029 acres of residentially zoned land and 495 acres of non-residentially zoned land would be developed; an additional 5,232 acres of agriculturally designated land would be developed at very low densities. Under Scenarios Two and Three (Measure A expires), development activity in residentially zoned sites would decline, and would shift instead to agriculturally zoned sites. Indeed, most of Fairfield's development under Scenario Three would be on agricultural lands not currently designated for residential development. Under Scenario Four (Measure A remains in place; however, current general plan designations lapse), new development would be about evenly split between areas currently designated for residential development and areas currently designated for commercial development.

Suisun City: Regardless of the scenario, land development in Suisun City will expand by 2,340 to 2,955 acres by the year 2010. If Measure A were allowed to expire (Scenarios Two and Three), these acres would be developed more intensely, and the city's population would grow by about 11,140. If Measure A were to remain in place, Suisun City would grow by 4,520 (Scenario One) or 7,245 (Scenario Four). Under Scenario One (Current general plans remain in place), new development would be focused in areas currently zoned for residential development. Under Scenario Four (Current general plan designations can be changed), an additional 216 acres of land currently designated for commercial uses would also be developed.

Vacaville: Regardless of the scenario, Vacaville will add another 22,000 residents by the year 2010—making it a major growth node for Solano County. The amount of land required to accommodate this growth will vary widely by policy scenario. Under Scenario One (Measure A and current general plan designations remain in place), new development will consume 3,611 acres currently designated for residential development; an additional 1,500 acres of agriculturally designated land would also be developed, albeit at the very low densities required under Measure A). Under Scenario Two (Measure A expires), fewer acres of residentially zoned land would be developed, while 614 acres of agriculturally designated land would be developed at single-family densities. Under Scenario Three (Measure A and current general plan designations both lapse), new residential development would consume 452 acres of land currently reserved for commercial development. Finally, under Scenario Four (Measure A remains in effect, but current general plan land use limitations are released), new development would consume 1,770 acres of residentially designated land and 843 acres of commercially designated land.

Vallejo: Under Scenarios Two, Three, and Four, Vallejo will grow by 7,500 new residents by the year 2010. Under Scenario Two—in which Measure A expires but current general plan designations remain—a total of 716 acres of land will be developed. Under Scenarios Three and Four (in which current general plan designations lapse), that total would fall to 442 acres. Under Scenario One, Vallejo would be the recipient of spillover growth from other cities, boosting land consumption to 2,913 acres. Most of this spillover growth would occur on parcels currently designated for agricultural uses but unprotected by Measure A.

Unincorporated Areas: Less than ten percent of the county's population growth during the next 20 years will be in unincorporated areas. Maintaining Measure A (Scenarios One and Four) would require this growth to occur at much lower densities—boosting land consumption to more than 50,000 acres. Allowing Measure A to lapse (Scenarios Two and Three) would significantly raise development densities, and reduce land consumption to less than 8,000 acres.

Solano Summary

There can be little doubt that Measure A is achieving its desired effect: preventing many hundreds of acres of exurban agricultural land and open space from being urbanized. (Measure A was designed to protect areas in active agricultural use; the extent to which it actually protects agriculture vs. general open space varies by city and county area.) Removing Measure A, as suggested under Scenarios Two and Three, would lead to the suburban development of thousands of additional acres of farmland and open space. (Measure A permits such lands to be developed, but at very low densities.)

Growth is fungible: if it can not occur in one location, it finds another. One of Measure A's other effects has been to displace growth from rapidly growing cities such as Benicia and Suisun City to other cities —chiefly Vallejo and Dixon. To the extent that such spillover growth makes better use of existing infrastructure and services, this effect may be desirable. To the extent that Measure A pushes growth into under-serviced cities, it may not. Measure A has been only partly successful at promoting compact and contiguous development forms. A better approach to such a goal would be to encourage the rezoning of excess commercial and industrial lands to residential uses. As Scenarios Three and Four indicate, such a change would go a long way to encouraging higher-density, contiguous residential development. Because many private homebuilders would favor rezoned commercial sites, exurban development pressures would be significantly reduced.

III. SONOMA COUNTY

Development Issues

The development future of Sonoma remains very much up for grabs. Regardless of whose population projections are used, the county is expected to continue growing. Cities in the southern part of the county—including Sonoma, Rohnert Park, Cotati, and especially Petaluma—have long tried to manage the rate and quality of their growth. Growth management has come to Santa Rosa and central Sonoma County more recently. The desire to manage its own growth was in fact the dominant reason behind the recent incorporation of Windsor. Sonoma County's northern cities, Healdsburg and Cloverdale, are more divided on the subject of growth. While welcoming the revenues associated with development, residents of both cities worry about the loss of traditional town character. Regardless of where they live, Sonoma County residents want to preserve some of their agricultural roots. This includes preserving pastureland, chicken farms, vineyards, and, in a few places, croplands. Generally speaking, they also wish to steer new development to the Highway 101 corridor, where urban services are currently available.

Six Policy Scenarios

Six different policy scenarios for the year 2005 were developed for Sonoma County in consultation with Sonoma County Planning Directors (Table 6). The six scenarios have a number of commonalities: all prohibit the development of wetland sites and sites with slopes in excess of 15 percent. And all allow unallocated growth (or spillover) to be re-allocated to the next most profitable development site anywhere else in Sonoma County.

Where the scenarios differ is in their treatment of agricultural lands, in the permanence of current general plan land use restrictions, and in the role of the market vs. local general plans in determining growth densities. Scenario One, for example, prohibits development only on prime agricultural lands, and on lands designated under local general plans for public uses, open space, and commercial uses. Development densities under Scenario One are determined in the private housing market. Scenario Two is identical to Scenario One except that new development is required to occur at densities set forth in local general plans.⁴ The extent to which general plan densities are either higher or lower than market densities varies by city. Scenario Three extends protections from development to all agricultural lands except those used for grazing. Scenario Four builds on Scenario Three. In addition to protecting all non-grazing agricultural lands, Scenario Four requires that new development occur at general plan densities. Scenario Four also allocates a uniform share of projected population growth (49.5 percent) to infill sites regardless of city (all the other scenarios set infill at the 1980-90 rate of each separate city). Scenario Five continues the agricultural land protections of Scenarios Two through Four, allocates growth at market densities, but also permits residential development on sites currently designated for commercial development. Scenario Six is the most laissez-faire of all the Sonoma scenarios. Development densities

Table 6: Summary of Sonoma County Land Use and Development Scenarios for 2005

Scenario	Land Development Prohibitions		Growth Allocation		Spill-over growth allocated to:
	Environmental Characteristics	Agricultural Land Type	General Plan/Zoning Prohibitions	Densities	
One <i>Status Quo</i>	Wetlands Slopes > 15%	Prime farmland only	Public uses, commercially-zoned, office and industrial, openspace, rural resource	Market based	next most profitable site anywhere in Sonoma County
Two <i>Build-out to General Plans</i>	Wetlands Slopes > 15%	Prime farmland only	Public uses, commercially-zoned, office and industrial, openspace, rural resource	General plan based	next most profitable site anywhere in Sonoma County
Three <i>Maximum Farmland Protection</i>	Wetlands Slopes > 15%	All farmland except grazing	Public uses, commercially-zoned, office and industrial, openspace, rural resource, intensive and extensive agriculture	Market based	next most profitable site anywhere in Sonoma County
Four <i>Maximum Farmland Protection; Higher City Density; City Infill at 49.5% for all cities.</i>	Wetlands Slopes > 15%	All farmland except grazing	Public uses, commercially-zoned, office and industrial, openspace, rural resource, intensive and extensive agriculture	General plan based	next most profitable site anywhere in Sonoma County
Five <i>Maximum Farmland Protection; Residential Development of Vacant Commercial Land OK</i>	Wetlands Slopes > 15%	All farmland except grazing	Public uses, openspace, rural resource, intensive and extensive agriculture; commercially-zoned land OK for development	Market based	next most profitable site anywhere in Sonoma County
Six <i>Laissez-faire</i>	Wetlands Slopes > 15%	None	Public uses, openspace, all other lands OK for development	Market based	next most profitable site anywhere in Sonoma County

are determined solely in the market. Other than limiting development on wetlands and steep slopes, Scenario Six puts no limits on the development of agricultural lands, or sites currently reserved for commercial development. In greater detail, the six scenarios include:

1. *Sonoma Scenario One* prohibits residential development in designated wetlands, on hillsides above 15 degrees of slope, and on agricultural lands designated as "prime".

As per current general plans, residential development is also prohibited from areas zoned for public use, commercial uses, and open space. Projected population growth that cannot be accommodated in a particular city is allowed to "spillover" into other cities (assuming room for additional development remains) or into unincorporated parts of Sonoma County. Development is allocated at residential densities determined in the marketplace. *This scenario is essentially a continuation of the status quo.*

2. *Sonoma Scenario Two* extends limitations on the development of agricultural lands far beyond those of Scenario One. Development is prohibited from agricultural lands. New development in cities, city-spheres of influence, and unincorporated county lands is required to occur at densities consistent with city general plans. In some cities, this means that development would occur at greater than market densities. In other cities, and for the county as a whole, general plan densities are below market densities. Development in the county would occur at market densities, subject to general plan limits. *This scenario transforms the role of the general plan from that of providing guidance to that of blueprint.*
3. *Sonoma Scenario Three* is more restrictive than either Scenarios One or Two in terms of agricultural land protection. Development is prohibited from all agricultural lands except those currently used for grazing. This includes sites designated as "locally important," of "state importance," and "unique," as well as "prime." Development is also prohibited from agricultural lands identified in the Sonoma County General Plan as being in "intensive" or "extensive" agricultural use. Development within cities and city spheres-of-influence can occur at market densities, while outside spheres, development densities are limited by the Sonoma County General Plan. *This scenario effectively protects all agriculturally designated lands (whether in use or not) from development.*
4. *Sonoma Scenario Four* combines Scenarios Two and Three. As in Scenario Three, development is prohibited from all non-grazing agricultural lands and all sites designated as agricultural in the Sonoma County General Plan. As in Scenario Two, new development within cities and city-spheres is required to occur at general plan densities. Scenario Four adds its own wrinkle. In all other scenarios, the share of growth occurring as infill is set at the historical level (that is the average for the 1980-1990 period). Accordingly, infill levels vary widely by city, from a high of 50 percent in Cotati to a low of 0 percent in Cloverdale. In Scenario Four, infill levels are set at a uniform 49.5 percent regardless of the city. The policy envisioned under this assumption would have the effect of forcing development into existing spheres of influence, thereby limiting the demand for rural and fringe land. Exactly how such policies would work is not clear. *Scenario Four is the Compact City alternative.*
5. *Sonoma Scenario Five* loosens a few of the restrictions of Scenarios Three and Four. Although still prohibited on agriculturally designated lands, residential development is permitted on vacant lands currently reserved for commercial development. *By limiting farmland development but permitting residential development on commercial lands, Scenario Five focuses growth around existing cities.* It does not, however, require that growth occur at higher-than-market-level densities.
6. *Sonoma Scenario Six* is the most laissez-faire of all the scenarios. Development would be permitted on all types of agricultural land (including "prime" farmland). The only general plan designations

for which development would be prohibited would be lands reserved for public uses and open space. All other land use designations — including commercially zoned land, rural resource lands, and agriculturally designated lands — would be available for development. City and county development densities would be determined in the private development market.

Two sets of CUF Model runs were undertaken for four of the six scenarios: (1) a set of runs based on population projections for the year 2005 as published by ABAG in *Projections '92*, and (2) a set of runs based on local population projections for the year 2005. A side-by-side comparison of the two sets of population projections (Table 7) shows that ABAG projects consistently higher levels of population growth for Sonoma County's northern cities (Windsor, Healdsburg, and Cloverdale), than do the cities themselves do. In Healdsburg, ABAG's year 2005 population projections exceed local projections by about 1,300; in Cloverdale the difference is 2,400 residents; and in Windsor, ABAG's projections exceed local projections by 4,700. ABAG's year 2005 forecasts for Rohnert Park and Sonoma— two cities with significant development potential — exceed local forecasts by 1,800 and 1,500 residents, respectively. ABAG's year 2005 projections for Santa Rosa and Sebastopol are similar to those produced locally. Only in Petaluma and Cotati are ABAG's projections less than those produced locally. In Cotati, ABAG's year 2005 projection lags the local projection by 1,100 residents. In Petaluma, the difference is more pronounced: ABAG predicts that Petaluma will add 16,516 new residents by the year 2005, Petaluma predicts that it will add more than 20,000 new residents. Overall, ABAG predicts that Sonoma County's nine cities plus all unincorporated areas, will add 112,880 new residents between 1900 and 2005; added together, the various locally generated forecasts total to 105,669 new residents.

Not all of these new residents are to be allocated by the CUF Model to vacant sites. Depending on past development trends, a certain share of the projected growth is assigned as infill (Table 7). In Cotati's case, for example, 50 percent of projected population growth is assigned to infill. In Healdsburg, by contrast, infill development will account for only 25 percent of projected growth. After subtracting infill, the amount of population growth to be allocated under ABAG projections exceeds the amount of population growth to be allocated under city and county projections by less than 1,300 persons.

Growth Spillovers

Under Scenarios One, Two, Five, and Six, there is sufficient developable land in Sonoma County and its cities to accommodate all projected population growth. This is not true, however, under Scenarios Three and Four, which, through a combination of development prohibitions and density stipulations, would reduce supplies of developable land below the level required to accommodate projected population growth. Adoption of these policies would therefore cause growth to spillover into other counties (Table 8). Spillover totals vary by scenario and projection. In the case of Scenario Three (ABAG Population Projection), 28,220 persons could not be allocated to sites within Sonoma County. For Scenario Four, this total would fall slightly to 21,947.

Table 7: Summary of Sonano County Year 2005 Growth Projections, and Infill Levels by Projection Source

Subarea*	Projected Population Growth: 1990-2005		Population Growth Assigned to Infill		Population Growth to be Allocated by the CUF Model	
	ABAG	Local Source	ABAG	Local Source	ABAG	Local Source
Cloverdale	6,576	4,176	2,864	836	3,712	3,340
Cotati	1,986	3,076	993	1,538	993	1,538
Healdsburg**	4,431	3,141	1,003	629	3,428	2,512
Petaluma**	16,516	20,126	8,258	10,063	8,258	10,063
Rohnert Park**	9,874	8,074	7,858	3,606	2,016	4,468
Santa Rosa**	52,687	51,387	15,807	15,417	36,880	35,970
Sebastopol**	2,196	2,256	1,562	1,557	634	699
Sonoma	4,279	2,704	1,465	541	2,814	2,163
Windsor	15,429	10,729	4,629	3,219	10,800	7,510
Unincorporated	0	0	0	0	0	0
Total	113,974	105,669	44,439	37,406	69,535	68,263

Notes:

- * Sub-areas consist of cities and their unincorporated spheres of influence; they exclude unincorporated places beyond city spheres-of influence such as Glen Ellen, Guerneville, and the Pacific coast
- ** Healdsburg projections include rural Healdsburg, Petaluma projections include rural Petaluma; Rohnert Park projections include rural Rohnert Park; Santa Rosa projections include rural Santa Rosa; Sebastopol projections include Rural Sebastopol.

Sources:

adapted from Association of Bay Area Governments, Projections '92.

Table 8: Inter-jurisdictional Growth Spillovers by Scenario and City

City	City/County Spillover (+: exporter, -: importer) using Adapted ABAG Projections*					
	Scenario 1A	Scenario 2A	Scenario 3A	Scenario 4	Scenario 5	Scenario 6
Cloverdale	0	861	1,174	-39	449	0
Cotati	0	0	-1,223	-1,543	-1,698	0
Healdsburg	0	2,683	1,169	1,160	806	0
Petaluma	0	0	5,289	4,711	4,116	0
Rohnert Park	0	108	1,888	4,915	1,888	0
Santa Rosa	0	9,173	12,936	12,475	12,536	0
Sebastopol	0	304	634	1,102	634	0
Sonoma	0	555	2,451	1,719	2,451	0
Windsor	0	-19,506	3,934	7,453	3,916	0
Unincorporated	0	-25,884	-6,677	-10,003	-31,743	0
Unallocated	0	0	28,220	21,947	0	0

City	City/County Spillover (+: exporter, -: importer) using Local Projections					
	Scenario 1L	Scenario 2	Scenario 3L	Scenario 4	Scenario 5L	Scenario 6L
Cloverdale	0	NA	802	NA	77	0
Cotati	0	NA	-660	NA	-1,452	0
Healdsburg	0	NA	253	NA	0	0
Petaluma	0	NA	7,094	NA	5,921	0
Rohnert Park	0	NA	4,340	NA	4,340	0
Santa Rosa	0	NA	12,026	NA	11,626	0
Sebastopol	0	NA	699	NA	699	0
Sonoma	0	NA	1,800	NA	1,800	0
Windsor	0	NA	644	NA	626	0
Unincorporated	0	NA	0	NA	-24,442	0
Unallocated	0	NA	21,126	NA	0	0

Notes: Spillover estimates based on population projections shown in Table 7

Under status quo Scenario One and laissez-faire Scenario Six, every city in Sonoma County could accommodate its projected population growth within its sphere of influence. The other four scenarios would generate significant amounts of city-to-county and city-to-city spillover. The extent to which a particular city would either generate spillover (that is, be a growth exporter), or receives it (that is, be a growth importer), varies by city and scenario (Table 8). Cloverdale, for example, would be a growth exporter under Scenarios Two, Three, and Five, but under Scenario Four (Compact Cities) would actually import a small amount of growth. Cotati, by contrast, would be a growth importer under Scenarios Two through Five. Under these scenarios, Cotati would accept growth displaced from other jurisdictions. Healdsburg would export more than 2,500 residents under Scenario Two (Build-out to General Plans), but would export many fewer residents under Scenarios Three through Five (Farmland Protection). Prohibiting the development of agricultural sites (Scenarios Three through Five) would cause Petaluma to export between 4,100 and 7,094 residents, depending on the scenario and choice of population projection. Rohnert Park would also generate significant spillover under Scenarios Three and Five, some of which would go to next-door Cotati.

As the Sonoma County city projected to grow the most, Santa Rosa would be the biggest potential generator of spillover. Under Scenario Two (ABAG population projections), for example, Santa Rosa would be unable to accommodate 9,173 new residents.⁵ Under Scenarios Three through Five (ABAG projections), Santa Rosa's exported growth total would exceed 12,400 residents. Under Scenarios Three and Five, Santa Rosa spillover would exceed 11,000 residents even under the somewhat-lower local-based population projections. Sonoma and Sebastopol would also be consistent growth exporters under Scenarios Two through Five.

Windsor is an extremely interesting case. Under Scenario Two (Build-out to General Plan)⁶ Windsor would be a huge importer of growth, especially from nearby Santa Rosa. By contrast, under Scenarios Three through Five, which protect agricultural lands, Windsor would become a large-scale growth exporter.

Where would all this spillover growth go? In the case of Scenario Two (Build-out to General Plans), nearly 26,000 residents would flow into unincorporated county lands, and thousands of acres of agricultural land would be developed. Under Scenario Three, however, most of that agricultural land would be protected, and city-to-county spillover would total less than 7,000 residents; the remaining spillover would be displaced from the county. Under Scenario Four, city-to-county spillover would exceed 10,000 residents, and under Scenario Five, it would jump to more than 31,500 residents. The choice of population projection affects the precise magnitude of inter-jurisdictional growth spillovers, but not the general pattern.

To summarize, land use policies that sharply limit the development potential of agricultural lands without providing necessary growth "safety valves" (e. g. Scenarios Three and Four) will cause growth to be displaced from one community to another and, ultimately, to be pushed out of Sonoma

County. Growth policies that restrict the development of agricultural lands, yet allow for the development of excess commercial lands, will displace growth to unincorporated areas, but allow the county as whole to accommodate all projected population growth. The biggest surprise is Scenario Two, which stipulates that development in cities and their spheres of influence should occur at general plan densities? Contrary to popular belief, such densities are not sufficiently high to prevent spillover. On the contrary, Scenario Two generates a city-to-county spillover of nearly 26,000 residents.

Patterns of Land Development

Figures 7 through 12 visually illustrate the pattern of new development likely to result from each scenario. Sonoma County is a huge and mostly undeveloped county, so differences in development patterns between scenarios are not always easy to make out. Under Scenario One: Status Quo (Figure 7), new single-family home development will be concentrated along the eastern edge of Petaluma, along the northern, eastern, and southern edges of Santa Rosa, throughout Windsor, and along the western edge of Cloverdale. Rohnert Park, Sonoma, and Sebastopol are allocated very little new development.

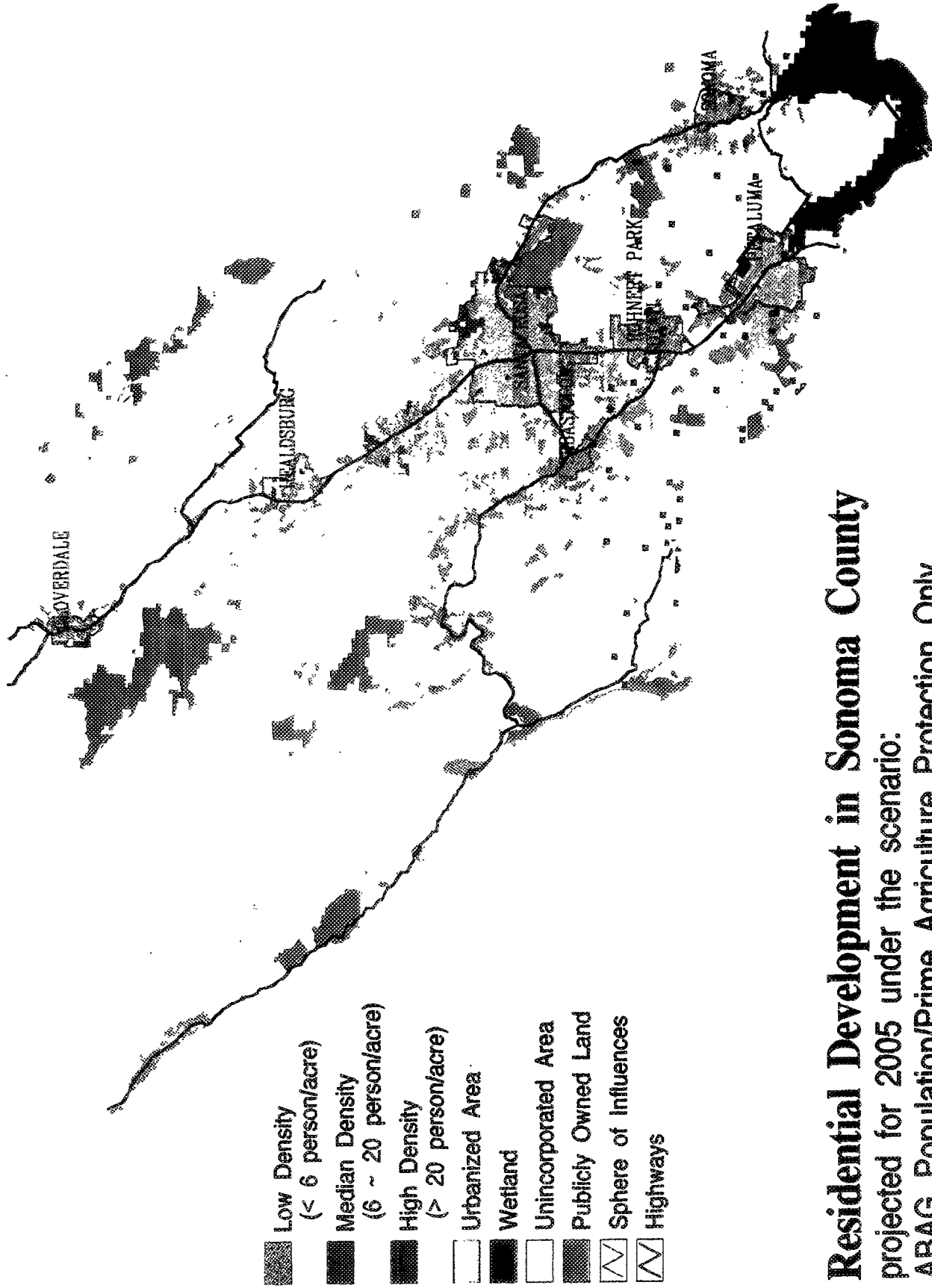
Development patterns in the southern and northern ends of Sonoma County under Scenario Two: Build-out to General Plans (Figure 8) are similar to those under Scenario One: Status Quo. They are very different, however, in the middle of the county. Specifically, growth which cannot be accommodated within Petaluma, Rohnert Park, and particularly Santa Rosa (because general plan-based densities in those cities are so much lower than market-based densities) spills out into the county, ringing Rohnert Park and Cotati with hundreds of acres of new development.

Development patterns under Scenario Three: Maximum Farmland Protection (Figure 9) are far more compact — in part because not all growth projected for the county is accommodated. In Petaluma, where agricultural sites on the northeastern side of the city are now protected, new development is shifted to the south side of the city. Additional development would spillover outside the city into unincorporated sites between Petaluma and Cotati. In Santa Rosa, new development is displaced from the south edge of the city to the north, where it occurs at somewhat higher densities than under Scenario One: Status Quo. Some additional growth is displaced northward outside Santa Rosa's sphere of influence. In Windsor, the protection of agricultural lands adjacent to Highway 101 shifts growth outward. A similar dynamic occurs in Sonoma, where growth that occurred inside city limits under Scenario One is displaced north and south outside the city.

The pattern of development under Scenario Four: Maximum Farmland Protection (Figure 10) is identical to that under Scenario Three (Figure 9), except in Windsor, where much less land is developed under Scenario Four than under Scenario Three. Land development patterns under Scenario Five (Figure 11) mirror those of Scenario Three.

Development patterns under Scenario Six: Laissez-faire (Figure 12) are a composite of Scenarios One and Three. In Petaluma, new development occurs along both the city's northeastern and southern

Figure 7: Sonoma Scenario One: Status Quo

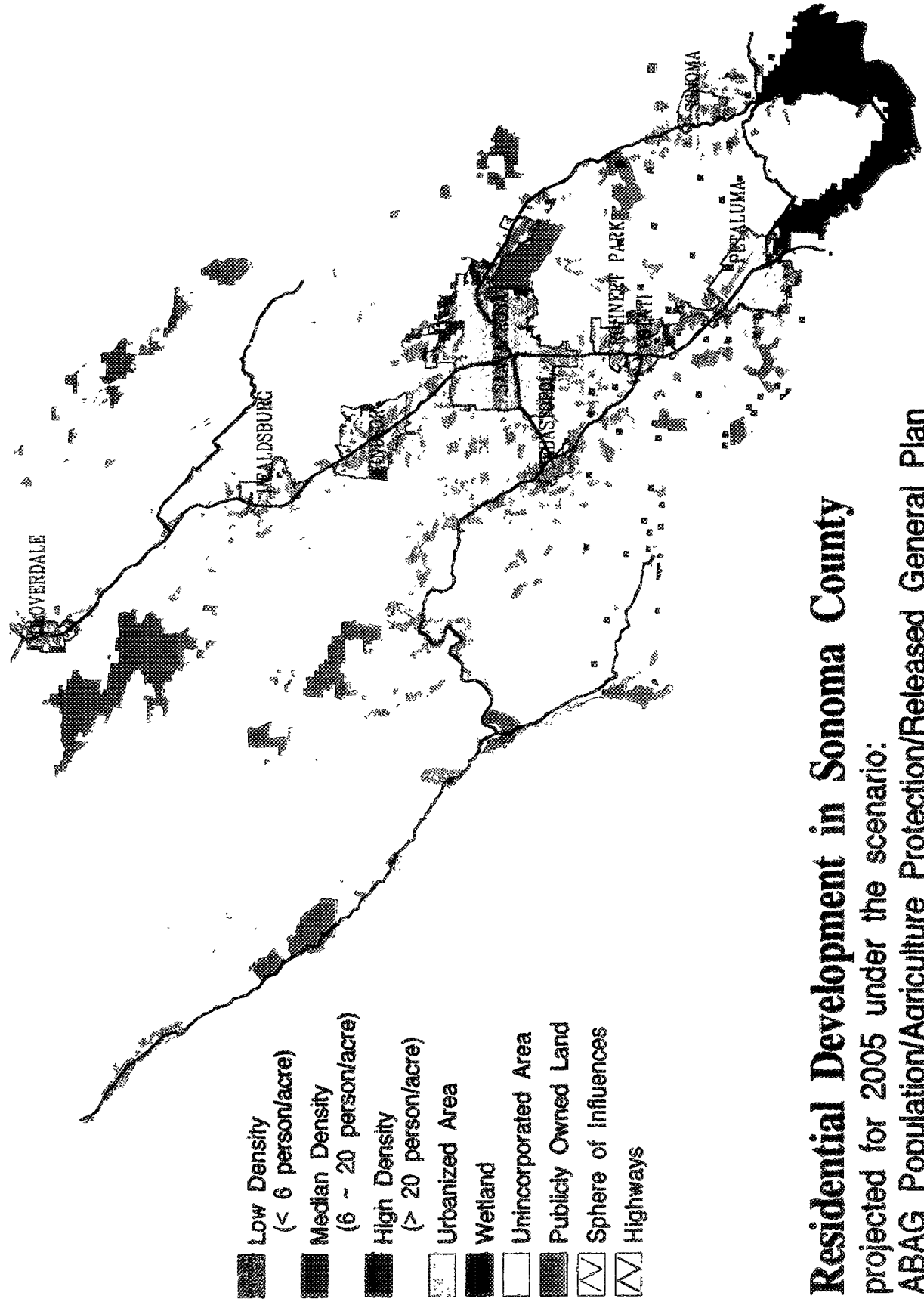


Residential Development in Sonoma County

projected for 2005 under the scenario:

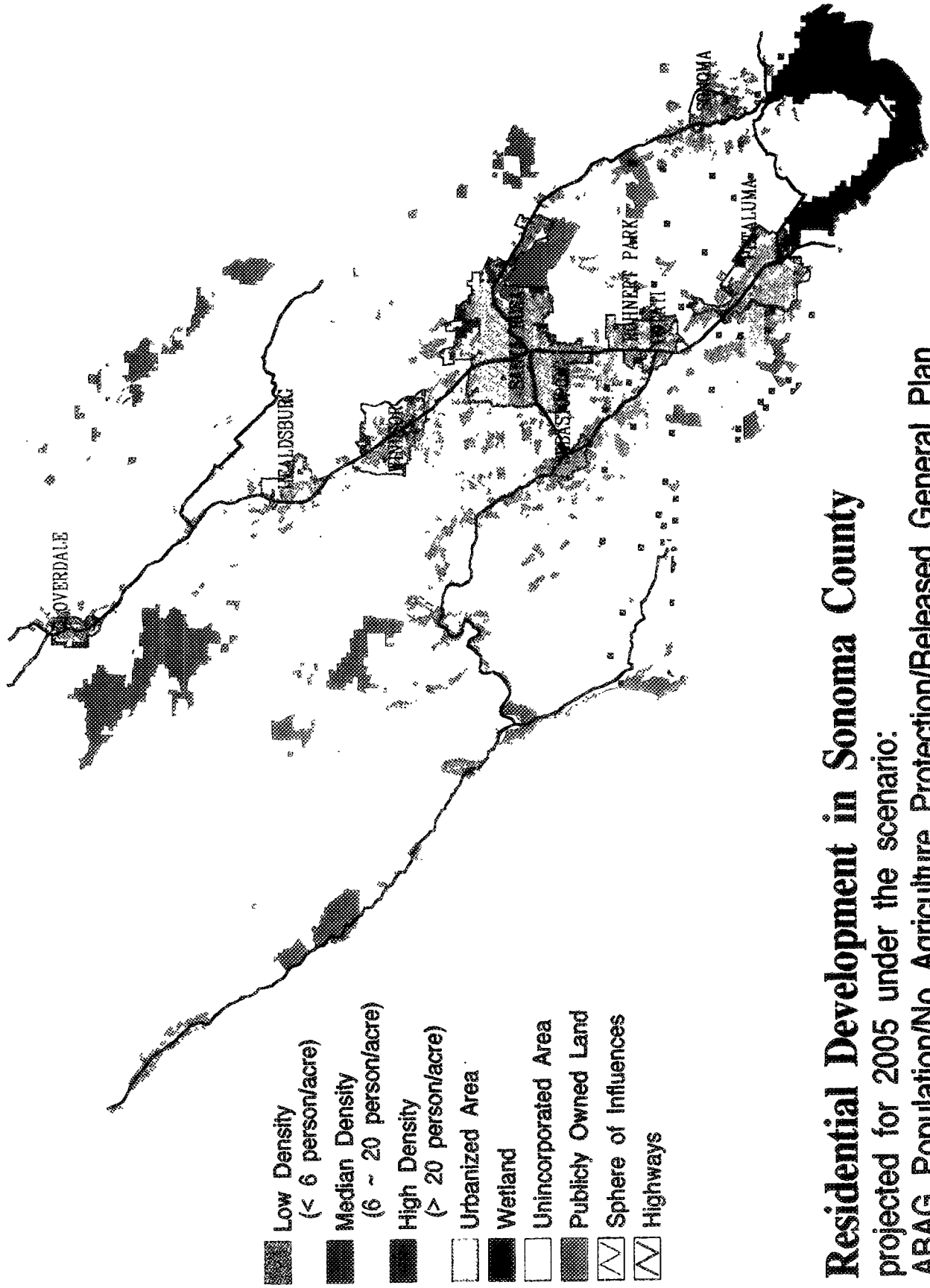
ABAG Population/Prime Agriculture Protection Only

Figure 11: Sonoma Scenario Five: Maximum Farmland Protection w/Development of Excess Commercial Sites



Residential Development in Sonoma County
 projected for 2005 under the scenario:
 ABAG Population/Agriculture Protection/Released General Plan

Figure 12: Sonoma Scenario Six: Laissez Faire



Residential Development in Sonoma County
 projected for 2005 under the scenario:
 ABAG Population/No Agriculture Protection/Released General Plan

edges. Similarly, in Santa Rosa, new development occurs along the city's southern edge (as in Scenario One), and along its northern and eastern edges (as in Scenarios Two through Five). New development in Windsor under Scenario Six occurs adjacent to Highway 101 (as in Scenario One). Two cities in which Scenario Six leads to new patterns of development are Sebastopol and Sonoma. In the former case, there is a significant increase in development activity along the city's eastern edge; in the latter case, Sonoma's eastern edge is significantly built-out. Cloverdale, under Scenario Six, becomes almost entirely built-out.

To summarize, Scenarios One and Six (which do not restrict the development of agricultural lands) allow for greater amounts of development within existing city spheres of influence. They produce, in essence, more contiguous forms of development. Scenarios Three through Five (which restrict the development of agricultural lands) tend to displace development to unincorporated areas of lower agricultural quality, producing less total development, but development that is of a less contiguous form. The scenario that produces the most sprawl is Scenario Two, which requires that cities develop at densities set forth in their general plans. Under this scenario, new development which cannot be accommodated in Petaluma, Rohnert Park, and Santa Rosa spills out into unincorporated lands.

Land Development Totals and Densities by City

Growth pressures are different in every Sonoma city, as are growth policies and constraints on growth. This section explores land development totals and densities for each of Sonoma County's nine cities (Tables 9 and 10). New development densities are computed by dividing the total population accommodated under each scenario by the average 1990 household size (U.S. Census, 1990), then by the number of acres to be converted to residential uses. Because development densities are to be determined in the marketplace for all but Scenarios Two and Four, development densities vary only slightly by scenario.

Cloverdale: New development in Cloverdale will consume between 300 and 600 acres by the year 2005, depending on the policy scenario and projection chosen (Table 9). Land consumption will be slightly lower under Scenarios Three through Five, which limit the development of agricultural lands, as well as under Scenario Two, which requires development to occur at general plan densities. The highest level of land consumption—601 acres—would occur under Scenario Six: Laissez Faire (ABAG Projection). Regardless of the policy scenario chosen, the density of new residential development in Cloverdale will be about 3.3 housing units per acre (Table 10).

Cotati: Under Scenario One: Status Quo (ABAG Projection), an additional 110 acres of land would be developed in Cotati by the year 2005; under Scenario Six: Laissez Faire (ABAG Projection), that total would rise to 140 acres. Scenarios Two through Five, Cotati would become an importer of growth—substantially boosting land consumption. Land consumption would rise to 188 acres under Scenario Two: Build-out to General Plans, to about 208 acres under Scenarios Three and Four, and to 248 acres under Scenario Five.

New development densities would average 2.8 units per acre under Scenario Six: Laissez Faire (ABAG Projection), and 3.6 units per acre under Scenario One: Status Quo (ABAG Projection). Under Scenarios Three through Five, in which Cotati becomes a net importer of growth, new development densities would rise into the range of 4.2 to 4.9 dwelling units per acre.

Table 9: Sonoma County CUF Model Results by City for Six Alternative Development Scenarios

Scenario & Forecast	Acres allocated to population growth by city sphere-of-influence:											TOTAL
	Cloverdale	Cotati	Healdsburg	Petaluma	Rohnert Park	Santa Rosa	Sebastopol	Sonoma	Windsor	Uninc.		
<u>Scenario One: Status Quo</u>												
ABAG	424	110	245	1,236	119	3,322	73	322	971	none		6,822
Local	418	190	184	1,236	119	3,281	73	283	707	none		6,492
<u>Scenario Two: Build-out to City General Plans</u>												
ABAG	387	188	163	1,269	118	3,235	70	303	*	40,895		46,628
<u>Scenario Three: Maximum Farmland Protection</u>												
ABAG	290	209	162	239	8	2,153	0	42	619	4,004		7,725
Local	290	209	162	239	8	2,153	0	42	619	4,004		7,725
<u>Scenario Four: Maximum Farmland Protection with Higher Infill</u>												
ABAG	365	207	131	235	8	2,120	0	36	576	3,677		7,353
<u>Scenario Five: Maximum Farmland Protection w/Development of Excess Commercial Sites</u>												
ABAG	373	248	188	334	8	2,189	none	42	620	2,272		6,273
Local	373	248	180	334	8	2,189	none	42	620	1,773		5,766
<u>Scenario Six: Laissez Faire</u>												
ABAG	601	140	253	912	263	3,325	81	350	1,011	none		6,936
Local	383	140	192	912	263	3,236	81	249	687	none		6,142

Notes: * Windsor total included with Unincorporated

Table 10: Sonoma County CUF Model Results by City for Six Alternative Development Scenarios

Scenario & Forecast	Gross Residential Densities (housing units per acre)									
	Cloverdale	Cotati	Healdsburg	Petaluma	Rohnert Park	Santa Rosa	Sebastopol	Sonoma	Windsor	
<u>Scenario One: Status Quo</u>										
ABAG	3.3	3.6	3.8	4.2	6.4	4.6	3.6	3.3	4.4	
Local	3.0	3.2	5.3	4.0	6.4	4.5	3.7	3.3	4.2	
<u>Scenario Two: Build-out to City General Plans</u>										
ABAG										
<u>Scenario Three: Maximum Farmland Protection</u>										
ABAG	3.3	4.2	5.4	4.7	6.0	4.6	none	3.3	4.4	
Local	3.3	4.2	5.4	4.7	6.0	4.6	none	3.2	4.3	
<u>Scenario Four: Maximum Farmland Protection with Higher Infill</u>										
ABAG	3.5	4.9	3.0	4.4	2.1	2.7	none	4.4	0.2	
<u>Scenario Five: Maximum Farmland Protection w/Development of Excess Commercial Sites</u>										
ABAG	3.3	4.3	5.4	4.7	6.2	4.6	none	3.3	4.4	
Local	3.3	4.8	5.4	4.7	6.2	4.6	none	3.3	4.4	
<u>Scenario Six: Laissez Faire</u>										
ABAG	3.3	2.8	5.4	4.3	6.4	4.5	3.6	3.3	4.2	
Local	3.3	1.5	5.0	4.5	6.4	4.6	3.6	3.3	4.3	

Healdsburg: New development in Healdsburg will consume between 131 and 253 acres by the year 2005, depending on the policy scenario and projection chosen. The least amount of new development—131 acres—will occur under Scenario Four: Maximum Farmland Protection; the most—about 250 acres—under Scenarios Six: Laissez-Faire and One: Status Quo.

Average new development densities would exceed five units per acre under Scenarios One, (Local Projection only) Three, Five, and Six. New development densities at the urban fringe would fall to an average of only about 3 units per acre under Scenario Four: Maximum Farmland Protection with Higher Infill.

Petaluma: Much less land would be developed in Petaluma under Scenarios Three through Five than under Scenario One, Two, or Six. Under Scenario One: Status Quo, an additional 1,236 acres of land would be developed by the year 2005. Under Scenario Two: Build-out to General Plans, that total would rise to 1,269 acres. Under Scenario Six: Laissez Faire, the total amount of acreage developed in Petaluma by the year 2005 would fall to 912 acres, some sites would be developed more intensely. Prohibiting the development of most types of farmland (Scenarios Three through Five) would substantially reduce land consumption in Petaluma into the range of 240 to 340 acres.

Regardless of the policy scenario chosen, new development densities in Petaluma will remain in the range of 4.2 to 4.7 dwelling units per acre.

Rohnert Park: The urbanized area of Rohnert Park will grow by roughly 120 acres by the year 2005 under Scenario One: Status Quo, and Scenario Two: Build-out to General Plans. Under Scenario Six: Laissez-Faire, new development in Rohnert Park would exceed 260 acres. New development densities under both scenarios would average 6.4 units per acre—making Rohnert Park the highest density city in Sonoma County.

Since so much of the undeveloped acreage in Rohnert Park is farmland, under Scenarios Three through Five (which prohibit development of various forms of agricultural land), new development would total less than ten acres.

Santa Rosa: Depending on the policy scenario chosen, the urbanized area of Santa Rosa will expand by either 3,200 acres, or by 2,200 acres. Under Scenarios One: Status Quo, Two: Build-out to General Plans, and Six: Laissez Faire, an additional 3,200 acres within Santa Rosa's sphere of influence will be developed by the year 2005. Under Scenarios Two through Five, which restrict the development of agriculturally designated sites, this total would fall to about 2,200 acres. Land consumption along Santa Rosa's north edge varies only slightly. The big difference is along the city's southern edge, where development would be allowed under Scenarios One and Six, but prohibited under Scenarios Two through Five. Except for Scenario Four: Maximum Farmland Protection with Higher Infill, new development densities will average 4.5-4.6 dwelling units per acre regardless of the scenario chosen.

Sebastopol: Because all undeveloped sites in Sebastopol are agricultural, the city would experience no new development under Scenarios Three through Five. Under Scenarios One: Status Quo, and Two: Build-out to General Plans, an additional 70-73 acres would be developed by the year 2005. Under Scenario Six: Laissez Faire, Sebastopol's urbanized area would grow by 81 acres. In both cases, new development would occur at an average density of 3.6 units per acre.

Sonoma: Sonoma is similar to Sebastopol in that most undeveloped sites within its sphere-of-influence are in agricultural use, and would thus be preserved under Scenarios Three through Five. Under those scenarios, additional development in Sonoma would total only 35 to 42 acres. Under Scenarios One, Two, and Six, by contrast, new development in Sonoma would range between 250 and 350 acres, depending on the scenario and projection chosen. Except for Scenario Four: Maximum

Farmland Protection with Higher Infill, new development densities will average 3.2-3.3 dwelling units per acre regardless of the scenario chosen.

Windsor: Windsor, unlike most other Sonoma cities, does not include significant amounts of agricultural land. Thus, scenarios which would preserve such lands (e. g. , Scenarios Three through Five) would not affect the pattern or amount of urban land conversion in Windsor as much as in other cities. Under Scenario One: Status Quo (ABAG Projection), the amount of additional land developed in Windsor by the Year 2005 would rise by 971 acres. Under Scenario Six: Laissez Faire, that total would increase to more than 1,000 acres. Under Scenarios Two through Five, the amount of additional developed acreage in Windsor would increase by between 576 and 620 acres. Except for Scenario Four: Maximum Farmland Protection with Higher Infill, new development densities will average 3.2-3.3 dwelling units per acre regardless of the scenario chosen.

Unincorporated County Lands: Under Scenarios One: Status Quo and Six: Laissez Faire, all population growth could be accommodated within existing city spheres-of-influence; none would spillover into unincorporated areas. Under Scenario Two: Build-out to City General Plans, unaccommodated growth would spill out into county areas, leading to the development of nearly 40,000 acres. Much of this development would occur at very low densities. There would also be some level of city-to-county spillover under Scenarios Three through Five, in which agricultural lands are protected. Under Scenario Three: Maximum Farmland Protection, 4,136 acres of unincorporated county land outside city spheres would be developed. Under Scenario Four, this amount would fall to 3,677 acres. Under Scenario Five, in which excess commercial sites could be residentially developed, the amount of city-to-county spillover would fall to 2,272 acres.

Land Conversion by Current General Plan Designation

General plan land use designations can *directly* limit development, but they can only *indirectly* encourage it. Depending on the site-specific economics of development, a general plan change that simultaneously tightens development restrictions in one part of the county and loosens them in another may or may not successfully redirect growth as intended.

The six scenarios each regard current general plan land use designations and limitations somewhat differently. Scenarios One: Status Quo, and Two: Build-out to General Plans, both assume that future residential development will be prohibited for sites designated for public uses, commercial, office, and industrial development, openspace, and rural resource areas. Where the two scenarios differ is in how they handle densities. Scenario One allows residential development densities within city spheres-of-influence to exceed general plan densities in residentially designated areas. Outside of city spheres of influence, the general plan density serves as a ceiling. Scenario Two: Build-out to General Plans assumes that general plan densities serve as a ceiling in the county and in every city. Since most city-based general plan densities are well below market densities, the effect of this assumption is to cause tremendous amounts of unallocated growth to spill-over into the county.

Scenarios Three through Five put further prohibitions on residential development according to general plan designation. In addition to the designations listed in Scenarios One and Two, new housing development is prohibited from sites designated in general plans as reserved for Diverse Agriculture, Land-

Intensive agriculture, and Land-Extensive agriculture. Only sites designated for General Agriculture may be developed. While it strictly limits the development of agriculturally designated sites, Scenario Five does permit housing development to occur on sites designated for commercial use.

Scenario Six: Laissez Faire prohibits residential development only on sites designated for open space or public use. All other sites, including all agriculturally designated sites, and all commercially designated sites are available for residential development.

How do the different policy scenarios affect the pattern of land consumption according to current general plan land use designation? Depending on the scenario, most of the undeveloped land in Sonoma that will be urbanized during the next 15 years is currently designated either for Low-Density and Medium-Density residential development, or as Rural Residential (Table 11).

Under Scenario One: Status Quo (ABAG Projection), 46.5 percent of the land likely to be converted to urban uses is currently designated for Low-Density Residential development; an additional 22 percent of the land area likely to be urbanized under Scenario One is currently designated for Medium-Density residential development. The remaining 31.5 percent includes a mix of sites currently designated for diverse and intensive agriculture, as well as sites designated as urban and rural residential.

Scenario Two: Build-out to General Plans generates a very different result. Scenario Two limits development densities to those specified in local general plans. When such densities are well below market densities—as is the case for most cities in Sonoma County—the growth that is not accommodated is displaced outward into unincorporated area beyond city spheres of influence. Generally speaking, such areas are currently designated for agricultural uses. Under Scenario Two: Build-out to General Plans, 17,335 acres of land area currently designated for Land-Intensive Agricultural use would be developed, albeit at very, very low densities. An additional 14,334 acres of land area designated for Diverse Agriculture would be developed, also at very low densities. More than 7,000 acres of land designated for Low-Density Residential development, and 3,300 acres designated for Rural Resource Development would also be developed under Scenario Two. Altogether, more than 46,000 acres of land would be developed under Scenario Two, most at densities well below one unit per acre.

The amount of land currently designated for low-density residential use which would be developed under the three farmland conservation scenarios (Scenarios Three through Five) is about the same as under Scenario One. The key differences between the three farmland preservation scenarios and Scenario One are in the development of lands currently designated for Medium-Density Residential uses, and as Rural Residential. Under Scenarios Three through Five, only 5 to 6 percent of new development would occur on lands currently designated for Medium-Density Residential development—down significantly from the 22 to 23 percent level of Scenario One. This development would in part be diverted to sites currently designated as Rural Residential, where it would occur at significantly reduced densities. Under Scenario Three, for example, 3,403 acres of land currently designated as Rural Residential would be developed, as compared with less than 300 acres under Scenario One. Even Under Scenario Five, which

would make significant amounts of excess commercial acreage available for development, two-thirds of new development would occur on sites designated as Rural Residential, or for Low-Density Residential development. It is indeed ironic that the primary effect of the three farmland protection scenarios would be to displace development from sites designated for Medium-Density Residential development (albeit sites of some agricultural value) to sites intended for Rural Residential development. Thus, Scenarios Three through Five would actually worsen the sprawl they are in part designed to combat.

By contrast, under Scenario Six: Laissez Faire, sites designated rural residential would face very little new development. Instead, residential growth would occur on sites currently designated for office and industrial uses, and, similar to Scenario One, on sites designated for medium-density residential uses.

Land Conversion by Agricultural Land Type

The California Farmland Mapping Project, undertaken in 1986, grouped all farmland in the state into five categories: (1) Prime: flat, fertile, and well-irrigated lands suitable for growing a variety of major cash crops; (2) State-Important: of lower fertility or greater slope, but under cultivation; (3) Locally Important: under cultivation for locally important agricultural products; (4) Unique: appropriate for locally unique crops and range uses; and (5) Grazing: not under cultivation, but useful for livestock grazing.

Each of the six scenarios treats Sonoma County agricultural lands somewhat differently. Scenarios One: Status Quo, and Two: Build-out to General Plans, prohibit the development of agricultural lands designated as "prime," and sites identified in the Sonoma County General Plan as Rural Resource, but do not otherwise limit the development of active or inactive farmlands. Scenarios Three through Five go to the opposite: development on all agricultural lands except those used for grazing is prohibited. Scenario Six: Laissez Faire, would abolish all development prohibitions, and make all agricultural lands— including prime farmland —available for development. Table 12 summarizes farmland conversion by type and city.

The only scenario in which any prime farmland would be developed is Scenario Six: Laissez Faire. Altogether, 471 acres of prime farmland, located mostly in Santa Rosa and Windsor, would be developed under Scenario Six.

Scenarios Three through Five would permit the development of between 3,548 and 4,847 acres of agricultural lands currently designated for grazing; no other agricultural lands would be developed under those scenarios. Grazing lands would account for about one-third of the land developed under Scenarios One, Two, and Six. For Scenarios One: Status Quo, and Six: Laissez Faire, the amount of grazing land developed would range between 1,770 and 2,316 acres, depending on the population projection. In the case of Scenario Two: Build-out to General Plans, more than 14,000 acres of grazing land would be developed, most outside existing spheres of influence, and all at very low densities.

Most of the farmland which would be developed under Scenarios One, Two, and Six is currently designated as locally important. About 3,200 acres of locally important agricultural land would be developed under Scenarios One: Status Quo, and Six: Laissez Faire. Under Scenario Two: Build-out to

Table 12: Sonoma County CUF Model Results by Agricultural Land Type for Six Alternative Scenarios

Where Name	Farmland Type	Agricultural Land Allocated by Scenario and Type									
		Scenario>>	1ABAG	1Local	2ABAG	3Both	4ABAG	5ABAG	5Local	6ABAG	6Local
Geardale	Grazing		264	260	260	264	273	279	279	279	122
	Locally-important		79	79	78					115	112
	Prime									28	16
	State-important		27	26	27					58	56
	Other		53	53	25	25	93	93	93	121	77
Geardale	Locally-important			81	80					30	30
	Other		110	110	108	209	248	248	248	110	110
Geardale	Grazing		74	33	25	33	27	34	34	33	10
	Locally-important		10	10	10					13	13
	Prime									55	55
	State-important		23	21	23					10	9
	Other		138	120	105	128	130	153	146	142	106
Geardale	Grazing		89	89	87	168	169	169	169	11	11
	Locally-important		1,092	1,092	1,126					771	771
	Other		56	56	56	71	165	165	165	131	131
Geardale	Locally-important		111	111	111					240	240
	Prime									16	16
	Other		8	8	8	8	8	8	8	8	8
Santa Rosa	Grazing		1,751	1,725	1,725	1,752	1,728	1,754	1,754	1,574	1,500
	Locally-important		1,132	1,119	1,090					1,210	1,202
	Prime									123	123
	State-important		42	42	24					41	41
	Other		397	394	395	401	428	435	435	378	371
Geardale	Locally-important		73	73	70					78	78
Sonoma	Grazing		14	8	12	14	14	14	14	14	8
	Locally-important		246	233	236					246	222
	Prime									28	
	State-important		30	27	29					30	19
	Unique		5		2					5	
	Other		28	16	24	28	28	28	28	28	
Geardale	Grazing		124	124	na	491	456	491	491	123	123
	Locally-important		600	424	na					633	338
	Prime									223	222
	State-important		117	30	na					29	2
	Unique		129	129	na					2	2
	Other		1	1	na	127	120	129	129	1	1
Sonoma	Grazing				12,245	2,124	2,117	1,027	806		
	Locally-important				24,328						
	State-important				1,908						
	Unique				289						
	Other				2,130	1,880	1,968	1,245	967		
Total Sonoma	Grazing		2,316	2,238	14,354	4,847	4,783	3,769	3,548	2,034	1,773
	Locally-important		3,271	3,150	26,823		0			3,258	2,927
	Prime									471	431
	State-important		240	146	2,011		0			168	126
	Unique		133	129	291		0			7	2
	Other		789	758	2,851	2,877	3,187	2,502	2,218	917	803
	Total		6,749	6,420	46,330	7,725	7,970	6,272	5,765	6,856	6,061

General Plans, the amount of locally important agricultural land which would be developed would rise to nearly 27,000 acres. The vast majority of this total, more than 24,000 acres, would be outside existing spheres of influence — the result of massive spillover from Sonoma County cities. The remaining farmland which would be developed under Scenarios One, Two, and Six, is a mixture of unique and state-important agricultural land.

The development of agricultural lands under Scenarios One, Two, and Six would have its greatest impact in Santa Rosa (between 2,700 and 2,900 acres of grazing, locally important, and state-important farmland would be developed), Petaluma (between 900 and 1,300 acres of grazing or locally important land would be developed), and Windsor (between 550 and 650 acres of grazing and locally important land would be developed). Agricultural lands in Cloverdale, Healdsburg, and Sonoma face considerably less development risk, even though the economies of those cities are more agriculturally oriented than other Sonoma County cities.

Summary

The current context for sub-regional planning in Sonoma County is very different than that of Solano County. In the Solano case, the focus of concern is Measure A, an existing, countywide land use regulation. No similar program exists in Sonoma County. Instead, the issue in Sonoma County is whether (and to what extent) regulatory policies adopted in one community (e. g. Santa Rosa or Windsor) will cause growth to be displaced to other communities, or to unincorporated areas of Solano County. The six scenarios simulated above suggest that any significant tightening of local land use regulations among cities in southern or central Sonoma County will in fact lead to significant amounts of inter-jurisdiction growth spillover. Specifically:

- * Requiring that development in city spheres of influence occur at densities stipulated in existing general plans (Scenario Two) will cause significant amounts of development to spillover into unincorporated areas. Simply put, assuming reasonable levels of infill development, the combination of existing city and county general plans will tend to encourage higher levels of land consumption and urban sprawl than necessary.
- * Total land consumption would be reduced and spillover growth avoided, by contrast, by encouraging private housing developers to build at (the higher) densities as determined in the private market (Scenarios One and Six). Development at market-determined housing would allow cities to build-out within their existing spheres of influence, as well as to prevent the development of prime agricultural lands.
- * Imposing additional restrictions on the development of agricultural lands, particularly those used for grazing or for locally important farm uses— while saving those uses from development— would serve to displace growth southward from Windsor, Santa Rosa, Petaluma, and Rohnert Park into unincorporated area outside Petaluma and Rohnert Park. Countywide, such policies would displace between 20,000 and 30,000 residents from the county. The imposition of comprehensive agricultural preservation policies (Scenarios Three through Five) would create significant growth

spillovers even if excess commercial lands were made available for development (Scenario Five), or additional infill development were strongly encourage (Scenario Four).

- * Differences between the Year 2005 projections produced by ABAG and those produced locally do not affect these results. Such differences are likely to be extremely small when compared with the differential impacts of different land use regulations on the overall pattern of development.
- * Growth patterns in Sonoma County are already sub-regional in nature. How much growth a particular city in Sonoma is or is not willing to accommodate will have direct and immediate impacts upon the growth of other Sonoma cities.

V. EVALUATION

The purpose of this report has been to demonstrate the use of the California Urban Futures (CUF) Model for analyzing realistic land use policy and planning alternatives at the sub-regional or county level. In this section we summarize the usefulness of the CUF Model for that purpose:

1. *How well does the CUF model incorporate current land use and general plan information?* Very well. The Sonoma and Solano county datasets include current land uses (at the 100m x 100m level) and current general plan land use designations and density ceilings.
2. *How easy is it to simulate alternative regulatory policies using the CUF Model?* Once the appropriate data layers have been set up, the CUF Model can easily be used to test the spatial impacts of specific land use regulations.
3. *How easy is it to simulate alternative density policies using the CUF Model?* The CUF Model can test how different density ceilings (as specified in local zoning or general plan ordinances) affect the general pattern of development. Currently, however, there is no "feed-back" loop between changes in density and profitability.
4. *How easy is it to simulate the effects of alternative infrastructure investment policies?* The effect of different investment policies on land use patterns depends on the extent to which specific investments are capitalized into land and building values. The current version of the CUF Model does not include a capitalization mechanism.
5. *How believable are the model results?* This depends. At the community level, changes in development policy tend to be produce understandable and consistent changes in development patterns. The model is less accurate at predicting the development of specific parcels.
6. *What are the CUF Model's key strengths?*
 - i) Its ability to simulate the cumulative, intra-jurisdictional effects of local land use controls.
 - ii) Its ease of use for county-wide planning and alternatives analysis.
 - iii) The ease with which different regulatory scenarios and alternatives can be tested and visualized.
 - iv) The model's stability and flexibility over a large range of scenarios
 - v) The ease with which the model results will support fiscal, transportation, and environmental impact assessment.
 - vi) The usefulness of the model data for local general planning.

7. *What are the CUF Model's key limitations?*
 - i) Its exclusive focus on housing development.
 - ii) The simplistic way that it handles "infill" development.
 - iii) Its inability to reliably predict the effects of specific infrastructure investments.
 - iv) Its inability to model how a shortage of development opportunities may impact the long-term price of housing.

8. *How costly is it to use the model, and to keep it in running order?* Once it is set up, the cost of running an additional scenario is fairly low. Keeping the data on which the model is based fully up-to-date for all nine counties would require additional staff personnel.

NOTES

¹For a fuller explanation of the workings of the UF model, see: Landis, et al., 1993; and Landis, 1994.

²Cities can, however, annex parcels which are beyond their sphere-of-influence boundaries (subject to LAFCO approval), and then rezone such parcel to either higher or lower densities.

³Densities are limited to one unit per forty acres, or one unit per eighty acres, depending on the agricultural designation in the Solano County General Plan.

⁴Every city's general plan categories, zoning designations, and density limits are different. Allowable residential densities in an R-1 district in Sonoma, for example, may be different than allowable residential densities in an R-1 district in Petaluma. To insure consistency between cities (and to facilitate the spillover allocation process), we developed a common land use categorization and density system based on the sonoma County General Plan. An R-1 district in Sonoma and an R-1 district in Petaluma, for example,, are both re-classified as RL (Low-density Residential), the designation used in the Sonoma County Plan.

The following land use designations and gross residential density ranges are used throughout Sonoma County for growth allocations based on the existing General Plan:

<u>Land Use Designation</u>	<u>Residential Density Range (persons/sqKM)</u>
Commercial (C)	2,500
Diverse Agriculture (DA)	6.25 to 12.5 depending on the jurisdiction
Grazing (G)	500
Industrial/Office (IO)	2,500
Locally Extensive Agric (LEA)	.5 to 2.5 depending on the jurisdiction
Low-density Residential (RL)	500
Mod.-density Residential (RM)	1,500
High-density Residential (RH)	2,500
Rural Resource (RR)	83.5-125 depending on the jurisdiction
Urban Residential (UR)	1,500

The effect of using a single countywide set of general plan allocation densities will be to underestimate the amount of development which may be accommodated in cities with higher average densities (e.g. Santa Rosa), and to overestimate the amount of development which may be accommodated in cities with lower average densities (e.g. Healdsburg).

⁵The countywide allocation densities used to allocate growth under existing general plans are well below the housing densities proscribed in Santa Rosa's current general plan. As a result, the model results may overstate the amount of spillover exported from Santa Rosa, particularly in Scenarios Two and Four. See note 4 for a fuller explanation.

⁶As it does not yet have an approved general plan, Windsor's development is currently guided by the County's General Plan.

⁷See notes 4 and 5 for a fuller explanation of this result.

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