### Title
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**How to concretize research on the coupling of ecosystems to human action? The case of plant communities in settlements**

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**Abstract**

Recent ecological studies have integrated human actions as a relevant dimension for maintaining ecosystems and current evolutionary processes. However, most of them rely on indicators which are subject to critical scrutiny in sociological discourse since the 1980s. Therefore, we bring the concept of style up to discussion. Analysing the styles of living can be considered as a strategy to understand the coupling of society to nature.

We examine our assumption in an interdisciplinary approach to urban ecology and landscape research aiming to explain the distribution of native and alien plants and its interaction with urbanization. In a tentative outline we determine four dependent species-related variables in 67 settlements near Frankfurt/Main (Germany). As predictor variables we use geological, habitat-related and infrastructural parameters and also variables based on observed styles of acting and living. The findings indicate that lifestyles, garden styles and spatio-temporal action patterns strongly influence plant species composition in settlements.

**Keywords:** human-environment interaction, lifestyle, plant distribution, plant biodiversity, urbanization, urban ecology

## Introduction

Current ecological systems and evolutionary change cannot be understood without integrating human activities conceptually into ecological reasoning and research. Therefore, the coupling of human and natural systems has become a major strand of recent ecological studies. By considering men as part of a world of co-evolving systems, ecological research often faces complex stories with mutual and varied cause-effect-relations, feedback loops and self-amplifying processes as (see e.g. Bunge 1979; Garnsey et al. 2006, Liu et al. 2007). While many researchers, especially in the field of land use and in urban ecology (Vitousek et al., 1997; Roy et al. 1999; Hill et al. 2002; Liu et al. 2003), accept the challenge and explore the coupling of ecosystems to human action, they barely investigate actions itself. Perhaps, the diversity and creativity of human action as well as sociological discourse appear to them as too elusive. Hence, they draw their conclusions mostly without neither conducting systematic research on society nor considering the standards of sociological knowledge.

Analyses of plant biodiversity, for example, show surprisingly that urbanized areas harbour more species than rural areas of similar size (Pyšek 1993; Marzluff 2001; Hope et al. 2003; Kühn et al. 2004; but see also Kowarik 1995; McKinney 2002; Deuschewitz et al. 2003). This phenomenon is often attributed to an increase of new species to a region, so called neophytes. Cities are viewed as hot-spots for the arrival and establishment of neophytes (Kowarik 1990; Pyšek 1998; Pyšek et al. 2003; Ottich 2004), which can exceed the number of native taxa and archaeophytes lost due to human activities (Roy et al. 1999; Hill et al. 2002; Chocholoušková & Pyšek 2003; Thompson et al. 2003). Additionally, some authors emphasize that cities are characterized by special climate (e.g. "heat-island" effect; McKinney 2002; Pickett et al. 2001; Wilby 2006) and by distinctive "city habitats" (Kowarik 1995; McDonnell et al. 1997; Pyšek 1993). Furthermore, socio-economic factors play a role in determining the patterns of plant community composition in settlements (Alberti et al. 2003; Grove et al. 2006a, Grove et al. 2006b; Liu et al., 2007; Pyšek et al., 2004; La Sorte & McKinney, 2006). In general, wealth has to become identified as the most influential driver. Since the income of households can be connected with increasing leisure time, it can be concluded that people are investing more time in estate- and plot-tending practices (Grove et al., 2006a; Hope et al., 2003). Therefore, the disappearance of plant species from settlements is due to a human obsession with order and tidiness (see also Sukopp 1983; Ludwig 1987; Ludwig 1991; Dechent 1988; Otte 1988; Brandes and Griese 1991; Züghart 2002).

However, this conclusion must be subject to critical scrutiny. Sociologists have pointed out since the late 1980s that in modern societies the pattern of social strata is scattered (e.g. Bourdieu 1984; Beck 1992; Spellerberg 1996). The level of education of a person, its income and its position in the prestige structure of society are not intertwined anymore. Therefore, we can not conclude from high income to much leisure time and related activities. Income might be a good measure, but the action patterns connected with a high or a low income are not evident. Furthermore, we have to take into account that modern societies are differentiated not only in horizontal but also in vertical dimensions. Certain groups of blue and white collar workers have an equal income, but differ strongly in their conduct of life.

In our study, we assume that the concept of style provides research strategies to integrate human activities adequately into ecological studies. According to this concept every unit action could be interpreted as an expression of a style that differs from other styles. The best known application of this concept is the concept of lifestyles (Jetzkowitz et al. 2007; Bögenhold 2004; Schneider and Kasper 2003; Luedtke 1989; Bourdieu 1984), but we stress that the concept can also be applied to particular aspects of human practices.

Styles of action can be defined as regular patterns of behaviour, which represent structural conditions of society as well as social affinities and individual decisions (e.g. Spaargaren and VanVliet 2000). A reliable construction of styles of action refers to observations on three levels (Jetzkowitz et al. 2007: 152; Luedtke 1989): (1) Action always includes an expressive and distinctive dimension. Although they do not intend, people stylise themselves and distinguish themselves from others by their actions. (2) Action always refers to the social dimension of the way of living. It concerns itself with the people with whom contact is maintained, with a view to uncovering the social networks in which people operate. (3) Action is always oriented by symbols, values and ideas of norms according to which people organize what they are doing.

We explore our assumption addressing a central problem of urban plant ecology. While on the one hand it is generally uncontested that the species composition of the flora in settlements is influenced by tendencies in social development and changes in human lifestyles (see Hard 1998), it is still vague how to depict urbanization as a social process on the other hand (McIntyre et al. 2000; Dow 2000; McDonnell et al. 1997). Often areas are described as "urbanized", if they exhibit a high proportion of urban land cover. In most studies, the process of urbanization is only described as an increase or a high proportion of urban land cover (see Roy et al. 1999). Therefore, a change of species composition as reported for urban areas seems to be linked to high degrees of urban land cover.

We consider a depiction of urbanization as a test for our idea to integrate human activities as co-evolving structures into ecological studies. Can the coupling of plant communities in settlements to human activities be studied and perhaps also explained by styles of acting and living?

## Methods

### Study area

The study was carried out in the region of *"Wetterau*", which is situated north-east of the conurbation of Frankfurt / Main (state of Hesse, Germany). The study area is dominated by agriculture, in most cases on loess soils, while the villages and small towns are mainly populated by commuters. The southern parts of the area are functionally interlinked with the economic entity of the Rhein-Main-region. To examine the pattern of species composition in 67 selected settlements, we tested the influence of 35 explanatory variables (infrastructural-, habitat-, sociological variables and a geological variable) on four dependent species composition-related variables.

### Field data and classification of plant species

To investigate the composition of plant species in the selected 67 settlements and determine the dependent variables, species were recorded on transect routes. Every occurrence of a certain species in a corridor of 5 m left and right of the route was counted. Stands of plant species were considered if they were at least 10 m away from the next occurrence of the same species. Therefore, a large, homogeneous patch of a single plant species was counted as one occurrence.

According to the different size of the settlements, the transect routes varied between 1200 m and 22,150 m. In order to compare the species composition regarding species richness and proportion of archaeophytes/natives and neophytes/urbanophytes, both simultaneously and independently of the transect length, the dependent variables we analysed were the “residuals of recorded to expected total species richness“, “residuals of recorded to expected species richness of neophytes“, “residuals of recorded to expected species richness of archaeophytes and natives“ and the “ratio of neophytes and urbanophytes to archaeophytes and natives“. The “residuals of recorded to expected total species richness“ were determined by drawing up a “species transect length relationship” for the plant species richness of all 67 surveyed settlements of the study area. The “residuals of recorded to expected total species richness“ for a settlement with a particular transect length is constructed by dividing the number of species actually found at this transect length by the expected level at this length, which is provided by the “species transect length relationship” of the entire study area. The “residuals of recorded to expected species richness of neophytes“ and the “residuals of recorded to expected species richness of archaeophytes and natives“ are constructed in the same way, with the exception that here a selection of 14 “flagship species”, which are especially characteristic for the study area, is made for each of the two groups.

The ratio of neophytes and urbanophytes to archaeophytes and natives was determined by designating recorded species either as neophytes (species which have appeared since 1500 AD) and urbanophytes as one group (hereafter called NU), and archaeophytes (which appeared before 1500 AD) or natives (hereafter called AN), which were typical for rural settlements in former times, as the other group. The classification was done according to the “BioFlor”-database (Klotz et al. 2002) and, regarding urbanophytes, (only *Hordeum murinum* and *Lactuca serriola*) after Wittig et al. (1985) and Hard (1998). This division into the two groups is well-established in European botanical research (Pyšek 1998; Dow 2000; Pyšek et al. 2003). The impact of human behavioural patterns in settlements should be strongest on ruderal plant communities. Therefore, in analyzing the ratio of NU to AN, native and

archaeophyte species which were according to Grime et al. (1988) and to the "BioFlor"-database (Klotz et al. 2002 ) not "ruderal" were omitted from all analyses.
Taxa which could not be easily determined in the field, like e.g. the genus *Arctium*, were also not considered in the analyses regarding "residuals of recorded to expected total species richness" and "ratio of NU to AN".

**Site variables**

The infrastructural variables were "building activity" (yes/no), "presence of farmland" (yes/no), "presence of infrastructure " (yes/no, occurrence of banks, post office, hairdressing salons, convenient stores, etc.), "public transport connections " (good/bad; good=less than 40 min to Frankfurt central station), "transport connections to Frankfurt by car" (good/bad; good=less than 40 min to Frankfurt central station), "demographic development over the last 30 years "(decrease, increase up to 50%, increase up to 100%, more than 100%), "distance from Frankfurt city limits" (Km) and "number of inhabitants".
The geological types of the study area were aggregated into the classes lime, sandstone, shale, loess, basalt, alluvium (clay, sand, gravels etc.). The geological diversity was calculated as number of the classes beneath each transect in the respective settlement according to the 1:25.000 geological survey maps of the study area "Wetterau".
The habitat variables in each settlement were measured as "size of habitats (potentially) suitable for weeds (m²)" / 1000 m transect, the "number of dead stands of weed due to herbicide applications" / 1000 m transect (hereafter called "frequency of herbicide application"), "frequency of outdoor animal husbandry" (horses, cattle, sheep, goats, poultry) / 1000 m transect. Suitable habitats were classified by the presence of species of the ruderal phytosociological groups Sisymbrion officinalis, Eragrostion, Chenopodion rubri, Fumario-

Euphorbion, Arction lappae and Polygonion avicularis (see Oberdorfer 1983; Ellenberg 1996). Not considered were habitats which were totally dominated by stands of *Urtica dioica* or shrubs like *Sambucus racemosa*. In the application of herbicides, no distinction was made between the individual substances (for example, an herbicide like “Round up“ or the more traditional application of salt). The sole deciding consideration was that the stands could be classified clearly and definitively as dead (brown or yellow). Stands in which the spraying or salting had taken place a long time ago where not counted.

**Sociological data and variables**

The sociological variables were “dimensions of everyday life“ of the inhabitants. These were constructed by aggregating data of a representative survey of households in the study area as follows.

The raw data were collected in standardized interviews with 1358 people (representatives of their households) in the aforementioned 67 settlements. Since the sample of households has to be representative for their impact on land use and mobility, we constructed our sample by random sampling on the same transect routes where the data on the plant species were collected. The focus of the questionnaire was placed on data concerning the lifestyles of the households in general, patterns of gardening and the mobility patterns of the individual members of the household. On the basis of these data, three independent typologies of lifestyles (Tab. 1), garden styles (Tab 2) and Spatial-Temporal Action and Movement Patterns (STAMPs) (Tab. 3) were constructed according to the concept developed by Jetzkowitz et al. (2007). The SPSS programme module Quickcluster was employed here, which is based on an interactive partioning algorithm. Every household was classified in its lifestyle, garden style and mobility style. Afterwards, all three classifications are subject to a homogeneity analysis (which is also described as a multiple correspondence analysis). The homogeneity analysis (acronym HOMALS – homogeneity analysis by means of alternating least squares) enables the analysis of several categorical variables. It maps the style categories onto dimensions which represent the conduct of everyday life. We refer to them as "dimensions of everyday life" or DEL. Thereby, for every dimension expressed in the respective household a metric value was obtained. In order to aggregate these values from the level of households onto the level of settlements, the mean value for every dimension in each of the 67 settlements was calculated.

**Statistical analysis of all variables**

On the level of the 67 settlements, *multiple linear regression analyses* were calculated to explain the dependent species composition-related variables "ratio of NU to AN", "residuals of recorded to expected total species richness", "residuals of recorded to expected species richness of neophytes" and the "residuals of recorded to expected species richness of archaeophytes and natives" (as well as, in a separate analytical stage, the frequency of herbicide application as an independent variable). As independent predictors the already mentioned categorical variables "construction activity", "presence of farmland", "presence of service infrastructure " etc. were considered in the analyses. The independent metric predictors were "demographic development", "distance from Frankfurt city limits", "number of inhabitants", "geological diversity", "frequency of herbicide application", "frequency of outdoor animal husbandry", "size of habitats potentially suitable for weeds" as well as metric values of the constructed DEL. The regression model which explains the greatest amount of total variance of the respective dependent variable was selected. The gradual inclusion of the predictor variables within the regression model was selected as the procedure, with inclusion occurring in the case of a significance value of under 0.05, exclusion in the case of a value of over 0.10.

**Results**

The multiple linear regression analysis yielded the following results for the dependent variable “residuals recorded to expected total species richness”. The model which explains the greatest amount of total variance pointed to two DEL and two structural variables as significant predictors (Tab. 4). An everyday life with a rhythmical and centre-orientated pattern of spatial use provides the greatest explained variance. This demonstrates how people use their subjectively defined habitat, like commuters who travel from their respective places of residence to their places of work. The dependent variable “residuals of recorded species richness of neophytes to expected species richness of neophytes“ does, however, correlate positively with a smaller distance from Frankfurt and a higher number of inhabitants (Tab. 5). For the “ratio NU to AN”, the model with the best explanation of total variance identifies as the most important explanatory variable the “frequency of herbicide application” (incl. salting), with a significant negative correlation (Tab. 6).[1] The DEL, which describes the relations within the local social structures, is selected in this model as the second variable and shows a significant negative correlation. The correlation between the DEL, on the other hand, which represents a high intensity of gardening practice, together with a good connection to Frankfurt via regional public transport, and a high proportion of neophytes in the ratio NU to AN, is significantly positive. Social circumstances support frequent weed control (Tab.7). Following range of ratios NU to AN were recorded: the highest number of NU-species to one species of AN could be found in the town Friedberg and the spa town Bad Salzhausen (1.88

[1] As the “residuals of recorded to expected species richness of archeophytes and natives” is explained in the regression model with the same variables as the central variable “ratio NU to AN”, we will not be discussing the results individually.

and 1.67), the lowest proportion occurred in rather rural villages such as Trais and Obbornhofen (0.58 and 0.50).

## Discussion

*Change of species composition along the rural to urban gradient: Is distance a causal factor?*

Some studies point to a strong correlation between the distance of a settlement from an urban centre and changes in species composition, along an urbanization gradient (Marzluff 2001; McKinney 2002). It is often reported in this context that more neophytes can be found the closer the settlement is to an urban centre (Dechent 1988; Pyšek 1998). Our investigations support this positive correlation between a high species richness of neophytes and proximity to Frankfurt am Main. We suppose that distance can be interpreted as the cause of this spatial distribution, only if dispersal processes alone are responsible for the species composition. It can be assumed, however, that other factors, for example, societal factors, also play a significant role (McDonnell et al. 1997; Hope et al. 2003). Particularly worthy of consideration are all those aspects of human behaviour which can alter the habitat of the settlement vegetation, such as the management of the garden or piece of land, or the mobility behaviour of inhabitants. These behavioural aspects have different manifestations in urban centres of population and in rural settlements.

*What influence do societal factors have on species composition in settlements?*

For the dependent variable “residuals of recorded to expected total species richness“, the model which explains the greatest amount of total variance (see Tab. 4) pointed first to a DEL which demonstrates how people use their subjectively defined habitat. This means that people's behaviour is subject to distinct rhythms of space use which are organised from a habitual central point (place of residence). Commuters, who travel from their respective places of residence to, for example, Frankfurt am Main, exhibit such behavioural patterns, as also do people who tend their own fruit and vegetable garden. Such behavioural patterns foster species richness, whereas forms of behaviour which are erratic and lacking a spatial center has a negative influence on these variables. This finding is supported by the fact that the DEL reflecting the mobility in human behaviour occupies the third place in the explained variance in the model. Dynamic forms of lifestyles occur in the case of, for example, young people or commuters, who typically have a high degree of mobility in their occupational and leisure routines (for example schoolchildren). Our model also demonstrates that the "presence of farmland" and the "service infrastructure" (bank, post office, hairdressing salon, etc.) present in a settlement have positive effects on the species richness. If both are present in one settlement, this is indicative of a diversification of socioeconomic relations.

The settlement with the highest species richness in the area of investigation exhibits, for example, a large number of neophytes and, at the same time, a large quantity of ruderal native plants and archaeophytes. In this settlement (with 34 inhabitants) there is a large estate which is cultivated in a conventional manner. A kind of free thinker's colony, which is independently active in various artistic and therapeutic areas, has been living adjacent to the estate since the 1970s. Due to the small number of inhabitants and the various mobility patterns and lifestyles that are in operation (on the one hand, traditionally agricultural and, on the other, urban and modern), the settlement is characterized by a high degree of socioeconomic diversity.

It is evident that the diversity of plants and the species richness are strongly determined by the mobility patterns of human beings. Dispersal processes certainly play an important role.

Several studies have demonstrated that people and vehicles can function as distribution vectors (see Bonn & Poschlod 1998; Von der Lippe et al. 2007; 2008). However, behavioural patterns in the settlement (estate maintenance, garden design) and certain factors that are linked to agricultural use also seem to control the species composition and the species richness of the settlements. The essential factor, however, is not, as many authors have assumed (Otte 1988; Brandes and Griese 1991; Lienenbecker and Raabe 1993), the presence or loss of suitable habitats. The variable "size of habitats potentially suitable for weeds" does not correlate either with the "residuals of recorded to expected total species richness" or with any other dependent variable.

A connection between the distance of a settlement from Frankfurt and the species richness is not supported by our data. The "residuals of recorded species to expected species richness of neophytes" do, however, correlate positively with a smaller distance from Frankfurt (see Tab. 5). This could be linked, on the one hand, to the fact that "ground related" vectors only play a minor role in the dispersal of the relatively numerous wind-distributed neophytes (see Klotz et al. 2002: 26). On the other hand, the human patterns of behaviour in operation in a settlement maybe of greater importance for native plants and archaeophytes than dispersal processes.

After a positive significant correlation with the number of inhabitants, which indicates that neophytes are more common in larger settlements and towns, the regression model also identifies a DEL as a further important explanatory variable. It describes the extent to which people formatively influence the surroundings of their place of residence by, for example, tending their estates and gardens, clearing areas and so on.

The dependent variable "ratio of NU to AN" is negatively correlated with the frequency of herbicide application (see Tab. 6). The lower the frequency of herbicide application (including salting) on weeds, the greater the proportion of NU. The higher the frequency of herbicide application, the greater the proportion of ruderal AN. This contradicts the commonly held view that a certain “fanaticism about tidiness and order” is responsible for the decline in a previously typical village ruderal flora, consisting of archaeophytes and native plants (Dechent 1988; Brandes and Griese 1991; Züghart 2002). These results rather indicate that the ruderal AN are dependent on disturbances which clear the habitat of every kind of vegetation and thus create a temporary absence of competition and suitable niches for seeds. If such interventions do not occur, many types of ruderal species, which are less able to compete, are suppressed by more competitive and persistent species such as *Urtica dioica*, which prefers the same habitat (Cornelius 1989; Lienenbecker & Raabe 1993; Otte 1996).

The positive correlation between a DEL, which primarily describes gardening practices, that is to say, practices in the care of potential habitats, and a high proportion of NU supports the evidence of a relationship of dependence between less intervention and a high proportion of neophytes. “Laissez-faire” gardening practices represent a positive characteristic of this DEL; here little interest is shown in the garden, it is barely tended and the lawn is mown once a year at the most. More competitive species which are less tolerant of interventions will benefit. Such patterns of behaviour can also be found, for example, among teachers, who allow everything to grow because of personal conviction, as well as among bank employees who work in Frankfurt and do not have the time or motivation to tend their gardens.

The DEL, on the other hand, which describes how the inhabitants of a settlement participate in local social structures, correlates negatively with a high proportion of neophytes. The more regular their participation in local life, for example, by belonging to a club or an association or being involved in local politics, the smaller the proportion of neophytes. Those who regularly take part in the life of the local community conform behaviourally to its norms and standards of tidiness, also when tending their gardens and estates. This benefits the archaeophytes and native plants. The good transport connections, on the other hand, contribute to a high proportion of neophytes via dispersal-related processes, as already mentioned.

The ratio NU to AN does not seem to be affected significantly by the “size of habitats potentially suitable for weeds”, the “number of inhabitants”, the “distance from Frankfurt” or the “geological diversity”. A high frequency of weed control practices (like, e.g. herbicide application and salting) as an intervention factor seems to be one of the main reasons for the continuity of a ruderal native species and archaeophytes.

*How lifestyles determine the species composition of settlement flora*

The frequency with which weeds are sprayed with herbicide or salted and, therefore, eliminated seems to have a decisive influence on the species composition of settlement flora in the locations of the study area, particularly with regard to the NU and AN ratio. However, what lies behind the frequency of herbicide application? The causal relationship on which it is based on becomes particularly clear when we consider the explanation of the “ratio of NU to AN”. The use of weed-killers in the maintenance of public, semi-public and private areas has the strongest causal influence on the “ratio of NU to AN”. Therefore, weed control practices seem to contribute to the continued presence of archeophytes and native plant species. However, this proximate cause requires an explanation. Weed-killers are not applied by themselves. With a further multiple regression analysis (Tab. 7), we can explain what social circumstances are at work here: in settlements, where people are bound to their place of residence in a concrete manner and integrated into the local social structures, where they also participate regularly in these social structures and behave according to their norms, as well as consciously exercising a formative influence on their surroundings, herbicides are used particularly frequently. Here we see the traditional formation of a community exhibiting “traditional” everyday life, which are characteristic for compact, rural settlements, and which does not make a strict separation between the private and public sphere and is, therefore, transferred as a social control onto gardens and estates. In other words, those who have an abstract, detached relationship with their place of residence and are unconcerned by the habitual practices of ground maintenance, do not create conditions of habitat and intervention that consequently benefit species of archaeophytes and native plant species.

The results of the investigation show that biodiversity parameters such as species composition and species richness of plant communities in settlements are to a significant degree dependent on the intended and unintended consequences of human behavioural patterns. These patterns are embedded in everyday life. Conduct of life, which can be characterized as sub-urbanized (e.g. high and rhythmic mobility, abstract and detached relationship with place of residence, “laissez-faire”-style in gardening practices) seem to promote NU-species, more traditional everyday life support the prevention of AN-species from disappearance.

Styles, even lifestyles, are just as subject to social change as the forms of agricultural production and the conversion of rural to urban areas. The interaction of these various factors creates and changes the settlement flora and makes up a large part of the process referred to as urbanization.

**Conclusions**

Our analysis supports the assumption so far that the concept of style can be considered as an appropriate tool for valid and reliable data sampling on types of human conduct of life. It is not a secret of social scientists that “typification, perceiving the world and structuring it by means of types and typologies, is (…) an essential and intrinsic aspect of the basic orientation of actors to their situations” (McKinney 1969: 1). Insofar the concept of styles provides guidelines to reconstruct similarities in the varieties of acting and living, which are meaningful to people, the constructed types are for the most part consistent with existential types, that are the types constructed by participants of a society under consideration (see Schütz 1954).

Although we stress that at present our data analysis is tentative and further statistical analyses and modelling are needed (Brunzel et al. forthcoming; Niggemann et al. submitted), we consider our typologies of lifestyles, garden styles and STAMPs as relevant relevant for ecological studies which focus on urbanization and urban ecology. Up to now the concept of style is little-noticed in landscape research (see Meeus and Gulinck 2008). We presume this will change, if our study proves that style typologies can not only function as the *explanandum* (deHaan et al. 2001), but also as the *explanans* in explanations of concrete couplings of ecosystems to human action.
A critical point is that data sampling for a complete typology of lifestyles requires a lot of resources. However, focussing on particular styles of action can be appropriate not only in respect to cost-effectiveness questions, but also to the objectives of a study. Sometimes the styles of city management or national or international policies are presumably more influential on shifts in biodiversity than the styles of everyday life (Kinzig et al. 2005). In any case the concept of styles provides a methodology for data sampling and processing which furthermore should be tested on validity and reliability. The effort seems to be worthwhile, since styles of action substantiate on the one hand the consequences of social organization on biophysical spheres and on the other hand the benefit of ecosystem services which nature provides (Lyytimäki et al. 2008).

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Tab. 1: Typology of lifestyles

| No | Lifestyle | Percentage | Characteristics |
|---|---|---|---|
| 1 | Unconventional and active | (17%) | Participation in diverse activities, integration of elements both from 'high' and 'low' or 'trivial' culture, or elements causing cultural tension<br>Affinity with entertainment technology<br>High frequency of extra-familial social contacts<br>Rejection of system- and tradition-related values |
| 2 | Established citizens | (14%) | 'High' cultural activities<br>Extensive use of technology to equip and safeguard homes (homeowners)<br>Active members of societies<br>Orientation to the community and general public<br>Rejection of hedonism in favour of community values |
| 3 | Big kids | (11%) | Pleasure-oriented activities, particularly outside the home<br>Affinity with modern work-saving household technology<br>No membership of societies, friends as preferred social contacts<br>Orientation to hedonistic values, but also traditional and system-oriented attitudes |
| 4 | Local elite | (6%) | Broad spectrum of activities<br>Technically well equipped<br>Pronounced political involvement<br>Membership of numerous societies<br>Orientation to the general public and community<br>Values: traditionalism and individual responsibility |
| 5 | Self-focused and searching | (10%) | Exhilarating activities outside the home, but also domestic withdrawal<br>A large amount of entertainment technology, otherwise below-average technical equipment<br>No membership of societies, friends and colleagues and preferred personal contacts<br>Emphatic rejection of family and community control<br>Values: hedonism and social individualism |
| 6 | Sociable and rooted in the locality | (17%) | Diverse 'Low/trivial' cultural activities<br>Extensive technical equipment<br>Membership of local societies<br>Neighbours and other society members as person contacts<br>Orientation to community, high importance placed on career and profession<br>Traditional and conventional values, but also hedonistic attitudes |
| 7 | Deprived and domestic | (10%) | Limited spectrum of activities, virtually no activities outside the home<br>Below-average technical equipment<br>Few society memberships<br>Only family members as contacts for interaction<br>Emphasis placed on family and community<br>Traditional and system-related values |
| 8 | Retiring and family-centred | (15%) | Domestic activities<br>Homeowners with above-average entertainment technology and household equipment<br>Few society memberships<br>Only family members as contacts for interaction<br>Little orientation to outside the home, retreat within nuclear family<br>Rejection of general values, concentration on welfare of the family |

Tab. 2: Typology of garden styles

| No | Garden Style | Percentage | Characteristics |
|---|---|---|---|
| 1 | The garden as a retreat and place of relaxation | (17%) | Equipment for relaxation<br>No vegetable patches<br>No equipment suitable for children<br>No use as a playground for children<br>Use for relaxation and for gardening |
| 2 | The lawn garden as a damn duty | (13%) | Lawn as a dominant element of garden design<br>Ideology: The garden is a labour-intensive duty<br>No use for gardening<br>No garden decoration or other distinguishing equipment |
| 3 | The traditional cultivated kitchen garden | (8%) | Extensive vegetable patches<br>No or less lawn<br>Ideology: The garden must be used traditionally<br>No or less use for relaxation or for partying<br>Gardening equipment |
| 4 | The flower garden as an idyll | (4%) | Extensive flowerbeds<br>No or less lawn<br>Ideology: The garden should be a sea of flowers<br>No or less use of the garden<br>Decorative equipment |
| 5 | The representative garden for various events | (6%) | Event equipment (e.g. swimming pool, brickwork grill)<br>Use for partying, for relaxation and for gardening |
| 6 | The paved garden for diverse use | (7%) | Extensive paving<br>No or less vegetable patches and lawn<br>No equipment for gardening<br>Rejecting ideology: The garden must be used traditionally<br>Diverse use except for gardening |
| 7 | The family garden with equipment suitable for children | (14%) | Equipment suitable for children<br>Use as a playground for children and for doing sport |
| 8 | The all-purpose garden including traditional used vegetable patches | (17%) | Ideology: The garden must be used traditionally<br>Gardening equipment<br>Above-average vegetable patches<br>Diverse use (including tradesman's work, playground for children, etc.) |

Tab. 3: Typology of Spatial-Temporal Action and Movement Patterns (STAMPs)

| No | STAMP | Percentage | Characteristics |
|---|---|---|---|
| 1 | Bound to urban life | (8%) | Leisure mobility to Frankfurt or another city in the region<br>Employment in Frankfurt |
| 2 | Commuting for work | (8%) | Employment in Frankfurt |
| 3 | Home-bound | (15%) | Working at home<br>No or less vacations<br>Garden as preferred leisure location |
| 4 | Mobile without relation to the locality | (10%) | Working in the region<br>Weak attachment to the locality |
| 5 | Employment in the locality | (12%) | Employment on the spot<br>Not working at home or in the region |
| 6 | Mobile for retreat | (18%) | Working at home<br>Many vacations<br>Leisure in the garden |
| 7 | Employment distantly | (9%) | Employment outside the region<br>Above-average distance to work place |
| 8 | Bound to the locality and the region | (13%) | Employment in the region<br>Family in the vicinity of the place of residence<br>Strong attachment to the locality |
| 9 | Immobile | (8%) | Staying at home |

Tab. 4: Multiple regression analysis with the dependent variable “residuals of recorded to expected total species richness” in 2003. Model which explains the greatest amount of total variance ($R^2$=0.366). For explanations of DEL’s see text.

| | Standardized coefficient ß | T | **P** |
|---|---|---|---|
| DEL: pattern of spatial use is rhythmical and centre-orientated | 0.405 | 3.474 | =0.001 |
| Occurrence of farms | 0.509 | 4.316 | <0.001 |
| DEL: pattern of spatial use is characterised by high and dynamic mobility | 0.276 | 2.677 | =0.010 |
| Occurrence of service infrastructure | 0.281 | 2.384 | =0.020 |

Tab. 5: Multiple regression analysis with the dependent variable “residuals of recorded species richness of neophytes to expected species richness of neophytes“ in 2003. Model which explains the greatest amount of total variance ($R^2$=0.649). For explanations of DEL’s see text.

| | Standardized coefficient ß | T | **P** |
|---|---|---|---|
| Distance to Frankfurt | -0.585 | -6.786 | <0.001 |
| Number of inhabitants | 0.388 | 4.565 | <0.001 |
| DEL: pattern of spatial use without estate-shaping influence | -0.224 | -2.815 | =0.007 |
| DEL: pattern of spatial use without local / regional activities | 0.158 | 2.015 | =0.048 |
| DEL: pattern of gardening practice is characterized by a low intensity / “laissez-faire” gardening practice” | 0.157 | 2.005 | =0.050 |

Tab. 6: Multiple regression analysis with the dependent variable “ratio NU to AN“ in 2003. Model which explains the greatest amount of total variance ($R^2$=0.703). For explanations of DEL’s see text.

| | Standardized coefficient ß | T | **P** |
|---|---|---|---|
| Number of herbicide applications (incl. salting) / 1000 m transect | -0.389 | -4.918 | <0.001 |
| DEL: relationship to the local social structure is characterized by regular participation | -0.301 | -3.694 | <0.001 |
| DEL: pattern of gardening practice is characterised by low intensity / “laissez-faire” gardening practice” | 0.262 | 3.716 | <0.001 |
| Public transport to Frankfurt | 0.302 | 3.627 | =0.001 |

Tab. 7: Multiple regression analysis with the dependent variable “Number of herbicide applications (incl. salting) / 1000 m transect”. Model which explains the greatest amount of total variance ($R^2$=0.370). For explanations of DEL’s see text.

| | Standardized coefficient ß | T | **P** |
|---|---|---|---|
| DEL: Not bound to the place of residence | -0.400 | -3.525 | =0.001 |
| DEL: relationship to the local social structure is characterised by a low degree of integration | -0.300 | -2.914 | =0.005 |
| DEL: relationship to the local social structure is characterised by regular participation | 0.272 | 2.340 | =0.023 |
| DEL: pattern of spatial use with estate-shaping influence | 0.214 | 2.083 | =0.041 |