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Forest Policy and Economics 6 (2004) 3–13

Forest Policy and Economics

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Are urban green spaces optimally distributed to act as places for social integration? Results of a geographical information system (GIS) approach for urban forestry research

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Received 19 December 2001; received in revised form 22 July 2002; accepted 29 July 2002

Abstract

The objective of this ongoing research is to analyse the social potential of urban green spaces to create opportunities to integrate youths, elderly people, foreigners, unemployed and other social groups into the urban life of large Swiss agglomerations. Urban green-space data are linked with social demographic data for these particular social groups. Three large cities in the different language regions of Switzerland have been selected for a comparative study: Geneva (French-speaking), Lugano (Italian-speaking) and Zürich (German-speaking). The green-space data derived from *vector25*, the digital landscape model in a vector format of the Swiss Federal Office of Topography, and the social demographic data from the 1990 Swiss census are compiled for further processing with the geographical information systems ARCINFO and ARCVIEW. In this way, a contribution to the development of a GIS-based research methodology is made. The goal of this approach is to obtain a highly aggregated planning tool for urban forestry and green-space development.

Keywords: Social integration; Urban green spaces; Urban forestry; Geographical information system (GIS)

1. Introduction

The objective of this research is to analyse the potential of urban green spaces to provide opportunities to integrate youths, elderly people, foreigners, unemployed and other social groups into the urban life of large Swiss agglomerations.

City dwellers are not a homogeneous category and hence have different needs and perceptions of urban green space. Furthermore, prior research has shown that with particular minorities, such as handicapped people, green spaces can play an important social integrative role if adequately designed (Nicolè and Seeland, 1999; Chiari et al., 2000). It can be assumed that green spaces can also play this social integrative role with regard to other categories (CH-Waldwochen, 1996; Dwyer

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PII: S1389-9341(02)00067-9

et al., 1991; Sommer et al., 1994). However, to make the most out of this green-space potential, design and planning of these spaces have to consider the needs of different social groups (Schwab, 1993).

To gain a good overview of the subject, we divided our research into two parts. In the first part, a GIS analysis was carried out to analyse the distribution of green spaces in the three cities taken into account, Geneva, Lugano and Zürich, according to the presence of social groups to be investigated in their neighbourhood. The results of this part show the spatial distribution of the different social groups and of the green spaces.

In the second phase of the research project, the users of the green spaces will be interviewed to find out if, as we presume, an integration process takes place in the urban green spaces and, if it does take place, to gain an insight into the integration process itself. From the second part we expect better comprehension of the integration potential, as well as a concrete vision from the city dwellers on how to manage the green spaces to further enhance the potential for social integration of green spaces in the cities.

This paper focuses on the first part of our research and on its results. The following two sections contain an introduction to the actual situation of the city dwellers and of the urban green spaces, as well as the expectations of the former from the latter. Then follows a section on the methodology and theoretical approach of the GIS analysis. The paper ends with a presentation of the results, followed by the conclusion and an outlook.

2. The urban situation in Switzerland with regard to green spaces

In Switzerland, the urban population was almost 5 250 000 in 1997 and comprised more than 70% of the total population. Between 1930 and 1990 the number of urban inhabitants increased from 1 450 000 to 4 730 000 (Schuler, 1997). The development of built-up areas showed an increment of 43% between 1981 and 1993 (municipal areas, core cities and communes in the agglomerations surrounding the urban belt). If the rural regions located at the border of agglomerations are also taken into consideration, this figure would increase by a further 20% (Statistical Yearbook for Switzerland 1998, p. 66). Expenditure for spatial planning all over the country has increased from 104 7000 000 to 248 400 000 Swiss Francs between 1980 and 1996. Swiss cities spend millions of Swiss francs annually for forest and green-space management, for nature conservation measures and environmental and forest education. An improved knowledge base and a green-space policy more oriented towards specific target groups could contribute a to more efficient use of funds and ease pressure on urban budgets.

Green spaces in Central Europe are designed close to nature and include parks, gardens and forests in the vicinity of cities. Today, they are not always sufficient to meet the particular demands of various social user groups of an urban and suburban population and to supply suitable spaces for recreation and social events. The combination of designed green space with related services, however, supports the dynamics of supplying 'green products' in an urban environment according to standards of sustainability (Jacsman, 1994; Nowak, 1994; Hull, 1992). In the future, and that is the underlying hypothesis of the research reflected in this contribution, the attractiveness and acceptance of these products and services will dictate the political and economic legitimacy of urban green-space design and management.

It is important to emphasise the multifunctional use of trees, green spaces, parks and forests and draw the attention of city dwellers towards biodiversity, plant succession and the dynamics of rural areas, which may allow them to develop a more conscious attitude towards nature in their immediate surroundings (Gobster, 1992; Clark and Matheny, 1991). Therefore, it is essential to obtain a comprehensive picture of the perception and acceptance of trees, parks and forests in selected Swiss cities and their suburban belts. Well-being is expressed in a deliberate use of tree and green spaces according to one's needs that has long since become an indicator of the quality of urban life. The role of cities as focal points of cultural life has been supplemented by providing their inhabitants with green spaces designed close to nature. Multicultural residential areas showing a prefer-

ence for certain tree or other plant species and outdoor amenities are particularly important indicators for the wide-ranging meaning of a green environment (Moll et al., 1995).

In Switzerland, as well as in the European Union, the number of migrant workers, asylum seekers and foreign residents will presumably further increase or remain more or less stable at a high level, particularly in the major Swiss agglomerations. The demographic development in the service-oriented societies of mid-western Europe shows a trend towards further urbanisation, a remarkable increment of the number of elderly people and groups with special demands for a certain social infrastructure (e.g. disabled, drug addicts, poor people, asylum seekers, unemployed people, drop-outs, etc.), a decreasing tolerance for individual car traffic and a desire for close-to-nature recreation in or nearby cities.

With regard to these trends, there is a need for detailed information on urban forests, parks and trees on public and private land. An inventory aimed at providing data on the frequentation of certain close-to-nature areas by distinct social groups can better facilitate an appropriate design and planning of urban and suburban green spaces (Laverne, 1993). Local and regional traditions shape the natural surroundings and represent socio-cultural values, which deserve attention and should be respected for sustainable planning, use and management of nature in and close to the cities.

Urban resource management for recreation requires complex and interactive co-operation between all partners involved in design and planning (Dwyer et al., 1989). Within this given setting, urban forests and green spaces should provide the following functions and objectives:

- Recreation and well-being;
- Aesthetics;
- Nature and landscape conservation;
- Biodiversity preservation;
- Climate and hygiene;
- Wood production; and
- Food production (in small home gardens and garden colonies).

3. A brief look at key-points for urban forestry and green-space management today and in the future

In a workshop with the green-space administrators of Geneva, Lugano and Zürich and other green-space specialists that took place prior to the research in 1999, four main relevant arenas were distinguished: the political situation; the economic limitations of an urban administration; today's biophysical situation and its future development; and the socio-cultural change in urban environments, particularly with respect to multi-ethnicity, the demands of a majority of elderly people and of the young generation. The following collection of statements represents the major results of this meeting and was a starting point for an identification process for the green-space problem.

3.1. Political situation

The lack of interest in urban green space or its low priority on the local political agenda reflects a major problem: the image of the cities' green spaces is yet generally perceived as quite good by the public. However, local politicians are either not aware of the costs of maintaining these spaces at the high standards of management in operation almost since the late 19th century, or are not prepared to see the problems connected with the challenges to this concept under new social conditions. Due to the widespread cutbacks in the budgets of urban-green administrations, local politicians tend to allocate funds to more urgent problems and to projects where politically rewarding and immediate results are expected. Short-term popular measures at low costs are preferred rather than long-term measures to maintain the status quo of green-space management.

3.2. Economic situation

An important problem is the restricted economic situation of urban administrations. There is less money for an increased number of management objectives due to more intense use of urban forests, parks or green spaces in general. Over-aged trees are costly to replace, or a planting design with

many flowers, for instance, is particularly prone to vandalism (Moll et al., 1995; Ware, 1994). The employment rate in the sector of public green services is difficult to maintain at levels of previous prosperous times. There is a lack of continuity in the economic chain, as the costs are calculated on a short-term basis, whereas the benefits become evident in the long run (Nowak, 1993).

3.3. Biophysical situation

The biophysical situation is generally perceived as very good. This reflects efforts to maintain the quality of the urban forests, parks, street trees and other green spaces in cities at a high level, which is in line with the policy of recent decades. Nevertheless, the quality has to be increased, especially because of the hygienic and aesthetic role of trees, parks and forests to counterbalance pollution (Rowntree and Nowak, 1991), and beautifiers will possibly be more significant and prominent in public discourse in the future (Sommer and Sommer, 1989). Therefore, long-term planning has to be assured and future risks have to be considered (diversity in plant selection as a possible solution to prevent major plant pest and disease outbreaks).

3.4. Socio-cultural situation

The perception and acceptance of green spaces in and around cities is, generally speaking, satisfactory as far as the public opinion is concerned, but the majority of citizens seems to be either not very well informed about or indifferent to the maintenance costs of urban green spaces. The increased pressure on the different green spaces, as well as on urban forests and their infrastructure for recreational purposes is a challenge to the traditional concepts of maintenance. The present management concepts of the urban green-space administrations are not always adjusted to increased numbers of users and little is known about their preferences concerning urban forests and green spaces. A silent potential for conflict may thus arise from the low level of information, which could lead to a lack of interest or vandalism on the user's side. There are many individual users who are quite sensitive about changes in urban and suburban green management, such as vanishing old trees or flowerbed arrangements. There seems to be an increasing discrepancy between the citizen's symbolic perception of a park or a forest (what people like the forest or park to be) and its present condition (Kürsten, 1993). An important aspect is the green-space potential surrounding cities. Commuters, for instance, living out in the countryside may expect less green in the city, whereas city dwellers may visit the city's green areas on weekends.

4. Methodology and theoretical approach

With the GIS analysis, the question to be answered is whether urban green spaces are optimally distributed to act as places for social integration. Urban green-space data are linked with social demographic data for particular social sections of the society, which are to be integrated in public urban life. The green-space data derived from *vector25*, the digital landscape model of the Swiss Federal Office of Topography (http://www.swisstopo.ch/en/digital/VECTOR25/vec25.htm), and the social demographic data from the 1990 Swiss census were combined and compiled for further processing with the geographical information systems ARCINFO and ARCVIEW.

4.1. Definition of the study areas

The distribution of different social sections in the city has to be documented according to socio-demographic criteria, in order to identify green spaces with the highest social heterogeneity, and thus the highest social integrative potential.

Two problems arise in defining the study area. Firstly, the official boundaries of the municipality do not represent the actual spreading of the city. And secondly, the municipality boundaries of Lugano, Zürich and Geneva are not comparable, because Zürich, for example, has undergone a process of merger with adjacent municipalities. This process has not happened to the same extent in the municipality of Lugano, for instance.

As a solution to these problems, a demarcation of our study areas was made on the basis of the

Table 1
Population density of different types of dwelling areas (Switzerland)

Type of area	Population density (/ha)
Residential	
One-storey, small exploitation	24
Two-storey, small exploitation	23
Two-storey, medium exploitation	37
Two-storey, high exploitation	45
Three-storey, dense exploitation	127
Four-storey, very dense exploitation	158
Residential area with industry	
Three-storey	64
Four-storey	97
Downtown	
Two-storey (hybrid use)	66
Three-storey (hybrid use)	64
Residential quarter, two–three-storey	50
Four-storey (hybrid use)	80
Five-storey (hybrid use)	95
Area for public buildings	35

census data, taking into account the number of residents living in an area of 1 ha. This information is available for the whole of Switzerland in a raster format of 100-m×100-m edge length from GEOSTAT (the service for spatial data of the Swiss Federal Statistical Office, Swiss Federal Administration; Bundesamt für Statistik, 1992). In his article on the use of census data in public transport planning in Swiss agglomerations, Gfeller (2000, p. 183) provides us with Table 1.

This table shows that all types of dwelling areas of a city (refer to the two lower sections of the table) have a population density of at least 50 people/ha. This is the reason why a minimum of 50 people/ha has been chosen to define which area to consider part of a city. To simplify the boundaries of the study area, we decided to approximate the area of interest to the nearest political boundaries of a community.

To define the extent of the research area, the population/ha, as well as the boundaries of the municipalities of the regions of interest (both obtained from GEOSTAT), were imported into our ARCINFO GIS. Raster cells with more than 50 persons living in a 1-ha area were selected. This selection gave a problem: a cell of 100 m side length is quite small and, for example, large parks or public buildings are not taken into account, because nobody lives there, but they are a part of the city. To solve this problem methodologically, the cells selected were transformed into polygons and their boundaries extended (buffered) by 500 m on every side. These polygons were merged to obtain larger areas without inner polygons smaller than 500 m minimum side length. The polygons have then been drawn back to 500 m side length to prevent artificial enlargement of the city area. Since a municipality as a whole transcends our study area, all the municipalities that intersect the calculated polygons were selected. This resulted in the defined city areas in Geneva, Lugano and Zürich that were used in this study.

4.2. Definition of the social potential of the city areas

Similar to the number of residents/ha, GEOSTAT also provides data about the number of people belonging to the following groups:

- Swiss citizens;
- Foreigners;
- German-speaking people;
- French-speaking people;
- Italian-speaking people;
- People speaking languages other than that which is prevalent in a city;
- Women and men in age groups of 5-year intervals; and
- Unemployed people

From these data it is possible to calculate the number of people belonging to the groups to be investigated. The groups taken into account are foreigners, people with another mother tongue than that of the city they are living in, old people (65 years and older), young people (between 15 and 19 years old) and unemployed people. The percentage of people living in 1 ha and belonging to a particular group was calculated and the 33rd-percentiles of this value were evaluated. The lowest and the highest 33rd-percentile divide the calculated hectare values into three classes, each

containing the same number of hectares. A reclassification was then applied. A value of 1 was assigned to hectares belonging to the first class, in which there was only a low number of people from the group considered. A value of 2 was assigned to hectares belonging to the second class, in which there was a medium number of people from the group considered. Finally, a value of 3 was assigned to hectares belonging to the third class, in which there was a high number of people from the group considered. The same procedure was repeated for all five social groups taken into consideration. Finally, the values for the different social groups in each hectare were summed up. The higher this sum, the higher the number of people belonging to the social groups considered, and the higher the heterogeneity of the population in this hectare. We call this sum the social integrative potential of 1 ha. The word potential must be stressed: this word emphasises that there are people belonging to the different groups to be integrated. Of course, that there are people belonging to these groups does not mean that they will integrate. Many more factors play an important role in the integration process. However, different groups sharing the same living space creates the possibility, and hence the potential for such integration.

4.3. Where are the green spaces?

Since this research focuses on the green spaces and their social potential, it is indispensable to know where the green spaces of the three cities are. This seems to be a trivial question, but considering the spread of the research area it is not. For the city centres, in fact, there are often green-space maps. This is not always the case for the adjacent municipalities. We decided to use the green-space data from *vector25*, the digital landscape model in a vector format from the Swiss Federal Office of Topography, the content and geometry of which is based on the 1:25 000 national map (http://www.swisstopo.ch). This digital landscape model is divided into eight layers. The data of interest are found in the layers 'hedges and trees' and 'primary surfaces'. The layer 'primary surfaces' describes the soil coverage. The objects that are considered to be green spaces can be selected through their object values: hedge (object value Z_Gebue); marsh and hedges (object value Z_SumGeb); marsh (object value Z_Sumpf); marsh in forest (object value Z_SumWa); marsh in open forest (object value Z_SumWaO); forest (object value Z_Wald); and open forest (object value Z_WaldOf).

The layer 'hedges and trees' includes single trees, fruit trees, rows of trees, hedges and orchards. Fruit trees have not been considered, since they are normally part of the agricultural space rather than the city green space used for recreation (and possibly for integration). Neither rows of trees nor hedges (both line data) have been considered, because they often represent street greenery, for example avenues, which are beautiful to look at, but normally do not represent places where people get together. Only single trees have been considered and compared in the *vector25* data set with the green-space data for the municipality of Zürich (GLA, 2000). It can be observed that where there are at least two trees within a distance of less than 50 m in the *vector25* data set, there is also often a green space in the digital map of the municipality of Zürich. As green spaces, the areas within a radius of 50 m from the points representing these groups of trees have been considered. The green-space layer of the cities of Geneva, Lugano and Zürich is thus given by a combination of the selected objects in the layer 'primary surfaces' and the derived green spaces from the layer 'hedges and trees' of the *vector25* landscape model.

4.4. Definition of the social potential of the green spaces

The results of steps 2 and 3 provided us with definitions of the social potential/ha and the definition of the green spaces. In order to obtain the social integrative potential of every green space area the two data sets needed to be correlated. This was carried out by dividing the study area into Thiessen polygons, each indicating the catchment area of a green space. This computation was simplified by assuming that persons living in a

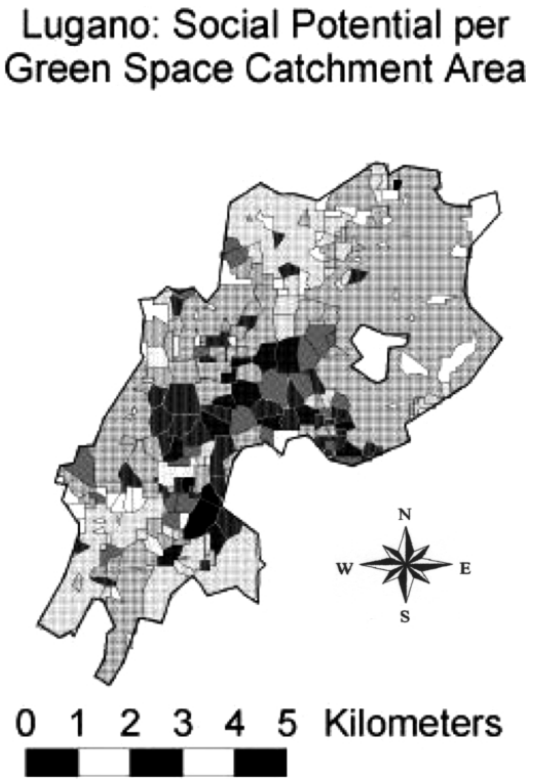

Fig. 1. Lugano: social potential per green-space catchment area.

city go to the nearest green space for their daily recreation needs. The social integrative potential of a green space was defined as the highest recurring value for the social potential in the respective green-space catchment area (majority value). The significance of the social integrative potential of the green spaces should be stressed. High social integrative potential for a green space means that the green space is situated in an area of the city where there are different social groups considered to be. High potential for the social integration of these different groups is therefore given, but integration does not necessarily take place. When does integration take place in a green space and how to design the green spaces in a way that helps integration are questions to be investigated through interviews in the second part of our research project. For the moment it is interesting to consider the resulting social potential for the green-space catchment areas, which are shown in Figs. 1–3. The darker the marking shown in the figures, the higher is the social potential of the corresponding green space and the higher is the social heterogeneity of the inhabitants living close to the green space (Fig. 4).

Finally, we calculated the correlation between the social potential and the percentage of green-space area divided by the catchment area (Figs. 5–7).

5. Results

The above figures are regression analyses correlating available green space with the degree of heterogeneity of the social target groups of this study, representing the social potential of green spaces to facilitate the integration of particular social groups.

The figure for Zürich shows a significant negative correlation between the available green space

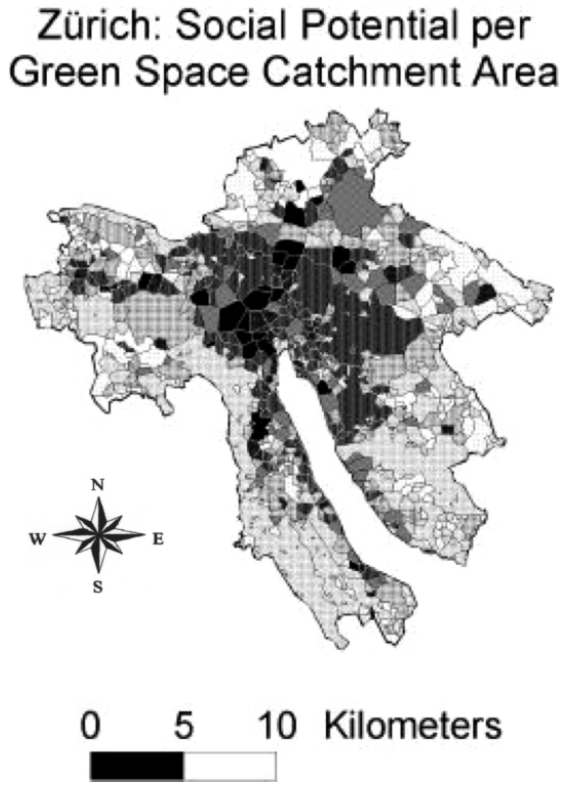

Fig. 2. Zürich: social potential per green-space catchment area.

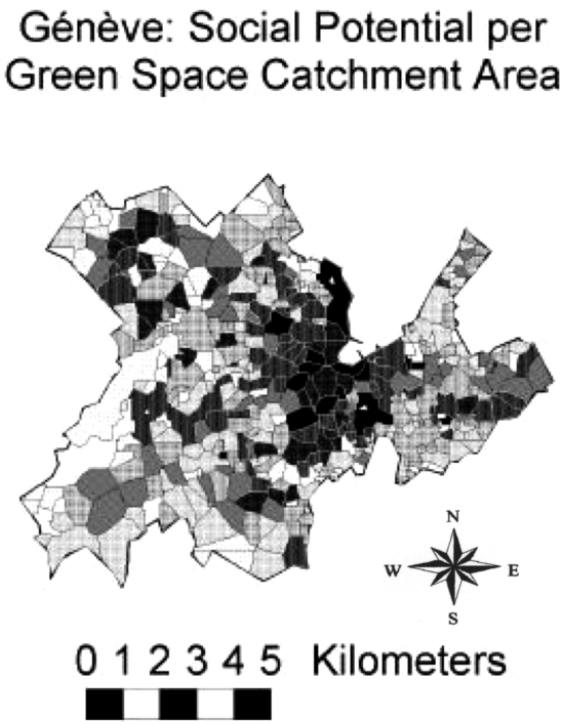

Fig. 3. Geneva: social potential per green-space catchment area.

and the heterogeneity of the social target groups. The correlation explains 88% of the variance. It is interesting to note from the diagram that high social integrative potential can be found in regions with few green spaces. Thus, the distribution of

Fig. 4. Social potential per green-space catchment area.

parks in the city of Zürich discriminates urban districts with a heterogeneous population. Interviews with visitors of urban forests and parks will show to what extent these urban green spaces play an important role in the perception of the respondents, and if it is an advantage for social integration to have a great social diversity of people living in the same region. If this is the case, the design of green spaces in areas with high social integrative potential could be considered for the city of Zürich.

The figure for Lugano shows a trend similar to that of Zürich, but the correlation for Lugano is not statistically significant ($R^2 = 0.332$). The population living in the study area of Lugano is approximately 10-times smaller than that of Zürich (Lugano, 67 334; Zürich, 658 753). Bearing this in mind, we may interpret the result by stating that

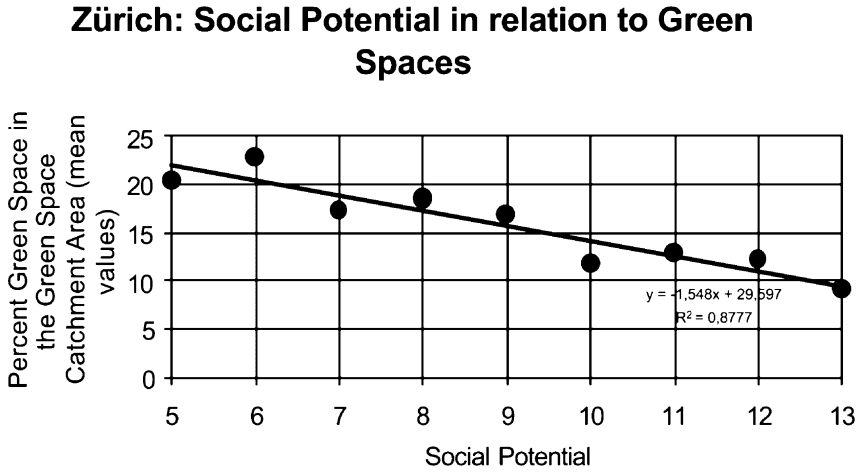

Fig. 5. Zürich: social potential in relation to green space.

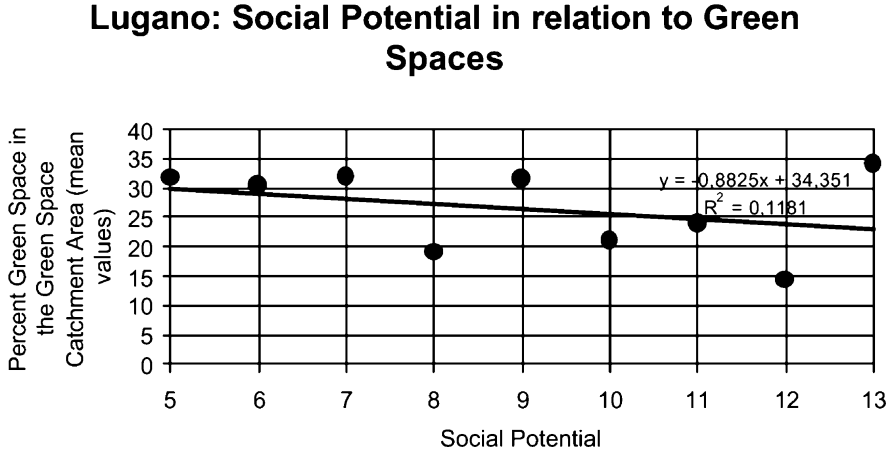

Fig. 6. Lugano: social potential in relation to green space.

Lugano follows the same developing pattern as Zürich, but being a smaller city the contrast between the different spaces is not that great at present.

The figure for Geneva, on the contrary, shows no correlation of the green spaces with the heterogeneity of the population. This indicates that the green spaces are evenly distributed over the whole city, and that the same amount of green space is available in zones where a high percentage of the social target groups of this study lives, i.e. where the population is more heterogeneous. Thus, Geneva shows a socially balanced distribution of green areas. Comparing the situation of Geneva with that in the other two cities, it is evident that Geneva has the best opportunity to make the most of the social integrative potential of its available green spaces.

6. Conclusion and outlook

The results of the GIS analysis, combined with an evaluation of the interviews to be made, will show how and to what extent social integration in and through urban green spaces is important for city dwellers in large agglomerations of Switzerland, what amenities they expect from tomorrow's

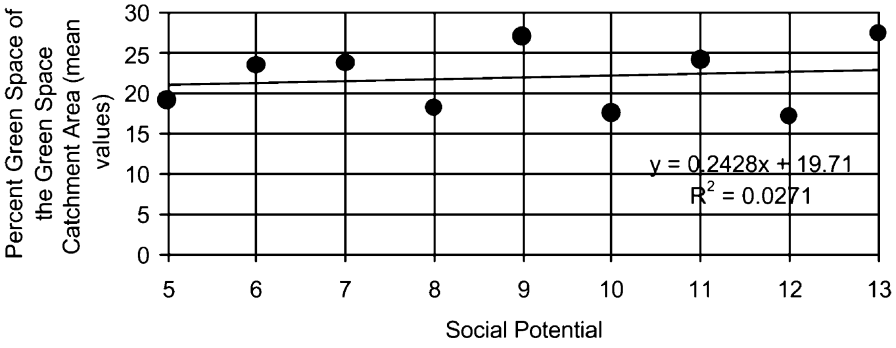

Fig. 7. Geneva: social potential in relation to green space.

green spaces and how they see themselves as an active part in planning, or remain sceptical as to whether green spaces can be relevant to improved opportunities for social integration. One thing is, however, sure: future green-space policy could be a field of applied social policy where supply of public services meets individual demands and expectations. Recreation, wellbeing and intercultural encounter to enhance mutual understanding and resolve conflicts are domains where various social and ethnic sections of a society can come to terms with each other. Where social segregation is often responsible for tensions and conflict, where social change, loss of employment opportunities and value orientation creates ghettos, it is time to mobilise the potential of green spaces as platforms for social encounter. This seems to be a promising arena for a sustainable planning and management of public urban green space.

GIS databases, which present highly aggregated data at different levels, are a very valuable step towards the analysis of very complex phenomena, such as cross-cultural research (Grove and Hohmann, 1992). For comparison of complex data sets, the GIS approach is an almost indispensable means of quantitative research, which must be supplemented by individual interviews or qualitative social research methods to obtain authentic assessments of the wishes and aspirations of concerned people. What they imagine could be planned and designed for the future, provided people are willing to participate in this process and make the most of the space where forest, parks and the public meet.

References

Bundesamt für Statistik, 1992. GEOSTAT Benutzerhandbuch, Bern.

Chiari, C., Nicolè, S., Seeland, K., 2000. Giardino per tutti. Integrazione sociale negli spazi naturali (Gardens for everyone. Social integration in green spaces). Architettura del Paesaggio 5, 4–7. Abstract in English.

CH-Waldwochen (Hg.), 1996. Naturerlebnis Wald. Gemeinsam mit Kindern und Jugendlichen im Wald. Zofingen.

Clark, J.R., Matheny, N.P., 1991. Management concepts for 'natural' urban forests. Proceedings of the Fifth National-Urban Forest Conference. American Forests, Washington, DC, pp. 22–29.

Dwyer, J., Schroeder, H., Gobster, P., 1991. The significance of urban trees and forests: toward a deeper understanding of values. Journal of Arboriculture 17, 276–284.

Dwyer, J.F., Schroeder, H.W., Louviere, J.J., Anderson, D.H., 1989. Urbanites willingness to pay for trees and forests in recreation areas. Journal of Arboriculture 15, 247–252.

Gfeller, M., 2000. Volkszählungsdaten zur Planung des öffentlichen Verkehrs in schweizerischen Agglomerationen. In: Strobl, J., Blaschke, T., Griesebner, G. (Eds.), Angewandte Geographische Informationsverarbeitung XII. Beiträge zum AGIT-Symposium Salzburg 2000. Wichmann, Heidelberg, pp. 174–185.

GLA, 2000.ai_atttri: shapefile with the spaces where the GLA (Gartenbau- und Landwirtschaftsamt der Stadt Zürich) is responsible (green spaces).

Gobster, P.H., 1992. Managing Visual Quality in Big, Diverse Urban Parks: A Case Study of Chicago's Lincoln Park. Managing Urban and High-use Recreation Settings, General Technical Report NC-163. USDA Forest Service, Minneapolis, MN, pp. 33–40.

Grove, M., Hohmann, M., 1992. Social forestry and GIS. Journal of Forestry 90, 10–15.

Hull, R.B., 1992. How the public values urban forests. Journal of Arboriculture 18, 98–101.

Jacsman, J., 1994. Erholungsplanung und ihre Auswirkungen auf den Wald. Grundlagen und Materialien der Professur Forstpolitik und Forstökonomie Nr 94/2.

Kürsten, E., 1993. Landscape ecology of urban forest corridors. Proceedings of the Sixth National Urban Forestry Conference. American Forests, Washington, DC, pp. 242–243.

Laverne, R.J., 1993. Mapping the complete urban forest. Proceedings of the Sixth National Urban Forest Conference. American Forests, Washington, DC, pp. 172–175.

Moll, G., Mahon, J., Mallet, L., 1995. Urban ecological analysis: a new public policy tool. Urban Ecology 1.

Nicolè, S., Seeland, K., 1999. Studio sulle potenzialità d'integrazione sociale offerte da spazi naturali. Due esempi di progetti con disabili in Svizzera e Germania (Forests, parks and trees: social integration through green spaces). Forstwissenschaftliche Beiträge der Professur Forstpolitik und Forstökonomie der Eidgenössischen Technische Hochschule Zürich, vol. 22. pp. 1–140. Abstract in English.

Nowak, D.J., 1994. Urban forest structure: the state of Chicago's urban forest. In: McPherson, E.G., Nowak, D.J., Rowntree, R. (Eds.), Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project, General Technical Report NE-186. USDA Forest Service, Radnor, PA, 201 pp.

Nowak, D.J., 1993. Compensatory value of an urban forest: an application of the tree-value formula. Journal of Arboriculture 19, 173–177.

Rowntree, R., Nowak, D., 1991. Quantifying the role of urban forests in removing atmospheric carbon dioxide. Journal of Arboriculture 17, 269–275.

Schuler, M., 1997. Eidgenössische Volkszählung 1990. Die Raumgliederung der Schweiz. 2. Veränderte Auflage. Bundesamt für Statistik, Bern.

Schwab, J., 1993. Planning for the urban forest. Proceedings of the Sixth National Urban Forestry Conference. American Forests, Washington, DC, pp. 254–256.

Sommer, R., Sommer, B., 1989. The factor structure of street tree attributes. Journal of Arboriculture 15, 243–246.

Sommer, R., Learey, F., Summit, J., Tirrell, M., 1994. The social benefits of resident involvement in tree planting. Journal of Arboriculture 20, 170–175.

Swiss Federal Statistical Office (SFSO), 1998. Statistical Yearbook for Switzerland. Neuchâtel.

Ware, G.H., 1994. Ecological basis for selecting urban trees. Journal of Arboriculture 20, 98–103.