Urban forests of Riga, Latvia – pressures, naturalness, attitudes and management

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Abstract

The urban forest landscape in Europe differs depending on the past history of political and social cultures. Latvia presents a special case, as perceptions of urban green spaces changed from a period of Germanic dominance, to a developed European country, later subdued in the Soviet era, and now to a European country on its way well out of transition. The human footprint has been relatively moderate, and there is little alienation between people and natural values. In the capital Riga, there are 15 large forest tracts, some connected with rural forests and others are isolated remnants of ancient or planted forests. These forest stands have originally been mostly dominated by Scots pine on poor dry soils, with a characteristic feather-moss layer. While recognition of the importance of urban forest ecosystems in resilience of the city is growing, recreational pressure and demands for aesthetical, novel, man-made landscapes are significant. Governance in Latvia almost completely overlooks the complexity of urban forest management and there have been no attempts at integration of ecological, social, aesthetic and recreational functions in all-encompassing landscape planning of Riga's forests with all relevant stakeholders participating. As a result, the "naturalness" of the forests has been largely shaped by recreation loads and management of forest ecological functions is lacking. As a case study of a region where the idea of political ecology is in infancy, an approach is presented for obtaining baseline information to link ecological and social needs. Firstly recreation loads of the forest stands were determined. Secondly, plant functional attributes were used to derive indicators to determine extent and reasons for ecological degradation of the forests. Thirdly, a Choice Experiment and the econometric conditional logit model were used to determine public preferences for forest

management practices (e.g. retention of deadwood, cutting of understorey, and recreational infrastructure). Then, the obtained results were used to make recommendations for urban forest management in Riga.

Introduction

In Europe, the inclusion and maintenance of natural areas in cities have long traditions from the start of development of civilisation (Cekule, 2010). The role of urban green spaces differs widely between European cities and towns due their different environmental and socio-cultural background. The forest culture of northern Europe in the eastern Baltic countries and Fennoscandia is rather similar, in that forest is a significant element of everyday lives, it is important in national economies, and is a major element of the landscape (Tyrväinen et al., 2006; Bell, 2008; Jankovska et al., 2010). In this respect, the recreational and aesthetic benefits of *natural* urban forest are traditionally important (Emsis, 1980), which differ from those in central Europe where land conversion processes have been profound. In Latvia, as in other countries of North Europe, the human footprint on nature throughout the twentieth century and the alienation between people and nature have had less impact. The development of urban forests in Riga, the capital of Latvia, has a long history. Riga has been the owner of forests since the thirteenth century and urban forests have always been accessible for inhabitants.

While recognition of the importance of urban forest ecosystems in resilience of cities is growing, recreational pressure and demands for aesthetical, novel, man-made landscapes are high. Governance in Latvia largely ignores the complexity of urban forest management and there have been no attempts at integration of ecological, social, aesthetic and recreational functions in all-encompassing landscape planning of Riga’s forests with all relevant stakeholders participating. Thus, forest structure is shaped by recreation loads and management of forest ecological functions is mostly lacking. While knowledge of the multiple functions of urban green areas in Riga does exist, it is not integrated in planning documents, in contrast to other European cities (Weng, 2007; James et al., 2009). In Riga there is no unified forest or green area management model or plan, and information exchange with state institutions is poor. Land ownership disputes still exist, and there is little consultation with the public, NGO's and other organisations (Gaiss, 2009). Tyrväinen et al. (2006) considered that problems in regard to city forest infrastructure exist in all of the new European Union countries. Generally, the intensity and ways of forest management are determined by forest policy and ownership, but the financial resources allotted for management of European city forests is often insufficient, leading to degradation of functions and decrease of use (Gundersen et al., 2006). The role of the city administration in Riga in forest management is restricted to elementary maintenance activities and inhabitants are beginning to question their need and the use of financial resources for their maintenance (Jankovska et al., 2010). Interestingly, the resources for urban forest management in Riga arise from forest harvest and other uses (e.g. hunting) on land owned outside of the city!

Urban forests are a part of a complex environment, complicated diverse and interconnected ecosystems. The wooded area is an indicator of sustainability in that it shows the availability of natural areas to inhabitants, which needs to be considered in city development and policy (Weng, 2007; Cekule, 2010). Spatially non-planned recreation and excessive recreation loads have impact on forest ecological functions and create a mosaic of disturbed and undisturbed forest compartments (Bell, 2008; Kuzmina and Treshkin, 2010). Planning of the urban environment needs to combine landscape design with ecological management to promote stand stability, ensure that recreation does not cause degradation of forest function, and to implement the respective infrastructure to increase forest accessibility while conserving its biological value (Emsis, 1980; Heyman et al., 2011).

In Riga there is a need to determine recreational load to forests and its impact on the vegetation. In the present study, the recreational pressure on forests was assessed using social interviews and analysis with GIS software, to predict impact loads. Field study was then used to examine the relationships between recreational loads and vegetation composition and stand structure. However, in addition to this, the preferences of the public are also important to know for the development of forest management strategies. Evaluation of economic benefits of projected management activities is essential for forest policy purposes. Knowledge of public willingness to pay is needed for planning government finances, and also in context of a trade-off between natural biodiversity of forests and their recreational properties. Attribute-based stated choice methods, based on individual preferences for specified real or hypothetical alternatives, are widely accepted by practitioners (McFadden, 1974). Therefore, in the final phase of background collection of data, community preference and willingness to pay were evaluated for different types of forest management activities, like deadwood and understorey removal, the construction of hard-surface paths and recreational amenities, and others.

Description of area

In Latvia after the Second World War, the urban forests in the inner city and green belt around the city were protected by the legislation of the Soviet period. About 0.8% of all Latvian forests are considered urban forests and 20% of urban areas are covered by forests (Donis, 2003). Cities such as Riga tend to be set within and surrounded by large tracts of forest, which expand beyond the urban boundary (Bell et al., 2005). The importance of these forests as protection belts has been stressed in legislation of the Latvian Republic after regaining independence (Donis, 2003). The Law on Protection Belts stipulates that forests form protection zones around cities, to diminish and decrease negative impact of anthropogenic impact, to create good conditions for recreation, and to improve health of humans. The width of these green forest belts needs to be adequate in regard to population size and its condition is under regulation of the municipality. The urban forests cannot be exploited for timber production as the main management goal, and clear-cutting is not allowed. However, thinning and sanitary cuts are allowed. Thus, the main management activities are focused on forest structure and health. The legislation does not specify differences between maintenance and management of rural and urban forest, and there are disagreements between management, functional significance and demands for real use of urban forests.

Riga, with an area of 304 km2, population of 706 000 inhabitants (density 2331 persons per 1 km^2) is one of the biggest owners of forests in Europe. Municipalities are given authority by National legislation on creation and management of city parks, squares and green belts and the management of green areas in Riga is regulated by the Riga Dome Building Regulations on use and Spatial Development in the Riga territory. All green areas are defined as nature areas. They are not classified by functional, landscape and natural elements, and include recreation areas, forest parks, agricultural land and forest. Presently, the nature areas contribute 54.2% of the area of Riga (Cekule, 2010), of which the inner city wooded area is 4244 ha. Riga also has forest territories that are internationally important due to occurrence of rare species and habitats of European Union importance, which require to be protected. However, the ecological quality of other green areas also needs to be considered. Most of the wooded area of Riga is classified as forest park with primary use by recreation, sports and tourism. Another category is forests, which are considered as areas with primary forest ecosystem function. Spatially, the inner city wooded areas are forest parks and those on the outskirts or in relatively less accessible areas are forests. In this paper, we consider these categories together and refer to them as forest.

The dominant tree species in forests of Riga is Scot's pine *Pinus sylvestris* L. (88% of total forest area). As most (80% of area) of the pine forests occur on poor sandy soils, they have high landscape appeal due to openness, but are highly sensitive to degradation (Straupe et al., 2012). The city forests have been planted or are fragments of older forest. Stand age is mostly 80-100 years. Riga city forests consist of 15 forest tracts; some are connected with rural forests and others are small, isolated forests (Fig. 1).

Recreational loads in Riga city forests

In a national-level survey of forest non-market services conducted in 2010 by the professional polling agency LTD SKD, the information obtained by on-site face-to-face survey included: (a) targets of recreation, (b) frequency of visits to forest (in working days, in weekends, in vacations/holidays), (c) distance to the site (in kilometers), and (d) mode of transport (on foot, by bicycle, car, public transport). The results showed that a recreational target of going for a walk was chosen by 60% of Riga city inhabitants and 34% of respondents travelled to the forest on foot. Mean distance for this recreational target in Riga was 1.5 km on working days. Using this data, a GIS model based on distance to forest was developed, which predicted the number of visits to a specific (focal) forest area for recreational activities, using the following steps:

1) generate the areas around residential neighbourhoods in given distance intervals;
2) generate zones around forest blocks in given distance intervals;
3) spatially join number of inhabitants in zones with forest polygons;
4) estimate the average number of visits/per year to forest blocks;

Figure 2 presents the results obtained from the GIS analysis about accessibility and average distribution of visits/year to forest areas on foot for the most popular recreational target of walking. The model is simplistic, in that it did not consider the existing site attributes road and path network, environmental qualities, and seasonality. However, competition between neighbouring forests in visitation was taken into account. While crude, this type of model can be used to group the forest tracts into recreation pressure classes. The highest recreational pressure occurred in isolated forests located in proximity to the city centre and in places with greater population density.

Impact of recreational pressure on vegetation

The vegetation was described in 45 sample plots (20 * 20 m) located dry pine forests in the 15 forest tracts (3 plots in each) in 2011. The projective cover of each plant species was estimated in vegetation layers. Preliminary work had focused on using traditional multivariate analysis methods to identify assemblages of species that were associated with recreation load in the respective forest tracts. A large part of the species showed low fidelity to a particular vegetation group. This can be explained by chance colonisation of species not typical of forest, and subsequent loss of species characteristic of pine forest. In some forest stands, pine was being replaced in the canopy by oak and other deciduous species, and in these areas the herbaceous layer was more typical of temperate forest. Thus, variable recreation load had created a mosaic pattern of grassland, adventive and introduced species. For example, species introduced in Latvia, such as the shrubs *Cotoneaster lucidum* and *Amelanchier spicata*, and the adventive forb *Impatiens parviflora*, are very expansive synanthropic species that have been naturalised in specific locations in urban forests. In other places, grassland communities had replaced the typical moss layer of the pine forests. While it appeared that plots could be visually classified by vegetation structure, the combination of species in plots was not predictable. However, multivariate analysis suggested a weak association of recreation load with number of species with different plant life strategies (Hodgson et al., 1999) and other functional attributes in plots.

To attempt to understand the main processes governing plant community formation, rather than describe plots by species composition, the plots were described by plant attributes. A matrix was derived with total cover in plots of species by plant structure (tree, tall shrub, low shrub, forb, graminoid, fern and moss), common habitat (boreal forest, temperate forest, grassland), introduced plus adventive species, nitrophilous species, and Grime plant strategy (stress tolerant, competitor and ruderal). Then, redundancy analysis (RDA) was conducted to identify gradients in vegetation composition based on these attributes, constrained on a matrix of environmental factors (recreation load and forest tract size). The RDA ordination showed significant ($p<0.05$) relationship of vegetation described by plant attributes with forest tract size and recreational pressure. The results showed that typical unaltered boreal pine forest vegetation with high cover of moss and stress tolerant species occurred in stands with low recreational load when forest tract area was large Figure 3. High recreational load was associated with a mixture of grassland species, graminoids, and competitors, independent of the effect of forest tract size. While the ecological value of forest is largely determined by species composition, the social value, i.e, what residents prefer, is imparted by the structure of the vegetation (plant attributes), which was then used to assess community preference.

Community attitudes – Choice experiment

Depending on the recreation load, the vegetation of urban forests has diverse structure, from typical open dry pine forest to patches overgrown with shrubs or a grass-dominated cover. In places, dead wood, which is important for conservation of biological diversity (Brūmelis et al., 2011), has accumulated. In management of urban forest, it is important to not only know the attitude of the forest users to the existing different types of forest landscape, but also willingness to pay. A Choice Experiment was conducted to determine public preferences for forest management practices (e.g. retention of deadwood, cutting of understory, and recreational infrastructure). Images of four typical dry pine forest stands that varied in vegetation structure (openness, shrubs and dead wood) were produced. These images (Figure 4) portrayed the Status quo situation. These were then modified to show changes in vegetation structure and amenities that would result from various types of management. On each image was also given the estimated cost of the management (Figure 4). Survey was conducted in Riga city's forests and neighbourhoods to determine community preference. A total of 506 respondents were involved. Each respondent was provided with 4 sheets, corresponding to the four Status quo situations (Figure 4), along with 7 management alternatives for each (for an example, see Figure 5).

A conditional logit model, based on the theory of latent random utility of alternatives (McFadden, 1974), was used to determine preference for management alternatives included in the model as dummy explanatory variables:

- $DeadwoodRemoval_j$ = 1, if deadwood (logs and snags)s is removed for an alternative *j*;
- $Bough\ Removal_j$ = 1, if boughs (dead breanches) are removed for an alternative *j*;
- $UnderstoreyRemoval_j$ = 1, if understorey is removed for an alternative *j*;
- $Amenities_j$ = 1, if recreational amenities (path, benches) are constructed for an alternative *j*.

A respondent's choice between alternatives is frequently related with a current state of management (status quo). It is expected that respondents prefer a current state due to general reluctance to change (Hanley et al., 1998; Horne et al., 2005). However, preliminary results showed that the percent of status quo choices varied from 5.3% to 11.4%, which was less than the mean frequencies of other alternatives. This can be explained by the relatively low level of forest management that had been conducted in the past. Therefore, an alternative specific constant $\mathrm{StatusQuo_j}$ was included into the model to capture these effects. For example, deadwood could be added to a site where it was lacking, to estimate preference for its removal. Also, cost of activities $\mathrm{Cost_j}$ was also included in the model to estimate willingness to pay.

The model used was:

$$U_j = \beta_1 \ln(Cost_j) + \beta_2 BoughsRemoval_j + \beta_3 UnderstoreyRemoval_j + \\ + \beta_4 DeadwoodsRemoval_j + \beta_5 Amenities_j + \beta_6 StatusQuo_j + \varepsilon_j,$$

where Uj is latent utility of the alternative j; εj is a random component; β's are unknown model parameters. Respondent choice between alternatives, based on their latent utilities, was modelled using a Gumpel distribution (Greene, 2012). The model was estimated separately for each of the sites (Table 1).

Table 1. *Estimation results of site-specific conditional logit models.*

	Site 1	**Site 2**	**Site 3**	**Site 4**
β_1, *ln(Cost)*	-0.208	-0.410***	-0.113	-0.203**
β_2, *Bough Removal*	0.284**	0.328*	-0.226**	-0.476**
β_3, *Understorey Removal*	0.829***	0.326*	-0.230*	0.139
β_4, *Deadwood Removal*	0.234*	0.677***	0.651***	0.892***
β_5, *Amenities*	1.829**	1.204***	0.160	1.174***
β_6, *StatusQuo*	0.608	-0.406	-0.396**	0.287

Significance: *** – less than 1%, ** – 1-5%, * – 5-10%.

All management activities had significant positive effect for Site 1 and Site 2, indicating that respondents preferred these activities. For site 3, removal of boughs was not preferred, and recreational amenities had no significant effect. This site is an open forest, and thus removal of boughs from this type of landscape did not seem important, and there was no need for paths and benches as walking through the forest was easy and aesthetically pleasing. Amenities were preferred in all other sites, as these landscapes were in various stages of overgrowing with shrubs. Deadwood removal was preferred at all sites, and is implemented. This is, of course, in contradiction to the importance of dead wood for biological diversity (Brūmelis et al., 2011). Thus, management for conservation will have to proceed hand-in-hand with increasing public awareness.

Alternative cost had an expected negative effect in all four models, but insignificant for Site 1 and Site 3. This means that people are generally not willing to pay for management, which might be associated with the financial situation of the respondents, or perhaps lack of knowledge of the real costs of management. However, willingness to pay (WTP) for different activities can also be calculated in models in real monetary terms (Lanz and Provins, 2011). Estimated marginal WTP values in Euros for the management activities are presented in Table 2 (deadwood removal was not estimated, as this practice is commonly used in all four sites).

Table 2. *Marginal willingness-to-pay values (euros)*

	Site 1	Site 2	Site 3	Site 4
Bough Removal	156	91	-568	–*
Understorey Removal	455	91	–*	146
Recreational Amenities	1004	335	403	1234

The preference for management alternatives is indicated by a positive marginal WTP. The need for recreational amenities was shown by significant WTP values that ranged from €335 to €1234. Variance in these WTP values can be explained by differences in amenities modelled in the images for the sites. For example, a complete set of objects (wooden paths, benches, info signs) was modelled for Site 4, while for Site 2 alternatives include dirt paths only. The negative WTP value (-€568) for bough removal in Site 3 corresponds with its negative effect discussed above. The highest WTP value of understorey removal (€455) was estimated for Site 1, which was the most overgrown and most difficult to traverse. Estimated effects and willingness-to-pay values of different management activities allow to develop a well-grounded forest policy, and to define community preferences and priorities of forest management programmes.

Recommendations and conclusions

There is a general deficiency of planning in management of urban forests in the city of Riga. On the background of insufficient management, recreation pressure has led to conversion of open dry pine forests to heterogenous ecosystems in various successional paths of change. There is wide public preference for management of these forests by shrub removal and establishment of amenities, such as paths, boardwalks, and benches, although willingness to pay is below the real costs for these activities. In places where open landscape still exists, amenities are required to funnel person traffic along convenient paths. In some areas, eutrophication is suggested by the invasion of deciduous trees and nitrogen-loving shrubs. Thus, management by shrub cutting would likely not succeed in returning the woodland to that what it was naturally, but based on social demand it needs to be done. Also, effort to stop the spread of invasive species is needed. Where deciduous species like oak is replacing the pine canopy, management should not be directed to maintaining a pine forest, but supporting a change in tree species composition. To improve habitat quality for biological diversity, some deadwood should be retained after tree mortality, along with promotion of public awareness of the biological value of these elements.

Thus, complex trade-offs between forest biodiversity, forest recreational attractiveness for the public, and management costs require evaluation and integration into spatial planning at different scales. Carefully organised surveys, such as those presented here, can help forest managers identify management alternatives preferred by the public and utilise this information for policy making.

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Figure captions

Figure 1. *Riga city forest tracts: 1-Bulli, 2-Bolderaja, 3-Kleisti, 4-Imanta, 5-Mezaparks, 6-Vecdaugava, 7-Katlakalns, 8-Sampeteris, 9-Jaunciems, 10-Babelite, 11-Ulbroka, 12-Smerlis, 13-Mangalsala, 14-Jugla, 15-Bikernieki*

Figure 2. *Distribution of forest recreational visits/year on foot to forest tracts at distance 1.5 km from the residential area in Riga city*

Figure 3. *RDA ordination of plots described by plant attributes constrained on environmental variables (recreation load and forest tract area).* Vectors in bold indicate association of environmental factors with plant attributes (grey vectors)

Figure 4. *Status Quo states in Rigas city's forests that were used in the choice experiment.*
(a) open forest with understorey (Site 1, Buļļi locality);
(b) mature mixed forest with understorey(Site 2, Imanta locality);
(c) open-type pine forest (Site 3, Mangaļsala locality);
(d) park-type pine forest (Site 4, Mežaparks) (Figure 1).

Figure 5. *Example of management alternatives used in choice experiment to determine resident preferences.*