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Landscape and Urban Planning 52 (2000) 101–116

LANDSCAPE
AND
URBAN PLANNING

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Long-term changes in indigenous vegetation preserved in urban areas

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Abstract

During the last decades models for an 'ecological approach' to physical planning of towns and cities have been discussed. Part of such an ecological approach is to utilize existing indigenous vegetation (natural and semi-natural forests, meadows, pasture land, heaths) and trees in parks and other green areas in future developed areas. This planning approach includes many economical, social and other advantages. In 1972, a research project was started at Järvafältet, situated 15 km north of downtown Stockholm, Sweden. Investigation plots were established at locations in proposed green areas within development zones. During construction and subsequent use, changes in vegetation and habitat (soil, ground water, climate, air and water pollution, impacts from the inhabitants) were studied annually from 1972 to 1981. Vegetation analysis in most plots is still (2000) being maintained. Trees were damaged during construction. Damage was mainly caused by increased wind velocity when surrounding trees were felled and by damage to root systems due to excavation and adding landfill. Damage during later use was much less. Vegetation field and bottom layer were little damaged during construction. During later use plant communities on shallow poor dry soils were damaged by wear and tear caused by trampling. There was much less damage to other plant communities during the 27-year study. Damage through other habitat changes during this period was not detected. A schedule showing interactions between planning, construction, use, habitat changes and vegetation is presented. Despite some damage to the preserved vegetation that has occurred, the local residents highly appreciate it as a recreation area. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Indigenous vegetation; Impact; Vegetation changes; Development; Urban areas

1. Introduction

Sustainable development is based on two principles: minimizing the impact on the environment and minimizing the use of limited natural resources. In the case of the latter, this concerns not just resources such as soil, clean water, fresh air, etc. Agenda 21, the document resulting from the UN environmental conference in Rio 1992 (United Nations, 1993), states that

biodiversity is also a part of the natural resources. One important source for protection of biodiversity is the vegetation of sites where new residential areas, industrial parks, etc. are to be built. Some of this vegetation can be utilized as parks and open space in future developed areas. This planning approach has many advantages (see Fig. 1) (Florgård, 1981):

- Essential habitats for plants and animals can be preserved.
- Vegetation in parks, etc. is already mature when the first occupants move in. This is a great advantage especially in areas with low growth potential.

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Fig. 1. Indigenous vegetation surrounding a pond in a green area within a developed area: useful, beautiful and inexpensive. Close to investigation plot no. 9, seven years after house construction.

- Preserved areas will differ from ‘traditional’ gardens and parks and be of interest to everyone, particularly as an exciting playground for children.
- Costs for construction and maintenance of green areas are minimized.

In Sweden, there exists a tradition in town and city planning dating back to the early 1900s, that has used indigenous natural and semi-natural vegetation as green oases in developed areas (Florgård and Dawe, 1988). In 1972, a research project was started at a future development area at Järvafältet, situated 15 km north of downtown Stockholm (Anon., 1973).

Up to 1905 the meadows as well as the forests at Järvafältet were grazed. From 1905 to 1972, the forests were maintained for wood production, which meant thinning and clearing of undergrowth, and was to some extent used for military training. The meadows were still grazed. When part of the area was transformed to a residential area from 1973 onwards, thinning and clearing was stopped almost completely

in the whole area, but grazing went on. All the time, all meadows and forests have been used for recreational purposes.

2. Objectives

The objectives of the described project are:

- to study the impact on and changes in the indigenous vegetation resulting from development and from wear and tear by the inhabitants;
- to study how indigenous vegetation was managed in the planning and design process;
- to develop methods for valuation of indigenous vegetation types as parts of residential areas;
- to propose changes in the planning process for preservation of indigenous vegetation within development areas;
- to propose methods for management and treatment of indigenous vegetation.

3. Methods

The study was started in 1972, before construction (which was carried out mainly during 1973–1975, in some areas up until 1981), and continued with annual investigations during later use by the inhabitants (from 1974 onward). Twenty-one investigation plots were chosen close to where construction sites were to be established. In order to analyze the effect of distance, the plots were placed at two distance intervals from residential blocks, <100 m and 200–400 m. Seven reference plots were set up at a distance of 1500–2000 m from construction sites. Vegetation analysis was carried out in five areas of 1 m² in all plots during 1972–1982, and is still (2000) being maintained in 11 investigation plots and 6 reference plots. Regarding trees, annual rings were measured in 1972, 1976, 1981 and 1987. Tree and bush growth has, since 1972, also been measured as coverage. The results of this are presented in Florgård (1991). Changes in habitat (climate, hydrology, pollutants and soil conditions) were studied during 1972–1977 and 1981.

Complementary to the vegetation analysis and as a part of the study of wear and tear, observations were made and photographs were taken annually from about 120 fixed points. Photographs are still taken annually from 7 points, and less frequently from 12 others. Systematic photographing and observation are also carried out in approximately 100 other areas, most of them situated in Sweden, but some also in Norway and Germany. A few of them are presented here.

A very important part of the investigation was the study of the planning and design process, the study of measurements made by constructors, and the study of wear and tear on the environment by the inhabitants. This was carried out with structured interviews and observations. The planning and design process and measurements were studied from 1972 to 1981, and wear and tear by the inhabitants were studied from the time it started in 1974.

Vegetation changes were analyzed through annual comparison of plant composition in plots in the investigated area and plots in the reference area. For this purpose, plant species were classified into 20 ecological groups, specially developed for this project and this area, and designed to make it possible to detect changes in vegetation due to changes in habitat, such

as climatic, hydrological, pollution and soil conditions, and direct damage of trampling, the construction vehicle traffic in vegetation areas, etc. A group called “Bare soil and bedrock” was added to the ecological groups. An overview of the 20 ecological groups and the group bare soil and bedrock is presented in Table 1.

To the main project, subprojects have been added regarding remote sensing of vegetation changes in development areas (1974–1977), treatment of vegetation to increase resistance to wear and tear (1974–1981), vegetation adapted to urban areas (1978–1984), experiments involving translocation of natural vegetation (1978–1986), vegetation areas as a resource in urban storm runoff water treatment (1979–1980), cost benefit analysis of utilizing natural vegetation as green areas in development areas (1982–1989), and soil construction for natural successions towards pine and spruce forests and heath vegetation (1990–1996). Results obtained from these projects are not presented here.

4. Results

4.1. Results (1972–1990) — an overview

Results from the main project and from the subprojects during 1972–1990 have been presented in many articles and reports. Most of them were published in Swedish, but some also in English and German (example Florgård, 1981, 1985, 1991). An overview of the results from the main project that were presented during 1972–1990 is as follows:

- The most important phase in the development process is the planning and design phase (see Fig. 2). In the planning and design process, the most resistant vegetation types can be chosen to be preserved as future green areas. Suitable construction methods can be selected and residential and road structures can be developed to minimize future impact on indigenous vegetation.
- Habitat was changed to some extent. Mean temperature in the developed areas increased by about 1°C. Wind velocity increased for the short period between clear-cutting and when the houses were constructed in the clear-cut areas. Mean ground water level was not affected, but the difference

Table 1
Ecological groups and group of bare soil and bedrock for analysis of vegetation changes

Denomination	Examples of species
1 Trees and bushes >1.5 m high	<i>Betula pendula</i> (Silver Birch), <i>Picea abies</i> (Norwegian Spruce), <i>Pinus sylvestris</i> (Scots Pine)
2 Trees and bushes <1.5 m high	The same as in group 1 and example <i>Ribes alpinum</i> (Alpine Currant)
3 <i>Vaccinium</i> sp. and heather	<i>Calluna vulgaris</i> (Heather), <i>Vaccinium myrtillus</i> (Bilberry)
4 Herbs adapted to dry sites (usually thin soil on bedrock)	<i>Polypodium vulgare</i> (Polypody), <i>Rumex acetosella</i> (Sheep Sorrel)
5 Herbs adapted to forests	<i>Maianthemum bifolium</i> (Two-leaved <i>Maianthemum</i>), <i>Melampyrum sylvaticum</i> (Wood Cow-wheat)
6 Herbs adapted to meadows with light trampling	<i>Campanula persicifolia</i> (Bluebell), <i>Hypericum maculatum</i> (St. John's wort)
7 Herbs quickly colonizing trampled areas ("lawn weeds")	<i>Plantago major</i> (Plantain), <i>Taraxacum ruderalia</i> (Dandelion)
8 Herbs quickly colonizing other damaged areas ("other weeds")	<i>Lamium album</i> (White Dead-nettle), <i>Tussilago farfara</i> (Colts-foot)
9 Herbs adapted to wet habitats	<i>Caltha palustris</i> (Marsh Marigold), <i>Filipendula ulmaria</i> (Meadow-sweet)
10 Grass adapted to forests	<i>Luzula pilosa</i> (Hairy Wood-rush), <i>Poa nemoralis</i> (Woodland Meadow Grass)
11 Grass species <i>D. flexuosa</i> and <i>F. ovina</i>	<i>Deschampsia flexuosa</i> (Wavy Hair Grass), <i>Festuca ovina</i> (Sheep's Fescue)
12 Grass adapted to medium wet habitats with light trampling	<i>Alopecurus pratensis</i> (Meadow Foxtail), <i>Arrhenatherum elatius</i> (Oat Grass)
13 Grass adapted to heavy trampling ("lawn grass")	<i>Agrostis capillaris</i> (Creeping Bent), <i>Poa pratensis</i> (Meadow Grass)
14 Grass adapted to wet habitats	<i>Deschampsia cespitosa</i> (Tufted Hair Grass), <i>Poa trivialis</i> (Rough Meadow Grass)
15 <i>Rubus idaeus</i> , <i>Pteridium aquilinum</i> and <i>Epilobium angustifolium</i>	<i>Epilobium angustifolium</i> (Rose bay), <i>Pteridium aquilinum</i> (Bracken), <i>Rubus idaeus</i> (Raspberry)
16 Mosses adapted to dry and medium wet habitats	<i>Hylocomium splendens</i> , <i>Pleurozium schreberi</i>
17 Mosses adapted to wet habitats	<i>Mnium cuspidatum</i> , <i>Sphagnum warnstorffianum</i>
18 Fruticose lichens	<i>Cetraria islandica</i> , <i>Cladina rangiferina</i>
19 Folios lichens	<i>Parmelia saxatilis</i> , <i>Umbilicaria deusta</i>
20 Crustaceous lichens	<i>Aspicilia cinerea</i> , <i>Rhizocarpon geographicum</i>
21 Bare soil and bedrock	Litter layer, Raw humus layer

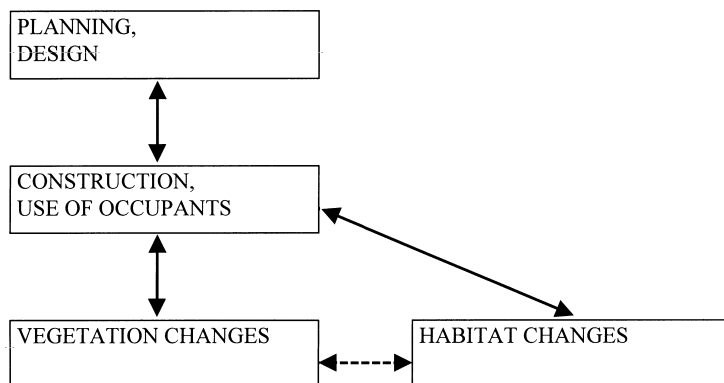


Fig. 2. Connections between planning and design, direct impact, habitat changes and vegetation changes. From Florgård (1991).

between flow peaks and lows increased. Content of sulphur dioxide in the air increased due to installation of a heating plant.

- Most habitat changes were not demonstrated to affect vegetation. Vegetation damage and vegetation succession were found to be a result of the direct impact of construction, such as excavating, landfill, driving vehicles in areas to be preserved, and from later use such as trampling. One exception was increased wind velocity caused by clear-cutting close to preserved areas. In very close proximity to cut areas, Norwegian Spruce (*Picea abies*) on wet soils, and Scots Pine (*Pinus sylvestris*) on shallow soil on bedrock, were felled by wind.
- Vegetation damage in the preserved areas was normally of limited extent. In the studied area, recreation and amenity functions were not disturbed by changes in vegetation, at least not heavily or for long periods.
- Where damage did occur, it was due to hydrological conditions, soil type, vegetation type and, most importantly, the type of impact from construction and later use by the new inhabitants.
- Trees in preserved areas were to some extent damaged during construction (1973–1981). Most frequently, the reason for this was damage to root systems by excavating or adding landfill close to (within 2 m from) trunks, and felling by wind as mentioned above. However, the number of felled and damaged trees was small in proportion to the total amount of trees preserved.
- Vegetation field layer and bottom layer were little affected during construction. One main reason for this was that the preserved areas were often fenced to protect them during construction. After construction the fences were removed. During later use (1974–1990), damage and succession could be measured in a limited number of vegetation types.

4.2. Long-term effects (1972–1998)

In this paper, the main project is evaluated with focus on long-term effects on vegetation between 1972 and 1998.

Pine forest of lichen type on shallow poor soil on bedrock: Fruticose lichens (ca. 50 mm high lichens, very vulnerable to trampling) with moss which grew on bedrock within 100 m from entrances to residential

blocks were severely damaged by trampling within one year of the first occupants moving in (Fig. 3). This plant community could not be found at the distance 200–400 m from entrances, but observations from other residential areas indicate that damage is severe even at this distance. By erosion, damaged lichens and mosses were transported to the foot of the slopes. There they built up a thin layer of new soil, initially colonized mainly by moss, mostly *Pohlia nutans*. A secondary persistent colonization by the grass *Deschampsia flexuosa* and to some extent *Agrostis capillaris* occurred. Changes are still going on, but very slowly. Bare bedrock was found to be colonized by crustaceous lichens (see Fig. 4). In years of severe drought, the amount of bare soil increased in the built-up area, but not in the reference area. Vegetation on other poor dry soils shows a similar pattern.

Other forest vegetation on poor dry soils: Areas with bare soil increased between 1972 and 1975 in plots situated <100 m from entrances to residential blocks, after which they stabilized. In plots situated 200–400 m from entrances, the bare soil areas remained more or less invariable until 1977, increased between 1977 and 1985, and showed only slight changes after that (Fig. 5). Bare areas were only slightly colonized by broad-leaved grass (*Poa pratensis* and *Agrostis capillaris*) from 1986, and increasingly until 1992. Since then, the amount of grass has decreased. In plots previous to the start of the project dominated by narrow-leaved grass (mostly *Deschampsia flexuosa* and *F. ovina*), changes have been small.

Spruce forest of bilberry type: Field layer in these spruce forests is dominated by *Vaccinium myrtillus*, *Deschampsia flexuosa* and mosses (example *Hylocomium splendens* and *Pleurozium schreberi*). The coverage of *V. myrtillus* is more or less invariable in the reference plots, but decreased between 1973 and 1998 in two investigation plots (Fig. 6). In one of the investigation plots, the coverage was invariable, because it was protected from trampling by bushes and small trees. In areas situated within 100 m from entrances to residential blocks, wear and tear is spread all over the forest floor, but in areas situated 200–400 m from entrances, it is located to paths (see Figs. 7 and 8).

Forests on moist soils: Close to two investigation plots, excavation to a depth of 2–3 m for pipes was

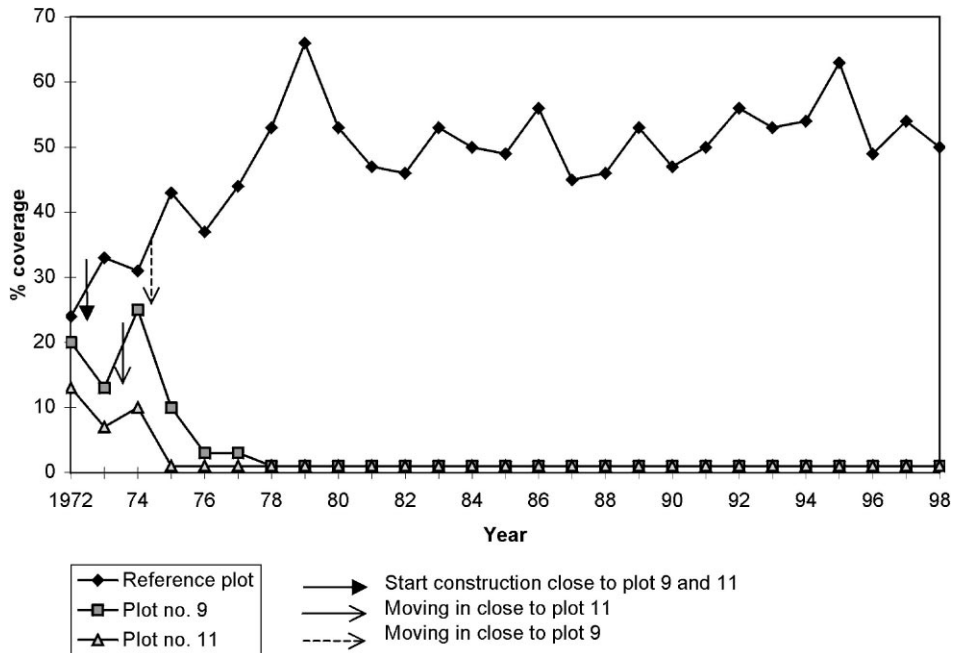


Fig. 3. Percentage of fruticose lichen cover in Scots Pine forest on shallow poor soil on bedrock. In the built-up area, serious damage is found to occur on fruticose lichen immediately after moving into the occupants, and a non-reversible succession starts.

carried out. This resulted in lowering of the ground water table during construction, but surprisingly it did not result in lowering of the ground water table after completion of construction. Therefore, the plots were not permanently drained. Coverage of species indicating high soil water content has not decreased (Fig. 9).

The reference plot had higher soil moisture than the investigation plots at time when the project started. In the reference plot, trees and bushes have established and have grown a lot (Fig. 10). The trees and shrubs are now draining the soil, and the amount of moisture-indicating species is decreasing.



Fig. 4. Percentage of crustaceous lichen on bedrock in pine forests. When vulnerable high (ca. 50 mm) fruticose lichens (and some mosses) have vanished, the bare bedrock surface is colonized by low (ca. 1 mm) crustaceous lichens.

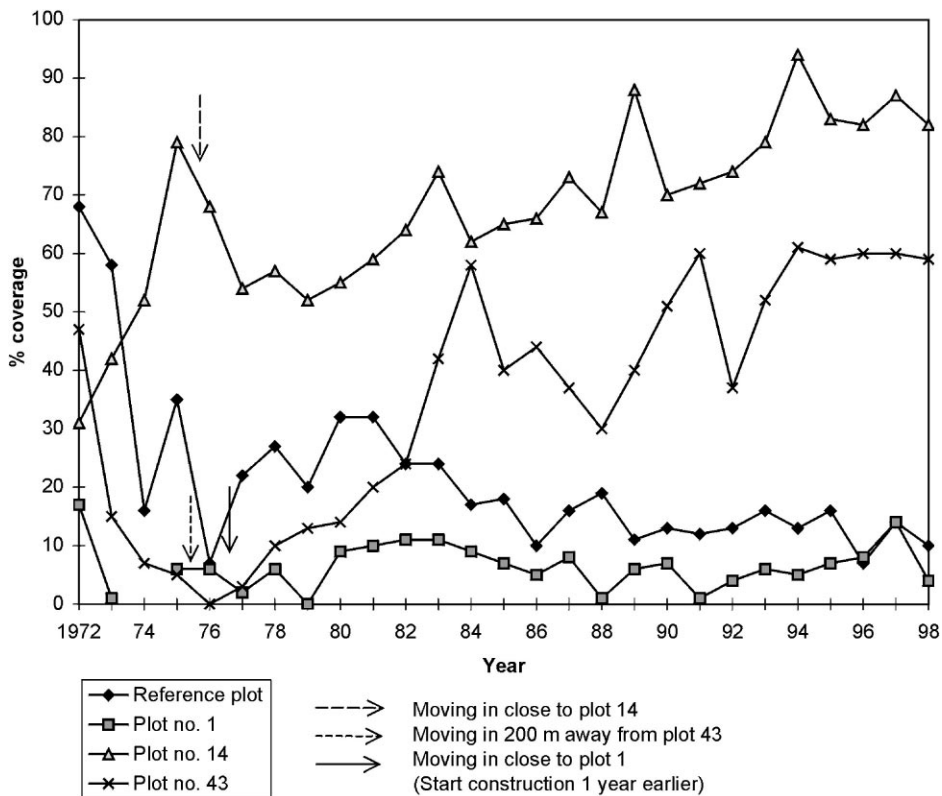


Fig. 5. Percentage of bare soil in forests on poor dry soils. Effects of trampling were first found in plot no. 14 close to (<100 m from) entrances to residential blocks. Vegetation here was dominated by herbs and *Vaccinium* sp. The effects were increased by vegetation treatment. In this plant society the effects of trampling at a distance of 200–400 m from entrances emerge later, as found in plot no. 43. A plot dominated by narrow-leaved grass species (*Deschampsia flexuosa* and *Festuca ovina*) was little affected.

Trees: Coverage in forests has increased in investigation plots as well as reference plots. An example of this is shown in Fig. 10. A single clearing seems to have no effect in the long run. The persistence and growth of old and young trees are exemplified and a typical development in a damaged area is shown in Figs. 11–15.

5. Discussion

5.1. Discussion of method

Treatment and impact on the investigation area and reference area has to a great extent been similar up to 1973. When the investigation area from 1973 onward was transformed to a residential area, forest thinning and clearing was stopped almost completely. In addition, the reference area has since been transformed to a

preservation area, which in this case also means that treatment by thinning and clearing decreased. On meadows, grazing went on in the investigation area as well as in the reference area. Difference in impact between investigation area and reference area depend for the greater part on development.

Observations and photographs are found to be an important complement to vegetation analysis. Without this complementary information it would not have been possible to generalize the conclusions.

As mentioned, in addition to the ecological groups, a group called “Bare soil and bedrock” was added. This was found to be of great value for the understanding of the wear and tear process. For example, this group was subdivided into soil horizons (litter layer, raw humus layer, etc.), which helped to show ongoing effects of heavy trampling or construction vehicle traffic in preserved areas.

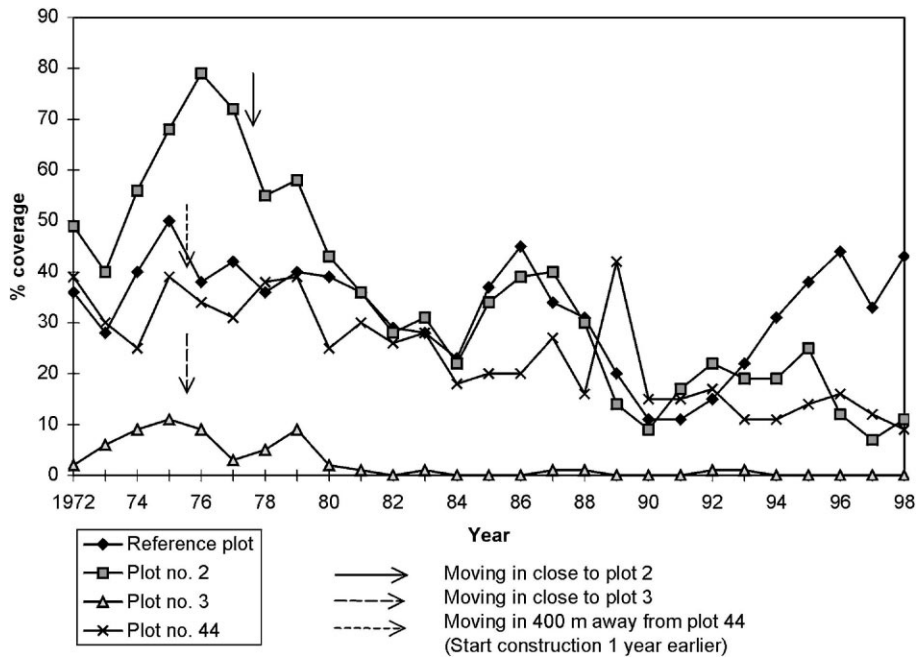


Fig. 6. Percentage of *Vaccinium myrtillus* and *Vaccinium vitis-idaea* cover in spruce forests of bilberry type. Plots no. 2 and 3 is situated close to entrances and a pedestrian road, and plot no. 44 ca. 400 m from entrances. All plots except the reference plot are affected, but at a distance of 400 m effects of trampling cannot be seen by the naked eye until 15 years after moving in.



Fig. 7. In an area situated close to entrances and to a pedestrian road, trampling occurs all over the surface. Almost all ground cover vegetation, previously dominated by *Vaccinium myrtillus*, has disappeared. Residential area close to the investigation area 3 years after occupants moving in.



Fig. 8. In a plot at a distance of about 400 m from entrances, trampling is directional. Paths in the *Vaccinium myrtillus* vegetation emerge. Close to plot no. 44, 5 years after occupants moving in.

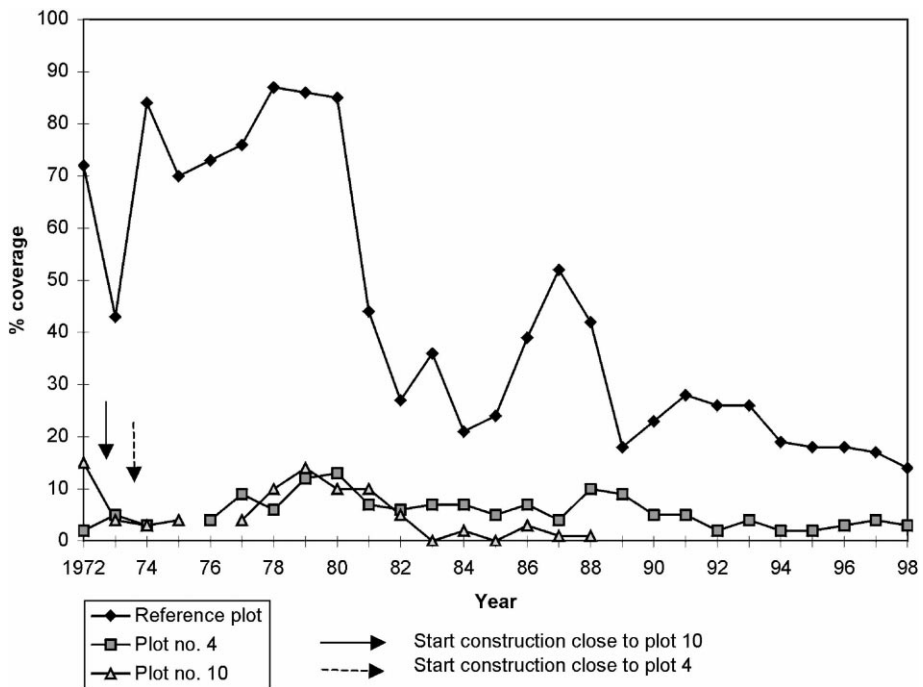


Fig. 9. Percentage of moisture-indicating herb cover in plots on moist soils. These herbs are little affected in the investigation area. Decrease in the reference plot is presumed to be due to tree and bush growth (see Fig. 10) and the drainage caused by this growth.

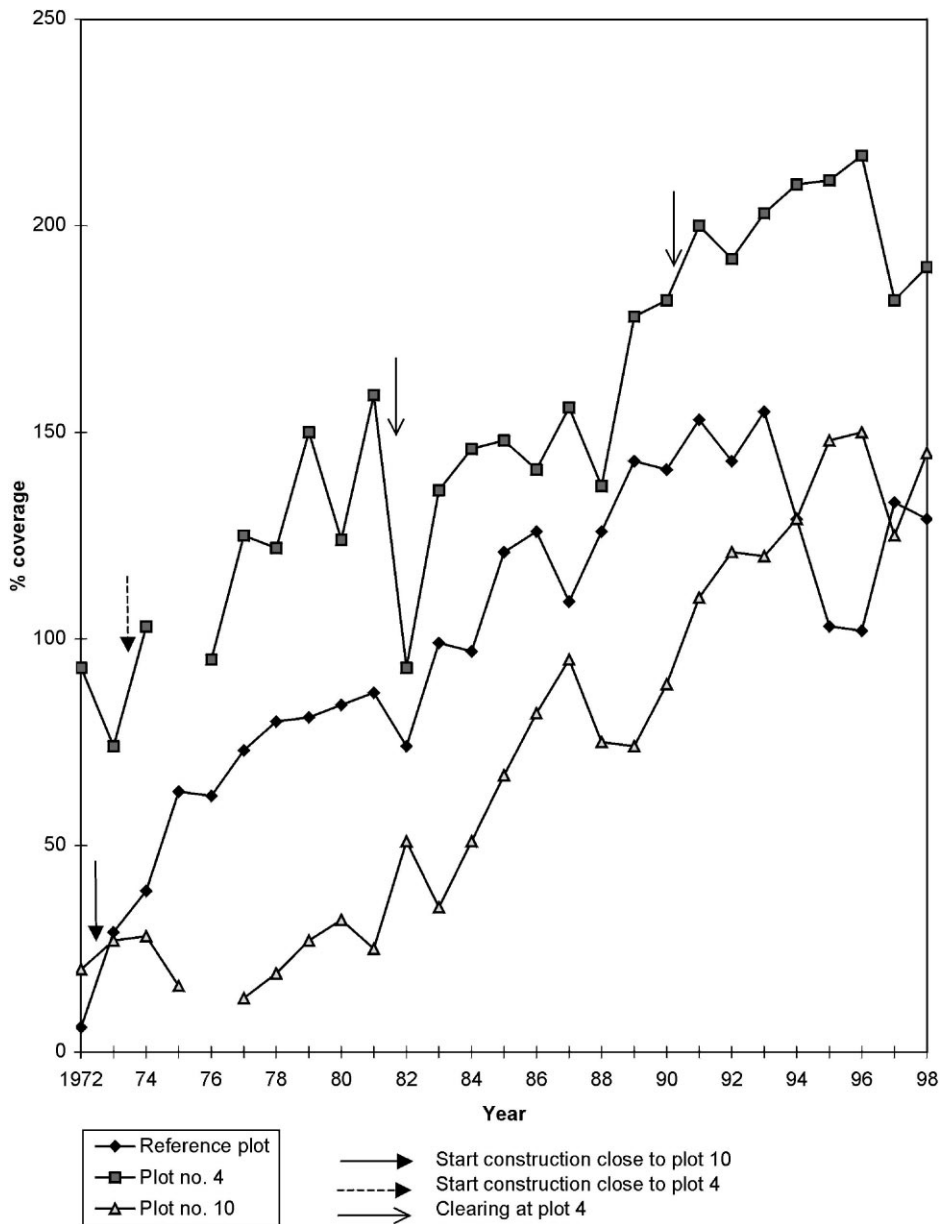


Fig. 10. Percentage of tree and bush cover in plots on moist soil. The coverage increases in all plots until 1991, and thereafter more or less stabilizes. Vegetation has recovered since heavy clearing before 1972, and seems now to have reached a mature stage. No effect of digging for pipe construction close to plot 4 and 10, and the temporary drainage it caused, can be seen. All plots react alike. Light clearing 1981 and 1991 have little or none long-term effect.

5.2. Discussion of results

Most damage to trees occur during construction and during the first few years of wear and tear.

Just a few years after construction, there is no impact from those initial years measured. Long-term effects, if any, cannot be separated from other impacts.



Fig. 11. Between the *P. sylvestris* and the two *P. abies*, soil has been excavated for constructional purposes, and roots thereby been cut. To the left of the pine, there are some very small *Betula pendula*. Close to plot no. 11, June 1974.

The trampling patterns differ according to distances from houses or, more correctly, distances from the entrances. Trampling reduces field and bottom layer in most plots in *Pinus sylvestris* and *Picea abies* forests within 400 m from entrances. In plots situated 50–100 m from entrances, the reduction started immediately after the occupants had moved in. In areas situated 200–400 m from entrances reduction was delayed by 5–10 years. Bare soil remains. In other words, major vegetation succession has not emerged, with one exception mentioned below. At a distance of 200 m and more, trampling is more common on

certain routes, which has resulted in the emergence of paths. Within 100 m from entrances, trampling is more widespread, and more or less all ground cover vegetation is subject to wear and tear. This receives little attention in the literature available on the subject.

Regarding trampling, in areas with very vulnerable vegetation on thin soil on bedrock, a succession towards grass-dominated types has emerged within 25 years. The vegetation in these areas is now quite non-vulnerable.

On other vegetation non-resistant to trampling on poor dry soils in forests, this succession has not



Fig. 12. After 6 months, one *P. abies* has been felled by wind, and the other has died. The *P. sylvestris* is still alive. January 1975.

occurred. Grass-dominated plots are little affected, and in plots with non-resistant herb-dominated vegetation naked areas still remain. The ground cover vegetation in itself is surprisingly perpetual. Existing areas with invariable grass-dominated vegetation have probably not emerged as a result of former trampling by man, but due to hundreds of years of grazing up to 1905. Prior to that, grazing in forests in this areas was common.

On poor dry soils, there is a clear connection between the reaction of vegetation on the one hand, and drought and wear and tear on the other. Trampling leads to a larger decrease in ground cover vegetation in

dry years than in years with normal precipitation. During rainy summers, vegetation will recover to some extent.

Frequent trampling has a severe impact on ground cover vegetation dominated by *Vaccinium myrtillus* and *Vaccinium vitis-idaea*. This was expected. However, we hypothesized that succession towards a plant society dominated by narrow-leaved grass species would emerge within 25 years. This has not happened. Areas with bare soil have spread. Yet, in other parts of the investigation area, there are sites dominated by *P. abies* with a ground cover vegetation with narrow-leaved grass. A new hypothesis is that succession



Fig. 13. June 1975, one year after moving in of occupants. The *Picea abies* have died from the damage to their root systems, caused by excavation, but the *Pinus sylvestris* is still alive. This implies that there are great differences in tolerance between species. *B. pendula* have been planted in a strip of rich top soil filled along the road.

towards a plant community dominated by narrow-leaved grass species will emerge, but that this takes a long time. Soil condition (the microbe fauna and flora as well as acidity) is perpetual and prevents non-adapted species from colonizing.

In plant communities on wet and/or rich soils, the changes have been small or non-existent. Dyring, (1984) and Ingelög et al., (1977) have found greater changes in plant societies on rich soils. The difference here may depend on the methods used. Both Dyring and Ingelög et al. have deliberately studied trampled

areas and related these to areas with no or little impact. On Järvafältet, however, the plots were chosen at random, and should thus be more representative. Even on Järvafältet, degraded areas on rich soils can be found, but not to any large extent. In other words, choosing trampled areas for study will emphasize trampling as a problem, while a randomized choice shows whether or not different plant societies are affected by trampling.

The coverage of moisture-indicating species in plots on wet sites was little affected. This confirms



Fig. 14. June 1985, 11 years after cutting the roots and 10 years after planting. The planted *Betula pendula* have hardly grown at all, but the natural have, and were higher than the planted trees in 1982. This implies that the undisturbed soil ecosystem in itself is an important resource, and a better growth substrate than the richer top soil, perhaps also combined with provenience problems for the planted trees.

observations from other sites, where it has been found that in areas with stratified soil in humid regions, a number of conditions must be met before upper ground water tables, of importance to vegetation, are lowered. The fact that tunnels are leaking, and drainage layers around house foundations as well as pipe systems are built, does not necessarily imply a lowering of the ground water table within the places where the preserved vegetation is situated. Just a few metres from construction, ground water table can be undisturbed on clay soils.

The increased tree and bush coverage in all forested plots could be explained by the difference in previous and contemporary maintenance. Treatment by thinning and clearing has decreased, which enables all forests to become more dense. This is a considerable problem. The reason is not only due to lack of money for maintenance, but also to the fact that public often do not know the value of that which is vanishing. Interviews carried out in this project show that they often believe that all thinning and clearing is a bad thing. For example, a part of a grazed forest with



Fig. 15. June 1993, 19 years after cutting the roots and 18 years after planting. The *Pinus sylvestris* is still healthy, and will probably survive for decades, maybe a century. Indigenous and planted *Betula pendula* cannot be distinguished by appearance.

widely scattered trees close to a residential area was in 1955 designated for preservation as a recreational area. The motive was its beauty and scientific value. From that time onwards, this area was not grazed or treated. Tree vegetation established itself. During 1955–1975 growth was very slow, but thereafter accelerated. During 1975–1980 the trees grew from a low and thin stand to a stand of several metres height with a density of more than 2 trunks/m². Within the stand, it was not possible to see more than some metres. The area was not used as a recreational area

any more, and its value for science was rapidly decreasing. The wear and tear caused by the inhabitants was far less than that of grazing cattle. The same process can be observed from photographs of part of the investigation area.

6. Conclusions

Damage to trees in preserved areas mainly occurs during construction. Changes in field and bottom layer

occur mainly during later use. The impact of construction has not been proven to have long-term effects on vegetation. The reaction of the vegetation depends on vegetation type and on distance to development and entrances.

Fruticose lichen type plant communities close to development areas were damaged in the first few years of wear and tear, a rapid succession resulting. After this initial period of change, however, the new ground cover vegetation was found to be surprisingly resistant.

In pine and spruce forests with a ground cover vegetation dominated by *Vaccinium myrtillus*, the outcome of excessive trampling is usually not succession, but bare soil. In areas situated 50–100 m from entrances to houses, the reduction starts immediately after that the occupants move in. In areas situated 200–400 m from entrances reduction is delayed about 5–10 years. Grass-dominated ground cover vegetation, on the other hand, is found to be quite invariable. This latter plant community has probably emerged from former long-term grazing. Such a succession, from *V. myrtillus* to grass dominance, takes a long time, probably more than half a century. Thinning would likely speed up the process.

The vegetation areas have not been affected to an extent where their value as recreation areas in the developed areas has vanished. On the contrary, the preserved vegetation is of great value to the local occupants. Through well elaborated planning and design, resistant and functionally well-suited vegetation can be preserved in development areas. With proper implementation, the impact of development on vegetation can be minimized.

Acknowledgements

Many people have made important contributions to the projects over the 27 years of the study. Special thanks are due to landscape architect Pär Söderblom, who initiated the main project, and Dr. Sc. Hans-Georg Wallentinus, for valuable feedback and input.

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