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Recovering bird diversity by landscaping a landfill: early stages of succession

Återskapande av fågeldiversitet genom utformning av en utfyllnad: tidiga stadier i successionen

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Abstract

A Finnish pilot project of landscaping a landfill is aimed at creating conditions for a diversified and abundant flora and fauna. In 1997–2005, one part, a recent sand heaping mound was managed, while a second part, a former communal waste dump, was left for free vegetation succession. The birds of the open landfill area (45 ha) and surrounding forest (30 ha) were censused by territory mapping during four breeding seasons (1997, 2003–2005). The changes in the avifauna of the landscaped part were compared to those of the unmanaged one and the surrounding forest. In the open habitats, the total abundance of ground-nesting birds remained relatively stable while the species nesting in scrub clearly increased. However, the ground-nesters increased in the recently landscaped heaping mound, but decreased in the unmanaged area. The bird diversity seemed to change in the expected manner, following the rapid early succession of vegetation. Accordingly, continuous management is needed to keep the species of the most open habitats as permanent members of the local avifauna.

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Introduction

Landfills are problematic in many ways, from the selection of an acceptable locality to the aftercare of the abandoned site (Gabrey 1997, Schmeisky & Podlacha 2000, Misgav et al. 2001). They are often established at a distance but not very far from human settlements in environments that may be of minor economic value, but that may include considerable natural resources from a conservation point of view. Following the establishment of a landfill, local environmental conditions are likely to considerably deteriorate the original flora and fauna of the district. However, organic waste often provides food for a vast number of scavengers, including gulls and corvids (Monaghan 1980, Vuorisalo et al. 2003, Bellebaum 2005). During the use of a dump, its direct and indirect effects may reach over much larger areas than the waste tip itself, including the surrounding soil, waters, and vegetation, as well as built-up areas in the neighborhood (e.g., Belant 1997, Gabrey 1997, Belant et al. 1998, Kilpi & Öst 1998, Tortosa et al. 2002, deLemos et al. 2006).

After the active use of a landfill, the area is useless for economic purposes and forms a considerable environmental risk due to increased methane production (EPA 2005) and to local release of various substances harmful to living organisms (Raloff 2001, deLemos et al. 2006). In order not to leave the waste exposed, an abandoned landfill is often covered with a layer of soil, and nature, i.e., ecological succession, left to take care of the rest. A possibly superior alternative is, however, well-planned landscaping and management of the disturbed environment if not to restore, at least to develop it in some ecologically or conservationally desirable direction (Misgav et al. 2001, Rebele & Lehmann 2002, New York City 2005).

As well-known, during the early stages of ecological successions biodiversity is, in general, lower than later on (Odum 1971). The rate of increase in diversity depends on the fertility of the soil and characteristics of the surroundings. This concerns the vegetation as well as the invertebrate and vertebrate fauna that depend on the resources provided by plants. Human activities often impact local biodiversity negatively, while the effects of well-planned management may lead to the reverse (e.g., Bradshaw 2000, Koehler 2000, Waltz & Covington 2004, Natuhara et al. 2005). Detailed knowledge of

the responses of different organisms to the availability of various environmental resources will increase successes in keeping biodiversity losses as low as possible (e.g., Marzluff & Ewing 2001). They also may give a chance to recover and enhance diversity after disturbances.

In the boreal zone, ecological succession usually leads to mature forests in about 100 years, and biodiversity reaches its peak during the same period (see Haapanen 1965, Esseen et al. 1997). The response of the Finnish avifauna to the forest succession follows the well-known general pattern somewhat modified by the fertility of soil (Haapanen 1965, 1966, Helle 1985, 1986). The most important feature of the habitat affecting the composition of the bird fauna is its structural heterogeneity that increases with time. So, the age of the vegetation provides a suitable general measure also of the succession of the bird community.

In this paper, I describe from an ornithological point of view the early stages of a Finnish pilot project of landscaping and managing a discontinued landfill. The approach is largely a descriptive one, primarily introducing the background and first steps of this long-term project. If the landfill and its surroundings were left to natural recovery, it is expected that the avifauna of the landfill and its surroundings should first increase when the plant diversity and structural heterogeneity in the open landfill area get higher but later degrade closer to that of the surrounding habitats. In the present case, however, the landscaping and management of the vegetation succession should partly prevent natural recovery and partly introduce new elements of diversity, finally resulting in a site of higher biodiversity than both that of the original community and that of the community that would have developed without any management. The first eight years of the project considered here should broadly indicate how the responses of birds begin to diverge between the managed and unmanaged areas.

Study area and methods

Landscape history of the study area

The site in question, the Vuosaari landfill near the eastern border of the City of Helsinki, southern Finland (60°14' N, 25°09' E) is situated in the middle of various economic, recreational, and conservational pressures, offering great challenges to planners and decision-makers. At present, it consists of two parts, a disused dump for community waste and a recent heaping area for masses of surplus soil from building sites. The waste dump was established at the beginning of the 1960s on a rural area of former fields surrounded by bedrock and forests near the southern tip of the wetlands of Porvarinlahti bay. It was used during two periods, 1966–1975 and 1979–1988. Since then, natural succession and some aftercare of the site covering about 25 ha has continued in spite of some occasional use for storage, up to the present. The nearby heaping area for earth was established in 1990 and expanded in 1998. In total, the open environment, the object of the present landscaping project – referred to here as the Vuosaari landfill – reaches up to 60 m above sea level and covers about 45 ha. Figure 1 shows four photos from different parts of the landfill.

At present, the landfill is mainly surrounded by forests, briefly bordering also wetlands and man-made open areas. To its north and west is a sparsely inhabited region of more than ten km² of forests, fields, and wetlands, including a nature reserve of international value called the Mustavuori herb-rich forests and Östersundom wetlands Natura 2000 area (Solonen 1999, Koivula et al. 2002, Uudenmaan ympäristökeskus 2004, Nordberg 2007). The nearby western forest, at present largely used for recreation, is planned to be built up to a densely settled area of single family houses (Helsingin kaupunkisuunnittelu 2005). In the south, behind a narrow belt of forests, lies the older part of the rapidly developing Vuosaari suburb (City of Helsinki 2006). In the southeast is Porslahti golf course, established recently on the heaping area of a former sewage treatment plant. Nearby is also Vuosaari gas power plant and dockyard developed during the last few years northwards to the vast area of the Vuosaari harbor, which wiped out a considerable forest area that bordered the Natura 2000 site mentioned above (Yrjölä & Koivula 2003, Nordberg 2007).

The avifauna of the Mustavuori-Östersundom area includes more than a hundred breeding species (Solonen 1999, Yrjölä & Koivula 2003), corresponding largely to the original state existing in the district prior to the opening of the landfill. Important bird habitats, including a nesting site of the Northern Goshawk *Accipiter gentilis*, were lost especially in connection with the enlargement and intensified use of the dumping area from the second half of the 1970s, as well as due to the establishment and expansion of the heaping area in the 1990s. Thereafter, the local habitat losses increased still further due to the building of the nearby gas power plant and especially in the 21st century because of the massive Vuosaari harbor project (see

Yrjölä 2003, Yrjölä & Koivula 2003, Yrjölä et al. 2005, Nordberg 2007).

After the establishment of the landfill, the local avifauna largely changed, consisting subsequently mainly of foraging visitors such as gulls and corvids. Additionally, the first breeding species to arrive following closure of the landfill were quite different compared to those of the immediate surroundings. The natural succession of the open landfill can be expected to lead to a species composition similar to that present before the disturbance (e.g., Odum 1971), largely represented by the present avifauna of the immediate surroundings, i.e. a bird fauna of a mature forest.

Landscaping and monitoring the landfill area

The City of Helsinki's Public Works Department's Environmental Production (PWDEP) began the landscaping of the heaping area of surplus soil at the Vuosaari landfill area in the summer of 1996. Landscaping was carried out making use of spontaneous and directed succession, as well as suitable soil types and moisture conditions (J. Toivonen, PWDEP, Helsinki). The vegetation was managed both by mowing (to stop or slow down succession) and sowing and planting (to increase food resources and the patchiness of habitats). In addition to the already existing vegetation types, the aim was to develop a diverse selection of open and semi-open habitats, as well as rich forest edges, for as diversified and abundant a flora and fauna as possible. Attempts were and will be made to maintain and develop suitable environments for various endangered species as well. The additional heaping of surplus soil after landscaping had already begun somewhat changed the nature and development of the area, but in 2003 this use ceased and landscaping again proceeded unhindered.

In the beginning of the monitoring period (1997), the landfill area was characterized by the bare soil or scanty vegetation of the heaping mound (successional age about 1–5 years), and the relatively barren and sparsely bushy meadows of the disused landfill (the age of the vegetation about ten years). During the following years of landscaping, surplus soil masses were relocated besides on the heaping mound also on some of the landfill's barren areas. Some areas were also used as temporary storage for various masses. A part of the open area of the landfill was reserved for storing of contaminated soil and other hazardous waste. In 2001–2005, especially during the last three years, the landscaping of the heaping mound proceeded with stones, stumps, and introduction of scanty vegetation characterized by heather *Calluna vulgaris* and thyme *Thymus serpyllum*. Sowing increased the vegetation in some places, while cutting kept it in the desired condition in others. In most of the landfill, the vegetation developed freely, producing relatively abundant vegetation of grass, herbs, and sparsely distributed bushes.

The present monitoring area, covering a total of 78 ha, consisted of the combined old landfill and heaping mound with some minor nearby open areas (45 ha) as well as a belt of the surrounding terrain up to about 100 m from the edge of the open habitat (33 ha). The surrounding habitats were partly barren, partly quite fertile middle-aged (about 50 years old) forests (30 ha), but also included a strip of bushy reeds (3 ha).

Breeding birds of the study area were censused by the territory mapping method (e.g., Koskimies & Väisänen 1991, Bibby et al. 1992) using seven visits in April–June in each year of study (1997, 2003–2005). The bird diversity was quantified by species richness (S = number of species), and by Shannon-Wiener index (*H'*) calculated by the Chang Bioscience calculator (http://www.chang-bioscience.com/virtualab.html). The similarity of bird assemblages was compared using Spearman rank order correlation coefficients (e.g., Martin & Chambers 2001). The changes in the avifauna of the recent landscaping area were compared to those of the unmanaged part of the landfill as well as to those of the surrounding forest. Possible indications of trends in diversity were preliminarily examined by Spearman rank correlation. The dependence of bird diversity on the successional stage of habitat characterized by the approximate age of vegetation was examined by linear regression. Analyses were conducted by SigmaStat 3.1 statistical software.

Results

Species composition and abundance

In the open landfill, the avifauna included annually 11–21 species (Appendix 1). They included one globally endangered species (Corncrake *Crex crex*), two species of special concern in the European Union (Barred Warbler *Sylvia nisoria*, Red-backed Shrike *Lanius collurio*), and two near-threatened species of national concern (Whinchat *Saxicola rubetra*, Northern Wheatear *Oenanthe oenanthe*). Both in 2004 and 2005, six new resident species were recorded. Only one species (Barred Warbler) seems to be have been lost after the first census. The number of territories of the most abundant

Figure 1. Different parts of the Vuosaari landfill. Upper left: The northern part of the heaping mound in the early stage of landscaping on 24 April 2004. Upper right: The eastern side of the landscaped heaping mound from the north southwards to the Vuosaari harbor on 9 June 2005. Lower left: A northeast view to the heaping mound over the bushy habitat of, among others, the Whinchat *Saxicola rubetra* and Common Grasshopper Warbler *Locustella naevia* in the middle part of the old landfill on 26 May 2004. Lower right: A southwest view of the bushy grassland of the southern part of the old landfill on 9 June 2005. All photos © Tapio Solonen.
Olika delar av Vuosaari utfyllnad. Övre vänster: Norra delen av grovtippen i ett tidigt stadium av landskapsplaneringen, 24 april 2004. Övre högra: östra sidan av den landskapsplanerade grovtippen från norr söderut mot Vuosaari hamn, 9 juni 2005. Nedre vänster: Utsikt mot åt nordost mot grovtippen med buskbiotop med bl.a. buskskvätta och gräshoppsångare i centrum av den gamla utfyllnaden, 26 maj 2004. Nedre höger: Utsikt mot sydväst över buskig gräsmark på den gamla utfyllnaden, 9 juni 2005.

Table 1. Population changes (number of pairs) of birds of the principal nest-site categories (see Appendix 1) in the actively landscaped heaping mound and the old landfill of the Vuosaari landfill.
Populationsförändringar (antal par) hos fåglar inom de huvudsakliga boplatskategorierna (se Appendix 1) i den aktivt behandlade avstjälpningsplatsen och den gamla utfyllnaden i Vuosaari utfyllnad.

	1997	2003	2004	2005	r_S	P
Landscaped heaping mound						
Ground-nesters *Bon på marken*	–	35	42	43	1.00	0.33
Above ground-nesters *Bon över marken*	–	10	18	16	0.50	1.00
Old landfill						
Ground-nesters	–	55	46	41	-1.00	0.33
Above ground-nesters	–	25	30	37	1.00	0.33
Total						
Ground-nesters	80	90	88	84	0.20	0.92
Above ground-nesters	31	35	48	53	1.00	0.08

bird species, Eurasian Skylark *Alauda arvensis*, remained relatively stable throughout the monitoring period. The number of the Common Whitethroat *Sylvia communis* seemed to have increased, while the White Wagtail *Motacilla alba* declined.

The breeding birds of the forest of the immediate vicinity of the landfill consisted of 26–40 species annually (Appendix 2). The abundances of single species remained largely unchanged or fluctuated irregularly without a clear trend. Some species with very large home ranges included the census area in their territories in some years: Northern Goshawk, Eurasian Sparrowhawk *Accipiter nisus*, Eurasian Woodcock *Scolopax rusticola*, Common Cuckoo *Cuculus canorus*, Tawny Owl *Strix aluco*, Long-eared Owl *Asio otus*, and Black Woodpecker *Dryocopus martius*.

The total number of territories was relatively unchanged in the open habitats (Appendix 1) but tended to increase ($r_S = 1.0$, $P = 0.08$, $n = 4$) in the forest (Appendix 2). In the open habitats, the total abundance of ground-nesting birds remained relatively stable while the numbers of species nesting in scrub tended to increase (Table 1). In the area of the actively landscaped heaping mound, the numerical response of ground-nesters appeared to be contrary (positive) to that of the birds of the old landfill area (negative). The total species abundance distributions, however, differed neither between years nor between the managed and unmanaged study plots ($r_s > 0.56$, $P < 0.01$, $n = 26$).

Species richness and diversity

In the open habitats, the number of bird species (S) increased, though not significantly ($r_s = 1.0$, $P = 0.08$, $n = 4$), due to the increase in the unmanaged part of the landfill (Figure 2). The positive contribution of the management seemed to have been yet minor. The number of species in the whole open landfill was 42.3% and 55.3% of that of the surrounding forest in the beginning and at the end of the study period, respectively.

The species diversity (*H'*) tended to increase in the pooled open habitats but not in the adjacent forest (Table 2). In the landscaped area, the change in diversity was very small whereas that in the unmanaged open area was greater. The stage of succession explained significantly the annual bird diversity of the study plots ($R^2_{adj} = 0.90$, $t_{10} = 9.0$, $P < 0.001$). Species diversity in the open landfill areas was 73.9% and 77.7% of that of the surrounding forest in the beginning and at the end of the study period, respectively. The contribution of the open habitats to the total bird diversity of the monitoring area ranged annually from 5.1% to 12.5%. The increase in the total species richness (26.0%) and diversity (8.4%) seems to have leveled off in the last few years (Figure 2).

Discussion

The present data were too scanty and the period examined too short for a reliable analysis of successional changes in the bird fauna. In particular, there were too few data points for proper statistical testing. However, some observations suggest tentatively that ecological succession was slowing down in the managed area while the unmanaged part of the study area was mainly responsible for the increasing bird density and diversity. Thus, although not statistically certain yet, the development of the habitat and bird fauna is likely to be in the direction intended with the landscaping plan and management.

Table 2. Development of bird diversity (Shannon-Wiener *H'*) in the different parts of the Vuosaari landfill in 1997–2005.
Fågeldiversitetens (Shannon-Wiener H') utveckling i Vuosaari utfyllnad 1997–2005.

Area *Delområde*	1997	2003	2004	2005	r_s	P
Landscaped heaping mound						
Landskapsplanerad grovtipp	–	1.827	1.927	1.904	0.50	1.00
Unmanaged landfill						
Obehandlad utfyllnad	–	2.250	2.336	2.552	1.00	0.33
Open habitats, total						
Öppna området totalt	2.040	2.202	2.253	2.399	1.00	0.08
Forest						
Skog	2.760	3.117	3.266	3.087	0.40	0.75
Monitoring area, total						
Hela bevakningsområdet	3.153	3.342	3.443	3.392	0.80	0.33

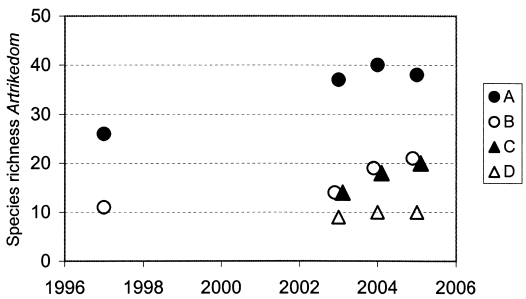

Figure 2. Development of bird species richness (S) in the Vuosaari landfill area in 1997–2005: managed heaping mound (open triangels), unmanaged landfill (black triangels), open habitats combined (open dots), and surrounding forests (black dots).
Utvecklingen av artantalet (S) i Vuosaari utfyllnad 1997–2005: utfyllnad under skötsel (öppna trianglar), utfyllnad utan skötsel (svarta trianglar), öppna biotoper tillsammans (öppna cirklar) och skog (fyllda cirklar).

Bird density

The bird density of the open landfill areas (ca. 300 pairs/km²) reached a rather high level during the eight years. This indicates that ecological succession has proceeded rapidly in places. The density is, however, less than half that of the surrounding forest (ca. 800 pairs/km²). The bird density in forest was quite high, partly due to the fertility of the habitat, but primarily because of the nearness of an edge, preferred by many species (e.g., Helle 1986, Solonen 1996). The differences in bird numbers between years were obviously partly due to general annual fluctuations, partly to the changes that occurred in the breeding habitats, especially ecological succession in the open environments. Some territories of the edge-preferring forest birds seemed to shift at times to the landfill area. The annual differences in the forest bird densities probably reflect particularly the fluctuations and changes in the general population levels and in the local distribution of territories between the survey area and areas outside.

Changes in bird diversity

In the early stages of succession, species richness (S) seemed to characterize the changes in bird fauna better than diversity (*H'*) that takes also the evenness of the abundance distribution into account. The total bird diversity of the open area did not reach that of the old landfill that developed in the frames of natural ecological succession during the monitoring period. This seemed to be due to the lower evenness in the abundance distribution of species in the total open area. Most of the species living in the less diverse managed area also occurred in the unmanaged one. It is expected that in the later phases of succession and management the species composition of the areas still diverge and both areas will contribute positively to the total diversity.

The leveling of the increase in the total species richness and diversity in the monitoring area is probably due to the annual variations in the occurrence and density of birds of forest habitats where the diversity has nearly reached its locally possible maximum level. However, the contribution of the open habitats to the total bird diversity of the area should continue to increase, supposing that the habitat patch diversity can be maintained, if not even increased, by the management regime

(cf. Pino et al. 2000). Though the bird diversity of the landscaped heaping mound has hardly yet increased, the contribution of this area to the total diversity of the surroundings will be important because it provides various barren and barely vegetated habitats necessary for some species that do not find them elsewhere in the neighborhood. The other larger open green area in the vicinity, the Porslahti golf course, provides only short-cut lawns used by some species of birds for foraging, but does not increase the breeding bird diversity of the district (cf. Tanner & Gange 2005).

Importance of landfills for biological diversity

The Vuosaari landfill and its immediate surroundings are already at present occupied by a relatively abundant and diverse avifauna (Solonen 1999, Yrjölä 2003, Yrjölä & Koivula 2003, Yrjölä et al. 2005). Especially the breeding bird fauna of the open habitats is distinctive. Among others, the Little Ringed Plover *Charadrius dubius*, Whinchat, Northern Wheatear *Oenanthe oenanthe*, and Common Linnet *Carduelis cannabina* occurred clearly more regularly and abundantly there than in the district in general. The landfill area also provides distinct scenes in the flat scenery of the southern coast of Finland, being especially tempting, among others, to various northern avian visitors during their migration periods and in winter (Solonen 1998 and unpubl.). Reaching up to 60 m above the sea level and with a free view in all directions, the heaping mound provides an excellent observation point for bird-watchers and an opportunity to see almost any bird species met in southern Finland. Though the landscaped area is not in the strictest sense "natural", in any case it provides a compromise between the original and disturbed environments of the district. At its best, it can be developed into a local hot spot of biological diversity and a refuge for some locally or even globally endangered species.

The present study and related projects conducted elsewhere (e.g., Koehler 2000, Rebele & Lehmann 2002, AES 2003, New York City 2005) exemplify the conservational potential of discontinued landfills. They also illustrate the importance of temporal and spatial scale in considering the diversity of different organisms. Birds seem to be good environmental indicators, among other reasons, due to their relatively rapid response to even minor changes in the available resources (e.g., Passell 2000, Twedt et al. 2002). However, they often respond slowly and to very general features of habitat as compared to some less visible organisms (Hermy & Cornelis 2000, Koehler 2000).

Prospects

The present results suggest that with help of landscaping and management of vegetation it is possible to maintain the typical characteristics of the local avifauna and diversify it still further. In this context, the continuous availability of open areas is of particular interest. From the beginning, a fundamental task in most attempts to keep the local biodiversity as high as possible is to guarantee the sufficient availability of habitats for species preferring early stages of succession. At the other end of the scale, in the late successional stages, habitats primarily need only passive conservation measures.

The results of territory mappings of birds reveal where the important habitats for each species are located and how the situation is developing. First of all, attempts should be made to keep the habitats of the locally declined species and other species of special concern as constant as possible. Usually this requires cutting of grass and herbs, and removing of saplings. Also the new species tempted to the area by suitable habitats and other resources are noteworthy. In the present case, the globally endangered corncrake holds special status, in particular because the suitable habitats in the surroundings have deteriorated due to the development of the Vuosaari harbor.

To be sustained, the diversity should be based on viable populations rather than on single territories or pairs of breeding birds that may disappear for any stochastic reason. Thus, attempts to increase the bird diversity should, in addition to species richness, also concern the raising of pair numbers of the less abundant species. This means that the area should provide habitats evenly for all the species considered.

Monotonous habitats can be improved by adding various elements important for birds such as suitable food and cover plants for nutrition and safe foraging. Breeding birds also need species-specific safe nesting sites. Some species occupy such large territories that areas of a few tens of hectares may be too small to provide resources enough for even one breeding pair. In such cases, the provision of a few alternative nesting sites and suitable foraging conditions may be of utmost importance for the species's local population.

In a plan for maintaining and increasing bird diversity in the Vuosaari landfill area (1996), I considered ca. 100 potential breeding species of which

about 50–60 might occupy the present open area in the near future (within some decades) with help of suitable management. After the first year of study, when only 11 breeding species were recorded, 16 new ones have occupied the area, at least occasionally, while only one seemed to be have been lost during eight years (Appendix 1). This suggests that the species pool of the area might be more or less saturated within a few decades.

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Sammanfattning

Avfallstippar är problematiska ur flera synpunkter, från val av plats när utfyllnaden startar till efterbehandlingen när den upphört. Ofta väljs platser av mindre ekonomiskt värde på måttligt avstånd från bebyggelse, men platsen kan ha naturvårdsvärde. Den ursprungliga floran och faunan förstörs vanligen, men ansamlingen av organiskt avfall ger föda åt exempelvis mås- och kråkfåglar. En avfallstipp har också ofta effekter på mark, vatten, vegetation och människor inom ett större omland. En övergiven utfyllnad saknar ofta ekonomiskt värde eftersom det finns risk för spridning av giftiga ämnen och bildning av metangas. Ibland lämnas utfyllnaden som den är eller täcks med ett lager av jord varefter man låter naturen ha sin gång. Ett möjligen överlägset alternativ är att utforma en sådan landskaps- och skötselplan för utfyllanden att man får en för specificerade naturvårdsmål önskvärd ekologisk utveckling.

Inom den boreala zonen leder fri utveckling av en öppen biotop till mogen skog på ungefär 100 år. Biodiversiteten når sin höjdpunkt under denna period för att sedan sjunka. Detta gäller för södra Finland, där den utfyllnad som skall beskrivas i denna uppsats ligger. Här skulle således biodiversiteten till att börja med öka med ökande invandring av vegetation och den ökande strukturella diversiteten när den växer upp. Så småningom skulle denna ökning plana ut och i ett senare skede sjunka till den lägre nivå som omgivningen har. Syftet med föreliggande projekt är att genom god landskapsplanering vidmakthålla en hög biologiska mångfald och även delvis lägga till nya komponenter av mångfald.

Undersökningsområdet

Projektområdet är Vuosaari utfyllnad nära östra gränsen av Helsingfors. Utfyllnaden är belägen mitt i ett komplex av olika markanvändning med krav från olika intressen såsom industriella, byggnation, rekreation och naturvård, således en utmaning för planerare och beslutsfattare. För närvarande består utfyllnaden av två delar, en gammal soptipp och en färsk grovtipp för jord från byggnadsplatser. Kommunalt avfall tippades åren 1966–1975 och 1979–1988. Denna del täcker c. 25 ha och har i stort sett haft en naturlig vegetationsutveckling och obetydlig eftervård. Tippen för jordmassor öppnades 1990 och utökades 1998. Hela utfyllnadens öppna område är c. 45 ha och har sin högsta punkt 60 m över havet. Större delen av utfyllnaden omges av en ungefär hundra meter bred zon av skog. Områdena runt projektområdet består av bebyggelse, jordbruksmark, en golfbana och våtmarker. Fyra delar av undersökningsområdet illustreras med foton i Figur 1.

Landskapsplanering

Helsingfors stad började landskapsplaneringen av Vuosaari utfyllnad sommaren 1996. Planeringen omfattade såväl klippning för att vidmakthålla eller sänka hastigheten för naturliga successioner som sådd och plantering för att öka födoutbudet

och öka antalet biotoper. Planen var således att utöver redan existerande vegetationstyper skapa en mångfald av nya öppna och halvöppna biotoper och artrika skogskanter, allt för att skapa en så rik och mångformig flora och fauna som möjligt. Fram till 2003 fortsatte tippning av jord, men efter detta år är det uteslutande arbetet med landskapsplanen som styr områdets utveckling.

I början av den period som beskrivs här (1997) bestod utfyllnaden mest av bar jord eller av gles, ett- till femårig vegetation samt av buskbevuxen ängsmark på den gamla soptippen. De flesta av landskapsåtgärderna genomfördes under åren 2003–2005 och omfattade omflyttning av jordmassor, utplacering av stenar och stockar, spridning av ljung och timjan, sådd av olika växter och slåtter. Inom större delen av området var dock vegetationens utveckling fri och här bildades en ganska rik vegetation av gräs, örter och glesa buskar.

Övervakningsområdet täcker för närvarande en areal av 78 ha. Däri ingår utfyllnaden, några små andra öppna områden (c. 33 ha) samt ett bälte ut till ungefär 100 m från utfyllnaden. Detta bälte var dels ganska fattig, dels rätt rik femtioårig skog (30 ha), dels en buskig vass (3 ha).

Inventeringsmetod

Fåglarna inventerades med revirkartering under sju besök under april–juni varje år. Artrikedomen (antalet arter, S) och Shannon-Wieners diversitetsindex (*H'*), beräknades. Likheten mellan olika fågelsamhällen jämfördes och förändringar i tiden analyserades med Spearman rangkorrelation. Sambandet mellan fågelsamhällets diversitet och biotopens successionsstadium (med åldern som mått) analyserades med linjär regression.

Artsammansättning och abundans

Den öppna utfyllnaden hade årligen 11 till 21 arter (Appendix 1), varav en art (kornknarren) är globalt hotad, två betecknas som särskilt hänsynskrävande i Europeiska unionen (höksångare och törnskata) och två betecknas som sårbara nationellt (buskskvätta och stenskvätta). Både 2004 och 2005 registrerades sex nya arter. Endast en art, höksångaren, verkar ha försvunnit sedan den första inventeringen 1997. Antalet par av den vanligaste arten, sånglärkan, höll sig ganska stabilt under hela perioden. Törnsångaren ökade och sädesärlan minskade i antal. Spearmans rangkorrelation visade visserligen inte signifikans, men den var positiv och kan således indikera början på en tillväxt av fågeltätheten. Tabell 1 visar att det var buskhäckande arter som stod för ökningen medan markhäckarna hade oförändrade bestånd. Förändringen i det nya landskapsplanerade området verkade vara motsatt (positiv) den i den gamla utfyllnadesdelen (negativ), men arternas abundansfördelningar var ändå lika. Arterna i den omgivande skogen bestod av 30–40 arter årligen (Appendix 2). Skogsarterna var stabila eller varierade utan någon tydlig trend. Några arter hade revir som var större än undersökningsområdet: duvhök, morkulla, gök, kattuggla, hornuggla och spillkråka.

Den totala tätheten i det öppna området nådde rätt högt under perioden (c. 300 par per kvadratkilometer), men denna täthet är fortfarande mindre än hälften av tätheten i skogen (c. 800 p/km^2). Den senare tätheten är förhållandevis hög för skog, vilket främst torde bero på att skogen är en smal zon, vilket gynnar flera kantarter.

Artrikedom och diversitet

Det fanns en icke signifikant tendens till ökning av antalet arter i det öppna området beroende på ökning av antalet arter i det obehandlade delområdet med naturlig succession (Figur 2). Ökningen av antalet arter har således hittills varit liten. Antalet i det öppna området var i förhållande till skogen 42% i början och 55% i slutet av undersökningsperioden.

Diversiteten (*H'*) ökade både i de öppna biotoperna och i skogen (Tabell 2), men ökningen var klart kraftigare i de öppna biotoperna. Av de öppna biotoperna var det dock ökning endast i den gamla obehandlade utfyllnaden, där den naturliga utvecklingen av successionen förklarade ökningen. Det fanns en svag tendens till att diversitetsökningen i hela området avmattats de senaste åren.

Det föreföll som om artrikedomen kunde förklara förändringarna i fågelfaunan bättre än diversiteten i början av studieperioden. Det senare måttet tar förutom till artantalet också hänsyn till jämnheten mellan arterna. Diversiteten för hela det öppna området nådde aldrig upp till skogens diversitet, och detta syntes bero på den lägre jämnheten mellan arternas abundans i den öppna terrängen. Den fortsatta utvecklingen förväntas dock bidra till att det öppna området i ökande utsträckning skall bidra till den totala inventeringsarealens diversitet. Hittills är skogen, där fågelfaunan redan nått sitt lokala diversitetsmaximum, dominerande för den totala diversiteten. I det område som avsatts för landskapsplanering har arbetena och effekterna av dessa bara börjat. På sikt kommer de nya inslag

som skötselplanen föreskrivet att bidra med nya arter och därmed högre diversitet.

Utfyllnaders betydelse för biologiska diversitet

Vuosaari utfyllnad har redan en rik fågelfauna. Speciellt särpräglad är det häckande fågelsamhället i det öppna området. Exempel på specifika arter som attraherats är mindre strandpipare, buskskvätta, stenskvätta och hämpling, vilka alla förekommer rikligare än i det omgivande landskapet. Den högt uppstickande utfyllnaden i det i övrigt platta landskapet vid Finlands sydkust verkar också attrahera flera nordliga flyttfåglar under hösten och vintern. Med sina 60 meter och fri utsikt i alla riktningar är utfyllnaden också en utmärkt observationsplats för ornitologer. Fastän området i sträng mening inte är naturligt, utgör det ändå en kompromiss mellan den ursprungliga naturen och de hårdare exploaterade omgivningarna. Om landskapsplaneringen blir framgångsrik kan Vuosaari utfyllnad utvecklas till en ”hotspot” för biologiska mångfald och till en refug för hotade eller sårbara arter.

Framtidsutsikterna

Avsikten att skapa ett mångformigt öppet landskap genom planering och skötsel verkar ha varit framgångsrik. Nästan alla arter som fanns ursprungligen finns fortfarande kvar och en del arter har tillkommit eller ökat i antal. I andra ändan av successionsskalan finns den omgivande skogen, som uppnått ett stabilt stadium och kan lämnas för fri utveckling.

Inventeringsmetoden, revirkartering, innebär att fåglarnas exakta förekomst i förhållande till de olika biotoperna blir i detalj dokumenterad. Det kommer alltså att bli möjligt att på en mycket detaljerad nivå avläsa effekterna av de vidtagna åtgärderna och styra vegetationens utveckling så att dessa gynnar specifika arter, t.ex. den globalt hotade kornknarren. För att inte riskera att fåtaliga arter försvinner av en slump är det också viktigt att försöka hålla så livskraftiga bestånd av dessa att risken för detta minimeras. Åtgärder som ingår i planeringen är därför att föra in vegetation som ger både föda och skydd året om och boplatser under häckningstiden.

I min plan för Vuosaari utfyllnad från 1996 räknade jag med att ungefär 100 arter kunde vara potentiella häckfåglar. Jag räknar med att 50–60 av dessa arter bör kunna finnas inom det öppna området inom de närmaste decennierna med hjälp av den pågående landskapsplaneringen. Redan har 16 nya arter tillkommit utöver de 11 häckande arterna i början av planeringsperioden. Bara en art har försvunnit.

Appendix 1.
The number of territories of birds in the Vuosaari landfill (45 ha) during the breeding seasons 1997, 2003, 2004 and 2005. Ground-nesting species (cf. Table 1) are denoted by asterisk (*).
Antal fågelrevir på Vuosaari utfyllnad (45 ha) under häckningssäsongerna 1997, 2003, 2004 och 2005. Asterisk anger markhäckande arter.

Species *Art*	1997	2003	2004	2005
*Alauda arvensis**	36	38	39	33
Sylvia communis	12	17	23	22
*Anthus pratensis**	13	18	16	20
Carpodacus erythrinus	10	9	14	15
*Saxicola rubetra**	5	9	9	7
*Oenanthe oenanthe**	9	6	9	6
*Motacilla alba**	15	8	7	6
Acrocephalus palustris	-	-	-	5
Carduelis cannabina	5	5	5	5
*Crex crex**	-	-	1	4
Lanius collurio	3	3	2	3
*Emberiza citrinella**	-	3	1	2
*Anas crecca**	-	-	-	1
*Charadrius dubius**	2	2	1	1
*Anthus trivialis**	-	4	1	1
*Locustella naevia**	-	-	2	1
Sylvia borin	-	-	2	1
*Phylloscopus trochilus**	-	-	-	1
Pica pica	-	-	-	1
Fringilla coelebs	-	-	-	1
*Emberiza schoeniclus**	-	-	-	1
*Phasianus colchicus**	-	2	1	-
*Luscinia luscinia**	-	-	1	-
Turdus merula	-	-	1	-
Turdus iliacus	-	1	-	-
Acrocephalus schoenobaenus	-	-	1	-
Sylvia nisoria	1	-	-	-
Number of species *Arter*	11	14	19	21
Number of territories *Revir*	111	125	136	137

Appendix 2.
The number of territories of bird species in the nearby surrounding forest (30 ha) of the Vuosaari landfill during the breeding seasons 1997, 2003, 2004, and 2005.
Antal revir av fågelarter skogen som omger Vuosaari utfyllnad under häckningstid 1997, 2003, 2004 och 2005.

Species *Art*	1997	2003	2004	2005
Fringilla coelebs	35	27	31	34
Phylloscopus trochilus	30	26	22	29
Turdus merula	11	19	13	24
Erithacus rubecula	7	10	10	16
Anthus trivialis	11	14	14	15
Parus major	11	10	10	13
Turdus philomelos	6	6	11	9
Emberiza citrinella	11	5	9	9
Turdus iliacus	15	5	10	7
Parus caeruleus	4	3	4	7
Columba palumbus	5	7	8	6
Prunella modularis	4	2	5	6
Turdus pilaris	-	2	4	6
Sylvia curruca	4	5	5	6
Dendrocopos major	-	1	3	5
Sylvia borin	9	5	9	5
Carduelis chloris	10	9	10	5
Ficedula hypoleuca	4	3	4	4
Carduelis spinus	-	2	4	4
Luscinia luscinia	2	2	3	3
Phylloscopus sibilatrix	-	4	3	3
Regulus regulus	1	4	3	3
Corvus corone	1	2	2	3
Sylvia communis	-	-	1	2
Certhia familiaris	-	1	2	2
Carpodacus erythrinus	-	3	6	2
Bucephala clangula	-	-	-	1
Columba oenas	-	1	2	1
Motacilla alba	-	-	-	1
Sylvia atricapilla	1	1	2	1
Muscicapa striata	5	3	5	1
Parus montanus	-	1	-	1
Parus cristatus	-	-	2	1
Parus ater	-	1	1	1
Garrulus glandarius	-	1	2	1
Pica pica	1	2	2	1
Loxia curvirostra	-	-	-	1
Pyrrhula pyrrhula	1	3	1	1
Phasianus colchicus	1	2	3	-
Troglodytes troglodytes	1	4	1	-
Hippolais icterina	-	-	1	-
Aegithalos caudatus	-	-	1	-
Carduelis carduelis	1	2	1	-
Carduelis cannabina	-	1	1	-
Number of species *Arter*	26	37	40	38
Number of territories *Revir*	192	199	232	240