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Management to Restore Semi-natural Ecosystems in a Dutch Nature Reserve

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INTRODUCTION

This paper is a review of a diverse landscape restoration in Holland. The restoration began in 1972 and was conducted by the University of Groningen's Department of Plant Ecology with much labor supplied by local communities. The project was more than just a restoration, it included a study of the methods used to document and assess their effectiveness. The study included two major sites but this paper will only cover the continental site in the Stroomdallandschap Drentsche A Nature Reserve (53° 05' N, 6° 40' E). The nature reserve lies along a drainage system of 3500 ha on the Drenthe Plateau within the province of Drenthe.

RESTORATION SITE

The Drentsche Valley of the Drenthe Plateau formed during the past two glacial periods. During the first glacial period, two hundred thousand years ago, glacial activity eroded the valley and deposited eroded materials from other areas. The second and most recent glacial period did not cover the region. However, sediment was deposited as glaciers near this region melted. Solifluction during the frozen period following the last glaciation allowed for the establishment of clay deposits that form the pans of present day heathlands. The current hydrology of the Drentsche valley is characterized by ground water flows influenced by layers of permeable and impermeable strata. Soils conditions are dominated by glacial till, alluvial deposits (sand) and peat.

According to Bakker (1989), complicated and interrelated landscape, soil, and hydrological conditions produce an extensive spatial heterogeneity for the establishment of different species. Overlying this are some 6000 years of settlement by man which have caused changes in geomorphology, hydrology, disturbance regimes and species composition. The action of humans over this time has increased the heterogeneity of conditions for plant growth. Conversely, introduction of fertilizers, during this century, has had the effect of reducing plant community and species diversity by favoring a few dominating species.

A 1984 vegetation survey of the region stated that the dominant plant communities found were indicative of high nutrient levels found over the whole reserve. The surveyors believed that these nutrient levels were due to fertilizers. Other communities which historically had been prevalent were described as "patchy" or "restricted to the edges of ditches." Both nutrient changes as well as effects of draining triggered their subordinate status (Bakker, 1989). While the decline of historically dominant species is discouraging, their presence makes restoration success hopeful.

MOTIVATION

The loss of plant community and species diversity throughout Europe is a major motivation for the restoration of semi-natural landscapes. This was cited as being partially the result of monocultures induced by nutrification as a result of fertilizers and atmospheric deposition (Klapp, 1965, Williams, 1978, Van Den Bergh and Dirven, 1983). The concern for losses of ecotypes and unique genetic combinations was included in the motivation for maintaining semi-natural ecosystems (Bakker, 1989).

The lack of "systematic documentation" of restoration projects and the limited number of comparisons of different methods of restoration were listed as justification for this project. At the beginning of the project, there was little knowledge, aside from undocumented professional experiences of restorationists of how to proceed.

In the 1970's, conservation minded groups and the European Union's Agricultural Committee expected several million hectares of marginal land were to be taken out of production in Europe. This land was most likely going to be left in an abandoned state. Conservationists were concerned that without grazing or mowing species diversity would drop. For these reasons and to provide non-restoration experienced land managers with a documented means of creating semi-natural landscapes, the intervention schemes were investigated.

INTENDED RESULTS:

The goals of the intervention methods in restoration of species rich grasslands were compiled into five main categories: inhibition of monotonous tall forb communities and woodland, the restoration of plant communities with rare and endangered species, formation of heterogeneous vertical structure in grass by varying grazing intensities, removal of abrupt ecotones by integrating former agricultural areas and nature reserves, and widespread removal of litter and nutrients from the soil (Bakker, 1989). An assumption of the restoration was that the grasslands achieved highest species and community diversity around the turn of this century. Therefore, restoration of these conditions meant no application of fertilizers or herbicides and maintaining the groundwater table at a stable level (Bakker, pp. 72-73) The system has evolved out of several millennia of interaction between humans, their livestock, plant communities and the abiotic environment.

METHODS AND INTERVENTIONS:

The methods of the restoration were conducted over the entire 3400 ha reserve. The project made use of local farmers in the application of the grazing and hay harvesting methods. The success of the restoration was determined on smaller study sites by the University of Groningen's Department of Plant Ecology. There was no difference between the methods on the study site and those of greater restoration area unless specifically mentioned. The grazing study area was comprised of 6 ha of pasture which had been converted from heathland in the

1950's, 2 ha of deciduous woodland and 3 ha of Calluna vulgaris / Erica tetralix heathland. The cutting or hay-making study plots were on three different parts of the reserve along different tributaries of the main river system.

The actual interventions consisted of grazing regimes, from light to heavy, cutting of hay by machine, mulching, burning, removing a layer of sod, adding fertilizer, plowing the C-horizon to the surface and no action. Some of the interventions were applied to both the heathlands and the grasslands others were applied to only one or the other. Seeds were planted to test if there were any restrictions to seedling growth. All seeded plants were removed before they could go to seed so as not to disturb the natural succession of the system.

Grazing of the pasture area was accomplished with Schoonebeeker sheep in light and heavy regimes. Year round, light grazing was at the rate of three sheep per hectare and the heavy was a mix from 25 sheep between July to December and 40 sheep between January and July.

Hay-making was applied to the three different riverside sites. The sites were laid out with nine adjacent strips 10 meters by 70 meters. The layout of the strips perpendicular to the streams was an attempt to represent varying moisture regimes. On each site regular fertilization was halted. A different management technique was then applied to each strip. The practice of hay-making was accomplished by mechanical methods and the cut hay was removed from the site. The cutting regimes consisted of the following; abandonment, September hay-making every two years, September hay-making every year, July or September hay-making alternating with each year, July hay-making every year, July and September hay-making every year, mulching (cutting and leaving the hay on site) every two years, mulching every year, winter burning every two years, and July hay-making every year with addition of nitrogen fertilizer. Not all of the above mentioned interventions were applied in each area.

On the heathland and grassland converted from heathland several experiments were tried. The goal in the grassland was to restore the heathland. In the heathland the goal was to maintain it as heathland. In the attempt to pull non-mobile nutrients out of the system, a section of the grassland was fertilized with nitrogen and then mechanically harvested. Another section had the top 5 cm of sod removed and two other areas had the C-horizon plowed to the surface. The heathland proper was either grazed or abandoned. These experiments were not carried out elsewhere in the reserve.

ASSESSMENTS

Diversity of landscapes, communities and species were the main determinants of success. It was acceptable to have relatively low diversity on the small scale if it produced rare or endangered species. Heterogeneity of abiotic conditions, such as hydrology, was also seen as a positive factor. The propagation of native species was not a determinant of success. If a species could survive in the micro conditions and did not negatively effect overall diversity then its establishment was deemed a success.

The investigation looked at land use dynamics, vegetation dynamics,

population dynamics and abiotic factors. The concept of "land use dynamics" deals with how the management of the reserve was carried out and how the land uses changed. By investigating vegetation dynamics the scientists hoped to answer questions concerning how species composition was altered by different intervention methods. Population dynamics dealt with concerns such as seed bank composition, seed dispersal and germination success. In examining the abiotic factors they intended to observe the effects of management interventions on the soil nutrients and groundwater.

The management investigations included an exhaustive list of measurements. These included measurements of soil characteristics, species make up, aboveground standing crop, below ground biomass, vegetation pattern, canopy structure, seed dispersal distance, and early growth rate. A general trend in the composition of vegetation was observed on all of the intervention sites. The species suggesting nutrient-rich conditions declined. It is believed that this is, in part, due to cessation of regular fertilizer application.

Overall, it was found that the grazers were relatively species non-specific. Utilization of different grass species by grazers varied with the time of year. Grazing did overall tend to bring about a higher number of species. The dominant vegetation of the grasslands tended to be correlated to the level of moisture in the soil, grazing frequency and grazing intensity. Heavy grazing did tend to favor species that put less energy into seed production.

Grasslands responded to low level grazing by developing mosaics of short grazed turf and lightly grazed patches. Low intensity grazing created extra structural diversity in the fields. This could not be accomplished by cutting, (Bakker, 1989). The mosaic that developed was not correlated to species composition. Heavy grazing was seen as comparable to haying and did not develop the mosaics. In addition, it was found that grazing did not remove as many nutrients as did hay making (see table 1).

The grassland responded to the various mechanical treatments by developing new dominant species and/or altering the concentration of other grassland species. Shifts were observed on a species basis as well as on the overall number of species. Fields that were abandoned showed a decrease in the number of species. Burned fields increased in diversity on the dry fields but the wet fields lost species. Mulching in all cases but one, decreased diversity. Machine cut fields that were hayed twice a year increased in diversity, once a year fields stayed the same or increased and one cut every two years saw a decrease. In general, a relationship for the grassland treatments was worked out based on the level of diversity induced. This relationship begins with the method that induced the highest level of diversity and progresses to the lowest: haying twice a year > haying once a year > haying once in two years = mulching twice a year > mulching once a year > mulching once every two years > abandonment. In short, the more intensive the intervention the higher the resulting diversity.

The heathland plot responded to grazing by becoming intermixed with grasses, most likely introduced by the sheep dung and wool (see table 1). The abandoned heathland turned into a woodland and the heathland converted to

grassland that had the top 5 cm of sod removed became a heathland. Of the converted heathland plots; the cut and fertilized plot developed species indicative of high levels of nutrients initially but then changed to intermediate indicators. The plowing up of the low nutrient C horizon resulted in the spreading of heath plants due to the lower concentration of nutrients.

The seed bank was predominantly in the top six centimeters of soil. Most of the seeds found were represented by mature vegetation on site. The plants that were expected to recolonize the plots generally did not have viable seeds in the seed bank. This implies that seed dispersal is the primary vector of establishment for these species.

The deliberate planting of seeds showed that establishment of target species was possible. Dispersal into these fields can be somewhat limited with transport by animals being the most conducive. Since sheep are in the field year round they have the ability to transport seed when they become ripe, whereas, the mowing machinery comes only once or twice a year and favors those plants that produce seed during the period of haying.

A topic that was not covered was the effect that the different measures taken had on the populations of animals. Did the constant disturbance regime cause an increase or decrease animal species diversity? Considering the effects that removing biomass and nutrients induce it can be assumed that there would be a corresponding change in their populations.

COMMENTS

A North American restorationist would find the methods and terminology here very interesting for three main reasons. First, this project is classified as a restoration. Second, the method of reclamation required a constant, high degree of management input for perpetuation of the system. Third, the human introduction of new species was carefully avoided.

The first and the third point seem to almost contradict each other. The plan calls for the establishment of increased diversity and attempts to create conditions conducive to communities of species that have been partially molded by humans and the local environment. But then they avoided planting species that, ideally, would be growing on their plots. Nor are they attempting to create a self perpetuating system with minimal human impact. Clearly this is not a normal restoration in the eyes of a pre-disturbance minded restorationist. The key to this perplexity lies in the second point, that of human input.

The fact that humans have been in Holland since 4000 BC makes the concept of pre-disturbance rather hazy. People have caused changes in plant genetics and diversity that are irreversible. Humans cannot be thought of as existing outside or separate from the environment in Europe as they are bound to it due to their history of interventions. If the goal were to establish the type of system that existed before the arrival of humans in the region they would be destroying hundreds of community associations that had evolved since their arrival. Diversity would be lost and they would be no better off than had they fertilized the whole region for agricultural purposes.

The project coordinators are basically trying to recreate a cultural ecosystem that existed before the 1900's, this period was not marked by one particular landscape but a range of many landscapes. Thus, they are trying to preserve extremely diverse, semi-cultural landscapes. In Europe, the issue of what is natural or native is at best unclear. Hybridization and human influence have influenced the vegetation of the region since before recorded history. Restoration is seen more in terms of manipulating natural forces that promote species diversity and other functions of ecosystems.

The practice of not seeding still raises questions. The answer to this conduct lies in economics. Since this was a project to describe management options for land managers, economically, the best choice of action would be to choose the least expensive route. Seeding the region is clearly a bigger economic expenditure than not seeding. Include the concern for establishment of individuals adapted to the micro-climates and their justification for removing the seedlings is satisfactory for research purposes. Had success not been achieved, they would have had to have looked at planting the necessary species.

TABLE 1.
A Few Examples of Plant Communities:

Heavily grazed:	*Holcus lanatus / Agrostis capilaris* community
	Leontodon autumnalis community
Lightly grazed:	*Carex Nigra* community
	Juncus effusus/ Agrostis stolonifera community
Intermediate:	*Agrostis capilaris* community
Heathland communities:	*Caluna vulgaris* community
	Erica tetralix community
	Agrotis cappilaris / Rumex acetosella / Caluna community
	Molinia / Holicus community
Converted Heathland / Grassland communities:	*Molinia / Caerulea* community
	Molinia / Gentiana community
Pasture communities:	*Carex acutiformis* community
	Calthion palustris community
	Elymus repens community
	Urtica dioica community
	Holcus / Poa community
Others:	*Cirsium arvense* community
	Lolium perenne community
	Elymus repens community
	Poa pratensis community
	Agrostis canina community
	Betula / Woodland community
	Molinia / caerulea community
	Molinia / Gentiana community

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