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Restoration of Ski Areas in the Swiss Alps

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The science of restoration ecology has grown in response to an increasing environmental need. This need is not limited to any one type of ecosystem, or any one continent (Bradshaw, 1983). In the spirit of exploring international restoration efforts, I will examine a restoration project being conducted by Dr. Krystyna Urbanska in the Swiss Alps on groomed ski slopes. Part of the focus of this project is rehabilitating an area that will continue to be used recreationally. The forces that have contributed to this site's degradation are being and will continue to be practiced. This project is finding ways to encourage plant growth while the disturbances associated with the ski industry continue.

Alpine projects offer unique challenges to restoration ecologists because of the severe nature of these regions. The following characteristics of alpine ecosystems must be considered before attempting restoration: Temperatures are perennially cool in alpine climates; the average daily temperature is 8^oC in mid-elevation areas (Brown, et al., 1978). The average growing season is 10-14 weeks in duration, but killing frosts can occur at anytime of year (Chambers, 1997 and Urbanska, 1994). The cool temperatures and short interim between hard frosts makes it very difficult for vegetation to become reestablished. High winds are characteristic of alpine areas and can cause desiccation of plant tissues due to accelerated evapotranspiration (Chambers, 1997). The wind also redistributes snow from windward to leeward slopes, thereby changing plant-water-soil relations and contributing to erosion (Chambers, 1997). The amount of solar radiation that penetrates the atmosphere is considerably greater at high elevations, and can reach levels up to1.6cal.cm^{-2}min^{-1} (Brown et al., 1978). These levels result in increased temperatures on soil and plant surfaces, and increase evaporation. Most precipitation occurs as snow during the winter months; only ten percent occurs during the growing season (Brown, et al., 1978). Seedlings and new transplants need more water than do mature plants; without enough available moisture, these plants will not survive long enough to become established. The number of species adapted to these conditions is typically lower for alpine regions than other ecosystems (Chambers, 1993), and ecologists must choose carefully when selecting plants species for restoration. The frequency and level of disturbance can profoundly affect any ecosystem, and is said to be common in alpine ecosystems (Chambers, 1995). Disturbances include human activities such as mining, hiking, and skiing. In addition, the activities of other animals such as grazing by herbivores or tunneling by soil inhabiting organisms can also impact the ability of the ecosystem to regenerate.

A Case Study

Dr. Krystyna Urbanska of the Geobotanical Institute in Zurich, Switzerland, has been working on a restoration research project in the Swiss Alps since 1986. Urbanska's goals for the research site are to increase species diversity and number of individuals, and to achieve a plant community that is self-sustaining (Urbanska, 1992). This paper will examine her research in detail.

Site Description

Urbanska's research site is located in the Northeastern Alps, on the southwestern slope of the Jakobshorn Mountain, near Davos, Switzerland. The slope has been used as a ski run since the early 1970s, and has been significantly altered due to the heavy earth-moving machinery used to clear and grade the slope (Urbanska, 1995). The grading procedure used to prepare the ski run removes the existing topsoil and vegetation; leaving the bare slope exposed to weathering and erosion. Daily maintenance of the ski run requires the use of heavy machinery which smoothes the snow after a day of skiing. As snow cover is often not uniform, there are areas covered only by a thin layer of snow that become further damaged as a result of these practices. The ski season is four and a half months long, and everyday hundreds of skiers visit the resort, further stressing the system.

The soil structure has been significantly altered because of these activities. The sustratum is characterized as siliceous (there is little or no topsoil remaining on this site), very heterogenous and rocky with no horizon development, and low organic matter and nitrogen content (Urbanska, 1995). During the summer, cattle and other herbivores are allowed to graze freely on the site (Urbanska, 1994). These conditions make it difficult for vegetation to reestablish naturally, and provided an interesting challenge for Urbanska and her team.

Species Selection

Restoration ecologists face several decisions when choosing plant material for a project, such as what to plant, where to acquire the plant material, and how to plant it. Species selection is the first step in this process. Ecologists must consider the indigenous ecosystem; the goal is to construct a biotic community that approximates as closely as possible the natural conditions of the site. It is important to include species that are native to the area, and whenever possible, it is preferable to use locally occurring material because it will be best adapted to the conditions at the specific site. For this project, Urbanska and her colleagues incorporated a wide range of native plants with different growth habits and methods of reproduction (Urbanska, 1995). Ten species were chosen that are representative of an alpine sedge grassland. These include several grasses, legumes and forbs (see appendix)(Urbanska, 1995).

Propagule Selection

Once species have been chosen, the plant material must be obtained. There are two basic choices; seeding or transplanting. Each of these options has advantages and disadvantages that should be considered before making a decision as to which method to use. Seeding is a fairly self-explanatory; it can be accomplished either by broadcasting the seed manually, using a seeder, or by hydroseeding. Seeding is generally cheaper than transplanting, less labor intensive, and is often a good choice for large areas. However, seeding is not always ideal for alpine restoration projects for several reasons (Chambers, 1993). Seeds in sufficient quantity for a restoration project may not be available. Alpine seed production (quality and quantity) varies from year to year based on climatic conditions (Chambers, 1995 and Urbanska 1986). In fact, many alpine species are not capable of completing their life cycle in one year because of the short growing season. Flower and seed production are often completed over two or more seasons

(Chambers, 1995). Therefore, the seeds that are produced by natural populations are critical to the continuation of the stand. Collecting seeds for a restoration project can negatively impact the health of remaining natural areas. Seedling establishment is further compromised by herbivory, and the in case of Urbanska's site, the disturbances associated with the ski industry. Urbanska chose to use a small amount of seeded material, and relied mostly on transplanted material (Urbanska, 1995).

Using transplants is another option; however, there are several methods that are practiced under the term transplantation, and it is important to distinguish between them to understand the implications of each. The first is a method that removes full-grown plants from one location and replants them in another location. This practice was more common in the past, but is still done in hopes of preserving rare species in cases where the original habitat is being destroyed (Fahselt, 1988). However, there are ecologists who argue that this method encourages habitat destruction and should not be practiced (Fahselt, 1988).

Another method involves harvesting parent plants and propagating them vegetatively in a greenhouse. Once these plants have well-developed root systems, they are planted back into the wild. This method is advantageous because it limits the amount of material taken from natural populations. This method has two major drawbacks: first, it can potentially compromise the donor populations; and the clones will have the same genetic make-up as the parent plants, thereby limiting the genetic diversity of the restoration site (Urbanska, 1994).

The last type of transplantation involves harvesting seeds from plants, and growing these in greenhouses until the seedlings are of a size that can survive in their native habitat. These plants are then transplanted into the restoration site (Urbanska, 1994). The advantage to this is greater genetic diversity than clonal material; however the problems with this method are the above mentioned unreliable production of seed, and that it can deplete the seed bank of the donor site (Urbanska, 1995).

Urbanska employed all of these options when obtaining plant material for her project. Vegetative cuttings were taken from the grass species (and other plants with similar physiology) from a donor site on the same mountain. These cuttings were grown in a greenhouse until of a sufficient size for further propagation. The plants for the restoration project were obtained by cloning the parent plants. By doing this, Urbanska was able to leave much of the donor population intact and still have enough transplantable material for her site.

In cases where vegetative cuttings were not possible (because of the growth habit of the species), whole plants were harvested from the wild. These species were then grown in the greenhouse and cloned in order to achieve the number of propagules necessary for the project.

Implementation Techniques

The research plots were carefully designed and planted to create clusters of single species and keep the interface between different species to a minimum. Six of the ten plots were planted with a mixture of grasses, legumes and forbs. The remaining four plots were planted exclusively with grasses. The intent was to reduce competition among different species, and to aid in establishment (Urbanska, 1994). Native plant material was transplanted into the plots, accompanied by a small amount of garden soil. Aside from this soil, and moving aside large rocks, Urbanska's team made no other manipulations to the soil. These transplants were approximately 35 cm^3 at the time of planting, and were planted 20 cm apart from one another. All trial plots were planted according to the design described above, to a final transplant density of 45-50 m^{-2}. After planting, seeds of several species were manually sown amongst the transplants. One hundred seeds of each species were sown in each plot near to a transplant of the same species (Urbanska, 1994).

Urbanska is of the opinion that newly planted/seeded alpine restoration projects should be protected for the first several seasons (Urbanska, 1997). While this may seem contrary to the goal of restoring a self-sustaining system, she believes that is essential, especially in cases such as her project where the plants will be exposed to extreme disturbances (Urbanska, 1992). After planting, biodegradable wood fiber mats were placed over the newly planted areas to provide what Urbanska describes as a "safe-site". These mats provide a more moderate microclimate while the plants establish themselves, and slowly break down over a period of years, by which time the plants are strong enough to survive on their own.

Monitoring and Assessment

The final phase of this restoration project is monitoring and assessment. This is critical in determining if restoration efforts have been successful, and how to design better projects in the future. Beginning in 1992, and continuing through 1994, Urbanska began collecting data from the plots. These censuses were one once a year, at approximately the mid-point of the growing period. The data collected were number of survivors of transplanted species, number of dead transplants (whenever recognizable), the number of immigrant species, and physiological age of all species at the sites (physiological ages defined as seedling, juvenile, non-reproducing adult, and reproducing adult) (Urbanska, 1994 and 1995).

Results

Six years after implementation, eight of ten transplanted species were thriving and found in all age states. There were only two transplanted species that did not perform well. *Trifolium repens* had all but disappeared in most of the plots. The transplanted *Chrysanthemum alpinum* did not survive in any of the trial plots, but immigrant seeds from other sites had begun to appear. The data suggest the wood fiber mats assist in successful recruitment of immigrant species. Germination rates are higher in unprotected areas, but seedling survival and establishment are significantly higher in the protected sites. Urbanska hypothesizes that the mats act as trap for seeds dispersed from neighboring sites, and provide a moderated microclimate that encourage establishment. Urbanska describes the newly established stand of vegetation as a safe-site in its own right, capable of providing the same protection as the wood fiber mats (Urbanska, 1995).

Conclusion

Restoring damaged ecosystems takes careful planning, commitment, and thoughtful examination of the results in order to be effective. By studying efforts like Dr. Urbanska's, we can learn much about the ecosystems we hope to restore and the ways to achieve our goals. Hers is an example of a thoughtfully planned, planted, and monitored restoration that can be used as a guide for similar projects. However, while we can develop guidelines for ecological restoration, each situation must be evaluated individually. Projects differ in climate, scale, goals, and budget, and these elements need to be weighed prior to choosing one restoration method over another. Restoration ecology is an expensive and complex science, and sometimes our efforts do more harm than good. Follow-up studies must be an essential component of any restoration plan. The data collected during assessment visits yields a way to quantify the success or failure of a restoration project. Without this information, it is impossible to understand the ecological processes that we hope to mimic.

One final note, no matter how much success we achieve, there is no substitute for naturally occurring ecosystems. Urbanska's results should in no way be translated to advocate the destruction of natural habitats simply because we are finding ways to restore them. Instead, we must change our perception of our own place in these biotic communities and find ways to live in harmony with them so there will no longer be a need for work such as this.

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APPENDIX

Species used in restoration Immigrant species

Agrostis repens. *Agrostis rupestris*

Biscutella levigata Campanula scheuchzeri

Carex curvula and sempervirens Deschampsia flexuosa

Chrysanthemum alpinum Gnaphalium supinum

Doronicum clusii Hieracium supinum

Elyna myosuroides Homogyne alpina

Hieracium pilosella Leontodon helveticus

Luxula lutea Salix herbacea

Poa laxa Sedum alpestre

Trifolium nivale and repens Senecio cariolicus

Arenaria biflora

Saxifraga alpestre

Gentiana spp.

Ranunculus grenierianus

Anthoxanthum alpinum

Festuca rubra

Veronica bellidioides