RAPID ECOLOGICAL INVENTORIES FOR ECOLOGICAL RESTORATION OF INDUSTRIAL LANDS

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ABSTRACT

Ecological inventories are critical for the success of site planning, implementation, and monitoring in ecological restoration of industrial lands. Inventories of large areas may need to be completed quickly because ecological restoration projects are often opportunistic. As part of a multi-phase ecological restoration project at an industrial site, we designed ecological inventories completed by 15 undergraduates during 5 days as part of a course exercise. Historical records, air photos and 1-day reconnaissance of vegetation patterns were used to delineate provisional community boundaries (13 communities total). We then intensively sampled for 4 days using random Z-walks to identify weeds, natives, and confirm community boundaries. Forty soil and water samples for pH, moisture, and nutrients (selected randomly and in areas with probable eutrophication) revealed provisional boundaries for the communities were accurate and most areas had high nitrogen and phosphorus. Weeds will continue to invade and soil impoverishment may be needed, though old building foundations are already adequate for planning alvar habitats. Circle calling surveys indicated there were 60 common bird species that could be supported with the creation of interior forest habitat and construction of boxes, brushpiles, and raptor poles. Pit, Sherman, and Hav-a-Heart mammal and herptile traps proved inadequate as they failed to account for behaviourial patterns, age-size distribution, and food preferences. Our rapid survey served its main purpose of allowing more detailed site planning but better mammal and herptile surveys are needed to ensure a functional ecosystem is re-established on site. The survey information we collected was combined with information from a previous urban environmental planning study to construct an initial design for long-term ecological restoration at our study site.

Introduction

Ecological restoration on industrial lands is one aspect of the emerging field of industrial ecology (Côté and Plunkett 1996). One general difficultly with ecological restoration is the need to perform rapid assessments in order to expedite the planning and implementation of a project. This can be exacerbated in industrial situations because the need for more immediate tangible outcomes is often greater than on public lands. We do not imply that the project must sacrifice scientific principles; rather, the datasets to be used will be less complete than if assessments and inventories over several seasons were possible. Generally, this can be accommodated by consulting historical databases to supply missing information about what species and functions were important on the site pre- or post-industrialization. Additionally, it is unrealistic to restore a site to a supposed pristine state. The best approach is to use a nearby reference community or ecosystem to gauge what is likely appropriate on the site, in terms of the biophysical limitations (see Aronson et al. 1995, Pickett and Parker 1995 for discussion). On-site monitoring for a short period (e.g. several months) can add necessary details about slope, bedrock, hydrology, soil conditions, contamination, extant populations of organisms, dormant populations of propagules (e.g. plant seeds). Some data will be omitted by this approach but if the alternative is lose the opportunity to restore a property, then this is acceptable. This especially is true where the restoration site still has some industrial activity in existence and the risk of lost opportunity may be greater as a corporation must quickly justify expenditures on restoration projects with visible results. In this sense, ecological restoration at industrial sites is a microcosm of the long debate over the best approaches to restoration and the conflict between pragmatism and science (see Bradshaw 1993, Cairns 1993, Cairns and Pratt 1995, Jackson et al. 1995, Hobbs and Norton 1996).

Since most industrial sites already are severely ecologically degraded, restoration efforts are unlikely to worsen conditions unless large-scale alterations of hydrology or other landscape-scale processes are planned. Such cases are likely rare as restoration ecology, especially on working industrial lands, tends to focus initially on creating small-scale communities with individuals adapted to the current (degraded) conditions that eventually will help direct succession towards other valued communities. Rather than attempt to micro-manage succession, industrial ecological restoration should work within biophysical limitations to create naturalized communities that meet the ecological requirements and, importantly, are consistent with shared social goals of the restoration experts and the client. These goals will be influenced by the ecological requirements but also will be affected by corporate culture, economic constraints, and aesthetic ideals. This is not novel to industrial ecology but it is vital to recognize this explicitly and act accordingly.

We will discuss how (and how quickly) an ecological inventory be performed for the purpose of supplying information for the planning and implementation of the ecological restoration of an industrial site in Niagara Falls, Ontario. Our research is based upon the precept that certain indicator taxa (often species) are most useful in planning and implementation (see Oliver 1993, Williams 1993, Oliver and Beattie 1996a, b, Small et al. 1996).

<u>Site Description</u>. The Cytec Canada plant in Niagara Falls Ontario was used for our study. Cytec Canada has asked the Universities of Guelph and Waterloo to devise a restoration plan for the majority of the lands on their site. These lands are abandoned and not likely to be used in further production.

<u>Surveys</u>. All of the surveys were completed during a 5 day period in July 1997 by the authors and a class of 15 undergraduates. Data were compiled and analyzed within a week of survey completion.

<u>Soil Survey</u>. Because the site was (and is) industrial, we needed to determine the general texture and evidence of any eutrophication or other pollution. We sampled in non-disturbed areas because this indicated the existing soils that support relatively native communities and allows us a reference state for planning restoration. There was little existing information about the site itself, though we were able to reconstruct the past 50 years of use from old surveying notes. We divided the site into thirteen putative communities, based on visible vegetation, and sampled to determine if the soils were different between these communities. We used a stratified random Z-walk sample that varied positively with the area's size. The sample size was kept small (100 samples in total) to expedite testing. Again, this does not provide a detailed site analysis but should detect severe problems with soil structure. Sampling was performed with a soil auger for detailed testing and a backhoe for testing of texture and saturation. In the laboratory, we tested one-quarter of all soil samples for nitrogen, phosphorus, and humus (using Anonymous' [1975] test), and pH (portable pH meter). Texture was determined visually. Saturation was

an observed property, i.e. how many hours did it take for a pit to fill (assuming it did not rain in the interim).

Texturally, much of the site is underlain with clay with silty or sandy loam on top. The site is riddled with old concrete building foundations as well as cinders and gravel from old building used as fill. This presents a challenge in restoration as organisms (e.g. trees, large shrubs) needing large and deep root systems will not flourish. As a consequence, we are planning the site to include meadow and prairie habitat. Several areas were saturated because of underground seepage (probably because old buried foundations prevent water drainage). This means some areas may be suitable for small wetlands. Most areas were suitable for these habitats as the nitrogen levels were around 11 kg/ha (low concentrations), the phosphorus levels were sufficient to support plant growth (100-200 kg/ha), and the pH was generally slightly acidic (6.5-7.0). There were some areas where nitrogen was extremely high (>150 kg/ha), especially in bodies of water or around decommissioned buildings where ammonium nitrate was produced. These sites will require amendments such as mulch to impoverish the soil to a level that will discourage weedy invasives and allow natives (especially prairie grasses) to compete effectively. Humus levels in these areas tended to be low, meaning that there is likely insufficient organic matter and aeration to support most weedy plants. In other areas, however, there is sufficient humus to support shrubs but this also will support weeds; inert mulches may prevent weed establishment where shrubs can be transplanted (from other areas on-site) as root-pruned plugs. Still other areas that are planned as shrub-dominated habitat may require more humus; again, this will require an anticipatory strategy to prevent weed establishment.

<u>Water Survey</u>. All watercourses were tested to ensure the water quality was sufficient to support plant and animal communities. We collected five 1 L samples and tested for conductivity (Orion Model 160 meter), turbidity (Hach 2100 A Turbidmeter), chlorides (argentometric method), phosphates (stannous chloride method), iron (phenanthrolene colorimetry), nitrates (cadmium reduction colorimetry), and sulphates (turbidmetric method) (Greenberg et al. 1992). We found high turbidity (meaning streambank rehabilitation is needed should there ever be a project to restore fish habitat) as well high chloride, sulphate, phosphate, conductivity (many other dissolved ions). The ionic indicators demonstrate that the streams are polluted and unsuitable for most desirable (native) vascular plants, fish, herptiles, and invertebrates.

<u>Vegetation Survey</u>. Using Riley (1989) and Anonymous (1997) as a guide to ranking species by rarity, all thirteen putative vegetation communities were surveyed using a random walk in a Z-shaped transect across the entire width and length of each habitat. The fields were walked twice by at least 4 different team members (there were 8 surveyors in total). Dominant species were identified and recorded every 20 m. Our survey indicated a high number of weedy species (not unusual considering the amount of old building fill on-site) which will require initial management by herbicides, mulch, or other methods but has the potential to become a prairie habitat (e.g. Wilson and Gerry 1993). Prairies are useful at our site because they are sufficiently low-lying and will not create safety hazards by blocking the sight-lines of various areas of the industrial plant Monitoring plots will be constructed because the propagule bank will have to be examined over several years to predict future weed problems. The survey was used to identify native forbs, herbs, shrubs, and trees that could be used in transplanting to restoration sites or as part of an on-site nursery. We intend to avoid using non-indigenous species in our efforts (see Bradshaw 1993) and will attempt to use a bioregional approach to restoration, i.e. using locally-adapted genotypes.

Sites on corporation property but away from the actual industrial site can be used to supply a small amount of plugs or seeds (see also Lippitt et al. 1994) but we are to use commercially grown stock for most restoration efforts. The corporation lands had a variety of habitats: slough forest, wet mid-successional fields, agricultural lands, hedgerows, floodplain meadows, wetlands, riverine forests, transportation corridors, and, of course, decommissioned buildings (or their rubble, as incorporated into the soil). The vegetation surveys indicated that the borders assigned to these communities were arbitrary but the plants did indicate the fundamental state of abiotic factors such as nitrogen, pH, soil texture. For example, downy brome (*Bromus tectorum*) heavily infested sandy soils with slightly acidic pH and medial levels of nitrogen. The old building foundations were rife with weeds but probably will make an excellent substrate for alvars. Most of the other parts of the industrial site harbours drought-tolerant aliens and natives with shallow roots because of the large amount of rubble on top of the clay foundation. Exceptions are in depressed areas where little rubble exists and the clay creates wet meadows and wetlands. Our intention is to minimize further disturbance of the areas with less rubble; these are undergoing autogenic succession. The rubble-strewn areas are the ones most in need of restoration. We plan to use hardy natives (e.g. goldenrods, Solidago) to help out-compete weedy aliens (e.g. common sow-thistle [Sonchus oleraceus]). Because nitrogen is not particularly high, we can use nitrogen-fixing species (though we cannot plant so many that nitrogen levels rise to the threshold where nitrophilous weeds will dominate).

Generally, the vegetation communities are amenable to restoration at relatively low-cost; our biggest challenge will be to ensure that the communities are not highly fragmented to avoid edge effects that will affect not only the plants but the animals that occupy the habitats (e.g. Zink et al. 1995)

Bird Survey. Birds are excellent indicators of the relative complexity of habitats, i.e. in terms of trophic structure and physical fragmentation. They are a key top-down control of insects in ecosystems and promote seed dispersal (of both natives and aliens). On the advice of our colleague, Ted Cheskey (Waterloo County Board of Education), we used a circle calling method. Eleven stations were chosen using a relévé method (i.e. distinguish habitats on the basis of their visible vegetation and select a putative representative sampling location within each). Around dawn each day, 5 or 6 people surveyed each station for 10 minutes and recorded every bird (based on visible observation or song) on a circular grid representing the survey area. The bird's actions were recorded (e.g. feeding, singing, flying, nest tending, parental care). Breeding-related activities are proportional to the number of visible observations; this is crude estimate of the suitability of habitats to sustain reproductive populations of birds. Most species are territorial and the identity of the species indicates how wide a territory is needed and available. This is indirect evidence of the state of the industrial site, i.e. how much restoration may be needed.

There were over sixty species of birds, mainly natives, at our site. Our survey indicated that the open fields were adequate habitat for species such as northern mockingbird (Mimus polyglottos) and raptors (e.g. red-tailed hawk, Buteo jamaicensis) but the lack of snags requires the installation of raptor poles. This will help regulate pest populations of non-native predators on-site (e.g. feral cats), excessive populations of rodents that can damage plants, and provides aesthetic enhancement for the workers and any visitors on-site. Interior species (e.g. ovenbirds) were infrequent because of habitat fragmentation and the parasitism by edge species such as brown-headed cowbird (Molothrus ater). The fragments will need to be linked with native vegetation to reduce edge effects; there was no evidence of fragments harbouring isolated populations of diseases or parasites, hence linking fragments poses little risk. Still other bird species will require vegetation that has been eliminated or reduced by fragmentation and invasive plants. For example, several breeding ruby-throated hummingbirds (Archilochus colubris) exist on-site but these are constrained by a lack of suitable plants, e.g. native honeysuckles (Lonicera), because of excessive light and competition from species such as garlic mustard (Alliaria petiolata) that tend to self-perpetuate advancement of edges along fragments.

Mammal and Herptile Survey. Like birds, mammals and herptiles are useful indicators for restoration projects and they have aesthetic appeal. Mammals and herptiles can be more difficult to survey (more labour-intensive and expensive because, typically, traps are needed) and they can be more gregarious and less site-specific. We used forty-five pit traps for surveys of rodents and herptiles. The traps were made from soup cans and coffee containers with punctures (to allow drainage). Thirty-eight Sherman traps were used to capture rodents only; they were baited with peanut butter, shell-on peanuts, and pieces of apple. Mid-sized mammals (rabbits, raccoons, opossums) were sampled using twelve Hav-a-Heart traps baited with the same materials as the Sherman traps. Traps were placed randomly along established mammal trails within each vegetation community and checked every 12 hours.

Most mammals were found in the mid-to-late successional habitats (old fields and forests); this is expected as there is less external disturbance and greater niche availability. The vole and mice populations did not appear to be excessive (we captured only 4 individuals), though once restoration begins it is expected these numbers will increase (hence the recommendation for raptor poles in the previous sub-section). The results obtained generally were inadequate as the number of traps and baits used failed to account for behaviourial patterns, age-size distribution, and food preferences. The baits used could not attract carnivorous mammals. The amounts of bait need to be varied to account for differences in optimal foraging patterns; these patterns are, in turn, related to the age and size of an animal. The pit traps did not capture herptiles and a more-labour intensive survey is needed; herptiles are useful indicators of the status of vegetation, soil, and water within habitats but we believe our other surveys satisfied this role. We still intend to sample herptiles to determine if there are any rare species on-site that will require refinement of restoration plans. The main utility of the trapping was that we attempted to attract pest species that could harm vegetation during restoration and found that the numbers were not excessive at present.

Implications. This study was not designed as a comprehensive scientific approach; the purpose was to maximize and expedite collection of specific information needed for planning restoration in an industrial context. We succeed in identifying major features, such as whether the soil and water were contaminated, the availability of plants for restoration, habitat fragmentation and the ability to support bird species, and the presence of mammalian pests. Our conclusions are conjectural and we are initiating a scientific monitoring program on-site to ensure a more comprehensive approach; however, this will require several years to complete. This time frame is not suitable to the needs of ecological restoration of an industrial site but is useful to ensure the restoration works. Our surveys indicated the site was ecological degraded but there was sufficient material and ecological function to allow a relatively inexpensive restoration plan to be designed and implemented. +

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TABLE OF CONTENTS