Assessing the Rehabilitation Potential of Disturbed Lands[1]

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Abstract--Those involved in the plant propagation industry can serve an upcoming trend by providing appropriate plant materials for site rehabilitation. To better understand what "appropriate" plant materials are, the nursery industry should understand the general concepts involved in determining the rehabilitation potential of a site, and in revegetation/rehabilitation planning.

INTRODUCTION

Ecological rehabilitation is a specific type of revegetation, one gaining popularity in private, public, and regulatory sectors. *Revegetation is* simply the establishment of vegetation on disturbed lands. This is a very broad term that does not distinguish among the various possible goals of placing plant materials on a disturbed site. More specific terms include:

- *Landscaping* which manipulates ecosystems or disturbed lands for social values such as aesthetics and recreational access;
- *Reforestation* which revegetates an area with tree species to yield commercial products;
- *Enhancement* which alters a site for improvement of a specific value;
- *Rehabilitation* which means to re-establish a stable ecosystem, one capable of replacing the ecological functions of the original ecosystem;
- *Ecological Rehabilitation,* a more specific term than the preceding, refers to rehabilitation with site-indigenous species (this falls short of restoration because it does not attempt to replace all ecological functions);
- *Habitat Creation* is the establishment of a historical ecosystem on lands that did not previously support that ecosystem (or on severely altered sites); and
- *Ecological Restoration* is the process of intentionally altering a site to establish a defined, indigenous, historic ecosystem. The goal of this process is to emulate the structure, function, diversity and dynamics of the specified ecosystem (definition according to the Society for Ecological Restoration).

Another term which is used broadly with widely disparate project goals in mind, *is Reclamation*. In California, *Reclamation* is defined as the combined processes that minimize adverse environmental affects of surface-mining and return land to a beneficial end use (the California Surface Mining and Reclamation Act of 1975). Reclamation can refer to the construction of compacted building sites for future development or to constructing a wetland in what had been an upland area. Reclamation has also been used in the sense of reclaiming land from the sea, which involves diking and draining wetlands.

1Paper presented at the Western Forest Nursery Association, Fallen Leaf Lake, CA, September 14-18, 1992.

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Why differentiate between these terms? Because the result of these different practices will shape the outcome of a project and will have a direct affect on the biodiversity of the resulting site. The preservation and conservation of the state's biodiversity is the target of a recent Memorandum of Understanding among various federal agencies and the California Resources Agency. In keeping with the state's concern about biodiversity, revegetation or rehabilitation using native, site indigenous species is quickly becoming the standard in California for wildland plantings.

REHABILITATION POTENTIAL

The practitioners of ecological rehabilitation include landscape architects, plant ecologists, geologists, foresters, wildlife and fisheries biologists. More often than not, an interdisciplinary team is necessary to adequately plan an ecological rehabilitation project. A range of factors affect the outcome of any rehabilitation project. "Assessing the revegetation or rehabilitation potential of the site," or "reading the site," is the first priority of the rehabilitation team.

These factors are represented by the following equation:

RP= (C*A*LS*E*P*D*I*M)

RP= Rehabilitation Potential
C=Climate
A=Aspect
LS =Slope Factor
E=Ecology
P=Pedogenic Development
D =Disturbance
I=Introduced Competitors
M =Soil Management

Climate, aspect, ecology, and pedogenic development are site-indigenous characteristics over which the practitioner has little or no control. However, the remaining factors are human-induced or influenced, and often under the control of those designing the project. A discussion of these factors follows.

The Factors

C = Climate

The climatic diversity of California is unrivaled in the United States, providing numerous challenges to the rehabilitation practitioner. California's climate varies from the cool, wet Pacific Northwest; to the hot, dry southern deserts; and from coastal marshes to alpine meadows.

Arid or semi-arid climates are often difficult to rehabilitate, because the correct soil-moisture regime for germination occurs infrequently. Elevation and topography determine to a large degree how the gross climatic regime will be expressed, and may exacerbate or ameliorate the climatic effect. Practitioners assess the gross climatic regime, as well as, localized effects such as storm movements, rain shadows, lake effects, and anabatic and katabatic winds.

A=Aspect

Aspect determines the amount and duration of solar radiation a site receives. In the northern hemisphere, northern exposures are cooler and wetter and southern exposures are hotter and drier; eastern and western exposures fall in between these two extremes. The role of aspect in the rehabilitation potential depends on the climate of the proposed project site. For many areas in California, northern exposures provide a better growing environment than do southern exposures. However, at high elevations, the cool, wet northern exposures translate into a shorter growing season, making the site more difficult to rehabilitate.

In addition, the rehabilitation plan must be varied to accommodate the diversity of aspects on a site. For example, in many central and southern California locations, the northern exposures support diverse oak woodlands, while the south exposures support annual grasslands. In this example, an attempt to create an oak woodland on a southern exposure would be ill-advised.

LS =Slope Factor

The ability to rehabilitate a site will be influenced by the stability of the slopes, i.e., the potential for surficial and/or deep-seated slope failure. The slope factor is a combination of the length of the slope and the steepness of the slope. This is the same concept familiar to those who have used the universal soil loss equation. The steeper and the longer the run of the slope, the more prone the site will be to erosion, and the more difficult it will be to rehabilitate the slope.

This factor addresses the stability of the slope, the erosion potential of the slope, and the droughtiness of the slope. For example, steep slopes may be unstable, prone to erosion, and more droughty than their gentler neighbors. As one would expect, it is generally easier to rehabilitate gentle (no steeper than 3:1 (horizontal:vertical)) slopes than those approaching 1:1.

E=Ecology

The ecology factor is a combination of the resiliency and the successional stage of the indigenous ecosystem that is to be rehabilitated. Resilience refers to the ability of the site to recover from perturbations, and is related to the frequency and the magnitude of natural disturbances with which an ecosystem has evolved. Old growth forests and some desert systems experience naturally-infrequent or low levels of disturbance, and therefore, have little innate resilience. Old growth forests have evolved in a relatively stable environment and do not readily regenerate following frequent or high levels of disturbance.

Sand dunes and riparian woodlands are at the other end of the spectrum. These systems are adapted to frequent and/or high levels of disturbances and exhibit considerable resilience. The vegetation of windblown dunes and flood-prone streams is dominated by species which resprout or reseed readily following a disturbance, making the site relatively easy to rehabilitate.

Some ecosystems may also require specific successional stages following a perturbation to attain their "climax" structure and composition. Planning for successional stages, which are usually unknown, can be very difficult.

P=Degree of Pedogenic Development

This factor refers to the degree of soil or soil horizon development. Soil development is determined by a number of factors such as parent material, climate, living matter, topography, and time. Dune or scourzone riparian soils are poorly developed with few or no differentiated horizons. On the other hand, many forest soils are highly structured, with identifiable horizons and sub-horizons. Ecosystems with little soil development are often easier to rehabilitate than those with highly developed soil profiles.

Some degree of soil mixing or loss is often characteristic of a disturbed site. Soil mixing results in the loss of ions from the B horizon, caused by mixing with the A horizon, and the dilution of beneficial soil biota. Rehabilitation of a site that supported a highly structured soil, and which has lost structure and horizon differentiation due to mixing, will be more difficult to achieve than rehabilitation of a site which under natural conditions had no soil structure. The change in soil chemistry may affect the response of plants to a substrate. Site-indigenous species may be closely tied to soil chemistry and biology, and the loss or dilution of these through mixing may have a long-term, adverse impact on the rehabilitation potential of the site.

D=Degree of Disturbance

The ability to rehabilitate a site will also depend on the degree of disturbance the site has experienced. A site which has experienced little to no human influence would be relatively easy to rehabilitate. The lack of human influence is suggested when most ecosystem functions are still evident and when spontaneous colonization is still a dominant process on the site. At the opposite end of the spectrum, are highly disturbed sites where human activities have completely altered the processes and functions of the site. On a highly disturbed site, ecosystem functions are not evident, and spontaneous regeneration of the site-indigenous species is not occurring. The latter site will be very difficult, perhaps impossible, to rehabilitate; any attempt at rehabilitation of such a site should probably be termed habitat creation.

The degree of isolation of the site will interact with the degree of disturbance. A site which is cut-off from similar ecosystems will be difficult to rehabilitate, because the practitioner will be responsible for the reintroduction of all biota. A site which is situated near or surrounded by similar habitat will be easier to rehabilitate. These nearby, intact habitats provide the full compliment of propagule sources and fauna important for biotic interactions (such as pollinators) that would otherwise be difficult to identify and/or obtain for re-introductions.

I=Competition from Introduced Exotics and Herbivory

Under this factor, I have lumped many different vectors which compete with the site-indigenous plant materials. Many California ecosystems have been altered by invasive exotics, which have the potential to out-compete the native species and permanently alter the resulting habitat. The most common example is the conversion of California's perennial grasslands to annual (exotic-dominated) grasslands.

If a site is contaminated with highly, invasive exotics (examples include blando brome, pampas grass, European beach grass, eucalyptus, tamarisk, and giant reed), control of the exotics will be necessary to re- . establish the indigenous ecosystem. Often exotic control is very difficult and expensive.

Other impacts to native systems in this factor include herbivory, not only exotic herbivores, but also explosions of native herbivore populations. The need for elimination of cattle from a rehabilitation site is obvious; however, the practitioners should also assess the potential for a native rodent population explosion.

Other exotic impacts to native systems include trampling by people and cows, and plant damage by offroad vehicles. The damage from trespass (pedestrian, bovine, and vehicular) includes direct physical damage to plant materials and compaction of soils. Soil compaction can restrict root penetration, decrease soil aeration and moisture retention, and cause a higher flux in soil temperatures.

M =Soil Management Techniques

A number of factors are included under the general heading of soil management techniques. The soil is the basement on which a rehabilitation project is built. Without careful examination and treatment of the soil, an otherwise well-planned project may fail. The soil with the best potential for rehabilitation is an uncompacted, intact, undisturbed soil. However, often this is not the case for rehabilitation sites.

For sites where soils have been moved or removed, important issues include the methods of soil removal, storage and replacement. If a highly structured soil exists on the site, an important issue during soil removal will be the separation of horizons, and perhaps, sub-horizons and/or the litter layer. Stockpile management can preserve or degrade a salvaged soil. Care should be taken to minimize the length of time a soil is stockpiled, minimize the depth of the stockpile, and to manage the stockpile to preserve the biotic component of the soil, such as providing an interim vegetative cover. During resoiling procedures, important issues may include the correct relayering of the soil horizons, the subsoil material and drainage, the depth of resoiling, and the alleviation of compaction. The importance of these management techniques or "issues" will be much less for sites which have little to no natural soil structure.

REVEGETATION PLANNING AND SPECIFICATIONS

Once a site has been thoroughly and adequately assessed, the plant material decisions begin. Whether or not the site's rehabilitation potential is realized will depend on the revegetation/rehabilitation plan and the appropriate choice of plant materials. Plans should include a statement of project goals; specifications for land shaping, grading, erosion control, and drainage; soil protection, resoiling, amending, and testing; species selection, genetic compatibility, sources, rates, and densities; planting methods, locations, protections, and schedules; irrigation; maintenance; performance standards; monitoring and remedial measures.