Restoration and Reclamation Review
Student On-Line Journal
Vol.1, No.2, Spring 1996
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Rehabilitation of Chile's Overgrazed, Overfarmed Espinales

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INTRODUCTION

Chile contains an astounding array of natural diversity, including the extreme arid conditions of the far North, the high spine of the Andes to the East, and temperate rain forest and large portions of the Southern Ice-cap to the South. In the middle of all this lies Chile's fertile central valley, home to both the majority of the population and the majority of its agriculture.

The vegetation of a large portion of the central valley (> two million ha) is dominated by a single tree species, the espino (Acacia caven). The ecosystem is consequently referred to as an espinal. The climatic zone occupied by espinales ranges from semi-arid (100 mm rainfall/year) in the north to semi-humid (1,000 mm rainfall/year) in the south. Although espinales were not the historically dominant vegetation, they do have considerable value for human populations. Espinales occur primarily in areas of extensive (i.e. unirrigated) agriculture; the ecosystems are typically used for continuous pasture or wheat production with long periods of fallow.

Unfortunately, the majority of espinales are at some stage of desertification. Overgrazing and crop production have led to a loss of vegetation, soil compaction and erosion, and consequent loss of productive capacity. The authors of the studies reviewed in this paper (Ovalle et al. 1990, Aronson et al. 1993) have suggested and begun to implement a number of studies aimed at reversing desertification in order to regain/sustain the productive capacity of the espinales. This work can be seen as a case study only in a very large scale sense. It is an example of an attempt to develop the understanding and techniques necessary to restore and/or rehabilitate a particular type of ecosystem spread out across an array of landscapes.

ORIGIN OF THE ESPINAL

Prior to the arrival of Europeans in the sixteenth century the dominant vegetation of the central valley was presumed to have been matorral, an ecosystem resembling the chaparral of California. It was dominated either by clumps or continuous canopies of sclerophyllous shrubs, such as *Lithraea caustica, Quillaja saponaria* and *Colliguaya odorifera* (Fuentes et al. 1986). Historically the espino, a native species (at least within the last 10,000-1,000,000 years), was probably restricted to disturbed habitats. Its spread and growth over the last 400 years appears to be due primarily to two factors: the introduction of domestic livestock, which serve as dispersal vectors, and increased disturbance, in the form of clearing of the matorral for firewood, grazing and crop production (Fuentes et al. 1989). Additional factors that may have led to its present dominance of the region include its nitrogen fixing capacity (Aronson et al. 1992)

and the drought tolerance of its seedlings.

With the spread of the espino came numerous other invasions, particularly of exotic annual grasses (e.g. *Bromus mollis*, and *Vulpia dertonensis*), but also of a variety of native shrubs (e.g. *Baccharis linearis* and *Trevoa trinervis* among many others). The presence of the espino appears to select for an herbaceous understory: It produces leaves late in the season, providing little competition during the early part of the growing season; its open canopy allows sufficient light through to sustain herbaceous growth, and yet keeps enough moisture in the system to prolong the growing season; lastly the nitrogen fixed in association with its roots is made available to shallow rooted species as its deciduous foliage decomposes.

PRODUCTIVE USES AND RESULTING PROBLEMS

The desertification of the espinales can be attributed primarily to a long history of unsustainable crop production and grazing. Crop production without the use of fertilizers quickly reduced soil fertility. Both shallow cultivation and heavy grazing have caused soil compaction and consequent reductions in infiltration. Loss of fertility and soil compaction, in turn, reduce vegetative growth, which leads to further losses of productive capacity, degradation of soil structure, and so on in a downward spiral.

While espino trees have the potential to slow or reverse desertification (see below) they are usually treated as a woody weed. In cropping systems, they make up a brief succesionary stage, resprouting from stumps, and are cut prior to the next cultivation. In pasture systems they are sometimes left in place, either as trees or shrubs; most espinos, however, are being lost to woodcutting. As supplies of large trees become scarce the local population increasingly turns to shrubs (espinos and other species) for energy needs.

THE NEED FOR RESTORATION

The pressing need for restoration and rehabilitation of this ecosystem arises from the fact that a rural population of approximately 300,000 people relies on it for its livelihood. The current situation is described by the authors as "low input, low output", which means that natural inputs into the system, water and sunlight are being used inefficiently. If vegetative cover, soil structure and soil fertility can be recovered, the region could potentially support the rural population on an ongoing basis.

SUGGESTED RESTORATION

Aronson et al. (1993) have developed a comprehensive scheme for restoring and rehabilitating Chile's espinales. Having surveyed a 23,000 ha transect to determine patterns of land use, they suggest the most appropriate type of land use for each type of site. Their plan runs the gamut from restoration to reallocation: somewhat degraded matorral can be restored to healthy matorral; land that has been under cultivation for a long period of time can be reallocated (i.e., converted to a type of land use that may bear little resemblance to the original ecosystem) to

agricultural use. Between these extremes are suggestions to restore those espinales that are in good condition to the condition commonly found 100 years ago, and rehabilitate those in poor condition to regain the ecosystem functions necessary to sustain productivity.

This focus on the restoration of an ecosystem that is itself a result of human disturbance may at first seem odd. It stems from the fact that espinos coexist well with an herbaceous understory, allowing for sustained levels of high (harvestable) productivity in a semi-arid climate. The authors believe that with proper management an espino system may have great value as a sustainable pasture or agro-forestry system and yet at the same time preserve some fraction of the pre-disturbance biological diversity.

The methods suggested depend on the present state of the ecosystem and the desired final state:

Restoration per se - Methods for restoration of matorral are not discussed. As they are suggested only for areas that currently contain significant amounts of matorral vegetation, this restoration would probably entail protection from grazing and woodcutting. However, Fuentes (1986) studied the natural recolonization and recovery of disturbed matorral vegetation and found both processes to be extremely slow, limited by, among other things, healthy populations of European rabbits.

Restoration of espinales - Approximately 40% of the espinales are considered suitable for restoration, i.e. they contain sufficient soil fertility and plant diversity to be returned to a productive state largely through altered management of existing vegetation. This management entails the protection of larger espinos and the thinning of dense stands of shrubby espinos. It is hoped that this will favor the presence of native perennials over exotic annual weeds that are of little forage value.

Rehabilitation - The remaining 60% of espinales are thought to need rehabilitation. A number of plant breeding endeavors are suggested to aid in the rehabilitation of severely degraded espinales. These include the isolation and comparison of multiple strains rhizobium bacteria in association with both the espino itself and an annual legume, *Medicago polymorpha*. It is hoped that these efforts will lead to increased efficiency of nitrogen fixation and consequent increases in soil fertility.

Reallocation - For those lands currently under wheat production the authors suggest the use of crop rotations, including the sowing of annual legumes for pasture.

In order to accomplish these ends, substantial government assistance would likely be necessary. The authors mention that there is a Chilean law providing land managers with 75% of the cost of planting trees. Incentives might also be needed to increase the short-term profitability of maintaining soil fertility, and keeping rather than cutting larger trees and shrubs. Lastly, the introduction of plant species to the system will require additional research and substantial extension efforts.

INITIAL RESULTS/EVALUATION

Two of the above approaches have been implemented and compared to existing land use practices. First, a comparison has been made between a rehabilitated espinal, espinales in various stages of degradation, and intact matorral. Rehabilitation apparently leads to dramatic increases in species richness, total plant cover, above-ground phytomass, soil organic matter, soil water availability, and length of water availability. For most of these traits, the rehabilitated espinal takes on the characteristics of largely undisturbed espinales. The exception to this rule is annual and perennial species richness, which in the rehabilitated espinal was only 3/4 and 1/2 half that found in undisturbed espinales, respectively. In order to better evaluate the potential for restoration/rehabilitation of espinales, it would be interesting to know both the relative abundance of native vs. non-native species in different types of ecosystem, the relative abundance of the different species, and details of the management strategies used in the rehabilitation. Unfortunately, detailed reports of pre- and post-rehabilitation states and management strategies are not available.

They found a number of pronounced differences between espinales in good condition and matorral: matorral consisted primarily of perennial species while espinal had more annuals; matorral vegetation also had more plant cover and greater amounts and duration of water availability than did espinal; conversely, mature espinal contained approximately ten times as much above ground biomass as did matorral.

The second approach that has been experimented with is the agro-pastoral system of crop rotations and legume-based pasture. A four year rotation was used, including winter wheat, and the legume *Medicago polymorpha*. Wheat yields in the rotation were between two and four times those obtained on other farms in the region. Similarly, live weight gains for ewes grazing the medic pasture were much higher than those typical for the region. Although data on soil fertility and structure are not presented, the authors mention that soil fertility also increased with the implementation of this system.

CRITIQUE

I think the overall framework constructed by the authors is extremely useful. By determining what land is capable of being restored to what productive state, it has the potential to make resource use considerably more efficient in an area where resources - both natural and capital - are scarce. Furthermore, by classifying the various management possibilities as restoration, rehabilitation and reallocation, the framework forces us to make a conscious decision regarding the degree of alteration in the original landscape we hope to end up with.

The authors also take a big step in suggesting the restoration of an ecosystem that was not present historically. As the landscapes we live increasingly diverge from their original state(s), it will be more and more necessary to preserve biological diversity within such altered systems. These studies suggest one instance in which this may be possible. My greatest reservation about the

ambitious restoration efforts suggested by these authors has to do with the failure to grapple with the larger political and economic questions that determine land use patterns. For restoration to occur on such a large scale it must not only be feasible but also fit with the prevailing economic and political system. For example, if there is a trend towards increasingly intensive agriculture in the espinales, as is the case in many parts of the globe, creating the capacity for sustainable extensive use of the land may a) receive little funding, and b) have little effect on land management over the long term. It should be noted that the authors are working with rural economists, although the results of that work are not presented in the above articles.

I would also, hypocritically, raise a concern about the lack of consideration given to restoration of matorral vegetation. The focus of these works is on the return of espinales to a productive state in which ecosystem productivity can be harnessed for human use. This, no doubt, is due to a consideration of precisely those political and economic factors discussed above: resources probably don't exist to embark on ambitious restoration projects. Nevertheless, restoration of this ecosystem has not been tried, and might turn out to be more feasible than the authors seem to assume.

Finally, I would cast doubt on the likelihood of reversing the trend towards invasion by unpalatable annual exotic weeds. It seems likely that these species have a competitive advantage largely because cattle don't eat them. Without the removal of cattle from the system many of these weeds would be expected to continue to compete with native perennial vegetation.

In sum, the authors' plan to restore an ecosystem type across an entire region is laudable and ambitious. It can only be hoped that support for this restoration effort will increase as the low productivity of degraded espinales becomes increasingly problematic.

REFERENCES

- This paper draws primarily from the following two sources (Additional references are cited in the text and listed below):

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