SER SOCIETY FOR ECOLOGICAL RESTORATION

USA: Arizona: Abandoned Farmland Restoration in the Sonoran Desert

Overview

Twenty-five to fifty percent of all the agricultural land in the Santa Cruz and Gila river valleys have been abandoned since the early 1950s. Most of the land was abandoned as water tables and prices dropped, resulting in abandoned agricultural fields that have few or no plants growing on them at all. There is little interest in restoring the lowland desertscrub native to this part of the Sonoran Desert because it is little known and uncharismatic. Much of the land is dominated by the short-lived shrub burrowweed (Isocoma tenuisecta). The low rainfall of only 25 cm/year on average suggests that the prognosis for natural succession is slim. Earlier studies found that reestablishment of the dominant saltbush and creosotebush were highly variable, with some fields having no plant cover. Most of the old fields have annuals and short-lived perennials persisting, but still have few long-lived shrubs. Lowland Sonoran desertscrub has little in the way of ecosystem services, has little grazing potential, and as such has less incentive to restore these ecosystems. Agricultural and urban development in southern Arizona has considerably reduced the land cover in this type of ecosystem, so restoration was seen as a means to expand the area of this unique desert ecosystem. Restored saltbush desertscrub would benefit groundwater recharge, less flood damage to county roads, reduction in dust, and would be an increase of wildlife habitat. The project sought to determine historic species composition for a given site, acquiring seeds of those species, introduce them to the site, and provide them with extra water for establishment.

Quick Facts

Project Location:
Sonoran Desert, Arizona, USA, 32.7922834, -111.61484630000001

Geographic Region:
North America

Country or Territory:
United States of America

Biome:
Desert/Arid Land

Ecosystem:
Other/Mixed

Area being restored:
2.5 hectares

Organization Type:
University / Academic Institution

Location

(https://www.mapbox.com/)

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TIMEFRAME

Project Stage:
Completed

Start Date:
1991-01-03

End Date:
1991-06-03

DEFINING THE PROBLEM

Primary Causes of Degradation

Agriculture & Livestock

Degradation Description

Historical aerial photos taken between 1936 to 1979 combined with soils and remnant vegetation found in small patches throughout the study area provided a portrait of an ecosystem highly disturbed by agricultural development and groundwater pumping. Farming operations started in the 1930s, but were small at that time. In the late 1930s the arrival of greater pumping facilitated significant groundwater mining in the area and set the stage for massive exploitation. The spread of industrial agricultural techniques and the rapid rise of massive farming enterprises contributed to the massive boom that started in the early 1950s, with agricultural efforts focused squarely on cotton production. The area of the project saw an explosive growth in acreage under cultivation from 1949 to 1954 when cotton prices collapsed. The short-lived history of farming on the study site had come to an end by the 1970s.

PLANNING AND DESIGN

Reference Ecosystem Description

The study site was near Toltec, Arizona in a one square mile section. The area was considered to be representative of the Santa Cruz floodplain, an ephemeral stream in the area that flows from south to north. The researchers found fragments of ironwood (Olneya tesota) and blue palo verde (Parkinsonia floridum) that indicated greater water availability in the past. The ecosystem is largely composed of creosote and saltbush flats. Given the radical alteration of the ecosystem from pre-settlement conditions due in large part to the dewatering of the landscape it is difficult to assess the precise condition of the pre-disturbance ecosystem. Both the Gila and Santa Cruz rivers were known to have more regular flows historically, suggesting that mesquite bosques existed along portions of each river, and the groundwater table was much higher historically which also might have supported significantly more trees of different varieties. The study site was near Toltec, Arizona in a one square mile section. The area was considered to be representative of the Santa Cruz floodplain, an ephemeral stream in the area that flows from south to north. The researchers found fragments of ironwood (Olneya tesota) and blue palo verde (Parkinsonia floridum) that indicated greater water availability in the past. The ecosystem is largely composed of creosote and saltbush flats. Given the radical alteration of the ecosystem from pre-settlement conditions due in large part to the dewatering of the landscape it is difficult to assess the precise condition of the pre-disturbance ecosystem. Both the Gila and Santa Cruz rivers were known to have more regular flows historically, suggesting that mesquite bosques existed along portions of each river, and the groundwater table was much higher historically which also might have supported significantly more trees of different varieties.

Project Goals

Because of the land ownership status and the sense that the land was worthless because of the lack of a regional airport being built from the 1970s forward, the land had been left entirely alone. The passage of the Arizona Groundwater Act in 1980 guaranteed that the land would never be farmed again. Because of the decline in this desirable flat-land as desert vegetation, the Desert Botanical Garden perceived that the lowland desert was important because it too was becoming more rare, and restoration of this land made it possible to expand the area of this unique ecosystem considerably.

Monitoring

The project does not have a monitoring plan.

Stakeholders

The project was conducted by the Desert Botanical Garden, which is in Phoenix, Arizona. The study sought to see if it was ecologically feasible to establish perennial shrubs on a typical abandoned field that showed no signs of recovery. The study site was chosen because it had not been farmed since the late 1960s and would not be again because of the passage in 1980 of the Arizona Groundwater Act. That legislation actually stipulated that land not irrigated between 1970 and 1975 could no longer be irrigated, thus precluding the land from every being farmed again. Another consideration for the project was that the land had been bought up in the 1970s by speculators who had become interested in the possibility of a regional airport going in to this area, these new land owners had no motivation to care about the condition of the land they owned.

PROJECT ACTIVITIES

Description of Project Activities:
For the project two 1.3 ha barren (less than 0.01 percent perennial plant cover) areas .7 km apart were chosen. Site 1 was abandoned between 1954 and 1960 while site 2 was abandoned between 1949 and 1954. Representatives of the original dominant vegetation, including creosotebush, desert saltbush, linear-leaved saltbush, mesquite, wolfberry and globemallow were growing on land that had last been cropped before 1949 within 1 km of site 1 And 300 m of site 2. These were the perennial species used in the seed mix. The seed was donated by local native seed companies or collected by DBG volunteers. Initial soil profiles were evaluated by digging two 1.8 m deep trenches with a backhoe. The top two centimeters were a very fine sandy clay loam with platey structure. From approximately 2-60 cm the profile consisted of sandy clay loam with a subangular blocky structure. Below 60-65 cm the profile contained a weakly cemented carbonate horizon (caliche) extending to the bottom of the pit. Other areas nearby were also examined where natural vegetation had occurred after a brief period of cultivation. In the upper 3-30 cm of these profiles there was more coarser-textured horizons (sandy loams) which rainwater can more quickly infiltrate. Planting took place in the winter rainy season in early January 1991 because of the greater predictability of winter rain and lower evaporation. To increase the amount of water available to the plantings, rainwater running off the barren soil was arrested by low berms arranged on the contour. Each site was surveyed to determine the direction of slope, which was typically less than 1 percent, then using a border disk they created two rows of nine parallel berms separated by water catchment areas 15 m wide. Each berm was 30 m long and 40 cm high. Then a stiff-tined ripper was used to create a 2.4 m wide seed bed on the uphill side of each berm, the ripper disturbed the soil to a depth of 10-15 cm and left large clods (5-10 cm diameter) on the soil surface. At each site, these seed beds were broadcast-seeded with a mixture of perennial shrubs. Only the lower sixteen of the available eighteen plots at each site were included in the experiment. The two plots on the high end of each site caught water from a much larger runoff area and thus would have produced spurious results. Half of each plot was designated at random and seeded with Mediterranean grass (Schismus barbata), six-weeks grama (Bouteloua barbata), three-awn grama (Bouteloua aristioides), and Indian wheat (Plantago insularis). Mediterranean grass is exotic but considered naturalized in the area and was included in the mix because it was the only available cool-season grass. Each combination of mulch and weeding treatments (four in all) was randomly assigned to four replicate berms at each site. Half of all berms received wheat straw mulch at the rate of 900 kg/ha (2 tons/acre). Site 1 was seeded and mulched January 3, 1991, after which the plot was run over by a tractor-drawn crimper, as series of weighted, blunt disks which push the straw into deep impressions in the soil. At this rate of straw application, straw covered about 50 percent of the soil surface. On site 2, seeded and mulched January 16, the straw as not crimped. Plots were randomly assigned weeding treatment were hand-weeded when weeds appeared in February, before being weeded again in March, April, and May. The principal weed in the mulched plots was wheat straw. All plots had uneven weed infestations, principally of narrow leaf goosefoot, filaree, and London rocket. Russian thistle or tumble weed did not reach great size or number until early May. In order to measure the effects of mulching and tillage on temperature and water availability, five gypsum moisture blocks were installed one meter apart at two depths, one and 15 cm, in three locations: in a mulched, weeded plot; in an adjacent unmulched, unweeded plot; and between two plots in unmanipulated soil: all at site 1. Thermocouples were also installed to measure the temperature of the soil at a depth of 1 cm at each location. The thermocouples and gypsum blocks were attached to a computerized data logger which took readings every minute, converted these to hourly averages, and stored the data electronically.

PROJECT OUTCOMES

Ecological Outcomes Achieved

Eliminate existing threats to the ecosystem:
The water catchments were found to work very well. Rain falling in the bare areas between plots flowed into the tilled plot at the front of each berm. Tillage in the seeded plot had proken up the surface crust allowing water to soak in more easily, and the berm next to each plot prevented any water

from flowing off the plot. The timing and amount of rainfall proved to be a major factor influencing the outcome of the experiments. The ground was worked at site 1 and site 2 on January 3, 1991 and planted at site 1 on the same day. Sixty-eight mm of rain had fallen since December 15, 1991, leaving a moist and friable seed bed. The area received 24 mm of rain on January 4-6, 1991, which proved to be ideal for seedling establishment at site 1. Site 2 was unable to be planted until January 16, by which time the soil had dried out. No significant rain fell until 15-20 March (24 mm measured on site), desert saltbush and Indian wheat seedlings emerged at site 2 shortly thereafter, but much later and in lower numbers than at site 1. There was found to be a clear effect of mulch on soil temperature and moisture retention. It was clear that the seedlings were very sensitive to moisture in the top 2 cm of soil, and mulched plots were found to improve soil moisture both near the surface but also at 13-15 cm in depth. Desert saltbush, linear-leaved saltbush, and Mediterranean grass emerged almost immediately after the rain on January 4. Warm weather after the March rains triggered germination of mesquite in several plots. Creosotebush and perhaps wolfberry as well as six-weeks grass and three-awn grass are more likely to germinate during the monsoon rains in the summer. No species other than desert saltbush emerged in sufficient numbers on site 1 to allow for the analysis of treatment differences. Desert saltbush was found to favor microhabitats behind clods and in low depressions formed by tilling in unmulched plots and throughout the mulched plots. They survived much better in the mulched, weeded plots. Although the total percent cover of desert saltbush after three months of grown (4-8 percent) was not impressive, the number of saltbush seedlings in all treatments (4 to 33) was substantially higher than it would be in mature stands. Annual grasses did not come up in sufficient quantity to have any effect on either weed suppression or desert saltbush establishment. The majority of saltbush seedlings were less than 5 cm high and unbranched, but some of the largest seedlings in the mulched plots had reached 30 cm and were woody and highly branched. On the other hand, mulching had a (barely) significant effect on average seedling height. In plots that were mulched and weeded, on the other hand, the mean height of the tallest seedlings was 13.6 cm compared to only 9.6 cm in unmulched, weeded plots. Overall, the project made clear that active restoration of abandoned farm lands is not warranted if native vegetation will gradually recover on its own. In those instances devoid of perennial vegetation, far from seed sources, and with barren and altered soil conditions, restoration is feasible.

Factors limiting recovery of the ecosystem:
Rainfall in the desert is ultimately the most stringent climatic factor influencing the success of a desert restoration. In this instance, not only do the plants need to germinate, but grow large enough to tolerate the drier, normal conditions. Water catchment systems and mulching clearly increase the chances for seedling establishment. In a poorer rain year, the results of this project show that there would quite possibly have been no seedlings at all on any of the unmulched plots. The low quantity of plants that were able to germinate indicate that repeated treatments is necessary in desert ecosystems, perhaps every three years a reseeding might be necessary. The project may have covered 2.6 ha but the actual seeded area was only .23 ha, making it clear that revegetation of the strips between berms would be difficult because of the soil conditions. One possible element to counter this is that the plantings increased activities of burrowing animals (ground squirrels, coyotes, badgers) elsewhere in the study area, such that they may perhaps break up the surface crust and facilitate subsequent plant establishment.

Socio-Economic & Community Outcomes Achieved

Economic vitality and local livelihoods:
A final wave of farm abandonment is likely to occur in the coming years because of "˜water farming' which will begin happening as rapidly growing cities come to need larger shares of water from the Central Arizona Project. The wave of retiring old fields has come with the purchase of farms by cities to offset their water usage. Water farming has no direct effect on the ability or inability of farm land to recover, since the water being used by the municipalities is very deep groundwater, however these abandoned farms may come with the political and economic incentive to restore some of the lost desertscrub habitat. The effort to restore lowland desert will continue to expand because abandoned farmland will not simply return to desert, but instead requires large-scale restoration techniques.

KEY LESSONS LEARNED −

LONG-TERM MANAGEMENT −

Long-Term Management

Restoration in old desert fields is best accomplished by building water catchments, mulching with coarse, woody debris that is slow to break down, and then by replanting a fraction of the restoration area repeatedly until a good rainfall year occurs. Seeding, mulching and catchment techniques need to be tailored to such a long-term approach. This "˜lazy but patient' method requires a long-term commitment but is not capital-intensive. The cost of seeds may be high but are spread out over the waiting period and offset by savings in irrigation. This approach mimics the natural succession, but enhances it by promoting water infiltration and also by ensuring that when good rainfall does occur seeds are there to take advantage of it.

FUNDING −

Sources and Amounts of Funding

The project was funded by a grant from the Jesse Smith Noyes Foundation.

LEARN MORE −

Other Resources

Jackson, Laura et al. 1991. Desert Restoration. Restoration and Management Notes 9(2): 71-80.