Riparian Revegetation: An Approach to Mitigating for a Disappearing Habitat in the Southwest [1]

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Abstract.--Revegetation of two test plots (20 and 30 ha) has been implemented in riparian habitats along the lower Colorado River in Arizona and California to test the feasibility of using this technique to mitigate habitat losses or for operational enhancement. The data base consisted of plant and vertebrate community data collected monthly for a period of six years. Significant plant and animal correlations developed through community models led to the design of plant communities that predictably would provide maximum wildlife use values.

Plant community development on revegetation sites have thus far produced higher wildlife use values than predicted. Both tree and shrub species are showing high growth rates. Costs vary from site to site and with the contractor, but we found that desert riparian communities can be replaced for about $10,000 per hectare.

Careful consideration must be given to site preparation and machinery required for preparation. Mitigation proposals should be reviewed for possible causes of delay. Care must be taken in selection of a competent and innovative contractor, but once selected, the contractor should be allowed to carry out the work without interference from the contracting agency. Once the mitigation plan has been implemented, careful monitoring should be conducted as long as necessary to insure that predicted results are obtained.

INTRODUCTION

Compensation for wildlife losses from federally supported projects has often been unsatisfying and in many instances impossible as viewed by private, state and federal conservationists. One strategy used by action agencies has been to buy or set aside a tract of good wildlife habitat to mitigate or compensate for losses in the project area. Subsequently, the secondary or replacement site may become a primary site with the agency wanting to buy or set aside another in place of it. This game of "habitat checkers," with wildlife habitat being lost with each move, has led to distrust of action agencies and unsatisfying results. Conservation agencies today are demanding wildlife compensation in place and in kind, when possible.

The rapid loss of riparian habitat in the arid Southwest (Phillips et al. 1964, Lowe 1964, Carothers et al. 1974) combined with its value as a wildlife habitat (Carothers et al. 1974, Johnson and Simpson 1971, Brown, Lowe and Hausler 1977, Hubbard 1977, Stevens et al. 1977, Wauer 1977) has caused much concern among conservation groups. This paper reports on the knowledge we have gained during our studies of riparian habitats and our efforts over the past three years to

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design and revegetate two experimental sites. If our efforts in revegetating riparian habitats are successful and costs are within a reasonable range, our guidelines and designs can be used for future mitigational efforts, for operational enchancement, and/or habitat improvement.

PLANNING

Planning for mitigation cannot be done adequately without six basic ingredients (Table 1).

Table 1.--Outline of procedure involved in planning for mitigation.

1. A solid base of data concerning the wildlife in the project area and in the area set aside for mitigation.

2. A thorough analysis of the data.

3. Creation of predictive models with which to create, in theory, a design for the mitigation.

4. Design of modifications required:
   a. Site preparation (e.g., clearing, root-ripping, leveling, putting in irrigation system, etc.)

   b. Equipment needs

   c. Costs

   d. A careful analysis of probable delays and what these mean to the overall mitigation effort

5. Implementing design.
   a. Labor requirements

   b. Labor sources

6. Monitoring
   a. Methods of gathering information

   b. Analytical and interpretive techniques

   c. Staff requirements

Before any plans can be made about how to modify an area for wildlife enhancement, there must be a solid data base from both the affected area and the area being set aside for mitigation.

Population data should be collected for all the major groups (birds, mammals, reptiles and amphibians) on a monthly or seasonal basis. In our study we collected monthly and seasonal data for birds and seasonal data for nocturnal rodents as well as general surveys of large mammals and reptiles. In the case of birds, we had the flexibility of being able to analyze populations by month or season. Vegetation measurements (foliage height diversity, patchiness, volume, etc.) were measured once in mature communities not subsequently disturbed in any appreciable way. In communities undergoing succession we measured vegetative parameters twice annually. We also obtained densities of each tree and shrub species in each study plot. If any of these areas were subsequently disturbed in some major way, they were abandoned or considered as a new study area and all parameters were remeasured. All of the censusing procedures used in our study are previously described (Anderson et al. 1977a, 1979).

Birds were found to be extremely responsive to habitat changes and were used as the primary test group. We found that the way birds reacted to the vegetation was very complex. Results radically inconsistent with long-term trends were obtained if only a single year or a single season of population data was considered. Although many avian population studies reported in the literature involve only the breeding season, there is no convincing proof that this is the most important season. We found, for example, that bird populations (including numbers of species as well as densities) reacted to structure (here used broadly to include patchiness, vertical diversity, responses to particular plant species, etc.) less in summer than in other seasons (Anderson and Ohmart 1977a, Anderson et al. 1979). Populations in various plant communities tended to be more similar in summer than in winter (Anderson and Ohmart 1977a, 1977b, 1979). Populations were larger and reacted differently to vegetative structure in mild winters and in summers following mild winters as opposed to cold winters and in summers following cold winters (Anderson and Ohmart 1977a, 1979). The important point is that a study should be of adequate duration to determine how climate affects the ways in which wildlife reacts to vegetative structure. Only then can a realistic evaluation of the impact of a disturbance on that group or a prediction of the outcome of manipulation designed for enhancement be made. Only in a general way were data for a single year sufficient to determine the value of one vegetation type versus another. In both summer and winter of 2 separate years the salt cedar community did not support as large a population of birds as did cottonwood-willow habitats (Table 2). However, a study conducted only in 1977-78 would have minimized differences between the two communities. In fact, differences between cottonwood-willow and salt cedar associations in winter 1977-78 were not

Table 2.--These data indicate that a study encompassing a single year might have led to different conclusions. In 1975-76, a relatively harsh winter, the differences between the salt cedar (SC) and cottonwood-willow (CW) communities in bird densities/40 ha were pronounced and remained very different in summer. In 1977-78, however, the differences between the two community types were not significant ($p>0.05$) and were much less pronounced in summer.

	1975-76	1977-78	Percent Difference
Winter			
SC	46	123	167
CW	122	144	18
Percent Difference	165	17	
Summer	1976	1978	
SC	127	356	180
CW	342	541	58
Percent Difference	169	52	

statistically different. Winter 1975-76 was much harsher than the following winter; the true wildlife use value of cottonwood-willow was more apparent during a severe winter (Anderson and Ohmart 1977a, 1977b, 1978a, 1979).

Over a five-year period we found that patchiness and foliage volume tended to be the most consistent aspects of vegetative structure with which avian densities and diversities were correlated (Anderson and Ohmart 1978b, Anderson et al. 1979, Anderson et al. 1979). Larger populations of several avian species were found in areas with quail bush (*Atriplex lentiformis*) than in areas of similar vegetative structure and composition, but which lacked quail bush. The presence of mistletoe (*Phoradendron californicum*) was important to fruit-eating birds in winter, while ink weed (*Suaeda* spp.) and wolfberry (*Lycium* spp.) were found to be important to Sage Sparrows (*Amphispiza belli*) and post-breeding populations of Phainopeplas (*Phainopepla nitens*), respectively (Anderson and Ohmart 1978a, Anderson et al. 1979).

On the basis of these findings we developed a plan for modifying vegetation for the enhancement of wildlife (Fig. 1, Table 3). The sites on which this plan is being implemented include one of about 30 ha of dredge spoil. The soils in this area are mainly sand on which little vegetation has developed over the past 25 years. A second site of about 20 ha consisted primarily of salt cedar (*Tamarix chinensis*). This exotic Old World species was cleared and is being replanted with native vegetation (see Fig. 1).

Salt cedar has formed dense stands within the levees and seriously restricts high water flows, making it highly undesirable. Because it is not of consistently high value to a vast majority of avian species in the lower Colorado River Valley (Cohan et al. 1979), large tracts can be replaced with native species with a community design less restrictive to water flow but with higher wildlife use values than salt cedar. Salt cedar has to a larger extent, replaced native vegetation in the valley (Ohmart et al. 1977).

Before implementing the revegetation plan, a number of considerations relative to site modification had to be considered. Since salt cedar sprouts rapidly from root stock, ripping of the roots had to be undertaken and was about 90 percent effective. The area then had to be leveled.

In desert riparian areas, which are subject to prolonged and extreme desiccation, it is imperative to insure that the roots of the new vegetation gain access to the water table. Root penetration to the water table is prevented or seriously impeded by dense soil layers (for summary and references see Anderson and Ohmart 1978b). Backhoeing or augering a hole for each tree insures a uniform soil texture to the water table. Finally, irrigation is required until the roots reach the water table.

Expertise in agroproduction was invaluable to our efforts, especially local farmers and extension service professionals. These consultants have provided information on water table depth and soil structure and chemistry.

Table 3.--Site revegetation diversity after clearing salt cedar. The area has a total of 30 subplots each with an area of 0.08 ha.

Number of subplots dominated by	
Cottonwood-willow	11
Honey mesquite	7
Quail bush	9
Number of subplots with	
Cottonwood-willow present	21
Honey mesquite present	23
Palo verde present	13
Quail bush present	17
Only cottonwood and/or willow	2
Only quail bush	1
Only honey mesquite	2
At least 1/4 bare soil	19
No bare soil	11
Number of plots immediately adjacent	
Vegetation dominated by salt cedar	16
Road and main irrigation canal	6
Small ponds	3
Agricultural situation	1

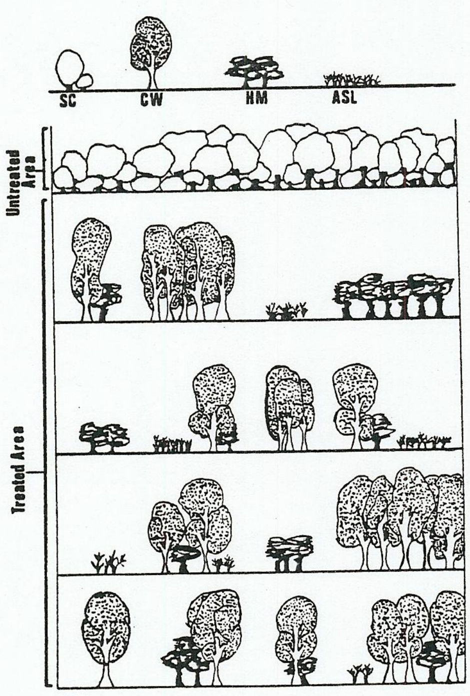

Figure 1.--Schematic illustration depicting vegetative diversity in a model designed for enhancement of wildlife. Note three fire lanes to be maintained in the area.

Serious consultation can save much time and expense and can help avoid failure. Experts who have agreed to serve as consultants and their areas of expertise should be listed in mitigation proposals.

Since revegetation efforts are expensive, site preparation costs should be kept minimal but not slighted. Irrigation systems, when required, should be relatively inexpensive and simple to install and maintain. Consultation with local irrigation experts (area farmers, agricultural extension agents, irrigation suppliers, etc.) can help avoid unnecessary costs when irrigation is required.

A carefully prepared list of required machinery should be included in mitigation plans. Again local expertise can be useful. For example, we needed a bulldozer capable of removing trees up to 20 feet tall and of pulling a root-ripper about 2 feet below the soil surface, a mechanical auger capable of drilling 3 to 4 m, a hydraulically controlled blade for leveling, and a tractor large enough to pull the blade. Local expertise provided specific information relative to the size of bulldozers and tractors required. Funds for renting or buying this equipment should be provided to the contractor. We cannot overemphasize the importance of including in any mitigation plans a detailed assessment of the equipment needed and a careful documentation of machinery specifications. Delays and higher costs are inevitable without careful planning.

We found that clearing and operating ordinary farm machinery in relatively rough terrain leads to a lot of mechanical failure. Schedule a full day of downtime for every full day of operation if the work is being done in relatively rough terrain. Even on dredge spoil, when power equipment is required, delays due to mechanical breakdown are frequent.

CONTRACTING

The agency responsible for mitigation may choose to have the work carried out under contract, preferably by a reputable contractor of high integrity. Mitigation is expensive--often very expensive. Plans for mitigation for which adequate funds are not available should not be proposed, or if proposed, the shortage of funds should be explicit. Therefore the contracting agency should select a contractor whose mitigation proposal has a high chance of success rather than selecting the cheapest bid with little chance of success. Where competence and success are equal, the contractor with the lowest bid should receive the work.

The contracting agency should allow the contractor total freedom but make field checks. However, persistent interference with elements of design, implementation, and maintenance can curtail progress.

IMPLEMENTATION

The contractor should have sufficient funds to either buy or rent all equipment necessary to implement the design. Any other arrangements may be totally unsatisfactory relative to the progress of the plan.

Timing of planting has been found to be critical in our area. In desert riparian areas the winter is the best time to proceed with planting. Evaporation is much lower; thus thorough saturation of the soil from the surface to the water table is easier. By the summer only enough water is needed to maintain a water-saturated soil column, plus that used by the plant. Trees or shrubs planted in the winter will have a developed root system and suffer fewer side effects should the irrigation system fail. In our revegetation efforts we have found that cuttings from wild stock started in a nursery have highest survival and growth rates. Plants from seeds germinated on site were hardier than those germinated in a nursery and transplanted (Anderson et al. 1979).

MONITORING

Initial revegetation efforts should be carefully monitored. We census birds monthly and rodents seasonally; vegetation growth is measured quarterly in our experimental areas. Each tree is marked with a numbered metal tag. Growth rates in a variety of soil types under various watering and fertilizing tests can be documented. Evaluations of predicted and observed results should be made frequently. Monitoring is critical; there should be adequate staff for data collection, thorough analysis, and interpretation.

Monitoring methodologies should be kept constant throughout data gathering. After a period of time, it might be possible to predict that if the vegetation is developing according to design and wildlife is reacting in ways close to that predicted, all will go according to plan until the vegetation reaches maturity. Pioneer efforts should be monitored until it is evident that the desired objectives have been achieved. Less intensive monitoring efforts may be possible as experience and knowledge are gained.

SUCCESS OF EXPERIMENTAL REVEGETATION PLOTS

On our experimental plots, palo verde (*Cercidum floridum*) honey mesquite (*Prosopis velutina*) willow (*Salix gooddingii*) and cottonwood trees (*Populus fremonti*) grew an average of 112 cm, 88 cm, 6 cm, and 38 cm, respectively, in three months (Anderson et al. 1979). Combined survival for these trees was 76 percent and was greatest (94 percent) for cottonwood. In January 1979, we planted 2,000 trees. After five months, survival was more than 95 percent, growth rates have exceeded expectations and it appears that by mid-summer many of these trees will be able to survive without additional watering.

Shrubs have also responded well. Wolfberry, transplanted in January, leafed out in spring, and many produced fruit in May.

Avian densities remained low for six months after planting in March 1977. By November of that year the number of birds per 40 ha exceeded, by 50 percent or more, densities found in the most abundant riparian vegetation types. Most of these birds were seedeaters and were consuming seeds of annuals which grew as a result of our irrigation (Anderson et al. 1979). Indications were that rodents, rabbits and snakes also increased in numbers.

During the first six months of revegetation the number of avian species observed during any single month was less than half the number observed in typical riparian vegetation. By February 1978 (11 months later) as many or more species were found on the revegetation plot as in typical riparian stands (Anderson et al. 1979).

ECONOMIC FEASIBILITY OF REVEGETATION

An effort to determine economic feasibility of revegetation on a relatively large scale, perhaps 400 to 500 ha, has been a major objective of our experimental efforts. Answers to such questions are largely value judgments. However, it seems clear that revegetation efforts are not likely to be considered inexpensive. In our judgment a high degree of success should be the major goal. To insure success, the cost of essentials cannot be reduced. Manpower requirements should be viewed as a worthwhile investment; there will be a greater return on the dollar with too much manpower than if there is a shortage. In the desert Southwest, root-ripping and augering are essential in site preparation.

Nonetheless, reduction of costs can be accomplished by using inexpensive but effective irrigational systems. Local farmers or extension service personnel have the best insight into the least expensive but most effective systems.

Although augering holes for every tree is costly, perhaps $200 per ha, it is essential to insure plant survival once the irrigation system is removed. Augering also reduces the time trees need to be watered from three or more years to perhaps eight to ten months. This means use of much less water and reduced irrigation costs.

In our estimation, revegetation of a 400 ha plot in the lower Colorado River Valley, involving the clearing of salt cedar, would require ten years (3 years for clearing and planting, 7 years for monitoring) and would cost between $3.5 and $4.5 million. Those who place high values on wildlife might view this as an inexpensive price to pay. Others, whose values lie elsewhere, might view such an expense as exorbitant. Clearing an equivalent area for agriculture and farming it for a total of ten years would cost about four to six times this amount. The returns from the two contrasting efforts cannot be compared in monetary terms.

In summary, we present a promising technique for mitigating for southwestern riparian habitats in kind and place. Though results are preliminary, the wildlife use values are already higher than the predicted values. Costs may seem high to some, but if a lesson is to be gleaned from our data it is this: action agencies should explore all alternatives prior to destroying a reach of valuable riparian habitat. Should it be necessary to destroy it they should be prepared to meet the high cost to replace it in kind and place.

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