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Task No 2."A review and Analysis of three Revegetation Projects by the U.S.Army Corps of Engineers." This report presents an analysis of revegetation projects at Dreaming Draw Dam, Cave Buttes Dam, and Bend Wash, Phoenix Arizona, and presents recommendations for arid lands revegetation.

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Task No. 3 "Revegetation Methods for Arid Areas".
This report presents a comparison of methods of revegetation used by the Arizona Department of Transportation, minning companies in the Phoeniz area, and the Desert Botarial Gardon.

Task No. 4 "Site Characteristics."
This report describes the site characteristics of the Adobe Dam Study Area.

Task No. 5 & 7 Seeding Success on Topsoiled and Hard Topspoles Slopes at Ddobe Dam".
This report presents statisfied analysis of the relative success of several seeding methods used at the Adobe Dam site.

Task No.6 "Evaluation of three watering and Molding Techniques on Transplanted Trees at Adobe Dam."
This report evaluated the relative success of alternative watering resigns and types of water used on transplanted trees of Adobe Dam.

Task 8."Final Evaluation and Recommendation on Reclamation at Adobe Dam."
This report summerizes the findings of Tasks 2 through 7 and presents a service of specific recommendations for acheiving success in arid lands revegetation projects.

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Report to the U. S. Army Corps of Engineers
Los Anglees District

Task No. 8
Revised 8-19-1983

Final Evaluation and Recommendation on Reclamation at Adobe Dam

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Contract No. DACW 09-80-M-1205

INTRODUCTION

From a review of the procedures (1) used at Adobe Dam, both planned and experimental, (2) used at other revegetation projects and (3) presented in the literature on vegetation, evaluations of the Army Corps of Engineers' Adobe Dam project and recommendations for future revegetation efforts can be developed. An initial review of the planned revegetation procedures and the experimentation will establish the background for the evaluation.

Revegetation procedures planned by the Army Corps of Engineers included both seeding and transplants. On the south facing surface of the dam, seeds were hydroseeded over two surfaces, (a) a four to six inch topsoil layer over rip-rap and (b) exposed rip-rap. The surfaces were dragged after seeding.

Experimental procedures relative to seeding included a monitoring scheme to determine seedling survivorship and tests to determine the affects of differing embankment preparations on seeding success. This latter study was accomplished by creating a representative slope of fill material with similar topographic conditions to the dam face but with no grading, rip-rap or surface topsoil. Seeding on this surface was compared with that on topsoil and rip-rap surfaces on the dam. An unexpected experiment developed when the eastern portion of the dam was seeded in midwinter and the western portion in early spring, premitting comparison of time of seeding.

Transplant experimentation included (1) modifications in watering regimes for transplants from the planned weekly watering to bimonthly and monthly, (2) modifications in use of mulch in the transplant water basins from only pine mulch to alternatives of no mulch or stone mulch, and (3) modifications in fencing of transplants leaving some plants unfenced compared with planned fencing of all trees and no fencing of creosote bushes.

EVALUATION

The Adobe Dam project benefitted by an unusually wet winter which made it difficult to fully evaluate the success of some of the experimental modifications, especially the watering regime. Table 1 compares the relative success, energy costs and aesthetic appearances of the planned and experimental revegetation procedures used at Adobe Dam.

Success of seeding was based on seedling survival of the seed species used in the seed mix. No location had a high seedling success rate. The topsoil and fill material were about equal while the rip-rap tended to attract annual weed species. Energy costs (i.e., equipment use) for different surface materials is highest for topsoil because it is an additional step over rip-rapping which is an additional step over smoothing the fill surface which is more costly than leaving the fill surface roughened.

Table 1. Comparison of seeding and transplant experiments in terms of success, energy costs and aesthetic appearance. Relative terms are High - H; Medium - M; Low - L.

	Relative Success	Relative Energy	Aesthetics
Seeding			
Surface			
Topsoil	M	H	M
Rip-rap	L	M	L
Fill	M	L	M
Seeding Date			
Mid Winter	H	na	H
Early Spring	L	na	L
Transplant			
Water Regime			
Weekly	H	H	H
Bimonthly	H	M	H
Monthly	H	L	H
Mulch			
Pine	H	H	L
Gravel	H	M	M
None	H	L	M
Fencing			
Yes	H	H	L
No	M	L	H

Aesthetic evaluation of seed areas is subjective but topsoil and fill areas had a pleasing shrub cover on the average while the rip-rap had localized patches of tumbleweed which died and turned brown in the winter. The high rating for mid-winter seeding is due to the greater cover of plants in areas seeded at that time of year. The seeding date experiment shows very definitely that slope seeding should be done to take advantage of natural moisture and low evaporative conditions.

Transplant success was relatively uniform regardless of treatment. The moist weather conditions during the experimentation tended to mask the experimental results. Some general conclusions can, however, be drawn.

Water regime. It is probably unnecessary to water tansplants every week if the water retention basins are adequate. Bimonthly watering should be sufficient.

Mulch. Pine mulch is a poor mulch to use because it is easily washed or blown away adding the costs of replacement. Gravel mulch, taken from on site, worked well and is needed to be placed only once. Lack of mulch causes drying of soil surface and surface erosion when high flow rates are used for watering.

Fencing. Some form of protective fencing is recommended for new trees such as mesquite and palo verde. Unfenced new plants tended to be browsed heavily by jack rabbits. Creosote bush, although slightly browsed, will grow adequately without fencing.

One should remember that each additional step in revegetation adds an additional energy cost as well as real cost. These costs must be weighed against the potentials for success and long term aesthetics. The need for success of revegetating an area and holding down costs must also be related to the engineering specifications and/or requirements established for a particular project. For example, seeding on unsmoothed fill has as much success with much lower energy costs and equal aesthetics as seeding on topsoil over rip-rap. However, engineering specifications established the need for a 6" rip-rap layer over graded fill. If this is required then the use of unsmoothed fill, although less costly, is impossible from the engineering standpoint.

Seeding

Seeding is appropriate for large areas where plant cover provides aesthetics and erosion control. For success in seeding operations, success in three areas is necessary.

I. Seedbed Preparation

Prior to any planning, soil analyses should be conducted. Soil analyses alert planning personnel to problematic soil conditions that exist, and provide an opportunity to ameliorate these conditions or to mitigate their potentially detrimental effects by using tolerant plant species. Soil analyses additionally provide the information needed to evaluate the necessity of applying top soil over fill materials. For the Adobe Dam revegetation project, the addition of topsoil was not required to establish good vegetative cover (Moore, Patten and Righetti 1983).

Grading operations should be designed to reduce slope angles when they exceed 25 percent. Additionally, grading should never create seedbeds that are smooth. Special measures to ensure that seedbeds are rough, with large stones left in place are strongly recommended. The variety of microhabitats so created, aids in the establishment of seeded species by decreasing moisture loss, creating shade, reducing erosion, and increasing water percolation.

In the interests of economy and maximum seeding success, the following slope treatments are suggested.

1. Use fill materials when soil analyses indicate they are appropriate. A rough surface is desirable.

2. If rip-rap cover is required for engineering reasons, it is recommended that fill material be visible between the stone, to provide sites for seed germination and establishment.

3. If engineering requirements necessitate greater rip-rap thickness, a thin layer of the appropriate soil medium (topsoil or fill, depending on soil analyses) should be applied over the rip-rap cover. The sites created as the soil washes into niches between the stones, provide suitable microhabitat for seed catchment and germination.

II. Species Selection

Species selected should meet special soil and climate requirements. Species listed in Task 3 (Willis and Patten 1983) have been successfully used in revegetation of arid sites. This list is by no means complete and notification of local Soil Conservation Service personnel is suggested for more complete listing.

A good species mix should include grasses, forbes and shrubs. The following guidelines have been suggested (Willis and Patten 1982).

	No. of Species	PLS/ft^2
Grasses	6-8	20-25
Forbs	3-6	3-6
Shrubs	2-3	2-4

These rates are typically doubled for broadcasting seeding. Seeding on more critical sites may require additional increases in the initial rate.

III. Seeding Operations

Time of seeding is crucial to success (Moore, Patten and Righetti 1983). Early seeding reduces the numbers of weedy species invading the site. For sites in the Phoenix area September through February seeding is recommended. When seeding coincides with periods where the frost probability is high, selection of frost hardy species is suggested. The rough seedbed can additionally provide some frost protection.

Broadcast seeding followed by an operation designed to cover the seed with soil has been proven effective in arid regions. On areas with difficult access, hydroseeding is useful.

Transplanting

Transplanting is appropriate where "instant" landscaping is desired, or in critical areas where the probability of seeding failure is high. Containerized transplants are favored, and excellent success has been achieved utilizing brief irrigation periods in arid areas (Moore 1983).

I. Site Preparation

Site preparations should be kept to a minimum as transplants must be able to become established and be supported in the native soils. Compacted conditions should, however, be relieved by ripping. Grading to create contours beneficial to directing runoff to transplanting sites is recommended. The maintenance of newly planted trees, including irrigation, is aided by easy access. Trees should not be placed in areas with difficult access. Efficient maintenance can be achieved by clumping the trees in small groups.

II. Species Selection

Species native to the project area should be used, as these species are naturally adapted to the site. Where landscaping plans call for the use of exotic species, care should be taken to assure that the species are tolerant of desert conditions. Equally important, is the selection of healthy, vigorous specimens. Plants should be inspected at the nursery and upon delivery. Conditions to be avoided include, pot bound trees, root defects, weak spindly trunks that require staking and plants with low root/shoot ratios. Inspection of the transplant candidates should precede acceptance of the plant materials (Moore 1983).

III. Planting Techniques

Holes for transplanting are typically dug by a backhoe. Rough, nonglazed sides promote root growth outside the original hole. Hole sizes should be twice the diameter of the root ball and two inches less than the height of the root ball. Prior to planting the tree, the hole should be filled to capacity with water and allowed to drain. In planting, care should be taken to correct minor root defects by pruning or straightening the affected roots. After planting, the transplants should be thoroughly watered to settle soil around the roots. Application of mulch retards water loss and its use is strongly recommended in dry areas. Stone mulch, as tested at Adobe Dam proved highly effective as a mulch material and was significantly longer lasting than pine mulch. Additionally, the stone mulch was available on site, and therefore very cost effective (Moore 1983).

In desert areas, supplemental irrigation is required for establishment of transplanted species. When planting dates fall outside favorable rainfall periods, the watering requirement increases. In comparison of three watering regimes at Adobe Dam (weekly, bimonthly and monthly), it is significant to note that even with monthly watering, none of the transplanted trees died. Minimum irrigation is therefore feasible; the actual schedule is best determined from frequent site inspections during the establishment of the newly transplanted species.

REVEGETATION PROCEDURES

The following list is a condensation of recommendations made in this and earlier reports. For more detailed explanations, the reclamation planner should refer to the earlier reports.

A. <u>Seeding vs. transplant</u>: Use seeding when large areas need to be covered with shrub or herbaceous plants and there is no need for immediate plantings of aesthetically pleasing woody species. Use transplants in localized situations where "immediate" vegetation is needed or to create a short-term aesthetically pleasing location. Transplants should not be used over large areas because of cost.

B. Soil Analyses: For both seeding and transplant locations, soil analyses should be done. Soils to be analyzed should include topsoil, borrow pit fill material and surface soils that will be disturbed and replanted. Tests for pH, sodium, alkalinity, nitrogen and phosphorus are necessary to plan for future soil amendments and seed mix.

C. Substrate surface: Surfaces to be seeded should be as rough as possible to provide multihabitats for seedling establishment. Smooth surfaces should be avoided to prevent erosion and seed loss. Surfaces should be lightly dragged after seeding.

D. Seed Selection: Seed species selection should be compatible with all site conditions. These include macroclimatic, microclimatic and soil substrate. A range of species covering a wide gradient of conditions will only result in partial success. Site specific seed species selection is best.

E. Seeding: Seeding should be done during good climatic periods, preferably between midfall and midwinter. This uses natural conditions to enhance seeding success. The method of seeding should be based primarily on cost because all three methods are relatively successful if the soil surface is properly prepared.

F. Transplant Site: The soil surface should not be compact, the hole should be much larger than the plant root ball, and surface contouring should be shaped to permit natural surface runoff into the transplant basin.

G. Selection of Transplants: Species indigenous to the area are preferred. Smaller (5 gal.) transplants will have greater success than larger (15 gal.) as long as they are initially fenced. Fencing should be removed after the plants are established.

H. Transplant Planting: The hole should be filled with water and allowed to drain prior to planting. After planting, transplants should be thoroughly watered and a gravel mulch (from on site) used. The transplant basin should be at least 6 inches deep with no berm or only a berm on the downhill side.

I. Transplant Watering: Bimonthly watering should be sufficient if the transplant basin is deep enough. Care should be taken to prevent erosion of the transplant basin.

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