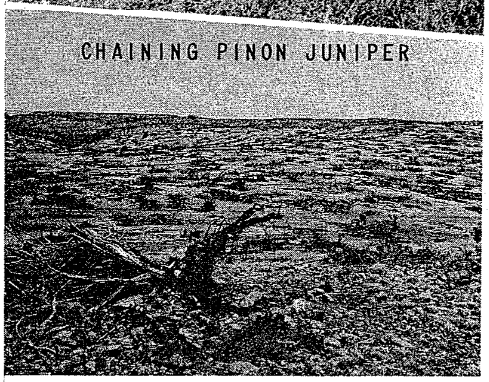
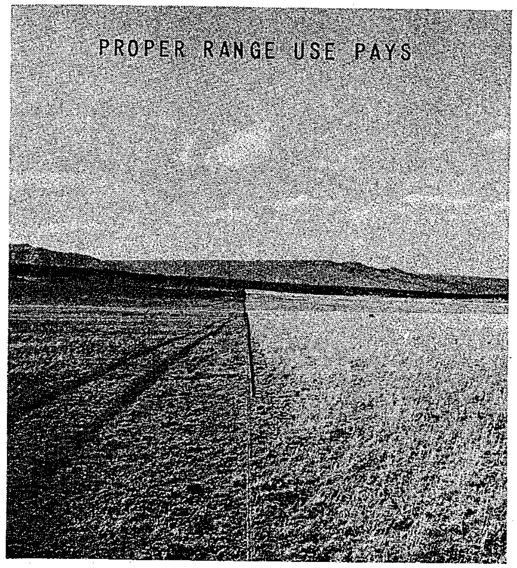
RANGE CONSERVATION - TECHNICAL NOTES





U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NEW MEXICO

RANGE TECHNICAL NOTE NO. 59

May 22, 1973

Re: Critical Area Stabilization - Seeding

This Range Technical Note transmits Report No. 7 of the New Mexico Interagency Range Committee.

This report can be used as reference for planning for the rehabilitation of disturbed sites.

Additional copies are available from the state office. Submit requests to the Plant Sciences Section.

Attachment

AO
WRTSC, Portland - 2
Adjoining States - 1

Critical Area Stabilization in New Mexico

TABLE OF CONTENTS

PAGE NO.

New Mexico Inter-Agency Range Committee
Report No. 7
Daniel L. Merkel, Soil Conservation Service
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CRITICAL AREA STABILIZATION IN NEW MEXICO

I. Introduction:

The New Mexico Inter-Agency Range Committee sponsored a Critical Area Stabilization Workshop in Albuquerque on April 27-29, 1971. The purpose of the workshop was to provide federal and state agency people an opportunity to exchange their knowledge and experience in critical area stabilization. The workshop had the benefit of representatives from 7 states, 17 agencies and 22 disciplines. The papers presented at the workshop were included in Inter-Agency Range Committee Report 7A, "Proceedings, Critical Area Stabilization Workshop," dated June 1971. There is no longer a supply of Report 7A. More detailed seeding recommendations are included in Report 10, "Seeding In New Mexico."

For the purpose of this report a critical area is defined as land which has been disturbed by construction or altered by over use or mismanagement and which requires special treatment, management and/or materials to return it to an ecologically acceptable condition. The major part of this report is directed to stabilizing sites denuded by construction.

This report includes recommendation for the major considerations involved in rehabilitation of disturbed sites. These recommendations were developed during the workshop by sub-committees. The agency representatives who assisted with each topic are listed. The permanent members of the Inter-Agency Range Committee are indicated by an asterisk.

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Wayne Ehrley, Landscape Architect, Phoenix, Ariz. & Santa Fe, NM

II. The Problem:

New Mexico and the Southwest are experiencing major changes in land use. Thousands of acres are being converted each year from agricultural use, mainly rangeland, to other purposes. Residential subdivision, transportation routes, commercial and industrial sites and public rights-of-ways are some of the uses to which land is being converted.

In most cases of land use conversion, the fragile vegetative cover is destroyed. The erosive soils are then opened to destructive forces of wind and water. The result, too often, has been loss of air and water quality. Excessive siltation in water courses and small dust storms near construction sites are common.

Controls of critical areas has been recommended or done by many state and federal agencies for several years. Results of control attempts have varied from excellent to poor.

Based on the present knowledge, equipment, materials and experience, the committee recommends the following when evaluating a disturbed site for treatment.

III. Resource Inventory:

A. Factors Influencing Land Use Decisions

Many of New Mexico's critical areas result from misuse of fragile sites, land use change and associated construction. The inherent characteristics of many soils makes disturbed sites susceptible to destructive erosion.

Basic to all good land planning and management is an up to date inventory of the natural resources and the environmental and ecological factors affecting these resources.

Some information useful in making land use decisions includes, but is not limited to the following: a list of available consultants; land ownership; hydrology; land use zoning; past and current management practices; kinds, extent and severity of existing land problems and their causes; managing agencies involved; present biotic uses; climatic data; land form data; geology and soils information; kinds, types and extent of vegetation present; general public factors to be considered, such as safety, aesthetics and recreation possibilities; land and cultural improvements, present and needed;

kinds and extent of land, water and air pollutants; possible legal problems present and anticipated; land legislation that may be needed, etc.

The following are some objectives of a resource inventory which should be considered before decisions are made:

1. To become aware of current resource plans.

2. To recognize existing decisions concerning resources and resource problems.

3. To obtain as much knowledge and information as possible about the land resources.

4. To identify the environmental and ecological factors affecting the resources.

5. To identify resource problems and their causes, extent and severity.

6. To identify past and present management practices and their effectiveness or ineffectiveness.

7. To identify the biota of the area being inventoried.

8. To record the type of use being made of the resources.

9. To determine the condition and/or quality of the resources.

10. To identify the present factors affecting the public and the public's concern about present and planned land practices and management.

11. To interpret soil survey information to determine potential and limitations for construction and revegetation.

All of the above should contribute to decisions by well informed land owners, administrators and planning leaders.

B. Factors Influencing Stabilization Decisions

The initial resource inventory should provide the basic guidance for critical area stabilization decisions. The data available should influence construction design, method of stabilization, future use of the area, species to be seeded, seeding time and method and management if revegetation is involved. Information on vegetation, soils, topography, climate, biotic factors, future use and other considerations should be complete enough to form a basis for the following treatment considerations:

1. Vegetation

a. Present Vegetation

The native vegetation on an area before disturbance is the best single key to the potential of a site. It gives a guide to the collective influence of all related factors acting on the site.

Special attention must be given to the expected alterations in the site due to disturbance. The same factors that make an area critical often alter the site's potential.

b. Amount of Vegetation

The amount of natural vegetation on a site indicates the stabilization alternatives. Sparce plant growth on flat, non-disturbed areas often indicates a need for mechanical stabilization measures to supplement revegetation.

c. Vegetative Composition

The vegetative composition before disturbance gives a good indication of the species to be included in the revegetation mix. The growing trend is to use species native to the site when reseeding an area. This has the advantage of increasing the aesthetic values of a treated area by blending it into the landscape.

If species other than those native to the site are to be used, the natural vegetation often indicates the best adapted plants. For example, salt tolerant species should be used to replace salt tolerant species.

2. Soil

a. Depth

Where possible, soils should be inventoried and recommendations made for their handling during and following construction. In most cases, scraping the topsoil from a site, stockpiling it during construction and placing it on the areas to be stabilized at the completion of construction is well worth the additional cost. The soil should be 18 inches or more to parent material if grass is to be the major source of stabilization. Shallower soils favor browse and forb growth. These should make up a large percent of the seeding mix where parent materials are near the surface.

b. Texture

The design of constructed slopes should give consideration to texture of the soil to be worked. Where possible the degree of slope should be adjusted according to soil textures to accommodate reseeding and other equipment.

Soil textures influence the kind and amount of temporary stabilization required. Textures also influence the species to be seeded on an area.

c. Inhibitory Factors

Special consideration should be given to treatment where the soil has limitations, such as high salts, or where additives have been introduced into the soil materials, as is often the case in mine tailing. In many cases, treatment is limited by materials which will be added to the site following stabilization. Salting of parking lots and highways is an example. Species used in seeding such areas should be selected for tolerance to growth inhibitors known to be present on the site.

d. Erodibility

The resource inventory should indicate erosive soils. These should be avoided in planning new development. If they are disturbed, increased cost of intensive stabilization measures should be expected and planned.

3. <u>Topography</u>

a. Slope

Natural slopes often control the designed constructed slopes and degree of revegetation success. Therefore, the resource inventory should be used to determine the most favorable areas for construction, etc.

b. Exposure

In mountainous regions, a northeastern exposure (if it supports an adequate feed supply) is preferred by wildlife. Therefore, disturbance in these areas should be avoided if possible.

Since south and west exposures are most difficult to revegetate and maintain, long steep slopes on these exposures should be avoided.

The difference in vegetative potential on various exposures should be recognized in preparing seeding mixes.

4. Climate

Species selection and time of planting must be based on meaningful climatic inventory information. The inventory should include season, amount, intensity and duration of precipitations; length of growing season; expected high and low temperatures, etc. Climatic data from the most representative weather stations should be used in planning a project.

5. Biotic Factors

a. Wildlife

The resources inventory should include data on the kind and amount of wildlife in the area. This information may influence the selection of plant species and mulches to be used. Species with high grazing preference are difficult to establish without some form of protection in areas of heavy wildlife populations. Since hay mulches often attract wildlife in these areas, artificial mulches may improve revegetation success.

b. Rodents

Control of rodents is often necessary to insure successful seedings on small areas.

c. Insects

Inventories should recognize the possibility of damage to new seedings by insects so proper control measures may be planned.

6. Future Use

The future use of critical areas should be considered in the resource inventory, especially when large areas like strip mine spoils are being treated. The finished slopes and seeded species should benefit the future planned use.

7. Other Considerations

a. Aesthetics

The resource inventory should include aesthetic values that are to be protected or re-established. Stabilization plans should include, where possible, design alternatives, seeding methods and species which enhance aesthetic values.

b. Patterns

Treatment boundaries should be designed to blend into the landscape as much as feasible.

IV. Design:

Design, as it is considered here, is the consolidation of resource data, its analysis, and evaluation resulting in the development of recommendations that meet construction, operation, and maintenance objectives. The proper treatment design for the stabilization of critical areas fits historically into the "Total Critical Areas Stabilization Job" in two ways:

1. Those designs which are planned before the final project plans are completed or before construction is begun.

2. Those treatment designs which are required after the project specifications are completed or after construction is completed; usually without benefit of prior consultation in the original project design or construction stages.

This report deals only with the first category. It recognizes the major objective of good design as improved long-range performance in stabilization of critical areas through coordinated effort of collaborative teams.

The goal of good design is to minimize the need for stabilization through the use of the latest innovations.

A. Design Considerations

The following are four items that should be considered in design of each project:

1. Planning and design are not the same. Good comprehensive planning will result in greater efficiencies during the design processes and thus better treatment of critical area stabilization projects.

2. Temporary Erosion Control Methods - Where sediments will degrade water quality in live streams or dust will reduce air quality, include temporary erosion control methods in construction plans. This will facilitate compliance with existing legislation.

3. Both vegetative and non-vegetative treatments for stabilization of critical areas should be considered. The best results are usually achieved when both types are designed in combination. The exclusive use of one treatment method to the exclusion of the other seldom results in a well designed stabilization project.

4. Contour grading - earthen structures should be designed to be visually compatible with the surrounding landscape.

B. Design Recommendations

Most new critical areas are a result of a construction project. In many cases the cost of stabilization of these areas would be decreased and success increased if some added measures were included in the design and construction plans. These include:

1. Slope - Where possible, all cut and fill slopes should be designed as 3 to 1 or flatter.

2. Topsoil - If the natural topsoil is deep enough, it should be stockpiled during construction. Following construction, the topsoil should be spread over the areas to be vegetated which have the greatest limitations to growth.

3. Runoff - Construction designs should provide for diversion of runoff away from new cut and fill slopes. Drainage through all new construction sites should be designed to reduce the erosive effect to a minimum.

4. Long Slopes - Slopes of more than 20 feet vertical drop should be broken with berms. If vegetation is the planned stabilizer, the berms should be located no more than 15 vertical feet apart on harsh sites and 20 feet where favorable soils and climates exist.

V. Plant Materials:

Vegetation is the most used means of stabilizing disturbed areas because it is a self-sustaining aesthetically acceptable treatment. It fulfills the environmental considerations which are now of prime interest. Low-maintenance, self-regenerating plant materials are becoming available through plant breeding and selection work of private and public groups. Although substantial progress has been made, there is a continuing need for development of climatically adapted, low maintenance plants and new techniques for propagation, establishment and management of vegetation in the treatment of critical areas.

Improvement needs to be made in the exchange of information about presently known and available methods, materials and equipment. Automated data processing is suggested as a means of assembling and utilizing known information.

A. Plant Materials Objectives

Vegetative stabilization will be more successful if the following is accomplished:

1. Get into use what we now have and know.

2. Recognize future plant materials needs and make plans to meet them.

3. Encourage integration of structural and vegetative treatments in the design and planning stages.

4. Develop and use more complete inter-agency recommendations for use of vegetation.

B. Plant Materials Selection

Several general principles apply to the selection of plant materials to accomplish a stabilization job. They include:

1. Species Selection - Species to be seeded should normally be well adapted to the existing soil and climatic conditions.

a. Climate. It is important to use only species that are adapted to the climate for a specific site. Important climatic factors are the amount and seasonal patterns of precipitation, frost-free period, and temperatures.

(1) Moisture. Each species has its maximum, optimum, and minimum moisture requirements. Species should be selected which have an optimum moisture requirement which corresponds with the precipitation and water-holding capacity of the soil. The amount and timing of this precipitation is fully as important as the water-holding capacity of the soil.

For many critical areas, such as road cut and fill slopes, the normal relationship of moisture, soils, and plants has been drastically altered. Nevertheless, it is important to understand this relationship; because, in stabilizing critical areas, our efforts are directed toward bringing the soil, moisture, and plants back to as near a normal situation as possible. This is why fertilizers, mulch, and supplemental irrigation may be necessary for establishing vegetation on critical areas.

The relationship of moisture to species selection is illustrated in Exhibit 1.

(2) Temperature. Each species also has a maximum, optimum, and minimum temperature range where it will exist and be productive. Some knowledge of the temperature data on the particular critical area is important.

The limiting influence of temperature on plant distribution is primarily from:

(a) Too short a period of favorable temperature (frost-free period) for plant maturity.

(b) Unfavorably high or low growing season temperatures for proper plant development.

(c) Occurrence of high or low temperatures which cause death of unadapted plants.

(d) Extended periods of low temperatures which kill dormant plants, especially during dry winters.

It is important to know the maximum, minimum, and optimum temperature ranges of the plants considered for seeding so proper selection may be made in relation to the actual temperatures of a specific area.

(3) Solar Radiation. The amount of solar radiation and its interception with the site surface is important in some instances. It is an important consideration in light colored soils or soils which tend to slick over.

b. Elevation

Each species has its maximum, optimum, and minimal elevational ranges in which they will survive. This becomes an important factor in species selection.

c. Soils

(1) Depth. Depth of soil is important from a standpoint of providing room for proper root development. Shallow soils constrict root development, which adversely affects top growth. Perhaps the most important consideration of soil depth is moisture-holding capacity. It is readily understood that a soil 6" in depth will hold only half as much water as a soil of similar texture which is 12" in depth.

(2) Texture. Soil texture is directly related to the moisture holding capacity of a soil. Likewise, soil texture will determine how readily soil moisture is available to the plants. A clay soil will hold more water than a sand at full capacity, but some of the water is held so tightly by the clay that it is unavailable for plant growth. See exhibit 2.

(3) Soil Nutrients. It is very important to use fertilizer in establishing vegetation on raw soils such as road cut and fill slopes. Soil tests provide a scientific basis for regulating the available nutrients in the soil. Fertilizer is used both for establishing vegetation and for maintenance of vegetation on raw areas. Each situation may require a different prescription both as to amount of fertilizer and method of application.

Aggressive spreaders, either by rhizones or stolens, should receive first consideration. Where a continuing fertilization program is not planned on low fertility sites, the species should be adapted to this condition or be able to fix its own nitrogen. The selected species should fill the requirements of the future use of the area. Native plants are usually best adapted, longest lived and require the least maintenance.

2. Seeding Rate - The seed mix should provide at least 40 to 50 pure live seed of adapted species per square foot when drilled and approximately 60 if broadcast. Where unlike soils are included in a single project, the mix should provide ample seed to give this rate of adapted species on each different soil. Excessive seeding rates often cause poor soil-seed contact and extreme competition which result in unsatisfactory stands. See Exhibit 3 for seeding rates of commonly used species.

3. Variety Recommendations - Improved varieties have been developed for many commonly used grasses. Seeding vigor, rate of establishment and longevity are factors for which they have been selected. Therefore, named varieties should be recommended and used when they have been evaluated and proven in an area. Certified seed insures the characteristics for which the variety was developed. See Exhibit 3 for recommended varieties.

4. Climatic Adaptation of Materials - Native species for which seed of named varieties is not available is usually satisfactory if the origin is not in excess of approximately 300 miles south or 200 miles east, west or north of the treatment area. Seed should come from areas of similar climate and soils.

5. Compatability - Usually it is undesirable to mix species with different rates of establishment; for example, rapid introduced establishing wheatgrasses with slow establishing native grasses. The more rapid establishing plants compete for moisture and reduce the success of the slower species. In cases where both kinds are to be used, they should be drilled in alternate rows.

6. Pure Live Seed - Pure live seed is used to designate seed quality. The percent of pure live seed in a given lot is figured by multiplying germination times purity. For example, a lot of seed that has 60 percent germination and 80 percent purity has a 48% PLS (60x80=48). Thus in a 100 lb. bag of this seed there are only 48 lbs. of good live seed. Because of the wide variation in the quality of native plant seeds, all seeding rates should be based on PLS.

C. Aesthetic Conditions

Forage production is not always primary. Therefore, consideration must be given to aesthetics. This frequently involves planting flowering forbs with a backdrop of shrubs or trees.

The chances of an adequate stand of natural shrubs or forbs from seed is unpredictable and often not practical for either erosion control or aesthetics. Transplanting of shrubs is expensive. Since most shrubs are slow in developing, a considerable period of time is required to stabilize an area with only shrubs. For these reasons, grass should be the basis of most stabilization mixtures and flowering shrubs and forbs should be used for landscaping.

VI. Seeding Methods:

A. Introduction

The method of seeding is one of the more important factors in the establishment of a permanent plant cover on critical areas. After it has been decided where to seed, the first considerations are what and how to seed. The principle decision must be to drill or broadcast. The final decision is which of the multitude of drills or which of the many methods of broadcast seeding to use.

B. General Conditions for Success of Seeding

1. Seedbed. What is a good seedbed? A good seedbed is one which will give the best possible moisture condition for germination and plant development. At the same time, it allows the seed to be placed in the soil to a proper depth. Generally, a good seedbed is described as one that is firm under the seed with not over ½ to 3/4 inch of loose top soil. This loose top soil mulch generally gives the best conditions for moisture and seed placement.

In dealing with critical areas, especially cut slopes, we are faced with seedbeds far from ideal. Many times the surface of the slope is so hard and smooth that seed will not stay in place. In such situations, the seed ends up at the bottom of the slope. There is a need for development of equipment that can be used efficiently on cut slopes to leave rough surfaces one or two inches deep so that the seed will stay in place and have a chance of being covered.

2. Removal or Reduction of Plant Competition. With the exception of ground denuded by construction activities, logging, or wildfire, almost every area in need of seeding has some type of plant cover. Stands of annuals or perennials are generally fully utilizing the soil moisture. This plant cover must be reduced to permit seedlings of seeded species to become established.

   Often critical areas have been denuded of vegetation and plant competition for moisture and nutrients is not a problem.

   If it becomes necessary to reduce plant competition in order to seed more desirable species, today many combinations of techniques and equipment are available.

   a. Cultivate. Cultivation, generally with some type of moldboard or disc plow, has been used for many years in preparing an area for seeding. Competitive vegetation is reduced to a minimum by this method. Wide blade sweeps to under cut the vegetation but which leaves it on the surface have been successful.

   b. Spray With Herbicides. On many deteriorated sites, it is not desirable to cultivate. Cultivation leaves an area in a condition to erode before a new cover can be established. The use of herbicides in reducing vegetation has been effective; and, by modifying the timing of spraying and seeding, this technique can be used on a variety of sites. The use of preemergents and post emergent chemicals can be considered in site preparation.

   c. Deep Furrow Drill. On areas where competition is not too severe, successful stands have been established on unprepared seedbeds. This is possible by adaptation of a drill to deep furrow seeding. The deep furrow drill disc eliminates sufficient vegetation in the furrow for seedlings to become established. Better use is made of moisture, and the furrow affords some protection to seedlings. This is best suited to level sites.

3. Cover Seed to Proper Depth. Two main principles of seeding are: (1) seed must be placed on mineral soil, and (2) seed must be covered either by soil or a suitable mulch material.

Blowing of mulch and seed on an area in one operation violates the principle of placing seed on a mineral soil. By actual count, from 60-70% of the seed hangs in the mulch and has little or no chance to get primary roots into mineral soil which is necessary for survival. In areas of high rainfall, this method of seeding has been successful by using high seeding rates. In areas of lower rainfall, placing seed in a mulch off mineral soil has contributed to seeding failures, even at very high seeding rates.

All seed must be covered to prevent extreme drying conditions. A seed germinating on top of the ground has little chance of survival. High temperatures, wind action, and dry surface conditions cause new seedlings to die before they are properly established. Optimum depth of seeding is roughly proportional to seed size. Small seeded species such as the lovegrasses or timothy should not be planted deeper than one-quarter inch. Large seeded species such as the wheatgrass should be planted to a depth of 3/4 inch. Planting can be deeper in sandy soil than in clay soils.

4. Seed Distribution. Uniform distribution of seed is essential. Proper seeding rate per acre but poor distribution will result in too much seed in one spot and not enough in another. This is often the result when seed is broadcast unless care is taken and the relative distribution of the seed checked frequently and corrected as needed. The most uniform distribution of seed is gained through use of a drill. For this and other reasons, a drill should be used whenever possible.

5. Time of Seeding. The proper seeding time varies with the area and species to be sown. Moisture and temperature patterns dictate the proper planting season. Moisture and temperature must be sufficient to germinate the seed and establish the seedling before adverse conditions occur.

   The use of mulch will extend the seeding season. More effective use of moisture is made by the proper application of mulch.

   An exception to seeding during the proper season is where areas are bared by construction or wildfire. If the seeding method is by broadcasting, it is generally desirable to seed immediately after the disturbance and before the surface hardens and crusts over.

6. Protection of Seedlings. Protection from grazing animals, foot traffic, etc. after seeding is important to insure seedling establishment and survival.

   a. Wildlife. Frequently repellants are needed to prevent wildlife from damaging certain species or small areas such as roadsides.

   b. Rodents. Seedings on small areas may be disturbed unless rodents are controlled.

   c. Domestic Livestock. Exclusion of domestic livestock for a minimum of two years is usually necessary to allow proper root system development of new plants.

C. Method of Seeding.

1. Drilling. Drilling is by far the superior method of seeding where site conditions permit. Seed is covered to the proper depth by the drill control; seed distribution is uniform; rate of seeding is positively controlled; and soil compaction can be accomplished if needed. There are several types of drills available for seeding.

   a. Rangeland Drill. This drill is a rugged seeder with high clearance designed to work on rough sites. It has performed well on rough seedbeds. It can be converted to a deep furrow implemented by removing the depth bands and cupping the disks enough to make good furrows. The depth of the furrow is controlled by adding or removing disk arm weights. Weights up to 70 pounds have been used under some conditions. This drill will not handle trashy seed.

   b. Oregon Press Drill. This implement was developed by the Oregon State University for seeding plowed or loose seedbeds. A heavy press wheel packs the soil. The seed is placed in the packed furrow and an adjustable drag covers the seed. This drill cannot be used on rocky or rough seedbeds. Trashy seed will not go through the feed on this drill.

   c. Ordinary Grain Drills. The drills in this group are designed and built for use on cultivated fields. They are usually too lightly constructed for seeding rough sites. Breakage is a problem and the seed is not placed properly in the ground. Although they are not well adapted for critical area seeding, they are better than broadcasting. If they are used, the spring tension on the disk should be removed or depth bands added.

d. Plains Double Disk Drill. This drill is equipped with two types of seed boxes; one for planting trashy seed such as bluestems and gramas, and another for planting fine seeds such as lovegrass. Both boxes can be used together or separately.

Seed placement is controlled by depth bands or other devices. These drills are not rugged enough to be used on rough sites.

2. Broadcasting. Broadcasting is any method which spreads seed directly on the soil without soil coverage. The seed, however spread, must be covered in some way if it is to germinate and become established.

Size of seed and condition of the seedbed are important factors if the seed is to become covered with soil. A seedbed which has 2 or 3 inches of loose soil or ashes will often sluff sufficiently to cover the seed.

Covering seed with a mulch is better than no coverage at all; but, mulch coverage is inferior to soil coverage.

If mulches are used in conjunction with seeding, best results are obtained by broadcasting the seed, covering with soil, and applying the mulch.

Disadvantages of broadcast seeding are: (1) requires heavier seeding rate; (2) covering of seed is poor compared to drilling; (3) distribution of seed is often poor; (4) loss of seed to rodents can be great; (5) establishment is generally slower; and (6) use should be limited to the most favorable sites of soil and climate.

a. Aerial Application. Aircraft must be equipped with a positive power driven, seed metering device. An adjustable opening which allows the seed to drop by gravity is not acceptable when a mixture of seed sizes and weights is being used.

The following are items which must be taken into consideration when planning and accomplishing seeding with an aircraft.

(1) Planning Seed Needs. Use the gross acreage to determine the amount of seed needed for the total project. It is cheaper to seed the whole area than it is to try to avoid small islands and other areas not included in the seeding project.

(2) Preparation Prior to Aerial Seeding.

(a) Mix seed prior to scheduled application.

(b) Weigh and mark weight on each sack of mixed seed. Each sack should not weigh over 50 pounds. Weights are used to pregroup each load prior to actual loading operations and also to keep an estimate of seed being applied per acre.

(c) Arrange for pilot to fly a reconnaissance to acquaint himself with area and feel out terrain and air conditions.

(d) Locate helispots so seeding can be accomplished with minimum of ferry time. Generally, one helispot per 1,000 acres is sufficient. However, this will vary with the pattern of area to be seeded.

(e) Keep seed dry. If there is a change of rain, do not leave seed in field overnight; or provide for covering with rainproof material.

(3) Procedure During Seeding Operation. Calibrate seeding rate. Place cardboard cards, 1-foot square, perpendicular to line of flight about 10 feet apart. Cover the cards with a light grease. Seed will stick to the greased cards. The number of seeds on each card can be counted and applied back to the desired number of seeds per square foot. The greased cards will also help determine the distribution of seed and the effective swath width.

The following is another formula which may be used to calibrate seeding rate:

$$R = \frac{P}{002 \times S \times W}$$

R = lbs./acre
P = lbs./min.
S = Speed of aircraft
W = Swath width
002 = a constant

b. Broadcasting Ground Application. Ground broadcasters are primarily of three types:

(1) Rotary Spreaders. With this type, the seed falls from a hopper onto a rotating ribbed disk which distributes the seed by centrifugal force. The width of throw depends on size and weight of seed, speed of rotating disk, and velocity of wind. Rotary spreaders may be carried by hand, mounted on a tractor or seedbed preparation unit, or trailed behind other equipment. They are generally powered by hand, gasoline engine, electric motor or power take-off. Limitations of this type of seeder are:

(a) Swath width and rate of seeding vary with speed of travel and speed of rotating disk. In most of these machines, there is no control over speed of the drive motor.

(b) Seed is not distributed as evenly as from a drill box. The amount of seed is greatest near the center of the swath.

(c) Where seed mixtures are used, seed separates by weight because there is no agitator to keep it uniformly mixed.

(2) Seeder Boxes of the Drill-like or Fertilizer-Spreader Type. This type of broadcaster has a fluted or force gear feed mechanism that lets seed fall out the bottom of the box onto the ground. The seed box is mounted on site preparation equipment such as brushland plows, or brush cutters.

In general, the seeder box type of broadcaster distributes seed more uniformly than does the rotary type. A recent adaptation of this type of broadcaster is the "seed dribbler." The dribbler was designed to be mounted on the side of a track tractor. The seeddrop mechanism has a direct drive from a rubber tired wheel riding on the tracks of the tractor. The seed is metered onto the track pad just as it breaks over the front idler. It drops off the pad in front of the track and is embedded in the soil as the tracks pass over it. Seed box units of common browse seeders can be adapted for use as "dribblers".

(3) Broadcast Units Using an Air Stream to Dispense Seed. The seed is metered from a hopper either by gravity or forced gear into an air stream. The airstream can be created either by exhaust from equipment engines or by a fan designed for this purpose. Seed distribution is poor when seeding is done on windy days. Swath width is unpredictable and varies with weather conditions.

The limitations of different seeding methods are summarized in Exhibit 4.

Therefore, consideration must be given to aesthetics. This frequently involves planting flowering forbs with a backdrop of shrubs or trees.

The chances of an adequate stand of natural shrubs or forbs from seed is unpredictable and, therefore, is not practical for either erosion control or aesthetics. Transplanting of shrubs is expensive. Shrubs are slow in developing, leaving areas bare for a considerable period of time.

Flowering shrubs and forbs should be used for landscaping in conjunction with grass for erosion control.

VII. Mulching and Fertilizing:

A. Introduction:

Establishment of permanent vegetation on critical areas is difficult in New Mexico, even at the relatively moist, higher elevations. Mulching and fertilizing usually improve the chances of success and shorten the time required to establish a suitable plant cover. Mulches function by reducing evaporation, moderating soil temperature, preventing crusting, and generally providing a more favorable microenvironment for seed germination and seedling growth.

Under conditions of adequate soil moisture, nitrogen and phosphorus fertilizers applied at the time of seeding speed early development of seedlings. Proper fertilization promotes rapid root growth to take advantage of available soil moisture, and increases top growth to provide maximum soil protection in the shortest time. Fertilizer, especially nitrogen, is essential when organic mulches are applied. Periodic fertilization is usually necessary to maintain vigorous established stands.

B. Objectives:

The two major objectives of proper mulching and fertilization are:

1. To obtain stabilization in the shortest possible time and assure that the work will have lasting benefits.

2. To assure that the expenditure will bear commensurate results.

C. Mulching Procedure Recommendations:

Mulching will enhance the chances of success of vegetation establishment on most adverse sites. In any mulching job, careful initial surveys must be made to determine the type of mulch to be used, the method and rate of application, and time of application. General plan should include mulching as part of the operation. The use of a trained crew or proper training of the crew is important.

1. Large Area Application

As a general rule, mulch should be spread or blown uniformly over the area immediately after seeds are planted. Usually, the most effective and economical mulch is grass hay applied at the rate of about 2 tons per acre. In the absence of hay, small grain straw makes an acceptable mulch. The hay or straw should be as free of viable seeds as possible, unless the grass hay is of a species adapted to the critical area.

a. Gentle Slopes

A mulch spreader works well for distributing hay on gentle slopes, where equipment can be used. These are usually areas with 3 to 1 or flatter slopes. The hay should be anchored mechanically with a mulch tiller, crimper or comparable equipment. Average length of cut stems should not be less than 6 inches and may vary upward to 18 inches or more. The mulch should be damp during application to prevent breakage.

b. Steep Slopes

A mulch blower is best for application on steep slopes where equipment cannot be used. The hay should be anchored with asphalt or other acceptable compound. The tacking substance should be injected into the mulch stream as it leaves the blower, at a rate adequate to bind the mulch material together. An adequate asphalt application may range from 200 to 300 gallons per acre. Mulch should be applied when wind velocity is low enough to allow the operator to place the material where required. In hydromulching, the mix should be at maximum workable density to get adequate coverage in one application. The crew must be adequately trained so the nozzle operator and truck driver work in unison.

2. Small Area Application

For small areas, the mulches and methods described above or one or more of the following alternative mulching methods may be used. Pilot testing is still recommended on all these materials except excelsior.

a. Excelsior at the rate of 1 to 2 tons per acre applied as a mat and anchored with pins, or blown on the area and anchored with asphalt is successful.

b. Petroleum mulches sprayed in a continuous film over seeds planted in moist soil helps retain moisture near the soil surface. Color of the material should be adjusted to provide optimum temperatures required for germination of the seeded species and season of year. Petroleum mulches are not recommended for clay or silty clay soil.

c. Bark and wood chips serve as good mulches, especially where these are readily available. Their use should be limited to fairly level areas where they will not be moved by wind or water.

d. Other materials, such as plastic films, gravel, stones, crushed rock, and jute netting may be successfully used for special situations.

3. Hydromulching

Hydromulching is not recommended for small areas. It is difficult to keep equipment in operating condition during moves from area to area. The unit cost is much greater on small areas than on large areas.

D. Fertilizing:

Fertilizing is generally needed to meet the objective of early establishment and lasting effect. Soil testing to determine the fertilizer needs is the first requisite to determine the kinds and amount of fertilizer to be used. Time and rate of application must be geared to amount and seasonal distribution of moisture. Special attention must be given to areas where extra moisture is available.

1. Rate and Kind

Added nitrogen is generally needed and usually gives measurable results on New Mexico soils. The rate of application must be carefully evaluated to prevent over-application or leaching into ground water. Tieup of available nitrogen by mulch materials must be considered in determining rate of application. In general, rates between 40 and 80 pounds of N per acre are adequate before the needs of the mulch are considered. The amount of additional nitrogen need for microbial decomposition depends on the amount and kinds of mulch material; usually 30 pounds per ton of incorporated organic material.

The use of phosphates will depend on the soil analysis, desired plant composition and past experience. Often little or no response can be expected from the addition of potassium. However, the need for potassium and/or other elements should be based on results of soil analysis.

2. Time of Application

The initial fertilizer application should be made at the time of seeding. Fertilizer applied for maintenance or stand improvement will give the best results if applied immediately before water application or rainfall. This will generally be early July or winter in much of New Mexico.

3. Maintenance Application

Maintenance applications every 2 or 3 years are beneficial if observation shows the vegetative cover is deteriorating. In certain conditions, the lack of maintenance fertilization will result in loss of the vegetative cover. This will make it necessary to redo the planting job. Thus an annual inspection of the cover is desirable so early treatment can be initiated. A rate of 40-60 pounds N per acre may be adequate for maintenance.

E. Economics

Any mulch application will be expensive. A representative cost is $150 to $220 per acre for hay mulch applied at 2½ tons. It is much more expensive in very critical areas. Costs may be reduced as experience is gained. Bulk purchasing will also lower the cost of materials. Logistics planning is a must and will speed the operation and reduce the cost.

Effort should be made to encourage contractors to learn mulching techniques and become properly equipped to do the total job.

Nitrogen fertilizer costs only about 10 cents per pound of N. Therefore, the cost of the fertilizer is a very small part of the total job.

VIII. Establishment and Maintenance:

A. Introduction:

Aside from unusual climatic factors, effective land use practices (appropriate for critical areas) depend principally on establishment and maintenance of plant materials. Under dryland conditions, competition from weeds can be a limiting factor in establishment of desired species. It should also be recognized that weeds may degrade the aesthetic quality of the ground cover. However, if weeds have desirable flowering traits, they may improve the appearance of an area.

Establishment and maintenance of desirable adapted vegetation, either that which is artificially seeded or endemic, on critical areas for erosion control and/or forage production is the goal of proper management.

B. Recommended Procedures:

The following are recommended management techniques to improve stand establishment and vigor:

1. Control of annuals in perennial grass.

a. Mechanical: Mowing is a practical way to control most annual weeds in perennial grasses during the first year. Mower blades should be maintained at a 4-6 inch minimum height to allow for proper balance between top and root growth. Frequency of mowing depends on growth conditions and the sensitivity of various species to cutting. A general recommendation is to leave a minimum of 50% by weight of the potential top growth of the grass unmowed. After establishment, mowing generally should be discontinued except to eliminate fire hazards or for other special purposes.

b. Herbicides

(1) Pre-emergence treatment of herbicides can be recommended for control of some weedy species. Additional research is needed before it can be recommended for widespread critical area use.

(2) Use of phenoxy herbicides should usually be avoided whenever mixed stands of woody and herbaceous vegetation are desired.

(3) Soil sterilants use is not considered a desirable practice on or in proximity to critical areas.

2. Control of Perennial Weeds Adjacent to Cropland.

Recommendations of the state experiment stations should be followed. Precautions must be taken to ensure drift and vapors from phenoxy, benzoic, or other herbicides do not reach sensitive broadleafed crops or other vegetation that may be damaged.

3. Control of Weeds in Mixed Woody-Herbaceous Stands.

a. Cultivation - Cultivation may be necessary to eliminate weed competition as related to establishment and maintenance of woody species used for windbreaks, aesthetics, etc. Hoeing may be required around individual plants.

b. Mowing - may be tolerated the first year of seeding but usually is not necessary in succeeding years.

4. Maintenance of Endemic Vegetation.

Application of fertilizer to endemic vegetation can often enhance cover while eliminating costs of seedbed preparation, seeding, supplemental irrigation, etc. More research is needed on fertilizer rates, timing, responses of various species, and relationships to precipitation. If continued maintenance is a problem, consideration should be given to seeding a more adaptable species.

C. Economics

Cost-benefit ratios, as applied to critical areas, are impractical to formulate, because, total benefits cannot be adequately expressed in terms of dollars. The survival of our closed ecosystem, earth, does not depend upon a precise dollar value so measures of benefits must be considered.

IX. Research and Other Needs

A. Resource Inventory

Climatic Data - The Committee feels there is much more climatic data available than what is in easy access to those planning stabilization work. This information should be assembled into an easy to use publication.

B. Plant Materials

The following are recognized immediate plant materials needs for stabilization:

1. A low palatability, low growing plant for roadsides.
2. A turf to withstand foot traffic.
3. Low maintenance and low water requirement recreation turf.
4. Low growing grass for irrigation and drainage ditch banks.
5. Plants suitable for economical utilization of partially treated sewage and agricultural wastes.
6. Rhizomatous and woody plants and forbs.
7. Temporary stabilization plants for construction and subdivision development.
8. Develop and harvest techniques for shrub seed.
9. Encourage commercial production of developed, adapted seeds and plants.
10. Assemble available information into data banks. The needs of all agencies, both in input and expected retrieval, should be recognized.

C. Seeding Equipment

1. A need exists for the development of a more successful drill that will function better on steep slopes and in mulches than existing equipment.

2. Equipment similar to that used in hydromulching, for distributing wood chips, saw dust and bark is needed.

3. Development of a mulch distributor that can be installed on the back of drills, or other seeders would aid in reducing cost of critical area stabilization.

D. Mulches

1. The Committee encourages research on and development of bio-degradable manufactured mulch materials.

2. Development of synthetic mulches that more effectively control soil moisture losses and temperatures under varying soil compositions and degrees of slope is recommended.

E. Fertilizers

1. Research to determine the best rate and kind of fertilizer to apply with various mulch materials is encouraged.

2. Further refinements in slow releasing nitrogenous fertilizers would be helpful.

3. Fertilizer formulations should be developed that are less susceptible to leaching from soil and thus less likely to move into streams.

4. Additional research on the proper fertilizer for maximum benefit to plants during establishment is recommended.

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EXHIBIT 1

SPECIES ADAPTATION TO MOISTURE

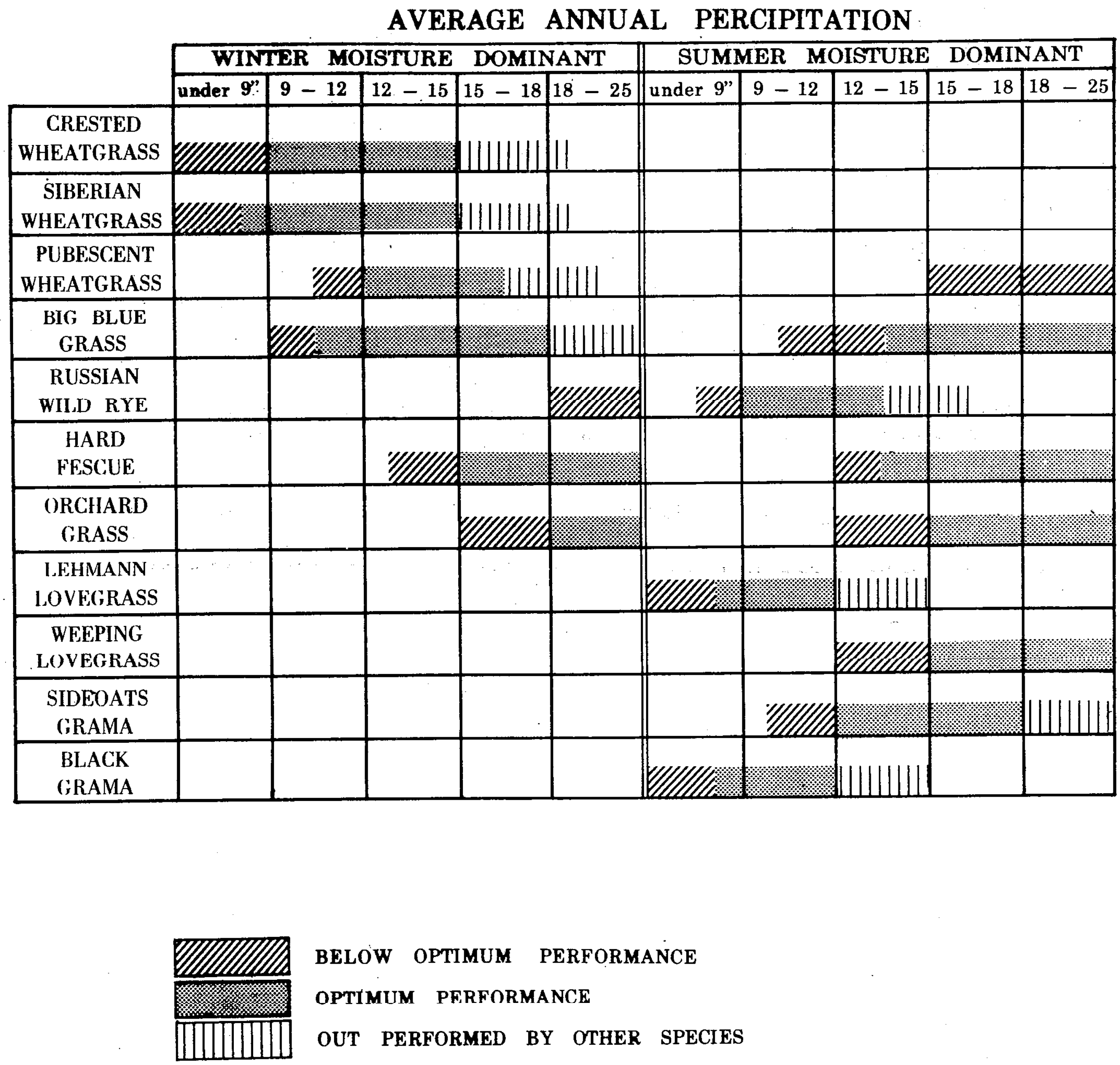

Exhibit 2

APPROXIMATE MOISTURE RETENTION VALUES FOR SEVERAL SOIL TEXTURES

	Moisture Retained (% by Weight)		
Texture	Saturation	Field Capacity	Wilting Point
Sand	25	8	3
Loamy sand	26	11	5
Sandy loam	36	21	9
Loam	44	23	10
Silt loam	37	28	13
Sandy clay loam	35	18	11
Silty clay loam	37	26	14
Clay loam	48	26	14
Silty clay	48	28	16
Clay	48	32	17

EXHIBIT 3

TABLE OF ADAPTABILITY OF SOME SPECIES AS TO SOIL TEXTURE

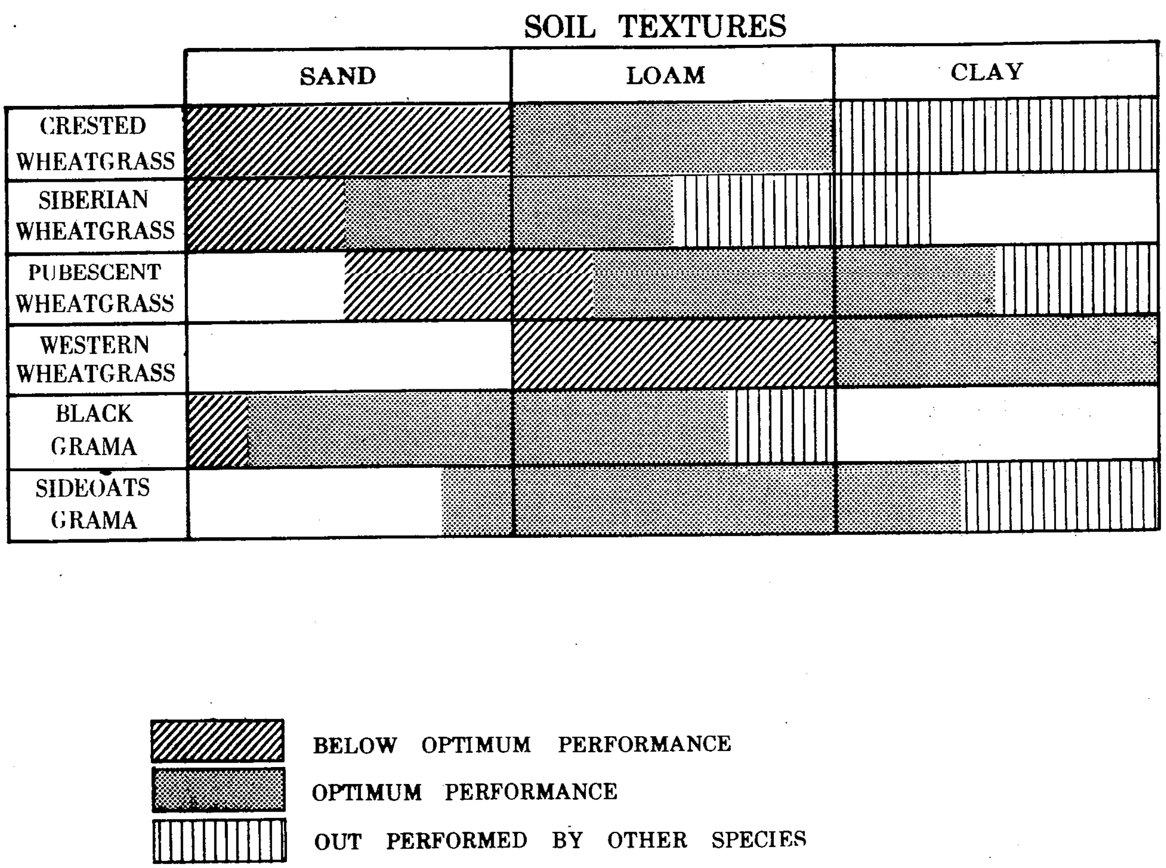

EXHIBIT 4

SPECIES SELECTION AND SEEDING RATE

VARIETY 2/	SPECIES	SEEDING RATE 1/ PLS/Ac.	10" to 14" PRECIPITATION SOIL TEXTURE GROUPS			14" to 18" PRECIPIT. SOIL TEXTURE GROUPS			OVER 18" PRECIPIT. SOIL TEXTURE GROUPS		
			Sandy	Loam	Clay	Sandy	Loam	Clay	Sandy	Loam	Clay
NA	Alkali Sacaton (Sporobolus airoides)	1		X	X			X			
NA	Arizona fescue (Festuca arizonica)	8								X	
'Kaw'	Big bluestem (Andropogon gerardii)	9				X					
'Nogal'	Black grama (Bouteloua eriopoda)	2	X	X		X	X				
'Lovington'	Blue Grama (Bouteloua gracilis)	3	X	X			X				
NA	Buffalo grass (burrs) (Buchloë dactyloides)	8					X	X		X	X
'Fairway' or 'Nordan'	*Crested wheatgrass (Agropyron desertorum)	8	X	X							
'Durar'	Hard fescue (Festuca ovina duriuscula)	3					X	X		X	X
NA	*Indian ricegrass (Oryzopsis hymenoides)	7	X			X	X				

EXHIBIT 4

SPECIES SELECTION AND SEEDING RATE

VARIETY 2/	SPECIES	SEEDING RATE 1/ PLS/Ac.	10" TO 14" PRECIPITATION SOIL TEXTURE GROUPS			14" TO 18" PRECIPIT. SOIL TEXTURE GROUPS			OVER 18" PRECIPIT. SOIL TEXTURE GROUPS		
			Sandy	Loam	Clay	Sandy	Loam	Clay	Sandy	Loam	Clay
'Llano'	Indiangrass (Sorghastrum nutans)	10				X			X	X	
'Amur'	*Intermediate wheatgrass (Agropyron intermedium)	17					X		X	X	
NA	Kentucky bluegrass (Poa pratensis)	1								X	
NA	Lehman lovegrass (Eragrostis lehmanniana)	1	X	X							
'Pastura'	Little bluestem (Andropogon scoparius)	7				X			X	X	
NA	Mesa dropseed (Sporobolus flexuosus)	1	X			X					
'Potomac' 'Latar' or "Pomar'	*Orchardgrass (Dactylis glomerata)	4							X	X	
'Luna'	*Pubescent wheatgrass (Agropyron trichophorum)	20		X	X		X	X		X	X
'Vinall'	*Russian wildrye (Elymus junceus)	10		X	X						

EXHIBIT 4

SPECIES SELECTION AND SEEDING RATE

VARIETY 2/	SPECIES	SEEDING RATE 1/ PLS/Ac.	10" to 14" PRECIPITATION SOIL TEXTURE GROUPS			14" TO 18" PRECIPIT. SOIL TEXTURE GROUPS			OVER 18" PRECIPIT. SOIL TEXTURE GROUPS		
			Sandy	Loam	Clay	Sandy	Loam	Clay	Sandy	Loam	Clay
'Elida'	Sand bluestem (Andropogon hallii)	14				X			X		
NA	Sand dropseed (Sporobolus cryptandrus)	1	X	X		X					
'P-27'	*Siberian wheatgrass (Agropyron sibericum)	7	X	X							
'Vaughn'	Sideoats grama (Bouteloua curtipendula)	12	X	X		X	X		X	X	
'Primar'	*Slender wheatgrass (Agropyron trachycaulum)	12						X			X
'Lincoln' or 'Manchar'	*Smooth brome (Bromus inermis)	12					X		X	X	
NA	Spike muhly (Muhlenbergia wrightii)	1					X	X			X
'Sodar'	Streambank wheatgrass (Agropyron riparium)	11		X	X		X	X			
'Blackwell'	Switchgrass (Panicum virgatum)	6				X				X	X

EXHIBIT 4

SPECIES SELECTION AND SEEDING RATE

VARIETY 2/	SPECIES	SEEDING RATE 1/ PLS/Ac.	10" TO 14" PRECIPITATION SOIL TEXTURE GROUPS Sandy	Loam	Clay	14" TO 18" PRECIPIT. SOIL TEXTURE GROUPS Sandy	Loam	Clay	OVER 18" PRECIPIT. SOIL TEXTURE GROUPS Sandy	Loam	Clay
'Alta'	Tall fescue (Festuca arundinacea)	11								X	X
'Jose'	Tall wheatgrass (Agropyron elongatum)	22								X	X
'Climax'	Timothy (Phleum pratense)	2								X	X
NA	Weeping lovegrass (Eragrostis curvula)	1				X					
'Barton' or 'Rosana'	*Western wheatgrass (Agropyron smithii)	16		X	X		X	X		X	X
NA	Yellow bluestem (Bothriochloa ischaemum)	2	X	X		X	X				
'Rambler'	Alfalfa (Medicago sativa)	8				X	X		X	X	
NA	**Bitterbrush (Purshia tridentata)	20					X		X	X	
NA	**Burnett (Sanguisorba minor)	8							X	X	
NA	**Fourwing saltbush (Atriplex canescens)	9	X	X	X		X	X			

EXHIBIT 4

SPECIES SELECTION AND SEEDING RATE

VARIETY 2/	SPECIES	SEEDING RATE 1/ PLS / Ac.	10" TO 14" PRECIPITATION SOIL TEXTURE GROUPS			14" TO 18" PRECIPIT. SOIL TEXTURE GROUPS			OVER 18" PRECIPIT. SOIL TEXTURE GROUPS		
			Sandy	Loam	Clay	Sandy	Loam	Clay	Sandy	Loam	Clay
NA	**Mountain Mahogany (Cercocarpus betuloides)	10					X		X	X	
NA	**Yellow sweetclover (Meliletus indicus)	7				X	X	X			
NA	**Winterfat (Eurotia lanata)	12		X	X	X	X	X			

1/ Pure live seed per acre when drilled as single species. Increase this rate by 60 percent when seed is broadcast.

Mixtures should be of grasses having similar growth habits. When possible, shrub and forb species should be included in the mixture.

2/ NA - No improved varieties available or available ones lack ample testing in New Mexico.

3/ (*) Cool season producers -- should be planted where winter moisture predominates.

4/ (**)Recommend the species be used only in a mix. Seeding rate of shrubs represents about 10 seeds per square foot.

EXHIBIT 5

SEEDING METHODS SUMMARY

Characteristic	Drilling	Hydromulch Broadcasting	Other Broadcasting
1. Topography	Steep Slopes Access	200' Length $1\frac{1}{2}$:1 Slope	No Limit
2. Obstructions	Limited	Unlimited	Unlimited
3. Compaction	Slightly Acceptable	Not Acceptable	Not Acceptable
4. Seeding Depth	Variable (Controlled)	Coverage, Limited Control	Coverage, no direct control, depends on soil sluff
5. Seed Size	Variable	Small Seed	Variable, small seed most desirable
6. Season	Limited by Moisture	Limited by low expected moisture	Least Limited
7. Seed Mixture	Not Critical	Not Critical	Not Critical
8. Existing Plant Competition	May Temporarily Reduce	No Reduction	No Reduction
9. Precipitation	Slightly Critical	Very Critical	Very Critical
10. Soil Texture	Not Critical	Critical	Critical
11. Litter	Small Amount Desirable	Critical	Critical
12. Seed Distribution	Uniform	Not Uniform	Not Uniform
13. Fertilization	May be done with proper equipment Fertilizer Placement in drill row	May be done during application No placement of fertilizer	May be done during application No placement of fertilizer
14. Inoculation	All right	All right	All right
15. Temperature	Not affected	Not affected	Not affected if seed is covered
16. Mulching	Separate treatment	Same treatment	Separate treatment
17. Aesthetics	In rows	No rows	No rows
18. Cost	Medium	High	Low
19. Equipment	Special in some cases	Scarce	Various hand and aerial methods