REVEGETATION PROGRAM

Development & Implementation Manual

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Range and Reveg LLC

Photo Provided by Range and Reveg LLC

ACKNOWLEDGEMENTS

The authors reviewed historical water transfer decrees and how they addressed revegetation. It became clear that a revegetation document was needed to assist with future revegetation efforts. The authors would like to thank those who provided reviews and edits as this manual was being developed. Their expertise and consideration are greatly appreciated and were critical to the development of this document. Thank You.

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INTRODUCTION

This document summarizes information developed from a review of previous revegetation efforts in the Arkansas River Valley in Colorado. The observations of previous efforts and results informed the development of this document. This document is an appendix associated with a project titled "EVALUATION OF LAND PROTECTION MEASURES WITHIN AGRICULTURAL TO MUNICIPAL WATER TRANSFERS IN THE ARKANSAS RIVER BASIN," funded by the Colorado Water Conservation Board and the Lower Arkansas Valley Water Conservancy District. The project evaluated the requirements of historic water transfer decrees as they relate to revegetation and dryland cropping of the dried-up lands

Understanding the land protection methods that have been effective and those that have not been effective should inform the direction of future water court decree requirements and provide for effective management of revegetation projects.

PURPOSE

This document provides a sound model primarily for revegetation in southeastern Colorado's Lower Arkansas River Valley. This document's considerations and methods can be used in other locations with minor modifications to account for climate, soils, crops, and revegetation species.
Re-establishing permanent vegetative cover in southeast Colorado is difficult. The chance of successful revegetation will increase by following the guidelines in this document. Note the term "grass" is used as the primary revegetation species. Broadleaf plants can be used in revegetation, but the presence of desirable broadleaf species limits herbicide application for weed control. Native broadleaf plants and shrubs increase over time without additional planting or can be planted after the grass is established.

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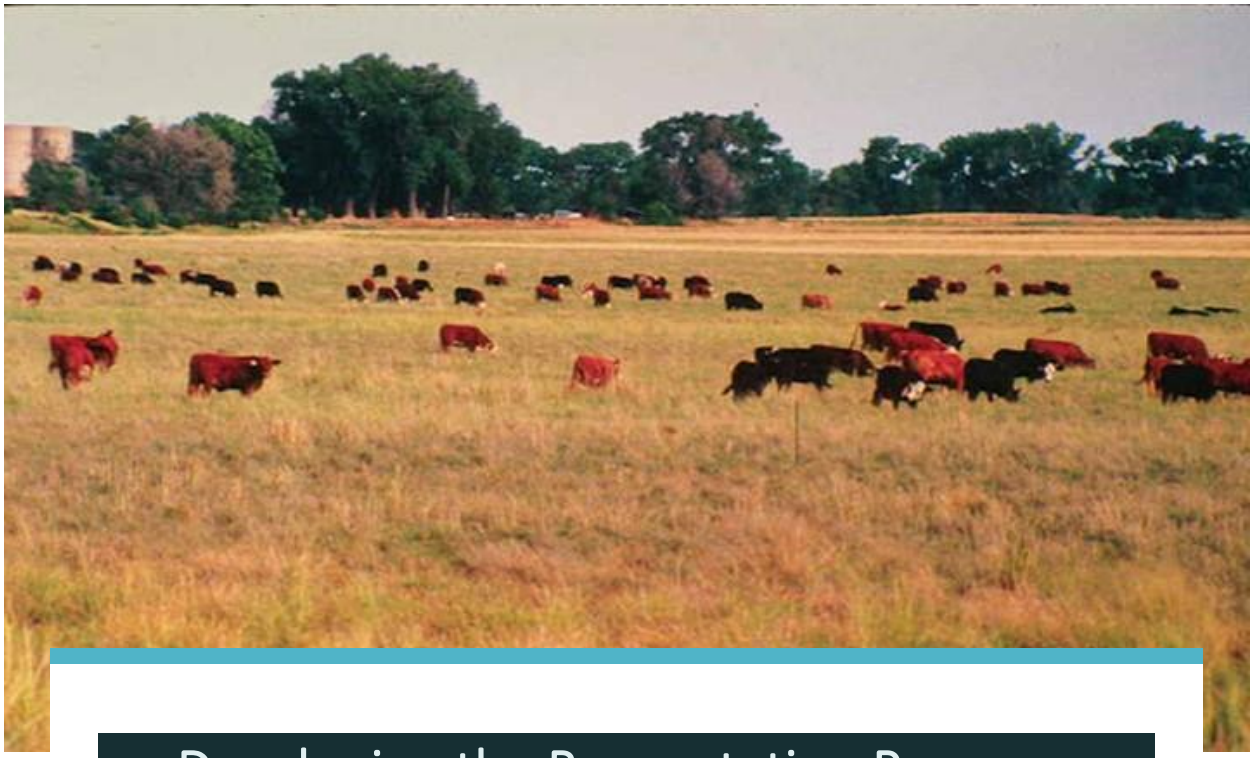

Developing the Revegetation Program

Planting and developing native grass species on previously irrigated farmlands pose challenges different from southeast Colorado's typical irrigated agriculture. Among the differences would be the relatively slow establishment and low seedling vigor of these grass species, the need for supplemental irrigation water, when available and where feasible, to provide moisture availability within the shallow root zone of the developing seedlings, the need for protection from aggressive weed competition, and protection from the environmental extremes of high winds and/or low moisture. Perennial grasses, once established, are competitive, but during the first two growing seasons, perennial grass species are typically not as competitive as an annual crop, weeds, or an established alfalfa crop.

The development of a revegetation plan and strategy for implementation has not been at the center of attention within water transfer decrees; indeed, the revegetation has, in many cases, been an afterthought to the transfer process. The following sections intend to provide a method of approaching the development and management of a revegetation program.

A revegetation manager considers these topics while developing a revegetation program. Then during implementation, the likelihood of success is expected to improve as these activities have proven successful in previous revegetation projects.

REVEGETATON MANAGER RESPONSIBILITIES

Monitoring by the revegetation manager is the primary focus. The manager should monitor these items:

a. Water availability for use in irrigation
b. Irrigation planning and implementation
c. Monitoring of soil moisture within the root zone
d. Weather
e. Weed issue development
f. Availability of herbicide applicators and mowers
g. Weed control planning
h. Development of grass seedlings
i. Need for seeding or reseeding
j. Additional activities needed to improve grass stand

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Special Consideration on Revegetation of Previously Irrigated Lands

Soils that have been under irrigation for many decades have unique chemical and physical issues. These issues make revegetation more difficult than revegetation on native soil that was dryland cropped. There may be an accumulation of salts that will inhibit revegetation. Decades of fine soil deposition may render the soil less able to take in water from rainfall or less available to roots, making the soil more droughty than native soils. Compacted plow pan layers may have developed over time, limiting the degree and depth of root penetration.

Information to Assist in Revegetation Plan Development

The beginning of any revegetation program starts with accumulating background information to develop a successful revegetation program.

Sources of information are available to assist in designing the individual revegetation project for the water transfer. The items listed below represent those necessary for project development.

MAPPING

It is helpful to have consistent mapping for all interested parties to a revegetation program. Accurate mapping of the project area helps in all planning activities, from seeding and weed control to supplemental irrigation and establishment determination. Mapping sources include USDA Farm Services Agency (FSA) historical mapping, GIS layers, and mapping associated with transfer engineering.

SOILS INFORMATION

Field soil information is valuable in planning for seed mix development, identifying potential problem soils, and monitoring for successful establishment. Soil mapping can be obtained by referring to the Natural Resources Conservation Service (NRCS) website "Web Soil Survey." This information is the most current from NRCS and is necessary for lands being revegetated for a water transfer.

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The Web Soil Survey provides general and site-specific soil information necessary to identify on-site issues and provide exact soil parameters. Obtaining on-the-ground soil samples from representative areas and a soil analysis report from a soil laboratory is generally valuable. The soil laboratory can identify deficiencies and limiting properties that may interfere with revegetation development. In general, native grasses do not need additional fertilizer to germinate or develop to full establishment. Adding fertilizer to a native

grass initial seeding may increase annual weed competition and be harmful to establishing a grass stand.

ECOLOGICAL SITE INFORMATION

Ecological site descriptions provide information about the historical climax plant communities for specific soil series. These Ecological Site descriptions include plant species composition and production. Species composition is influenced by climate and soil characteristics and includes other environmental factors. This information is part of the Web Soil Survey information for each soil. Should these be unavailable, note nearby areas of native vegetation.

EXPECTED SITE FUTURE USE

A revegetation plan should consider the land's planned use after revegetation. For example, seed mix variations may be appropriate within a given Ecological Site to meet a specific need or management scenario for livestock or wildlife, in addition to resource protection. Depending upon the expected final use, a habitat evaluation and vegetation inventory may be a part of the ecological site information collected as part of the initial background information developed.

SITE INVENTORY

A site inventory of existing conditions helps develop a revegetation plan. The site inventory includes identifying weed infestations that must be dealt with, historical irrigation patterns and their applicability in irrigation of the grass plantings, and water availability, which will be critical in determining the ability to manage the moisture needs of the seedlings effectively.

Site & Seedbed Preparation

The seedbed preparation for grass seeding should consider the existing site condition, weed infestations, and supplemental irrigation methods to be used. The choice of how to prepare the seedbed depends on the above factors, and the alternatives below illustrate the associated impacts. The seedbed cover should protect the planting and seedling development from high soil temperatures and

wind-driven evaporation in a weed-free environment, allowing maximum grass development.

Cover Crop Usage in Preparation of Revegetation Seedbed

The method of choice in developing the site and a good seedbed capable of protecting new seedlings is planting cover crops. In the context of the revegetation activity, a cover crop is the growing of an annual grain crop, terminated before maturity, which produces substantial stubble and residue that remains on the soil surface and into which the native grasses are seeded. Typical farming methods prepare the seedbed, and the cover crop is planted.

Cover crops with volunteer potential, such as rye and wheat, should not be used as a cover crop as volunteer growth will compete for growing space and water with the grass seedlings. Sterile hybrids should be considered as cover crops unless cover crops are terminated, as described in the paragraph above.

COVER CROP SEEDBED

Use cover crops to protect the seedbed and seedlings from wind erosion damage, increase soil organic matter, decrease weed competition, improve soil water efficiency, decrease soil compaction, and decrease excessive evaporation from sun and wind. Annual cover crops adapted to the site, such as sorghum, are grown to near maturity and cut (terminated) before a seed head is formed, leaving the cover crop standing stubble in place.

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After cutting, stubble height should be 12 to 18 inches. The standing cover crop stubble can catch snowfall, adding soil moisture. Thus, a more favorable environment is created for native species germination and/or seedling growth and vigor. Revegetation species are then seeded into the standing stubble.

Growing a cover crop reduces weed infestations in several ways. First, the cultivation and herbicide application needed for seedbed preparation reduces weed competition. Second, the growing cover crop suppresses weeds by direct competition and/or shading weeds. If crops are planted in 30-inch rows, cultivation and herbicides can be employed for weed control. Cover crops that are drilled will rely on herbicides, shading, and competition to control weeds. Irrigation furrows are used and maintained if furrow irrigation is to be used for supplemental irrigation of the seeding the following season.

SEEDBED WITHOUT GROWING A COVER CROP

An alternative method of preparing a seedbed for grass planting is to have crop residue from a previous existing crop adequate to protect the grass seedlings. Existing crop stubble and residue providing the same protections as a planted cover crop are essential.

This approach has several potential limitations that must be considered:
- Will the seeding and developing seedlings be adequately protected?
- Is there a weed infestation that needs to first be addressed?
- How is adequate soil moisture to be maintained?
- If supplemental irrigation water is available, how will it be applied?

Answering these questions will impact the success of the grass seeding and development.

BARE SOIL SEEDBED

Planting directly into bare soil is discouraged if the site lacks adequate crop residue. In this situation, none of the desired protections are available for the native grass seeding, exposing seedlings to wind erosion, soil drying, and soil crusting. Each of these conditions makes grass stand development difficult.

Seed Mix & Seeding

SEED MIX

Develop the seed mix considering the determination of adapted species and cultivars of native grasses:

i. Select species that will not require irrigation after grasses have met the stand establishment criteria. This means the grasses can survive on native precipitation alone without supplemental water. Native, perennial species should preferably be chosen as they are typically best adapted to the environment at the site over the long term.
    a. The NRCS Plant Materials Technical Note 59 (revised) March 20, 2012, which can be found on the Colorado NRCS website, has cultivar information that provides the best adaptation to the site. Refer to other references such as US Grass Cultivars publications, Plant Materials Plant Guides, and Fact Sheets.

ii. Observe and evaluate nearby native vegetation. Existing native sites indicate the species that will do well in the area, including earlier seral species characteristic of highly disturbed sites that may initially establish better on recently retired cropland sites. It should be remembered that prior management, such as grazing practices, may affect the makeup of the plant community.

iii. Refer to the Ecological Site Description based on the predominant soils to be revegetated. Ecological Site Descriptions can be found on Web Soil Survey website.

iv. Review successful revegetation projects within the area. Native species are preferred over non-native species. Non-natives may not be as long-lived or tolerant of variable climatic conditions as the native species.
    a. Should a non-native species be included in a seed mix, it should make up only a small percentage of the seed mix.

SEEDING

i. Seeding rates should be based on NRCS Plant Materials Technical Note 59 or another area-specific referenced document.

a. NRCS Tech Note No. 59 provides a full seeding rate for each species. When combined into a seed mix, a proration is used to obtain the desired amount of each species.

ii. Certified seed is preferred over non-certified seed. Certified seed provides guaranteed genetic identity, seedling establishment, uniformity, growth and plant characteristics are more stable and reliable with certified seed.

iii. Named varieties of seed are acceptable if certified seed is not available.

iv. Using "Variety Not Stated" (VNS) is not recommended as the origin is unknown and may not thrive in the local climate.

v. Seeding time may vary; November 1 to April 30 is generally a standard seeding window in the Lower Arkansas Valley. Seeding after April can be accomplished with a good water supply to germinate the seed and keep moisture available for the seedlings' early development. NRCS Plant Materials Technical Note No. 59 or another area-specific referenced document can be used to assist in determining seeding dates.

vi. Seed grass with a grassland (or "rangeland" or "reclamation") drill. This is especially important due to the differences in size, shape, and weight between seed types of grasses and other rangeland plants compared to agricultural crops. The grass seed requires planting at depths of one quarter (1/4) inch to one half (1/2) inch depth and placed with good firm seed-to-soil contact for best germination potential. The key features of a grass drill include:

a. Multiple seed boxes for different size and weight seeds, allowing for an even distribution of various seeds.
b. Seed box agitators to ensure accurate metering and delivery of various seed types (from heavy, smooth seed to the smaller fluffier seed).
c. Disc opener mechanism. Double disc is preferred, as there is typically a need to cut through some degree of the previous crop or cover crop residue to place the seed into the soil properly.

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d. Depth bands allow shallow seeding and prevent seeding too deep.
e. Packer wheels for good soil compaction in the seeded drill row, providing good seed-to-soil contact.

Water Needs & Irrigation Management

Meeting the water needs of the germinating seeds and the developing seedlings is the most critical factor in developing grass toward successful establishment. Without adequate and timely moisture available for the seedlings within the accessible root zone, the plant will wither and die without the opportunity to develop.

Supplemental water, if available, should be provided during the first two growing seasons to ensure seeding success. Actual timing and rate of water application should be based on rainfall and monitored soil moisture levels. Generally, the irrigation target should be to apply water at one-week intervals at a rate of 0.75 to 1.00 inches per application. During the second growing season, enough supplemental water should be applied so that, when combined with natural precipitation, two inches of moisture are received per month during May, June, and July. After July of the second year, supplemental irrigations can be discontinued if a satisfactory stand has developed.

The accessible root zone for native grasses is variable by species and stage of development. The native seeds are planted ideally at one-quarter (1/4) to one-half (1/2) inch depth, making the critical root zone during the initial stages of growth the top few inches of the soil. Therefore, the target is to keep the soil where grass roots are found moist and above wilting point, during the first month of the growing season. A note for additional consideration is that not all of the seedlings will germinate at the same time. Many different germinations will occur during the initial seeding development. Frequent, shallow irrigations will assist in germination and initial root development.

As the growing season proceeds, the depth and lateral spread of the root zone will increase; however, most root development will be within 12 to 24 inches within the initial year of growth. Over several seasons, the plant will mature with extensive root system development utilizing a much deeper root zone.

Two approaches to soil moisture management during revegetation development have been observed within southeast Colorado -- revegetation relying only on natural precipitation and revegetation with supplemental water.

REVEGETATION WITH ONLY NATURAL PRECIPITATION (DRYLAND)

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Revegetation plantings can establish with only natural precipitation. However, success rates in these scenarios have been meager in southeastern Colorado. As discussed above, the availability of consistent soil moisture in the root zone is the primary issue. When relying on only natural precipitation, it is imperative to provide the soil moisture protection (catchment and conservation) of a good cover crop to reduce unnecessary evaporation and loss of moisture. In the dryland revegetation environment, greater amounts of crop residue and litter on the ground will enhance the opportunity to protect the moisture in the soil. The use of good cover crop and seedbed preparation enhances the probability of success of a dryland planting.

Dryland revegetation programs and plans should consider the likelihood and potential cost of needing to reseed the native grasses, possibly over multiple seasons, to ensure a viable seed source when the climatic conditions are conducive to the seeding development. Decisions regarding the need for replanting should preferably wait until after the second growing season in order to better determine the degree and rate of establishment. Appropriate weed control must be maintained throughout the process, minimizing competition for the available moisture.

REVEGETATION WITH SUPPLEMENTAL WATER

The use of supplemental irrigation to provide for the water needs of the native grass seeding has proven to be a more reliable and faster method of establishing vegetation. The advantage of irrigation is the ability to maintain available moisture consistently and uniformly within the root zone for the developing seedling,

enhancing the development of the native grasses. With proper grass species selection, and after substantial growth and root development, supplemental irrigation should no longer be needed. Adapted native species will typically survive without further irrigation.

Two methods have been used to provide supplemental irrigation water to revegetation fields: furrow irrigation and sprinkler irrigation. Both methods aim to efficiently control the irrigation water to meet the plant's needs.

1. Furrow irrigation, the historical irrigation practice on most revegetation fields, has some limitations. It fills the soil profile during the application, reducing efficiency and possibly using more water than is necessary to meet the plant needs. During the initial irrigation, the crop residue developed with a cover crop may hinder the free flow of water down the furrow. Secondarily, in successive applications, the free flow of water down a furrow will be impeded by plant growth, by both seeded grasses and weeds, causing inefficiencies in the irrigation. In the Upper Arkansas River Basin on hay meadows, flood irrigation may be less efficient and more difficult to control due to irregularities in land surface topography.

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2. Sprinkler irrigation is the recommended method, as each application of irrigation water can be regulated to apply as much water as needed. When controlling the amount of water during each application, the available water supply can irrigate more ground than flood irrigation. Sprinkler irrigation allows for a more uniform amount of water to be applied across the field at rates that match the amount needed to refill the root zone required by the developing seedlings. This efficiency may allow for more frequent applications and irrigating additional seeded acres efficiently, and in a timely manner.

Whether by furrow or sprinkler, supplemental irrigation is still supplemental to natural rainfall. The revegetation manager will need to closely monitor the soil moisture levels within each field, determining when an application of water will be needed. Keep in mind the grass plants' growth stage and degree of root

development. New seedlings may germinate at various times across seasons and multiple irrigation applications and may not germinate until the second season, or even later. This results from varying seed dormancy mechanisms among species; variable climatic (photoperiod, temperature, and moisture) conditions that may affect release of dormancy mechanisms over time.

Natural rainfall conditions greatly influence the need for supplemental irrigation during the second growing season of grass planting. During the second season of growth, the revegetation seeding may benefit from additional irrigation to provide good soil moisture deeper into the root zone for the plant's root zone to develop into a mature grass stand. The manager will evaluate the conditions and growth stages of the native grasses in making determinations for additional supplemental irrigation.

Weed Control

Weed control in a revegetation program is second in importance only to providing supplemental water to the developing grass stand. Weed control activities are necessary and critical for management, as weeds compete aggressively for available moisture, nutrients, and sunlight, reducing their availability for the developing seedlings. At a minimum, weed infestations slow the growth and development of a grass stand, and can potentially overtake and displace a developing grass stand in the absence of applied weed control measures.

The goal of weed control is to develop a clean, weed-free seedbed for planting cover crops and seeding grasses the following season. Elimination or significant reduction of weed infestations at this stage of the process effectively alleviates potential complications of weed competition once the grass seeding has taken place. When growing a cover crop, weed control is primarily through herbicide application and can also benefit from cultivation. Contact a Certified Crop Advisor or Colorado State University Extension for herbicide recommendations.

Weed control within developing grass seedlings generally is comprised of mowing and/or herbicide applications. Biological control is an option but has not been shown to be effective on a large scale in the Arkansas Valley.

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Mowing should be used to reduce the competition from weeds when herbicide options are not feasible or recommended. Mowing is the only option in the early development stages, as newly germinated grass seedlings are usually susceptible to herbicide damage until the third or fourth leaf stage in development. Higher herbicide concentrations can also damage the development of older plants, depending upon grass species, herbicide type, and timing of application.

Mowing can be used to control annual weeds during the first and possibly second growing season until the grass can withstand herbicide application. When weeds are mowed, a stubble of at least six inches in height must be left on the soil surface. The mowing operations must be conducted before the weeds develop viable seeds and before weed height produces excessive litter. The clipped residue from mowing must be left on the soil to protect it from solar evaporation.

When appropriate, herbicide treatment is preferred. It is typically more effective and uniform (when properly applied) in achieving weed mortality or suppression, thus suppressing or removing the grass seedlings' competition. Some perennial weeds may not be suppressed by mowing or may actually be stimulated in vigorous compensatory regrowth by mowing – thus indicating the need for prescribed herbicide treatment, where feasible. Low-growing weeds below the minimum mowing height shall require herbicide application(s) for adequate control. For example, bindweed is a low-growing, perennial weed that negatively impacts seeded grasses by competition for water and nutrients. Although herbicides cannot eliminate bindweed it can be “set-back” long enough to allow seeded grasses to germinate and grow. Herbicides should be used on noxious weeds to prevent their spread. Herbicide applications will be conducted before the weeds develop viable seeds, and according to label directions and other pertinent literature pertaining to proper weed growth stage timing of application.
Read and follow all herbicide label directions.

Flash grazing for weed control is another option, but lack of tight control on animal numbers and length of time grazed can result in the loss of a grass stand. Flash

grazing is generally not recommended and should never be used during the first and second season of establishment and development.

Established grass fields may continue to have weed issues that will need to be addressed. Therefore, continued monitoring of established fields will be required on a regular basis, with any weed infestation issues addressed when found.

Evaluation of Seeding & Early Seedling Development

Monitoring and evaluating grass plantings are a continual process conducted by the manager routinely to make weed control and irrigation decisions. Monitoring the development of the grass stand on its way to establishment is undertaken on a periodic basis, generally annually, due to the slow growth of the seedlings.

The recommended approach to evaluating the seedling stand through the first two growing seasons is summarized in the following table as a seedlings per square foot rating. This per square foot rating indicates status or likelihood of ultimately developing into an adequate established grass stand. Due to the small plant size at this stage of development, it is evaluated by conducting a number of plot counts to obtain an average number of plants per square foot in a given seeded stand. By taking an adequate number of plot counts over the field, an estimate can represent the status of the field in terms of potential for grass stand establishment.

Stand Rating	Grass Seedlings per Square Foot
Good to Excellent	>3
Adequate	2
Questionable	1
Inadequate	<1

This stand rating is considered valid for evaluating stands that are one to two years old following initial seeding to estimate the likelihood of reaching adequate stand establishment. This evaluation method is recommended for determining initial seeding success or failure and the need for replanting. Following the second growing season, should the plant population not be ‘Adequate’ or above, replanting should be considered unless circumstances suggest re-evaluation at a

later date is warranted. If weed infestation is controlled and there is enough plant or litter cover to protect the soil, consider seeding directly into the existing seedbed without further seedbed preparation by mechanical tillage or other physical disturbance.

Evaluation of Grass Stands for Establishment: Third Year After Seeding and Beyond

The criteria above "Evaluation of Seeding and Early Seedling Development," is a tool to assist in the decision if a one or two-year-old grass stand has potential for success or if reseeding is necessary. The following criterion is to determine if the grass stand is "established." This criterion should only be used for grass stands three years old or older.

A demonstrated and effective criterion for determining the establishment of a revegetation field in southeastern Colorado is:

> *A field shall be considered established when the basal cover of acceptable perennial dryland plants suitable for the climatic and soil conditions for this area, as referenced within the appropriate ecological site, shall be 15% or greater basal cover with no deficient areas larger than 1 acre in size over 90% of the field. Basal cover is the area of ground surface, measured one inch above ground level, occupied by the basal portion of the plant. Basal cover is different from foliar cover.*

Evaluating fields using this criterion is efficiently accomplished using the methodology below.

> *The cover shall be measured using a point intercept method where transects are taken diagonally to the drilled seeding on the field. At each interval, a point shall be evaluated for acceptable plant basal cover material. The percentage of "hits" to the total points evaluated shall be determined.*

In taking the transect, each appropriate perennial, native plant must be healthy and well established, likely three years of age or older, to be counted.

Fields shall be evaluated at or near the end of the growing season on an annual basis.

EVALUATION FACTORS

Each field shall have received only natural precipitation with no supplemental irrigation during the season before the establishment evaluation. This condition is important to ensure that supplemental irrigation has no undue influence at the time of establishment evaluation.

Weeds shall have been adequately controlled with no evidence of significant (large or expanding) weed infestations.

Monitoring of Revegetation Programs

There are numerous sources of monitoring information. A few examples are:

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"Sampling Vegetation Attributes Interagency Technical Reference 1734-4, Bureau of Land Management" or "Colorado Resource Monitoring Guide". The goal of monitoring is to document changes in vegetation cover over time and compare the changes to the standard set in the decree. Monitoring will determine the success of prior actions and future land treatment activities affected by these results. It should be noted that water transfer decrees may not specifically set out the type or method of monitoring. If possible, the type and method of monitoring should be in the decree.

A complete monitoring discussion is beyond this document's scope, but a few recommendations are included here.

MONITORING METHODOLOGY

1. The “Line-Point Intercept” technique is a fast and inexpensive method to measure vegetation. When sufficient samples are taken, the results are reasonably accurate. The Step-Point method is also acceptable, but care should be taken to eliminate bias when walking.
2. What to measure:
    a. Foliar cover – the area of ground covered by the vertical projection of the aerial portion of the plants.
    b. Basal cover – the ground area covered by the plants' basal portion. Typically, this is measured one inch above the ground surface.
3. Recommended Measurement Method: Basal cover is the recommended criterion after the third growing season in the revegetation context. Utilize the seedling measurement criteria described above prior to the third year. Foliar cover can vary significantly with precipitation, impacts from wind and/or pests, and may not be an accurate year-to-year comparison. Basal cover is less influenced by highly variable yearly precipitation and other environmental factors.

MONITORING RESPONSIBILITY

Monitoring in reference to revegetation can mean several activities. Activities include monitoring required by the revegetation manager, monitoring seedling development throughout the revegetation process, and monitoring by the court or interested parties for compliance with required actions and results.

SEEDLING & REVEGETATION DEVELOPMENT MONITORING

As discussed, the development from seed to a healthy, established grass field is a slow process. Therefore, some monitoring is done periodically, usually annually near the end of the growing season. This is the appropriate time to assess changes and development that have occurred during the previous season. Some items to consider monitoring and documenting annually are:

a. Classification of a given field
b. Previous field classification for comparison
c. Weed control activities and effectiveness
d. Supplemental water usage

e. Specific concerns or issues to address
f. Establishment evaluation
g. Monitoring considering legal requirements

Many revegetation programs will have legal requirements for monitoring and reporting to either the court, parties to a water court transfer, or interested entities such as counties. This monitoring should be defined in a transfer decree, permit or agreement and likely will contain many of the items previously listed.

Dryland Farming Considerations

Various crop growth models, crop production indices, and economic spreadsheets from numerous Agency sources estimate the potential for dryland crop success.

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One of the best predictors of dryland cropping success is the existence of successful dryland cropping in the area. Successful means that the cropping is economically feasible and that crops can be produced without excessive erosion by wind and water. Unfortunately, the variable climate, particularly precipitation, in southeastern Colorado makes these estimates unreliable. If the area does not have a viable dryland farming culture at present, it is possible that dryland farming has been tried and abandoned due to lack of success. Listed below are factors affecting the suitability of dryland farming in the Lower Arkansas Valley.

Considerations include:

a. the soil's ability to store water for crop use between precipitation events
b. pH – near neutral
c. lack of toxic material in the soil
d. inherent soil productivity
e. no physical or chemical barriers to crop growth
f. no excess soil water that would inhibit root growth
g. no excess flooding or ponding

h. no excess slope
i. a climate that provides adequate water for crop growth

Many areas along the Lower Arkansas Valley have not demonstrated the ability to meet the dryland considerations above.

Accountability for Completion of Revegetation

How to complete revegetation in an acceptable and successful manner has been the question raised during the review of previous revegetation projects. Thus, it is useful to include recommended accountability methods in this 'Revegetation Manual."

The delineation of responsibility to complete a revegetation requirement has been approached from two perspectives: water rights seller (usually a landowner) and water rights purchaser.

a. Considerations when a farmer/landowner is responsible for conducting the revegetation activity. This model has not been successful in most cases. For several reasons, the revegetation has not taken place or has not been successful. The landowner/water seller may not want to invest water sale dollars in protecting the land; the landowner may be an absentee owner and cannot find an operator to apply the needed practices or is unwilling to fund the revegetation process; the landowner may not have the technical expertise or equipment to implement revegetation; the land may be sold post-water right sale, and the new owner is either unaware of the revegetation requirement or does not have the financial resources to complete revegetation. In almost all cases, a landowner will find the costs extremely high. Indeed, the expected cost of the revegetation exceeds the appraised value of the lands as dry grasslands.

b. A purchaser of water rights has the requirement to complete the revegetation of the land. Generally, if the purchaser is a municipality, the municipality has resources to conduct revegetation activities if the requirement is in place. In most cases, responsibility for revegetation may not be explicitly assigned within the decree.

In either approach, the oversight responsibility and completion accountability must be well-defined. It should be understood that there are many aspects to successful

revegetation. Completing a program can be expensive and thus must have extensive accountability.

Post-Establishment Revegetation Management

Generally, the management of revegetated lands has not been a focus beyond the determination of the establishment of the grass stands after seeding. This approach has been demonstrated to be lacking in management effectiveness for the longer-term protection and productivity of the land resource.

Weed control

In many cases, there will still need to be management of weeds over the life of the grass stand to prevent incipient infestations detrimental to the grass stand or potentially becoming a nuisance to neighboring landowners. Therefore, a continued weed management program with the same goals as during the establishment of revegetation needs to be implemented.

Grazing management

Post-revegetation use should be defined prior to revegetation as the planned use affects species selection. The purpose of grazing should be to improve or maintain the health and vigor of the established vegetation. Care must be taken in selecting and preparing an appropriate grazing management plan for implementation on these lands. They must be considered more vulnerable to degradation from grazing pressure than native grasslands. As discussed previously, the soils have been changed through the effects of many years of irrigation, and the revegetation plants will need considerable time following a determination of establishment to develop fully in terms of grazing tolerance / resilience, resource protection, and desired forage value compared to native grasslands.

The number and kind of animals, season of use, and length of the grazing period need to be defined. Animal numbers should be balanced with forage available. Vegetation should be inventoried prior to grazing to assist in monitoring. Monitor after grazing to determine if vegetation goals have been attained. Changes in grazing may be needed for the next grazing period. The grazing plan should include allocating periods of no-grazing (rest). A contingency plan should be in effect in case of drought, fire, or other disturbances. At all times, the condition of the grass must dictate when changes need to be made. Sources of information and technical assistance could include various state or federal agencies.

In developing a grazing plan, the recommended procedure would be to implement a grazing plan that would require strict management to assure that animals are removed prior to any potential overgrazing, followed by extended periods of rest and regrowth prior to another grazing event. A “high intensity – short duration” grazing plan would be ideal if infrastructure (fences and animal water supply) is available to facilitate this system. If not, animal numbers balanced with the grazing resource followed by rest (no-grazing), and an allowance for grasses to develop seed is recommended. Over-grazing could result in the loss of established grasses. A grazing management specialist should be consulted in preparing a grazing plan. Strict grazing management must be in place and assured.

Photo Taken by Don Hazelett

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