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Chapter 8

Controlling Plant Competition

Selecting Methods and Procedures for Plant Control

Generally, range or wildlife habitat improvement projects seek to achieve desirable plants through the elimination or replacement of undesirable species or both. Control measures are thus designed to: (1) reduce the competitive effects of existing species (Evans and Young 1987a,b; Robertson and Pearse 1945), (2) allow the establishment of seeded species (Harper and Benton 1966; Toole and others 1956), and (3) facilitate reestablishment, or improve the vigor of, desirable native plants (Plummer and others 1970a; Stevens 1987b).

Although control measures are often needed to reduce weedy competition, wholesale elimination of a species is not always necessary. Some practices, including chaining or burning (Plummer and others 1968), are used to reduce the density of target species and promote changes in the composition of the existing community.

Chaining and burning have been used to stimulate regrowth of decadent stands of antelope bitterbrush (Edgerton 1983; Martin 1983), mountain mahogany, cliffrose, and aspen. These processes improve availability of Gambel oak (Plummer and others 1968), and the forage production of big sagebrush (Young and Evans 1978b) sites.

Control measures are often sought that will eliminate all existing species, particularly on sites dominated by cheatgrass (Young and others 1976b), medusahead, or cluster tarweed (Carnahan and Hull 1962; Hull and Cox 1968). Disking, plowing, or use of chemicals are most effective where complete control measures are required (Eckert and Evans 1967; Haas and others 1962). Remnant native plants are useful and should be retained on most range or wildlife sites. However, control measures are seldom so refined that individual species can be retained when others are destroyed.

If seeding is to be successful, the existing competition must be sufficiently reduced to allow establishment of new plants (Evans and Young 1978). If a mixed array of plants are seeded, the period of establishment may be prolonged by 2 to 5 years.

Consequently, to be effective, considerable reduction in the presence of existing plants is often necessary (Monsen and McArthur 1985; Stevens 1987b). In addition, the control measures used must also prevent the recovery of targeted species for sufficient time to allow seeded species to fully establish (Fulbright 1987; Hutton and Porter 1937).

Methods of Plant Control

Mechanical Control

Various techniques and implements are available to mechanically treat rangelands (Abernathy and Herbel 1973; Anderson and others 1953; Herbel and others 1973). Many implements used in conventional agriculture have been adapted for use on wildlands. Trained personnel are normally available to operate, modify as necessary, and maintain the machinery. Consequently, many range and wildlife habitat improvement projects rely on the use of modified farm equipment. Numerous equipment items have also been developed specifically for range and wildland sites (Larson 1980). The functions, capabilities, and uses of equipment used in wildlands are described in chapter 9.

Mechanical control measures may be more or less effective in reducing unwanted plants than burning or herbicide treatments. However, some aspects of mechanical control provide advantages to overall rehabilitation and restoration programs. Attributes of mechanical treatments are summarized as follows:

1. Different types of equipment are available to treat specific circumstances.
2. Treatments can be selectively used to remove target species.
3. Mechanical control can be effective in the removal of live plants and seeds.
4. Treatments can be conducted at different seasons to retain or lessen impacts on key species.
5. Treatments are not always restricted to a specific season or period as is burning or chemical control.
6. Control measures usually aid in creating a seedbed, and in seeding.
7. If necessary, litter and surface protection can be provided to lessen runoff and erosion.

Fire and Herbicide Control

Fire and herbicides are viable methods of controlling plants. Both techniques have specific limitations and advantages (Hyder and others 1962; Pechanec and Stewart 1944; Young and Evans 1978b). Either are applicable measures if weedy species can be selectively controlled and desirable plants can be retained or are able to recover. Both methods can be used to eliminate competition prior to seeding (Young and Evans 1978b; Young and others 1976a,b). Descriptions and use of herbicides and fire are discussed in detail in chapters 10 and 11.

A considerable amount of plant residue and surface litter is often left in place following herbicide treatments. This debris may enhance the seedbed (Evans and Young 1984). However, neither burning nor herbicide treatment provides a suitable seedbed for most species. Some means of mechanical seeding or seed coverage is required to plant an area following burning or spraying (Evans and Young 1984). In contrast, mechanical plant control measures, chaining, disking railing, and so forth not only remove weedy competition but simultaneously aid in seeding.

Biological Control

More than one approach is usually feasible for reducing the density of undesirable plants. Land managers have some latitude in selecting treatments for most rehabilitation projects. Sometimes, biological control measures are quite effective. Regulating grazing intensity, seasonal use, and selective foraging can improve the vigor and density of certain plants (Hubbard and Sanderson 1961; Vallentine 1989). Unregulated grazing can harm and even destroy well planned projects. Grazing of range and wildlands is considered a biological control measure, as foraging impacts by domestic livestock, wildlife, and insects can, in part, be regulated. Grazing also impacts other biological systems affecting plant communities.

Improvements achieved through controlled grazing and seeding (Shown and others 1969) are usually most noticeable on mesic sites. Blaisdell and Holmgren (1984) reported that the composition of desert shrublands, including certain salt desert shrublands, will respond favorably to grazing management, although changes may require many years of careful treatment. Improvement in vegetative conditions is often a cumulative response. Plant density may increase as plant vigor improves and more seed is produced to facilitate seedling establishment. These changes often occur over a long period of careful management.

Grazing can be used to reduce the presence of some weedy or less desirable plants. Cattle grazing has been effective in reducing seed production and stand density of cheatgrass, but has not been effective in elimination of the annual grass. Plummer and others (1968) reported that grazing of burned stands of Gambel oak by livestock and deer aided in suppressing shrub regrowth. However, species not eagerly eaten by grazing animals are difficult to control without excessive damage to other plants.

Regulating livestock grazing has been an effective means of improving the vigor and density of selected existing plants (Astroth and Frischknecht 1984). Broadleaf herbs and some grasses that are sought by grazing animals may not recover even though a significant reduction in grazing occurs. Species such as alfalfa (Rosenstock and others 1989), small burnet, arrowleaf balsamroot (Plummer and others 1968), and bluebells continue to be selectively used even when livestock or game numbers are reduced. Changing the grazing season is most beneficial to species of herbs highly preferred by grazing animals (Frischknecht 1978).

Elimination of livestock grazing of some preferred shrubs including Stansbury cliffrose, Martin ceanothus, curlleaf mountain mahogany, and antelope bitterbrush has resulted in improved plant vigor. However, if heavily browsed, these shrubs may require 3 to 5 years to respond. Forage yields and seed production may respond dramatically, yet recruitment of new seedlings may be prevented by understory weeds. Thus, many shrublands disrupted by grazing and infested with annual weeds may not recover satisfactorily as a result of simply eliminating grazing.

Regulating game use of seriously depleted rangelands has been achieved by seeding selected portions of the habitat. Revegetating segments of some big game winter ranges has succeeded in concentrating game use on the seeded areas. This has lessened grazing of adjacent ranges and allowed for natural recovery. This practice is particularly successful if highly palatable species are planted to attract grazing animals and change seasonal use. Orchardgrass, small burnet, penstemon, black sagebrush, fourwing saltbush (Nichlos and Johnson 1969), sainfoin, and alfalfa can be seeded in areas where they are adapted to attract and regulate animal use. Other plants, particularly Lewis flax, mutton bluegrass, wild buckwheat, prickly lettuce, salisfy, showy goldeneye, redstem ceanothus, and creeping barberry are species that demonstrate similar usefulness. These species often recover quickly following restoration treatments. Not all provide a major part of the diet for game or livestock, but they are selectively grazed and attract animals.

Livestock grazing is often recommended as a method of dispersing and planting seed by trampling. Eckert and others (1987) report soil relief is important to seed entrapment, germination, and seedling establishment. Moderate trampling favors emergence of perennial grasses; heavy trampling is detrimental to the emergence of perennial grasses and forbs. Moderate trampling can be both beneficial or detrimental to seedling establishment depending upon the position in the soil where seeds germinate. Surface germinators are enhanced by moderate trampling, but species requiring more soil coverage are not.

Grazing systems are not always effective measures for controlling weedy plants or enhancing the establishment and increase of desirable species. Once weeds such as juniper and pinyon, broom snakeweed, halogeton, red brome, or cheatgrass gain dominance, their density may not be diminished by changing grazing practices. Other more desirable plants are not likely to increase unless the weedy competition is reduced. Consequently, seriously depleted plant communities recover very slowly or not at all with grazing management. Unless a number of desirable remnant plants exist, the change may be too slow and ineffective to be regarded as a viable alternative.

Successional Changes

Other means of biological control can be employed to bring about changes in plant composition. Natural changes in plant succession following logging or wildfires can affect large areas. Many sites cannot be revegetated by artificial plantings, but significant improvement can be achieved by protection and natural changes. Slight shifts in plant composition on extensive areas can significantly influence forage or habitat resources. Natural changes in the density of broadleaf herbs, particularly Utah sweetvetch, arrowleaf balsamroot, or nineleaf lomatium can occur as a result of fire in sagebrush or bunchgrass communities. A slight increase can be beneficial to spring and summer foraging by game and wildlife. Similarly, an increase of wild buckwheat or black sagebrush, on harsh, exposed winter ranges can significantly enhance winter forage conditions for some big game animals. Fluctuations in density and herbage production of certain shrubs including big sagebrush, low rabbitbrush, and antelope bitterbrush occur as the composition of understory weeds is reduced. Redstem ceanothus and western chokecherry increase rapidly as overstory trees are removed. Rather dramatic differences can occur within a short time. The natural shift in species presence, density, and vigor can substantially change the seasonal forage base and habitat conditions.

Both logging and burning are commonly used to improve wildlife habitat conditions in many forest communities (Steele and Geier-Hayes 1987). The approach of altering successional change normally requires a long period, but is a well-accepted management technique. Other considerations such as maintenance and economic costs are easily justified. Natural recovery of depleted arid and semiarid rangelands does not occur quickly, and artificial rehabilitation is often recommended. Nevertheless, sites can be managed to facilitate improvement through natural succession.

Differences in annual precipitation and other climatic conditions have long-term effects on plant communities (Bleak and others 1965; Plummer and others 1955). Drought conditions can eliminate or weaken certain species. Contrasting “wet years” can enhance establishment and increase plant density. Implementing revegetation measures during favorable years or periods is advisable, but predicting “good years” is not always possible. Delaying or implementing control measures until years when favorable moisture appears likely to occur can be justified.

Improvements in plant communities are not restricted to years or periods of high precipitation. During the drought period of 1987 to 1990, cheatgrass and other annual weeds produced extremely low seed crops. Seed production of native perennial grasses was more favorable, and considerable spread of the perennials occurred.

Delaying plans for control measures until mid or late winter when buildup of winter moisture occurs is possible in many circumstances. Coordinating plans for artificial control treatments to coincide with expected natural community changes should be carefully considered.

Insect and disease outbreaks (Nelson and others 1990) (see chapter 15), wildfires, winter injury (Nelson and Tiernan 1983), and other factors can result in extensive plant dieoff. Contingency plans should be developed to capitalize on these situations.

Factors Influencing the Selection of Methods and Equipment

Primary Objectives

Land rehabilitation or restoration measures are developed to satisfy certain objectives. Most often, range and wildlife habitat rehabilitation and restoration programs are designed to: (1) improve forage quantity and quality, (2) enhance vegetative cover for wildlife, (3) control weeds and their management problems, (4) improve or maintain esthetic and recreational values, (5) correct watershed problems, and (6) enhance the succession and natural development of native communities.

If improvement of forage production is a principal objective, measures required to create a managed pasture situation may be justified (Astroth and Frischknecht 1984; Cook 1966). Seeding or treating to support a single species, or grazing at a specific period may justify extensive conversion treatments (Cook 1966). Thus, disking, plowing, or herbicide spraying would likely be required to eliminate competition and successfully seed a specific crop. If year-long foraging is desired or needed to sustain wildlife and livestock, a complex of species would be needed (Monsen 1987). Treatment practices would be used that would facilitate the introduction of some species without the complete elimination of others (Monsen and Shaw 1983c).

Attempting to minimize the impacts of treatments upon esthetics or selectively reducing certain species while retaining others are complex actions that must be contemplated in selecting appropriate equipment. In most cases, the selection of equipment or treatment practices is ultimately based on the need to control weedy plants. Other factors, although important, generally do not dictate restoration measures. If plant competition cannot be controlled, treatment procedures should not be implemented.

Plant control measures are usually closely aligned with seeding or planting. Techniques that reduce competition, provide a good seedbed, and permit planting in one operation are preferred (Schumacher 1964). However, not all of these objectives can usually be achieved in one procedure. The effectiveness of rehabilitation or restoration programs is determined by the control measures and seeding procedures used. A land manager must select the appropriate equipment and treatments that will modify the vegetation in the manner desired.

Sites that provide the greatest potential for forage production (Anderson and others 1953) or for improved wildlife habitat values normally justify the greatest investment. Complete renovation and seeding can be justified on areas that yield high returns.

However, attempting to evaluate the importance of a site based upon forage production is often unwise. Sites that furnish midwinter forage, especially during adverse winter conditions, are extremely valuable locations. They furnish critically needed forage and cover, although production may not be comparable with other sites. Attempting to restore those areas using costly and extensive procedures may be well justified. For example, planting or enhancing the status of wild buckwheat, green ephedra, or smooth sumac on small restricted sites can significantly improve the midwinter range condition of many critical game ranges.

Various criteria have been developed to identify range sites that should or should not be treated (Cook 1966; Plummer and others 1968). Some recommendations do not advise treating steep slopes or shallow soils when an increase in herbage production would not occur. However, these sites are usually an integral part of the habitat for game animals and watershed resources. Forage productivity may not be as important as animal concealment or watershed protection.

Rehabilitation or restoration measures must be compatible with circumstances at the planting site. Treatments must be conducted in a manner that will yield the greatest return. Sites should be evaluated to determine their productive capabilities. Improvement measures should be designed to assure that adapted plants and techniques are used to achieve plant establishment and survival.

Most ranges, and particularly game ranges, are diverse sites. Usually only one method is used to treat an entire area. However, several different measures are often justified to revegetate individual portions of an area being treated.

Site Access

Topography and surface conditions influence the operability of equipment used in rehabilitation and restoration. Many range and wildland sites include some steep or poorly accessible areas. Getting equipment onto a site and furnishing support and maintenance during the operation is essential. Aerial seeding and anchor chaining are perhaps the most versatile techniques currently available for treating mountainous terrain (Skousen and others 1986). Equipment of this type is expensive to transport, consequently, it is not economical to treat small areas or fragmented tracts that require numerous moves and frequent "setup."

Rough, irregular sites limit the use of most conventional machinery. Rocky soil conditions and dense woody vegetation interfere with equipment operation and cause considerable breakage.

Topography also influences seasonal access and operating efficiency and effectiveness. Uprooting and breakage of woody plants is best accomplished when soils are partially frozen and plants are cold and brittle. Late fall and early winter access is necessary to treat many shrublands. Treatment of riparian sites is best accomplished during periods of low runoff and when soils are dry. This often requires late fall and winter access.

Soil surface conditions may differ considerably on irregular sites. Soils may be moist and frozen on certain aspects, yet dry and friable on adjacent sites. Differences can be great enough to reduce the success of plant control measures. Yet, delaying treatment until all sites are open and accessible may not be practical. Consequently, the period when sites can be effectively treated may be very short for some rather large areas.

Status of Existing Vegetation

Plant Competition

Usually only one or two species of undesirable plants are of primary concern. However, mixed stands can and do support different growth forms (shrubs and grasses) that require different control measures.

Most perennial herbs cannot be eliminated by surface scarification resulting from railing or chaining (Barney and Frischknecht 1974; Tausch and Tueller 1977). These plants must be uprooted by disking or plowing (Cook 1966; Drawe 1977), or eliminated by chemical spraying, or in some cases, burning (Robertson and Cords 1957). Annual herbs, particularly those that produce a buildup of seed in the soil, must be treated in a manner that kills existing plants and prevents or reduces establishment by seed (Evans and Young 1987b; Young and others 1969). Deep plowing or scalping to sidecast surface soil and weed seeds away from planting furrows are appropriate techniques (Schumacher 1964). Herbicide spraying can also be used to prevent floral or seed development (Evans and others 1976). Weeds can also be consumed by fire if burning is done before seeds drop from the plant (Plummer and others 1968).

Large woody plants and rough rocky sites are not conducive to soil tillage such as plowing or disking. These areas can be burned if sufficient fuel is available to carry a fire. Mechanical control measures are usually limited to railing, chaining, or other techniques that uproot or crush the vegetation. These practices usually create a good seedbed. Chemical spraying can also be effective on trees and large shrubs, although selective herbicides are recommended in order to prevent damage to desirable species that may be present.

In most instances, a combination of treatments is needed to gain control over sites dominated by more than one weedy species. For example, chaining or burning juniper-pinyon woodlands may successfully control the trees, but cheatgrass would not be affected.

Plant Tolerance and Response

Many resprouting species recover following cutting, burning, pruning, or chemical defoliation (Vallentine 1989). Repeated treatments may be necessary to eliminate these species. Treating at the appropriate season can increase vegetative kill. In addition, the establishment of seeded species and the recovery or release of other existing natives can result in further suppression of the targeted plants (Wight and White 1974).

Undesirable species that recover by root sprouting, stem layering, or other means of vegetative propagation must be uprooted (Allison and Rechenthin 1956) or chemically treated. Repeated treatments or a combination of treatments may be necessary to eliminate particularly persistent or noxious weeds (Vallentine 1989). Such retreatments may be justified on highly productive ranges, meadows, and riparian areas. However, complete control may not be practical on most sites.

Complete elimination of resistant herbs is not always warranted. If density or recovery of weedy plants does not interfere with the establishment of seeded species or the recovery of desirable natives, extensive control is not necessary (Monsen and Turnipseed 1990). Spot treatment or treating narrow strips or bands may be sufficient to interseed weedy sites (Schumacher 1964; Stevens and others 1981b; Wight and White 1974). Clearings must be large enough to allow seedling establishment and normal plant growth (Giunta and others 1975). Treated sites should remain free of weeds for 1 to 3 years to allow establishment of seeded plants.

Control of annual weeds usually requires the elimination of live plants and new seedlings (Davis and Harper 1990; McArthur and others 1990a). Most annuals, particularly cheatgrass, medusahead, Russian thistle, and Belvedere summer cypress, recover quickly following treatment if soil-borne seeds are allowed to germinate (Evans and Young 1984). Removal of the live plants is not sufficient to assure successful seeding. New weed seedlings can appear quickly enough to suppress seeded species.

Mechanical or chemical fallowing is used to reduce newly germinating weed seedlings, although present restrictions limit the use of some herbicides. Deep furrow drilling (Young and McKenzie 1982), disk chaining (Wiedemann 1985), anchor chaining (Davis and Harper 1990) using the Dixie (Jensen 1983) or Ely chain, pipe harrowing, or other soil tillage treatments can be successful in eliminating weed seedlings. Soils are not completely plowed or turned with these implements, but sufficient tillage occurs to uproot and kill enough weeds to allow establishment of planted seedlings. Soil surfaces must be overturned 3 to 5 inches (8 to 13 cm) by disking to bury most weed seeds deep enough to prevent emergence.

The Extent and Duration of Weed Control

The foremost issue in most restoration or rehabilitation projects is the establishment of seeded species. Weeds must be eliminated during this period to assure seedling establishment and survival (Samuel and DePuit 1987). Many grasses and broadleaf herbs seeded on rangelands establish quickly and grow rapidly (Houston and Adams 1971). Once these species achieve initial establishment, they are sufficiently competitive to resist extensive competition. In contrast, many shrub seedlings establish much slower and are vulnerable to competition for a number of years (Giunta and others 1975).

Weeds must be controlled for extended periods to allow slow-growing species time to establish. Many introduced weeds have unusual regenerative capabilities and can suppress seedling establishment of many natives, particularly some shrubs. Young stands of shrubs such as Stansbury cliffrose, green ephedra, serviceberry, skunkbush sumac, curlleaf mountain mahogany, blackbrush, and Martin ceanothus can be severely decimated if cheatgrass, red brome, or medusahead are allowed to reestablish 3 to 5 years after the shrubs are seeded (Plummer and others 1968). Seedlings of these shrubs are vulnerable to excessive herbaceous competition for many years following seeding. Even though the shrub seedling may survive 1 to 3 years, their ultimate survival is still tenuous.

Seeding companion species is a viable and recommended method of reducing the early reentry of weeds (Vallentine 1989). Some perennials are sufficiently competitive to prevent recruitment of weeds, yet allow the establishment of slower growing seeded species. Timothy, orchardgrass, mountain rye, alfalfa, western yarrow, and Sandberg bluegrass are frequently seeded in alternate rows with shrubs or slower developing herbs to control the rapid entry of weeds. Manipulating row spacing, seeding rates, and planting at different dates are methods useful in attaining establishment of slow-growing species (DePuit and others 1980; Samuel and DePuit 1987). Seeding nurse crops or companion species under arid conditions must be done carefully to prevent unnecessary competition.

Most woody plants, including stands of juniper-pinyon, big sagebrush, matchbrush, rabbitbrush, black greasewood, or snowbrush ceanothus do not need to be completely eliminated to allow the establishment of seeded species (Plummer and others 1968). The presence of some remaining plants may actually be helpful. These species may be partially thinned or damaged by railing, chaining, or burning. Their recovery, either through new growth or by reproduction, is usually not rapid enough to prevent establishment of the seeded species.

Thinning, suppression, or partial elimination of some plants are often required to release other associated species. In many projects the recovery of certain native herbs and shrubs is of primary importance. Partial control of the dominating weedy species is often sufficient to release the remnant plants (Aro 1971). The released plants recover quickly and are able to provide considerable competition within 1 to 2 years. Favorable recovery of Woods rose, blue elderberry, black sagebrush, low rabbitbrush, black chokecherry, fourwing saltbush, spiny hopsage, antelope bitterbrush, desert bitterbrush, squawapple, Apache plume, and many other shrubs has occurred following control of associated plants.

Plant control must have a long-term effect (Hull and Stewart 1948). Some plants recover and reoccupy the site if only a few plants are left following treatment. Big sagebrush, Sandberg bluegrass, and black greasewood are examples of plants that recover rapidly and may reduce recovery of other desirable species (Johnson and Payne 1968).

Effects of Control Measures on Seedbed Conditions

Range sites that do not harbor desired plants usually must be seeded to achieve a more desirable vegetative composition (Eckert and Evans 1967). Regardless of whether sites require seeding or will recover naturally, a suitable seedbed is necessary (Eckert and others 1987). Seeding is usually programmed to coincide with weed control or site preparation treatments. Seedings are usually more successful if conducted soon after weedy competition is removed (Young and others 1969) to take advantage of the seedbed conditions created by disking, railing, and chaining (Plummer and others 1968). It is important that plant control methods create or improve the seedbed. Generally, mechanical treatments overturn or disrupt the soil surface. Disrupting the soil surface by deep plowing or other drastic measures can destroy favorable seedbed conditions. Tillage provided by chaining, pipe harrowing, or railing is usually sufficient to adequately cover seed and compact the seedbed, but is less disruptive to the soil surface than plowing or disking.

If plant control measures are also used to facilitate seeding, the work should be conducted at the optimum time for seed germination and seedling establishment (Bleak and Miller 1955). This may or may not coincide with the optimum period for plant control. Seeding is sometimes done during inappropriate periods to take advantage of loose soil conditions or soil sloughing. Seeding is often done immediately after a burn in loose ash and flocculated soils. Seeding is not recommended in midsummer or when seeds may germinate prematurely. If plant control measures are relied upon to cover the seed, the operation should be done when soils are tillable and proper planting depths are attainable. Chaining sites when soils are dry and loose results in deep planting and a very loose seedbed. These conditions are not conducive to seedling establishment. In contrast, chaining areas in early winter when soils are wet and slightly frozen prevents deep seeding and results in a firm seedbed. Broadcast seeding on top of snow over disturbed soil can be a successful seeding practice.

In general, mechanical plant control favors seeding as soil disturbances and tillage create a useful seedbed. Burning or spraying may leave some surface residue or litter that can aid seedling establishment, but additional seeding methods are normally required.

Availability of Personnel and Equipment

Although many factors influence the selection of equipment and techniques to treat wildlands, the availability and operative experience of existing personnel is a primary consideration. Most implements used on wildlands are costly and are not widely available. In addition, these implements are often used on steep, inaccessible sites that require highly skilled operators. A large support staff, spare equipment, and repair facilities may be required to sustain a major rehabilitation project. Without this contingent of personnel and equipment, rehabilitation procedures may not be effective. However, using the wrong piece of equipment cannot be justified simply because of poor preparation and planning.

Treatment procedures are usually as effective as the equipment operator. Chaining, railing, or plowing results differ considerably among operators. Field personnel and equipment operators should be advised of their role and responsibility in rehabilitation projects. Although methods used on steep slopes should be designed to lessen water runoff, equipment operators must be given flexibility to safely and efficiently operate the machinery. Chaining or railing up and down steep slopes does not always create rills or generate damaging runoff. Sufficient litter and surface debris usually remains in place to control erosion when juniper-pinyon or brush fields are treated.

Equipment operators should be directed to map or plot travel routes ahead of time to allow efficient operation of all equipment. Procedures used in monitoring fire suppression activities should be adopted to assist revegetation when aircraft or large equipment are used.

Economic Benefits and Treatment Costs

Attempting to project and quantify operation costs and resulting benefits is difficult for range and wildlife projects. Equipment operation costs including transportation, setup, maintenance, operations, and depreciation are identifiable expenses. However, equating returns based solely upon herbage production is not indicative of all benefit values. For example, attaching an accurate value to the establishment of certain secondary species that provide seasonal forage or protective cover for wildlife is difficult. Also, attempting to place a value on the habitat resources of a changing plant community is equally difficult. The long-term values of rehabilitation projects, particularly watershed protection, stability of wildlife populations, esthetics, and recreational uses are important considerations in most improvement projects. In addition, the continued degradation and loss of resource values, and the increased rehabilitation costs of deteriorated sites that are left untreated is of major consideration. All treatment benefits should be recognized in order to select appropriate plant control measures.

Treatment Impacts on Associated Resources

Converting the vegetative composition from one plant type to another (for example, trees to herbs) creates a dramatic change in scenery. Also, removing existing mature plants and establishing other species that have the same life form will still create a significant change in appearance for a number of years following treatment. Young plantings provide differences in ground cover, animal concealment, esthetics, forage production, and so forth. However, some benefits are registered quickly including improvement of ground cover and forage production.

Visual impacts are most noticeable immediately after treatment (burning, chaining, plowing). However, these effects are usually short lived. Natural changes usually occur rapidly and mask initial impacts. Foregoing appropriate restoration measures because of the initial impacts to esthetics is not justified. Plant communities that support weedy species are usually esthetically unpleasant as well, and the conversion process should be viewed as an improvement.

Plant manipulation procedures are a part of the improvement process. Sites dominated by weedy annuals or supporting unwarranted numbers of woody species should be regarded as disclimax conditions. Restoration of these areas will ultimately enhance all resources.

Certain steps may be taken to limit visual impacts, particularly when extensive changes are proposed. Treatments can be used that retain some plants in appropriate areas. Treatments can be laid out in a mosaic design to lessen visual impact. Treatments that result in straight lines and square corners are not recommended. Treatments can also be conducted over a period of years to stagger the number of acres treated at one time, and allow some sites to recover satisfactorily before further treatment is initiated.

Sites located on similar aspects can be treated at the same time leaving areas on different aspects for later treatment. If this is done, areas treated at any one time should be large enough to support the increased use that is normally imposed on new seedings. In addition, restoration measures should be confined to the areas needing treatment. Attempts to appease esthetic concerns should not result in inappropriate areas being treated simply because they are less visible, and problem areas left untreated because of high visibility.

A variety of herbaceous and woody species can and should be seeded in most areas to provide initial cover and herbage. Many native herbs and some shrubs that are released when weeds are removed will recover quickly. In almost all situations, the recovery of desirable natives can be encouraged to effectively enhance the initial cover. Chaining, railing, and burning can be used to stimulate regrowth and improve vigor of certain species through the removal of weedy competition. Antelope bitterbrush, snowbrush ceanothus, blue elderberry, chokecherry, Gambel oak, and Rocky Mountain maple are but a few of the shrubs that respond quickly. Quick recovery under more arid circumstances is often more difficult to achieve, but seedings of big sagebrush, rabbitbrush, winterfat, and fourwing saltbush grow quickly and can be used to lessen initial visual impacts.

Site renovation programs are often conducted to rectify and protect highly valuable onsite and associated offsite resources. Important watersheds often require treatment to maintain downstream values. Wildlife habitat projects may be required to stabilize game herd productivity, reduce heavy animal losses that occur during harsh winters, and prevent trespass damage to agricultural crops. The related resource values of most range and wildland projects are important, and few restoration projects are developed to satisfy or benefit one resource.