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SEEDING SHRUBS IN THE FIELD[1]

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ABSTRACT

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Production from degraded rangeland may be increased by sowing with shrubs. Before reseeding an area it should be established that a change in plant cover is desirable and that the terrain is suitable for seeding. Rainfall or water supply should be adequate to ensure survival of seeded species. It may be desirable to sow mixtures of species. Care should be taken in the preparation of the seed bed and in optimizing seeding rate, spacing and depth. Factors which may be important in ameliorating harsh environmental conditions include the use of mulches, water ponding and soil compaction.

1. INTRODUCTION

Much of the world's rangeland has been degraded, some severely (Perry, 1978); if rangeland can be returned to good condition, productivity will be greatly increased. Unwanted plants, severe droughts, improper cropping practices and past abuses by grazing animals have resulted in low production and/or high erosion. Manipulative practices have been developed because the land manager wishes to change the plant composition or production on all or part of a site, thereby making sites more useful (Herbel, 1981).

The potential for increasing forage production from sub-climax rangeland through resowing is not generally appreciated (de V. Booysen, 1978). Intensive procedures may be required to maintain the vegetation necessary for the production of livestock, the control of soil erosion, the improvement of wildlife habitat and the preservation of recreational areas.

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The relative costs of revegetation may be high but the potential benefits are also great (Herbel et al., 1977). Revegetation requires attention to detail and substantial management because of the risk involved; even correct practices do not guarantee good results. The land manager should attempt to maximize the benefits rapidly while maintaining or improving the resource and minimizing the need to repeat the practice. Revegetation is generally a difficult undertaking because of labour and equipment requirements, and limiting climatic, soil and topographic features. Revegetation is accomplished by transplanting or seeding propagules. Seed may be sown either directly (e.g. by drilling) or indirectly (e.g. by scarifying the soil surface to trap wind blown seed). This paper summarizes the principles and practices of direct seeding.

2. PRINCIPLES

The principles for range reseeding given below have been previously discussed by Plummer et al. (1968), Merkel and Herbel (1973) and Herbel (1981, 1983). The first principle in any range seeding project is to establish that seeding is both necessary and desirable. Seeding is expensive and establishment is risky; seeding should be avoided if possible. A useful stand of desirable plants may be alternatively achieved by selective plant control or a change in grazing management. Before undertaking reseeding, the potential of a site should be determined. Where desirable vegetation has been severely depleted, natural recovery can take several years, or may never occur. Under such conditions, reseeding may be the only hope of re-establishing desirable plants. Introduced plants may be more productive or may better meet a specific need than native plants.

For seeding to be successful the terrain and soil must be suitable. Deep, fertile soils on level to gently sloping land are preferred. Shallow or rocky soils seldom have the potential to justify expensive reclamation measures. The degree of soil salinity must also be assessed and accommodated.

Precipitation and the availability of water must be adequate to ensure germination, establishment and survival of seeded species. Water requirements are dependent on temperatures; in temperate climates a minimum of 250 mm of annual precipitation may be needed. Where precipitation is limited, only the more drought resistant species should be used. Existing vegetation is a good indicator of moisture requirements.

Plant species selected for seeding must be compatible with management objectives, for example with respect to palatability or growth period. It is important to use species and varieties that are well adapted to the soil, climate and topography of the site being revegetated. If native plants are to be sown, species of local origin should be used. Improved ecotypes, varieties and introduced species may also be available for revegetation.

There are advantages to sowing mixtures of plant types. A disease or insect infestation can eliminate one species, whereas a mixture may have a greater capacity to survive such factors. Mixtures may include species adapted to the different conditions often encountered in variable terrain. Mixtures of grasses, forbs and shrubs may better satisfy the various aims of revegetation, e.g. grazing, erosion control.

Correct seeding dates are important. The best time to seed non-irrigated areas is immediately before the season of the most reliable rainfall, and when temperature is favourable for plant establishment.

Seedlings of most species used for sowing rangeland are slow growing and do not compete with existing, unwanted plants. A good seed bed reduces or removes competing vegetation, improves the micro-environment for seedling establishment and improves soil moisture conditions.

Many areas are deficient in soil water; mulching provides more soil water, reduces high soil temperatures and reduces erosion; summer fallowing or establishing basins or pits also provides more soil water.

The optimum depth of seeding depends on the plant species. Equipment should be used that places the seed at the desired depth. Stands are frequently lost because seed is planted too deep; a rough guide is to plant seed at a depth of 4-7 times the seed diameter.

It is important to use enough seed to ensure a good stand, but too much can produce a stand of seedlings so thick that individual plants compete with each other. At least one shrub and 10 desirable herbaceous plants per 9 m^2 should be present after revegetation. Seeding equipment needs to be checked frequently to ensure that it is delivering seed at the desired spacing and rate. Species of plants, seed viability and potential productivity of the site are the major factors influencing the optimum seeding rate. Seeding rates providing 125-250 pure live seeds (PLS) m^{-2} should be used when sowing with a drill. Broadcast seeding is an inefficient method which should be avoided; many seeds are left on the soil surface where germination and seedling establishment are tenuous. Where broadcast seeding must be used, a rate of 500 PLS m^{-2} is recommended.

Dormancy of most seeds can be reduced by stratification, i.e. subjecting them to temperatures of 0-4^{o}C for 6-20 weeks in moist sand, peat moss or newspaper. For some shrubs, dormancy is overcome by treatment with thiourea or scarification (with sulphuric acid or mechanical abrasion).

Revegetated areas must be properly managed; seedings must be protected from grazing by animals until the end of the second growing season, or until the seeded species are well established. Spraying to control weeds competing with the new seedlings can improve establishment. Rodents, rabbits, insects and other pests should also be controlled.

3. SPECIES AND ENVIRONMENTAL FACTORS

Selection and propagation studies have demonstrated that a number of native and exotic species can be successfully established within most saltbush/grass communities in the Intermountain Region of the western United States (Blaisdell et al., 1982). Species selected for their forage, cover, productivity, adaptability and ease of establishment included Artemisia spp. (sagebrush), Atriplex canescens (fourwing saltbush), Ceanothus martini (Martin ceanothus), Chrysothamnus nauseosus (rubber rabbitbrush), Cowania mexicana (Mexican cliffrose), Ephedra viridis (green mormontea), Eurotia [Ceratoides] lanata (common winterfat), Purshia glandulosa (desert bitterbrush), P. tridentata (antelope bitterbrush) and Sambucus cerulea (blueberry elder).

Seeds of Atriplex canescens remain viable for many years under ordinary dry storage (Springfield, 1970). After ripening is complete (in 10 months) only about half the seeds contain embryos. De-winging seeds with a hammermill facilitates handling and hastens germination. Size of seed is variable and, for de-winged seed, the number per kilogram varies from 0.3×10^6 to 1.7×10^6. The optimum temperature for germination is 13-24°C; seeds are fully saturated with water within 24 h (Springfield, 1970). Seeds should be planted 13-25 mm deep in a prepared seed bed. Mulching usually improves seedling establishment. Because A. canescens is cross-pollinated, it is not possible to establish genetically similar plants from seed (Wiesner and Johnson, 1977).

In a hot arid environment, reducing soil temperatures can improve seedling establishment (Herbel, 1972a). The effects of a layer of dead shrubs on soil temperatures were studied on a fine sandy loam site in southern New Mexico. A single cut shrub was used as light cover and a layer of three cut shrubs was used as heavy cover. The maximum air temperature 10 cm above the ground surface for a summer period was 33°C. The average daily maximum soil temperature at a depth of 13 mm was 57°C under no cover, 49°C under light cover and 36°C under heavy cover. Sosebee and Herbel (1969) studied the effects of maximum daily soil temperatures of 39°C or 53°C on germination of 12 grass species and one shrub in soil at field capacity. Emergence of Atriplex canescens was 0.5% of viable seed at high temperatures and 170% of viable seed (as determined by a standard germination test) at low temperatures. The latter indicated a more favourable environment than conditions used in a standard laboratory germination test. No seedlings survived after 21 days at high temperatures but 98% survived at low temperatures. In a similar 21 day trial, but with various levels of soil water, it took 7 cm of water for survival of two grass species at low temperatures and 23 cm for survival at high temperatures (Herbel and Sosebee, 1969).

In difficult environments, mulches should be considered for shrub establishment (Springfield, 1972). Straw and hay anchored with a disc plow are commonly used. Other natural mulches include leaves, peat, sawdust, woodchips, manure, gravel, brush and stubble. Stubble mulching involves sowing an annual crop the year before the intended seeding of shrubs, to prevent wind erosion and provide a more favourable micro-climate for shrub seedlings. The annual crop is seeded in rows 25-50 cm apart and is prevented from forming seed (Merkel and Herbel, 1973).

Synthetic mulches include liquids that can be sprayed on a soil surface to form a thin film, such as resin or asphalt emulsions, and canvas, burlap and plastics that are laid on the soil surface after seeding (Springfield, 1972). If seeds are sown when solar radiation is high, the mulch should be reflective. A thin coating of almost any reflective material will reduce soil temperatures and soil water tensions. Mulching (with plastic film, cinders or foliage of Juniperus spp.), deep furrowing and fallowing, increased penetration and retention of soil moisture, delayed crusting of the soil surface and reduced soil temperatures (Lavin et al., 1981). Drilling on the surface of the soil was as successful as deep furrowing.

Compacting soil after sowing (with heavy wheels, diameter 20 cm, width 5 cm, weight 9.2 kg) reduced soil water required for germination and emergence of annual forbs on a loamy sand soil (Yadav and Gupta, 1977). To obtain a 75% emergence without compaction, 9% soil water in the seed bed was needed; the use of a packing wheel resulted in the same emergence with 6-7% soil water. In contrast, Atriplex halimus (Mediterranean saltbush) could not emerge from a compacted surface (Koller et al., 1958). Seeds were sown in moist shallow furrows at a depth of 2-5 cm. In some furrows, the covering soil was firmly packed while in others it was left loose. On drying, the packed soil formed a hard crust which most of the germinating seedlings could not penetrate. In furrows covered with loose soil, full rows of seedlings appeared within 3-4 weeks after sowing.

Ponding of water assisted in reclaiming bare scalds in arid (less than 250 mm annual precipitation) portions of New South Wales in Australia (Newman, 1966). The treated areas were relatively flat, and the soils were deep clay to clay loam. Banks were constructed to pond water to depths of 15-25 cm. Results were poor but some stands of several saltbush species were obtained.

Concentrating water into the seed bed, through various land forming procedures, does not always ensure seedling establishment (Herbel, 1972b). Surface soil dries rapidly in hot, arid and semi-arid areas. This may form a heavy crust on medium to heavy textured soils. If the surface could be protected to reduce evaporation, seedling emergence and establishment would be greatly enhanced.

4. EQUIPMENT AND PRACTICES

The types of drills used for range seeding are the rangeland drill, the press seeder, the grain drill, the range interseeder and the browse seeder (Herbel, 1981). These drills can be modified to plant chaffy seed. The major broadcasting methods are aerial seeding and ground applications with rotary spreaders or mechanisms using an air stream. Cook (1976) suggested that drilling is superior to broadcasting, but Hodder (1976) indicated that broadcast seeding may have a place in reclamation of mine spoils. Much of the earlier work was done on unprepared seed beds, but when seed beds are well prepared, broadcast seeding can be successful.

In the north-east pastoral zone of South Australia, successful regeneration of rangeland depends on trapping wind-borne seed, concentrating moisture from light rain and protecting young seedlings from the blast effect of wind-borne sand (Young, 1969). A tyned pitter was developed for use in this area, and has resulted in natural revegetation with desirable plants such as Maireana and Atriplex species.

In north-western Australia, a plow with opposed disc blades and a centrally mounted ripper point was developed for furrow seeding (Fitzgerald, 1969, 1982). Early experience indicated that a bank formed from loose soil heaped onto compacted ground collapsed when wet. The bank of loose soil proved more stable when a ripper point was placed between the disks. Cenchrus ciliaris, C. setigerus and Aerva javanica have been successfully seeded with this technique.

In New South Wales, a mixture of Atriplex nummularia, A. vesicaria, Maireana brevifolia and M. pyramidata was successfully established on hard-pan sites by tyne pitting and broadcast seeding (Stanley, 1978). Initial establishment was favoured by above average rainfall; A. nummularia proved to be more tolerant of prolonged flooding than either A. vesicaria or M. pyramidata. However growth of the latter two species was greater during a subsequent hot dry period while A. nummularia and M. brevifolia began to die. M. brevifolia responded to subsequent rainfall but A. nummularia did not recover.

In the Intermountain region of the USA, Eurotia lanata is an excellent forage producer in calcareous soils (Stevens et al., 1977). Aerial broadcasting followed by some disturbance such as chaining or pipe harrowing gives a light soil cover within the depth range 1.6 - 6.4 mm and produces the best stands. Late fall or winter plantings are the most successful in Utah.

In southern Arizona, establishment and survival of Atriplex canescens was much higher on a calcareous soil (pH 8.0) than on a neutral non-calcareous soil (Cable, 1972). Transplanted A. canescens survived better where noxious plants were removed by grubbing than where they were removed by spraying with picloram or on untreated controls.

In northern Arizona, A. canescens and Kochia prostrata were successfully seeded in two of three pinyon/juniper sites (Lavin and Johnsen, 1975). Furrows in cultivated plots were spaced 0.3 m apart and the seed was planted 6 mm deep.

In studies with transplants of A. canescens, a vesicular arbuscular endomycorrhiza was found growing in association with the root system (Williams et al., 1974; Aldon, 1976). A mycorrhiza was also found in Amelanchier oreophila, A. utahensis, Artemisia tridentata, Cercocarpus montanus and Eurotia lanata (Williams and Aldon, 1976). It may prove important to inoculate seed of shrubs.

5. CONCLUDING REMARKS

Despite many advances, shrub sowing remains unreliable. There is a need for better description of the environmental parameters required for good establishment so that sowing techniques can be made more reliable. Better adapted species and improved sowing methods will reduce the risks and costs of revegetation and make it a more acceptable tool for land managers.

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