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MECHANICAL TREATMENTS AND INTERSEEDING ON NORTHERN PLAINS RANGELANDS

by

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This paper is a literature review of mechanical treatments and interseeding on the Northern Plains. The mechanical treatments included are waterspreading, ripping, contour furrowing, pitting, scalping, and disc plowing. The primary literature covered is that related to work that has been performed on the Northern and Central Great Plains.
INTRODUCTION

The Northern and Central Great Plains comprise the Northern Plains. This includes vast areas in Alberta and Saskatchewan, Canada, and the states of North and South Dakota, Wyoming, Montana, Nebraska, and Kansas (Rauzi and Fly, 1968). Much of this area is occupied by wheat and other crops but most is devoted to range livestock production (Weaver and Albertson, 1956).

Climate is highly variable from year to year. The average annual precipitation ranges from 10 to 20 inches. The average growing season is from 60 to 180 days. Frequent droughts and hot, drying winds characterize the area (Rauzi and Fly, 1968).

Domestic livestock were introduced into the Northern Plains in the 1800's. By 1900, the plains buffalo had virtually been eliminated and replaced by thousands of cattle. As early livestock operators had no previous knowledge of the ecology of the area, serious overgrazing occurred. Continuous overgrazing and drought combined to damage the more palatable and productive species in favor of less desirable species (Weaver and Albertson, 1956).

Today, livestock production is limited by low forage availability. High land prices and high operating costs mean that increased forage production from these deteriorated ranges would be an extremely desirable goal (Taylor, 1967).
The literature of methods designed to bring about a rapid and economic improvement of these ranges by surface modification through mechanical treatments and interseeding is reviewed in this paper.
WATERSPREADING

Definition

Waterspreaders are systems of dikes constructed to automatically divert runoff water from gullies, stream channels, or courses and distribute it over adjacent rangeland flood plains or valley floors (Valentine, 1971; Miller et al., 1969).

Objective

Pierson (1955) separated the objectives of waterspreading into two parts, the primary being the control of erosion and conservation of moisture. Secondary objectives were listed as sediment retardation, increased forage production, restoration of ground water, stream flow regulation, and improvement of wildlife habitat.

Benefits

In Montana, Branson (1956) found a 260 percent increase in herbage yield, total basal ground cover increased, protein, phosphorus, and calcium content of plants increased, and plant composition changed with big sagebrush (Artemisia tridentata) and plains pricklypear (Opuntia polyacantha) decreasing and foxtail barley (Hordeum jubatum) increasing. Monson and Quesenberry (1940 & 1958) found that the heavy growth of western wheatgrass (Agropyron smithii) was rapidly crowding out the
sagebrush (*Artemisia nova*). Forage production increases averaged from 300 to 350 percent. While natural precipitation had reached to a depth of 6 to 8 inches on check plots, flooded areas had water down to four feet. Houston (1960) reported yield increases up to 353 percent. Western wheatgrass increased at the expense of blue grama (*Bouteloua gracilis*). Frank Sparks of Plevna, Montana, found that a system of waterspreading dikes provided a much needed hay base for his ranch in addition to providing an erosion control measure (Handl, 1975).

In South Dakota, Mooney (1956) reported harvests of 400 tons more hay per year and between 40 to 50 thousand pounds of No. 1 certified alfalfa seed with the system than without it. As much as 6 inches of silt may be deposited from a single runoff. Alfalfa is killed but western wheatgrass can push its way through and flourish.

In Canada, Hubbard and Smoliak (1953) reported herbage production increases as high as 3400 percent. Pierson (1955) stated that a realistic figure for forage production increases would be from 3 to 5 times the former grazing capacity.

**Costs**

Branson (1956) quoted $9.96 per acre as construction cost and from zero to $6.55 per acre as maintenance costs. It cost Monson and Quesenberry (1958) $1.50 per acre to construct their waterspreader. They reported that results have more than justified the expense. Houston
(1960) reported that the annual gross returns from the system per acre were 7 to 10 times the annual costs per acre. Taking inflation into consideration in the last few years, waterspreading is still a paying proposition when comparing it to the expense of acquiring additional land. Mooney (1956) set construction costs at $6.70 per acre and maintenance and operating costs at less than 20 cents per acre per year. Hubbard and Smoliak (1953) figured dikes 1.5 to 2 feet high cost 36 cents per acre. Pierson (1955) reported that a waterspreader costs the Bureau of Land Management from $1 to $20 per acre depending on the complexity of the system and amount of construction involved.

**Design and Adaptation**

Waterspreaders are not built to a pattern but are built to fit the ground (Vallentine, 1971). Some factors important to the design and suitability of a system are volume and frequency of the runoff, or the maximum volume of water the system must accommodate without damage. Another important factor to consider is water quality. Dissolved salts can pollute downstream waters or add too much salt to the soil. Soil characteristics such as salt content, texture, slope, structure, and permeability are also important (Pierson, 1955). The watershed area should provide at least one flooding per year for satisfactory forage production. Areas with less than nine inches of average annual precipitation are generally not suitable for waterspreading. Also water-
spreaders should be restricted to sites whose soils are deep enough to store at least 4 inches of water (Miller et al., 1969).

Summary

Waterspreading, in addition to improving deteriorated ranges through moisture additions, also through its by-product, the sediment, fertilizes the land to enhance the productivity and prevent further problems downstream. It is best adapted on rangeland watersheds previously over-grazed with greater than 9 inches of rainfall, adequate soil water storage capacity, and at least one flood from runoff water in intermittent gullies during the growing season.
CONTOUR FURROWING

Definition

The Range Term Glossary Committee (1974) of the Society of Range Management defined a contour furrow as:

"A plowed or listed strip on a contour line for the purpose of water retention."

Objective

The purpose of contour furrowing is to reduce runoff and thus erosion, siltation, and overflow on lower lying lands and to conserve runoff moisture for increased grass production (Brehm and Malmsten, 1954; Soiseth et al., 1975).

Equipment

Barnes (1952) and Barnes and Nelson (1945) used a groover (lister adaptation) and an ordinary moldboard plow. Brehm and Malmsten (1954) listed cultivators, modified listers, and toolbar machines equipped with small shovels as possible machinery for contour furrow construction. Branson et al. (1962) used a converted disc plow to make their furrows. Fisser et al. (1973), Soiseth et al. (1973), and Branson et al. (1966) used the Model B contour furrowing machine developed by the U.S. Forest Service. Branson et al. (1966) also used a motor patrol to construct their broadbase furrows. Wight and Siddoway (1972) used a machine
similar to the Arcadia Model B.

Furrows

In Wyoming only closely spaced (2 to 5 feet) furrows were effective in improving shortgrass range. The depth of the furrows was from 4 to 5 inches and width varied from 5 to 10 inches (Barnes and Nelson, 1945; Barnes, 1948, 1950 & 1952). Fisser et al. (1973) placed furrows 10 to 12 inches deep and 5 feet apart. Dams were placed in the furrows every 10 feet.

In Montana, Wight and Siddoway (1972) on panspot and saline upland sites constructed contour furrows 6 to 8 inches deep and 18 to 20 inches wide on 5 foot centers. Check dams were placed every 15 feet in the furrow. Furrow bottoms were ripped an additional 8 inches below the furrow. Branson et al. (1962) used a 3 foot spacing for their furrows. Soiseth et al. (1973) placed furrows 18 to 20 inches wide, 5 feet apart, and 6 to 10 inches deep. Rippers ahead of the discs reached to a depth of 16 inches. Dams were placed in the furrows every 16 feet.

In Nebraska, Brehm and Malmsten (1954) reported that furrow size and spacing depend on the purpose and amount of runoff to be intercepted. If vegetation response is desired, furrows should be 2 to 5 feet apart and less than 6 inches in depth. Wider and deeper furrows are required for reduction of runoff. They also presented graphs, charts, and formulas for figuring the expected runoff, storage capacity of the furrows,
and size and spacing of the furrows.

Branson et al. (1966) made furrows 5 feet apart, 8 to 12 inches deep, 20 to 30 inches wide, and dammed them at 40 to 20 foot intervals. Their broadbase furrows consisted of a series of low dikes 1.5 to 2 feet tall which do not qualify as waterspreading dikes because water is not diverted onto them; only moisture from adjacent hillsides is retained.

Cover Removed

Soiseth et al. (1973) reported that their furrows totaled 30 to 40 percent of the surface of the area.

Furrow Capacity

Branson et al. (1966) reported that immediately after construction, furrows could store more than two inches of water but that after 9 years water retention capacity of the furrows stabilized at one half inch.

Time to Furrow

Brehm and Malmsten (1954) suggested early spring or late fall as the better times to furrow. Barnes and Nelson (1945) and Barnes (1952) stated that early spring before much growth starts is the best time to furrow on shortgrass range. Branson et al. (1966) stated that in regions of high summer precipitation spring furrowing is best.

Benefits

In Alberta, Canada, Hubbard and Smoliak (1953) reported that contour
furrows were of no value because they became filled with ice and snow during the winter, were more than 10 feet apart, were too shallow (4 to 5 inches deep), and because the overturned sodded furrow slice was exposed to the eroding action of the wind and water.

In South Dakota, Nichols (1969) on dense clay sites found that furrowing was of no value due to erosion and siltation caused by heavy rains and lack of protective vegetation. Natural recovery of the range by secondary succession was as rapid and effective in the absence of furrowing due to deferment and improved growing conditions.

Barnes and Nelson (1945) and Barnes (1952) on shortgrass range reported heavier stocking rates, increased sheep gain per acre, and more grass left at the end of the season. Fisser et al. (1973) reported increased forage production on clay loam soils by contour furrowing and broadcast seeding of crested wheatgrass (*Agropyron cristatum*). The vigor of nuttall saltbush (*Atriplex muttallii*) was also improved by the furrowing.

Branson et al. (1962) reported forage production increases from contour furrowing and broadcast seeding of crested wheatgrass and yellow sweetclover (*Melilotus officinalis*) on slick and semi-slick sites. They suggested, however, that damming the furrows every 40 feet may be a better treatment for improving the slick soils as the dams would prevent water from moving from the impermeable soil and allow it to soak in. Working with panspot sites, Soiseth et al. (1973) reported increased
forage production, reduced sodium hazard, and increased infiltration on clay loam soils from contour furrowing. Wight and Siddoway (1972) reported a 100 percent increase in precipitation-use efficiency, a 43 percent increase in soil water, a reduction in clubmoss (*Selaginella densa*) and cactus (*Opuntia* sp.) and an increase in western wheatgrass and blue-bunch wheatgrass (*Agropyron spicatum*), and a 58 percent increase in the nitrogen content of the wheatgrasses the first year after treatment on clay soils with low infiltration capacity from contour furrowing.

Branson et al. (1966) reported an average increase in forage production of 500 pounds per acre from contour furrowing and broadcast seeding of crested wheatgrass from 26 sites in four states. Contour furrowing also increased moisture storage and moved salts downward to 60 centimeters and more. They also reported yields over 1500 pounds per acre from the two sites sampled from broadbase furrowing. Biswell (1968) stated that the amount of improvement from furrowing will depend on soil conditions, frequency and amount of precipitation, and the kind and condition of the vegetation.

Costs

Hubbard and Smoliak (1953) reported that for a machine that furrows in one direction only, the cost will be 40 to 80 cents per acre, but for a furrower that runs both ways, this cost could be halved. Barnes and Nelson (1945) stated that costs depend on the spacing interval. Con-
tour furrowing is more expensive than pitting because it requires an instrument to see that the furrows are level and it is slow to install. Branson et al. (1966) reported costs for a four state area that range from $3.50 per acre for contour furrowing and broadcast seeding.

Longevity

Fisser et al. (1973) estimated that the increased production effects of their furrows would last 30 years although after 10 years the furrows had lost 30 percent of their original water holding capacity. Nichols (1969) reported furrows silting over within a few years on dense clay sites. Branson et al. (1962) recorded production results from furrows still effective after 10 years. Soiseth et al. (1973) reported increased forage production from furrows constructed 11 years previously. Wight and Siddoway (1972) stated that site characteristics and quality of construction determine the longevity of contour furrows. The water holding capacity of furrows decreases with time with most of the decline occurring in the early period after construction (Wight and Siddoway, 1972; Branson et al., 1966; Fisser et al., 1973).

Adaptation

Contour furrows should be restricted to areas with slopes of less than 20 percent, where soil is 10 inches deep or more, where there are few rocks, and where there is significant runoff, thereby eliminating sands or sandy sites (Brehm and Malmsten, 1954; Wight and Siddoway,
Branson et al. (1966) reported that of 8 vegetational types in four states treated by contour furrowing, nuttall saltbush responded most favorably. The treatment was unfavorable on winterfat (Eurotia lanata), black grama (Boutelousa eriopoda), and needleandthread (Stipa comata) sites due to salinity problems and course textured soils.

Water Versus Nutrients

Hubbard and Smoliak (1953), Houston (1965), Rauzi and Fly (1968), and Barnes (1952) stated that moisture is the major limiting factor of range forage production. Wight and Siddoway (1972) reported that nutrient availability is the major limiting factor. Wight and Black (1971) stated that water does not limit plant growth to the extent that nutrient availability does.

Summary

Contour furrowing is best adapted to medium or fine textured soils where there is a significant amount of runoff. The furrows trap the silt-laden runoff water from flowing downstream and causing problems. In addition they allow the water normally lost through runoff more time to penetrate the soil making more water available for increased plant growth. The tillage reduces the competition for water and stimulates the more productive mid grasses by making more water and nutrients available per remaining plant. Furrow spacing and size depend on the purpose and amount of runoff to be intercepted. Exact contour placement
of furrows is not critical where check dams are placed in the furrows. Site characteristics and quality of construction determine the longevity of the furrows. Closely spaced furrows are more effective in stimulating vegetative responses than wider spaced furrows. Early spring appears to be the best time to furrow. On deteriorated rangelands with remnants of climax species it appears to be an economical range improvement practice. Contour furrowing and seeding in the furrows is a practice called interseeding to be covered later.
Pitting

Definition

Pitting is making shallow pits or small basins of suitable capacity and distribution in the soil to catch and hold precipitation and reduce overland flow from rainfall and snowmelt, and on some sites to renovate the existing vegetation (Myles, 1974; Range Term Glossary Committee, 1974; Vallentine, 1971).

Objective

The purpose of pitting is to catch, hold, and store rainfall and runoff water for increased plant growth and erosion control and to encourage productive mixtures of native grasses (Barnes et al., 1958; Vallentine, 1971). Wight and Siddoway (1972) stated that pitting prevents water from running off the land.

Equipment

Barnes and Nelson (1945), Barnes (1948, 1950, & 1952), Rauzi and Lang (1956), Lang (1958), and Rauzi (1973) used an eccentric one-way disc. Rauzi et al. (1962) and Rauzi (1968) used a disc pitting and seeding machine described by Becker and Lang (1953). Houston (1965 & 1971) used an offset disc to make pits. Branson et al. (1966) used two types of pitters, the eccentric disc and the spike tooth or rotary pitter. Wight and Siddoway (1972), Ryerson et al. (1974), Ryerson (1970),
Taylor (1967), and Wight and White (1973) used a modified one-way disc plow. Biswell (1968) stated that the equipment most commonly used is a one-way disc with alternate discs two inches larger in diameter and mounted 2 inches off center.

**Pits**

In eastern Colorado Myles (1974) reported that pits are usually 3 to 7 inches deep and 1 to 4 feet long depending on soil conditions and the machine used.

Barnes and Nelson (1945), Barnes (1948, 1950, & 1952), Barnes et al. (1958), and Biswell (1968) gouged small basins 16 inches apart giving a waffle-like appearance. Since the pits aren't connected they don't have to be on the contour. Only closely spaced mechanical treatments such as pitting were found to be effective in improving shortgrass range production and composition. Spacing greater than 5 feet had no significant effect on forage production. Rauzi et al. (1962) and Rauzi (1968) used a pitting and seeding machine which constructed pits at right angles to the slope 7 inches wide, 4 inches deep, 5.5 feet long, and 8 feet apart with 17 inches of spacing between rows which was described by Becker and Lang (1953). Lang (1958) made pits 4 feet long, 7 inches wide, and 4 inches deep in work in the Big Horn Mountains.

Wight and Siddoway (1972) and Wight and White (1973) constructed pits 4 feet long, 6 inches wide, and 4 inches deep. Ryerson et al.
(1974), Taylor (1967), and Ryerson (1970) constructed pits 8 inches wide, 4 inches deep, and 30 inches long.

In reporting observations from six states Branson et al. (1966) reported that pits made by an eccentric disc varied from 2 to 6 feet long, 6 to 8 inches wide, 3 to 6 inches deep, and were spaced 16 to 42 inches apart while those made by a spike tooth or rotary pitter were 10 to 18 inches deep and were spaced 3 to 6 feet apart. The pits made with the eccentric disc pitter were 6 feet long, 6 to 8 inches deep, and were spaced 42 inches apart which is larger than normal.

Cover Removed

Barnes and Nelson (1945), Barnes (1948, 1950, & 1952), Barnes et al. (1958), Rauzi and Lang (1956), Lang (1958), Rauzi (1973), and Rauzi et al. (1962) estimated that pitting covered 30 percent of the surface of the area. Wight and Siddoway (1972) and Wight and White (1973) covered 30 percent of the ground surface either with pits or overturned sod. Ryerson et al. (1974), Taylor (1967), and Ryerson (1970) disturbed 45 percent of the surface of the area.

Longevity

Barnes (1950 & 1952), Barnes et al. (1958), and Rauzi and Lang (1956) reported that shortgrass range pitted 10 to 13 years previously still supported one third more grazing capacity and more lamb gain per acre but the effectiveness of the pits had declined due to siltation and
revegetation. They concluded that pits should be reconstructed every 10 years if high productivity is to be maintained.

Rauzi et al. (1962) and Rauzi (1968) found that the pits on south facing slopes had completely weathered away 4 years after pitting. Siltation and revegetation on upland and bottomland pits reduced their water holding capacity. A pitted pasture can maintain increased grazing capacity for 15 years with proper grazing management. Rauzi suggested that resting a pasture a year or two during the growing season to allow plants to regain vigor before repitting would be a good policy. Rauzi (1973) stated that range site, climate, and management determine the effectiveness and longevity of pitting and that pits could be expected to last 15 years on fine sandy loams near Cheyenne, Wyoming.

Branson et al. (1966) reported that pits made by the eccentric disc pitter were obliterated 8 years later. Wight and White (1973) estimated the longevity of their pits to be 26 years. Ryerson et al. (1974) and Ryerson (1970) reported that the effects of pitting were still evident 9 to 14 years later.

Pit Capacity

Barnes and Nelson (1945), Barnes (1950 & 1952), Barnes et al. (1958), Biswell (1968), and Rauzi and Lang (1956) reported that newly constructed pits could hold 0.3 inches of rainfall. The pits constructed by Branson et al. (1966) could store 0.4 inches of rain.
Time to Pit

Barnes and Nelson (1945), Barnes (1950 & 1952), and Barnes et al. (1958) reported that early spring is the best time to pit. Houston (1971), Ryerson (1970), Ryerson et al. (1974), and Taylor (1967) reported pitting in the fall. Wight and Siddoway (1972) and Wight and White (1973) pitted in the spring.

Speed of Construction

Barnes (1948, 1950, & 1952) reported that with a 10 foot disc, 5 to 8 acres per hour or 30 to 50 acres per day could be pitted. Using an 8 foot disc 15 acres could be pitted per day. Becker and Lang (1953) reported that their pitting and seeding machine can cover 2 acres per hour.

Roughness to Travel

Barnes et al. (1958) suggested pitting in strips or skipping strips to lessen the problem of traveling across the pitted area. Vallentine (1971) recommended skipping roads and trails.

Seeding the Pits

Seeding western wheatgrass into pits on dense clay range sites in South Dakota was of little value because residual plants recolonized the areas as rapidly and more effectively by rhizomes (Nichols, 1969).

Seeding crested wheatgrass into the pits on shortgrass range was
unsuccessful but was successful on areas where competitive vegetation was sparse. When pits are seeded, grazing should be deferred to protect the seedlings for at least a year. Where mid grasses are absent, as in ranges in poor condition, complete seedbed preparation and seeding should be considered. In the Northern Plains seeding with pitting has generally been unsuccessful. In the Southwest desert area pitting is primarily done to conserve moisture for seeding purposes whereas in the Northern Plains pitting is done to conserve moisture and to encourage a better mixture of grasses (Barnes, 1952; Barnes et al., 1958). Competition from existing vegetation caused a pitting and seeding trial using crested wheatgrass and Russian wildrye (Elymus junceus) in the Big Horn Mountains to fail (Lang, 1958). Lang (1960) in the Teton National Forest reported poor stand establishment from pitting and seeding crested wheatgrass.

Houston (1971) reported that pitting and seeding alfalfa was superior to pitting alone in increasing perennial grass production even though establishment was low because the alfalfa contributed nitrogen to the grass. Taylor (1967) stated that pitting does not provide a suitable environment for seeding in the Northern Great Plains. Ryerson (1970) stated that seeding with pitting is not recommended.

**Adaptation of Pitting**

Myles (1974) stated that pitting is effective on medium textured
soils with high intensity storms. Factors he suggested to consider in assuring success and economy are soil type, time of year, vegetative cover, precipitation amount and time, type of equipment, whether to contract or own equipment, whether to interseed and if so, what varieties to use, longevity of pits, roughness to travel, and the economy of other soil treatments or grazing management as an effective alternative.

Barnes and Nelson (1945), Barnes (1948, 1950, & 1952), Barnes et al. (1958), Rauzi et al. (1962), and Rauzi and Lang (1956) reported that pitting is very effective on shortgrass range where there is a mixture of short and mid grasses in increasing production and improving composition. Even on slopes with a mid grass aspect, although composition was unaffected, forage production was increased slightly. Composition, however, was found to be more important to success of pitting than soil type. Pitting had little production effect on pure stands of wheatgrass, sagebrush-wheatgrass types, or desert shrub types. Light sandy soils with sparse cover, dense stands of sagebrush, and steep slopes should be avoided because of erosion problems, competition, and equipment operation problems.

Houston (1965) reported that pitting reduced soil moisture stress on two clay loam soils but had no effect on silty clay loam, overflow clayey, or fine sandy loam soils due to texture and inherent infiltration rates. Taylor (1967) stated that pitting is most practicable on areas where there is runoff moisture and where cool season mid grasses
are less than their potentials. Biswell (1968) stated that pitting is best adapted to arid areas of sporadic rainfall where most may be lost to runoff.

**Costs**

Myles (1974) gave a figure of $2.00 per acre or $1.00 per acre if cost shared for contract pitting. He stated that owning your own equipment may be slightly cheaper than contracting. He pointed out, however, that costs are highly variable, depending on the type of job and whether you use your own equipment or contract.

Barnes and Nelson (1945), Barnes (1948, 1950, & 1952), and Barnes et al. (1958) reported that pitting is less expensive than contour furrowing and that the cost is low (from 50 cents to two dollars per acre) relative to returns. Becker and Lang (1953) described a pitting and seeding machine which was lower in cost than conventional pull-type pitting machines.

Branson et al. (1966) stated that spike tooth pitting by contract costs $1.65 to $3.58 per acre while eccentric disc pitting costs $1.00 to $5.00 per acre depending on machine, acreage, and other factors. Wight and Siddoway (1972) found that of 5 treatments pitting cost the least. Wight and White (1973) concluded that assuming a life of 15 years, pitting would increase the carrying capacity 0.8 animal unit months per acre, but would cost $3.50 per acre which would make it unec-
onomical if other costs were added. Ryerson (1970) estimated the costs of pitting to be $1.50 to $3.50 per acre.

Benefits

Nichols (1969) on dense clay range sites found pitting to be of no value. Pits silted over and eroded away because they lacked protective vegetation and because of heavy rains. Natural recovery by secondary succession when encouraged by deferment and improved growing conditions was found to be as rapid and effective as pitting. If protective vegetation is present when an area is pitted, the pits may retain their water retaining capability and not erode away.

Myles (1974) reported that in some cases increased forage production has been over three times as high as non-pitted range. An estimate of benefits can be made from average local prices times the estimated increase in stocking rate plus reductions in erosion and flood damage, recharging of ground water supplies, and benefits to wildlife. Benefits will be greater for a landowner who also owns cattle. These benefits can then be compared to costs to see if pitting is economically feasible. He also stated that benefits vary with soil type, vegetation, and storm intensity.

On shortgrass range and fine sandy loam soils, Barnes and Nelson (1945), Barnes (1948, 1950, & 1952), Barnes et al. (1958), and Rauzi and Lang (1956) reported that because of its ease of application and its
effectiveness in increasing forage production, pitting was found to be the best of mechanical treatments tried. Pitted areas carried more sheep per acre, lamb gain per acre was greater, and more perennial grass was left at the end of the grazing season than the check areas.

They listed some of the effects of closely spaced mechanical treatments such as pitting, as thinning the cover, retention of water, renovation and stimulation of the vegetation, increased food and water per remaining plant from less competition, composition change from blue grama to western wheatgrass and enhanced composition of cool season mid grasses which hold snow and make 40 percent more moisture available for their use in early spring for increased forage production when warm season species can't use it. Other effects are increased feed in early spring, greater mulch accumulation for improved moisture conservation by improving penetration and reducing evaporation, greater variety of feed available, and more vegetative carry over from year to year.

Reasons given for greater gains per head and per acre on pitted areas were greater amount of forage, better variety of forage, better early spring forage, and forage remaining greener later into the summer. Although gain per head was almost identical on pitted and check areas western wheatgrass plans on pitted areas gave greater lamb gains per acre in direct proportion to the increased stocking rate with the same degree of utilization on both areas. They concluded, however, that with extensive revegetation shortgrass competition may cause vegetational
conditions to revert to the original shortgrass type.

Rauzi et al. (1962) and Rauzi (1968) repitted the pastures used by Barnes with a redesigned machine and observed 5 to 10 years later that, although the pits weren't as effective as those made by Barnes, pitting produced increased forage yields, more sheep days of grazing per acre, more sheep gain per acre, a heavier stocking rate, an increase in western wheatgrass and a decrease in blue grama. Water intake rates and storage capacity of the pits steadily decreased as the pits weathered and became revegetated. In both studies interseeding was found to be superior to pitting.

Lang (1958) found greater water intake, greater forage production, and greater height growth and seedstalk production from principal species from pitting in the Big Horn Mountains. Lang (1960) reported increased forage production from pitting and seeding in the Teton National Forest although seeding was rated as poor based on stand establishment. Rauzi (1973) reported increased production of perennial grass and sedges on pitted areas and areas pitted and sprayed with atrazine on fine sandy loam soils at Cheyenne, Wyoming. Biswell (1968) concluded that the greatest benefit from pitting is maximum penetration of rain from sporadic storms during the dry season when full utilization of the rainfall is vital.

Houston (1965) on clay loam soils reported moisture stress was lowest and water availability was highest on areas pitted due to less runoff
and more moisture infiltration and storage. Branson et al. (1966) reported that spike tooth pitting is of questionable value and that eccentric disc pits although obliterated probably produced the stand of seeded crested wheatgrass by removing competition and improving water and soil conditions. Houston (1971) reported increased western wheatgrass and perennial grass yields from pitting on an overflow site but that pitting had little effect on silty and dense clay sites.

On coarse textured soils Wight and Siddoway (1972) found that pitting increased precipitation use efficiency, increased soil water, increased the nitrogen content the first year after treatment, and improved species composition which they thought could be relatively permanent. On a sandy range site Wight and White (1973) found that pitting increased plant nitrogen content for two years after treatment, increased soil water content, and increased yields of sedges (Carex spp.) but increased total perennial grass in one year only.

Ryerson et al. (1974) found pitting to increase perennial grass and sedge production. Western wheatgrass responded more to pitting and fertilization than fertilization alone. Ryerson (1970) reported that pitting increased soil moisture and reduced competition from clubmoss which increased perennial grass production, increased total production, increased standing vegetation, increased organic mulch, and increased basal cover percentage of perennial grasses. However, pitting also increased fringed sagewort (Artemisia frigida). In dry years there were
no difference in total moisture between treatments and the check but in average or wet years 2.1 acre inches more water was stored to a greater depth by pitting. Protein content of the forage and yields were increased most next to the inverted sods due to increased nitrogen and moisture under the sods. Vegetative responses were attributed to increased depth of water storage and increased water at spring growth. Interseeding increased forage production more than pitting.

Taylor (1967) on silt loam soil reported an increase in total vegetation from an increase in vigor, ground cover, and production of desirable species and a decrease in blue grama. Maximum response was near pit edges and overturned sods which suggested optimum competition removal and also nutrient cycling under the overturned sods.

Summary of Pitting

Of all mechanical treatments used on the Northern Plains as range improvement methods, pitting is usually the least expensive to install. Costs vary from 50 cents to $5.00 per acre. The most commonly used piece of equipment has been the modified disc plow with discs eccentric, notched, or cut away.

Pits vary in size from 3 to 7 inches deep, 6 to 8 inches wide, 1 to 6 feet long, and spaced 16 to 42 inches apart. Pitting rows greater than 5 feet apart has little effect on the vegetation. Pitting removes or covers up between 30 to 45 percent of the surface of the area treated.
Pits can hold between three and four tenths of an inch of rainfall. The longevity of the pits varies with range site, climate and management. Some pits last only a few years while others are estimated to last as much as 26 years. The effects of pitting may remain long after the pits have weathered away.

Pitting in the spring appears to be best although some fall pittings have also been successful. Pits can be installed at a rate of from 2 acres per hour to 8 acres per hour depending on the machine used and soil conditions. All roads and trails should be left undisturbed for access through the pitted area. Pitting and seeding has usually been unsuccessful in the Northern Plains. It is successful only where the vegetation is sparse and there is little competition to the seeded species.

Pitting with few exceptions has consistently increased forage production through improved soil water conditions, reduction of competition, greater nutrient cycling, and desirable species composition changes toward the mid grasses. Benefits vary with soil types, vegetation and rainfall.

Pitting is best suited to medium and fine textured soils where there is significant runoff and where the composition is a mixture of short and mid grasses with mid grasses being less than their potential for the site. Areas to avoid are very coarse textured soils, poor and excellent condition ranges, rocky soils, slopes greater than 8 percent,
pure stands of western wheatgrass, desert shrub types, dense sagebrush areas, dense clay sites with a lot of loose soil from freezing and thawing, and all roads and trails. Pitting should run at right angles to the slope if not on the contour.
RIPPING

Definition

Ripping is a mechanical treatment which penetrates and shears range soils to a depth of 8 to 36 inches depending on restrictive layer depth. It is a range improvement practice where species of a rhizomatous nature can spread into the ripped soil (Vallentine, 1971; Range Term Glossary Committee, 1974). Wight and Siddoway (1972) stated that ripping improves infiltration by fracturing restrictive soil layers.

Objective

The objective of ripping is to break up subsoil compacted layers to increase water infiltration and storage and to improve root, organic matter, and nutrient penetration. Restrictive layers limit forage growth by reducing the area from which roots can extract water and nutrients (Range Term Glossary Committee, 1974; Branson, et al., 1966; Vallentine, 1971).

Equipment

Barnes and Nelson (1945), Barnes (1952), and Barnes et al. (1958) used a subsoil chisel. Branson et al. (1966), Fisser et al. (1973), and Soiseth et al. (1973) used the Arcadia Model B contour furrowing machine and Wight and Siddoway (1972) used a machine similar to it. Branson et al. (1966) reported that equipment used to rip is usually equipped with
wheels and vertical blades and requires a crawler tractor to pull. Wight and Siddoway (1972) also used a rotary subsoiler. Ryerson (1970) reported that ripping costs from $3 to $5 per acre. Vallentine (1971) stated that ripping is expensive and costs from $6 to $15 per acre.

**Rips**

Barnes and Nelson (1945), Barnes (1952), and Barnes et al. (1958) pulled a subsoiler 12 to 15 inches below the surface. The machines used by Branson et al. (1966), Fisser et al. (1973), Soiseth et al. (1973), and Wight and Siddoway (1972) ripped the soils an additional 8 inches below an 8 inch furrow depth. Wight and Siddoway (1972) also punched holes in a 3 by 3 foot grid pattern with their rotary subsoiler and stated that the holes could hold .3 inches of water per acre. Ryerson (1970) reported that the BLM used 2 inch chisels and 10 inch sweeps in various combinations of depths (2 to 4 inches), angles (45 to 90 degrees), and number of trips through an area. Branson et al. (1966) reported that blades penetrated the soil 14 to 30 inches. A 20 inch wing ripper opened a furrow 2 feet wide and 5 inches deep. Nichols (1966) ripped 12 to 14 inches deep and spaced rips 6 feet apart.

**Benefits**

The ripper used by Barnes and Nelson (1945), Barnes et al. (1958), and Barnes (1952) failed to increase forage production at any interval. Although ripping was combined with contour furrowing, Branson et al.
(1966), Fisser et al. (1973), Soiseth et al. (1973), and Wight and Siddoway (1972) reported their results as due to contour furrows and mentioned nothing of the effects of the ripping. On medium textured soil Wight and Siddoway (1972) reported that ripping increased soil water occasionally but no yield responses were noted. Ryerson (1970) reported that ripping favored the production of western wheatgrass and also fringed sagewort but stated that ripping with narrow chisels is not recommended.

Branson et al. (1966) reported that ripping as a general practice has not given large yield increases or improved soil conditions much. Auger ripping decreased perennial grass production. The wing ripper increased forage production on two lowland sites which they thought supported the view that surface, not subsoil, modification is needed to retain moisture and sediment and increase forage production. Construction-type ripper teeth which are wider than auger support blades also create a wider surface furrow which improves infiltration and retention.

Nichols (1966) on a heavy clay site reported that ripping opened compacted soils to water and increased grass production and the number of western wheatgrass plants.

**Summary of Ripping**

Ripping, chiseling, rotary subsoiling, and deep plowing are parallel terms. Ripping as a range improvement practice in the Northern Plains
is expensive and usually unsuccessful in increasing forage production. Because of the expense and high risk of failure, ripping should be done on a small area on a test basis before large areas are treated. A small area which is potentially productive but has a restrictive layer limiting plant growth should be considered. A ripper which can break up the subsoil restrictive layer and also give moderate surface modification appeared to be the most promising.
SCALPING

Definition

Wight and Siddoway (1972) stated that scalping is a seedbed preparation method for inserting desirable species into the range vegetation. Ryerson (1970) stated:

"Scalping consists of removing 10 to 25-inch wide strips of native vegetation and leaving undisturbed strips between. When these scalped strips are seeded the practice had been called range interseeding."

Objective

The purpose of scalping is moisture conservation because as more water is retained and not lost to runoff, more forage will be produced (Handl, 1975). Wight and Siddoway (1972) stated that scalping is a way to improve species composition without seeding. Where climax species such as western wheatgrass are present they rapidly invade the scalped area.

Equipment

Frank Sparks of Plevna, Montana, used a self-constructed contour scalping device (Handl, 1975). Wight and Siddoway (1972) used a lister-type implement. Ryerson (1970) used an experimental scalper-seeder unit built on a three point hitch toolbar.
Cost

Ryerson (1970) estimated costs for scalping to be from $3 to $5 per acre.

Scalped Strips

Frank Sparks scalped strips 28 inches wide and 3 inches deep on 67 inch centers. Dams were placed in the scalped strips where needed. A new strip was placed for every 5 feet of drop carefully on the contour. All roads and trails were avoided (Handl, 1975). Wight and Siddoway (1972) constructed contour scalped strips 22 inches wide and 3 inches deep on 5 foot centers which covered 75 percent of the surface in the spring. Ryerson (1970) scalped strips 22 inches wide and 1.5 to 3 inches deep and placed them 5 feet apart on the contour.

Benefits

Sparks reported forage production doubling in two growing seasons from scalping. He estimated that the decaying undercut and overturned blue grama and clubmoss sod contributed 300 pounds per acre of nitrogen to the native grasses. Competition is greatly reduced, humus is built up, infiltration is increased, and grasses have better root systems, more vigor, and grow earlier (Handl, 1975).

On a sandy range site Wight and Siddoway (1972) found that scalping increased precipitation use efficiency, increased the nitrogen content the first year after treatment, improved species composition which
they thought could be relatively permanent, and was most effective in increasing soil water by trapping more snow in the furrows.

Ryerson (1970) reported that scalping without seeding is a rapid range improvement method where rhizomatous wheatgrasses are in the native cover because they vigorously invade the scalped strips. Scalping increased soil moisture storage the greatest with most held under the inverted sods. Scalping was found to be superior to pitting in improving soil moisture and fertility and reducing runoff.

Summary of Scalping

Scalping removes a strip 22 to 28 inches wide and 1.5 to 3 inches deep on 60 to 67 inch centers. Costs range from $3 to $5 per acre. Scalping increased forage production by improving soil moisture, reducing competition, increasing nutrient cycling, and improving species composition toward the more productive and desirable mid grasses. Scalped strips are normally seeded which is termed interseeding.

Scalping is best used when rhizomatous grasses such as the wheatgrasses are present in sufficient numbers and can invade the scalped strips as soon as it would take the seeded species to become productive. In this case, interseeded seed would be wasted. Scalping is used where there is a significant amount of runoff (which eliminates sandy range sites) and where rhizomatous mid grasses capable of quickly invading the scalped strips are present and below their potential for the site. Poor
and excellent condition ranges, steep slopes, rocky soils, and all roads and trails should be avoided in scalping.
DISC FLOWING

**Discing**

Rauzi (1974) discovered that disc plowing and rotovator treatments on a clayey range site increased herbage production and improved species composition but became infested with annual grasses and forbs on a sandy range site. He recommended seeding a desirable species to insure a stand following a severe tillage treatment. Albert Thatcher (1966) stated that on shortgrass range contour furrowing and pitting may not be as effective as discing on clayey range sites because they are not as severe as they should be.

Dolan (1966) and Dolan and Taylor (1972) on clay loam soils reported the results of using a disc and spring tooth harrow in the spring 30 years previously on clubmoss infested rangelands. They found that as the intensity of mechanical treatment increased, clubmoss decreased, litter increased, and desirable forage production increased. Fringed sagewort also increased, however, as intensity increased. They concluded that clubmoss cannot readily re-establish itself following partial to complete destruction by mechanical treatment in that particular environment. Heady (1952) also found that discing promoted an increase in grasses and a decrease in selaginella.

White (1969) working with panspot soil improvement pointed out that mechanical treatments (plows, discs, lister) must be deep enough to
break up the claypan and mix it with friable soil material from above or below (gypsum) to increase water penetration. If sodium accounts for greater than 10 percent of the positive charges surrounding the clay particles, the improvement may be short-lived as the claypan will reform. If sodium is less than 10 percent, lasting improvement may result. He warned that mechanical treatments should be done on an experimental basis before large areas are treated and that vegetational changes associated with mechanical treatments be carefully evaluated as to what is causing an increase or decrease in the forage production. He stated that a treatment which throws soil materials onto adjacent undisturbed soil may destroy shortgrasses and trap water to stimulate growth of species such as the wheatgrasses.
SUMMARY OF MECHANICAL TREATMENTS

Waterspreading, contour furrowing, pitting, ripping, scalping, and discing are mechanical treatments used in improving deteriorated range-lands. Mechanical treatments intercept and retain moisture normally lost to runoff making it available for increased plant growth and reduce erosion at the same time. Mechanical treatments increase the productivity of the range by increasing soil water, improving species composition, increasing the nutrient supply, and improving soil aeration.

Mechanical treatments are best adapted to medium and fine textured soils where there is significant runoff and where the composition of mid grasses is less than its potential. Mechanical treatments are limited to semi-arid and arid areas of the West where there are at least 8 inches of annual rainfall. Because of their marginal economics and the constraints they place on vehicular traffic mechanical treatments have had only limited acceptance.

Pitting is probably the easiest to apply and most economical mechanical treatment of those reviewed. Results of mechanical treatments are determined by climate, soils, grazing management, vegetation types, type of equipment, and how the equipment is used (Vallentine, 1971; Branson et al., 1966; Wight and Siddoway, 1972; Barnes, 1950; Taylor, 1967).
CHAPTER TWO—INTERSEEDING

Definition

Interseeding is the introduction of a legume and/or productive, adapted grass into shallow furrows with partial disturbance of the existing sod. Interseeding is a compromise between complete seedbed preparation and the slow natural reseeding of secondary succession (Vallentine, 1971; Hervey, 1960; Derscheid and Johnson, 1970).

Objective

The primary purpose of interseeding is to re-establish native species of higher successional order than those between the rows on old fields or depleted ranges while minimizing the hazards of wind erosion. Another objective is to introduce legumes and cool-season grasses into warm-season shortgrass range (Vallentine, 1971; Hervey, 1960).

Equipment

Becker et al. (1956) described in detail a machine for interseeding developed in Wyoming. Derscheid and Johnson (1970) and Vallentine (1971) reported that an interseeder must have a furrow opener, control of furrow depth and seeding depth, seedbox, packer wheels, agitators for light weight seed, and wide-mouthed feeder spouts for feathery seed.

Furrows

The width of the furrows depends on the vigor of the existing sod,
the species being interseeded, and the moisture regime. Wider channels are required where the sod is more competitive and in drier areas where there is great moisture competition (Vallentine, 1971; Derscheid and Johnson, 1970). Rauzi (1968), Becker et al. (1956 & 1957), and Rauzi et al. (1962 & 1963) constructed furrows on 40 inch centers which averaged 18 inches in width and left 22 inches of undisturbed sod between. Rumbaugh and Thorn (1964) and Rumbaugh (1965) constructed furrows on 30 inch centers which averaged 6 inches in width and left 24 inches of undisturbed sod between. Ryerson (1970) and Wight and White (1973) used 22 inch wide furrows with 38 inches of undisturbed sod left between. Furrows were, therefore, on 60 inch centers. Sparks used a self-constructed 28 inch contour scalping device on 69 inch centers which cuts 3 inches deep. Dams were placed in the furrow where needed (Handl, 1975). Schumacher (1964) used 14 inch wide furrows and 26 inches of undisturbed sod was left between the furrows. The average depth of the planted seed in all of the above studies was one-half inch. The average depth of the furrow slice was four inches.

**Time to Seed**

Houston and Adams (1971) found that fall seeding was superior to spring. They indicated, however, that cool seasons should be seeded in early spring or late fall for best results. Most workers, however, seeded in early spring (Rauzi, 1968; Derscheid and Johnson, 1970; Schu-
Species to Seed

South Dakota workers reported that the choice of species depends on what season of use is planned or needed to the area, the composition of the area to be interseeded, and other areas available for grazing (Derscheid and Johnson, 1970). Inoculated alfalfa adds to total yield and provides nitrogen for the grasses where indigenous legumes have been destroyed. The protein content of grass grown in mixtures with alfalfa is higher than when grown alone. Ideal species should be capable of dispersion by vegetative processes as well as by seed, be drought resistant, winter hardy, disease resistant, and resistant to frequent removal of top growth and trampling by livestock (Rumbaugh and Thorn, 1964 & 1965). Rumbaugh et al. (1965) described a root spreading type of alfalfa used in interseeding.

Benefits

Becker et al. (1957) and Rauzi et al. (1962) reported that interseeding alfalfa (Medicago sativa) and crested wheatgrass into blue grama sod has given greater sheep gains per acre and per head. Introducing legumes and cool-season grasses into the shortgrass range of the Great Plains contributes to summer grazing and extends the grazing season in both spring and fall. Compositional changes included an increase in western wheatgrass and a decrease in blue grama. The cool-season
species utilized the spring moisture before warm-season grasses started to grow.

Rauzi (1968) on a sandy site found that interseeding alfalfa and crested wheatgrass into shortgrass rangeland gave greater sheep gains per acre, increased sheep days of grazing per acre, and increased forage production. Crested wheatgrass by trapping and holding snow for increased spring moisture, accounted for most of the increased production because the alfalfa had died out after 5 years from drought. On a sandy range site Rauzi et al. (1963) reported that a furrow width of greater than 18 inches is necessary for adequate shortgrass competition removal and successful interseeding of Russian wildrye, a cool-season grass capable of increasing production and lengthening the green-feed grazing season.

Houston and Adams (1971) reported increased yields on a clayey site from interseeding alfalfa and adapted native grass species. Fringed sagewort, which sprouts adventitious roots from stems when disturbed also increased with the interseeding. They concluded, however, that a successful stand of the interseeded species is not necessary because of the rapid increase in yield from the furrowing operation alone of the native species already present.

Rumbaugh and Thorn (1964 & 1965) purposely interseeded small seeded alfalfa into areas of competitive sod across South Dakota to measure the probability of failure. Most plantings were either success-
ful or partially successful. Plantings in one county, however, failed completely because of desiccation from drought and infestations of grasshoppers.

Ryerson et al. (1970) reported that interseeding on clubmoss infested range sites increased herbage production and was more effective than pitting. Wight and White (1973) found that interseeding increased production by increasing the production of western wheatgrass and from production of the seeded species on a sandy site. Sparks doubled the number of cattle his ranch could carry by interseeding alfalfa with no problems with bloat (Handl, 1975).

Cost

Wight and White (1973) stated that interseeding costs about $8.00 per acre. Becker et al., (1957) set costs at $3.00 per acre. Houston and Adams (1971) stated that interseeding is a cheap and profitable method of range improvement.

Grazing Management

The seeded species must be the key species in grazing management until there is enough old growth to reduce their attractiveness to livestock. Newly established seedlings must be protected from livestock when they are more attractive than the surrounding vegetation. Prior to emergence, grazing of the existing sod may be permitted as it reduces the competition. Livestock should be removed, however, when they start
to eat or trample the new seedlings. Some winter grazing of these key species is possible during establishment but it must be based on the requirements of the seeded species. Once established, use of 50 percent by weight is recommended (Vallentine, 1971; Derscheid and Johnson, 1970; Schumacher, 1964).

Where to Interseed

Vallentine (1971) and Schumacher (1964) reported that interseeding is most successful and most commonly used on sands or sandy sites and shows promise on silty sites. Go back fields and poor condition ranges where the between-row cover is lower successionally than the seeded ecotypes are suitable. Difficulty on clayey sites has been encountered due to equipment operation problems and soil crusting.

Nichols and Johnson (1969) found, however, that both drilling and broadcasting of biennial sweetclover into western wheatgrass increased total yield 2.4 times and increased the protein content and vigor of western wheatgrass on heavy clay sites.

Summary

Where grazing deferment and natural succession cannot improve a range within a relatively short economical period, interseeding is a method of improvement which is rapid and economical. It is best suited to ranges where the native legumes or productive, palatable, and dominant
grass species have been destroyed or are drastically reduced below their potential for the site. It is limited to areas where the wind erosion hazard is great with complete seedbed preparation. This usually means sands or sandy sites although silty sites show promise and infrequently on clayey sites due to problems of equipment operation and soil crust- ing.

Species seeded should be adapted to the site and higher successionally than the range to be interseeded. The seeded species should be the key management species for utilization purposes even after establishment. In addition to increased productivity and improved condition of the range, other associated benefits include reduced runoff, increased infiltration, increased protein content of grasses, extended grazing season, increased soil mulch cover, reduced erosion, increased palatable grazing, and increased wildlife.


