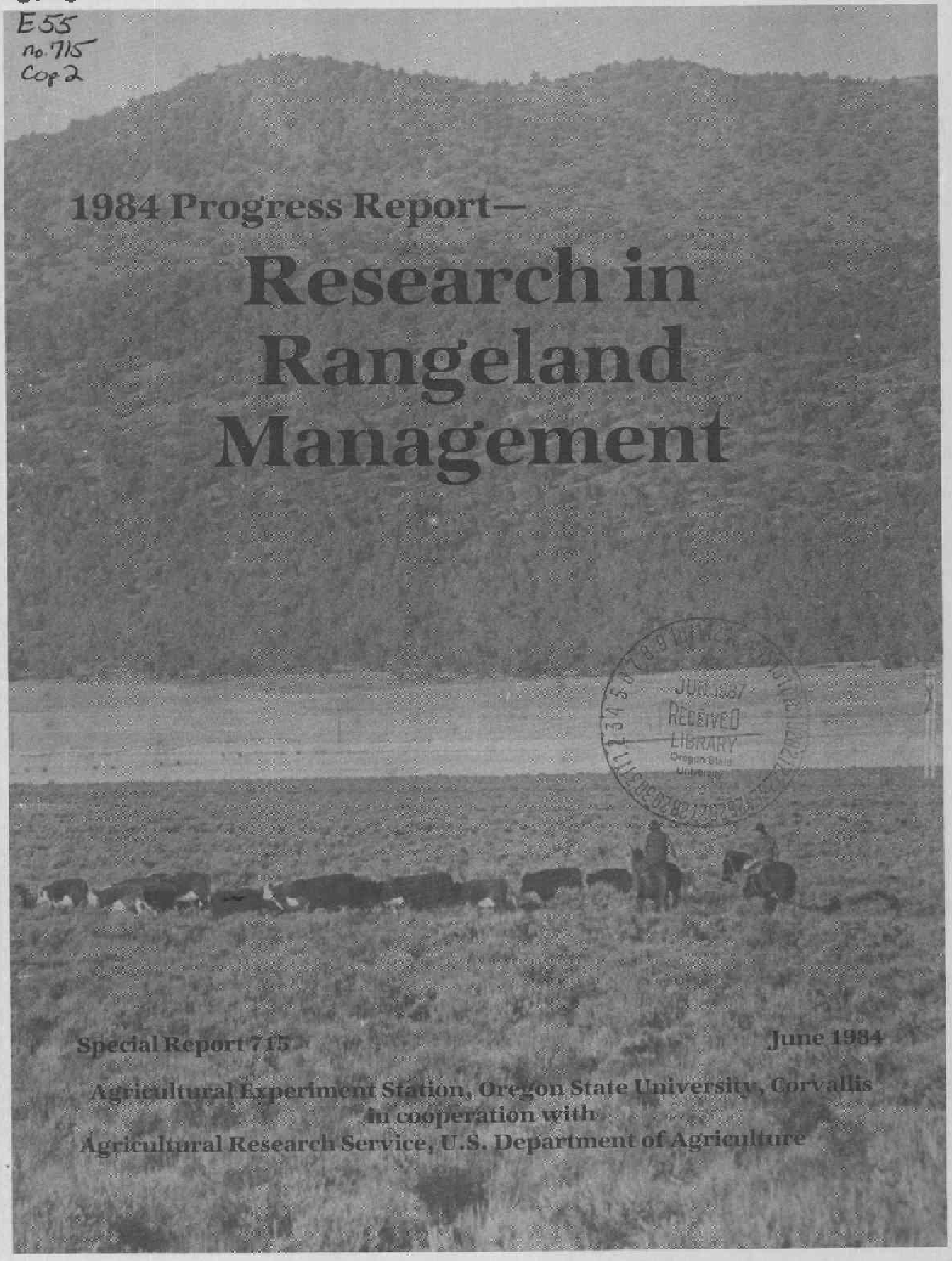

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CONTENTS

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AUTHORS

THOMAS E. BEDELL
professor, Department of Rangeland Resources at Oregon State University.

JOHN C. BUCKHOUSE
associate professor, Department of Rangeland Resources at Oregon State University.

DEIRDE H. CARLSON
graduate research assistant, Department of Rangeland Resources at Oregon State University.

PAUL S. FRIEDRICHSEN
associate professor and Douglas County Extension Chairman, Roseburg

MARSHALL R. HAFERKAMP
range scientist, Eastern Oregon Agricultural Research Center, U.S. Department of Agriculture - ARS at Burns.

WILLIAM C. KRUEGER
professor and head, Department of Rangeland Resources, Oregon State University.

DENIS P. LAVENDER
professor, Forest Science Laboratory, Oregon State University.

RICHARD F. MILLER
associate professor, Eastern Oregon Agricultural Research Center, Oregon State University, Burns.

BARRY J. SCHRUMPF
director, Environmental Remote Sensing Applications Laboratory at Oregon State University.

STEVEN H. SHARROW
associate professor, Department of Rangeland Resources at Oregon State University.

FORREST A. SNEVA
range scientist (retired), Eastern Oregon Agricultural Research Center, U.S. Department of Agriculture - ARS at Burns.

TAMZEN STRINGHAM
research assistant, Agricultural and Resource Economics at Oregon State University.

MARTIN VAVRA
professor, Eastern Oregon Agricultural Research Center, Oregon State University, Union.

RIPARIAN SHRUBBY VEGETATION PROTECTION AGAINST HERBIVORE GRAZING

John C. Buckhouse

Throughout the entire western rangeland region, riparian zones are subjected to grazing and browsing pressure from wild and domestic herbivores. Riparian zones are especially critical focal points in semiarid and arid rangelands. Damage to shrubby components of the vegetative communities by heavy livestock and/or wild ungulate grazing has been frequently reported. Yet evidence exists that a stream corridor in good condition can be maintained and grazed through appropriate managerial constraints.

Apparently, the key to rejuvenating an abused stream and providing improved water quality is to provide the shrubby component of vegetation with adequate protection to enable it to grow to sufficient size to withstand some twig removal by browsing animals. In the past, this has been accomplished at the cost of fencing and the associated lost grazing opportunities.

Water quality in terms of temperature and sediment load is greatly affected by streamside vegetation. The shrubby vegetation next to the stream can help stabilize the bank and provide protection from direct solar radiation of the water's surface. This shrubby vegetation is also a prime target for browsing by domestic and wild herbivores. There are heavy pressures on livestock owners and rangeland owners/managers in the West to halt grazing in riparian zones or to fence these areas so aquatic habitats and water quality may be protected. These options are very costly, particularly because access to water is so essential for livestock in the arid and semiarid parts of the country. Low-cost, innovative techniques are needed. Plastic-mesh bud caps have been used inexpensively to protect replantings in forest clearcuts. Their application to riparian zone plantings needs feasibility-testing to determine if quick, low-cost rejuvenation of overgrazed streambanks might be possible while continuing to permit needed livestock browsing of mature riparian vegetation.

PREVIOUS RESEARCH

The water quality problems associated with bank denudation and the thermal enrichment associated with riparian vegetation removal have been documented. In addition, the ability of a healthy riparian system to withstand grazing pressure is documented. To my knowledge, however, there are only a few studies in this region which deal with amelioration of impacts. And of those studies, none deal with non-fencing means of providing protection to establishing vegetation.

However, a potentially germane study conducted in Oregon dealt with a number of physical barriers evaluated for the degree of deer browsing protection they afforded Douglas-fir seedlings (DeYoe and Schaap, 1982). The researchers indicated that physical barriers were able to provide effective protection to the seedlings. The question of physical and scent barriers to browsing animals in herbaceous and shrubby vegetation communities remains unresearched.

METHODS

Willow (*Salix* ssp.) cuttings were protected along a barren section of Central Oregon's Bear Creek. This is an area which is subjected to livestock and wildlife grazing and is representative of semiarid watersheds throughout the western United States in general and the intermountain ranges of the Northwest in particular.

In addition, a replicated study of potted willows subjected to grazing by cattle has been conducted. This grazing trial eliminated the forces of vandalism which played havoc with the unsupervised wildland plots.

Eighty-five willows were potted for each of four treatments: Vexar 4-inch tubing, plastic mesh tubing, big game repellent-treated willow, and untreated controls. Each was potted in a gallon milk container in a sandy loam soil mixture.

RESULTS AND CONCLUSIONS

This is part of an ongoing study which has yet to be fully evaluated; however, several observations are germane at this point:

1. The plastic mesh and Vexar tubes discouraged removal of willow by beaver.

2. Vexar tubes stood upright fairly well, even under snowy conditions. However, the willows protected by plastic mesh were more subject to being weighted down.

3. Vandalism was a problem in certain areas. The protection devices are readily visible and were easily pulled from the ground.

4. None of the protections withstood the ravages of high water. Those willows which were inundated had their protective devices swept away by the current.

5. The ability of these devices to protect willows from livestock still remains to be seen; however, thousands of dollars are being expended annually to evaluate mitigating techniques which will enable herbivore use and still protect other riparian values in streamside ecosystems. Hundreds of thousands of dollars of revenue in terms of red meat production and fisheries habitat hang in the balance, pending a successful managerial tool for protecting riparian values while at the same time harvesting the resources they produce. Therefore, a continuation of this effort is deemed extremely important.

LITERATURE CITED

DeYoe, D. R., and Schaap, W. 1982. Comparison of eight physical barriers used for protecting Douglas-fir seedlings from deer browse. Seventy-Third Western Forestry Conference and Technical Committee Meetings. Portland, Oregon. Nov. 29 - Dec. 2, 1982. 27 p.

WATER USE BY WESTERN JUNIPER

Richard F. Miller

Western juniper (*Juniperus occidentalis*) is located throughout eastern Oregon, southcentral Washington, southwestern Idaho, northern Nevada, and northeastern California. This species has more than doubled the land area it occupied before the late 1800s. Dense stands are found on approximately 1,772,500 acres, with at least an equal amount of additional land area being occupied by scattered or invading stands of juniper. Range condition appears to have little effect on the establishment of juniper seedlings. Seedlings establish readily on areas supporting well developed herbaceous and woody vegetation.

We have little information on the ecology and physiology of this species. Because of limited knowledge, the ability to manipulate plant communities and predict community response in juniper occupied areas is extremely limited. This paper will report results and preliminary conclusions from ongoing research evaluating patterns of water use by western juniper throughout the year. Specific objectives of this research are to estimate the amount of water utilized by western juniper throughout the year and to determine what environmental factors influence their levels of water use.

METHODS AND PROCEDURES

Water and growth measurements on western juniper have been taken from September 1982 to the present on the Squaw Butte Experimental Range. The two study sites (one-half mile apart) are classified as a mountain big sagebrush - Idaho fescue (*Artemisia tridentata* subsp. *vaseyana* - *Festuca idahoensis*) habitat type, approximately 5,100 feet in elevation. Soils are rocky and average 60 inches in depth. Herbage production is 600 pounds per acre with a shrub canopy of 13 percent. Average annual precipitation is 12 inches, however, precipitation has exceeded the average during this study.

Environmental factors measured are air and soil temperature, humidity, soil water, precipitation, and photosynthetic active radiation. Tree measurements included internal plant water level (a measure of the internal water status of the plant), stomatal resistance, transpiration, leaf growth, and reproductive development. Plant measurements were taken periodically throughout the year on six mature trees on each site.

RESULTS AND DISCUSSION

The amount of water transpired into the air by juniper is primarily influenced by soil temperature, air temperature, and vapor pressure deficit, a measure of the air water content (as temperature increases, so does the air's capacity to hold water; as humidity decreases, the amount of water the air actually contains as compared to what it can hold at saturation also decreases, thus the dryness or vapor pressure deficit increases). Each of these three parameters play a major role in determining water loss by juniper at different times of the year. The amount of water lost through juniper in the winter is minimal, limited by frozen soils, subfreezing air temperatures, and low vapor pressure deficit (Figure 1). As long as soils remain frozen, transpiration will be minimal regardless of air temperature and air dryness (vapor pressure deficit). This is because of the inability of juniper roots to conduct water at sub-freezing soil temperatures. As soils thaw in March (as was the case at Squaw Butte in 1983 and 1984), the amount of water lost is influenced by air temperature and air dryness. In early spring, junipers transpire water as soon as leaf temperature rises above freezing and water thaws in the foliage. This may be for only a few hours during the day. As soon as leaf temperatures drop below 32°F, transpiration essentially ceases.

As the growing season progresses and freezing temperatures become less frequent, air dryness becomes the primary factor determining the rate of water lost by western juniper. At sunrise, solar radiation stimulates stomatal opening. As the day progresses, and temperatures increase and relative humidity decreases, water is transpired at an increasing rate. Stomates close about sundown. During the summer of 1983, lack of soil water did not appear to limit juniper transpiration by causing the stomates to close.

It is likely that soil water depletion does not have a gradual effect on juniper water consumption. It is more likely that transpiration will not be limited until a threshold in internal plant water, caused by droughty conditions, is reached. Soil moisture conditions since September 1982 apparently have not reached this threshold. Early morning internal plant water levels have been found to decline under two different conditions (Figure 1). During the winters of 1983 and 1984, internal plant water levels were at their lowest. Although the amount of water lost through plant leaves is very small at this time, water absorption through the roots is even slower because of frozen soils. Also in May, plants were not able to replenish early morning internal water content from the previous day's transpiration. This was a time when above normal air temperatures and low moisture content in the air caused relatively large amounts of water loss by transpiration. Although soils contained large amounts of water, it is likely that cool soil temperatures and/or limited root absorbing surface (root growth probably occurring at this time) limited the ability of juniper to compensate for high levels of moisture loss this early in the growing season. Juniper appears to not be able to compensate for high levels of water loss early in the growing season as compared to later.

CONCLUSIONS

In summary, frozen soils and freezing air temperatures limit transpiration of juniper through much of the year. In above freezing conditions, the rate of water lost through juniper is primariy determined by the dryness of air. In areas where soils remain unfrozen or are frozen for short periods of time, juniper can transpire water and produce sugars for a longer period of the year, thus making it more competitive with associated vegetation. This may be one of the reasons why its occurrence in central Oregon is greater than on the high desert where soils are frequently frozen throughout most of the winter. As its opportunity to grow in the winter and early spring increases, so does its ability to compete with dormant herbaceous vegetation and deciduous shrubs. Even though some shrubs are evergreen, their leaf areas in winter are usually greatly reduced (i.e., big sagebrush maintains approximately 50% of its leaf area in winter) and the capacity of winter leaves to produce sugars and transpire water is generally low. So sagebrush, with its winter persistent leaves, is capable of growing and producing sugars earlier in the spring than such associate species as rabbitbrush and various perennial grasses. However, it is probably less efficient at using soil water and nutrients than juniper in the winter and early spring.

On a warm summer day, on a site receiving 12 inches of precipitation annually, a stand of juniper trees (167/acre, averaging 12 inches in diameter) can potentially transpire, in one day, 1 percent of total moisture received on the site for the entire year. Since we know a significant proportion of the precipitation will be lost to runoff and evaporation from the soil surface and plant canopies, the percentage of total soil moisture transpired would be much greater.

As stated earlier, some of the above conclusions are preliminary. Additional work needed to verify some of these statements include: (1) to better determine the influence of soil temperature on photosynthesis and transpiration, (2) determine if the relationships between water use by juniper and environmental factors are constant across the western juniper zone, (3) determine if these principles change with tree age, (4) determine the level of soil water or internal plant water that will shut down transpiration, and (5) determine when and where in the soil profile juniper is withdrawing soil moisture.

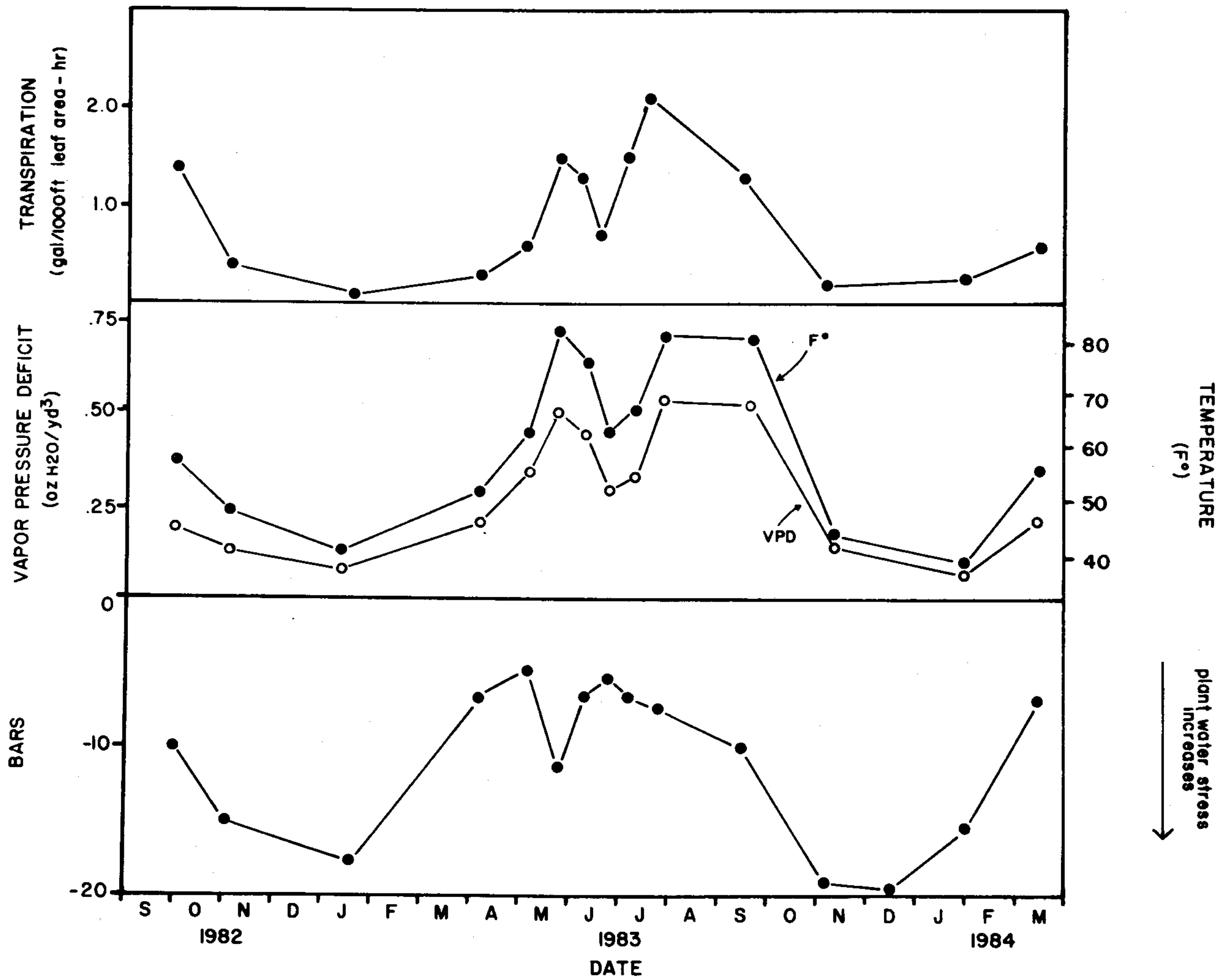

Figure 1. Seasonal transpiration, vapor pressure deficit and temperature (all three taken at midday) and internal plant water (measured just before sunrise). Transpiration and internal plant water were measured on 12 mature trees on two locations. One tree 14.5 inches in diameter, or two trees 9.5 inches in diameter would contain approximately 1,000 ft^2 of leaf area. Both transpiration points for 1984 are estimated since measurements have not yet been corrected for actual leaf area.

FORAGE SOURCES FOR EASTERN OREGON CATTLE RANCHES WITH FEDERAL GRAZING PERMITS

Thomas E. Bedell and Tamzen Stringham

Publicly owned rangelands provide many products and values. One primary product in all of the western rangeland states is forage for livestock grazing. In most Oregon counties east of the Cascades, the majority of rangelands are managed either by the Bureau of Land Management (BLM) or the U.S. Forest Service. In these areas, the ranching industry developed around the interrelationships of using rangeland in spring, summer and early fall, grazing hay aftermath before the winter, and then feeding hay made from private lands back to the livestock.

The term "dependency" came about because livestock were grazed/fed on private land during the fall, winter and early spring, but spent varying amounts of time during the spring, summer, and early fall on rangelands, much of which were public. Without access to public lands, the numbers of livestock would be significantly less; ranching units depend on public range to maintain economic viability.

During the 1980-1983 period, the Departments of Rangeland Resources and Agricultural and Resource Economics of Oregon State University cooperated in a study in 11 counties to characterize the beef cattle industry which depended on federal grazing. A number of physical and economic characteristics were assessed. This report summarizes the sources of forage that dependent ranchers used.

PROCEDURES

The work initially covered Baker, Grant, and Harney counties under funds from the Oregon Cattlemen's Association, U.S. Forest Service and Bureau of Land Management (1980 and 1981). In this part, face-to-face interviews were conducted. Subsequently, because of time and funding constraints, a shorter survey was made of permittees in Crook, Jefferson, Wheeler, Deschutes, Klamath, Lake, Malheur, Umatilla, Union, and Wallowa counties by letter and telephone. This work was funded through grants from the USDA Federal Extension Service and BLM. Populations of ranchers were stratified by county and herd sizes (0-199, 200-499, 450-699, 700-999, and more than 1,000) and samples drawn from these populations. Each operator remained anonymous. Operators were asked to estimate where their cattle were at all times of the year. Categories were: deeded range (seeded, open native, timbered), private rented range, BLM, Forest Service, state/other public sources, deeded or rented meadow, deeded or rented hay/crop aftermath, and hay fed. For this report, these categories were condensed into private range, BLM, U.S. Forest Service, other range, irrigated pasture/meadow, aftermath, and hay. Since virtually all data were estimates of one type or another (numbers or time), all cattle were considered equivalent to one animal unit.

RESULTS

For all the 11 counties, a total of 295 usable surveys occurred. Summary figures mask a great deal of variation. Overall, BLM provided 12 percent, the U.S. Forest Service 8 percent, and private and other range 27 percent of the total year-round forage or slightly less than 50 percent (Table 1). But this varies among seasons and counties (regions) quite importantly. As an example, BLM was not important (from the total perspective -- not an individual ranch) in the northeast counties. But for Malheur, Lake, and Harney counties, BLM provided 35, 26, and 23 percent of the total, respectively, which is a larger percentage than from the private range sources. Conversely, the Forest Service provided as much as 23 percent of the forage in Wallowa County to as little as 3 percent in Baker County and none in Malheur County. Overall, hay fed was the largest category, averaging 32 percent. This may well be the major contributing factor to high cost of operation, since an AUM of hay costs more than an AUM of range forage, regardless of the source. Hay fed ranged from 39 percent in Klamath County to as low as 20 percent in Umatilla County, almost a two-fold difference.

Rangeland in Umatilla County provided 61 percent of the year's forage (Table 1), and in counties like Crook, Harney, Malheur, and Wallowa, more than 50 percent is from range. Irrigated lands were especially important in Klamath (20 percent), Jefferson-Deschutes-Wheeler (17 percent), and Union (14 percent) counties.

In the southeastern region (Klamath, Lake, Harney, and Malheur), the BLM provides more forage than any other range source, both seasonally and on a year-round basis (Table 2). During May, the amounts were Malheur (69 percent), Lake (66 percent), Harney (57 percent), and Klamath (27 percent) (data not shown). For the April through August period, the averages by county were Malheur (65 percent), Harney (45 percent), Lake (51 percent), and Klamath (12 percent). National forests in the southeast region contributed less than the other areas (contrast Tables 2, 3, and 4). However, in Klamath County the national forests provided more than 35 percent of the forage for the July through September period so the average of five percent masks that. This was because Malheur County has no national forests and Lake and Harney counties are similar with 11 to 20 percent of June through August forage coming from national forests.

The tier of central Oregon counties had less BLM forage than the southeast region but more than 20 percent of the AUM's occurred in May and June from that source (Table 3). On a county basis for May and June, BLM provided from 33 and 25 percent in Baker County, 26 and 27 percent in Crook, 22 and 24 percent in Jefferson-Deschutes-Wheeler, to 6 and 4 percent in Grant which has scattered parcels known as "Section 15" (Taylor Grazing Act) land. The national forests provided another 15 to 20 percent of the June through September forage for central Oregon dependent ranches (Table 3).

In the northeastern region, the national forests provided 14 percent of the year-round forage, considerably less than the private range (Table 4). However, in Wallowa County the average was 23 percent with from 31 to 46 percent of the total AUM's in June through October coming from national forests.

In Union and Umatilla counties, comparable figures were 14 to 32 percent for June through September with only 6 to 15 percent of October's forage coming from the national forests. The northeastern region was defined more from a geographical than an ecological standpoint. For example, more aftermath is available in Umatilla County (14 percent) than Union (10 percent) and Wallowa (7 percent). Further, much less hay is normally fed in Umatilla County (20 percent) compared to Union (28 percent) or Wallowa (31 percent). A higher percent of the total AUM's comes from rangeland in Umatilla County (61 percent) compared to Wallowa (53 percent) and Union (48 percent).

SUMMARY

BLM and U.S. Forest Service lands supplied 20 percent of the year-round forage for ranches with federal grazing permits. This occurred in all months but was concentrated mainly from April (22 percent) through October (20 percent) (Table 5). In some counties the overall contribution of BLM and Forest Service was greater than the private range sources (Table 1). It is obvious that federal lands are very significant to the operations of many dependent eastern Oregon beef operations. Equally obvious is the fact that large adjustments in both production and regional economies would result if the federal lands were withdrawn from the forage base.

Table 1. Forage sources for all eastern Oregon ranches with federal grazing permits

	Central				Southeast				Northeast			
	Crook	Wheeler Jefferson Deschutes	Grant	Baker	Klamath	Lake	Harney	Malheur	Umatilla	Union	Wallowa	Avg.
	Percent											
BLM	11	10	3	12	6	26	23	35	>1	>1	>1	12
USFS	5	6	13	3	12	5	4	--	10	9	23	8
Private range	37	31	30	27	14	8	19	18	50	38	30	26
Other range	1	--	1	--	--	3	5	2	>1	1	--	1
Irrigated pasture	9	17	7	10	20	11	6	7	6	14	8	10
Hay/crop aftermath	7	2	10	13	9	11	14	8	14	10	7	10
Hay	29	33	36	35	39	36	29	31	20	28	31	32

Table 2. Seasonal forage sources (percent) for southeast Oregon ranches with federal grazing permits

Forage source	J	F	M	A	M	J	J	A	S	O	N	D	Total
BLM	4	2	2	40	55	44	40	35	30	22	2	4	22
USFS					2	12	16	17	16	3			5
Private range	4	4	7	15	22	30	22	24	22	19	10	7	15
Other range	2	2	2	3	1	2	2	2	4	5	4	3	2
Meadow and Irrigated pasture	1	1	2	6	18	18	20	21	20	13	8	4	11
Crop/hay aftermath	1	1	1	1	1	--	--	2	9	34	56	26	10
Hay fed	88	90	86	34	1	--	--	--	--	5	21	57	34

Table 3. Seasonal forage sources (percent) for central Oregon ranches with federal grazing permits

Forage source	J	F	M	A	M	J	J	A	S	O	N	D	Total
BLM	--	--	.5	6	22	20	14	9	7	6	22	5	9
USFS					2	15	19	20	18	6	--		7
Private range	6	2	2	46	64	49	44	44	39	34	30	14	31
Other range						.5	.5	.5	.5	.5	.5	.5	.2
Meadow and Irrigated pasture	2	--	--	2	9	15	21	24	22	26	13	8	11
Crop/hay aftermath	2	1	1	1			1	2	12	30	36	14	8
Hay fed	89	96	94	35	2					4	12	58	33

Table 4. Seasonal forage sources (percent) for northeastern Oregon ranches with federal grazing permits

Forage source	J	F	M	A	M	J	J	A	S	O	N	D	Total
BLM					1	1	1	1	1	1			.5
USFS	2	2	2	6	12	24	30	29	31	22	7	4	14
Private range	2	2	15	37	65	59	54	54	54	55	44	27	39
Other range												4	.3
Meadow and Irrigated pasture			1	8	21	17	15	15	15	11	7	.5	9
Crop/hay aftermath	12	9	9	10	1					11	11	38	10
Hay fed	84	87	72	39	.5						9	29	26

Table 5. Seasonal forage sources (percent) for all eastern Oregon ranches with federal grazing permits

Forage source	J	F	M	A	M	J	J	A	S	O	N	D	Total
BLM	1	1	1	20	28	24	20	16	14	10	8	2	12
USFS	.5	.5	.5	2	5	16	21	21	21	9	2	1	8
Private range	4	3	8	32	49	45	39	39	37	34	26	15	28
Other range	1	1	1	1	.5	1	1	1	2	2	2	2	1
Meadow and Irrigated pasture	1	.5	1	5	15	17	19	21	20	17	9	4	10
Crop/hay aftermath	4	3	3	3	.5	--	.5	1	8	26	42	25	9
Hay fed	87	91	85	36	1					3	14	50	32

SEEDING RANGELANDS WITH A RANGELAND IMPRINTER IN EASTERN WASHINGTON AND SOUTHEASTERN OREGON

Marshall R. Haferkamp, Richard F. Miller, and Forrest A. Sneva

Drilling is considered a superior method of planting seed except where terrain or obstructions prevent the use of a drill. It is one of the best methods for obtaining uniform distribution of seed and proper depth of planting on a firm seedbed. In loose soil, cultipacking is sometimes needed to obtain the required firmness.

Broadcasting seed is generally recommended where drills cannot be used and only where there is some assurance seed will be covered. Broadcast seeds are exposed to rapidly fluctuating moisture conditions and depredation by birds and rodents. Seedlings from broadcast seeds often fail to root well and short portions of the roots are often exposed to dessicating action of sun and wind.

Several methods have been used to enhance coverage of broadcast seeds. Cultipacking, dragging brush or chains, and trampling by livestock are all effective methods. The land imprinter of recent orgin also may improve establishment of seedlings from broadcast seed.

The imprinter, developed by Robert M. Dixon, U.S. Department of Agriculture's Agricultural Research Service, consists of large steel cylinders that imprint a variety of geometric designs on the soil surface. The patterns are designed to reduce water runoff and enhance infiltration. The imprinter can be used as a primary implement on near barren land or as a secondary implement on loose plowed land. This implement has the potential to press broadcast seeds into the soil and produce small depressions which provide micro sites for germinating seeds. Either one or both processes could improve establishment of seedlings from broadcast seed.

Studies were initiated in 1981 and 1982 to evaluate the effectiveness of the land imprinter versus the rangeland drill for establishing Nordan crested wheatgrass *(Agropyron desertorum)*. Plantings were in eastern Washington and southeastern Oregon.

STUDY I

In 1981, personnel of the Eastern Oregon Agricultural Research Center, in cooperation with the U.S. Department of Agriculture's Soil Conservation Service, initiated a study to evaluate the establishment of weeds and seeded plant species on ash-covered rangelands modified by fire, herbicides, or discing and planted by drilling or imprinting. The project was funded by USDA-ARS.

The study site, 27 miles east of Ritzville, Washington, is representative of areas receiving a 2-inch deposit of ash of the silt loam texture from the Mount St. Helens eruption. Soils are in the Benge series, silt loam in texture, and occur on 0 to 15 percent slopes.

Vegetation consists mainly of annual grasses, forbs, and bluegrasses with scattered plants of bluebunch wheatgrass *(Agropyron spicatum)* and Thurber's needlegrass *(Stipa thurberiana)*. Dominant annual grasses include *Bromus tectorum* and *Ventenata dubia*.

PROCEDURES

Seedbeds were unprepared or prepared by spring or fall discing, summer or fall burning, or summer burning plus fall spraying with glyphosate (1 pound active ingredient per acre). Plots were seeded with Nordan crested wheatgrass at 6 pounds pure live seed per acre. Seeds were planted with a rangeland drill or broadcast after the plots were imprinted with a land imprinter filled with water. Success of seedbed preparation and planting was evaluated by determining density of competing species in early May 1983 and determining standing crops of competing vegetation and frequency and density of crested wheatgrass seedlings in mid-June 1983.

RESULTS

Neither the seedling densities nor the standing crops of competing vegetation appeared to affect seedling densities of crested wheatgrass as much as the thick litter layer remaining when seedbeds were not prepared with burning or discing. Average Nordan seedling densities were 0.5 per square foot on all but the untreated seedbeds and fall burned seedbeds rolled with the imprinter (Table 1). Drilling significantly increased seedling density on seedbeds prepared by fall burning and summer burning plus glyphosate. Differences were, however, not significant when seedbeds were unprepared, disced, or burned in summer. Nordan seedlings were more evenly distributed with drilling than with broadcasting after imprinting on all seedbeds except the untreated ones or those prepared by summer burning and discing (Table 2).

Table 1. Mean density of crested wheatgrass seedlings growing on experimental range seeding plots near Ritzville, Washington, in June 1983

Method of Planting	Untreated	Disc: Spring	Disc: Fall	Burn: Summer	Burn: Fall	Summer Burn: Fall Glyphosate
	Number per square foot					
Drill	0.1a[1]	0.7a	0.7a	1.8a	2.0a	3.8a
Imprint	>0.1a	0.5a	1.1a	1.6a	0.3b	2.1b

[1] Means within columns followed by the same letter are not significantly different at P<0.05.

Table 2. Percent frequency of crested wheatgrass seedlings growing on experimental range seeding plots near Ritzville, Washington, in June 1983

Method of Planting	Untreated	Disc		Burn		Summer Burn Fall Glyphosate
		Spring	Fall	Summer	Fall	
	- - - - - - - - - - - - - - - - - - - % - - - - - - - - - - - - - - - - - - -					
Drill	13a[1]	60a	53a	67a	90a	100a
Imprint	7a	47a	77a	60a	40b	73b

[1] Means within columns followed by the same letter are not significantly different at $P<0.05$.

STUDY 2

Beginning in fall 1982, the effectiveness of establishing Nordan crested wheatgrass seedlings by broadcasting seed before or after imprinting was compared to planting with a rangeland drill equipped with regular or deep furrow openers. The study site, an *Artemisia tridentata* subsp. *wyomingensis/Stipa thurberiana* habitat type, is on the Squaw Butte Experiment Station. At this location soil depth is 30 inches; elevation is 4,620 feet. Shrub canopy cover is 20 percent and herbage production averages 570 pounds per acre.

PROCEDURE

Seedbeds were either unprepared or prepared by brush beating or brush beating followed by discing. Brush beating was applied during August 1982, and seedbeds were disced in August 1982 and again in October 1982 after *Bromus tectorum* seedlings had emerged. Crested wheatgrass seed was planted at the rate of 6 pounds pure live seed per acre in October 1982, and seedling densities and frequency were determined in September 1983.

RESULTS

An average 0.7 seedling per square foot was established by drilling on the untreated seedbeds, and 1.1 seedling per square foot was established by drilling on the brush beat seedbeds (Table 3). Only an average 0.25 seedling per square foot was established with broadcasting seed before or after imprinting. The most seedlings 2.2 and 3.5 per square foot were established by drilling and imprinting after broadcasting, respectively, on seedbeds prepared by brush beating and discing. Almost one seedling per square foot was established by seeding after imprinting. Seedling distribution as determined by percent frequency was similar to seedling density. The greatest density and best distribution resulted from drilling on seedbeds prepared by brush beating and brush beating plus discing, and from broadcasting seed before imprinting on seedbeds prepared by brush beating plus discing (Table 4).

Table 3. Mean density of crested wheatgrass seedlings growing on experimental range seeding plots on the Squaw Butte Experiment Station in southeastern Oregon in September 1983

Seedbed Preparation	Regular Drill	Deep Furrow Drill	Imprint Seed	Seed Imprint
	- - - - - - - - - Number per square foot	- - - - - - - - - -		
Untreated	0.8a[1]	0.6a	0.2a	0.3a
Brush beat	1.3a	0.9ab	0.2b	0.3b
Brush beat-disc	2.2b	0.3c	0.9c	3.5a

[1] Means in rows followed by the same letter are not significantly different at $P<0.01$.

Table 4. Percent frequency of crested wheatgrass seedlings growing on experimental range seeding plots on the Squaw Butte Experiment Station in southeastern Oregon in September 1983

Seedbed Preparation	Regular Drill	Deep Furrow Drill	Imprint Seed	Seed Imprint
	- - - - - - - - - - - - - -	% - - - - - - - - - - - - - - - -		
Untreated	55a[1]	43a	23a	40a
Brush beat	72a	50ab	25b	33ab
Brush beat-disc	95a	28b	80a	98a

[1] Means in rows followed by the same letter are not significantly different at $P<0.01$.

SUMMARY

We must remember these seeding were planted and seedlings established during periods of above average precipitation in Washington and Oregon. More than one seedling per square foot established on 37 percent of the plots and

1 to 0.5 seedling per square foot established on 29 percent. More than 1 seedling per square foot is considered a good stand and 1 to 0.5 seedling per square foot a fair stand.

In Washington and Oregon, the removal of litter and plant competition enhanced seedling establishment. Removal of litter by burning or discing exposed mineral soil, and discing provided a loose seedbed that allowed the imprinter to operate most effectively.

Drilling was superior to imprinting on seedbeds prepared by fall burning, summer burning plus fall glyphosate, and brush beating. Drilling and imprinting produced similar results on unprepared seedbeds and those prepared by discing, summer burning, and brush beating plus discing. The cause for similar seedling densities resulting from drilling and imprinting after summer burning when compared to the superiority of drilling over imprinting after fall burning is unknown. Competing vegetation, however, was denser after summer burning and the number of *Ventenata dubia* seedlings was twice as great after summer burning.

Imprinting was superior to drilling in number of seedlings established in year 1 only when seed was broadcast just before imprinting into brush beat and disced seedbeds in southeastern Oregon. Good stands were established by both methods, however, pulling the water-filled land imprinter will probably require more horsepower than a comparable sized rangeland drill.

TWENTIETH-YEAR RESULTS FROM A PLANTATION GRAZING STUDY

William C. Krueger and Martin Vavra

Our long-term study of an experimentally grazed forest plantation on the Hall Ranch of the Eastern Oregon Agricultural Research Center is providing new insights into agroforestry. Measurements of tree and cattle responses and changes in vegetation have continued throughout the study. At the conclusion of data collection in fall 1983, the plantation completed the first phase of the study and thinning of the resultant stands was implemented.

One objective of this study was to determine the feasibility of interim grazing of forested land from immediate post-logging to tree canopy closure and the effect of such grazing on survival and growth of forest regeneration from planted coniferous tree stock.

EXPERIMENTAL PROCEDURE

A 30-acre tract of mixed coniferous forest, predominately grand fir (Abies grandis) was clearcut in summer 1963 and broadcast burned in summer 1964. Residual cull logs were oriented perpendicular to the prevailing slopes. Within this tract, three 5-acre pastures were fenced to exclude cattle.

In fall 1964, all three pastures were seeded to grass utilizing a split-plot design (seeded vs. unseeded) on a random basis. Each plot was 0.5 acre and oriented perpendicular to the slope. Forage species were seeded on the lower half of each treatment at a rate of six pounds per acre with a mixture including orchardgrass (Dactylis glomerata), tall oatgrass (Arrhenatherum elatius), timothy (Phleum pratense), smooth brome (Bromus inermis), and white clover (Trifolium repens). The upper half of each plot designated for seeding was further divided longitudinally into two equal subplots, one seeded to blue wildrye (Elymus glaucus) and the other to mountain brome (Bromus marginatus) at the rate of eight pounds per acre.

In the spring of 1965, coniferous seedlings (2-0 and 3-0 stock) from the U.S. Forest Service Nursery in Coeur d'Alene, Idaho, were planted in each pasture on a random block basis at the rate of 1,000 trees per acre (Figure 1). Species planted were: ponderosa pine (Pinus ponderosa), Douglas-fir (Pseudotsuga menziesii), western larch (Larix occidentalis), and western white pine (Pinus monticola). Spacing was six feet within rows with rows oriented across the slopes and seven feet apart.

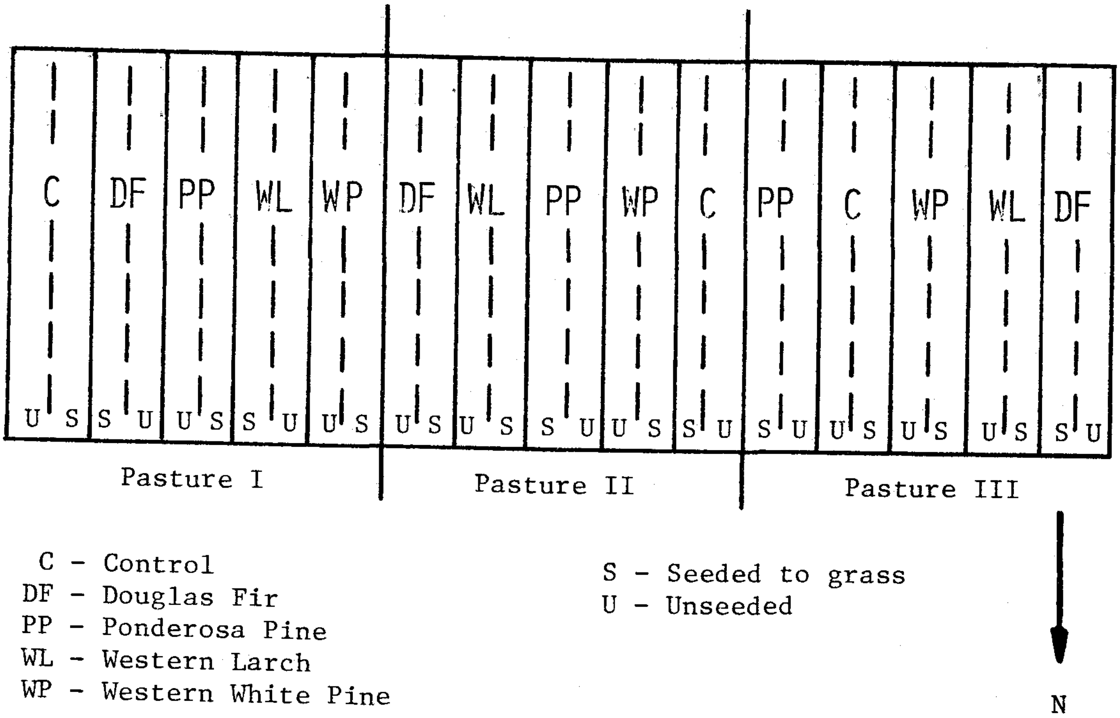

Figure 1. Field design of tree plantations on the Hall Ranch of the Eastern Oregon Agricultural Research Center.

Cattle grazing was initiated in July 1966 with the introduction of five yearling heifers annually in each pasture until 1972 when cattle grazing in Pasture III was discontinued. Grazing was continued in Pastures I and II on an annual basis through 1983. Therefore, grazing treatments were: Pasture I grazed by cattle, Pasture II grazed by cattle and game, and Pasture III grazed only by game. Cattle dispersion was affected by development of the water source at the ridge top and placement of salt blocks at the base of the slope. Cattle entry into the pastures was timed with the phenology of forage and tree species -- varying from June 15 to July 15 each year. Cattle remained on pasture for approximately one month.

Records of survival and height growth of planted coniferous seedlings were tallied twice annually - before and at the conclusion of grazing -- from 1966 through 1978 and in fall 1983 after grazing. In 1983, diameter at breast height (dbh) was also measured for each species. In addition, evidence of seedling damage and probable causes of mortality were recorded from the time of planting (1965) to 1978.

RESULTS AND DISCUSSION

Survival was unchanged from 1977 levels (Krueger and Vavra 1983). Ponderosa pine and Douglas-fir had the best survival ranging from 55 to 62 percent. Survival of western larch and western white pine ranged from 22 to 36 percent. Mortality stabilized the fourth year after planting. Trampling by cattle accounted for 8 percent of mortality (less than 5 percent of planted ponderosa pine and Douglas-fir). Big game and rodents caused 18 percent of mortality. The rest of the mortality was caused by a variety of factors and drought was assumed to be the major problem. There were no significant differences in survival or growth between plots seeded to grass and those unseeded.

In all cases, maximum growth of planted trees was attained in the pasture grazed by both cattle and big game (Table 1). In an operational sense, we would not expect to control access of big game to a plantation, so the comparison of results from the pasture grazed by cattle and big game with that grazed by game only simulate the choices a land manager would face. When this comparison was made, the trees grown in the pasture grazed by cattle and game were taller and larger than those in the pasture that excluded cattle use (Table 2). The lowest response was for ponderosa pine and the greatest response was for western larch. The benefit to tree growth from cattle grazing was surprisingly large for western white pine and western larch. However, because of lower survival, these stands were stocked at about 250 to 300 trees per acre. These open stands provided more forage and, especially in recent years, concentrated grazing in those parts of the pasture. The added benefit to tree growth from cattle grazing was probably caused by a number of factors; among those should be improved moisture relations from grazing of the understory and a fertilizer effect from cattle urine and dung. These effects would obviously be exaggerated where cattle grazing was most intense.

The treatment design allowed us to evaluate the basic effects of adding cattle grazing when big game grazing was present or adding big game grazing when cattle grazing was present. The addition of cattle grazing to pastures grazed by big game generally increased tree growth much more than the addition of big game to pastures grazed by cattle. Big game grazing was nearly as effective as cattle grazing for increasing growth of Douglas-fir. Big game were about half as effective as cattle for increasing growth of ponderosa pine and added very little to enhance growth of western white pine or wester larch. The synergistic effect of grazing cattle with big game did produce the largest growth response in planted conifers and that response as not equal to adding of individual grazing effects.

Table 1. Height and diameter (dbh) growth of planted conifers in 1983, 18 years after planting.

Species	Cattle & Game Grazing Height (ft)	Cattle & Game Grazing Diameter (inches)	Cattle Only Height (ft)	Cattle Only Diameter (inches)	Game Only Height (ft)	Game Only Diameter (inches)
Ponderosa pine	19.9	4.8	18.6	4.6	17.6	4.4
Douglas fir	25.5	4.4	21.7	3.7	21.6	3.5
Western white pine	24.0	3.9	22.4	3.9	16.7	2.5
Western larch	29.2	5.0	28.6	4.5	21.2	3.1

Table 2. Percentage increase in growth for trees in pastures grazed by cattle and big game compared to trees in pastures grazed by game only.

	Ponderosa pine	Douglas-fir	Western white pine	Western larch
DBH	9	26**	56*	61**
Height	13*	18+	44*	38**

t Statistically significant at $P \leq .10$

* Statistically significant at $P \leq .05$

** Statistically significant at $P \leq .01$

The first phase of this study has been completed. It is clear that under the management applied to these experimental pastures, grazing by both cattle and big game enhanced the productivity of trees in the plantation. Seeding of the plantation to forage species under this system had no effect on tree growth. However, forage seeding will enhance the forage supply and should make management easier on large plantations. The potential for development of this agroforestry practice is good since it provides income from cattle production in the short term while improving growth of trees. We will continue these studies after the plantation is thinned to provide information on these cattle-timber-big game relationships for the growing forest.

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AGROFORESTRY: OPTIMIZING LIVESTOCK AND FOREST PRODUCTIVITY[1]

Deirdre H. Carlson, Steven H. Sharrow, and Denis P. Lavender

As the degree and variety of demands on our renewable natural resources increase, the principles of multiple use must play an ever-increasing role in land management planning and operations. Perhaps this explains the considerable attention that agroforestry has received worldwide in recent years.

Simply defined, agroforestry is an integrated system of management whose goal is to optimize the production of agricultural and forest products from a given parcel of land. Such a system holds particular promise for foothill lands in the Pacific Northwest, where profits can be increased through product diversification or through greater overall production of marketable products. A major advantage of this multi-product system may be improved cash flow resulting from the marketing of both short-term (livestock) and long-term (timber) products. Grazing provides immediate financial returns which help to offset the annual costs of timber growing during the early years of a plantation's life, while timber harvest provides a substantial block of income periodically as timber is sold.

A commonly expressed concern relating to agroforestry practices is the potential damage to young trees resulting from browsing or trampling by livestock. Work conducted in both western (Hedrick and Keniston 1966; Leininger and Sharrow 1983) and eastern (Krueger 1983) Oregon suggest that conifer plantations may be grazed by livestock without suffering significant damage if season and degree of grazing are appropriate. In fact, data presented by Hedrick and Keniston (1966), Leininger and Sharrow (1983), and Krueger (1983) all suggest that tree growth may be greater on grazed than on ungrazed plantations. Whether increased tree growth on grazed areas results from reduction or competition between trees and understory vegetation for moisture and light or from a "fertilizer effect" of animal urine and feces remains unclear.

Soil nutrient status and its relation to site productivity is an important concern in both forest and rangeland management. The potential value of using nitrogen-fixing plants to improve soil nitrogen status, in lieu of an expensive fertilizer program, has been recognized on range, pasture, and forestlands for many years. In pasture systems, improved forage production, higher forage quality, and greater livestock gains per acre have generally followed successful introduction of nitrogen-fixing legumes. While the value of nitrogen-fixing species has been postulated for forest production systems, few field trials have actually been conducted.

Since forest soils are often low in available nitrogen, and accelerated nutrient loss may follow timber harvesting, the introduction of nitrogen-fixing plants into timber plantations has great potential to increase site

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[1] This work is being conducted as a cooperative effort between the Department of Rangeland Resources and the Department of Forest Science at Oregon State University.

productivity. Two basic strategies have been envisioned to incorporate nitrogen-fixing plants into forestry operations: (1) crop rotation systems in which a nitrogen-fixing plant is grown for several years, then removed and the tree crop planted, and (2) various kinds of mixed species systems in which the commercial tree crop is grown concurrently with a nitrogen-fixing plant (Haines and DeBell 1979).

In an agroforestry system, the use of nitrogen-fixing forage species such as clovers should increase the availability of nitrogen to trees, as well as providing a high quality forage base for livestock production. The grazing animal plays several potentially important roles in the production system:

(1) It is the "factory" which harvests and transforms forage into saleable products.

(2) It is a management tool which may be used to control the species composition of the ground vegetation and to minimize competition between the understory vegetation and the timber crop.

(3) It provides a mechanism by which plant material may be rapidly broken down and the nutrients returned to the soil for plant growth.

Little of the nutrients consumed by livestock are retained to build animal tissue; most pass through the animal and are deposited as feces or urine. For instance, approximately 75% of the nitrogen consumed by sheep is returned to the pasture as urine, 90% of which is readily available for use by plants (Whitehead 1970; Whatkin and Clements 1978).

The goal of the work reported here is to test the concepts discussed above by observation of a small-scale mixed-crop agroforestry system employing Douglas-fir (*Pseudotsuga menziesii*) as a timber crop, subterranean clover (*Trifolium subterraneum*) as a nitrogen-fixing understory crop, and sheep as the livestock component. Specific parameters which are being measured include tree growth, forage production, forage utilization by livestock, amount and severity of browsing and trampling of trees by livestock, and the amount of nutrients which pass back to the pasture through livestock as urine and feces. Because of the relatively recent initiation of the study, only information pertaining to forage production, forage utilization, and livestock impacts on trees is available.

EXPERIMENTAL PROCEDURES

The study site is in MacDonald Forest, approximately 7 miles north of Corvallis, Oregon. The experimental design is a split plot with two replications of all possible combinations of three tree planting treatments: (1) unplanted--no trees planted, (2) 8 x 8--trees planted eight feet apart in a grid-like pattern, and (3) cluster--trees planted in a group of five trees/cluster with clusters spaced 25 feet apart; and two management systems: (1) grazed--clover planted and the plantation grazed by sheep, and (2) ungrazed--no clover planted and the plantation not grazed by sheep.

The timber plantations were planted with two-year-old (2-0) Douglas-fir stock in 1979 by Dr. Denis Lavender as the basis for an evaluation of a mixed-crop timber production system employing Douglas-fir as the timber crop and red alder (*Alnus rubra*) as a non-leguminous nitrogen fixer. The strategy adopted was to allow several years for the Douglas-fir trees to become established, then to plant red alder between the clusters in the cluster planting. The 8 x 8 plantings serve as control areas.

These original plots were split, and half of each plot was planted with 20 pounds/acre of subterranean clover seed in fall 1983. The resulting plots are approximately 0.15 and 1.1 acres in size for 8 x 8 and cluster treatments, respectively. All plots were fertilized with approximately 370 pounds/acre of 10-24-0-12 fertilizer in October 1982. Grazed plots were grazed by a flock of 33 ewes from June 13 to July 21, 1983, and again by a flock of 20 ewes from January 11 to January 22, 1984. The flock of sheep spent from one to four days in each plot. Sheep were removed from plots when it was judged that tree damage would occur if they were to remain longer.

Browsing, trampling, and barking impacts of sheep on study trees were evaluated by examination of trees immediately before and after sheep were in each plantation. Browsing which occurred when sheep were not on the plantations was attributed to wildlife, primarily deer. Differences in the status of trees before vs. after sheep grazing were attributed to sheep. Browsing impacts were expressed in three ways: (1) % of trees browsed = # of trees browsed/# trees examined, (2) % of laterals browsed = average # of lateral branches browsed/ # trees browsed = severity of a browsing event, and (3) % of terminals removed = # of trees with terminal leaders removed/# of trees examined.

Forage standing crop and forage utilization by sheep were estimated using the movable cage technique. Ten 2.2-foot^2 quadrats were harvested both within and outside of exclosure cages immediately after sheep left each plantation. Forage utilized was calculated as the difference between the standing crops within and outside of each cage. Total yearly forage production was calculated from 15 quadrats which were harvested in every treatment plot during late June 1983.

RESULTS AND DISCUSSION

A dense stand of subterranean clover was established on the grazed treatment plots by spring 1983. Vegetation on the ungrazed plots consisted primarily of annual grasses.

Forage production was substantially greater on grazed than on ungrazed plots (Table 1), probably as a result of the introduction of clover on grazed plots rather than a grazing effect per se. The spring 1983 grazing period was delayed until June to avoid grazing the plots when young Douglas-fir trees had succulent new growth present. Experience (Leininger and Sharrow 1983) suggests that grazing use of young Douglas-fir plantations be avoided during the period from bud burst until the new foliage has "hardened off", as the palatability of conifer foliage is highest at that time. By the time sheep were introduced into the plantations, the forage had become very dense and somewhat rank.

It was difficult to achieve high levels of utilization while minimizing browsing impacts on trees under these conditions. Levels of herbage utilization ranged from 40% on unplanted plots to approximately 20% on plots with trees. This level of forage use was accomplished with relatively little livestock grazing impact on trees (Table 2). Approximately 30 to 40% of the trees on grazed plantations showed some sign of browsing by sheep. However, when browsing did occur it was very light with less than 2% of current year's foliage growth removed from browsed trees.

Compared to sheep, wildlife had a substantial impact on the plantations. Not only was a large proportion of the trees browsed by wildlife, but the amount of foliage removed from each tree browsed was greater from wildlife than from sheep grazing. The study plantations border a forested area which provides habitat for a large deer population. Most of the wildlife use measured on our plantations is believed to be from deer which graze the trees primarily during late winter and early spring.

In addition to the June grazing period, sheep were placed on the study plantations in January to consume forage which had accumulated during the fall and early winter growing period (Table 3). This grazing use was deemed necessary to achieve maximum establishment and growth of subterranean clover by removing the herbage overburden and reducing competition between clover and the grasses present on the plantations. Since Douglas-fir trees had only mature, relatively unpalatable foliage at this time of year, mid-winter presented an opportunity to "clean up" the pastures before spring growth. This was accomplished without significant browsing impacts on the trees (Tables 3 and 4).

CURRENT STATUS

It is much too early to draw any conclusions from the information gathered in this study. The project is expected to continue until the understory forage base is lost because of tree canopy closure on the cluster plots. The experiences which we gained this year have been encouraging. A considerable amount of forage was consumed by sheep with little browsing impacts on the timber crop. Height and diameter growth of the Douglas-fir trees are being measured. Within the next two or three years, we expect to have some indication of whether the clover/grazing program is affecting tree growth.

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Table 1. Forage production and utilization for the 1983 grazing period. Data are mean ± standard error.

	No Trees		8 x 8 Tree Planting		Cluster Tree Planting	
	Grazed	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
Herbage Produced (lb/AC)	4987 ± 729	2196 ± 44	6116 ± 903	1987 ± 161	5295 ± 152	2643 ± 88
Herbage Utilized (lb/AC)	2147 ± 187	--	1272 ± 54	--	1259 ± 309	--
Herbage Utilized (%)	40.4 ± 2.3	--	22.1 ± 4.1	--	20.8 ± 5.1	--
Sheep Days of Use/AC	663	0	443	0	219	

Table 2. Browsing impacts sustained from wildlife (before study) and sheep (during 1983 grazing period) in relation to herbage use. Data are mean ± standard error.

	8 x 8 Tree Planting		Cluster Tree Planting	
	Grazed	Ungrazed	Grazed	Ungrazed
1) % of Trees Browsed:				
Wildlife	81.8 ± 0.5	88.8 ± 7.2	76.5 ± 1.1	72.7 ± 6.4
Sheep	41.8 ± 1.5	--	32.6 ± 16.6	--
2) % of Laterals Browsed:				
Wildlife	15.1 ± 5.0	14.9 ± 1.0	12.5 ± 2.9	4.0 ± 0.3
Sheep	1.9 ± 0.8	--	0.4 ± 0.3	--
3) % of Terminals Taken:				
Wildlife	18.3 ± 3.2	19.9 ± 5.4	9.1 ± 2.1	5.5 ± 0
Sheep	7.0 ± 0.1	--	3.8 ± 2.6	--
4) % Herbage Utilization	22.1 ± 4.1		20.8 ± 5.1	

Table 3. Standing crop and utilization of forage for the 1984 late winter grazing period. Data are mean ± standard error.

	No Trees, Grazed	8 x 8, Grazed	Cluster, Grazed
Standing Crop (lb/AC)	1622 ± 121	2119 ± 22	2008 ± 60
Herbage Utilized (lb/AC)	327 ± 12	624 ± 31	504 ± 24
Herbage Utilized	20.3 ± 0.8	29.5 ± 1.8	25.1 ± 0.5
Sheep Days of Use/AC	174	128	95

Table 4. Browsing impacts from wildlife and sheep for the 1984 late winter grazing period. Data use mean ± standard error.

	8 x 8 Planting		Cluster Planting	
	Grazed	Ungrazed	Grazed	Ungrazed
1) % of Trees Browsed:				
Wildlife	0.4 ± 0.3	0	0.4 ± 0.2	0
Sheep	34.7 ± 10.9	--	20.0 ± 1.0	--
2) % Laterals Browsed:				
Wildlife	0	0	0	0
Sheep	4.3 ± 1.7	--	1.5 ± 1.1	--
3) % of Terminals Taken:				
Wildlife	0	0	0	0
Sheep	0	--	0	--
4) % Herbage Utilization	29.5 ± 1.8	--	25.1 ± 0.5	--

REMOTE SENSING TECHNOLOGY AND MATERIALS FOR USE IN EXTENSION PROGRAMS

Barry J. Schrumpf and Paul S. Friedrichsen

The launch of the space age has brought satellite TV, battery-powered hand tools, new light-weight metal alloys, heat resistant ceramics, and space blankets into many everyday activities. Extraordinary new views of Earth taken from the moon and by meteorological and earth resources satellites have revolutionized weather forecasting, natural resource monitoring, and exploration geology. Data from satellites provide new information sources and constitute an integral part of the technology called *remote sensing*.

This technology is defined as "the measurement or acquisition of information of some property of an object or phenomenon by a recording device that is not in physical or intimate contact with the object or phenomenon under study" (Colwell 1983). The technology is very old; for as long as people have perceived distant objects and made mental and physical records, they have employed the basic techniques of this technology. When photography was developed in the mid-nineteenth century, the tools for remote sensing began to emerge; early cameras were carried aloft by balloons, pigeons and kits, and then by airplane in 1909. Although tremendous advances in remote sensing technology awaited the era of space travel, computers and advanced electronics, useful application of remote sensing to natural resource management began much earlier.

Aerial photographs have been used for about 50 years by federal agencies and other land managers as a tool for mapping vegetation, distinguishing physiographic features, depicting land use changes, administering crop production control, etc. The major sources of these photos have been federal agencies such as the U. S. Department of Agriculture, Forest Service, Agriculture Stabilization and Conservation Service, and the U. S. Department of Interior, Bureau of Land Management. These agencies from time to time (usually ten- to fifteen-year intervals) would contract to have aerial photographs taken at various scales (1:12,000 to 1:20,000) covering the land area under their management or administrative jurisdiction. Through these earlier years most technological advances were improvements in aircraft, cameras, films, filters, and film processing and were generally classed as refinements of existing technology.

To this existing technology new advances have been added in sensor development, analytical techniques and demonstrated applications of the technology (Colwell 1983; Johannsen and Sanders 1982). Sensor systems with new names--multispectral scanners, imaging spectrometers, synthetic-aperature radar--extend the ability to "see" into portions of the electromagnetic spectrum unavailable to the human eye and photographic films. These new capabilities make it possible to detect changes in moisture content of plants, the temperature of plants, soil, water, and rock and to see through smoke and cloud cover to image the earth below. This new technology is now becoming available to resource managers, including private farmers and ranchers for use in acquiring information for better management.

The competition in allocation of resources and the continued economic pressures on production agriculture make it imperative that both public and private land managers have accurate and timely information for decision-making processes. An initial requirement is for complete inventories of resources, supplemented by subsequent comparative information for determining rates and direction of changes of the resource base, and for monitoring the results of management programs. Remote sensor products in common use for resource management include satellite multispectral scanner data and aerial photography. These are frequently used for inventory and monitoring purposes to provide information needed for planning and management.

Since 1972, the United States has sponsored an earth resources satellite system known as Landsat. The fifth in this series was launched in March 1984. Each satellite has been equipped with a multispectral scanner that provides pictures of the earth of sufficient detail for mapping geomorphic features, soils, and natural plant communities, for making some crop identifications, for detecting major plant phenological events (leafing out and senescence) and hydrologic changes, and for monitoring other changes such as those caused by fire, strip-mining and irrigation development. The data are archived and constitute a historical record of land cover and use and changes therein.

Landsat data are available as pictures and forms suitable for processing with a computer. The maps prepared by analysis of these data forms can depict kinds, amounts, and locations of vegetation types, wildlife habitat, fuels for wildfires on rangelands, widespread insect damage in forests, and flooding of agricultural land. The vegetation maps may be used as a first stage of an inventory that can also include one or two scales of aerial photography and field data measurements. Each data level serves as a "stage" in a statistically designed sampling procedure.

"Conventional" aerial photography has long meant 9" x 9" black and white photographs; however, other films, notably natural color and color infrared, and other film formats (70 mm and 35 mm) have become increasingly common during the past two decades. One person, using aerial photographs, can evaluate a tremendous area and a large number of sites; data so obtained contain one less source of variation than if the data were acquired by several field crews. Furthermore, the data can be extracted from the photographs any time during the year; acquisition of information is not restricted to a field season. Aerial photographs can be acquired at extremely small scales (1:130,000) up to very large scales (1:600); each scale has its advantages and disadvantages and appropriate application. Generally speaking, however, the smallest scale should be used that can be reliably employed, this has the benefit of reducing costs and some sources of variation among photographs.

The information that can be extracted from aerial photographs is highly dependent on the knowledge the interpreter already possesses about the resource area. This is particularly true when working with smaller scales of photography, although the amount of extractable information can be considerable given sufficient training and experience.

Photointerpreters can be more readily trained to use large scale photography. Trees and shrubs can be identified and measurements made of heights and ground cover. Identification of tree and shrub species is very much a function of growth form, size, foliar density, branching pattern, leaf size, and similar characteristics that permit a plant species to be very distinctive in appearance or, conversely, to look very similar to other species. Season of photography is also extremely pertinent to species identification and should be timed to image the species of interest when its contrast with other species is maximized. Very large-scale photography (scale ≈ 1:600) can be used to assess surface stones with one-inch diameters, pedestalling around stones and plants, and the integrity of bunchgrass clumps. Color infrared (CIR) film at all scales is frequently preferred to black and white or natural color because of the contrast that is achieved between photosynthetic plant material and the soil background.

The following are two examples of how remote sensing can be used in Extension programs.

(a) Coordinated resource plans are being encouraged by federal land management agencies in dealing with livestock permittees on public rangeland. The process brings all concerned parties together: U. S. Forest Service, Soil Conservation Service, Bureau of Land Management, and Fish and Wildlife Service; Oregon State Departments of Forestry and Fish and Wildlife, Extension Service, and the private land owner. Together, they work out a coordinated management plan for the use of resources on a given allotment in a manner that best meets the resource objectives of all parties concerned, including those of the producer. Extension agents can use their role to present new information and technology that may be helpful to the process.

For instance, water availability on arid or semiarid ranges has long been a limiting factor to livestock distribution and proper range utilization. Color infrared photographs can be used to detect small moist areas, seeps or springs, and associated vegetation that indicate candidate locations for water development.

Other examples pertinent to range management programs could include uses of satellite pictures to measure the area of range fires and seeded areas and for monitoring flooding as is occurring in the Harney and Warner Lakes Basins.

(b) Another possibility for use of remote sensing techniques in Extension programs is in the area of irrigated crop management. Color infrared 35 mm film is being used by some large farming operations to monitor crop conditions on a weekly basis. Extension agents could use this technique as a great assistance in visually showing producers the effect on crops of:

improper fertilizer placement,
poorly functioning irrigation systems,
insect or plant disease outbreaks,
changes in soils,
drainage problems, etc.

Remote sensing technology provides new tools that Extension educators can use to help managers and producers remain competitive, productive, and successful managers of the vegetation, soil, and water resources.

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PREVIOUS RANGELAND MANAGEMENT
PROGRESS REPORTS

These progress reports are available upon request from the Eastern Oregon Agricultural Research Center, Star Rt. 1 - 4.51 Hwy. 205, Burns, Oregon 97720.