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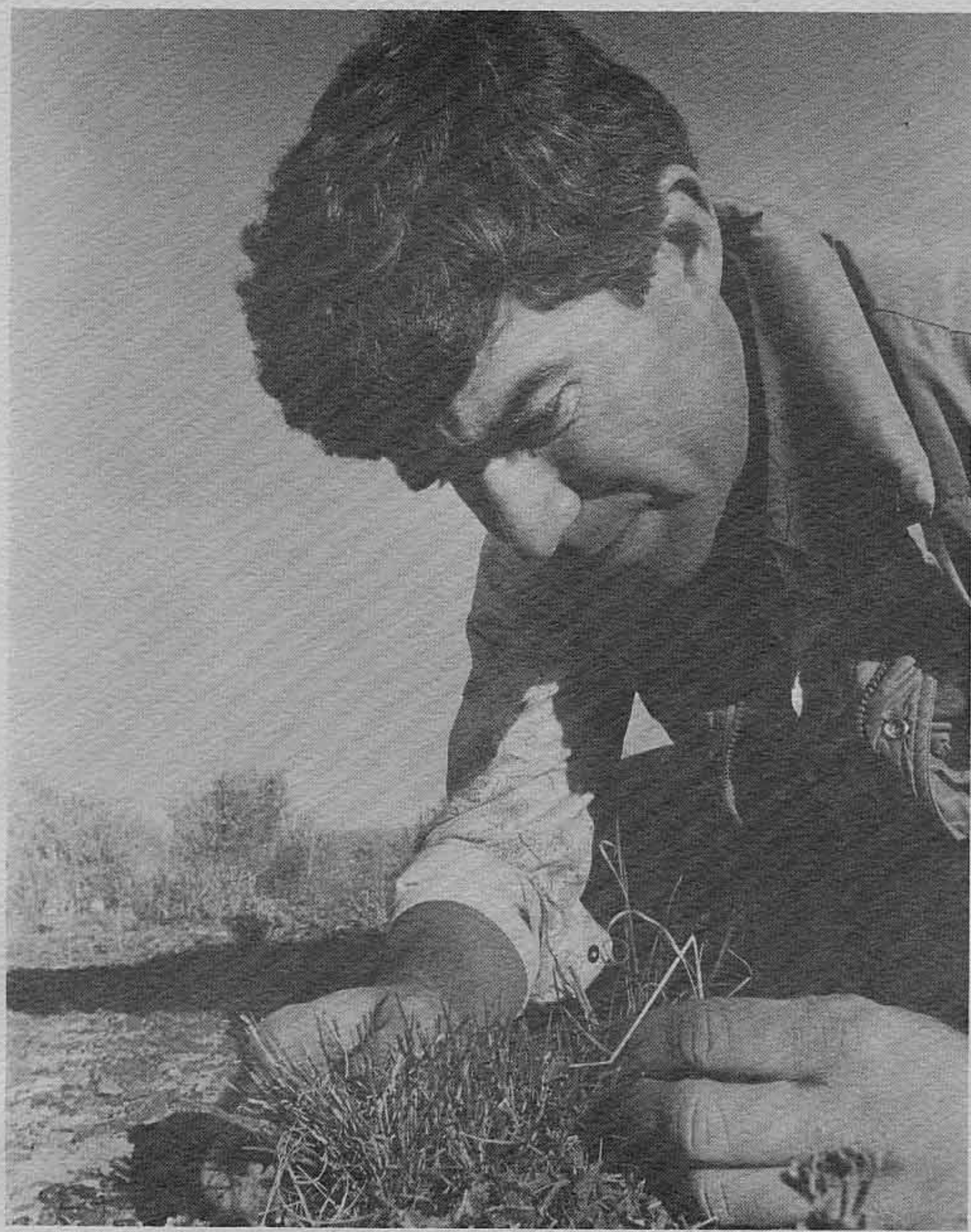
# Research in Rangeland Management



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# UNDERSTORY HERBAGE RESPONSE TO WESTERN JUNIPER (JUNIPERUS OCCIDENTALIS) REMOVAL IN CENTRAL OREGON[1]

M. R. Vaitkus and L. E. Eddleman

Western juniper (Juniperus occidentalis) was historically restricted in distribution in Oregon. However, over the last 100 years, active expansion has occurred into sagebrush grasslands, where it has gradually developed into continuous forests. Evidence suggests that increasing size and density of western juniper trees leads to a decline in palatable forbs and grasses. For the most part, mechanisms by which juniper negatively impacts associated vegetation have not been identified. Efforts currently directed toward improvement of newly invaded rangelands most often do not include followup monitoring of herbage response, so neither ecological nor economic project analysis can be made.

In the summer of 1982, this project was begun to examine site-specific impacts of juniper on associated vegetation and soils, and the response of vegetation and soils to juniper removal. Specific objectives were: (1) to determine whether understory herbage production was affected by the presence of western juniper trees, and (2) to determine herbage production response to the removal of western juniper trees.

## METHODS

The study area was southeast of Prineville in central Oregon on a gentle N, NW-facing slope at approximately 4,000 feet elevation. It was characterized by relatively shallow (25 inches) skeletal, cobbly clay and silt soils, derived from weathered basalt. Precipitation in this area averages 17 inches annually.

The site was dominated by juniper with a canopy cover of approximately 20%, and it was considered a closed community since the growth rate of trees smaller than three feet tall was very slow. Density of juniper trees was 60 per acre. Associated vegetation included three subspecies of big sagebrush--Wyoming, mountain, and basin (Artemisia tridentata ssp. wyomingensis, vaseyana, and tridentata), low sagebrush (Artemisia arbuscula), cheatgrass (Bromus tectorum), and native perennial grasses, such as bluebunch wheatgrass (Agropyron spicatum), native bluegrass (Poa sandergii), and squirreltail (Sitanion hystrix). Locally isolated areas of vigorous bunchgrasses and on-site soil characteristics suggested that the area had once supported a richer flora.

Paired plots containing trees of similar size and density were chosen for this study. These trees were separated into three size classes (large, intermediate, and small) on the basis of canopy diameter. In the fall of 1982, we hand-cut trees from one of the two paired plots and

[1] This work was sponsored and funded by the Oregon State University Agricultural Experiment Station.

measured herbage response in the summers of 1983 and 1984. We determined herbage production on a tree basis within each size class. The herbage production data presented here deal only with the largest canopy size class, those trees with canopy diameters exceeding 5 meters.

We measured herbage production along belt transects established within four 90-degree quadrants radiating from the bole of each individual sample tree and included samples both from beneath the canopy (understory) and from the interspaces between canopies.

## RESULTS

Herbage production in the natural untreated juniper stand was dominated by cheatgrass in the understory area beneath the tree canopy and by native bluegrass in the interspace area between trees (Table 1). Cheatgrass, although abundant beneath the canopy, contributed very little to the production in the interspaces. Potential forage grasses, such as squirreltail and bluebunch wheatgrass, were more abundant in the understory than in the interspace, but only squirreltail contributed significantly to the total herbage supply. All perennial grasses declined in production from 1983 to 1984, regardless of their position relative to the tree canopy.

In contrast to the untreated area, canopy removal resulted in a herbage production increase both years. This response was species-specific and its magnitude dependent upon species location relative to the canopy. The first year after tree removal, native bluegrass and perennial forbs showed little change in production in either the understory or interspace. Squirreltail increased in the understory and declined in the interspace; bluebunch wheatgrass decreased in the understory and increased greatly in the interspace. Annual forbs increased in both areas.

The second year after tree removal, most responses in herbage production were similar, but more pronounced. Native bluegrass production was still not significantly affected in either the understory or the interspace. Perennial forb biomass production remained unchanged in the understory, but increased in the interspace. All other species and groups of species, especially annual forbs, increased greatly after canopy removal.

Overall, the greatest relative increase in production two years after tree removal was in the understory area, but the interspace area contributed more to the total response simply because it constituted the majority of land surface.

## CONCLUSIONS

Two years after canopy removal, annual forbs constituted the greatest amount of herbage production associated with western juniper. Tall annual willow-weed (<u>Epilobium paniculatim</u>) was especially dominant. Annual grasses also accounted for a significant amount of the increase in herbage production on this site. Some species, such as native bluegrass, responded little to tree removal. Desirable forage species, such as squirreltail and bluebunch wheatgrass, increased in production, especially in the interspace, yet fluctuated in production from year to year under a natural canopy.

Much effort is currently expended toward improvement of juniper-dominated rangelands. Our observations indicate that there is an increase in herbage production after tree removal. Yet results of this study also indicate that production may not represent more forage. On degraded rangelands the greatest response to juniper removal may be in annual forbs and grasses. Perennial grass species did increase, but not to a major extent, during the two years of this study. Factors such as these need to be considered in making realistic predictions concerning improvement of juniper rangelands. On some sites the increase in production of desirable species after juniper removal, in the absence of reseeding, may not be sufficient to justify tree removal as an economically efficient practice for increasing forage production.

Table 1. Herbage Production (lbs/ac) from a Western Juniper Stand

| Plant Species | 1983 Canopy Present | 1983 Canopy Removed[2] | 1984 Canopy Present | 1984 Canopy Removed[2] |
|---|---|---|---|---|
| **A. Canopy Zone Understory[1]** | | | | |
| Squirreltail | 65 | 80 | 25 | 127 |
| Bluebunch wheatgrass | 8 | 3 | 2 | 40 |
| Native bluegrass | 73 | 72 | 63 | 63 |
| Cheatgrass | 122 | 218 | 122 | 290 |
| Perennial forbs | 33 | 15 | 35 | 60 |
| Annual forbs | 45 | 132 | 60 | 107 |
| Other | 27 | 23 | 18 | 63 |
| Total | 373 | 543 | 325 | 750 |
| **B. Interspace** | | | | |
| Squirreltail | 9 | 4 | 3 | 18 |
| Bluebunch wheatgrass | 1 | 35 | 0 | 28 |
| Native bluegrass | 170 | 175 | 91 | 99 |
| Cheatgrass | 7 | 2 | 3 | 11 |
| Perennial forbs | 50 | 52 | 47 | 100 |
| Annual forbs | 52 | 192 | 34 | 212 |
| Other | 75 | 39 | 58 | 99 |
| Total | 364 | 519 | 236 | 567 |

[1] Canopy zone understory made only 6% of the total area.
[2] Canopy was removed in the fall of 1982.

# SUCCESS OF BROADCAST SEEDING ON UNTREATED, IMPRINTED AND CHAINED RANGELANDS

David Ganskopp

Drilling is typically the preferred and traditional method of seeding disturbed rangelands unless the character of the landscape or the scale of the operation prevents the use of large equipment. In such cases, broadcast seeding may be the only means of establishing a vegetative cover on the site. Broadcast seeding should be used on rangelands only when there is some assurance that most of the seed will be covered. Without adequate coverage, seedlings root poorly and perish as the soil surface rapidly dries.

In the summer of 1982, the Lakeview District of the Bureau of Land Management (BLM) faced an extensive range revegetation project following several large scale wildfires. Because of a shortage of rangeland drills and tractors, the BLM was forced to apply aerial broadcast seedings to large acreages. This project was superimposed on their efforts.

## LOCATION AND METHODS

In July 1983, a wildfire removed nearly all vegetative cover from a large area just south of Alkali Lake in Oregon. A helicopter broadcast seeded the study plots in October 1983 with a mixture of cereal rye (Secale cereale) at 14 pounds/acre, and crested wheatgrass (Agropyron desertorum) at 7 pounds/acre. These rates leave from 20 to 30 seeds of each species scattered on each square foot of soil surface. The cereal rye was expected to provide soil stabilization in its initial growing season while the crested wheatgrass was expected to develop more slowly, to eventually dominate the site, and to provide long-term soil stability and forage.

After broadcast seeding (November 1983), three treatments were applied to the seedbed. These were: 1. Chaining, in which a large anchor chain, composed of 50 to 70 pound links, was stretched between two crawler tractors and pulled over the seedbed; 2. Imprinting, in which a large water-filled drum, surfaced with a variety of geometric designs, was pulled across the soil surface with a crawler tractor; and 3. Untreated, in which the broadcast seeds were simply left undisturbed on the soil surface. The chaining and imprinting treatments were expected to force broadcast seeds into the soil and to provide small depressions which gather moisture and enhance the environment for germinating seeds.

Success of seedbed treatments was evaluated in July 1984 by determining the density of cereal rye, crested wheatgrass, and competing cheatgrass (Bromus tectorum) plants. Experimental design was a randomized complete block with three replications and three seedbed treatments.

## RESULTS AND DISCUSSION

Five days after seedbed treatment, blowing soils eliminated all surface evidence of imprinting or chaining activities on the study plots. Precipitation in the following months (November 1983 - July 1984) totaled 6.56 inches at the Alkali Lake weather station, providing slightly less than normal moisture for developing seedlings.

Experimental plots were evaluated in mid-July 1984. Imprinted plots supported the greatest numbers of cereal rye and crested wheatgrass seedlings of all treatments (Table 1). Seedling densities for both species were nearly four times greater on the imprinted areas than on the chained and untreated areas. Essentially no differences between the chained and untreated plots existed for both crested wheatgrass and cereal rye.

Table 1. Density per square foot of cereal rye, crested wheatgrass, and cheatgrass seedlings on treated seedbeds near Alkali Lake, Oregon in July 1984. Means within rows sharing a common letter are not significantly different (P>0.05)

| Species | Untreated | Chained | Imprinted |
|---|---|---|---|
| Cereal rye | .3a | .4a | 1.6b |
| Crested Wheatgrass | .8a | .8a | 4.4b |
| Cheatgrass | .6a | .4a | .3a |

The trend across treatments was reversed for densities of competing cheatgrass plants. Cheatgrass densities were highest on untreated plots and lowest on the imprinted areas. Mean densities were not significantly different (P>0.05) among seedbed treatments, however.

Seeding success is judged <u>excellent</u> in the Great Basin if seedling densities are greater than 0.75 per square foot. Success is deemed <u>good</u> if densities are between 0.5 and 0.75 seedlings per square foot (Vallentine 1971). Based on these criteria, crested wheatgrass success would be judged excellent on all treatments, and the long-term goals of the BLM were accomplished on all treatments. Both short- and long-term goals, however, were satisfied only in the imprinted plots where densities of both cereal rye and crested wheatgrass attained satisfactory levels. On the imprinted plots, herbage production averaged 26 pounds per acre for crested wheatgrass and 547 pounds per acre for cereal rye.

In this project, the timing, soils, and precipitation patterns probably were ideal for broadcast seeding and imprinting treatments. Seeding was accomplished just before fall precipitation.

The superiority of the imprinted treatment was most likely related to compaction of a loose seedbed and to the subsequent coverage of imprinted depressions and seed by blowing soil. Similarly, seedling emergence in the chained areas was most prominent where tractor tracks compacted and indented the loose mineral soil.

These interpretations are somewhat preliminary and speculative, as the conclusions are based on seedling counts acquired in an initial growing season. Competitive processes and environmental factors in subsequent years may impact plant establishment and alter interpretations to some degree.

SUMMARY

The success of seedling establishment of broadcast cereal rye, crested wheatgrass, and residual cheatgrass was evaluated on untreated, chained, and imprinted plots on a burned area near Alkali Lake, Oregon. Seedling densities on imprinted plots demonstrated a fourfold superiority over untreated and chained plots for both seeded species. Crested wheatgrass densities were satisfactory in all treatments, however. Essentially no differences were detected between the chained and untreated seedbeds.

LITERATURE CITED

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# CATTLE AND ESTABLISHMENT OF CONIFER SEEDLINGS: PRELIMINARY FINDINGS FOR SOUTHWEST OREGON

Paul S. Doescher and Mabel Alejandro

One important factor restricting reforestation of many timberlands is the failure of tree seedlings to survive on sites characterized by rapid establishment of shrub and herbaceous vegetation. Because of accelerated juvenile growth rates exhibited by many of these species, resources are quickly made less available for tree growth.

In southwest Oregon, reforestation has been particularly difficult because of the combined effects of competitive understory vegetation and dry climatic conditions. In the past, silvicultural prescriptions have strongly emphasized the use of herbicides to control competing vegetation. However, recent court decisions banning the use of herbicides on federal properties have forced foresters to consider alternative approaches of vegetation management. Methods such as hand slashing and paper-mulching are being considered as alternatives to herbicides. These techniques are often expensive in comparison to herbicides.

One management approach which may effectively promote forest regeneration is the incorporation of controlled cattle grazing with intensive forest management. We are developing a research program in southwest Oregon which has as its primary goal the assessment of cattle grazing as a means to promote establishment of conifer seedlings. It is assumed that controlled grazing will reduce competing vegetation and increase the availability of soil moisture and nutrients for tree growth. If livestock grazing increases growth and survival of conifer seedlings, then this research will provide a basis for improvement of both grazing and forest management systems. Several projects have been initiated since this program was begun in January 1984. This report describes initial research activities in southwest Oregon.

## SALT CREEK STUDY

As a pre-study to future, comprehensive research projects in southwest Oregon, an experiment was designed on a one-acre clearcut in the Salt Creek drainage east of Medford, Oregon. The purpose of this research was to determine whether amounts of soil moisture available to conifer seedlings could be increased when competing vegetation was grazed by cattle at critical phenological periods.

## MATERIALS AND METHODS

Douglas-fir and ponderosa pine seedlings were planted during the spring of 1983 and native vegetation controlled by herbicides. During the fall of 1983, perennial ryegrass and orchard grass were broadcast seeded and established on certain plots. This allowed for a comparison of tree growth under seeded and unseeded conditions. The area was fenced during the spring of 1984 and conifer seedlings subjected to the following conditions:

1. Conifer seedlings grown in the absence of herbaceous competition.
2. Conifer seedlings grown with ungrazed grasses.
3. Conifer seedlings grown in association with grasses grazed by cattle.

Grazing was applied during the first week of June when grasses were in the boot stage. The grazing period lasted for seven days. We felt grazing during this period presented the animal with a very palatable forage, and defoliation at this time allowed maximum suppression of competing vegetation. Information recorded following the grazing treatment included:

1. Browsing of conifer seedlings.
2. Water stress of conifer seedlings throughout the growing season.
3. Forage utilization.

## RESULTS AND DISCUSSION

Results showed that controlled livestock grazing can be compatible with the objectives of forest management. Presence of highly palatable forage species served as an attractant, such that minimal browsing and trampling of conifer seedlings were noted. Of 135 conifer seedlings surveyed after the grazing trial, only two seedlings exhibited lateral browsing and only one seedling was trampled. In no instance were terminal branches browsed by livestock. This observation was impressive in light of the 70% utilizatin of seeded forages on the site.

Grazing also effectively increased the amount of soil moisture available for tree growth. When grasses surrounding Douglas-fir seedlings were grazed, water stress measurements were similar to those found for seedlings grown without herbaceous competition (Figure 1). Douglas-fir seedlings grown in association with ungrazed grasses exhibited pronounced water stress earlier in the growing season. We feel that careful grazing management extended the growing season of Douglas-fir seedlings approximately three weeks.

## THE MULESHOE PROJECT

Our experience with the Salt Creek study has aided us in the design of a comprehensive research program entitled The Muleshoe Project. Whereas the previous research was performed on a land area of one acre, this project will encompass about 50 acres.

## RESEARCH PLAN

The study area is approximately eight miles northeast of Butte Falls, Oregon, on land administered by the Medford District of the Bureau of Land Management. The forest community is mixed-conifer with Douglas-fir the dominant tree species.

Experimentation is being carried out on two adjacent sites. The first is a 26-acre unsuccessful ponderosa pine plantation. Severe soil compaction caused by logging practices and improper establishment of pine have significantly reduced wood production of this site. Site preparation on this area involved scarification and piling of pine by bulldozing, followed by ripping of the soil to reduce the soil compaction problem.

The second site is a 24-acre mixed-conifer forest community recently tractor-logged using designated skid trails. Slash on the site was burned during the fall of 1984.

Research will examine tree growth response as influenced by cattle grazing on sites allowed to revegetate naturally after site preparation, and on sites seeded with palatable forage species. Appropriate treatments were seeded in the fall of 1984. Because of poor winter growing conditions, sites were reseeded in March 1985. Pastures were seeded with a mix of perennial ryegrass, orchard grass, white clover, and subterranean clover. Douglas-fir and ponderosa pine seedlings (2-0) were planted (5:1 ratio) during the spring of 1985.

The following treatments have been applied:

Treatment 1
After initial site preparation and tree planting, this treatment is being managed according to silvicultural prescriptions. No grazing will occur in this treatment.

Treatment 2
After site preparation, native vegetation has been allowed to establish on the site. This treatment will receive livestock grazing.

Treatment 3
This treatment compares ungrazed seeded forages with tree growth response. This treatment assesses conifer survival and growth under maximum competition from forage species.

Treatment 4
This treatment is similar to Treatment 3, but includes livestock grazing. A carefully controlled grazing management program has been employed to achieve proper utilization of forage species and minimize browsing of Douglas-fir seedlings.

Factors to be intensively measured include:
1. Tree growth and survival.
2. Water and nutrient availability for tree growth.
3. Livestock performance.

It is hoped that this research trial will help us evaluate on a large scale the feasibility of cattle-grazing as a silvicultural tool. Preliminary findings of this research effort will be presented at the Range Field Day meetings.

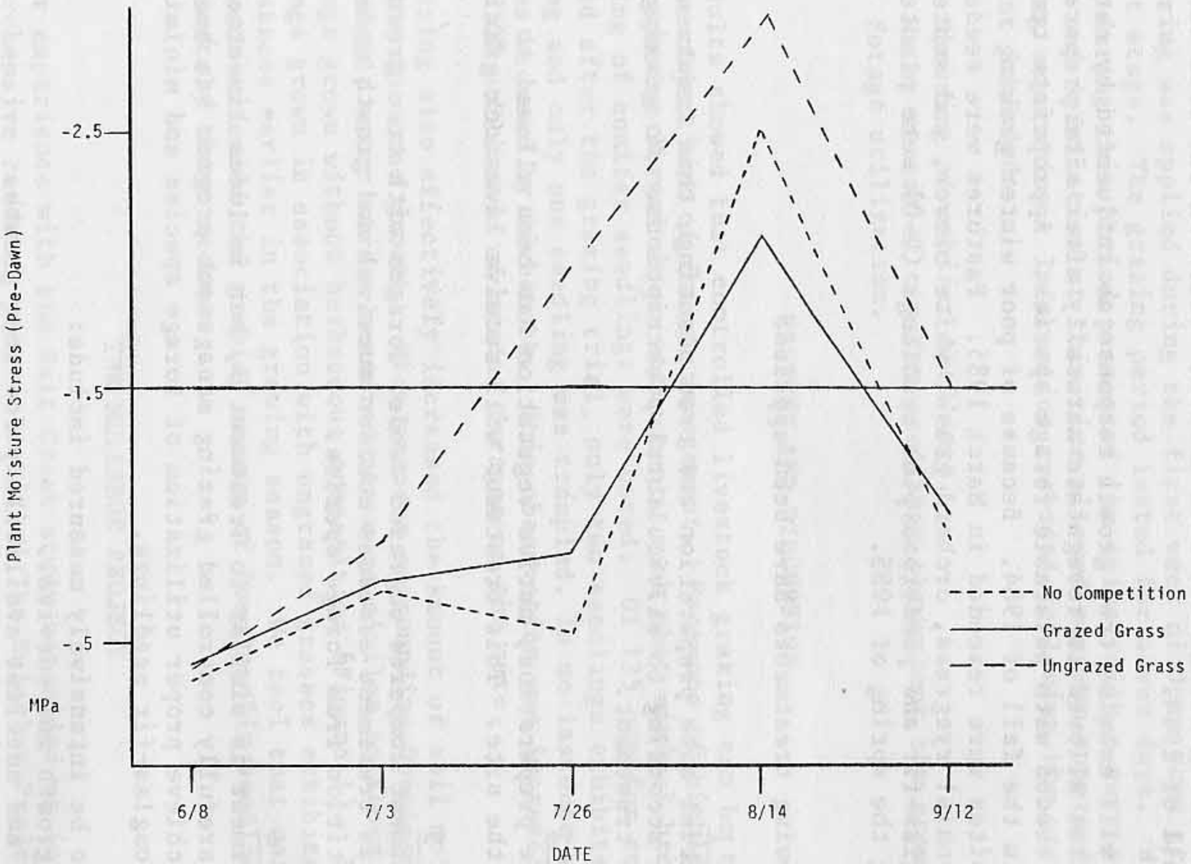


Figure 1. Plant moisture stress (as measured by pressure chamber) during the 1984 growing season for Douglas-fir seedlings grown in association with: (1) no herbaceous competition, (2) ungrazed grasses, and (3) grasses grazed by livestock. As moisture stress increases (i.e. numbers become more negative), tree growth declines. Values greater than -1.5 MPA indicate the point at which seedling growth is inhibited.

# DESERT SHRUB COMMUNITY VARIABLES AND SPECTRAL REFLECTANCE PROPERTIES

Barry J. Schrumpf, Dennis L. Isaacson, and William J. Ripple

Studies of the ecology and physiology of plants and their roles in forage production, competition for resources, plant succession, and in hydrologic and nutrient cycles may be aided by remote sensing. Remote sensing implies the acquisition of information about a subject, usually from some remote vantage point, and therefore, without direct contact with the subject. This often involves flying a camera or other sensor system in an aircraft or spacecraft and producing a picture or numerical data set that can be analyzed and interpreted. During the last decade, remote sensing development activities have focused on identifying and mapping ground cover such as agricultural crops and plant communities. More recently, research in remote sensing is tackling questions regarding plant growth and development and physiological condition in order to use a capability for detecting these variables in predictions of yields, irrigation scheduling, estimations of biomass distributed across the landscape and changing with time, and quantifying the interactions of the vegetation, soil, and topographic characteristics of the landscape with the components of the hydrologic cycle. The development of this capability requires basic research of plant canopy variables such as phenology, biomass, and water content in relation to their reflectance and emittance spectra.

## OBJECTIVE

This research was initiated to define relationships of reflectance spectra to plant canopy variables and some associated site variables, with particular attention paid to plant-held water. Since water content of plants is dynamic, this variable was also studied to define diurnal and seasonal variations. Specific objectives were:

1) characterize patterns of plant moisture change which could be expected to influence measured reflectance, and

2) study the relationships between *in situ* measured spectral reflectance from a desert shrub canopy with selected shrub canopy variables.

## STUDY AREA AND METHODS

The sites selected for this research were on land administered by the Eastern Oregon Agricultural Research Center (EOARC) and on adjacent land administered by the USDI Bureau of Land Management (BLM). The specific sites were intermittent lake beds and adjacent uplands supporting Bolander silver sagebrush (ARCAB) and Wyoming big sagebrush (ARTRW), respectively.

OBJECTIVE 1.

Series of day-long observations were made on ARTRW and ARCAB on two dates, July 18 and August 23. Leaves were picked from the terminal three inches of shoots and placed in pre-weighed sealable plastic bags which were kept until the day's end and then weighed to obtain wet weights. The time of each collection, nominally five minutes in duration, was recorded, as were picker name, location, and date. Most samples contained from 50g to 100g of fresh leaves. After weighing, leaves were oven-dried in paper bags at 45°C until weights of samples ceased to change, a minimum of 72 hours. The dried leaves were weighed to obtain dry weights. Moisture amounts were calculated from the difference of net wet and net dry weights, and recorded on a wet weight basis:

$$\frac{\text{net wet weight - net dry weight}}{\text{net wet weight}} \times 100$$

Collections were made alternately from ARTRW and ARCAB at regular intervals from near-dawn until late afternoon by each of three collectors. Collections were not from single plants, but from plants within a nominal diameter of 20m and from shoots in all positions of individual plant canopies. Samples were a mix of persistent and ephemeral leaves.

OBJECTIVE 2.

Data for this experiment were collected from five plots dominated by ARCAB and involved repeated radiometric observations as the plot biomass was incrementally reduced between measurements. Photographs, as 35mm slides, were taken coincident with radiometric observations, and the biomass removed was weighed, dried, and re-weighed. Radiometric observations were measures of reflected solar radiation and emitted thermal radiation.

The measures were made with a Barnes Model 12-1,000 Modular Multiband Radiometer that provided field measurements corresponding to the spectral bands of the Thematic Mapper, a remote sensing system on the Landsat satellite. The radiometer was also equipped with an additional spectral band in the middle infrared (Table 1). A circular ring, 2.93m$^2$ in area, was placed over each plot to demark the bounds of the radiometer field of view to guide biomass clipping and to indicate the plot boundary on all photographs.

On each plot, six sets of observations were recorded. Each set included a recording of seven radiometric measurements, one each for the seven spectral bands of the radiometer, one 35mm slide and (except for the first set) a bag or bags of biomass clipped from the plot. After the radiometer and camera were positioned over the plot center, a stake marking the plot center was removed and radiometric measurements were taken. Next, the stake was replaced and the 2.93m$^2$ ring was centered around the stake, and a photograph was taken. A surface of about one-fifth of the plot was then cleared of biomass by clipping plants at the soil surface, and the biomass was placed in pre-weighed plastic bags, sealed, and labeled. Once this set of observations was completed, the stake and ring were removed, and observations of the next set were made (Figure 1). After all biomass had been clipped and removed and radiometric and photographic observations of the same bare plot were completed, the system was centered over the next plot and another series of data was collected.

Table 1. WAVELENGTHS FOR THE BARNES MODULAR MULTISPECTRAL RADIOMETER (MMR)

| Barnes Radiometer Bands (MMR) | Wavelength (μm) | Thematic Mapper Equivalent |
|---|---|---|
| MMR 1 | 0.45 - 0.52 (blue-green) | TM1 |
| MMR 2 | 0.52 - 0.60 (green) | TM2 |
| MMR 3 | 0.63 - 0.69 (red) | TM3 |
| MMR 4 | 0.76 - 0.90 (near infrared) | TM4 |
| MMR 5 | 1.15 - 1.30 (near infrared) | |
| MMR 6 | 1.55 - 1.75 (middle infrared) | TM5 |
| MMR 7 | 2.08 - 2.35 (middle infrared) | TM7 |
| MMR 8 | 10.40 - 12.50 (thermal infrared) | TM6 |

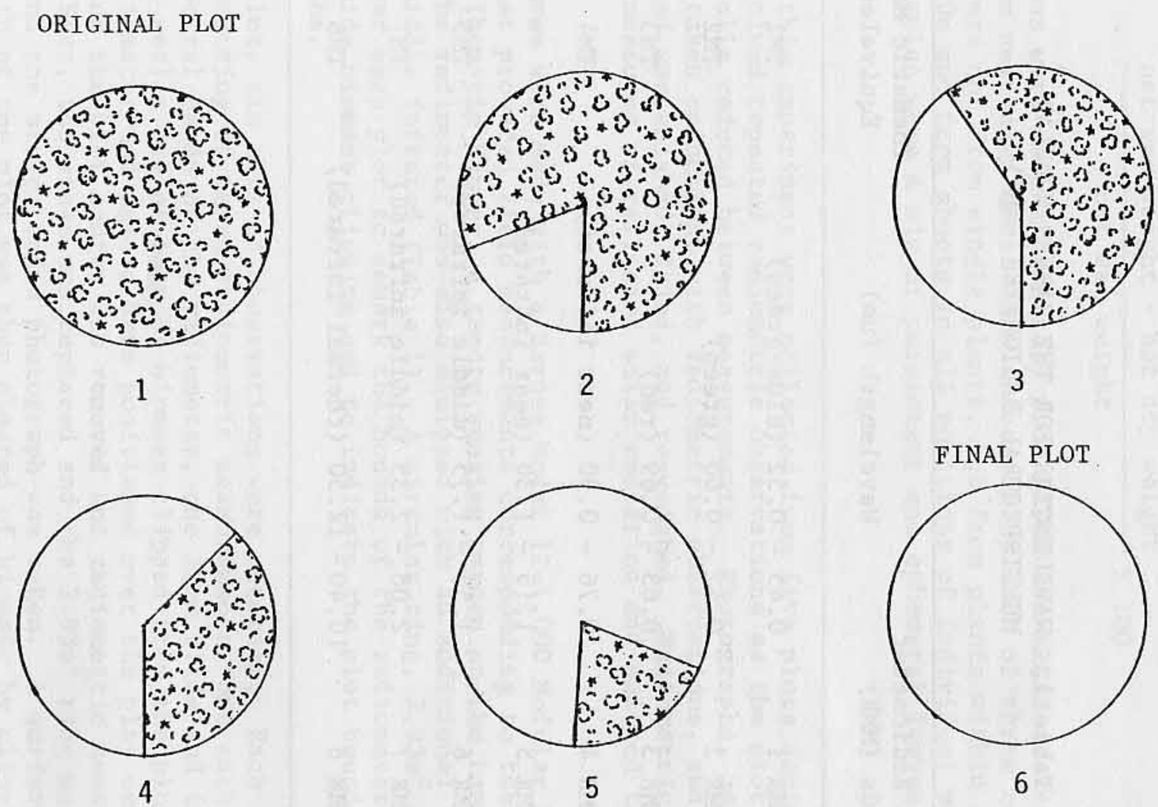


Figure 1. Diagram of the sequence of vegetation removal used in collecting six sets of radiometric and plot data were acquired from ARCAB dominated plots.

Plant materials were weighed for wet weights and the samples were placed in a drying oven at 45°C for a minimum of 72 hours and re-weighed.

Dot counts on the vertical photographs were used to estimate the proportions of each plot covered by green plant material, shadow, soil, and stems. Estimates were derived by projecting the slide, counting the total number of dots from a superimposed square grid which fell inside the ring, counting the dots associated with each cover type, and dividing the cover type counts by the total.

To remove the effects of interdependence in the data, the data were transformed by subtracting observed values in one set from the previous set of observations. In other words, data were prepared for analysis by creating a data set which represented the change in radiometric, photographic, and plot variables caused by biomass removal in order to remove the effect of approximately 80% redundancy in the original data set.

## ANALYSIS AND RESULTS

### OBJECTIVE 1.

Moisture data were first examined for differences among pickers and between species, and for differences in quantities picked among pickers and through time. Comparisons were by one-way analysis of variance, and differences in estimated plant moisture content among pickers were seen. To remove an apparent picker bias, the data were standardized for subsequent analysis. Individual observations were multiplied by $\bar{\bar{y}} / \bar{y}_{i}$, where $\bar{\bar{y}}$ is the grand species moisture mean and $\bar{y}_{i}$ is the picker moisture mean. Relationships between time and plant moisture content were examined with standard linear regression techniques.

Pickers collected markedly different quantities of leaves, but the relative quantities picked were consistent. One picker always picked significantly more than the other two, but pickers' coefficients of variation were nearly the same and stable for all collections. Differences in moisture content were observed in two cases. One picker collected samples with significantly less moisture from ARCAB on July 18, and a different picker collected ARTRW leaf samples with significantly more moisture on August 23. These differences, though small and on the order of 2.3% absolute moisture, were such that it was decided to adjust observations by the method mentioned above.

There were clear and significant diurnal changes in moisture content of leaves of ARCAB on both dates and of ARTRW on July 17. There was no significant pattern of change determined for ARTRW on August 23. Figure 2 summarizes the results for diurnal moisture variation for ARCAB and ARTRW on July 17 and August 23.

There were also marked changes in moisture content during the season. The mean of three observations taken on May 31 from ARTRW was 67.0%, and the means from July 18 and August 23 were 60.7% and 51.8%, respectively. The mean of six observations taken on June 11 from ARCAB was 69.4%, and the means from July 18 and August 23 were 59.3% and 49.9%, respectively.

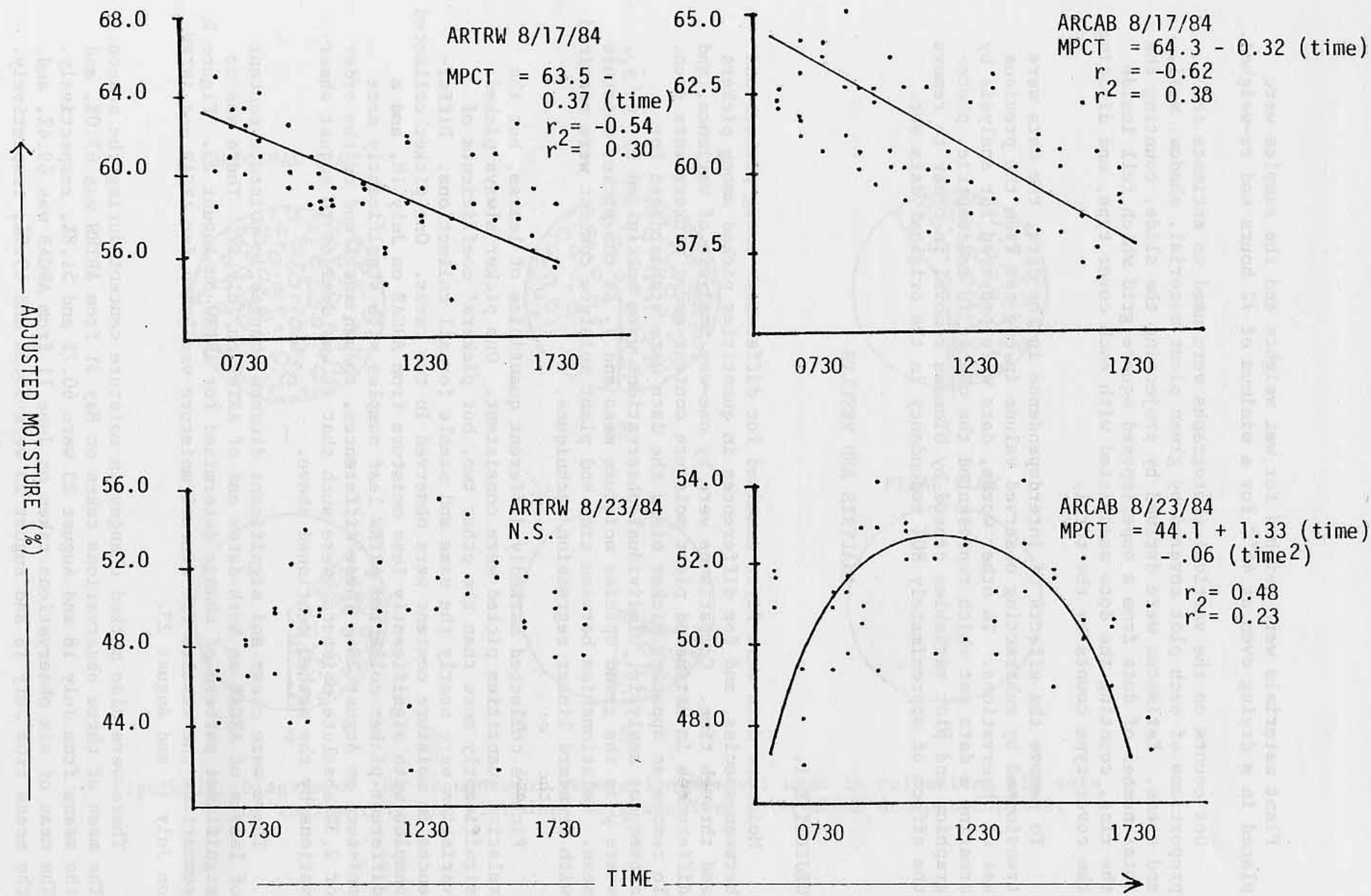


Figure 2. Summary of changes in Plant Moisture Content (MPCT) of *A. tridentata* subsp. *wyomingensis* (ARTRW) and *A. cana* subsp. *bolanderi* (ARCAB) on two dates.

OBJECTIVE 2.

The primary purpose of analysis was to determine the effectiveness of radiometric data, particularly the middle infrared, in predicting quantity of plant-held or above-ground moisture. Analysis proceeded by driving simple correlations, then by application of multivariate techniques for relating radiometric data sets with plot data sets and finally by examination of the relationships between simple linear combinations of radiometric bands and plot-derived variables. The data were first examined for intercorrelations within the radiometric and the plot-derived variables, respectively. Table 2 presents correlation matrices showing these relationships. As can be seen in Table 2a, Barnes radiometer bands one and two were highly correlated, as were bands six and seven in their response to plot conditions, and band four was most independent in response. Wet biomass, dry biomass, total moisture, and plot proportion in green plant cover were strongly correlated, as seen in Table 2b, and cover proportions in stems, shadow, and soil exhibited low correlations with all other variables.

After examining correlations within the respective data sets, correlations between sets were studied. Table 3 summarizes correlations between radiometric data and plot-derived data. Band seven was the band most highly correlated with dry biomass, total moisture, and plot proportion in green plant cover, and band four was most highly correlated with wet biomass. Just as plot proportion covered by soil, stem, and shadow showed low correlations, these variables showed low correlations with radiometric data as well.

Subsequent to examination of radiometric-plot data correlations, a number of linear combinations of Barnes spectral data were calculated and correlations with plot-derived data were derived. Table 4 presents a summary of these correlations showing that for all plot variables save shadow, there were linear combinations which gave higher correlations than single-band data.

The radiometric and plot-derived data were also analyzed by the multivariate techniques of partial multiple correlation (PMC). PMC analyses were conducted in two ways: one in which the original data were organized as 13 columns and 25 rows, with the first seven columns being the seven radiometric band observations and the last six being plot variables; and one with the six plot variables being the first (left-hand) set, and the last seven being the radiometric data. Wet biomass was dropped from the set of plot variables because its inclusion, as a simple sum of two other variables, dry biomass and moisture, risked having the computing algorithm characterize the data as a singular matrix. A summary of PMC results is presented in Table 5. Of the radiometric bands, band seven was the best extractor of variation in plot variables, and moisture was the plot variable best explained by radiometric data.

## DISCUSSION AND CONCLUSIONS

OBJECTIVE 1.

Although there were differences in the patterns of change and absolute moisture amounts between ARTRW and ARCAB, both species would be suitable for studies of desert shrub responses to environmental stress, and the spectral detection of those responses.

Table 2. CORRELATION MATRICES DERIVED FROM CHANGES IN RADIOMETRY AND PLOT-DERIVED MEASUREMENTS

Table 2a. Correlations between the radiometric bands of the Barnes radiometer

Correlation Coefficient (r) Matrix for Spectral Variables

| | B1 | B2 | B3 | B4 | B5 | B6 | B7 |
|---|---|---|---|---|---|---|---|
| Band 1 | 1.00 | .97 | .87 | .39 | .63 | .55 | .49 |
| Band 2 | | 1.00 | .90 | .42 | .61 | .53 | .46 |
| Band 3 | | | 1.00 | .08 | .56 | .76 | .73 |
| Band 4 | | | | 1.00 | .54 | -.24 | -.39 |
| Band 5 | | | | | 1.00 | .65 | .49 |
| Band 6 | | | | | | 1.00 | .97 |
| Band 7 | | | | | | | 1.00 |

Table 2b. Correlations between the plot-derived variables

Correlation Coefficient (r) Matrix for Canopy Variables

| | Dry BM* | Moistot** | Cover | Shadow | Stems | Soil | Wet BM* |
|---|---|---|---|---|---|---|---|
| Dry Biomass | 1.00 | .88 | .75 | .17 | -.29 | -.21 | .81 |
| Moistot** | | 1.00 | .66 | .20 | -.25 | -.29 | .80 |
| Cover | | | 1.00 | -.10 | -.30 | -.03 | .47 |
| Shadow | | | | 1.00 | -.04 | -.24 | .13 |
| Stems | | | | | 1.00 | -.12 | -.24 |
| Soil | | | | | | 1.00 | -.25 |
| Wet Biomass | | | | | | | 1.00 |

* Dry Biomass; Wet Biomass

** Total Moisture

Table 3. CORRELATIONS BETWEEN RADIOMETRIC DATA AND PLOT-DERIVED VARIABLES

Correlation Coefficients (r) between the Spectral Bands and the Canopy Variables

| | Dry BM* | Moistot** | Cover | Shadow | Stems | Soil | Wet BM* |
|---|---|---|---|---|---|---|---|
| Band 1 | -.14 | -.24 | -.15 | -.17 | -.19 | -.19 | .00 |
| Band 2 | -.11 | -.22 | -.11 | -.20 | -.19 | -.22 | -.02 |
| Band 3 | -.42 | -.52 | -.39 | -.25 | -.02 | -.09 | -.30 |
| Band 4 | .62 | .69 | .46 | .11 | -.23 | -.33 | .64 |
| Band 5 | -.10 | .02 | -.26 | -.06 | .13 | -.20 | -.04 |
| Band 6 | -.65 | -.65 | -.67 | -.25 | .26 | -.06 | -.50 |
| Band 7 | -.70 | -.74 | -.70 | -.29 | .26 | .11 | -.54 |

* Dry Biomass; Wet Biomass
** Total Moisture

Table 4. SUMMARY OF SINGLE-BAND AND LINEARLY-COMBINED SPECTRAL CORRELATIONS WITH PLOT-DERIVED VARIABLES

Most Significant Bands and Linear Combinations

| | Band | (r) | Transformations | (r) | Transformations | (r) |
|---|---|---|---|---|---|---|
| Dry BM* | 7 | -.70 | 4 - 6 | .80 | 4 - 7 | .79 |
| Moistot** | 7 | -.74 | 4 - 3 | .88 | 5 - 6 | .86 |
| Cover | 7 | -.70 | 4 - 6 | 73 | 4 - 7 | .71 |
| Shadow | 7 | -.29 | 5 - 6 | .27 | 5 - 7 | .27 |
| Stems | 6,7 | .26 | 4 - 6 | -.31 | 4 - 7 | -.29 |
| Soil | 4 | -.33 | 6 / 5 | -.51 | 7 / 5 | -.50 |
| Wet BM* | 4 | .64 | 4 - 3 | .69 | 4 - 6 | .69 |

* Dry Biomass; Wet Biomass

** Total Moisture

† The transformations that were tested include band ratios, band differences, normalized differences, and the difference-difference transformation. The band differences resulted in the strongest relationships with the canopy variables.

Table 5. MULTIPLE CORRELATION RESULTS FROM PARTIAL MULTIPLE CORRELATION ANALYSIS

| RADIOMETRIC VARIABLES | | | | PLOT VARIABLES | | | |
|---|---|---|---|---|---|---|---|
| Variable | Multiple Correlation | Mult-R Squared | F | Variable | Multiple Correlation | Mult-R Squared | F |
| Band 7 | 0.83 | 0.69 | 6.57** | Moisture | 0.91 | 0.83 | 11.57** |
| Band 6 | 0.76 | 0.58 | 4.10** | Dry Biomass | 0.84 | 0.70 | 5.78** |
| Band 4 | 0.71 | 0.51 | 3.08* | Green Cover | 0.79 | 0.62 | 4.05** |
| Band 3 | 0.66 | 0.44 | 2.37(N.S.) | Stem Cover | 0.54 | 0.29 | 1.00(N.S.) |
| Band 2 | 0.57 | 0.32 | 1.44(N.S.) | Soil Cover | 0.40 | 0.16 | 0.47(N.S.) |
| Band 1 | 0.55 | 0.30 | 1.28(N.S.) | Shadow Cover | 0.39 | 0.15 | 0.43(N.S.) |
| Band 5 | 0.43 | 0.18 | 0.68(N.S.) | | | | |

* $P \leq 0.01$
** $P \leq 0.05$
N.S. Not Significant

The results of the observations on moisture content during this past season are clear in demonstrating the need for measurement of plant-water status coincidental with radiometric measurement. With estimated differences of nearly 8% diurnally and 15-20% (on a wet weight basis) seasonally, moisture was so variable that a careful accounting must be taken of plant moisture status with time.

A likely approach to doing this would be to collect a set of leaf moisture samples before commencing radiometric data collection, and another afterward. Since decreases in ARCAB-held moisture fitted a linear model, there is justification for extrapolative adjustment of moisture content to correspond with radiometric observations. The results also suggest that a single collector should be assigned the task of collecting leaf moisture samples, since among-collector differences were significant in some cases, and coefficients of variation were stable. In any case, results from the data clearly identify the need to incorporate collection of leaf moisture data to account for the dynamic change in plant-held moisture.

OBJECTIVE 2.

The purpose of this experiment was to test the general hypothesis that changes in the shrub canopy variables could be explained by changes in reflectance. Reflectance measurements in radiometer bands seven, six, and four did change in such a fashion that a statistically significant relationship was demonstrated for moisture, dry biomass, and green cover. No such relationships were demonstrated for the other bands, or for the other plot variables.

The specific hypothesis of interest was that variations in aboveground moisture could be explained by variations in middle infrared, and it was found that a strong, significant relationship did exist between total plant-held water and reflectance in the middle infrared (Barnes radiometer band 7).

## SUMMARY

Results of this initial study are encouraging in that relationships between reflected radiation and plant canopy variables were found to exist. The specific relationship, that of plant-held water and reflectance, was shown to be the strongest. This is particularly encouraging in light of the role of water, either directly or indirectly, in nearly every plant process. There is potential, therefore, in developing remote sensing capabilities for assessing and monitoring plant physiological status; research will continue to this end.

# WINTER PASTURE GROWTH--WORKING TOWARDS AN "ALL GRASS WINTERING SYSTEM" FOR SHEEP

Raymond G. Jaindl and Steven Sharrow

Winter traditionally is a difficult period for livestock producers in the temperate areas. Pasture and range forage production is often low and nutritional needs of livestock may be high to support late gestation or early lactation of animals giving birth in late winter or early spring. Differences between the quantity and quality of forage available to livestock and their nutritional needs are commonly provided as feed supplements. The relatively high costs associated with conserving feeds as hay or silage, or of purchasing supplementary feeds, have focused attention on the feasibility of meeting winter livestock feed requirements through the efficient production and utilization of pasture forage. Livestock/pasture production systems which employ this approach have been referred to as "all grass wintering systems."

The term "all grass wintering" is a bit misleading because in most cases the need for supplementary feeds is reduced but not eliminated. The basic approach of these systems is to employ a rotational short-duration grazing system which maximizes pasture growth during the winter and allows rationing of forage produced during the previous fall. Rate of pasture growth may be slow during the winter, so a long period between grazing events is needed for sufficient forage to accumulate.

Rotation lengths of between 60 and 120 days between grazing events have been recommended for portions of New Zealand. Long rotations accompanied by high stock densities (for example, 400 to 800 ewes per acre for 1 to 2 days) result in long regrowth periods for the pasture plants, minimal trampling damage, maximum forage utilization, and greater management flexibility. To achieve this management intensity, pasture must be subdivided into many paddocks either through permanent fencing or through nonpermanent electric fencing. Although a disadvantage of this system is the greater labor required, benefits have been reported to be a decreased cost of animal production through more efficient utilization of pasture, decreased need of hay or other feed supplements, and a more even, higher plane of nutrition for livestock (Halford 1972).

For the forage rationing aspects of an "all grass wintering system" to be successful, managers must be able to estimate the quantity and quality of forage which will be available in the future and the seasonal nutritional requirements of livestock (Parker 1973). This process of allocating forage, known as "forage budgeting", involves a quantitative knowledge of the pasture resource. By evaluating forage resources on hand and estimating future pasture production, possible shortfalls or surpluses can be identified early, allowing time to plan accordingly (Cooney and Thompson 1978).

Estimates of the seasonal nutritional requirements of livestock are available; however, little more than guesses can be made about winter pasture production in western Oregon or about the effect of winter grazing on the amount and composition of forage produced. In 1983, a study was initiated to investigate these parameters to help determine the feasibility of an "all grass wintering system" in western Oregon.

## EXPERIMENTAL PROCEDURES

The study area is approximately two miles northwest of Corvallis on the OSU Agricultural Experiment Station Wilson Farm. In 1982, the area was sprayed with Roundup, rototilled, and then seeded to white clover (Trifolium repens) and perennial ryegrass (Lolium perenne). The experimental design is a randomized, complete block with three blocks and six grazing practices per block. The six grazing practices consist of a single grazing event during the winter grazing period (December 1 to April 30) occurring on approximately December 1, January 1, February 1, March 1, or April 1, and an ungrazed control. Stocking rates are based on an allowance of 3 pounds dry matter/sheep/day, a three-day grazing period, and a 350 lb/acre residual dry matter remaining after grazing. Breeding ewes are used to graze plots during the winter. All paddocks are grazed as a single pasture for short periods every 25 to 35 days by ewes with lambs from May to September.

Paddocks to be grazed and the ungrazed control are sampled several days before grazing (within seven days) and each month thereafter. Grazed paddocks are also sampled immediately after grazing to determine the amount of residue remaining. Yield and production are estimated from ten randomly located 2.2-foot$^2$ circular plots which are clipped to ground level.

The components of pasture yield (species composition, tiller number, leaves per tiller, clover stolon growth) are monitored monthly by hand sorting subsamples from three plots for each paddock. Samples are sorted into perennial ryegrass, other perennial grasses, annual grasses, white clover, subterranean clover (Trifolium subterraneum), forbs, and dead material. The number of ryegrass tillers per sample is recorded.

## RESULTS

Daily herbage accumulations on the ungrazed control and grazed paddocks are summarized in Figure 1. These data suggest that no forage accumulation occurred in January, and very little or none accumulated in February 1984, regardless of treatment. In fact, herbage mass declined by an average of 8 lb/acre/day in January, a month of subfreezing temperatures.

Total forage production for the 1983-84 growing season differed between grazing practices. Paddocks grazed in December and April produced the least, while January- and February-grazed paddocks produced the most total forage. Total forage production was 5,750, 5,480, 5,320, 4,760, 4,430, and 4,400 lb/acre for February-, January-, March-, control, December-, and April-grazed paddocks, respectively. A visual comparison of daily herbage accumulation rates (Figure 1) suggests that differences in total yearly production resulted primarily from less growth in April on paddocks grazed in December or April compared to areas grazed in January or February.

Herbage mass (Figure 2) decreased between January and March, regardless of treatment. On April 1, the ungrazed control and April-grazed paddock (which at that time was ungrazed) had the most herbage mass (1,210 and 1,220 lb/acre, respectively), followed by January- or February-grazed paddocks (840 and 780 lb/acre, respectively). By May 1, however, the January-, February-, or March-grazed paddocks and the control all had similar amounts of herbage present, approximately 2,910 lb/acre.

Pasture species composition and the tiller dynamics of perennial ryegrass plants were examined to determine the factors behind differences in total yearly production between treatments. Herbage on the paddocks was primarily composed of perennial ryegrass, white clover, and annual grasses. There were few differences between treatments in percent of perennial ryegrass, white clover, or annual grass except in March and May. In March, annual grass made up 31%, 2%, 11%, and 5% of the ungrazed control, December-, January-, or February-grazed paddocks, respectively. In May, ryegrass was 19%, 34%, 44%, 45%, 56%, and 50% of the herbage in the control, December-, January-, February-, March-, or April-grazed areas, respectively.

Ryegrass tiller numbers differed between treatments. The data suggests that in an ungrazed situation, tiller numbers increased from January until March, decreased in April (possibly from self-shading), and then increased again in June and July during the spring and summer grazing period. In all of the grazed paddocks, tiller number decreased immediately after grazing, then subsequently increased so that by the beginning of May these areas had from 1.5 to 3 times as many tillers as the ungrazed control.

## DISCUSSION AND PROJECT FUTURE

Conclusions about the feasibility of management systems should not be drawn from a single year's experience. However, several generalizations are suggested by our data:

1. Little or no growth can be expected to occur on either grazed or ungrazed pastures during periods when average daily temperatures are less than 44°F, such as occurred during the winter of 1983-84. It is interesting to note that the average daily temperatures in Corvallis for January and February of 1984 were slightly higher than the long-term average (Redmond et al. 1984).

2. Since minimal growth occurred during the winter, grazing had no effect on winter pasture production. However, our data suggest that time of winter grazing does have an effect on forage production the following spring.

3. Little forage accumulated on any plot during the December through January period. Therefore, under climatic conditions similar to or colder than we encountered this year, an "all grass wintering system" would primarily be concerned with rationing of forage produced during the previous fall, rather than attempting to stimulate additional forage production.

The long-term effect of winter grazing on pasture composition and plant dynamics cannot be determined from only one year's data. A second field season is under way, and plans have been made to continue this study through the 1985-86 growing season. Ultimately, this information will be used to develop a forage budgeting model for use on perennial ryegrass - white clover pastures in western Oregon.

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Redmond, K. T., B. T. Kropp, and A. H. Murphy. 1984. Local Climatological Data for Corvallis, Oregon. 1983 Summary. Report SCP-2. 15 p.

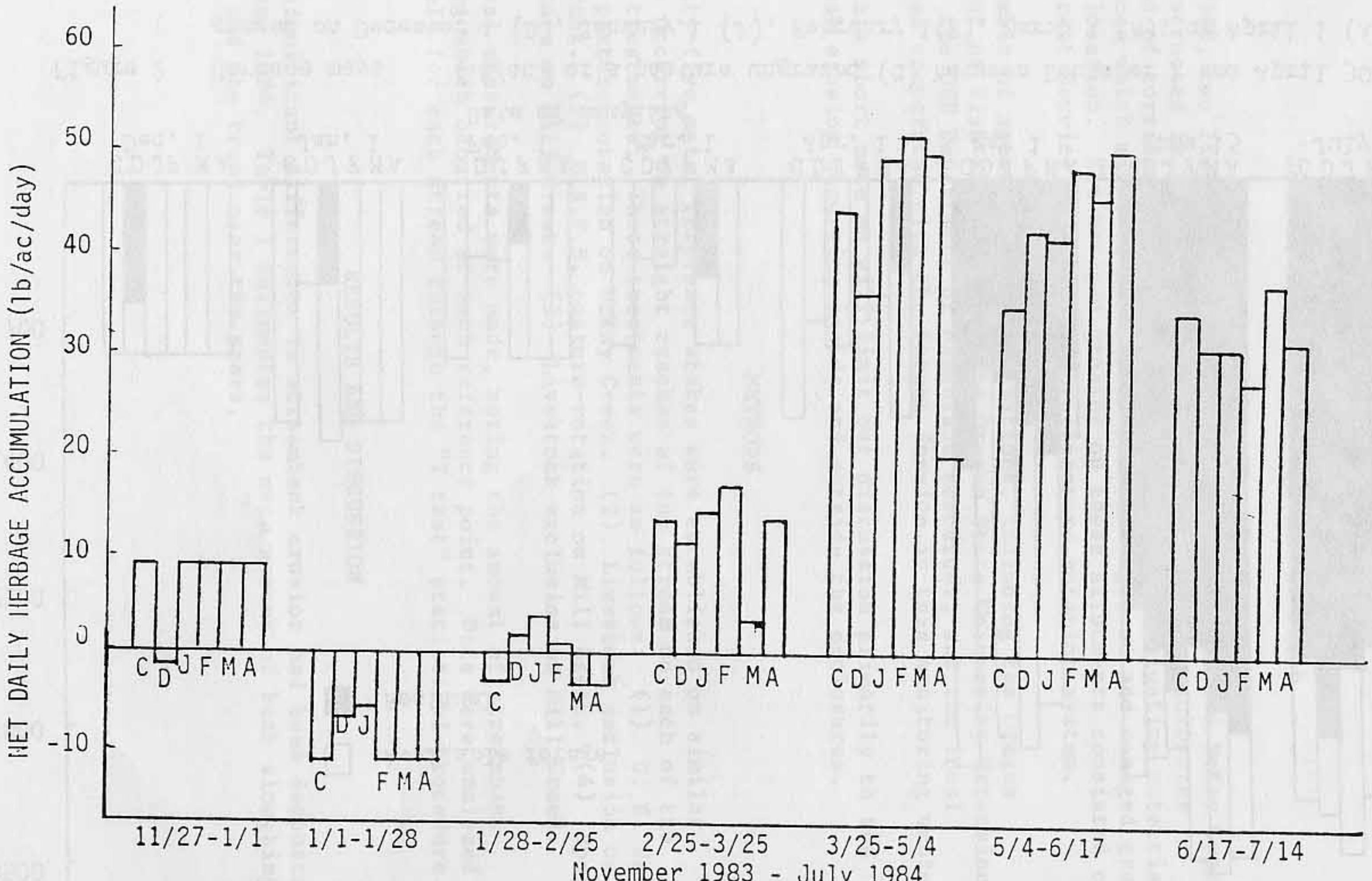



Figure 1. Net daily herbage accumulation (lb/ac/day) of pastures ungrazed (C) between December 1 and April 30 or grazed on December 1, January 1, February 1, March 1, or April 1.

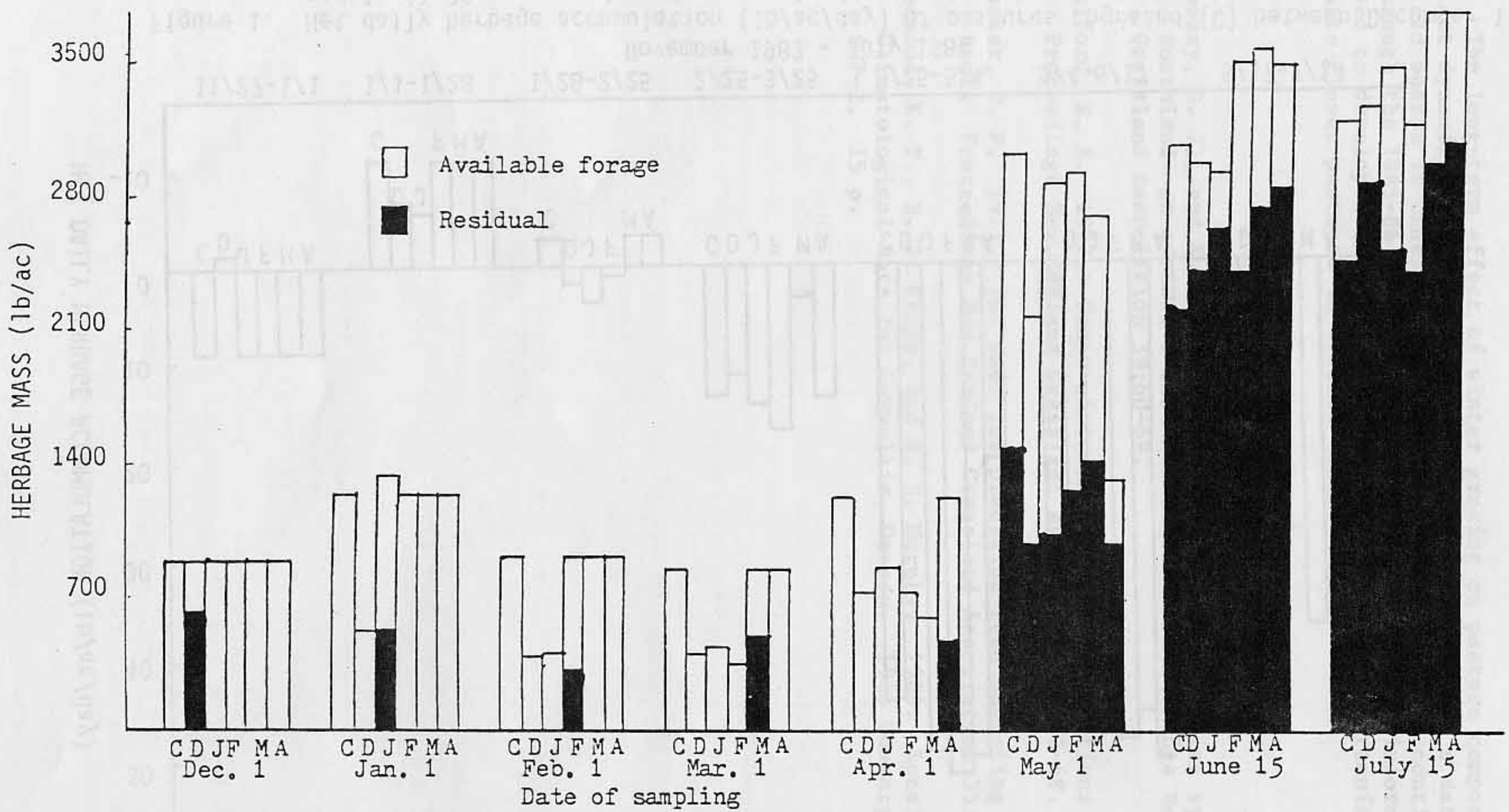



Figure 2 Herbage mass (lb/ac.) of a pasture ungrazed (C) between December 1 and April 30 or grazed on December 1 (D), January 1 (J), February 1(F), March 1 (M), or April 1 (A).

## RIPARIAN EROSION INSIDE AND OUTSIDE OF EXCLOSURES ON MILL AND MCKAY CREEKS: A VALIDATION OF MANAGEMENT[1]

John C. Buckhouse and Thomas R. Bunch

In 1980, two livestock exclosures, one each on Mill and McKay Creeks, were constructed in the Ochoco National Forest. These exclosures consisted of corridor fencing with an objective of evaluating potential differences which might be manifested between ungrazed and managed grazing at this location. The managed grazing on these allotments consisted of a U. S. Forest Service controlled, three-pasture rotation system.

A number of agencies and organizations, including the Oregon Department of Fish and Wildlife, the Oregon State University Extension Service, the OSU Department of Rangeland Resources, and the local permittees cooperated with the Forest Service in this monitoring venture.

In this short note we will limit our discussion primarily to the streambank erosion occurring inside and outside the exclosures.

### METHODS

Twenty-five metal reference stakes were established on similar cutbanks occurring on straight reaches of the stream on each of the grazing treatments. These treatments were as follows: (1) U. S. Forest Service pasture-rotation on McKay Creek. (2) Livestock exclusion on McKay Creek. (3) U.S.F.S. pasture-rotation on Mill Creek. (4) Special use pasture on Mill Creek. (5) Livestock exclusion on Mill Creek.

Annual measurements were made, noting the amount of streambank sloughing which occurred at each reference point. Data were analyzed separately for each stream through the "T test" statistical procedure.

### RESULTS AND DISCUSSION

No significant differences in streambank erosion had been demonstrated as of June 1984. Table 1 delineates the mean amount of bank sloughing (in inches) and the trend over the years.

[1] This study and monitoring were done in cooperation with the U. S. Forest Service, Mill and McKay Creeks permittees, Oregon Department of Fish and Wildlife, and Oregon State University.

| | McKay Creek | | Mill Creek | | |
|---|---|---|---|---|---|
| | Pasture Rotation | Exclosure | Pasture Rotation | Special Use | Exclosure |
| 1982 | 0.86 | 1.08 | 1.51 | 1.81 | 4.96 |
| 1983 | 2.67 | 2.07 | 3.32 | 2.54 | 5.94 |
| 1984 | 3.17 | 2.09 | 4.79 | 4.38 | 6.68 |

Table 1. Cumulative average bank sloughing (in inches) under various grazing treatments in McKay and Mill Creeks.

To date, it would seem that the managed grazing systems ameliorate many of the negative impacts associated with abusive grazing practices. Both the pasture-rotation and special use pastures were, in this instance, not significantly different statistically from the ungrazed exclosure.

Several visual impacts appeared when comparing the riparian zone inside and outside the exclosures. Since livestock grazing was prohibited within the exclosures, vegetation expression was manifested differently there. More standing biomass could be seen inside and the possibility of changing growth form of shrubs (from prostrate to upright) may have been occurring. In terms of the ecological expression of vegetation community species composition, however, it appears that at least at that time there was no difference between the managed and the excluded sites.

## CONCLUSION

After four years of grazing exclusion on portions of McKay and Mill Creeks in central Oregon's Ochoco National Forest, there were standing biomass and some growth form expression differences between the managed grazing sites and the livestock prohibition sites. Vegetation species composition seemed to be essentially unchanged. Bank sloughing was not significantly different between the managed systems and the livestock excluded systems.

Our natural resources are too precious to be wasted away through laissez-faire practices which permit overgrazing. Active, comprehensive resource management, including appropriate grazing management and direct livestock control, is able to ameliorate many of the negative impacts associated with abusive grazing. And such management is necessary and proper to ensure that true multiple use values, sustainable over time, are always available to us and to our progeny. We are pleased to report that it appears that this positive kind of management is indeed occurring at these Ochoco National Forest sites.

# WATER USE BY WESTERN JUNIPER
# A PRELIMINARY MODEL

Raymond F. Angell and Richard F. Miller

Western juniper (Juniperus occidentalis), a deep-rooted species, is both increasing in density and moving into previously unoccupied areas of Oregon. It is the dominant species on many sites. Western juniper is well adapted to our environment and has direct impact on productivity of other, more desirable species. This paper describes one effort at predicting the consumptive water use by western juniper. Water use is estimated by predicting daily transpiration patterns of juniper trees on a site. When fully tested, this model will assist management personnel in quantifying the cost of increased density in juniper or invasion in terms of consumptive water use.

## MODEL DESCRIPTION

The objective of the model is to predict the amount of water used by a western juniper stand by estimating diurnal changes in rate of transpiration. The model has been developed to combine with existing models of climate and soil water balance to provide a more realistic estimate of total evapotranspiration on sites occupied by western juniper. The model operates according to the flow chart in Figure 1. Data required to operate the model are daily maximum and minimum air temperatures and estimated soil temperature. Daylength is calculated, using on site latitude and julian day.

Estimated hourly temperature is based on daily maximum and minimum temperatures and daylength. Estimated hourly temperature is used to predict the level of atmospheric demand for water or evaporation potential (vapor pressure deficit or VPD). VPD is the driving force in transpirational water loss. Actual levels of VPD are a direct function of temperature and relative humidity. However, few weather stations measure humidity so VPD is estimated from temperature values.

Conductance is the second major factor determining rate of water loss through western juniper leaves. Conductance a measures the rate water passes through the leaf surface into the atmosphere. When stomates are closed, conductance is low and when stomates are wide open, conductance is high. Varying environmental conditions can change conductance rates between maximum and minimum levels both on a daily and seasonal basis. The model sets the conductance level based on soil temperature, VPD, and whether it is daylight or darkness. During darkness, stomates close so conductance values drop to a minimum. At sunrise, stomates open. Cold soils can also limit soil water acquisition, thus reducing conductance levels from maximum. Combinations of cold soils and high VPD can cause closure of stomates, resulting in reduced potential conductance values, thus reducing transpiration rates. At this time, rate of conductance is set to specific levels based on soil temperature and VPD. As more data are collected, predicted conductance will be more dynamic and will be based on the above mentioned variables and others which the data indicate are important. Transpiration per unit area is then predicted as the product of VPD and conductance. Hourly estimates of transpiration per unit area are accumulated over each 24-hour period to give daily water use. Daily totals are accumulated to get seasonal transpiration. Equations developed at the Squaw Butte Station are used to estimate total leaf area (LA) per acre of western juniper based on mean basal area and trees per acre for the site. Daily and seasonal water use figures are then expressed as inches (or cm) of water transpired on the site by the entire stand of western juniper.

## MODEL OUTPUT

The model is operational but is not tested against data other than that obtained at Squaw Butte. Over the next 12 months, as more data become available, it will be refined and tested. Output from the model for 2 days (May 9 and Aug. 1) is shown below (Figure 2). On sunny, warm days, the VPD curve matches the observed data fairly well. There is a consistent tendency to underestimate VPD maxima, although intermediate values seem to fit well, as on August 1. At those times, model predicted transpiration was 10 to 15 percent greater than transpiration estimated from observed data. This overestimate appeared to arise from an overestimation of stomatal conductance by juniper on August 1. Note that on May 9, the model's estimate of conductance closely matches the data, even though model conductance is set to specific levels at this time. As the season progresses, the model may be increasingly overestimating conductance because of changes in soil water balance. Data collected to date do not permit us to quantify this relationship. When more data are collected, this should be possible.

Seasonal fluctuations in transpiration rates are portrayed in Figure 3. Frozen soils early in the year restrict water uptake stimulating stomatal closure, thereby reducing transpiration. As the season progresses, soil temperature increases and atmospheric demand for water becomes greater. This increases transpiration rate of western juniper leaves until the plant is stressed sufficiently to close its stomates. The model appears to closely predict changes in transpiration and should provide a useful tool for land managers to help quantify the impact of western juniper on our rangelands.

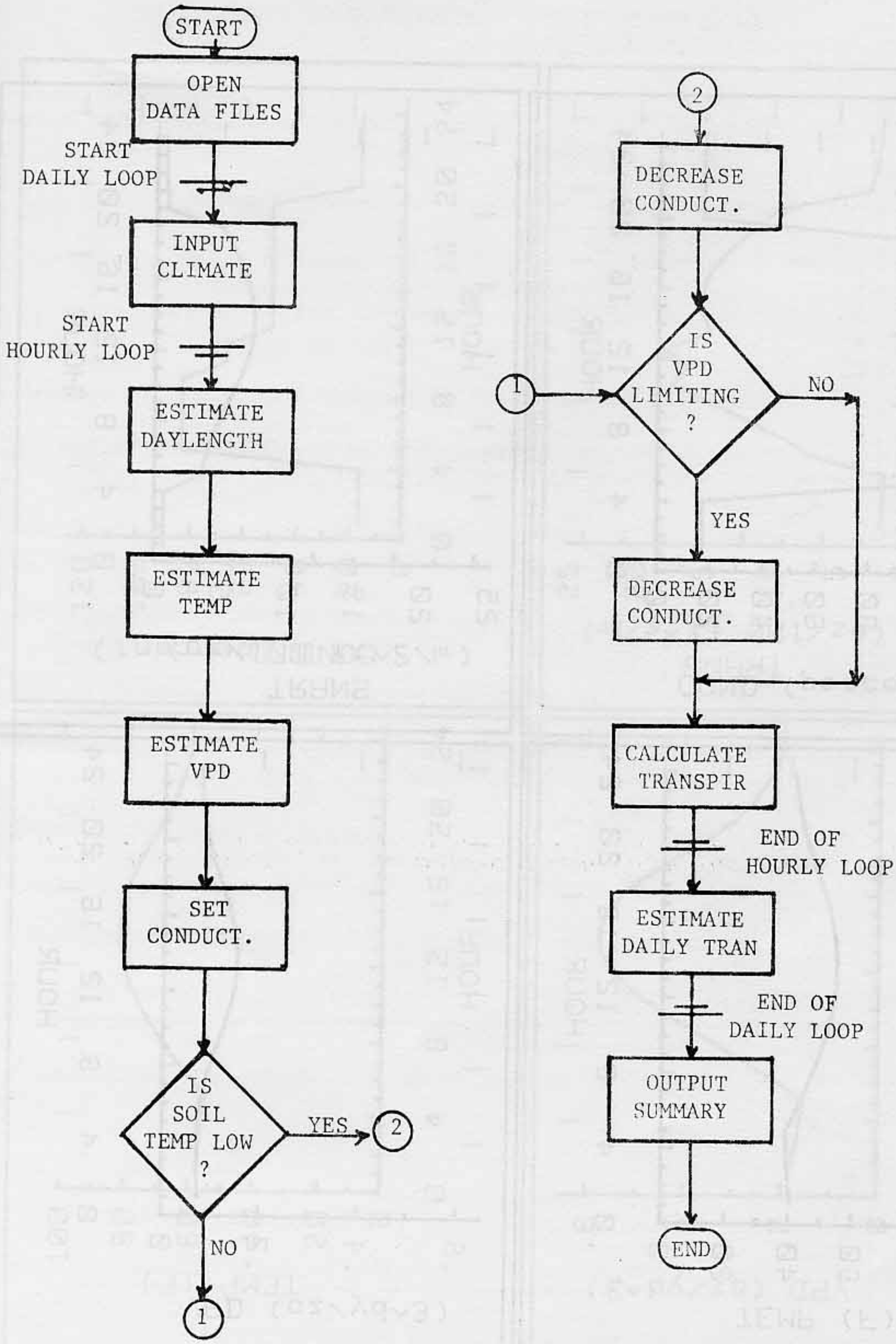
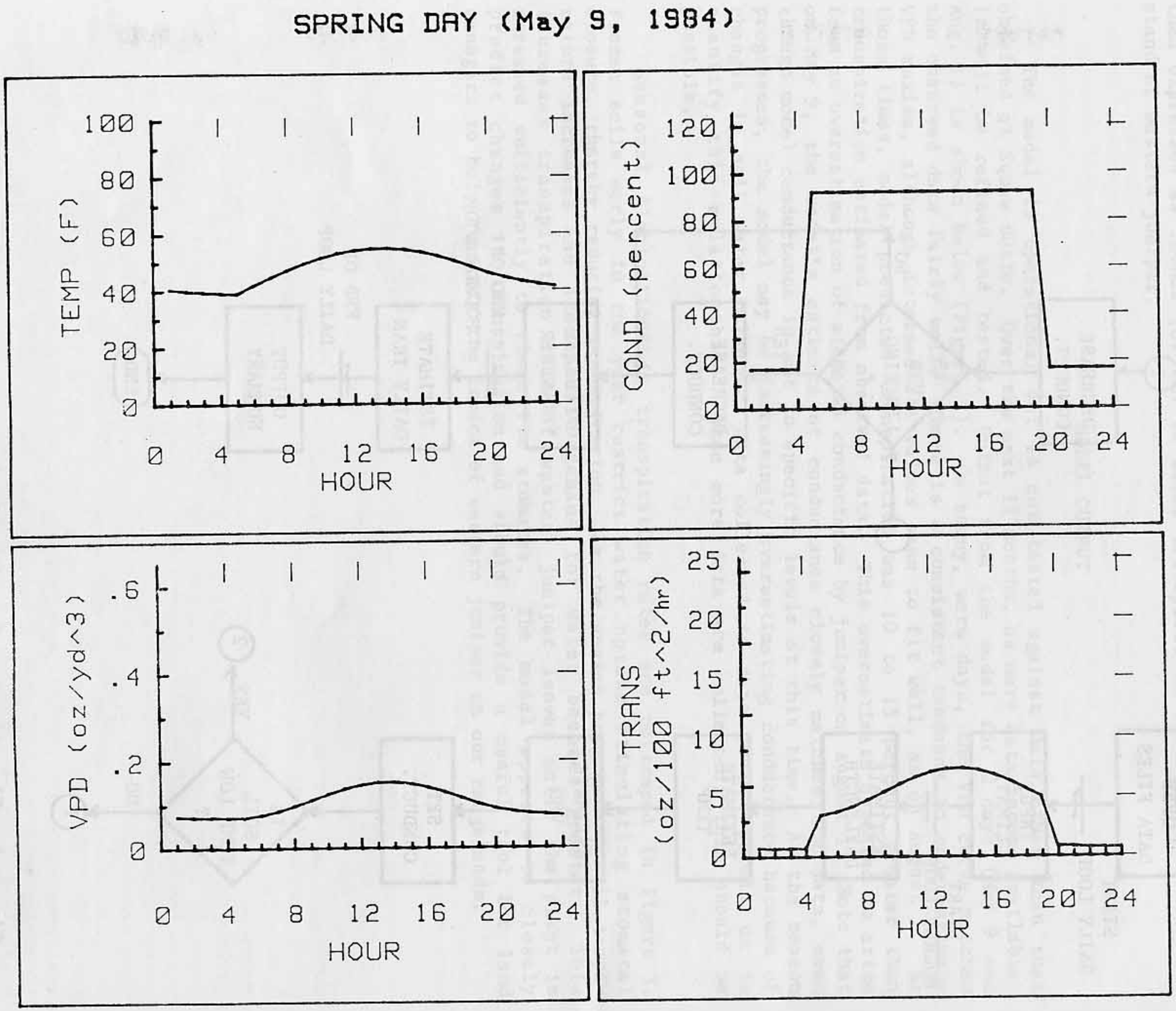



Figure 1. Flow diagram of western juniper water use model, showing sequence of calculations used to estimate transpiration.

Figure 2a


SPRING DAY (May 9, 1984)
TEMP (F)
100
80
60
40
20
0
0 4 8 12 16 20 24
HOUR
COND (percent)
120
100
80
60
40
20
0
0 4 8 12 16 20 24
HOUR
VPD (oz/yd^3)
.6
.4
.2
0
0 4 8 12 16 20 24
HOUR
TRANS (oz/100 ft^2/hr)
25
20
15
10
5
0
0 4 8 12 16 20 24
HOUR

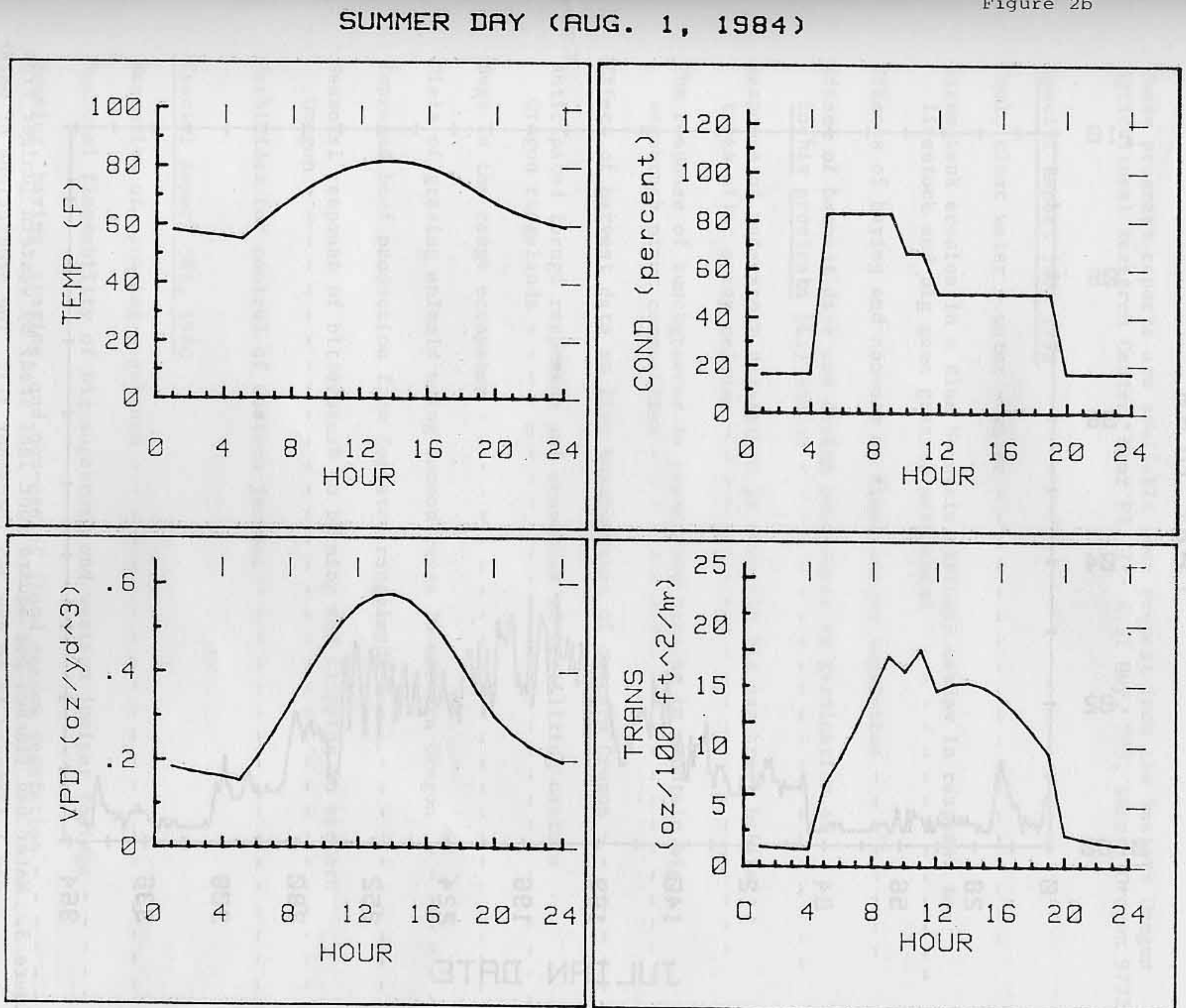



Figure 2. Model outputs in English units for a spring day and a summer day. The model estimates temperature, vapor pressure deficit, and conductance prior to predicting transpiration. Hourly transpiration is summed to get daily and seasonal values.

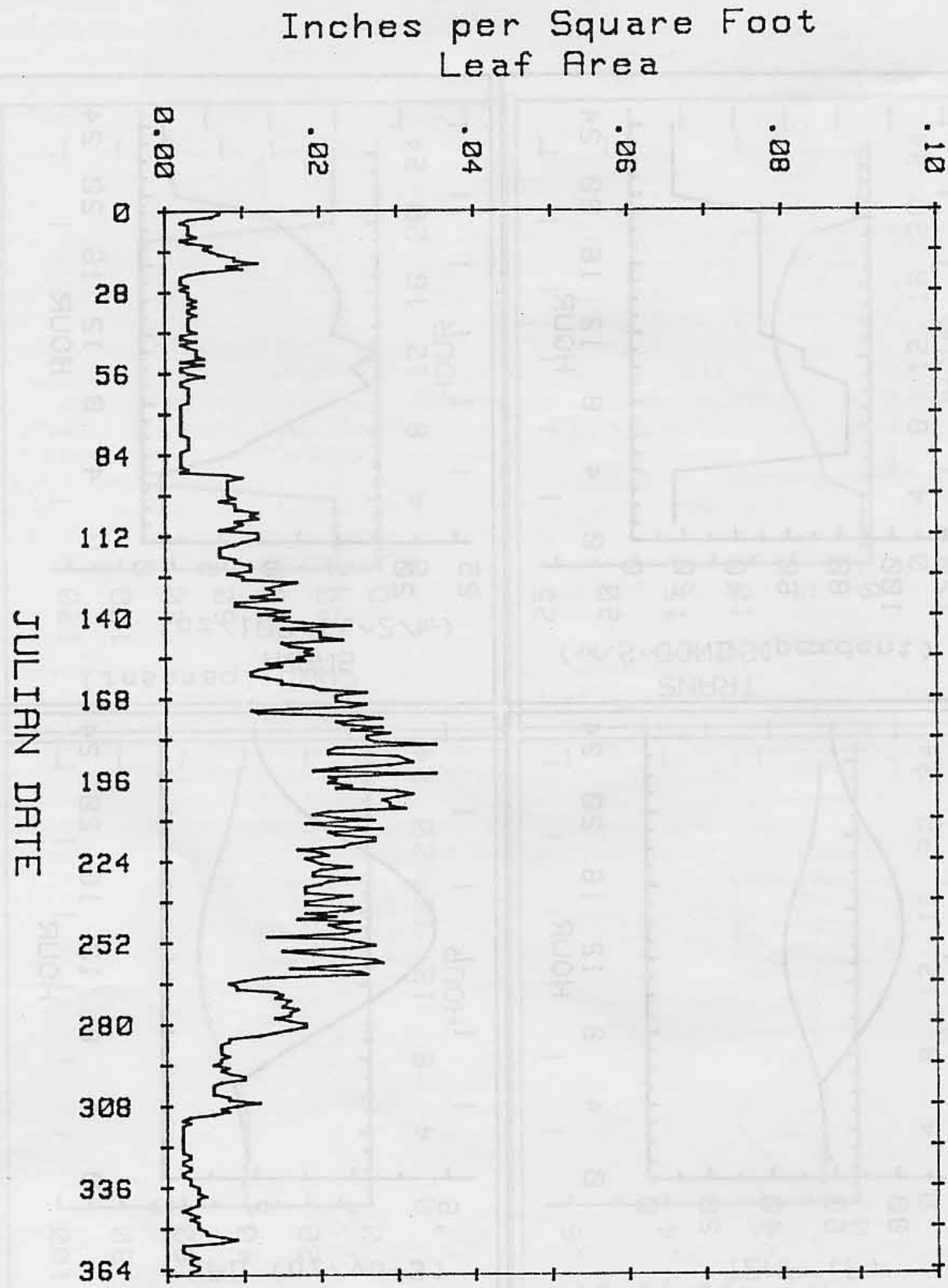



Figure 3. Water use (inches per square foot leaf area) by western juniper from day 1 (January 1) to day 365 (December 31). The predictions of water use between July 1 (day 182) and September 30 (day 273) are likely overestimated because of changes in soil water not predicted in the model at this time.

## PREVIOUS RANGELAND MANAGEMENT PROGRESS REPORT

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

Special Report 586, 1980 (continued)



Special Report 620, 1981



Special Report 663, 1982

Special Report 663, 1982 (continued)



Special Report 682, 1983



Special Report 715, 1984