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AUTHORS

RAYMOND F. ANGELL
assistant professor, Range Management, USDA, EOARC

JOHN C. BUCKHOUSE
professor, Acting Associate Dean & Director, College of Agricultural Sciences, Oregon State University.

LEE E. EDDLEMAN
associate professor, Department of Rangeland Resources, Oregon State University.

MICHAEL L. MCINNIS
assistant professor, Department of Rangeland Resources, Oregon State University, Eastern Oregon State College, LaGrande.

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

JEFFERY A. ROSE
research assistant, Department of Rangeland Resources, Oregon State University.

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

ECOLOGY OF WESTERN JUNIPER

Lee E. Eddleman

Western juniper (Juniperus occidentalis ssp. occidentalis) has markedly increased its range in Oregon during the last 100 years. Fire control, grazing pressure, and climate have combined to bring about this spread. Although it has moved most successfully into the mountain big sagebrush communities it is not limited to this type but has also been successful in other shrub steppe systems as well as grasslands. The expansion that has taken place follows a normal population growth pattern for a plant species which has lost its primary control factor or, as viewed from the other side, has gained suitable sites for establishment and growth.

From the management standpoint it is important to know as much as possible about the biology and ecology of western juniper to develop and implement procedures for slowing down the rate of spread and reducing the rate at which existing stands thicken. Those studies reported on below represent some aspects of the biology and ecology under investigation in central Oregon.

STUDY AREA

Research on the biology and ecology of western juniper is being carried out in Crook, Deschutes and Harney Counties with emphasis in Crook County. Intensive studies have been located on Combs Flat southeast of Prineville, and on Lytle Creek east of Grizzly Mountain.

Sex Expression in Established Stands

Study sites on Combs Flat were established to monitor sex expression of western juniper in 1982. A total of 232 trees were examined in consecutive years. These trees ranged in size from 3 feet to 36 feet in height, with 135 more than 10 feet. Trees were located in three 131 x 164 foot (.49 acre) plots and each tree numbered for repeated measurement. Tree numbers per plot were 121, 56, and 55 (x 2.04 for trees /acre). Female cone abundance was monitored for 4 years and male cone abundance monitored for 3 years.

Of the 232 trees, 11 were male in the sense that they produced only male cones each year; 90 trees produced only female cones. Seventy of the trees produced both male and female cones in the same year. Sixty-one did not produce cones of either sex during the study. This latter group was made up of trees of 3 to 10 feet in height.

Consistently high yearly female cone production occurred on 7 trees and 42 trees consistently produced large numbers of male cones. In general, trees which produced large numbers of either male or female cones in the first year continued to do so each year. A large percentage of the population is capable of producing female cones (65%), however, established stands such as these appear strongly dominated by the male expression of sex which is indicative of high stress levels associated with closed stands.

Sex Expression in Invasion Stands

Western juniper invasion areas on the north edge of Combs Flat were sampled in the winter of 1986. Five .49 acre plots were sampled with all trees measured for height and canopy radius. Additionally, sex was determined and the abundance of male and female cones estimated for each tree.

Table 1. Reproductive characteristics of western juniper in the invasion phase on Combs Flat, near Prineville, Oregon

Tree Height		M	F	M/F	UK	Abundant Seed	Total
10 ft plus	%	8.6	40.2	41.4	8.6	42.5	
	No.	2.5	11.9	12.2	2.5	12.5	29.5
less than 10ft	%	1.6	4.1	7.4	86.8	4.0	
	No.	1.6	4.0	7.3	85.1	4.0	98.0
						Total trees/Acre	127.5

(M = male, F = female, M/F = male and female cones, UK = unknown sex, Abundant seed = 4-5 berries or more/ square foot of crown surface, % = percent of trees/acre, No. = number of trees/acre.)

Table 1 shows that most of the trees which produce cones of one kind or another are either producing female cones or a mix of male and female cones. In contrast to established stands the dominance of female cone-producing trees is apparent. Of trees under 10 feet tall only 11.5% show potential for producing berries (F plus M/F). On a per acre basis only 4 trees less than 10 feet tall were producing significant numbers of berries.

Western juniper in the 3 to 6 foot height range on the Combs Flat area produced a berry or two on an infrequent basis, but consistent abundant berry production occurred only in trees over 6 feet high and was confined to a very small percentage of those trees in the 6-to 10-foot height range. For three locations examined in central Oregon where western juniper was invading, 11.4% of those trees less than 10 feet in height produced one or more berries and 3.5% produced abundant berries one year or more out of two.

Removal of trees before they begin producing and dispersing seed onto an area is important since seeds probably retain their viability for many years. The presence of trees with large numbers of berries is also an attractant for bird species which feed on them and which then contribute to the spread of seed about the area. On the Combs Flat invasion area, removal of 16-17 trees per acre would appear to halt seed production in the area. When stands are younger, less than 10 feet in height, removal of a very few trees could potentially halt the addition of new seed into the area.

Establishment Sites

Field observations indicated that western juniper seedlings require some protection against environmental extremes to establish. Seedlings and juveniles were commonly found beneath sagebrush plants and larger juniper trees. Of practical importance is the possibility of reducing the rate of invasion and stand thickening through the control of other plant species and/or certain individual juniper trees in the existing population.

Locations of western juniper seedling establishment were recorded on 5 plots each .25 acres in size on areas being invaded and on areas fully stocked with larger trees. The base of trees less than 10 feet tall were examined for the presence of dead or dying sagebrush or other shrubs, for rock, and for bunchgrasses living or dead. Those trees present under other western juniper trees were considered to have established under their canopies.

Table 2. Establishment locations of western juniper on Combs Flat, near Prineville, Oregon, as determined from trees under 10 feet tall

		Juniper	Sage-brush	Rabbit-brush	Bunch-grass	Rock	Bare	UK	Total
Invasion Area	%	56	18	3	8	5	1	12	
	No.	58	18	3	8	5	1	12	*130
Stocked Area	%	88	4	-	<1	-	<1	7	
	No.	730	36	-	2	-	4	54	*826

(Juniper = western juniper, Sagebrush = big sagebrush, Rabbitbrush = grey rabbitbrush, Rock = rock edge, Bare = bare ground, UK = unknown, % = percent of total trees, No. = number of individuals/acre) * There were an additional 27 trees/acre of 10 or more feet in height on the invasion area and an additional 100 trees/acre of 10 or more feet in height in the stocked area.

The majority of new western juniper trees are found beneath the canopy of a small percentage of the large dominant existent junipers. These large trees are mostly heavy berry producers but not exclusively so. Juniper reproduction is seldom seen beneath trees of less than 20 feet tall. In the absence of large junipers, as much as 80% of establishing junipers are found beneath big sagebrush (Eddleman 1987), and in this study big sagebrush is a dominant location for establishment in those areas away from the influence of juniper canopies.

In general, the importance of maintaining minimal big sagebrush densities is indicated as is the removal of trees before reaching 20 or more feet in height. It is not known whether the abundant regeneration found under some large junipers was from seed deposition from berries produced on the tree or whether seed were deposited there as the result of animal activity. However, since several of these trees are non-berry producers, animal activity, particularly that by seed-eating birds, in spreading seed is suggested.

Growth Rate

Data on height - age were collected from 234 western juniper trees found in 3 plots each .49 acres in size on fully stocked stands on Combs Flat. Twenty dominant trees which were at least 60 years old and older were cross-sectioned at 3.28 foot (1 meter) intervals to obtain height growth rates during the early phases of establishment.

Table 3. Height growth rates of western juniper on Combs Flat. Lifetime growth rates are for those trees initiated in each decade

	Decade beginning-									
	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980
Lifetime in/year	3.5	3.5	3.5	3.5*	2.4	1.6	1.2*	1.2	1.2	0.8

(* 3.5 in/year for 50 years would equal 14.6 feet. 1.2 in/year for 30 years would be 3 feet.

Lifetime growth rates were maintained for those trees established before 1930. There was a steady decline in growth rates for those trees establish from 1930 on. By 1930, populations were approximately 55 trees per acre. Growth rate decline in individuals established in later years may reflect the development of competition with other plant species, a gradual closing of the juniper stand to the point individuals are competing with each other, or changes in other unknown environmental factors. Invasion of western juniper into big sagebrush stands would not be apparent for at least 10 years since it would take approximately that long for the trees to overtop the sagebrush plants.

Height growth rates of the dominant trees were much greater than the average of the population. These trees grew at 3.5 in/year for the first decade of their life but gradually increased to 6.6 in/year at 34 years of age and maintained growth rates in excess of 5.1 in/year through the rest of there lifetime. Dominant trees had a lifetime average height growth rate of 5.3 in/year. The oldest trees aged on Combs Flat were 90 to 100 years old and these either had or were developing rounded tops indicating a general cessation of height growth.

Growth rate data for the dominant trees indicate that at least 27 years would be required to reach 10 feet in height and at least 40 years to reach 20 feet in height. These values are a probable minimum time required to reach these heights but do give rough guidelines as to the time span between establishment, the initiation of berry production, and the beginning of heavy berry crop production.

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COMPETITION FOR SOIL MOISTURE BY WOODY SPECIES IN THE JUNIPER ZONE

Richard F. Miller and Raymond F. Angell

Plant dominance throughout most of the juniper zone and sagebrush steppe was historically shared by woody plants and perennial bunchgrasses. Environmental characteristics, however, within these areas, particularly the annual distribution of precipitation, generally favors woody plant species over perennial bunchgrasses. Before the introduction of domestic herbivores, plant communities in the juniper zone were not in a state of equilibrium but in a constant state of change. The majority of these plant communities were constantly shifting toward shrub dominance. So called "pristine" conditions within the juniper zone and most of the sagebrush steppe were only weakly stable, dependent on periodic fires to maintain the grass component. This is an important concept since it means plant community succession towards shrub dominance was going on before the introduction of domestic herbivores. Grazing by domestic herbivores does not give juniper or sagebrush the competitive edge. Good grazing management, poor management, or no grazing at all will not alter the direction of this process. None of the above will change the long-term competitive edge of woody plants. Poor grazing management, however, may accelerate shrub succession or open up plant communities to invasion of exotic species such as cheatgrass and medusahead. Perhaps the greatest impact on plant succession by domestic herbivores is the reduction of fine fuels, which reduces fire frequency. Also grazing during the growing season, even under judicious management, will allow a larger portion of the soil water to be available to ungrazed plants. So grazing management alone or even total protection will not maintain the perennial grass component. Fire or some other form of periodic brush removal must be a part of the management plan to maintain dominance of large perennial bunchgrasses.

The purpose of this paper is to discuss characteristics of western juniper, sagebrush, and green rabbitbrush that enable them to compete so effectively with perennial grasses. This paper will also discuss the process of woody plant competition in the western juniper zone.

WESTERN JUNIPER

Western juniper is rapidly increasing in both density and range throughout eastern Oregon. This species is impressive in its ability to compete in semi-arid systems where few other tree species are able to survive. Western juniper extends the range of conifers, in the Northwest, far into the sagebrush steppe where no other conifers can survive. For a species to effectively compete in this semi-arid environment it must effectively acquire limited nutrient resources and avoid or tolerate drought. Western juniper has developed effective mechanisms to both compete for water and avoid drought.

One of the key factors enabling western juniper to grow and compete in semi-arid environments is its leaf. Western juniper looses considerably less water per square inch of leaf than sagebrush, rabbitbrush, and cool-season bunchgrasses. By reducing the amount of water lost per unit of leaf area, western juniper is able to maintain a relatively large leaf surface throughout the year and survive the hot dry conditions in July and August. Although juniper trees are relatively small compared to other coniferous trees, they display a relatively large leaf area for their size. For example, a western juniper 12 inches in diameter at the base has a leaf area of about 2,050 square feet. The display of large leaf areas enables western juniper to harvest large amounts of light and CO_2, which are converted to sugars for growth and maintenance of the tree. Western juniper also maintains a large portion of its leaves throughout the growing season. Annual leaf turnover in western juniper is approximately 15%, allowing western juniper to start the growing season with almost a full component of leaves. The presence of a large leaf surface area, early in the growing season, allows the tree to utilize relatively large amounts of nutrient resources early in the spring, when many associate species are just beginning to develop leaf area. Western juniper leaves help this species effectively compete with other shrubs and grasses.

Western juniper woodlands have a significant impact on soil water reserves, limiting growth of other plant species and possibly significantly reducing water yields from the watershed. The following is an example illustrating the potential impact on a watershed by a western juniper woodland. For our example the juniper woodland consists of approximately 100 trees per acre averaging 12 inches in diameter. This woodland would have approximately 201,000 square feet of juniper leaf surface per acre (4.6 square feet of leaf surface to 1 square foot of ground). On a pleasant spring day, with minimum-maximum temperatures ranging from 38 to 56°F and relative humidity dropping to 24% at midday, the woodland would transpire about 1,400 gallons of water per acre over a 24-hour period. On a moderately hot summer day, with good soil water reserves still present and temperatures ranging from 59 (early morning) to 86°F (midday) and relative humidity dropping to 22% by midday, this same woodland would transpire 3,200 gallons of water per acre over a 24-hour period (this probably is near the maximum amount this stand can transpire in 24 hours). If we start adding up the days during the growing season, from late April to late July, the amount of water transpired by western juniper represents a major loss. We also have many sites in eastern Oregon with tree densities greater than 100 trees per acre. A site receiving 12 inches of annual precipitation, receives only 326,000 gallons of water per acre, of which only a portion is available for plant growth. Runoff, interception, and evaporation reduce the amount of water entering the soil reservoir.

Factors influencing seasonal water use by western juniper are soil water content, soil temperature, air temperature, and relative humidity (vapor pressure deficit). Soil temperatures below 50°F reduce the ability of juniper roots to uptake water. As soil temperatures approach 36°F, little water is absorbed due to a decrease in root permeability. Western juniper transpires little water during the winter due to cold soil and subzero air temperatures, and minimal evaporation potential. Past work in central Oregon, however, has reported soil water content to be less in juniper stands than on sites where juniper has been removed. Less soil water content, however, is not due to transpiration but to tree canopy interception, increased runoff (Buckhouse and Mattison 1980), and frost heaving. Current work (Eddleman and others) in this zone shows 70% of the precipitation falling on a juniper canopy never reaches the ground. This would account for 14 to 25% of the total precipitation in a juniper woodland containing a 20 to 35% tree canopy. Greater frequency of frost heaving has also been observed to occur in the juniper interspace as compared to juniper removal sites, increasing the potential for soil water loss through evaporation.

As water consumption increases with an invading stand of juniper, we can expect several things to occur: (1) a reduction in understory species, (2) a shortening of the growing season because of an increase in rate of soil water depletion, (3) a decline in the amount of annual precipitation entering the soil water reservoir, and (4) eventually a decrease in growth of the trees themselves. This raises several important questions. As the juniper canopy increases at the expense of the understory canopy, what happens to sheet erosion? Work done by Buckhouse and others reported the largest erosion rates on rangelands occurred on sites with western juniper. A second question is how do juniper woodlands affect riparian communities within the same watershed? With juniper woodlands transpiring large amounts of water in the uplands, and a decline in soil water infiltration, there may be a potential for decreased spring flows, stream flows, and lowered water tables in riparian areas below. This potential probably increases as annual precipitation on the site increases.

ASSOCIATE SPECIES: SAGEBRUSH & RABBITBRUSH

Previous work has shown big sagebrush has a greater impact on herbage production than rabbitbrush. Sagebrush has a strongly developed lateral root system; rabbitbrush has a taproot system enabling it to seek out deeper soil water reserves. In central and eastern Oregon, however, both species frequently grow on soils less than 24 inches deep, intensifying competition for soil water between shrubs and perennial grasses.

Both Wyoming big sagebrush and green rabbitbrush initiate early spring leaf growth at approximately the same time. Initiation of spring growth in big sagebrush and green rabbitbrush must be carefully observed so not to misidentify material that has overwintered as early spring growth. The large ephemeral leaves are the first to initiate growth in sagebrush at the terminal of each stem. These leaves will be surrounded by the past years winter persistent leaves until stem elongation occurs approximately 2 weeks later. Small leaf buds (less than 0.1 inches) present on green rabbitbrush during late winter or early spring are formed in the fall, persisting through the winter, are sometimes mistakenly identified as early spring growth.

One of the primary reasons sagebrush is more competitive than rabbitbrush and many of our perennial grasses is its ability to use greater amounts of soil water early in the spring (Figure 1). The primary mechanism allowing sagebrush to get a head start is its ability to maintain leaves throughout the winter. Sagebrush maintains approximately one third of its leaf surface through the winter. As soon as soil and air temperatures warm enough to initiate growth, sagebrush already has a relatively large leaf surface present to transpire water and manufacture carbohydrates. This depletes soil moisture at a rapid rate early in the spring. Rabbitbrush and perennial grasses, however, must start with little or no leaf surface area at the beginning of the growing season.

Green rabbitbrush leaves are capable of transpiring greater quantities of water (Figure 2) and fix larger quantities of CO_2 per square inch of leaf than big sagebrush. This partially compensates for starting behind sagebrush in leaf area displayed. Big sagebrush, however, maintains a larger leaf surface

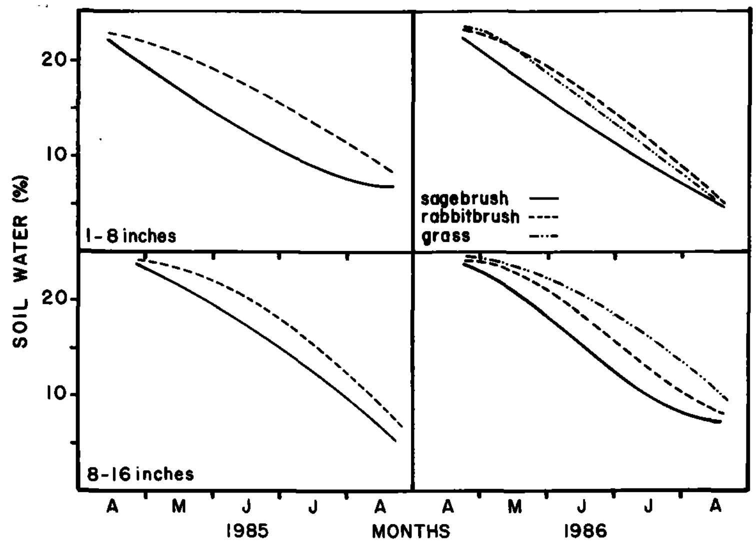

Figure 1. Percent soil water content at two depths in plots containing Wyoming big sagebrush only, green rabbitbrush only, and perennial grasses only. Vertical bars are 95% confidence limits for the mean.

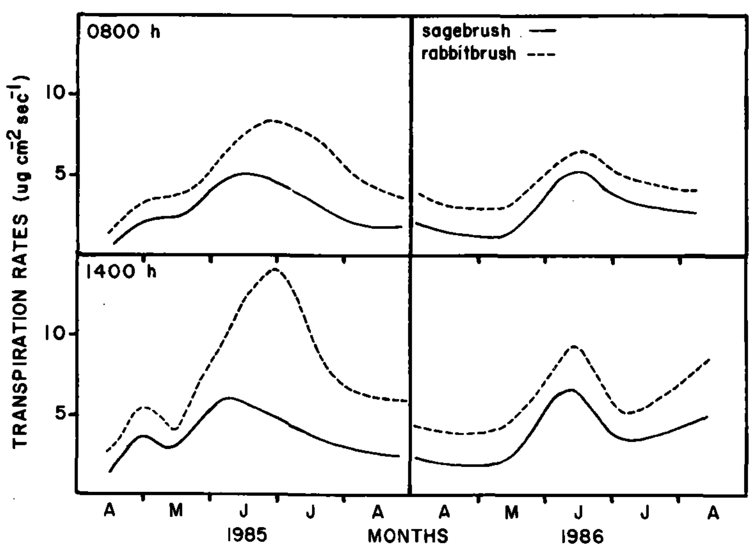

Figure 2. Seasonal transpiration rates in Wyoming big sagebrush and green rabbitbrush.

area (evaporation surface) per unit of canopy than green rabbitbrush throughout the growing season (Table 1). If both rate of water lost and size of evaporation surface are taken into consideration then 1 square foot of big sagebrush canopy would lose 1.2 to 2.5 times more water to the atmosphere than 1 square foot of green rabbitbrush canopy, depending on the time of year. This means an equivalent amount of sagebrush canopy cover will have a greater impact on understory vegetation than rabbitbrush.

In summary, the more rapid depletion of soil moisture around isolated Wyoming big sagebrush plants suggests the plant is potentially more competitive for soil moisture than green rabbitbrush and perennial bunchgrasses. Presence of overwintering leaves and a relatively large leaf area within the canopy of Wyoming big sagebrush may be important characteristics allowing the plant to capitalize on soil moisture early in the growing season when evaporation levels are low, increasing its water use efficiency. Although soil moisture withdrawal by big sagebrush roots may occur simultaneously with herbaceous vegetation, it occurs at a faster rate in big sagebrush because of a larger evaporation surface displayed in its canopy, particularly early in the spring. The ability to utilize water early in the spring may be especially advantageous during years of drought.

Table 1. Leaf surface area within the shrub canopy for Wyoming big sagebrush and green rabbitbrush in 1985.

Date	Sagebrush	Rabbitbrush
	---ft2 leaf area/ft2 canopy----	
April 4	0.8	trace
May 1	1.4 *1	0.3
June 1	2.0 *	0.7
June 28	2.5 *	0.8
August 1	1.3 *	0.5

1 * leaf area per unit of canopy is significantly different ($P \leq 0.05$) between species within dates; comparison not made for April 4. Differences between means were tested with a Student's t-test.

CONCLUSIONS

Livestock producers and resource managers must contend with the fact that woody plant species are more competitive than large perennial bunchgrasses regardless of grazing management practices throughout most of the western juniper zone. This advantage primarily comes from the ability of several woody species to effectively use soil moisture early in the spring and the ability of woody plants to more effectively use deeper soil moisture. The primary water source for soil moisture accumulated in the lower soil profile comes from the snow pack with spring rains recharging the upper portion of the soil profile. Grasses, with their fibrous root system, are more competitive for soil moisture in the upper profile, which their roots more fully occupy. Shrubs, however, are more competitive for the deeper water. Wet winters and dry springs tend to favor shrubs; dry winters and wet springs favor grasses. Under normal conditions, however, early soil water use by juniper and sagebrush will favor them over time. Historically, fire maintained the balance of the grass and shrub component. Today, a management system or plan must contain a tool for periodic brush removal (i.e., fire, chemical control, etc.) if a dominant grass component is to be maintained. Good grazing management or total protection will not maintain the grass component.

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WESTERN JUNIPER, PONDEROSA PINE, AND GRASS

Jeffrey Rose and Lee Eddleman

Encroachment of highly competitive woody plants can be a serious problem throughout western rangelands. Western juniper (Juniperus occidentalis Hook) is such a competitor. It has moved into a wide variety of areas over the past 50 years. A number of factors have lead to the movement of western juniper off the less productive rocky ridge tops and scab areas, where it historically has been found, onto more productive lands. Reduction of natural fire frequency and introduction of domestic livestock are often pinpointed as the two main causes of western juniper expansion.

Concern is centered on encroachment of western juniper into highly productive areas of the sagebrush steppe in central and eastern Oregon. Western juniper's highly competitive nature permits it not only to move into an area but also to dominate it, and in the process substantially reduce understory herbaceous production. Bedell and Bunch (1978) found that removal of western juniper in central Oregon could increase associated understory production by almost 30%. Much of the past research associated with western juniper's competitive ability has centered around effects on understory vegetation; little work has been done on the effect of western juniper on other tree species.

Ponderosa pine (Pinus ponderosa Dougl.) can often be found in association with western juniper in the more mesic areas of western juniper's distribution. Ponderosa pine is a valuable timber species throughout drier areas of the western United States. In areas where western juniper and ponderosa pine occur together it is possible that pine growth is adversely affected. In the summer of 1984, this study was initiated to examine effects of western juniper on herbaceous understory and ponderosa pine growth. Objectives of the study are (1) determine the effect of western juniper on understory production, (2) determine the effect of western juniper removal on diameter and height growth of ponderosa pine.

METHODS

Study areas were near Prineville in Crook County, Oregon. One study area was approximately 12 miles east of Prineville on a northeast slope and the second was 15 miles northwest of Prineville on a south slope near Grizzly Mountain.

Western juniper and ponderosa pine occur intermixed as the overstory, with western juniper occurring more frequently. Density of ponderosa pine is approximately 150 to 200 trees/acre and density of western juniper is about 300 to 350 trees/acre. Soils range from a shallow rocky clay loam to a moderately deep sandy loam. No one soil type is dominant, and there are intergrades between the two. All areas are bordered on the upper slope by ponderosa pine forest and on the lower slope by a continuous juniper woodland. Dominant shrubs are: mountain big sagebrush (Artemisia tridentata spp. vaseyana Nutt.), green rabbitbrush (Chrysothamnus viscidiflorus (Hook.) Nutt.), gray rabbitbrush (Chrysothamnus nauseosus (Pall.) Britt), bitterbrush (Purshia tridentata Pursh), and wax current (Ribes cereum Dougl.). Perennial grasses present include: Sandberg's bluegrass (Poa sandbergii Vasey), bluebunch wheatgrass (Agropyron spicatum Pursh) Scribn. & Smith), Idaho fescue (Festuca idahoensis Elmer) and junegrass (Koeleria cristata Pers.).

Four treatments were established:

1) Control- all trees left at original densities,
2) Ponderosa pine thinned to 130 trees/acre,
3) Western juniper cleared,
4) Western juniper cleared and ponderosa pine thinned to 130 trees/acre.

Western juniper and ponderosa pine were hand cut in the summer and fall of 1984. Before trees were removed, all western juniper were measured initially for basal diameter (at 12 inches), height, and canopy radius. Ponderosa pine were measured initially in the spring of 1985, before growth started, in the fall of 1985 after growth had stopped, and again in the fall of 1986 after growth had stopped. Diameter at breast height (dbh) and total tree height were taken in each year.

Understory herbaceous vegetation response was estimated from percent cover of individual species. Values are presented for groups of plants based on growth form and include: perennial grass, annual grass, perennial forb, annual forb, and shrubs.

RESULTS

Basal Area Growth

No significant response in basal area growth occurred one or two years after western juniper removal. Trends in the data showed that ponderosa pine trees in treatments where western juniper was removed had greater diameter growth in 1986. Basal area growth per tree was greatest in trees over 12 in dbh two years after western juniper removal (Figure 1). Ponderosa pine trees under 4" dbh had the smallest basal area growth. In the larger two diameter classes, pine trees in plots where western juniper was removed had higher diameter growth, regardless of thinning practice. Larger trees may be better suited to capture additional resources made available after western juniper removal.

Basal area growth was smallest in all diameter classes where only ponderosa pine trees were thinned to 130 trees/acre (treatment #2). Western juniper roots may be able to move into and exploit the additional resources made available by ponderosa pine removal. Rate of ponderosa pine root expansion may be slower than western juniper root growth, allowing western juniper to move its roots into areas once occupied by ponderosa pine roots.

Basal area growth per acre was greatest in plots where western juniper was removed. Similar trends can be seen when compared to growth per tree. Plots where western juniper was removed had greater diameter growth as compared to plots with western juniper present. Ponderosa pine trees in plots where pine was thinned to 130 trees/acre had the smallest total diameter growth.

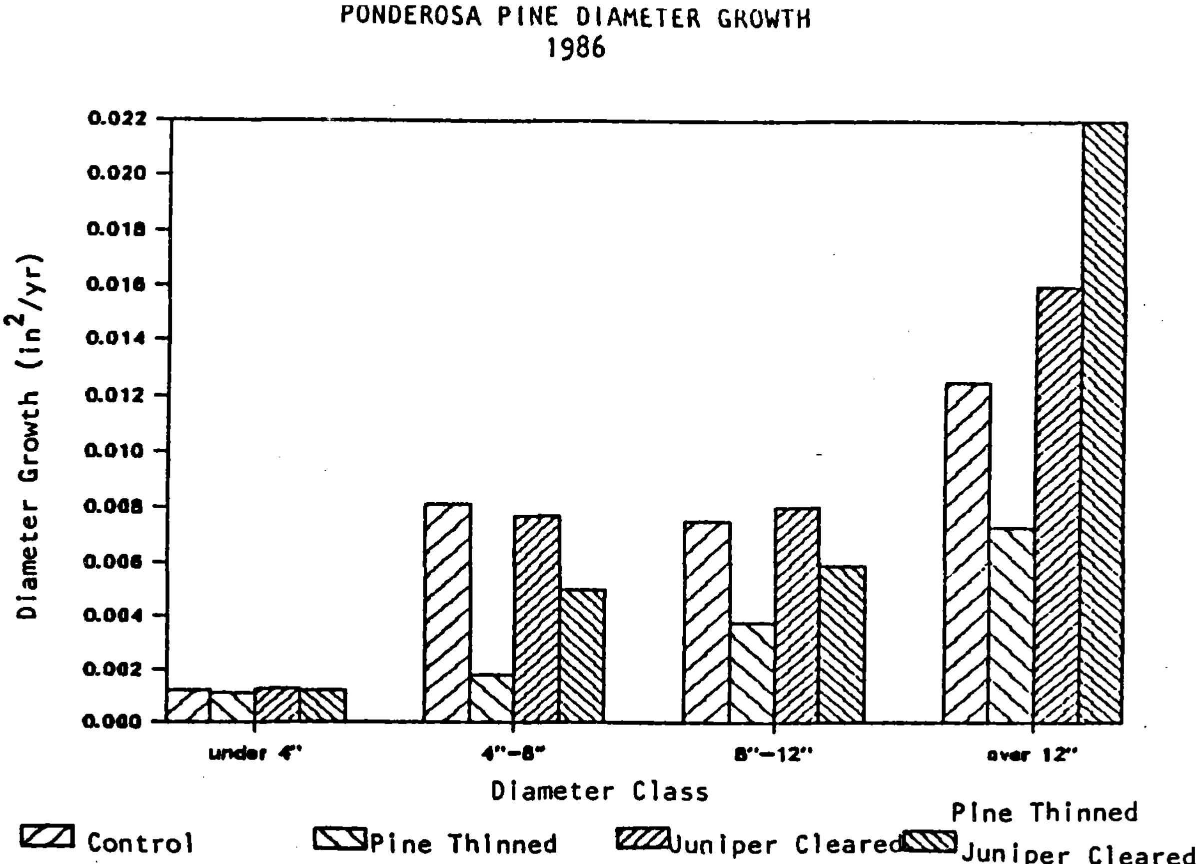

Fig. 1. Diameter growth for ponderosa pine, from 1986 growing season

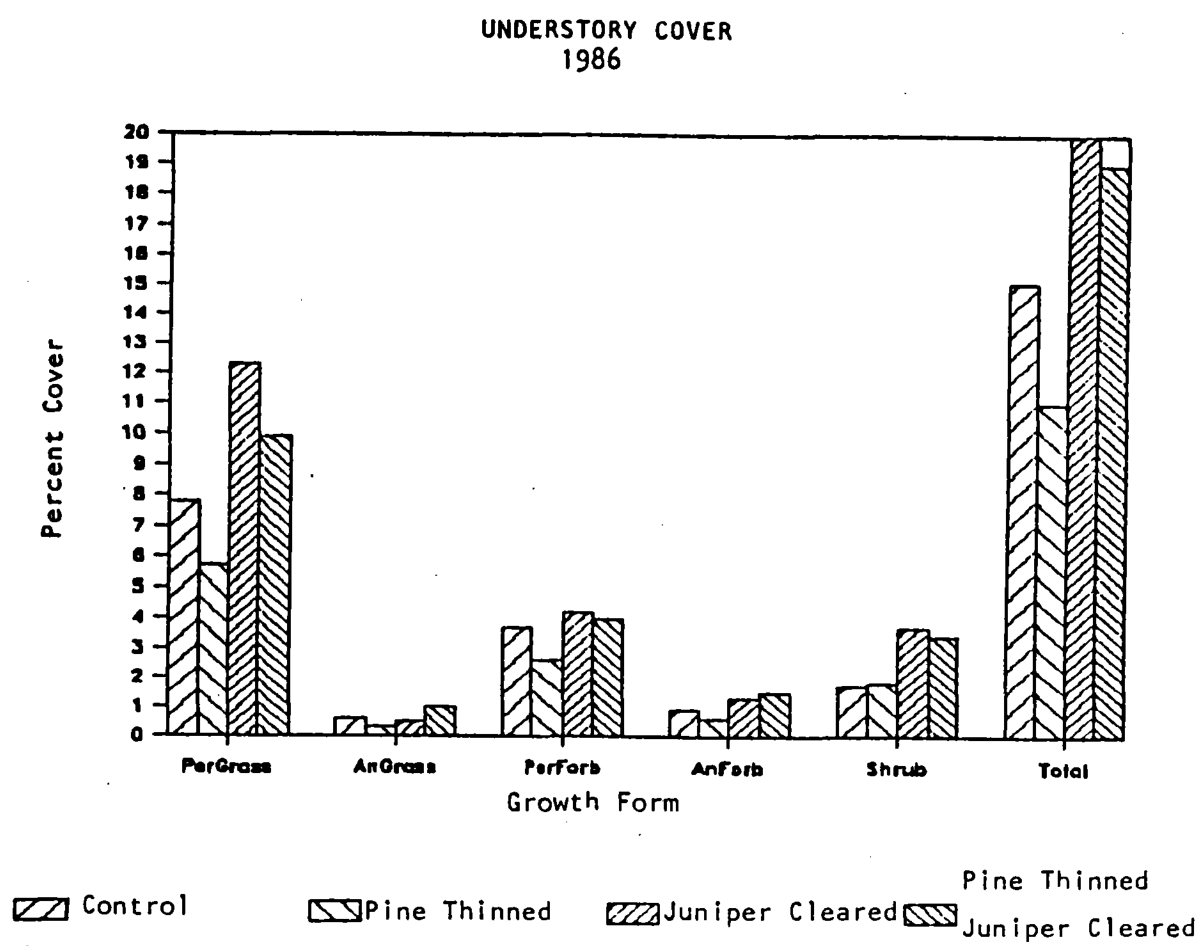

Fig. 2. Percent cover of understory vegetation grouped by growth form, PerGrass (perennial grass), AnGrass (annual grass), PerForb (perennial forb), AnForb (annual forb), Shrubs, and Total cover.

Understory Production

Percent cover estimates were used in 1986 to determine understory response. Plants were grouped according to growth form for analysis. In all groups cover was greatest in plots where western juniper had been removed (Figure 2). Total plant cover was significantly higher in treatments where western juniper was removed (treatments 3&4). Total cover was 15% in the control (treatment 1) where no trees were removed and 11% in treatments where only ponderosa pine was thinned (treatment 2). With juniper removal, total cover was 20% in treatments where only western juniper was removed (treatment 3) and 19% in treatments where western juniper was removed and ponderosa pine thinned to 130 trees/acre (treatment 4). Perennial grass cover was 12% in treatment 3, western juniper removed, and 6% in treatment 2, pine thinned. Idaho fescue, bluebunch wheatgrass, and bottlebrush squirreltail comprised a large majority of the perennial grass group. Perennial forbs, largely composed of lupine and milkvetch, also had higher cover values in treatments where western juniper was removed. Annual plants had higher cover values in plots where both pine thinning and juniper removal occurred. Over all groups, annual plants had the smallest cover values regardless of treatment. Perennial plants with larger root systems may be able to capture additional resources made available by tree removal.

A trend similar to that found in ponderosa pine basal area growth is that understory cover values were least in all groups, except shrubs, where only ponderosa pine was thinned. Reduced cover values may also indicate that western juniper is capable of exploiting resources made available by pine removal. Reduced cover values may indicate that understory plants may not be able to move into these "opened" areas as fast as western juniper.

CONCLUSIONS

Removal of western juniper appeared to benefit larger ponderosa pine trees (more than 12" dbh) more than other diameter classes. Larger trees may have been more capable of capturing the additional resources made available by removal of western juniper. Roots of larger trees occupy large volumes of soil, giving them a better opportunity to access resources freed by western juniper removal. As ponderosa pine diameter class declined the response to treatments also declined.

Reduced growth in ponderosa pine in plots where thinning occurred and western juniper was left at the original density may be explained by the aggressive nature of western juniper. Western juniper is capable of establishing under existing trees and shrubs and in bunchgrasses. It is also capable of turning on its photosynthetic machinery when environmental conditions become favorable which is an effective competitive mechanism allowing western juniper to utilize resources before other plants become active. The window of activity is often much later for many associated plants including ponderosa pine and perennial grasses. When pondersoa pine is removed, western juniper may be able to move into unoccupied areas with its root system thereby closing the site to other species including ponderosa pine. Thinning alone in ponderosa pine/western juniper stands may only benefit western juniper and actually be detrimental to ponderosa pine. To gain full potential growth of ponderosa pine, western juniper may need to be removed, or substantially reduced.

Understory response to treatment, as measured by percent cover, indicated that western juniper removal benefits understory plant growth regardless of thinning treatment of pine. Perennial grasses seemed to benefit the most from western juniper removal; annual plants showed little change regardless of treatment. Low natural levels of annual grasses and forbs in this area may account for the lack of response. Total cover was greatest in plots where only western juniper was removed.

Management of mixed ponderosa pine and western juniper for both timber and forage may best be accomplished by removal of western juniper and retention of ponderosa pine at original densities. Areas with greater densities of ponderosa pine than those present on the study sites may require thinning and western juniper removal to obtain maximum production of both forage and timber.

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WATERSHED MANAGEMENT IN THE JUNIPER ZONE

John C. Buckhouse

Visualize an ideal lifeform to exist in a harsh climate and successfully compete for the water, energy, and nutrients frequently found in short supply there. The juniper species in the western United States clearly fulfills that vision.

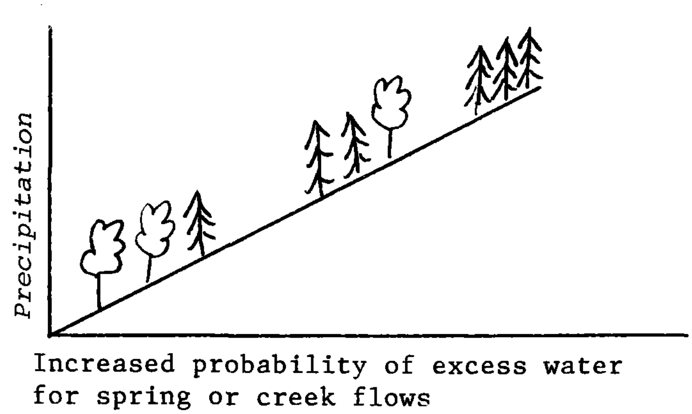
Jeppson (1978) found that Central Oregon sites occupied by western juniper consistenly exhibited lower volumes of water in the soil depths beneath the surface than did similar sites which had been cleared of juniper... even in the winter. He suggested that the physiology of western juniper was such that the plant is able to transpire in any season.

Gifford (1975) working in Southern Utah with Utah Juniper reported similar results. Sites occupied by juniper experienced an early and thorough transpirational extraction of soil moisture. Miller et al. (1987) were able to plot monthly variations of juniper water use and were able to tie the consumption of water to its availability and other environmental characteristics.

Observations by Gifford (1973) indicated that removal of juniper may have positive hydrologic implications on a site. Although range improvement practices inevitably decrease infiltration rates of water into the soil because of compaction and alteration of soil structure, if sufficient retention/detention storage is created, water may remain in contact with the soil longer and result in a greater volume of water actually entering the soil. Field managers frequently cite instances after tree removal and herbaceous plantings where overland flows are decreased, soil moisture is increased, and sometimes springs appear or ephemeral streams flow longer into the dry season.

Yet a study by Williams et al. (1972) in Utah did not offer much hope for semi-arid sites to experience greater flows after removal of the trees. They suggested that herbaceous forage could be dramatically increased, but that increased water yields in the river systems of the area were unlikely.

Most likely, both these conflicting observations are accurate. I suggest that a stylized model such as the one below is operating:



Western juniper in Central Oregon begins to appear at elevation/precipitation zones associated with at least 11 inches of annual precipitation. Ponderosa pine begins to appear somewhere around 15 inches of precipitation and by the time the precipitation level reaches close to 20 inches, the juniper is declining and other conifers dominating.

If juniper were removed at the lower precipitation zone and replaced with herbaceous vegetation, there is likely to be enhanced forage values and possibly a more uniform distribution of vegetation and, therefore, less bare ground and erosion hazard. It is unlikely, however, that creation of new seeps or springs would occur. The vegetation, be it woody or herbaceous, is using it all. As one moves into more favorable precipitation regimes, the likelihood increases that excess water will become available. Excess water would be expected at a 15-inch precipitation level; more at a 20-inch precipitation level. Forest research indicates that in forested areas with precipitation in excess of 40 inches, as much as a 20 percent increase in the quantity of water which flows from the site may be gained. Obviously, this savings is water which would have been transpired by the trees but instead has been rerouted.

Fire seems to be one of the most effective, and most economical, tools we have to combat juniper encroachment. Fire is the Achilles' Heel in this otherwise wonderfully adapted plant.

From a watershed point of view, fire will have a less dramatic impact leading toward soil compaction than will mechanical removal practices which involve heavy machinery. This is a positive feature.

The calculated risk with fire, however, is the exposed soil. If storms occur on the site before vegetation has time to become established, the site is very vulnerable to erosion. This erosion may have consequences beyond the tragic loss of soil; it may also pollute downstream water with increased phosphorus, sodium, and potassium which are released by the burn. Buckhouse and Gifford (1976) noted that potassium had the potential to be flushed from a burned juniper site at a rate of about 5 ppm immediately after a burn, compared to near zero ppm on unburned sites. Phosporus had a rate of 0.75 ppm after the burn versus near zero ppm before fire; calcium about 15 ppm compared to 5 ppm beforehand. Buckhouse and Gifford noted that within a year, the calcium nutrient losses/release was at pre-burn levels, and the other nutrients maintained their post-burn levels for at least a year.

De Bano et al. (1987) have studied the biomass and nutrient relationships extensively and quantified nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur tied up in Utah juniper biomass. They found fire to act as a rapid mineralizing agent for the nutrients. They also found that less ammonia-nitrogen was present on cut-tree sites where slash had been piled and burned as compared to cut-tree sites where slash had not been burned. In contrast, nitrate production was greater on the cut-tree sites where slash was burned.

Wright et al. (1974) found parallel responses in ash juniper in Texas when they investigated potential erosion losses. Up to 2.75 tons per acre on 15 percent slopes and 22 tons per acre on 53 percent slopes were vulnerable to loss immediately after fire; the erosion rates were at the pre-burn levels within 9 to 15 months on the moderate slopes and within 15 to 18 months on the steep slopes.

CONCLUSION

Juniper is a competitive plant which transpires precious water from the system. Removal of the tree allows that water to be redirected. In low precipitation zones, the water will be almost entirely consumed by other vegetation. At higher precipitation zones, some excess water is likely. Removal of the tree is not without a watershed cost, however. The cultural practice employed to remove the tree will have some negative impact on infiltration rates of water into the soil. Heavy equipment has the most impact. This impact is ameliorated by retention/detention storage increases which are possible through range improvements. These might be increased herbaceous vegetation or even an increase in juniper debris in contact with the soil.

Fire is an economical and efficient way to remove juniper in some instances. It does, however, leave a window of vulnerability open to the site until such time as revegetation occurs.

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BEEF CATTLE PRODUCTION ON WESTERN JUNIPER RANGELANDS[1]

Michael L. McInnis and Martin Vavra

Successful beef cattle production is both a science and an art dependent upon three principal components: 1) the forage resource; 2) the animal resource and 3) management alternatives. The science of beef cattle production requires knowledge of the basic biology of both the forage resource environment and cattle. The art of successful beef cattle production puts this knowledge to work by balancing the forage resource with the animal resource using a set of management alternatives to optimize livestock production.

Beef production systems relying on native vegetation of western juniper rangelands necessitate special care in matching forage quality and quantity to requirements of breeding and growing cattle. This is because the relatively short growing season within western juniper rangelands can impose restrictions on the growth and nutrient composition of native forages, and hence red meat production. A review of the nutrient availability of native forage species and nutrient requirements of cattle can point to several management practices which may help increase the efficiency of beef cattle production on these rangelands.

Nutrient availability must be thought of in terms of the chemical composition of forages, and the amount of forage biomass produced. Forage quality is generally related to plant maturity and precipitation. Annual precipitation in the western juniper zone is typically about 8-10 inches. Most precipitation falls during the winter, and the hot summers are usually dry. This weather pattern dictates perennial grasses complete their annual growth cycles while soil moisture remains adequate. Yearly variations in the amount of precipitation make it nearly impossible to predict forage quality at specific dates throughout the growing season, but research has shown a dramatic decline in nutritive value of perennial bunchgrasses from spring through fall. Figure 1 shows this decline averaged over several years and grass species in eastern Oregon.

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1 The intent of this paper is to summarize our knowledge of methods to enhance beef cattle production on western juniper rangelands. Much of the information for this report is based on the following publications:

Bedell, T.E. 1980. Range nutrition in relation to management. Oregon State University Extension Circular 1045, 4pp.

Vavra, M., and R.J. Raleigh. 1976. Coordinating beef cattle management with the range forage resource. Journal of Range Management, 29(6):449-452.

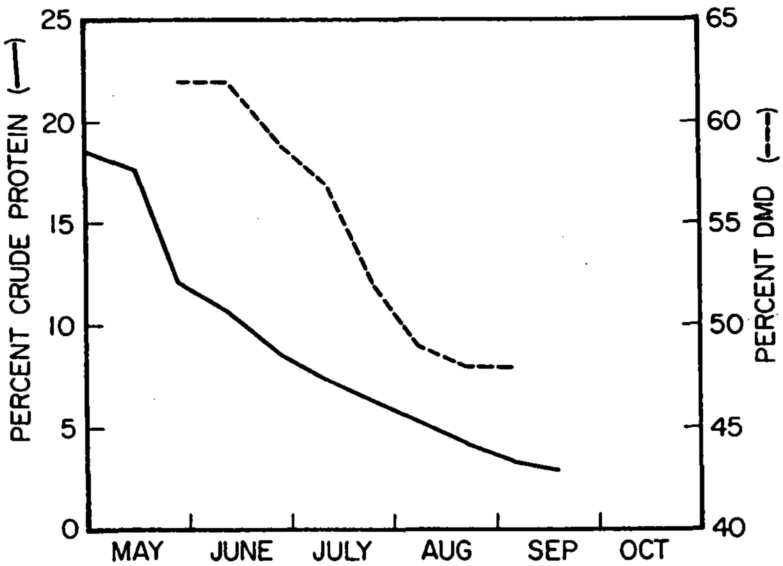

FIGURE 1. Seasonal declines in percent crude protein and dry matter digestibility of perennial bunchgrasses in the Oregon high desert (Bedell 1980).

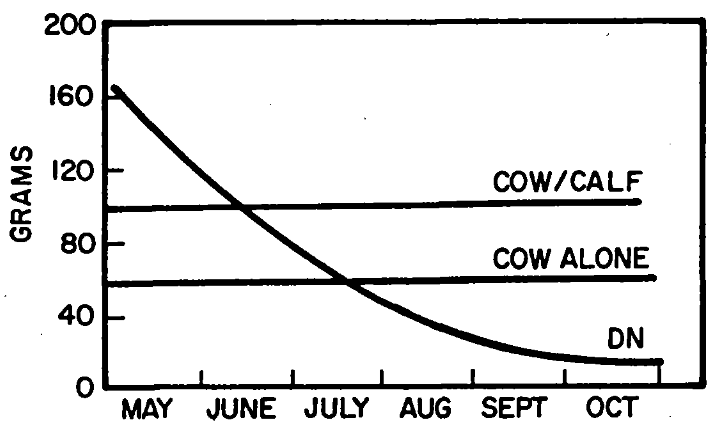

FIGURE 2. Digestible nitrogen provided by range forage (DN) compared to levels required by cows with calves and dry cows. (Bedell 1980).

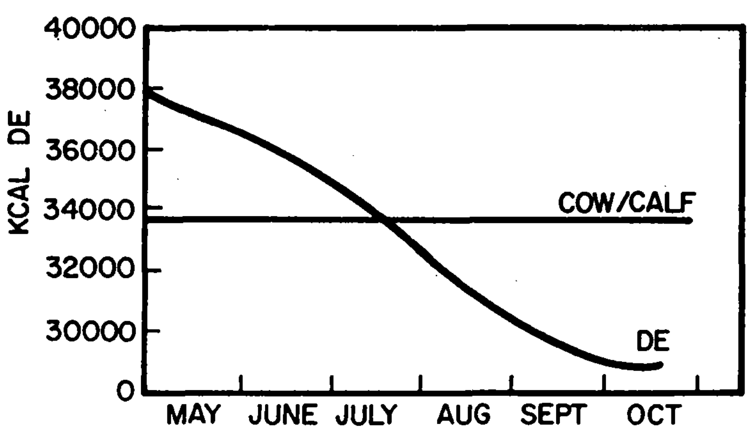

FIGURE 3. Digestible energy provided by range forage (DE) compared to levels required by cows with calves (Bedell 1980).

When animal requirements for protein and digestibility are compared to annual availability of these nutrients from native forages, it is apparent diets may become nutritionally deficient by mid-June to mid-July (Figures 2 and 3). A comparison of these curves shows protein becomes limiting before energy for young cattle and nursing cows. This is one of the principal reasons why performance of these cattle declines rapidly when the forage matures. Studies conducted at the Eastern Oregon Agricultural Research Center (EOARC) in Burns showed a sharp decline in pounds of daily gain for yearling steers and suckling calves beginning in July (Figure 4).

The species composition of range forage can influence animal performance. Plants which mature rapidly (such as Sandberg bluegrass and cheatgrass) also decline rapidly in nutritive value compared to plants which remain green for longer periods of summer months (Figure 5). Bluebunch wheatgrass and Idaho fescue are the characteristic grasses of relatively undisturbed plant communities in the Western Juniper Zone (Franklin and Dyrness 1973). Juniper encroachment and deteriorating range condition can change composition of the herbaceous understory from productive perennial grasses such as these to relatively unproductive species such as cheatgrass and Sandberg bluegrass. The impact on red meat production can be dramatic. Computer simulation shows nearly double the amount of beef produced from juniper rangelands in good condition compared to those in poor condition (McInnis, file data).

In our area, most calves are born between January and May. Cow-calf pairs typically utilize native range until fall or early winter when calves are weaned. Cattle management practices including early weaning, shortening the breeding season, timing of calving, and range supplementation can be used effectively on western juniper rangelands to optimize beef cattle production.

An alternative to allowing calves to stagnate on declining forage quality is to wean them sooner than usual and feed them a high quality forage. Work conducted at EOARC showed nearly twice the average daily gain on calves weaned at 177 days and fed a ration containing meadow hay, barley, and cottonseed meal as compared to calves which remained with their dams until mid-October (Wallace and Raleigh 1961).

A short breeding season is one method of realizing greater efficiency from the forage resource. Advantages of a shorter breeding season include a more uniform calf crop that can be put on a single feeding and management program at weaning, increased weaning weights, and the ability to identify low producing cows. A breeding season of about 63 days (3 estrous cycles) allows animals to be maintained on highly productive pastures for better nutrition.

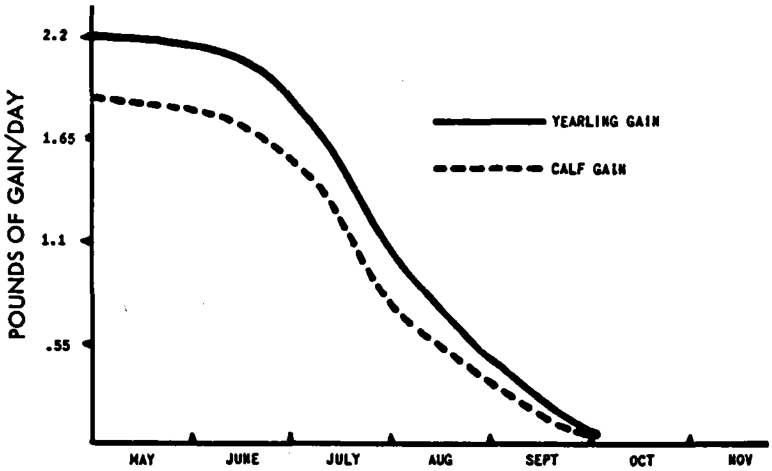

FIGURE 4. Average daily gain of yearling steers and suckling calves in eastern Oregon (Vavra and Raleigh 1976).

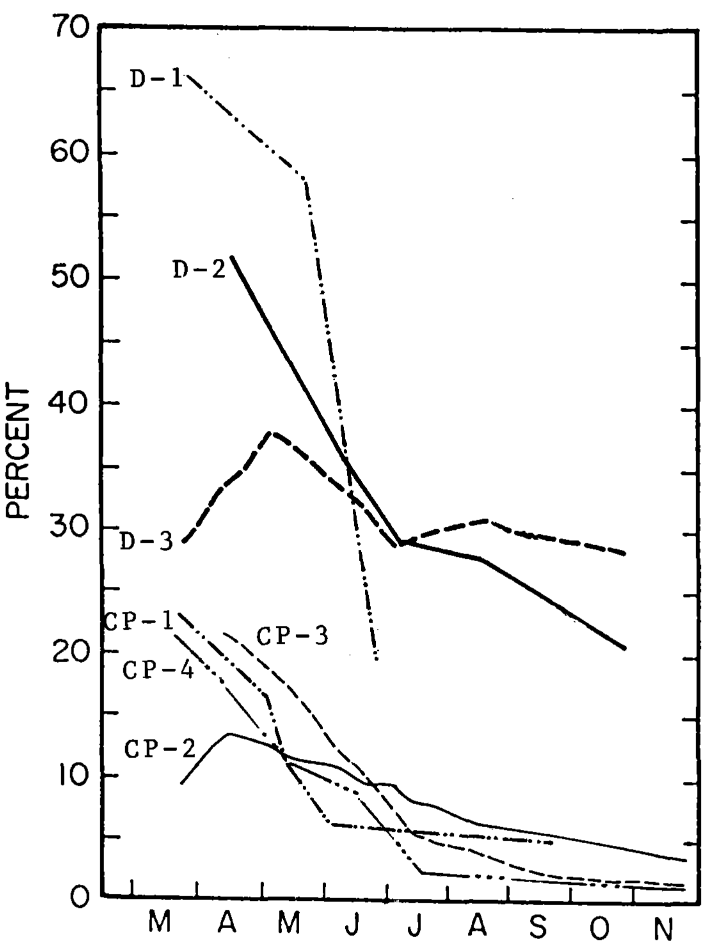

FIGURE 5. Seasonal trends in crude protein (CP) and apparent digestibility (D) of Sandberg bluegrass (1), bluebunch wheatgrass (2), Idaho fescue (3), and cheatgrass (4) in south-central Oregon (Bedell 1980).

In our area, calves are born at a time when native range forage is at its highest nutritional value. By the time a calf begins to consume this forage, its quality is declining rapidly. More efficient use of the forage resource could be made if calving could be timed so that a calf is old enough to utilize these plants when they reach their peak production and quality. Calving during October and November has several advantages: cows are confined to hay meadows where diseases can be easily treated; fall weather is usually more favorable than during cold spring months; and breeding can be accomplished while cows are still concentrated.

Supplementation of range forage can help fill the "nutrient gap" common on juniper rangelands by mid-summer. In developing a supplementation program it is important to first estimate the amount of nutrients consumed by cattle grazing native forages. This will provide the information necessary to determine the amount of supplement required to maintain practical rates of gain. A supplementation program developed at EOARC produced an additional 100 pounds of gain on yearling steers during a 120-day period with an average of 2 pounds of supplement per head per day (Raleigh 1960).

Finally, the beef production business is really the business of growing grass. Western juniper rangelands maintained in good condition will generate more forage of higher quality than degraded environments. It is a truism that "grass is wealth". The key to beef cattle management in the Western Juniper Zone, as elsewhere, is to match the forage resource with the animal resource using a set of management practices to maintain a sustained yield of the forage crop.

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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