Prescribed Fire for Eastern Oregon Rangelands: Management Considerations

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ABSTRACT

For many eastern Oregon ranchers, prescribed fire is an economically viable option of obtaining forage. Returns of prescribed burning, varying from 18 to 43 percent, are possible on high desert and seeded foothill ranges, respectively. Management information about planning a prescribed burn is presented, an economic worksheet to aid in making fire decisions is provided and instructions for its use are given.

PRESCRIBED FIRE FOR EASTERN OREGON RANGELANDS:

MANAGEMENT CONSIDERATIONS

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Fire, once a natural component of many range ecosystems, was probably the first tool used by man to influence vegetation. It is once again receiving renewed interest as a vegetation manipulation tool because it has low to moderate costs and its use can often accomplish multiple objectives. Prescribed burning means skillful use of fire as planned to meet specific objectives on a given land area. For eastern Oregon ranchers, prescribed fire may be an economically viable option of obtaining needed forage.

Management information to be considered when planning a prescribed fire is presented. This information includes effects of fire on grasses, forbs, shrubs, and junipers. Practical insights on the use of prescribed fire are offered and potential economic returns are estimated. A simple worksheet as an aid to making fire decisions is provided and instructions for its use are given.

Effects of Fire

Prescribed fire can be used to: (1) improve forage yield, accessibility and quality; (2) prepare sites for seeding; (3) improve wildlife habitat; (4) reduce hazardous fuels; (5) improve watersheds by increasing groundwater supplies or reducing flash runoff. Prescribed fire also has some undesirable effects, including air quality considerations, but these generally are short lived.

Major effects of prescribed fire are summarized here. This summary of information is based on research with prescribed fire that has direct application to eastern Oregon rangelands. The following publications were extensively used to develop the summary material:

Blaisdell, J.P. 1953. Ecological Effects of Planned Burning of Sagebrush-grass Range on the Upper Snake River Plains, USDA Technical Bulletin 1075;

Champlin, M.R. 1983. Big Sagebrush Ecology and Management with Emphasis on Prescribed Burning, Ph.D. thesis, Oregon State University.

Harniss, R.O. and R.B. Murray. 1973. "30 Years of Vegetal Change Following Burning of Sagebrush Grass Range." Journal of Range Management 26:322-325;

Wright, H.A., L.F. Neuenschwander, and C.M. Britton. 1979. The Role and Use of Fire in Sagebrush-grass and Pinyon-juniper Plant Communities. USDA Forest Service Intermountain Forest and Range Experiment Station General Technical Report INT-58;

Grasses

The effect of fire on grass species depends on the time of year of the fire, atmospheric conditions, soil moisture, and growth form of the species. Most of the desirable grass species are least harmed if burned in the fall after senescence. However, early spring burning, when the soil is frozen, may be safer than fall or late summer burning.

Relative responses to burning of some common eastern Oregon range grasses are illustrated in Table 1. Most needlegrasses are severely damaged by fire. If Idaho fescue is burned when the soil is moist, it will recover from the effects of fire in two to three years. Needle-and-thread, depending on the intensity of the burn, will usually return to preburn production in three to eight years.

Table 1. Relative Response of Some Common Eastern Oregon Range Grasses to Burning

Severely damaged	Slightly damaged	Undamaged
Needle-and-thread (*Stipa comata*)	Bluebunch wheatgrass (*Agropyron spicatum*)	Cheatgrass (*Bromus tectorum*)
Threadleaf sedge (*Carex filifolia*)	Big bluegrass (*Poa ampla*)	Crested wheatgrass (*Agropyron desertorum*)
Thurber needlegrass (*Stipa thurberiana*)	Columbia needlegrass (*Stipa columbiana*)	Douglas sedge (*Carex douglasii*)
	Cusick bluegrass (*Poa cusickii*)	Intermediate wheatgrass (*Agropyron intermedium*)
	Idaho fescue (*Festuca idahoensis*)	Plains reedgrass (*Calamagrostis montanensis*)
	Indian ricegrass (*Oryzopis hymenoides*)	Prairie junegrass (*Koeleria cristata*)
	Nevada bluegrass (*Poa nevadensis*)	Pubescent wheatgrass (*Agropyron trichophorum*)
	Squirreltail (*Sitanion hystrix*)	Riparian wheatgrass (*Agropyron riparium*)
		Sandberg bluegrass (*Poa sandbergii*)
		Tall wheatgrass (*Agropyron elongatum*)
		Thickspike wheatgrass (*Agropyron dasystachyum*)
		Western wheatgrass (*Agropyron smithii*)

Data source: Wright, H.A., L.F. Neuenschwander, and C.M. Britton. 1979. *The Role and Use of Fire in Sagebrush-grass and Pinyon-juniper Plant Communities.* USDA Forest Service Intermountain Forest and Range Experiment Station General Technical Report INT-58.

Bluebunch wheatgrass, squirreltail, and bluegrasses are slightly damaged by fire. After a fire, Bluebunch wheatgrass returns to preburn production in one to three years. Bluegrass damage appeared to be greatest for pedestaled plants having an accumulation of litter in the crown. Indian ricegrass, although not subject to intensive study, appears to be only slightly damaged by fire; however, it is slow to increase production afterwards.

Cheatgrass, the introduced wheatgrasses, Prairie Junegrass, and Sandberg bluegrass are generally unaffected by fire. Fall burning of crested wheatgrass results in only small changes in stand although yield may be reduced during the first growing season after burning. However, when burned after growth initiation in the spring, burning can reduce yield for two years. Other wheatgrasses respond somewhere between crested wheatgrass and bluebunch wheatgrass with the exception of the rhizomatous wheatgrasses such as thickspike wheatgrass which increase after burning.

Forbs

Forbs, as a group, respond better to burning than grasses. Fall burning does not harm most forbs, because they are often dry and disintegrated. Relative responses to burning of some common eastern Oregon forbs are presented in Table 2. Plant species spreading by rootstocks or root shoots such as western yarrow, purpledaisy fleabane, longleaf phlox, flaxleaf plainmustard, lambstongue groundsel, Orange arnica, and common comandra are least harmed and spread most rapidly after burning. Forbs spread by seed production like arrowleaf balsamroot and tailcup lupine, even though undamaged by fire, increase slowly after burning.

Table 2. Relative Response of Some Common Eastern Oregon Rangeland Forbs to Burning

Severely damaged	Slightly damaged	Undamaged
Hairy fleabane (*Erigeron concennus*)	Astragalus (*Astragalus* sp.)	Arrowleaf balsamroot (*Balsamorhiza sagittata*)
Hoary phlox (*Phlox canescens*)	Matroot (*Penstemon radicosus*)	Common camandra (*Commandra umbellata*)
Littleleaf pussytoes (*Antennaria microphylla*)	Munro globemallow (*Sphaeralcea munroana*)	Common sunflower (*Helianthus annus*)
Low pussytoes (*Antennaria dimorpha*)	Northwestern paintbrush (*Castilleja angustifolia*)	Coyote tobacco (*Nicotiana attenuata*)
Mat eriogonum (*Eriogonum caespitosum*)	Pinnate tansymustard (*Descurainia pinnata*)	Douglas knotweed (*Polygonum douglasii*)
Uinta sandwort (*Arenaria uintahensis*)	Plumeweed (*Cordylonthus ramous*)	Flaxleaf plainmustard (*Sisymbrium linifolium*)
Wyeth eriogonum (*Eriogonum heracleoides*)	Red globemallow (*Sphaeralcea coccinea*)	Flixweed tansymustard (*Oescurainia sophia*)
	Sticky geranium (*Geranium viscossissimum*)	Foothill deathcamas (*Zigadenus paniculatus*)
	Tailcup lupine (*Lupinus caudatus*)	Gayophytum (*Gayophytum diffusum*)
	Tapertip hawksbeard (*Crepis acuminata*)	Goldenrod (*Solidago* sp.)
	Tongueleaf violet (*Viola nuttallii*)	Goosefoot (*Chenopoduim* sp.)
	Tumblemustard (*Sisymbrium altissimum*)	Lambstongue groundsel (*Senecio integerriumus*)
	Wavyleaf thistle (*Circium undulatum*)	Longleaf phlox (*Phlox longifolia*)
	Whitlow-wart (*Draba verna*)	Orange arnica (*Arnica fulgens*)
	Wild lettuce (*Lactuca* sp.)	Pale alyssum (*Alyssum alyssoides*)
		Purpledaisy fleabane (*Erigeron corymbosus*)
		Russian thistle (*Salsola pestifer*)
		Velvet lupine (*Lupinus leucopyhllus*)
		Western yarrow (*Achillia lanulosa*)
		Wild onion (*Allium* sp.)

Data source: Wright, H.A., L.F. Neuenschwander, and C.M. Britton. 1979. *The Role and Use of Fire in Sagebrush-grass and Pinyon-juniper Plant Communities*. USDA Forest Service Intermountain Forest and Range Experiment Station General Technical Report INT-58.

Shrubs

In general, sprouting shrubs are not harmed by fire, while non-sprouting shrubs are severely harmed or killed. Since prescribed fire is often used to reduce undesirable shrubs, this knowledge of sprouting is extremely important. A summary of the effects of fire on major shrub species found on eastern Oregon rangelands is shown in Table 3.

Although big sagebrush is easily killed by fire, it will reinvade by seed. Black and low sagebrush also reinvade by seed. Reinvasion is quicker on more mesic sites and in moister years.

Antelope bitterbrush is severely damaged by fire and because it is a weak sprouter it often has difficulty reestablishing. For this species to resprout after burning, the soil must be wet at burning or shortly thereafter. Even then mortality is generally high the following year.

Rabbitbrush presents problems on areas to be burned as the various species resprout vigorously after burning. Horsebrush responds similarly.

Juniper

On many thousands of acres of Oregon rangelands, western juniper is a formidable plant suspected of requiring enormous amounts of water and known to outcompete all other plants surrounding it. Unfortunately, information available on the management of western juniper, particularly by prescribed fire techniques, is limited.

Eradication with fire is easiest when western juniper trees are small (less than 6 feet tall). As trees become larger, more intense fire is required to carry the fire and kill the trees. Conservative fire management practices often prevent using fire in closed stands of large

Table 3. Relative Response of Some Common Eastern Oregon Shrubs to Fall Burning

Severely damaged	Slightly damaged	Undamaged
Antelope bitterbrush (*Purshia tridentata*)	Curlleaf mahogany (*Cercocarpus ledifolius*)	Ceanothus (sprouting) (*Ceanothus* sp.)
Big sagebrush (*Artemisia tridentata*)	Desert bitterbrush (*Purshia glandulosa*)	Common snowberry (*Symphoricarpos albus*)
Black sagebrush (*Artemisia nova*)	Mountain mahogany (*Cercocarpus montanus*)	Gambel's oak (*Quercus gambelii*)
Broom snakeweed (*Xanthocephalum sarothrae*)	Mountain snowberry (*Symphoricarpos oreophilus*)	Horsebrush (*Tetradymia canescens*)
Ceanothus (nonsprouting) (*Ceanothus* sp.)	Serviceberry (*Amelanchier alnifolia*)	Rabbitbrush (*Chrysothamnus spp.*)
Cliffrose (*Cowania mexicana*)	Silver sagebrush (*Artemisia cana*)	
Low sagebrush (*Artemisia arbuscula*)		
Three-tip sagebrush (*Artemisia tripartita*)		

Data source: Wright, H.A., L.F. Neuenschwander, and C.M. Britton. 1979. *The Role and Use of Fire in Sagebrush-grass and Pinyon-juniper Communities*. USDA Forest Service Intermountain Forest and Range Experiment Station General Technical Report INT-58.

juniper trees. Besides tree height, other factors influencing the effect of fire on western juniper include herbaceous fuel levels, weather conditions, and season. Juniper survival related to tree height and burning conditions is illustrated in Figure 1. This information can be used as a guide in selecting sites to burn and then in developing specific prescription techniques.

Although Figure 1 documents juniper survival for only a limited range of fuel and weather conditions, it does provide some basis for managerial use of fire. Under very moderate conditions (25-30 percent relative humidity, 5-10 mph wind, and 70°F temperatures) with fuel amounts (primarily consisting of bunchgrass, sagebrush, and bitterbrush) ranging from about 1 to 4 tons per acre, a back fire should consistently kill small trees. But, expect trees 6 to 10 feet and higher to survive. At higher temperatures (70-75°F), larger trees except those 16 to 20 feet and higher should be killed. Under more drastic burning conditions (10 percent relative humidity, 5-12 mph wind, and 80°F temperatures), essentially all trees below 15 feet in height and some 60 percent of the trees 16 feet and higher should be killed.

Forage Response

Forage response to prescribed fire is not well documented. Forage production on two of three big sagebrush-bluebunch wheatgrass sites in Lake County more than tripled by the fourth year after burning. At the other site, production more than doubled. Forbs and cheatgrass, however, accounted for at least 75 percent of the yield increase. In southeastern Idaho, herbaceous production doubled after fire. On this big sagebrush

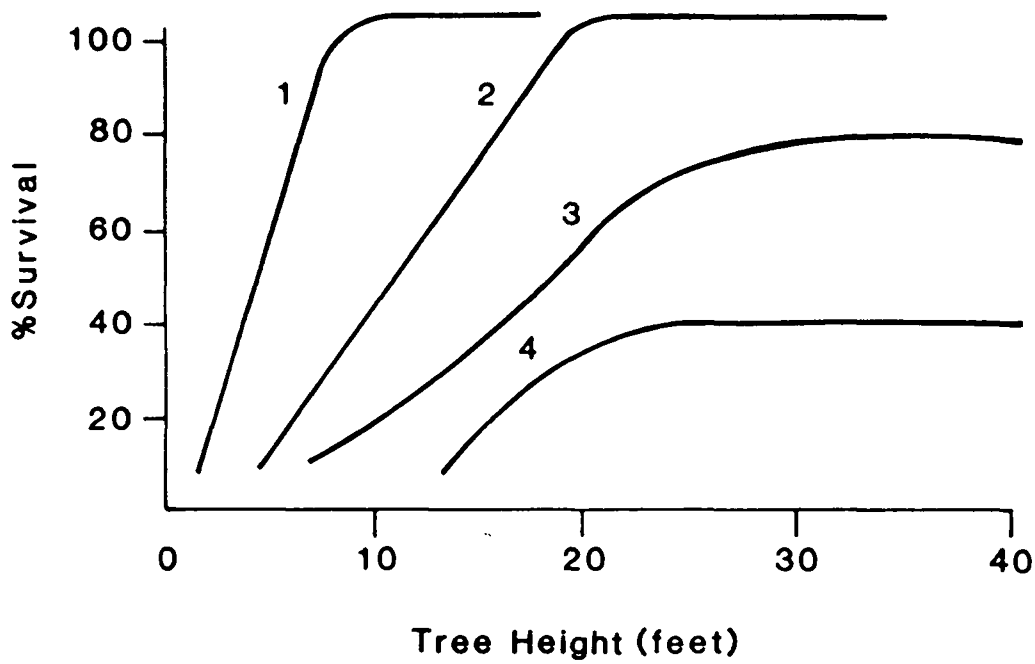

Figure 1. First year survival of juniper in a juniper-big sagebrush-bunchgrass range related to burning conditions of: 1) backfire, 25-30 percent relative humidity, 5-10 mph wind, and 70 degree F temperature; 2) backfire, 25-30 percent relative humidity, 5-10 mph wind, and 70-75 degree F temperature; 3) headfire, 18-20 percent relative humidity, 5-10 mph wind, and 75-85 degree F temperature; and 4) headfire, 10 percent relative humidity, 5-12 mph wind, and 80 degree F temperature.

Data source: Martin, R.E. 1978. Fire Manipulation and Effects in Western Juniper (Juniperus occidentalis) Hook. Proceedings of the Western Juniper Ecology and Management Workshops. USDA Forest Service Pacific Northwest Forest and Range Experiment Station General Technical Report PNW-74.

site near Dubois, Idaho, total production was initially depressed by fire. After three years, however, production was about one and one-half times preburn levels and continued to remain at this level for the next nine years. After 12 years, production began to decline (Figure 2) as big sagebrush recovered its dominance. Because of limited prescribed fire-forage response, the U.S. Forest Service uses forage response data from chemical spraying projects as an estimate of the response that could be obtained from planned burning.

Management Considerations

The decision to use prescribed fire as a vegetation manipulation tool should be based on many factors. Impact on grasses, forbs, shrubs, juniper, and forage response, as previously discussed, must be carefully considered. Other factors, however, such as production potential of the site, fuel availability to support fire spread, and the economics of prescribed fire must not be overlooked.

Site Production Potential

Vigor of vegetation presently occupying a range site is the best indicator of site production potential. For example, a tall, robust big sagebrush site likely indicates a deep, well drained soil with sufficient moisture and soil properties to support a productive stand of grasses. Conventional wisdom which advocates treating best sites first cannot be denied, however, the site also must possess sufficient herbaceous fuel (fine fuel) to carry fire.

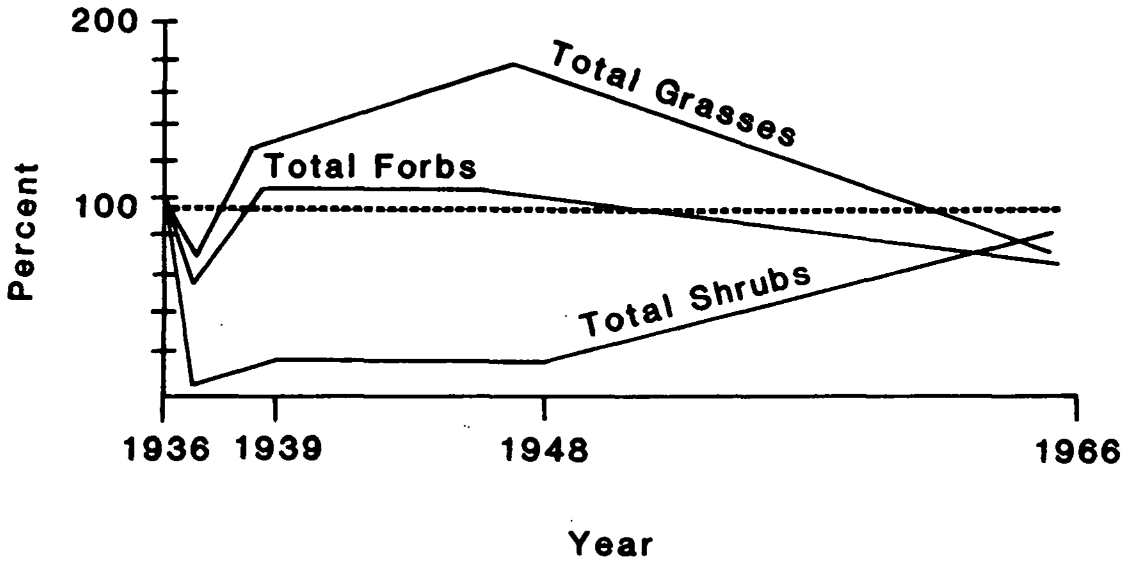

Figure 2. Relative change in grasses, forbs, and shrubs over 30 years on big sagebrush range near Dubois, Idaho. Harniss, R.O. and R.B. Murray. 1973. "30 Years of Vegetal Change Following Burning of Sagebrush Range." Journal of Range Management 26:322-325.

Availability of Fuel

Prescribed fire should not be considered as a management tool on sagebrush range unless the canopy cover of big sagebrush is at least one-third of the total plant cover. At this level of canopy cover, understory production is generally suppressed. Also, it is doubtful if successful burns can be consistently conducted under moderate climatic conditions where sagebrush cover is less than 20 percent (Figure 3). Areas occupied by Wyoming big sagebrush are difficult to burn because limited canopy cover and lack of contiguous fine fuel effectively limit fire spread. Once the canopy cover criterion is satisfied, it is important to have at least 250 pounds of fine fuel per acre to carry the fire. In many cases, this may necessitate not grazing the area in the growing season before the burn. The majority of successful sagebrush range burns have been conducted on areas where the dominant sagebrush is basin big sagebrush or mountain big sagebrush. Low sagebrush areas are not likely candidates for prescribed fire because fire will not easily move through low sagebrush; also, the production potential of these sites is limited.

Prescribed fire techniques alone should not be considered as a management tool on essentially closed stands of juniper because drastic fire conditions are required to carry fire. On sites where trees are small (less than 6 feet) and relatively sparse, fire fuel levels of 250 pounds per acre should carry fire and effectively kill juniper. As juniper height and density increase, more fine herboceous fuel and more drastic fire conditions are required. Under typical burning conditions at least 900 pounds of fine herbaceous fuels are required to kill juniper trees in the

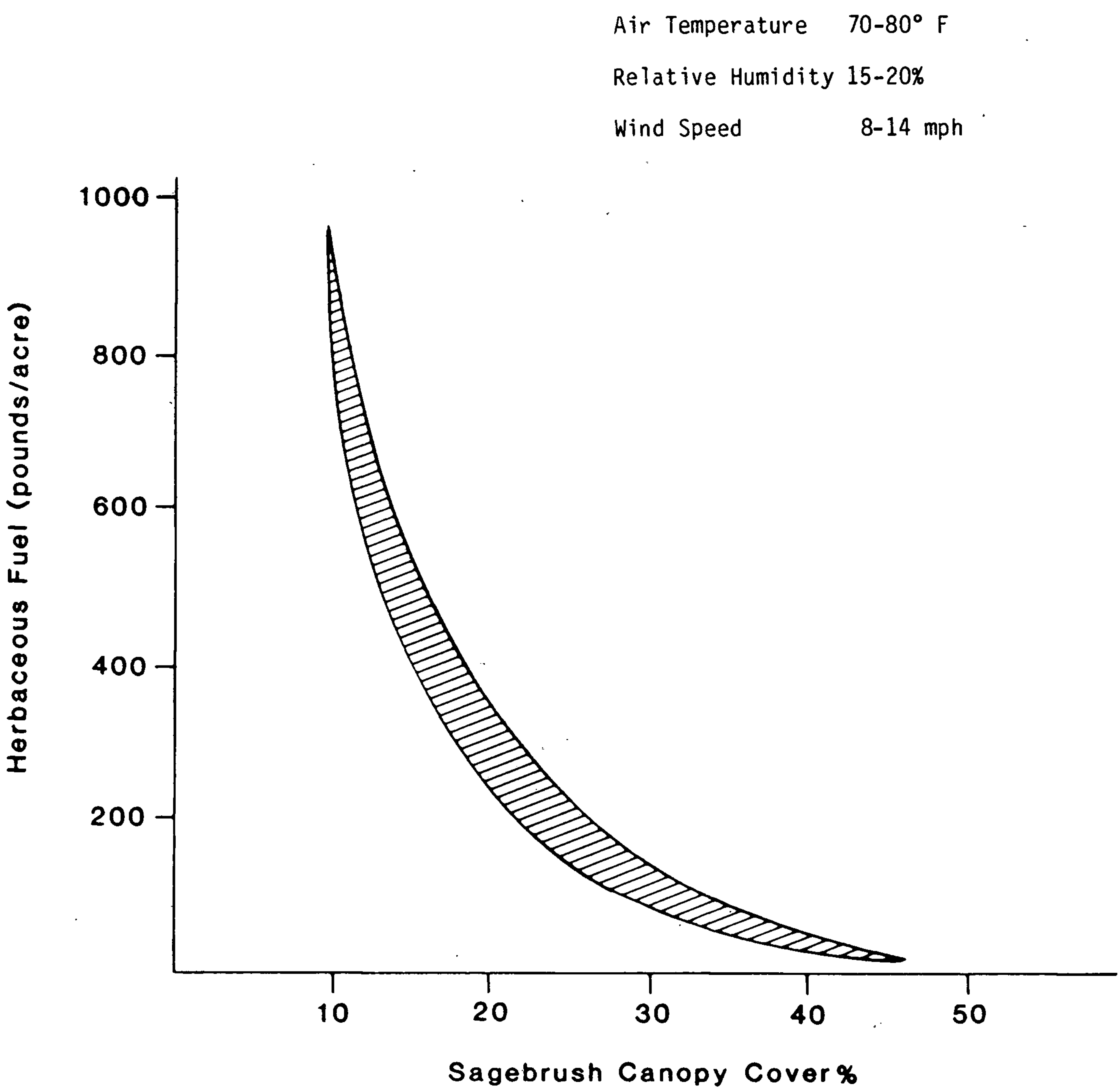

Figure 3. Approximate relationship of sagebrush canopy cover and herbaceous fuel loading for successful fall burning in eastern Oregon.

6-8 foot range, whereas 2,000 pounds of fine fuel can support a fire that will kill most, but maybe not all, juniper trees.

Economics

Insights about the economics of prescribed fire are provided in Table 4. Estimated annual rates of return to prescribed fire given alternative burning costs and forage responses are presented. Returns are based on a 10-year forage response, no forage utilization in the year of or the year immediately after burning, 100 percent utilization of the forage response, and forage valued at $0.01 per pound which is equivalent to a charge of about $6.67 per AUM. If forage production gained by planned burning approaches that of chemical spraying (275 pounds per acre for high desert native range to 530 pounds per acre for seeded foothill range) and costs are similar ($8-$10 per acre), returns to planned burning could range from 18 to 43 percent. Sometimes, however, burning costs can be appreciably reduced by taking advantage of natural barriers to fire. Planned burning costs in these special cases can amount to much less than $8-$10 per acre, thereby greatly improving the return to prescribed fire.

Management Tips

To realize the maximum benefit from prescribed fire, the following management insights are offered:

(1) Gain experience with prescribed fire on small, level sites with moderate fuel amounts before attempting larger burns;

(2) Develop a burning program in concert with your total range improvement program. Prescribed fire is just one tool in the rangeland manager's improvement kit;

Table 4. Estimates of the Annual Rate of Return Generated Over a 10-Year Period by Prescribed Burning on Eastern Oregon Range Sites at Alternative Forage Responses and Burning Costs

Forage Response	Alternative Burning Costs ($ per acre)								
(lbs. per acre)	$ 8	$10	$12	$14	$16	$18	$20	$22	$24
				(Percentage return)[a]					
100	2%	--	--	--	--	--	--	--	--
150	10	5%	2%	--	--	--	--	--	--
200	16	10	7	4%	2%	--	--	--	--
250	21	16	12	8	6	4%	2%	--	--
300	26	20	16	12	10	7	5	4%	2%
350	30	24	19	16	12	10	8	6	4
400	34	28	22	18	16	13	10	9	7
450	38	31	26	22	18	16	13	11	10
500	42	34	29	24	21	18	16	14	12
550	45	38	32	27	24	20	18	16	14

[a] Based on a forage response value at $0.01 per pound which is equivalent to a charge of about $6.67 per AUM. Yield responses are considered available for 100 percent utilization. Forage was not utilized nor was a cost attached to lost production in the year of or the year immediately after the burn.

(3) Use prescribed fire as well as other range improvement techniques, on a management unit basis;

(4) Use terrain features, such as rocky berms, low sagebrush sites, roads, snow fields, etc., whenever possible to control prescribed fire as fire line preparation is a major cost item of using fire;

(5) Base burn decision on weather conditions and site conditions not on the basis of a calendar date;

(6) Be prepared to stop a burn if it is not going according to the plan; this may range from not starting a planned burn to extinguishing the fire;

(7) Use burning techniques and burn when conditions minimize air pollution. Emissions are related to the intensity of the burn, fuel moisture content and burning technique. Backfires produce less smoke and generate fewer pollutants;

(8) Burning in fall or early spring will minimize damage to dominant cool season grasses. Do not burn after heavy seed crops of sagebrush as sagebrush establishment via seed can be rapid particularly if good moisture conditions occur;

(9) Frequent burning depletes perennial grasses and promotes annuals;

(10) Sagebrush is difficult to burn under moderate climatic conditions unless sagebrush cover is at least 20 percent and there is at least 250 pounds of herbaceous fuel per acre.

(11) Except for a few cases, low sagebrush or black sagebrush sites will not carry a fire unless conditions are extreme;

(12) Avoid burning cheatgrass, horsebrush, or rabbitbrush problem sites because fire will encourage even more growth of these species.

(13) Good soil moisture down to 12-18 inches is desirable before burning, because these soil moisture conditions promote regrowth of herbaceous vegetation;

(14) Do not graze burned areas during the first growing season after burning;

(15) When an area has less than one desirable plant per 10 square feet, it is generally practical to reseed after burning;

(16) Longevity of a burn effect depends on the site, percentage kill of target species, and grazing management;

(17) After burning, compare actual burning effects to projected effects and determine the reason for any differences. This evaluation should be useful in planning burning work.

Budgeting the Decision

Because of the uncertainty associated with burning costs and forage responses, it is imperative that the economics of each prescribed fire decision be carefully evaluated before the actual commitment of any capital or physical resources. One method of evaluating these decisions is through the use of a prescribed fire worksheet which is illustrated in Exhibit 1.

The worksheet is a simple budgeting framework which determines if the estimated cost of obtaining forage through the use of prescribed fire is more or less than the estimated value of the annual forage responses. The worksheet should be viewed as a general guide in the evaluation process rather than a rigidly followed form to be completed. Yet, close adherence to the procedure will guarantee that the economics of the decision is carefully thought through. Specifically, the worksheet is used to estimate

Exhibit 1
Prescribed Fire Worksheet

I. Burning Costs

A. Labor costs: ____________ x ____________ = $ ____________
(labor hours) (wage rate)

B. Equipment costs: fixed costs ____________
variable costs ____________ = $ ____________

C. Rental or custom charges: = $ ____________

D. Other costs: fixed costs ____________
variable costs ____________ = $ ____________

E. Total cost of burning the site = $ ____________
(A + B + C + D)

II. Value of Forage Responses

	Production Year	Column 1 Change in production on burned area (AUM's, lbs. or tons forage)		Column 2 Unit value of production		Column 3 Discounting factor from Table 5		Column 4 Calculated discounted annual value of production
F.	Burn	____	x	____	x	____	=	____
G.	1	____	x	____	x	____	=	____
H.	2	____	x	____	x	____	=	____
I.	3	____	x	____	x	____	=	____
J.	4	____	x	____	x	____	=	____
K.	5	____	x	____	x	____	=	____
L.	6	____	x	____	x	____	=	____
M.	7	____	x	____	x	____	=	____
N.	8	____	x	____	x	____	=	____
O.	9	____	x	____	x	____	=	____
P.	10	____	x	____	x	____	=	____

Q. Total discounted value of production available to the ranch operation for utilization due to burning ____________
sum of F through P

III. Cost and Return Comparison

Cost of burning site ____________ vs. value of production ____________
(E) (Q)

costs and the value of forage responses associated with a prescribed fire decision for the period of time from the year of burning through the tenth production year after burning. Although forage responses often are obtained beyond the tenth year, costs and forage responses within a 10-year period most significantly affect the prescribed fire decision.

To obtain added economic insight, at least two different worksheets reflecting different burning cost and/or forage response expectations should be computed for each prescribed fire site. Use of this worksheet in this way can be both a time and money saver as it directs the decision-maker away from unprofitable decisions.

Instructions

The worksheet is divided into three sections: I) burning costs, II) value of forage responses, and III) cost and return comparison.

Burning costs are estimated in Section I. The largest cost component of a prescribed burn is usually the original investment in the actual treatment. Such costs as constructing fire breaks, fuel for torches, burning crew labor, stand-by fire suppression crews and equipment, and seeding, if necessary, should be estimated in this section. Burning costs, not counting seeding, generally should approach the costs of spraying sagebrush at $8 to $10 per acre. Costs, however, could be considerably higher or lower depending on labor and equipment needs, experience with prescribed fire, and availability of natural fire barriers.

Labor cost, line A, is calculated by multiplying estimated labor hours required by the hourly wage rate paid labor or what labor is worth in its next best productive use, whichever is higher.

Equipment costs, line B, include fuel, oil, and repairs associated with all equipment used in the process of burning. If equipment is specifically purchased primarily for prescribed fire use, fixed costs (annual depreciation, interest on investment, taxes, and insurance) also should be included in the equipment cost estimate. If more than one site is burned during the year in question, fixed costs charged against each burn site should be prorated on a total acres burned basis.

Rental or custom charges, when used as an alternative method, are identified on line C. These charges often include all costs: materials, equipment, and labor costs.

Other charges which might or might not be directly related to prescribed burning but which are related to the realization of additional production should be entered on line D. These charges might include the cost of seeding or the extra cost of herding livestock during the year of the burn. Costs, if any, related to non-use of forage during the year of the burn are entered on line F. If capital investments are made, initial investment prorated over the expected life of the burn also should be included on line D.

The cost section is completed by summing the individual cost items (A through D) on line E. This sum represents the estimated cost to burn a range site and then utilize the forage response attributed to burning.

The total value of the forage response available to the ranch operation for utilization from burning is estimated in Section II. Only those changes in forage production occurring in the year of the burn and in the following 10 production years are estimated here as they most significantly affect the economics of the burning decision.

Each year, estimated changes in forage production on the treatment site are entered in the first column of lines F through P. Each of these lines correspond to a production year with line F corresponding to the production year the site is burned and line P representing the tenth production year after burning. Changes in production can be either positive or negative. For example, if grazing on the treatment site is restricted in the burning year to increase fine fuel levels before fall burning, this loss in production is estimated and placed in column 1 of line F. Also, if grazing is deferred for one or more production years after burning, annual losses in production are estimated and placed on the appropriate line under column 1. Production losses, regardless of the production year they are projected to occur, are preceded by a minus sign to indicate they are actually an additional cost associated with prescribed fire. Any production year with a loss in production also shows a negative value in column 4. Production increases, on the other hand, may vary from a few pounds to several hundredweight per acre depending on range conditions, intensity of burn, and management practices. Research has shown that forage production on burned range sites is usually less than preburn levels up to two years after burning, after which, substantial increasing forage responses lasting longer than 12 years are possible.

Once changes in production have been estimated, the annual unit value of production is determined and entered in column 2 of lines F through P. Estimates of the value of changes in production must be realistic. The local market value or lease rate for forage can be used as a guide in determining the current unit value of production. The unit value of changes in production in subsequent years also must be estimated and entered on the appropriate lines. These values are more difficult to estimate because of future uncertainties. Your own knowledge of the local market value of forage in the past few years is the best information you can use in developing these projected values; however, do not overlook the future effect of inflation on these values. The value of added production must be determined in units consistent with production estimates made earlier.

Discounting factors used to complete column 3 are found in Table 5. These factors are used to convert or discount future revenues and costs to present dollar values to facilitate comparison with the present cost of burning. Discounting of future dollars can be thought of as a means of calculating the "cost of waiting" for returns to be produced. To determine the discount factors appropriate to your "cost of waiting," select either the interest rate you pay for borrowed capital or the opportunity cost rate which could be earned if the capital required for prescribed burning were invested in its best alternative use. The higher rate is the most appropriate. Then, in Table 5, find the appropriate discount factors in the interest rate column and enter them in the corresponding lines under column 3 of the worksheet.

The discounted annual value of production, column 4 of lines F through P, is calculated by multiplying the change in production (column 1) by the unit value of production (column 2) by the discount factor (column 3). Remember, losses in production are considered costs and are preceded by a minus sign which is carried through to column 4.

This section is completed by summing the discounted annual value of production estimates appearing in column 4 of lines F through P, on line Q.

Table 5. Discount Factor

Instructions: Select most appropriate interest rate. That is either the interest rate for borrowed capital or the opportunity cost rate which could be earned if the capital or the opportunity cost rate which could be earned if the capital required for range burning were invested in its best alternative use, whichever is higher. Proceed down that column and record the discount factors in the appropriate lines (F through P) under column 3 of the Prescribed Fire Worksheet.

Production Year	Alternative Interest Rates					
	8%	10%	12%	14%	16%	18%
Burn	1.0	1.0	1.0	1.0	1.0	1.0
1	.9259	.9091	.8929	.8772	.8621	.8475
2	.8573	.8264	.7972	.7695	.7432	.7182
3	.7938	.7513	.7118	.6750	.6407	.6086
4	.7350	.6830	.6355	.5921	.5523	.5158
5	.6806	.6209	.5674	.5194	.4761	.4371
6	.6302	.5645	.5066	.4556	.4104	.3704
7	.5835	.5132	.4523	.3996	.3538	.3139
8	.5403	.4665	.4039	.3506	.3050	.2660
9	.5002	.4241	.3606	.3075	.2630	.2255
10	.4632	.3855	.3220	.2697	.2267	.1911

This sum represents the total discounted value of production available to the ranch operation for utilization from prescribed burning.

In Section 3, the direct cost of burning, line E, is compared to the total discounted value of production, line Q. If line Q is equal to or greater than line E, prescribed burning of the site in question is the most profitable decision available to you. If, on the other hand, the reverse is the case, this means money which would have been spent on prescribed burning is best expended on another ranch activity. In this situation, it may be that even though prescribed burning is profitable, it might not be the most economical investment because of more productive uses of capital.