A Tool for Estimating the Financial Returns on Forage Grasses Seeded in Thinned Ponderosa Pine

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Highlight: *A method is described for determining the approximate internal rate of return from seeding forage grasses in thinned ponderosa pine stands. Although this method is applicable to an array of forage production costs, market-based forage values, and forage production levels, it is most useful to public land administrators for scheduling forage-seeding investments on both forested and open rangeland.*

Response of understory vegetation to precommercial thinning in pine stands is a matter of record. Grelen et al. (1972) reported that herbage yields are inversely related to tree basal area in slash pine (*Pinus elliottii* var. *elliottii*). McConnell and Smith (1965, 1970) found significant growth increases in understory vegetation in recently thinned ponderosa pine (*Pinus ponderosa*) stands. But what are the economic implications of promoting forage in pine stands? Are public investments in forage seeding economically feasible in thinned stands? Little has been published on this subject even though forest administrators are confronted by increasing demands for range use (McGuire, 1973).

This article describes and illustrates a method to determine the approximate internal rate of return expected from seeding forage grasses in thinned ponderosa pine stands on public lands (Fig. 1). As an economic guide, this method is useful to public land administrators for scheduling forage-seeding investments on both forested and open rangeland. However, here we discuss only its application to forested rangelands, since our purpose is to direct attention to the forage production potential of the millions of acres of overly dense ponderosa pine stands in the Pacific Northwest (Fig. 2)—a potential that could be realized as these stands are thinned, by coordinating forage and timber management planning. We do not identify a specific rate of return to use as a cut-off point for terminating forage-seeding investments. The user must make this decision based on his professional experience and the policy constraints, including minimum rate of return, if any, dictated by his employing agency.

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A Marginal Analysis

A joint analysis of precommercial thinning and subsequent treatments to reduce fire hazard, to reduce erosion potential, and to increase grazing capacity would be desirable. An evaluation of the joint returns from precommercial thinning and subsequent seeding of forage grasses is available (Sassaman et al., 1973). However, decisions are often not made on that basis. This analysis is for situations in which the decision to precommercially thin has already been made and the level of treatment that is required to reduce fire hazard and erosion potential is known. In this situation we consider only expenses over and above those committed by

Fig. 1. *A thinned ponderosa pine sapling stand with seeded forage.*

Fig. 2. *An overly dense ponderosa pine sapling stand.*

"prior decisions" in evaluating the desirability of seeding forage grasses to increase grazing benefits. Since our method was developed for public land decision makers, all costs and benefits directly associated with forage production are included in the analysis regardless of to whom they accrue. However, one should recognize that the public is not entirely indifferent about who pays the bills and who receives the benefits. Additional calculations are required if one wishes to evaluate the "fairness" of the public grazing fee, or to contemplate whether subsidies to ranchers are implicit in the public investment decision.

Advantages of Seeding Forage Grasses in Thinned Pine Stands

A primary advantage of seeding grasses after proper slash treatment is greater usable forage. In a precommercially thinned, unseeded stand, with slash treatment (crushed) to reduce fire hazard, usable forage production is negligible at first and then increases slowly because the crushed slash, which remains on the ground for years, hinders animal movement and reduces grazing potential. Forage species seeded in soil disturbed by machine piling and burning, the common slash treatment method that precedes seeding, establishes a desirable ground cover before the low-value, noxious, or early drying and flammable annual species recover naturally (Garrison, 1961).

Another advantage is that a larger proportion of the selected and planted understory vegetation is usable for grazing than is possible with a ground cover in the weedy stage of secondary succession. Furthermore, more usable forage means less left on the ground as flashy fuel, so the fire hazard associated with understory vegetation is reduced on areas that are managed for both forage and timber.

Other advantages of seeding valuable forage species are more difficult to quantify and, although not developed in this discussion, they are worthy of mention. Some of these involve: esthetics—forage can mask unsightly forest debris and bare soil; watershed—forage can protect watershed values by preventing erosion; and wildlife habitat—forage can increase wildlife habitat values for some species by providing food and cover.

Forage Yields

Yield data from forage seeded in thinned ponderosa pine stands are scarce. Schwendiman (1968) prepared a summary of grass species adaptability trials on certain forested lands of the Northwest, including seedings made in forest burns. Other sources of information on seeding summer rangelands in the Northwest are the "Oregon Interagency Guide for Conservation and Forage Seedings" (Soil Conservation Service, 1971) and the U.S. Department of Agriculture's Farmer's Bulletin No. 2091 (Rummell and Holscher, 1955).

Although these data are notable, their validity as a basis for estimating planted forage yields in thinned ponderosa pine stands is untested for many site conditions on mountain lands. Therefore, our method for evaluating forage-seeding opportunities is structured so that it is usable with five average annual forage yields, ranging from one-tenth to one animal unit month (AUM) per acre for 20 years. Although one AUM per acre per year may seem high, it is reasonable for some timbered sites if: (1) timber stocking is reduced to 180 stems or less per acre for a high or medium site and 125 stems per acre for a low site, depending on the tree vigor of the residual stands, (2) grass species are chosen with proper regard to site adaptability, and (3) grazing begins in the third growing season and is limited to a season, rate, and management practice that will not cause stand depletion.

Estimating the expected forage production may be difficult since yield data for seeded forage in thinned stands are scarce. The job is further complicated because the forage yield data needed for this analysis is the net increase associated with the decision to seed grasses for forage production. However, gross seeded yield is an acceptable measure of forage production, if natural forage yields expected after the timber thinning operation are too small to make domestic grazing worthwhile.

Often prior decisions include slash treatment and seeding forage grasses for other purposes that incidentally increase grazing capacity by significant amounts. When this is the case, the net increase is determined by estimating the forage potential of the two situations and subtracting the amount attributable to the prior decisions.

Grazing Benefits

Grazing benefits are more than receipts to the public treasury. Benefits are what the users of the public grazing permits[1] would be willing to pay rather than do without. According to Margolis (1969), "the measurement rule used to determine the value of a government output is: estimate what the users of the public product would be willing to pay." Thus, the demonstrated willingness-to-pay for private grazing leases provides the basis for our estimates of public grazing benefits associated with the seeded forage. Costs are viewed similarly; they include not only expenditures incurred by the public treasury, such as slash treatment and seeding costs, but also expenditures incurred by the rancher that are necessary to use the leased AUMs. Economic efficiency is achieved only when investments are made to the extent that an additional dollar of investment yields a dollar of benefit including benefits to all parties. This is such a pervasive idea in the resource economics literature that returns to the public treasury are usually mentioned only as a side issue. Therefore, the costs of added fencing and water developments are proper forage promotion costs, whether they are incurred by the rancher or the government.

Our method uses the local going rate for private grazing leases as a basis

[1] In this article the term "public grazing permit" is used in a general manner. It is not a specific term that is tied to any particular government agency. It includes all types of grazing leases, permits, and other legal instruments which provide for grazing on public lands.

Table 1. Worksheet, with sample data, for determining the market-based value of an AUM of public grazing.

Cost items	Public ($/AUM)	Private ($/AUM)
1. Lost animals	0.75	0.30
2. Moving livestock to and from grazing allotment	1.50	1.00
3. Herding (includes riding costs for proper distribution of animals and gathering costs associated with the removal of animals at the close of the grazing season)	0.75	0.25
4. Salting, feeding, and watering	0.50	1.00
5. Fence and water maintenance	1.00	0.75
6. Other	0.50	0.70
7. Total operating costs	5.00 (a)	4.00 (b)
8. Local going rate on private leases		5.00
9. Total private costs		9.00
10. Market-based value of an AUM of public grazing (item 9 less item 7a)	4.00	

for estimating the initial market-based value of an AUM of public grazing. If the goods and services provided by public lease are not the same as those provided by private lease, or if an AUM of public grazing costs more (or less) to harvest than an AUM of private grazing, the estimated market-based value of an AUM of public grazing should be adjusted to reflect these differences. Table 1 is a worksheet to determine the market-based value of an AUM of public grazing; it contains sample data for the example described in the "Application" section of this presentation.

In determining the costs needed in Table 1 to develop a market-based value for public grazing, we need to distinguish between developing grazing potential in a new area and merely increasing the capacity of existing allotments. If, as in most cases, the capacity of present allotments is increased, the costs per AUM for herding, salting, and other operations often decreases as the carrying capacity increases, because the cost of accommodating additional animals on a given area is less than the average cost. It is this incremental cost per AUM that is needed for this analysis.

Forage Production Costs

Slash treatment, forage-seeding, fencing, and water development costs are one-time investment costs that may be included in the capital costs of forage production. The amount of the slash treatment costs that is chargeable to forage production is affected by the management decision of whether the slash would be treated to reduce fire danger if forage were not seeded. So the net slash treatment cost associated with forage production is the *difference* between the cost of the slash treatment that precedes forage seeding and that which would be incurred (if any) to reduce fire danger.

Since some average proportion of seedings fail, we need to reflect those failures in determining our seeding cost by: (1) determining the additional costs attributable to the forage production decision and (2) dividing that by the proportion of seedings that are successful. For example, if the additional seeding costs are $8 per acre and we are successful 75% of the time, we get on the average 0.75 acres for each $8. Therefore, the per acre cost is $8 per .075 acres or $10.67.

The delay of benefits and the loss of forage during closure of the allotment are also costs that result from seeding failures. These costs appear to be less than the reseeding cost and are not adjusted in this analysis because to do so would complicate the analysis unreasonably. As a result, the chance that the rates of return are overestimated increases as the proportion of failures increases. For internal rates of return of less than 10% and seeding failure rates of 25% or less, the change in the internal rates of return is less than one-half of 1%.

Exclusion fencing costs are directly related to the policy of delaying grazing until the third growing season on seeded acres. Two ways of implementing this policy are fencing cattle out of the seeded areas within an allotment unit (exclusion fencing) or closing the entire unit, thus forgoing all forage production of the unit for two growing seasons. The cost of exclusion fencing involves a major and a minor cost. The major cost is the fence (materials and labor) around the seeded area. The minor cost is the value of the unused natural forage that would have been produced on the seeded area during the two growing seasons it is fenced. The cost of closing the entire unit for two growing seasons will vary with the amount and value of the unused forage.

Table 2 provides a format for summing the forage investment costs. Costs that occur subsequent to the initial seeding costs are discounted at

Table 2. Worksheet, with sample data, for determining the capital costs of the increased forage production in thinned ponderosa pine stands.

Forage production costs	Cost at time of activity ($/treated acre)	Discounted cost at time of seeding ($/treated acre)
1. Slash treatment (exclusive of those required to reduce fire danger)	20.00	20.00
2. Forage seeding (exclusive of those spent for soil erosion control on areas disturbed by fire management slash treatment activities)	3.00	3.00
3. Exclusion fences	12.00	12.00
4. Irrecoverable forage from closure of allotment unit for 2 years in lieu of fencing seeded areas within the unit	0	0[a]
5. Water developments	3.50	3.05[b]
6. Miscellaneous	0	0[c]
Capital costs of forage production (discounted cost at time of seeding)		38.05

[a] Sum of the market-based value of the irrecoverable forage per treated acre for year 1 times 0.93 to discount for 1 year at 7% and the market-based value of irrecoverable forage per treated acre in year 2 times 0.87 to discount for 2 years at 7%.
[b] $3.50 times 0.87, to discount for 2 years at 7%.
[c] $0 times the appropriate discount factor to discount each cost to time of seeding at 7%.

7% to the time of seeding to simplify the analysis. This results in a bias when the internal rate of return eventually determined is above or below 7%. If greater precision is desired, these costs should be discounted at a rate that approximates the internal rate of return for that investment. These discount factors are for rates of return in the range 5 to 9%:

Years costs are deferred	Interest rate (%)		
	5	7	9
1	0.95	0.93	0.91
2	0.91	0.87	0.83
3	0.86	0.82	0.75

When a grazing allotment unit is closed for 2 years as an alternative to fencing the seeded areas within a unit, the cost of the unutilized (lost) forage should be expressed as the number of AUM's lost per number of *treated* acres in the unit, or simply as AUM's per treated acre. From this expression, the dollar value of the lost forage per treated acre can be determined. For example, consider a 5,000-acre unit with 500 treated acres. If the natural forage production rate is one AUM/10 acres, the 5,000-acre unit will have an annual forage yield of 500 AUM's. If the unit is closed, these 500 AUM's of grazing would be lost each year the unit is closed. This is the equivalent of one AUM lost per treated acre. And if an AUM has a market-based value of $4, this amount, when properly discounted, is one of the relevant economic costs of growing forage that should be included in the capital cost of forage production worksheet (Table 2). Note however, that the sample data in Table 2 includes no value for unutilized forage; an exclusion fencing cost is included instead.

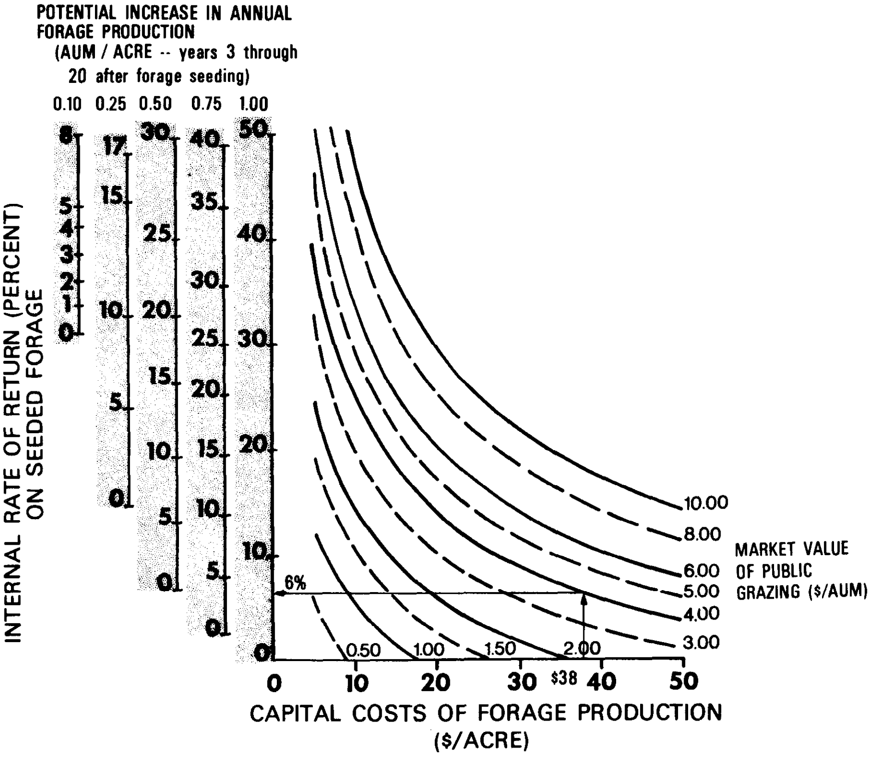

Fig. 3. *Internal rate of return (percent) earned by forage-seeding investments at five levels of forage production and an array of forage production costs and market values of public grazing.*

Application

Let's examine a sample forage-seeding investment, whose data are listed in Tables 1 and 2, and learn how to use Fig. 3 with our sample data to estimate the rate of return. The curves in Fig. 3 are influenced by the assumption that grazing begins in the third growing season after seeding and continues at a relatively steady rate through the 20th growing season. Hence, their position will shift if the assumption is modified (e.g., the curves will shift upward if the grazing benefits are utilized before the third growing season).

In our example, the operating cost of a public grazing permit exceeds that of a private grazing lease by $1 per AUM (Table 1, item 7). And since the local going rate for private leases is $5 per AUM (Table 1, item 8), the market-based value of the public permit is $4 per AUM (Table 1, item 10). Capital costs are listed in Table 2, including discounted costs at time of seeding. Note that an exclusion fencing cost of $12 per treated acre is listed, so no cost is shown for irrecoverable forage in allotment unit since the unit remains open for grazing during the 2 years after seeding. Since natural forage yields are very sparse in the timber stands prior to thinning, no cattle grazing is anticipated without seeding desirable forage species. Therefore, no cost is included in our analysis for unused natural forage in the seeded areas during the two growing seasons they are fenced. Other discounted costs per treated acre include: $20 for slash treatment, $3 for seeding (in addition to that spent for erosion control), and $3.05 for water developments. There are no miscellaneous costs in our example. Total capital costs are $38.05 per acre.

The internal rate of return from our sample problem is determined with Fig. 3: (1) locate the $38 capital cost on the horizontal axis, (2) draw a vertical line to intersect the $4 per AUM market value curve, (3) from this intersection point on the curve, draw a horizontal line to intersect the vertical axis, and (4) read the internal rate of return at the intersection point of the horizontal line and the appropriate forage production scale. In our example, we assumed forage production to be one AUM per acre per year, so the rate of return, which is read on the one AUM scale, is 6%.

The concept of internal rate of return as developed in the economic literature is intended to be used as an investment guide. The decision rule is to make investments whose internal rate of return is greater than the minimum rate of return acceptable to the organization. Since our analysis includes only the grazing benefits of seeding forage grasses, this rule may be inadequate by itself.

Because of uncertainty about the cost, market value, and forage yield, it is helpful to know what the rate of return would be for a range of values. This could easily be done with our method using Fig. 3. To illustrate, let's check the sensitivity of the rate of return to three variables—capital cost of forage production, market value, and annual forage production potential—with values of $38, $4, and one AUM, respectively,

If we assign a value of $50 to the capital cost of forage production in place of the $38, and all other values remain unchanged, the internal rate of return decreases to 3.5% when we proceed as before with Fig. 3. Likewise, a value of $30 would produce an 8% internal rate of return.

Suppose the market value of a public grazing permit were $5 instead of the $4 per AUM. The new internal rates of return from an annual forage production potential of one AUM per acre and capital costs of $38, $50, and $30 per acre, approximate, respectively, 8.0%, 5.5%, and 11.5%.

Finally, suppose the value of the annual forage production potential is reduced from one AUM per acre to 0.75 AUM per acre. The original three rates of return would decrease from 6.0%, 3.5%, and 8.0% with capital costs of $38, $50, and $30 per acre and a market value of forage at $4 per AUM, to about 3.0%, 1.0%, and 5.0%, respectively. Obviously, the internal rate of return is quite sensitive to the size of the potential increase in forage production, so one must be careful when selecting the most appropriate forage production scale in Fig. 3.

Summary

We have described a method for determining the approximate internal rate of return expected from investments in seeding forage grasses in thinned ponderosa pine stands. This method focuses on the adjusted market value of an AUM of public grazing and the capital costs of forage production. The internal rate of return may be determined by this method when the forage market value (dollars per AUM), the capital costs of forage production (dollars per acre), and the annual forage production potential (AUM's per acre) are known. Other important benefits of rehabilitating ground cover, besides producing forage for domestic stock, are recognized but are not included in this analysis.

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