Cattle Grazing and Wood Production with Different Basal Areas of Ponderosa Pine

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Highlight: *Ponderosa pine stands were thinned to various basal areas on the Wild Bill Range near Flagstaff, Arizona, to determine the effects on beef and wood production. Beef gain potential was maximum at zero basal area and was one-third less when ponderosa pine was present at basal areas of 20 ft^2/acre. Physical relationships and the 1972 prices suggest that the combined economic value of grazing and saw log production would be maximum in tree stands having a basal area of about 45 to 60 ft^2/acre.*

Cattle grazing and timber production, two major uses of forested lands, are often competitive. Trees strongly influence livestock production through their effect on forage plants. Although the relationships of forage yields to tree overstory stocking have been documented in many locations (Ffolliott and Clary, 1972), little information is available on the direct relationship of livestock production to wood production or to an index of tree dominance such as tree basal area.

Production economics, which examines relationships among various resource values, provides a useful framework to determine the best use or combination of uses of public lands (Lloyd, 1969; O'Connell and Brown, 1972). Typical production economics procedures utilize production functions and product-product relationships, usually to optimize economic returns. While the primary goal of public land managers is rarely to optimize economic returns, these relationships can help form an effective framework for land management decisions.

Studies of the Wild Bill Range, established in the early 1960's near Flagstaff, Ariz., provide a basis to determine such product-product relationships. One of the objectives at Wild Bill was to determine the effects on beef production and timber production when tree stands are thinned to different basal area levels. This information should be useful for land managers, economic planners, and others who are interested in managing forested lands more effectively.

Study Area and Methods

The Wild Bill study area is on a ponderosa pine (*Pinus ponderosa* Laws.)-bunchgrass range (Pearson and Jameson, 1967). Elevation is 7,600 ft, and the land is generally level to moderately sloping with a southwest aspect. Soils are gravelly silt loam, derived from basalt.

This study utilized one clearcut range unit, four thinned range units, and a control range unit. In 1967, approximately two-thirds of the original control unit was consumed by wildfire and another unit was substituted as the control. The principal forage species were Arizona fescue (*Festuca arizonica* Vasey) and mountain muhly (*Muhlenbergia montana* (Nutt.) Hitchc.).

Livestock management and forage measurements were described by Pearson (1972). Tree basal area was reduced to predetermined growing stock levels during 1963 and 1964. The tree stands were inventoried in 1971 by point sampling techniques (Grosenbaugh, 1958), the sample trees were bored to determine growth rates, and volumes (Ffolliott et al., 1971) were computed for the beginning and end of the study. The

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Table 1. Characteristics of the Wild Bill Range units–averages for 1965–1971.

Characteristic	2 (Clear)	3 (Thin)	4 (Thin)	5 (Thin)	6 (Thin)	7 (Control to 1966)	8 (Control from 1967)
Tree basal area (ft²/acre)	0	21 ± 1	31 ± 3	50 ± 4	62 ± 6	130 ± 9	109 ± 8
Tree crown cover (%)	0	12 ± 1	21 ± 3	30 ± 3	33 ± 3	60 ± 5	58 ± 3
Annual bolewood production							
Total (ft³/acre)	0	17 ± 1	31 ± 3	29 ± 2	32 ± 3	–	49 ± 5
Merchantable (ft³/acre)	0	18 ± 3	31 ± 4	24 ± 3	31 ± 4	–	35 ± 5
Merchantable (bd ft/acre)	0	73 ± 6	68 ± 12	88 ± 11	120 ± 17	–	50 ± 9
Annual understory production							
Grass (lb/acre)	447	485	374	263	199	39	149
Forb (lb/acre)	540	77	87	77	48	17	23
Shrub (lb/acre)	2	7	2	T	1	0	T
Total (lb/acre)	989 ± 34	569 ± 29	463 ± 63	340 ± 50	248 ± 33	56 ± 6	172 ± 15
Beef gain (lb/acre/year)	31.8 ± 3.5	22.0 ± 4.4	17.0 ± 2.4	12.9 ± 1.7	10.6 ± 1.7	1.4 ± 0.2	–
Yearling days/acre/year	22.5 ± 3.1	15.8 ± 2.7	14.0 ± 1.5	10.5 ± 1.7	7.6 ± 1.3	2.0 ± 0.1	–

average tree diameter was 7½ inches although considerable variation was present.

Grazing studies were initiated in 1965 and continued through 1971. Yearling cattle, supplied by forest permittees, grazed the Wild Bill Range from June through September each year.

Product Relationships

Beef gains on the different range units were closely related to the amount of tree overstory, due to differences in forage production (Table 1). One-third (29 to 34%) of the beef gain potential was lost as the tree basal area increased from 0 to 20 ft^2/acre (Fig. 1). This relationship demonstrates the large differences in average annual beef gain potential at different levels of tree basal area.

Animal stocking rates were such that average forage utilization varied from 24 to 33% with an overall mean of 28%–close to rates required for maximum profit (Pearson, 1973). Since the average stocking rates were near optimum, they will be used as a direct indication of livestock carrying capacity at Wild Bill.

Beef gains among the range units were very closely related to animal stocking (indicated carrying capacity) with an average of 1.35±0.04 pounds of beef gain/yearling day. Average daily beef gains were similar because the differences in stocking rates per acre were due primarily to differences in forage production and not to differences in utilization levels.

Livestock carrying capacity was inversely and linearly related to *total* tree volume growth. A similar relationship has been described for central Arizona (Ffolliott and Clary, 1974). However, when only the increment of volume on *merchantable* stems is considered, the function is curvilinear (Fig. 2). The downward curve results from relatively little more merchantable volume growth on range units with greater tree stocking than on those units where tree stocking has been somewhat reduced. Range units with greater stand basal areas had more trees in small nonmerchantable sizes (<6 inches dbh) and a lower average tree diameter. Thinning operations tended to remove these smaller trees, thus increasing the average tree diameter of the residual stand, and merchantable volume growth more nearly equaled total volume growth in the thinned range units.

The relationship of livestock carrying capacity to board-foot volume growth has a quite different form. Board-foot growth, calculated from sawtimber-sized trees, reached a peak in range unit 6 (timber basal area 62 ft^2/acre), but was much lower in the high tree basal areas of the control range unit. Since a considerable gap in tree basal area occurred

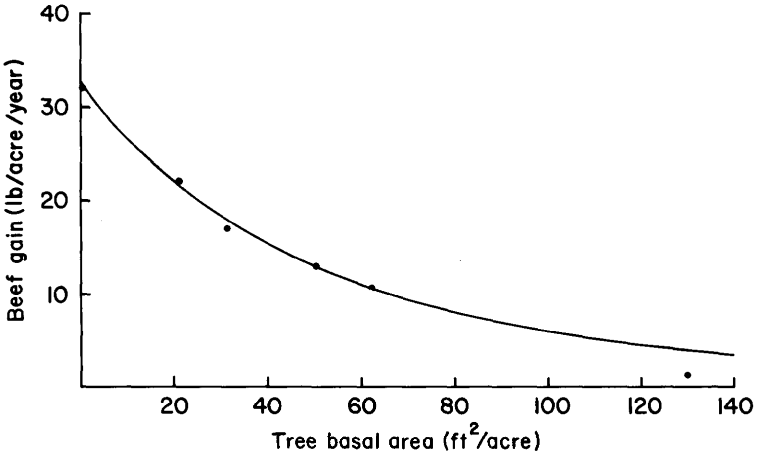

Fig. 1. *Relationship of beef gain to tree basal area.*

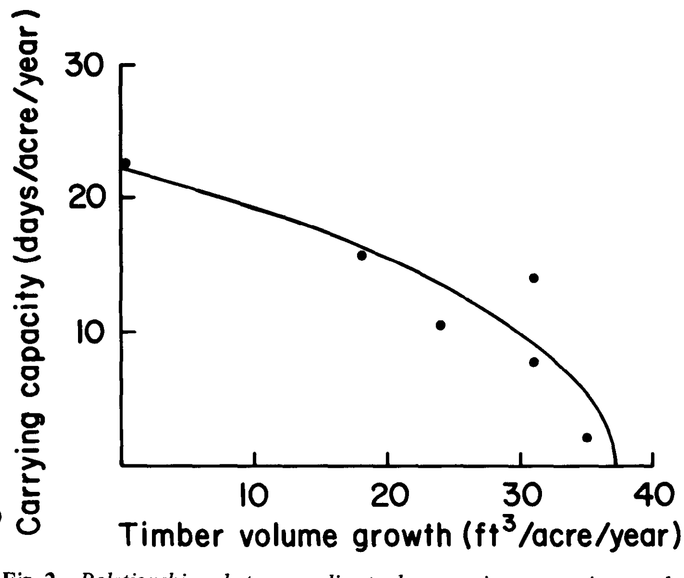

Fig. 2. *Relationship between livestock carrying capacity and merchantable timber volume growth.*

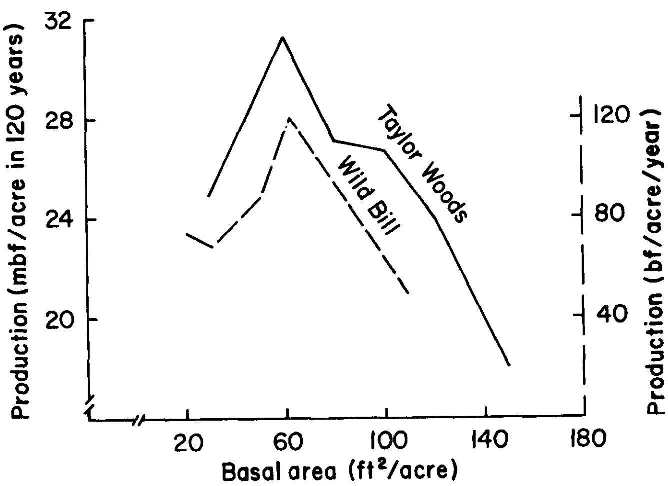

Fig. 3. *Board-foot production in relation to ponderosa pine basal area. (Taylor Woods data from Schubert 1974.)*

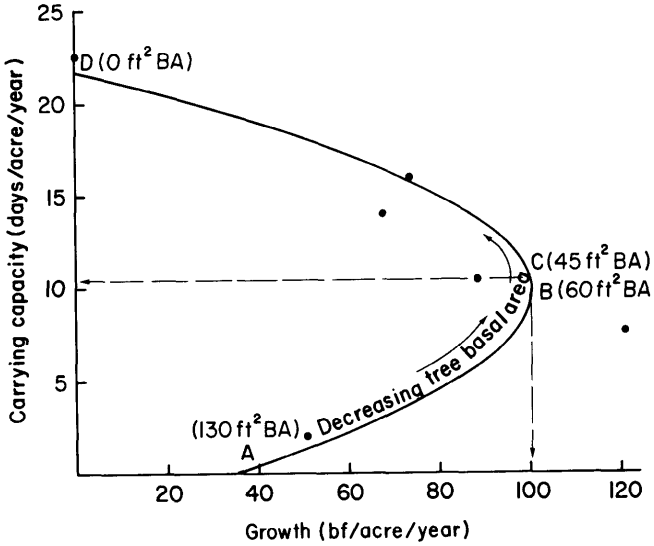

Fig. 4. *Relationship between livestock carrying capacity and board-foot timber volume growth.*

between range unit 6 and the control range unit, the pattern of tree growth was compared to that of nearby Taylor Woods (Schubert, 1974). Results from both areas demonstrate a pronounced peak of board-foot growth at about 60 ft^2 of tree basal area per acre (Fig. 3). Because average beef gain and livestock carrying capacity are closely correlated with tree basal area, and because the peak of board-foot growth appears to be fairly assured at about 60 ft^2 of tree basal area, we have fitted a curve to the data comparing livestock carrying capacity and board-foot growth (Fig. 4). The fit of the calculated relationship is not tight, but it is logical and is supported by the results described above.

At higher tree basal areas, the relationship between livestock carrying capacity and sawtimber growth is complementary (O'Connell and Brown, 1972) because production of both can be increased with a partial reduction in tree basal area. After a certain point, continued reductions in basal area reduce sawtimber growth, and grazing and timber production become competitive (Fig. 4).

Economic Relationships

The shapes of these curves are important in determining economic optimum product mixes. In relationships where the two products substitute for one another at a constant rate, the best economic solution is usually to specialize in production of either one product or the other (Lloyd, 1969). In relationships of the type illustrated in Figs. 2 and 4, where the relationships are nonlinear and convex outward, the rates of substitution are variable. In such cases an economic optimum can usually be obtained only by producing some of both products.

Determining the true net economic values of different products having different cost inputs, such as livestock pasturage (which is used annually) and cubic feet of wood (which is produced annually, but harvested periodically), requires careful consideration. When considering public lands, the inputs of public monies should also be considered for each level of management.

The rental value of livestock carrying capacity (or pasturage), which excludes the additional cost of labor and capital to produce beef, is more easily determined and evaluated than is the net value of beef gain as such. Therefore, livestock carrying capacity was the range measure selected for comparison with wood production to ascertain which combination of these two forest outputs yield the greatest dollar value. The primary wood product from southwestern national forests is sawtimber; therefore board-foot volume growth was the wood product measure selected for the economic evaluation. Product values in 1972 were \$99.55/Mbf for saw log stumpage and \$5.82/animal unit month for grazing (O'Connell and Boster, 1974). Corresponding unit values are 10 cents/board-foot of timber and 12 cents/yearling-day.

Assuming all points on the curve in Figure 4 represent equal costs to management over a planning horizon, the maximum economic output would be at 100 bd ft of timber/acre/year and 10.5 yearling-days of grazing/acre/year (point C). At this point the marginal rate of substitution of the two products is tangent with the ratio of the two product values. Animal carrying capacity is maximum at point D and sawtimber production is maximum at point B. Point A represents untreated conditions, or no tree removals. As more trees are removed in the initial treatment (moving up the curve from point A toward point D) more initial costs are incurred. The cost of completely converting a ponderosa pine stand to grass (point D) is \$30 to \$40/acre more expensive (Turner and Larson, 1974) than managing the stand at point C. When variations in costs for initial stand improvement are included, the economic optimum level of management moves to some point between points C and B, or between, say, about 45[1] and 60 ft^2 of tree basal area.

It does not appear that this economic optimum range of basal area is likely to change much over time. The point of optimum product-product yield will not occur at tree basal areas greater than that at point B (for conditions similar to Wild Bill) because it represents maximum timber yields. On the other hand, the value of animal products would have to increase substantially in relation to timber products in order to lower the economic optimum tree basal area level below that at point C, because of increasing costs to further reduce basal area levels. Therefore, it appears that the basal area range of approximately 45 to 60 ft^2 which was the economic optimum in 1972 may hold generally true for some time to come.

[1] Estimated from the carrying capacity-tree basal area relationship.

Summary

The presence of ponderosa pine in any density will probably decrease the beef gain potential or livestock carrying capacity. In fact, about one-third of the maximum beef gain potential on Wild Bill was lost as tree stands approached 20 ft^2 basal area/acre. Conversely, thinning dense tree stands can improve the livestock potential while at the same time maintaining or improving wood yields on merchantable stems. The economic optimum combination between animal production and wood production will vary according to whether the wood production is considered in all size classes or whether it is considered only in larger size classes.

The physical product-product relationship together with the 1972 unit prices suggest that the combination of product values would have peaked at approximately 45 to 60 ft^2 of tree basal area when managing for both livestock carrying capacity and board-foot yield in trees averaging 5 to 10 inches diameter.

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