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FORAGE PRODUCTION UNDER THINNED DOUGLAS-FIR FOREST

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Abstract: In the Pacific Northwest, trees may take up to 60 years to mature for harvest. This ties up land for other commercial purposes. Depending on tree species, commercial thinning opens up the tree canopy to reduce competition among trees. In Douglas-fir forests, commercial thinning reduces the tree density per acre from 450 to 200. Under the trees, the space created by thinning allows desirable forages for livestock to thrive. These forages can be invigorated by applying nitrogen in early spring and the resultant feed used for grazing or hayed to support livestock. This study investigated how much forage could be produced under 25-year old and 55-year old Douglas-fir thinned forest when fertilized with nitrogen (N) at 75 lbs/acre in early spring. Cumulative forage dry matter yields averaged 2.14 and 1.27 tons/acre for forages growing under 25- and 55-year old trees, respectively. Cumulative forage grown on open space with similar treatments yielded 4.15 tons/acre dry matter which is 27% higher than estimates from the USDA soil survey of 3 tons/acre in similar soil and climatic conditions. Currently, animal stocking rate is one beef cow/calf to two acres. If woodland owners adopted silvopastoral systems like this one, a new animal stocking rate of 4 and 6.5 acres per cow/calf unit under the 25- and 55-year silvopastoral systems respectively, is recommended. This, however, will depend on location and aspect of the land. Using thinned forestland for forage production is another way to diversify agriculture and increase income for forest landowners.

Key words: Forages, Douglas fir, nitrogen, perennial rye, livestock, stocking rates, commercial thinning, Pacific Northwest, soil survey.

INTRODUCTION

In the Pacific Northwest, timber is a major crop bringing income to many small scale farms. The dominant and most productive tree species is Douglas-fir (*Pseudotsuga menziesii)*. Douglas-fir is planted at a density of 400-500 trees/acre. Depending on location and management, commercial thinning at 15-20 years reduces stocking density to 170 - 200 trees/acre with average spacing of 10 by 15 feet. At this stage, live tree crowns are about 30% allowing sunlight to penetrate to the ground promoting grass growth and other understory plants (Emmigham and Green 2003). Trees are harvested at age 40-60 years when they are fully mature.

Forty years is a long time to wait to harvest logs for income. However, planned forestry (agroforestry) might provide better economic returns if thinned forests can be utilized for forage production to provide supplemental income. Economic analyses by Kurtz (2000), Kallenbach (2006) have demonstrated that well planned forestry can provide above average long-term returns on investments. One of the five recognized agroforestry practices is silvopasture, which is the growing of perennial grasses and/or grass-legume mixes in a forest stand for livestock pasture. In this system, the trees not only provide long-term investment, but also provide the animals shade in summer and serve as windbreak in winter. In turn, the forage base provides feed for beef cattle which ultimately provides livestock sales for short term income (Kallenbach et al. 2006).

Research has shown different relationships between trees and the forage. Clason (1999) found that timber and forage growth benefited from fertilization due to suppression of competing vegetation in a commercial loblolly pine plantation, while other research shows that without careful management, competition from many forage species reduces tree growth. For example, fescue can reduce height of black walnut (*Juglans nigra* L.) by 45% compared to no ground cover due to competition for nutrients and moisture (Kallenbach et al. 2006). In western Oregon, forage production under Douglas-fir trees tended to increase with increasing degree of tree aggregation from single-tree grids to cluster grids (Sharrow 1991). Because of the hilly nature of the landscapes in this region, trees are planted in cluster grids.

Forage growth is a function of light interception and temperature. Silvopastoral systems provide forages with an environment where both solar radiation and temperature vary spatially on daily and seasonal time scales (Sharrow 1991). The light quantity and quality reaching plants affect their morphology and dry matter allocation. Conifers have been found to reflect and scatter much less far-red light therefore enhancing carbohydrate buildup in forages growing in the understory. These forages usually receive about 40% less photosynthetically active radiation (PAR) but consistently produce over 60% of biomass compared to sites receiving 100% PAR (Feldhake et al. 2005).

Our objective was to determine how much forage can grow under 25- and 55-year old thinned Douglas-fir stands as a basis for recommending silvopastoral systems to small woodland owners in the Pacific Northwest USA who need to diversify their income base.

RESEARCH DESIGN

This study was conducted on-farm near Harlan, Oregon (44° 33' 07 N and 123° 48' 23 W). The soil type at this location is Eilertsen silt loam. Average annual precipitation is 92 inches/year with mean annual temperature of 54 ^{o}F. Three treatments were setup (South-side - SS, Center - CC, and North-side - NN) based on location of forage plots in relation to edge of the woodlot and aspect. The SS treatments were at the edge of the woodlot on the south-most section that gets more sun, the CC treatments were located 100 feet from the SS treatments towards the center of the woodlot, and the NN treatments were located 200 feet away from the SS treatments and received the least amount of sunlight. This set up was used for both the 25- and 55-year old trees. Average tree height was 65 feet and 100 feet for the 25- and 55-year old trees respectively. The treatments were replicated three times in a randomized block design for a total of 18 plots. The control plots were set out in the open without trees. The plots measured 10 by 33 feet and were fertilized with 75 lb N/acre once on April 1st of 2007 and 2008.

The site was gated and no animals were allowed to graze until after each harvest. The forage grasses were a mixer of perennial ryegrass and orchardgrass. Cumulative annual forage yield data were collected for two years (2007-08) and harvesting was done a day before the farmer turned in his animals for grazing. At harvest, a 42-inch swath was removed from the center of each plot with a flail type mower, weighed, and recorded. Wet forage yields were adjusted to dry weight by drying a subsample to constant weight at 135°F. All data were subject to analysis of variance using SAS (SAS 1997). A Fisher protected LSD test procedure was used for mean separations at P<0.05.

RESULTS AND DISCUSSION

Growing conditions

Climatic conditions at the study area favored rapid forage growth in spring and early summer, but the late summer dry period reduced growth substantially. The use of nitrogen invigorated the forages and they competed and grew well suppressing weeds. Harlan, Oregon has good cool weather that favors growth of cool season forages even during summer with average high temperatures of 65 °F.

Forage yields

Cumulative forage yields generally decreased as you moved deep into the woodlot from the South. As expected, forage yield from the control (4.15 tons/acre) was significantly higher than all other treatments (Table 1). Differences in cumulative yield were not significant for the forages growing under 55-year old trees. However, for the 25-year old trees, treatments at the south end of the woodlot had significantly higher forage yields than those towards the north end but not with those at the center (Table 1). These observations may be related to how plants invest nitrogen in the different components of the photosynthetic apparatus. The investment of nutrients follows the pathway where plants will modify their biomass allocation to aboveground structures if carbon gain is negatively affected by low light levels. Biomass allocation to aboveground structures is attained by increase in specific leaf area which in turn increases light interception by orienting blades horizontally (Fernandez et al. 2004). Since forages in the SS treatments had more light, they allocated more to biomass buildup than those beyond the center of the woodlot.

Table 1. Average dry matter forage yield for perennial ryegrass and orchardgrass mix fertilized with 75 lb N/acre under a thinned Douglas-fir forest in Harlan, Oregon.

	Silvopastoral System	
Treatments	**Under 25-yr Old Trees**	**Under 55-yr Old Trees**
	--------------------------- *tons/acre)*-------------------------	
South-side Plots (SS)	2.53b†	1.49bc
Center Plots (CC)	2.12bc	1.27bc
North-side Plots (NN)	1.76cd	1.04c
Control	4.15a	4.15a
LSD	**0.59**	**0.59**

†Within columns, means followed by the same letter are not significantly different at P = 0.05 by Fisher's protected LSD.

Silvopasture studies in the Midwest USA have shown cumulative forage production to be about 20% more in open fields compared to where pasture is grown under trees although forage quality was found to be greater in the silvopasture system compared to the open field system (Kallenbach et al. 2006). The increased forage quality under shade can partially offset reduced forage productivity under the trees. In our study, forage yield was reduced by 39%, 49% and 58% under the 25-year trees and 64%, 69%, and 75% under the 55-year old trees for the SS, CC, and NN locations respectively, compared to forage growth without trees. Cool season grasses such as orchardgrass and perennial rye have been shown to tolerate shade of up to 80% (Lin eta la. 1999).

Average stocking rate for beef cattle in western Oregon is one cow/calf to two acres of pasture. This means that during spring, summer, and part of earlier fall, woodlot owners can utilize thinned forests for forage production to raise more livestock or sale hay. Based on cumulative average forage production without trees of 4.15 tons/acre and 2.14 tons/acre under the 25-year trees and 1.27 tons/acre under the 55-year old trees, in this time period, beef producers can set aside 4 and 6.5 acres per cow/calf unit under the 25- and 55-year silvopastoral systems respectively. Kallenbach (2006) shows that beef animals raised under silvopastoral systems had equal average daily gain (ADG) and gain/acre as animals grazed on open field system with gain/acre being influenced by both cumulative forage production and forage. Kephart and Buxton (1993) reported that perennial cool season grasses grown under shade produced more CP and less NDF than same grasses under full sunlight. Therefore, at this stocking rate we do not expect widespread feed supplementation for animals being raised under this silvopastoral system.

CONCLUSION

1. Cumulative forage production for a perennial rye - orchardgrass mix grown under 25- and 55-year old Douglas-fir trees and fertilized with 75 lb N/acre was reduced by an average of 48%, and 69% respectively, compared to similar pastures without shade. Forage production under shade was influenced by exposure to the South and age of the trees.

2. Woodland owners could potentially derive substantial future income from their forests if they adopted well managed silvopastoral systems after commercially thinning their Douglas-fir forests. Animal stocking rate could go as high as 4 and 6.5 acres per cow/calf unit under the 25- and 55-year silvopastoral systems respectively. Success of individual systems will ultimately depend on location, management, and aspect of the property in relation to the southern sun.

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