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Summary

Integrated timber and livestock systems (silvopastoral) are common in several regions of the United States. Grazing of three timber stands in eastern Nebraska showed no signs of tree damage due to rubbing or soil compaction. Steer gains were lower under the silvopastoral system compared to a typical pasture system (1.05 lb/day versus 1.70 lb/day). Growth of timber in silvopastoral stands was reduced (35.0 cubic feet per year versus 37.8 cubic feet per year); however, total productivity of the silvopastoral system (timber plus livestock) was greater ($20.98/acre) than with traditional timber systems.

Introduction

Silvopastoral systems are defined as the intentional integration of timber and livestock production. They are common in the pine forests of the southeastern United States, the conifer forests of the Pacific northwestern United States and are used in a number of situations in the Pine Ridge area of northwestern Nebraska. Several benefits are associated with the practice, foremost of which is the cash flow advantage of annual sale of cattle while the timber crop develops. In addition, there are direct benefits to tree growth due to the reduction in competition between the trees and understory vegetation for soil nutrients, water, and sunlight. Grazing is also a cost-effective method of control of the understory vegetation without the use of herbicides. From the forage perspective, shade and lower air temperatures tend to produce a higher quality forage. Cattle have the advantage of shade, reducing animal stress due to high temperatures. There are, however, several potential disadvantages of silvopastoral systems. Foremost is the concern of soil compaction and root damage due to grazing when the soils are wet. Cattle can damage trees by rubbing them, reducing the potential timber value, especially on fine hardwoods such as black walnut. If a forest system is overgrazed, forest reproduction may be damaged leading to a loss in forest diversity over the long term. However, with good management, cattle and timber production can be a profitable enterprise providing both short-term cash flow from livestock production and long-term capital gains from timber sales.

The purpose of this study was to demonstrate the interaction of cattle and trees in silvopastoral systems located in eastern Nebraska. Established initially as a demonstration site, our goal was to assess damage to two tree plantations — a scotch pine stand (*Pinus sylvestris L.*) and a green ash stand (*Fraxinus pennsylvanica Marsh.*) — by grazing livestock. As the study progressed, little damage was seen in either plantation. In 1999 the decision was made to conduct a preliminary study on a ponderosa pine (*Pinus ponderosa P. & C. Lawson*) stand to determine the effect of grazing on tree performance. The study objectives were redefined and data on tree growth and cattle performance were obtained and analyzed to determine the impact of grazing on tree and livestock performance. Only tree performance data from the ponderosa pine plantation are reported here. Cattle performance was based on the entire silvopastoral grazing period.

Procedure

Site Description

The study was conducted at the University of Nebraska Agricultural Research and Development Center (ARDC) Forestry Unit at Mead, Nebraska. The soil is a Sharpsburg silty clay loam with a 1% to 2% slope. The site is approximately nine acres and was planted to ponderosa pine (*Pinus ponderosa P. & C. Lawson*) in 1986 as part of a regional provenance test. The trees (one-year-old container grown seedlings) were planted in six replications on a 12-by-12-foot spacing in plots of 400 plants per replication (approximately 1.5 acres per replication). The site was sown to tall fescue in 1988. Since then, smooth brome grass has invaded the site and dominates most areas within the plantation. Replications 1 to 4 were thinned in the winter of 1997-98 following 10-year data

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collection for tree performance. Limited labor at the time restricted the ability to thin the remaining two replications, which were thinned in January 2001. The trees removed were selected based on tree performance and insect and disease resistance. The resulting stand is a savannah dominated by ponderosa pine and a mix of cool season grasses. Beginning in late April 2001, plots 1 to 4 were grazed by 6 head of steers for 52, 32, and 42 days in 2001, 2002, and 2003 respectively (Table 1). Cattle continued to be grazed on other silvopastoral sites, when not on ponderosa pine, from late April until early September of each year. Plots 5 and 6 were left ungrazed as a control.

Data Collection

Height and diameter at breast height (DBH; 4.5 feet above the ground) of the trees in all plots were measured following grazing in 2001, 2002 and 2003. If multiple stems occurred below 4.5 ft, the diameters of all stems were measured.

Silvopastoral grazing (SPG) steers were managed in the same system as control cattle in every year of this study. The only differences would be access to the SPG location during corn residue grazing and summer grazing. Control steers were a contemporary group utilized for grazing systems research in 2001 (*2003 Nebraska Beef Report,* pp. 65-68), 2002 and 2003 (*2005 Nebraska Beef Report,* pp. 68-72). Control steers grazed smooth brome grass from late April until mid May and warm season native range from mid May until September. Briefly, steers on the SPG study were received in November, weaned and placed on corn residue and allowed access to the SPG location from December until late February each year. Following corn residue grazing steers were placed in a drylot until SPG grazing was available. Following grazing, steers were placed in the feedlot and finished.

Table 1. Total grazing days for cattle on silvopastoral systems and the ponderosa pine silvopastoral plot.

Item	2001	2002	2003
Ponderosa pine (days)	52	34	42
Silvopastoral sites (days)	97	112	138

Table 2. Revenue generated with silvopastoral systems compared to trees alone.

	2001[a]		2002[a]		2003[a]	
	Gr[b]	UnGr[c]	Gr[b]	UnGr[c]	Gr[b]	UnGr[c]
Stem Vol. (ft^3/acre)[d]	152.0	201.3	186.1	235.4	222.0	276.9
Vol./year (ft^3/acre)[e]			34.1	34.1	35.9	41.5
Pulpwood ($/acre)[f]	23.16	30.67	28.35	35.86	33.82	42.18
Rev. Incr.($/acre/year)[g]			5.19	5.19	5.47	6.32
Cattle rev. ($/acre)	25.71		23.00		19.81	
Gr. Rev. Incr ($/acre)[h]	—		23.00		18.96	

[a]Tree measurements following grazing expressed as total amount.
[b]Gr (grazed) = Mean number of 66 Ponderosa pines per acre in the grazed plot
[c]UnGr (ungrazed) = Mean number of 98 Ponderosa pines per acre in the ungrazed plots
[d]Stem Vol. (volume) = stem only volumes calculated based on basal area and stem height
[e]Vol. (volume)/year = increase in tree volume from previous year.
[f]Pulpwood prices are the value of pulpwood per acre per year assuming a one time complete harvest, based upon volume per acre and pine pulpwood ($19.50/128 cubic feet) prices from the 2004 central timber market.
[g]Revenue increase per year from tree growth calculated as ((Vol./year/128 cubic feet) x $19.50).
[h]Gr. Rev. Incr. (Gross revenue increase) = revenue increase per year over timber alone; value based on differences in growth each year.

Table 3. Ponderosa pine stand characteristics[a].

Item	Gr[b]	SE	UnGr[c]	SE
			2001	
Trunk diameter (in)	7.2	0.8	6.8	0.9
Tree height (ft)	21.5	2.2	23.6	2.2
Basal Area (ft^2/acre)	20.9	5.0	25.8	7.1
Stem Vol. (ft^3/acre)[d]	152.0	29.9	201.3	41.6
			2002	
Trunk diameter (in)	7.7	0.9	7.1	1.0
Tree height (ft)	22.9	2.1	24.9	2.4
Basal Area (ft^2/acre)	24.1	6.1	28.6	7.7
Stem Vol. (ft^3/acre)[d]	186.1	41.1	235.4	56.6
			2003	
Trunk diameter (in)	8.17	1.0	7.6	1.1
Tree height (ft)	24.2	2.6	25.9	2.4
Basal Area (ft^2/acre)	27.2	6.8	32.3	9.0
Stem Vol. (ft^3/acre)[d]	222.0	46.4	276.9	61.2

[a]Tree measurements following grazing expressed as total amount.
[b]Gr (grazed), Mean number of 66 Ponderosa pines per acre in the grazed plot
[c]UnGr (ungrazed), Mean number of 98 Ponderosa pines per acre in the ungrazed plots
[d]Stem Vol. (volume) stem only volumes calculated based on basal area and stem height (Tree Volume = (Tree Basal Area × Tree Height ÷ 3)

Data Analysis

Data were analyzed to determine mean DBH, mean tree height, and basal area for each tree and for each replication. (Note: Basal area is the cross-sectional area of a tree at 4.5 ft. and is a common forestry measure of stand density.) In addition, stem volume per acre, stem volume increase per acre per year and

Table 4. Steer performance of silvopastoral and control cattle.

	2001		2002		2003	
	Silvopastoral	Control	Silvopastoral	Control	Silvopastoral	Control
Winter						
Days	154	154	141	141	135	135
Initial wt, lb	526	527	567	565	512	514
Daily gain, lb	1.61	1.41	1.74	1.50	1.79	1.83
Summer						
Days[a]	145	145	116	116	139	139
Initial wt, lb	774	740	813	777	762	761
Daily gain,lb	0.85	1.68	1.30	1.93	1.01	1.50
Finishing						
Days	86	86	92	92	82	82
Initial wt, lb	898	973	964	1002	903	970
Daily gain, lb	5.22	4.5	4.81	4.24	4.74	4.30
Final wt, lb	1351	1360	1418	1381	1292	1360
Economic analysis						
Break Even, $/cwt		64.11		64.97		63.26
Grazing value[b], $/hd	47.53		78.88		65.33	
P. Pine value[c], $/acre	25.71		23.00		19.81	

[a]Days grazed on the silvopastoral grazing location may be different due to steer management.
[b]Grazing value of the silvopastoral grazing location ((Silvopastoral final wt x Breakeven for control steers) - all cost, associated with silvopastoral system (not including grazing) = Grazing value for the silvopastoral area).
[c]P. Pine (Ponderosa Pine) value is the grazing value divided by total day on the ponderosa pine area.

approximate pulpwood value were calculated. The stem volume gains were compared within years and among treatments using 2001 tree measurements for each treatment as the starting value for comparisons. Additional revenue generated with the SPG steers was determined by evaluating the difference in economic value compared to the control cattle each year, using breakeven calculations as described in the *2001 Nebraska Beef Report*, pp. 29-34. Briefly, SPG final slaughter weights were multiplied by control cattle breakeven. This resulted in a steer value for SPG steers. Following this calculation, all costs associated with the SPG system except those associated with grazing were subtracted from steer value. The amount remaining after costs was then divided by total SPG days. This allocated a dollar value to the SPG area on a per steer basis.

Results

The analysis of tree response showed only small differences in stem volume increase between grazed and ungrazed plots (Table 2). While it is difficult to generalize these data to the long-term case, as most tree growth response studies typically run for a minimum of 10 years and usually 20 to 50 years, some observations are appropriate.

The initial differences (2001) in tree dimensions between grazed and ungrazed plots is likely not related to grazing. The differences in total tree growth (DBH, height and basal area) between grazed and ungrazed plots (Table 3) may be due to differences in thinning dates of ponderosa pine and may reflect a delayed response to drought conditions during the study period. However, the changes in stem volume in 2002 and 2003 are a valid evaluation of the impact on tree growth of cattle grazing in silvopastoral systems. The changes in stem volume per acre per year would suggest that grazing cattle in ponderosa pine has limited impact on total tree growth.

While there appears to be little difference in tree growth among the grazed and ungrazed plots, the effects upon the cattle were greater. Daily gains were lower during the summer grazing period when compared to control steers. The lower daily gains with the SPG system may be partially due to SPG pasture being dominantly cool season grasses. Cool season grass quality would decline during the warm summer months. The increased competition by the trees and grass for moisture during the summer months also may depress forage quantity and (or) quality. Control steers grazed warm season native range from late May until September. The improved forage quality during warm summer months with warm season grass may be responsible for the improved gain by control steers; however, the SPG steer gains were higher during the winter and feedlot periods when compared to control steers (Table 4). The SPG area may provide added protection that may benefit steer performance during the corn residue grazing portion of winter. Additionally, feedlot daily gains have been consistently higher following SPG. This increased gain may be compensation for the reduced summer gains. Breakeven averaged $64.11/cwt, giving grazing values of about $47 to $79 in the total silvopastoral grazing area. The value of the ponderosa pine area ranged from $20 to $26/acre.

The lower daily gains during summer grazing are offset by timber

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growth on the SPG area. When comparing SPG to grazing unfertilized smooth brome pastures, there is a 50% reduction in stocking rate. This reduction recognizes that unfertilized smooth brome pasture would supply 80 days grazing per steer per acre and that SPG supplies 43 days grazing per steer per acre on average. Fluctuating the stocking density utilized under SPG systems may be necessary depending on the stage of tree development. It may be beneficial to alter stocking rates as the tree stand density changes. As trees mature, the stocking rates may need to be reduced as tree canopy density increases, shading out the grass. However, as stands are thinned, grass production increases and stalking rate may be increased accordingly. Conducting grazing as it was in this study would not be recommended on trees less than five years old. Rapid grass removal may be conducted on tree stands as young as three years of age with minimal tree damage; however, tree species should be carefully evaluated prior to grazing.

Based on the average yearly volume increase of 37.8 cubic feet per acre with the ungrazed location and a value of $19.50 per cord of pulp wood (a cord is 128 cubic feet), we could expect an increase in gross return of $5.75 per acre per year (average increase in gross return over two years). However, combining the annual income from tree growth in the grazed areas and the additional return from livestock, the silvopastoral grazing system would provide $20.98 per acre per year additional income over timber stands alone (Table 3).

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