Agroforestry Systems 10, 187–197, 1990.

An analysis of a silvopastoral system for the marginal land in the Southeast United States

C.W. DANGERFIELD Jr.[1] and R.L. HARWELL[2]

[1]*Extension Agricultural Economics, Coliseum, The University of Georgia, Athens, GA 30602, USA*

[2]*Agricultural Economics and Rural Sociology, Barre Hall, Clemson University, Clemson, SC 29634-0355, USA*

Key words: Agroforestry, southeast, pines, cattle, NPV, multiple use, sensitivity, inputs

Abstract. Almost 20 million acres of non-forest cropland in the South can be classified as marginal. Demand projections for forest products call for a 40 percent increase by year 2030. Recent regenerated tree acres lag behind harvested acres. Multiple land use practices combining trees and grazing adjusts cash flows forward mitigating negative flow period associated with conventional forest production. Profit opportunities for private, non-industrial landowners can be increased by ranking inputs in order of changes to net present value (NPV). A sensitivity analysis of an agroforestry scenario, including trees, beef cattle, and pasture, allows producers to concentrate management efforts where returns are greatest. Model results show greatest returns to NPV was realized from improvement to Chip-N-Saw income. The least increase in NPV came when the cost of control burns was changed.

1. Objective

Societal goals for agricultural land include conserving soil and water, controlling environmental pollution, and using both depletable and renewable resources wisely. Though not inconsistent with producer goals, financial stability is also necessary if a productive agriculture is to be sustained. When producers can be shown that an agricultural enterprise 1) is profitable, 2) produces a positive cash flow, and 3) shows efficiency and consistency, then implementation is likely to follow.

The purpose of this paper is to determine the economic efficiency relationship between measures of enterprize profitability and varying levels of inputs. This will be accomplished by using input sensitivity analysis to examine the effect on profitability measures of an agroforestry enterprise, a multiple use agricultural cropping activity that is compatible with concerns of society for resource management. Input sensitivity analysis provides information necessary to assure that the agroforestry enterprise can be made compatible with financial goals of producers.

The setting is the Southeast United States and the agroforestry enterprises are loblolly pine, bahia grass, and coastal bermuda grass. Anyone wishing to replicate the results of this study for their use would use a livestock budget, with complementary forage production, that is relevant for their area. This principle also holds for using forest species applicable to other study areas. In this context this study provides a methodology that can be applied to many areas with a complete example showing the application for a specific area.

2. History

Research literature and limited practical experience suggest that under good management resources exist to improve producer profits, cash flows, and production efficiencies through agroforestry [16, 17]. Bond and Campbell [3] developed budget information necessary for multiple land use operations in Louisiana slash pine forests in 1951.

Pearson and Whitaker [15] explored returns from various grazing rates in longleaf pine in 1972 and found them all to be positive under good management. More recently, Haney [7] has used extensive modeling to show the economic attractiveness of integrated land management on returns to investment in timber and forage/beef production in the Coastal Plain of Virginia.

Lundgren et al. [13], and Fedkiw [6] have explored the economics of various timber/grazing management practices and have examined the profitability of rotational grazing schemes. Earlier work by the authors examined the profitability and cash flow of various agroforestry scenarios compared to monoculture pine for southern Georgia [8].

3. National importance

Recent emphasis for agricultural enterprises is that they fall into a category termed 'low input sustainable agriculture' (LISA). Agricultural producers are being encouraged to implement LISA production practices through legislation such as the Conservation Reserve Program (CRP) and the Sodbuster and Swampbuster provisions in the 1985 Farm Bill.

3.1 Marginal land

In the South, a significant proportion of row crop production comes from lands identified as being 'marginal' [19]. Marginal land can be identified in

terms of profit potential or, in a conservation sense, in terms of erosion potential. Currently, over two-thirds of total land in the South is in forestry uses [21].

According to a recent USDA study, 8 million acres of cropland and pasture in the Upper Coastal Plain and Piedmont Regions yield lower returns from their present use than they would in timber production [22]. The Soil Conservation Service lists 11 million acres of non-forest marginal lands in the South as having serious, excessive erosion, with additional lands having erosion protection only because they are in pasture, idle, or in uses other than row crops.

3.2 Producer implementation

Farmers will acquire incentive to implement LISA practices if they can be shown to be profitable. For an agroforestry enterprise this means a favorable net present value (NPV) at some prescribed discount rate [1].

Simply put, NPV is the value of the investment after the effects of interest and inflation have been taken out. The cash flows (costs and incomes) that occur through time are recalculated and expressed in today's dollars. The NPV method allows comparisons to be made between different investment alternatives over dissimilar time periods [1].

The 8% discount rate was selected to equal the desired return that was expected to be earned on the agroforestry investment. It is assumed here that 8% is the long run cost of using operator owned capital [19].

Under the assumption of an 8% discount rate, an NPV value of $0.00 marks the point at which earnings yield exactly 8%. The higher the NPV, the more profitable the example. The discount rate is not known with certainty over time. It is helpful to know what happens to the NPV as the discount rate changes.

Farmers will be further encouraged if the cash flow is favorable. For an agroforestry investment, this means smoothing the lumpy income stream, particularly removing the negative cash flows so typical of the early years of a timber investment.

An owner of marginal cropland will look on an agroforestry investment more favorably if the outcome is consistent and the resource use more efficient. This can be shown by: 1) establishing the relationship between NPV and variations in the discount rate; 2) ranking the contribution each input makes to NPV; and, 3) measuring the dollar change in NPV with dollar changes in input values.

Other factors related to operator utility (satisfaction) of the agroforestry enterprise, and societal goals of conservation, pollution, and resource use

are often measured subjectively at the firm level and are beyond the scope of this paper.

4. Methodology

In previous work by the authors cited above, it was shown that an agroforestry beef-forage/pine timber operation increased profitability and improved cash flows over monoculture pine [8]. In the earlier study, YIELDPLUS (V1.1c), a computerized tree growth simulator developed by the Tennessee Valley Authority [9], was used to model the agroforestry enterprise. The current study uses CASH (V 3.5), a computerized cash flow and sensitivity analysis program developed at the University of Minnesota [2], to conduct an analysis of the earlier results.

4.1 YIELDPLUS

Since the earlier study yielded input for the present investigation, a brief review of the methods used is appropriate. YIELDPLUS is designed to predict growth and yield for stands of timber described by an array of production specifications. As a secondary feature, the model analyzes the financial consequences of a timber investment scenario based on the specification of costs and returns data, including income tax considerations. The model is useful in refining a management plan and has obvious applications in timber investment analysis across time.

Cattle grazing was introduced into the model (from beef cattle budgets [4]) with modifications to tree spacing as follows. A 4′ × 8′ × 40′ spacing (454 trees/acre, same as the forestry enterprise) allowed bahia or bermudagrass to be planted and maintained in the stand according to recommended practices [4, 5, 10, 11, 12, 19]. Trees were spaced 4′ apart in the row with two rows 8′ apart and then a 40′ wide forage growth strip. Hay crops were produced for the first two years following tree planting to reduce cattle damage to trees. Annual fertilization of pasture grasses has been shown to enhance tree growth [10, 11, 18]. This increased growth effect was approximated by raising the site index from 60 to 65 feet at 25 years, increasing total wood yield about 8.8% [9].

4.2 CASH

YIELDPLUS results [8] served as the basis for the sensitivity study utilizing the CASH model [2]. CASH can be used to enhance an in-depth investment

evaluation by computing the sensitivity of various measures of enterprise performance to changes in expenditures, prices, discount rates, and other selected inputs.

NPV is examined at various discount rates. The discount rate can be viewed as the opportunity cost of using money. This means that the discount rate represents the next best use of money invested in the agroforestry enterprise. This allows assessment of the effects of the chosen discount rate on NPV. In cases where investment money must be borrowed, CASH results also include nominal discount rates.

Sensitivity of NPV and equal annual income (EAI) to changes in selected cost and revenue activities were calculated. EAI expresses enterprise income on an annual annuity basis. This indicates the relative impact of a change in the cash flow associated with each activity. The larger the amount indicated, the greater the impact resulting from a given percentage change for a given input item.

5. Results

5.1 Profitability

Table 1 contrasts projected yields of pulpwood and sawtimber for a regular forestry enterprise with the agroforestry enterprise. The agroforestry operation yields approximately 9 percent more total wood flow than the regular forestry practice. This wood flow difference is due primarily to the effect of fertilizer applied to forage grasses in the agroforestry enterprise.

Measures of profitability for the forestry and agroforestry enterprise combinations involving timber and grazing income are given in Table 2. Both before and after-tax values for all operations are profitable. The agroforestry per acre NPV of anticipated returns is $498.02 before taxes and $1,139.28 after taxes. The NPV of agroforestry is 71% higher than for the regular forestry enterprise.

Table 1. Per acre woodflow summary report for scenarios of Southeastern U.S. flatwoods, coastal plains, loblolly pine thinned at age 15 and clear-cut at 25 yrs

	Trees Per Acre	Site[a] Index	MBF[b] Sawtimber	Cords Pulpwood	Total cords Woodflow
Forestry	650	60	2.95	37.51	49.10
Agroforestry[c]	454	65	6.73	28.44	53.43

[a] Average height of dominant and co-dominant trees at 25 yrs.
[b] Thousand board feet, Scribner rule.
[c] Enterprise includes beef cattle and forage.

Table 2. Financial profitability analysis, per acre for scenarios of Southeastern U.S. flatwoods, coastal plains, loblolly pine thinned at age 15 and clear-cut at 25 yrs

	Net Cash Flows	Before Tax NPV[a]	After Tax NPV	Before Tax IRR[b]	After Tax IRR
		$		%	
Forestry	1154.38	553.59	719.32	16.4	16.4
Agroforestry[c]	1968.77	948.02	1139.28	23.1	22.8

[a] Net present value.
[b] Internal rate of return.
[c] Enterprise includes beef cattle and forage.

The increased profitability is mainly because of extra income provided by the forage/beef cattle activity. Improved IRR values are also evident in Table 2, reflecting the beneficial effects of generating positive cash flows early in the investment period.

After-tax NPV returns are larger than before-tax values because of tax programs effects on forestry. These provisions include the ten percent investment tax credit on reforestation expenses and complete amortization of allowable expenses over an eight year period. Also, because interest expenses are deductible with forestry investments, the after-tax discount rate is correspondingly lower than the before-tax rate (in this case, 8.0 and 5.8 percent, respectively).

5.2 Cash flow

Results presented in Table 3 compare the typical cash flow patterns of a conventional forestry and agroforestry enterprise. The heavy negative flows in the initial stages of the straight forestry case is improved through the introduction of beef and forage in the agroforestry enterprise. During the early years of the agroforestry enterprise, tree growth interference with forage production is minimal. Therefore, accumulated net income from the combined agroforestry enterprise is higher (less negative) during the early years and much higher than forestry by end of rotation.

It should also be noted that total investment is higher with the agroforestry investment than for the forestry enterprise. This is because fences, waterpoints, and particularly cattle must be provided for the agroforestry enterprise as demonstrated in Table 2.

5.3 Resource efficiency and dependability

As the discount rates varies, NPV varies also. Table 4 illustrates this relationship. As an example, if the producer felt that the discount rate may

Table 3. Before tax cash flow by year for a forestry enterprise and an agroforestry enterprise with loblolly pine, beef cattle, and pasture, uninflated dollars, per acre, southeast U.S., 1989

Year	Forestry		Agroforestry	
	Net	Accumulated	Net	Accumulated
1988	−85.00	−85.00	−71.27	−71.27
1989	−5.00	−90.00	6.73	−64.54
1990	−5.00	−95.00	8.06	−56.48
1991	−5.00	−100.00	8.06	−48.42
1992	−5.00	−105.00	8.06	−40.36
1993	−5.00	−110.00	8.06	−32.30
1994	−5.00	−115.00	8.06	−24.24
1995	−5.00	−120.00	8.06	−16.18
1996	−5.00	−125.00	8.06	−8.12
1997	−5.00	−130.00	8.06	−.06
1998	−10.00	−140.00	8.06	8.00
1999	−5.00	−145.00	8.06	16.06
2000	−5.00	−150.00	8.06	24.12
2001	−5.00	−155.00	8.06	32.18
2002	−10.00	−165.00	3.06	35.24
2003	236.18	71.18	301.50	336.47
2004	−5.00	66.18	8.06	344.80
2005	−5.00	61.18	3.06	347.86
2006	−10.00	51.18	8.06	355.92
2007	−5.00	46.18	8.06	363.98
2008	−5.00	41.18	3.06	367.04
2009	−5.00	36.18	8.06	375.10
2010	−10.00	26.18	8.06	383.16
2011	−5.00	21.18	3.06	386.22
2012	−5.00	16.17	8.06	394.28
2013	1211.61	1227.80	1653.26	2047.53

possibly vary from the level used, the resulting effect on NPV can be estimated. From Table 4, if the real discount rate varied from six percent to eight percent, NPV would decrease by $274.59 per acre ($761.51–$492.92). This allows comparison with changes in NPV that would be expected in other enterprises with the equivalent changes in the discount rate.

Table 5 shows the impact upon NPV and EAI of a 10 percent change in certain cost and revenue budget items. Both measures are based on the same set of numbers but shed light on different aspects of the evaluation. NPV is most useful when estimating the market value of an investment based on an anticipated stream of net revenues. EAI is helpful in relating the anticipated value of the income stream, however uneven, to some equal annual return.

Table 4. Profile of Net Present Value (NPV) for an agroforestry enterprise at various discount rates, dollars per acre, southeast U.S. 1989

Real Rate	Nominal Rate	NPV
0.00	3.00	$2961.74
2.00	5.06	$1874.65
4.00	7.12	$1196.30
6.00	9.18	$ 767.51
8.00	11.24	$ 492.92
10.00	13.30	$ 314.76
12.00	15.36	$ 197.61
14.00	17.42	$ 119.52
16.00	19.48	$ 66.76
18.00	21.54	$ 30.59
20.00	23.60	$ 5.45
22.00	25.66	$−12.28
24.00	27.72	$−24.97
26.00	29.78	$−34.18
28.00	31.84	$−40.97
30.00	33.90	$−46.05

The information in Table 5 is based on the underlying assumption that, as each cash flow item is changed, the other items, and total output, are held constant. The greatest impact on NPV (and EAI) would result from changes in chip-n-saw (C-N-S) revenue during the final tree harvest in year 25. Beef

Table 5. Sensitivity of net present value (NPV) and equal annual income (EAI) for an agroforestry enterprise to a 10 percent change in input values, per acre southeast U.S., 1989

Item changed	NPV Change	EAI Change
Cost item		
Management	$ 4.50	$0.32
Planting	$ 5.00	$0.36
Weed Control	$ 2.50	$0.18
Land Taxes	$ 7.50	$0.54
Pasture & Hay	$15.19	$1.09
Control Burn	$ 0.84	$0.06
Harvest #1	$ 2.22	$0.16
Harvest #2	$ 7.36	$0.53
Revenue item		
Hay Income	$ 4.81	$0.34
Beef Income	$25.06	$1.79
Pulpwood #1	$15.76	$1.13
C-N-S #1	$ 6.40	$0.46
Pulpwood #2	$17.06	$1.22
C-N-S #2	$58.74	$4.20
Saw Timber #2	$16.19	$1.16

Table 6. Sensitivity of net present value (NPV) and equal annual income (EAI) for an agroforestry enterprise to a $1.00 change in input values, per acre southeast U.S., 1989

Item changed	NPV change	EAI change
Cost item		
Management	$15.00	$1.07
Planting	$ 1.00	$0.07
Weed Control	$ 1.00	$0.07
Land Taxes	$15.00	$1.08
Pasture & Hay	$11.42	$0.82
Control Burn	$ 1.68	$0.10
Harvest #1	$ 0.68	$0.05
Harvest #2	$ 0.52	$0.04
Revenue item		
Hay Income	$ 1.92	$0.14
Beef Income	$ 9.53	$0.68
Pulpwood #1	$ 0.68	$0.05
C-N-S #1/1	$ 0.68	$0.05
Pulpwood #2	$ 0.52	$0.04
C-N-S #2	$ 0.52	$0.04
Saw Timber #2	$ 0.52	$0.04

cattle income make the second greatest impact. As an example, Table 5 shows that for every 10 percent improvement in C-N-S revenues, per acre NPV would improve by $58.74 and per acre EAI would increase by $4.20. The producer would be encouraged to concentrate on size diameter classes for C-N-S products. An aggressive timber marketing program should be designed to enhance C-N-S sales. The table also helps a producer recognize that extra effort put into beef production is likely to have positive effects on profits. Improved forage management, through controlled grazing, would raise beef enterprise profitability [14]. Forward pricing of beef cattle sales also would raise revenues of the beef/forage enterprise [4].

In contrast, certain items in the budget are shown to have minimal effects upon NPV and EAI. A 10 percent change in controlled burn expenses changes NPV only $0.84 and EAI $0.06 per acre. Changing the exact cost of this item could probably be moved down on the producer's attention list.

In addition to relative impacts on the investment performance measures, specific impact estimates can be calculated from the results shown in Table 6. For example, if pasture and hay expenses were changed by $1, per acre NPV changes by $11.42 and per acre EAI changes by $0.82. This perspective may be useful for the producer, with limited capital, who wants to know where to get the biggest efficiency improvement in enterprise profitability for each additional cost dollar spent or revenue dollar taken in.

Table 6 illustrates that a $1 change in taxes or management creates the

greatest change in NPV and EAI. Taxes may be an area outside the control of a producer, but a change in taxes would be very important to a change in enterprise profitability. Also, management expenses strongly influence profit measures. If a timber producer is going to invest in forest management assistance, quality of that help is shown to be of utmost importance.

Pasture and hay costs, and beef cattle income also show large impacts for each additional dollar involved. This is because these items recur annually throughout the life of the enterprise. Items such as planting and weed control happen only once, rendering a much smaller impact upon NPV and EAI.

6. Conclusion

Agroforestry is gaining increased acceptance among southern timber operators. Research, both biologic and economic, generally supports the enterprise. Results shown in Tables 1 and 2 are strongly positive for profitability. Cash flow is significantly improved, as shown in Table 3.

Sensitivity analysis provides additional understanding to investors in at least two ways. First, since future events are not known with certainty, the impacts of specific outcomes upon investments can be estimated. For instance, it is useful to know how much NPV and EAI will change with a particular change in budget items. Such information is presented in Tables 4 and 5. Second, dollars are often limited for enterprise investment. When this is the case, information such as that contained in Table 6 can show where those input costs should go. Implicitly, those areas are identified where management efforts should be concentrated.

Finally, the long run goals society holds for land use, strongly incorporated in the sustainable agriculture concept, can more assuredly be realized when the producer is confident of profitability, cash flow, and efficiency.

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