THE IMPACT OF FOREST LAND USE ON REGIONAL VALUE ADDED

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Abstract–Rural development policies frequently target the enhancement of regional value-added activities. The effectiveness of such policies is typically analyzed in aggregate terms. Aggregate measures include total number of jobs created or total value-added impact. Regional economic development, however, is more complex and includes components such as income distribution, wage/skill levels of jobs created, and impacts on factor ownership. Evidence from other studies suggests that the Southern United States will experience significant increases in timber production intensity during the next 50 years. The connection between raw material production and processing has important effects on the creation and distribution of value added. In this paper, the impact of sustainable timber production on income distribution in a highly timber-dependent region was analyzed, using a social accounting matrix with mixed exogenous/endogenous accounts that specify the forward linkages of raw material production to primary and secondary wood processing.

I. INTRODUCTION

The impacts of natural resources on the economic growth and development of rural regions is related to returns to factor inputs used in regional production. Returns to factor inputs, expressed as value added, include returns to land, labor, and capital resources. The tracking of these returns from production sectors through factor ownership to regional institutions (including households) is an important component of economic development analysis. Furthermore, the impact of increased production from natural resources on labor and capital allows policies to be formulated which reflect and react to the workings of market-oriented regional economies.

During the 1980s rural communities across the United States came under severe economic stress (Deavers 1991; Task Force on Persistent Rural Poverty 1993) and underwent increased divergence from urban incomes (Rowley et al. 1991). Furthermore, communities in forested regions faced the challenge of choosing between economic development strategies with associated incompatible land uses. The traditional means of economic growth was through natural

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resource extraction (mining) and renewable resource management (timber). Environmental interests challenged these land uses (VonGoethem 1987; and Temple 1993). Should productive forests located in these regions be intensively managed for timber production, aesthetic benefits, water quality, wildlife habitat, or a combination of these outputs? The economic implications of these widely varying land uses for regional households is at the root of the controversy. What are the impacts of differential employment opportunities for factor inputs among these land uses?

Empirical evidence suggests that natural resource outputs of forested regions are in a state of change. A major regional shift is underway in the source of U.S. timber supply. This is due primarily to availability of highly productive timber lands in the South and restrictions in timber harvesting from public lands in the West. Haynes and Adams (1992) argue that the southern region of the United States will emerge as the major source of domestic timber supply during the next century. Alig and Wear (1992) examined the extent of this expansion and concluded that the South will experience large increases in timber production, particularly on privately owned lands. Market prices combined with other public and private long-term investment incentives will provide the motivation for increased timber production on private timberlands in the South.

How will these changes impact regional economic development? What household income groups are the primary gainers from growth in the forest products industry (production and processing)? Do low-income households benefit from intensive timber production? Are significant returns to factors of production, particularly land and capital rents, flowing out of the region? Will changes in resource productivities cause significant inter-regional factor flows? Answers to these questions are prerequisites for rational formation of public policies.

Literature on the economic development of forested regions has included (1) the identification of forward and backward industry linkages (Sartorius and Henle 1968); (2) export-based theory of forest product led regional growth (Connaughton et al. 1985; Schuster and Medema 1989); and (3) analysis of forested regions using input-output methods (Flick and Teeter 1988; and Pedersen, Chappelle and Lothner 1989). Recent literature has tied development of forested regions to questions of income distribution (Rose, Stevens, and Davis 1985; Davis and Johnson, 1987; Coxhead and Warr 1991) and factor market equilibriums (Boyd and Hyde 1989; Daniels, Hyde and Wear 1991).

Regional input-output analysis is a fundamental tool used in sectoral analysis of regional economies (Richardson 1985; Miller and Blair 1985). Extending input-output to social accounting matrix (SAM) analysis is more recent (Pyatt and Round 1985; deMelo 1988; and Pyan 1988). This extension is the result of

general dissatisfaction with sectoral input-output analysis in the estimation of regional economic development criteria (Pyatt and Round, 1985; Keuning and DeRuijter, 1988). SAMs are used to more fully analyze regional economic development (Eckaus et al. 1981; Cohen 1988; Skountzos 1988; and Cole 1989), with particular emphasis on the distribution of income (Adelman and Robinson 1986; Bottiroli Civardi and Targetti Lenti 1988; Havinga et al. 1987; and Esparza 1989).

An important contribution of our analysis is the development of a more complete understanding of how forest land-use for sustainable timber production generates and distributes income within rural forested regions. The analysis presented here contributes to our understanding by tracking income flows while simultaneously accounting for the capital growing stock assets of forests and the underlying dynamics of forest land productivity. This is done through integrating forest inventory data on both timber resources and site productivities with regional economic data. Furthermore, this analysis contributes to our knowledge of the dynamics of rural forested regions by directly addressing the linkage between raw material production and processing with the generation and distribution of value added. Timber production provides raw material to primary and secondary wood processing sectors. Expansion of primary and secondary processing in a region is limited by the availability of timber in the region. Similar input-output methods have been applied to capture linkages of agriculture and farm structure to a regional economy (Johnson and Kulshreshtha, 1982) but have not been applied within a social accounting framework. This analysis is based on sustainable timber production potentials and investment criteria as the stimulus for increased regional value added. As such, it examines one side of the land use picture for the Southern United States: that of increasing the intensity of land use for timber production.

This paper provides (1) an ex-post analysis of income distribution for a timber producing region using a social accounting matrix; and (2) an ex-ante analysis of the increased potential for sustainable timber production for the same region, including the forward linkages of timber production to wood processing. It examines the potential for timber production as the primary land use to the exclusion of other land use alternatives. Additional work into land use alternatives, land use compatibility, and alternative economic development strategies are suggested as potential extensions to the modeling framework and avenues for future research.

II. METHODS

The SAM framework

This paper uses a SAM focused on regional timber production and wood processing, with particular attention given to resource ownership (Table 1). Rows of the SAM track receipts (revenues), and columns track expenditures. In producing output, production sectors use and compensate factor inputs specified as labor, capital, and land. These factors are compensated through forestry and non-forestry enterprises. Furthermore, forestry is disaggregated into timber production and wood processing activities. Timber production enterprises are further disaggregated into industrial private, nonindustrial private and public ownership. Households receive compensation from enterprises and are disaggregated into three income groups: low (less than $15,000 annual household income); medium (between $15,000 and $40,000 annual household income); and high (over $40,000 annual household income). The balanced SAM equates regional receipts with respective regional expenditures.

Transforming the social accounting matrix into a predictive model requires several steps. Cohen (1988) discusses these as (1) subdividing the social accounting matrix into exogenous and endogenous accounts, (2) expressing flows as average propensities of their corresponding column totals, and (3) generating multipliers through matrix inversion.

Analytically, the SAM accounts for predetermined production (or supply) of timber based on sustainability between forest growth and removals. Forward linkage to wood processing is pre-determined by the availability of raw material. Thus, what is important to determine are the interdependencies of the supply-determined sectors with other production sectors, factor resources, enterprises, households, and other institutions. This supply-determined approach is adapted from input-output analysis (Miller and Blair 1985) and applied to the social accounting matrix in such a way that gross outputs for the supply-determined sectors and final demands for the remaining sectors are exogenous.

Technical coefficients from the production accounts through the household accounts of the SAM are calculated in a_{ij} form where a_{ij} is calculated as z_{ij}/X_j and denotes the flow, z_{ij}, (measured in dollars of value) from SAM sector i to SAM sector j, and X_j is the total gross output of SAM sector j.

The SAM is used to distinguish endogenous and exogenous accounts (Pyatt and Round 1985). For a three-sector model with the third sector output predetermined, the following equation captures the supply-determined relationships as follows (see Miller and Blair 1985):

$$\begin{bmatrix} (1-a_{11}) & -a_{12} & 0 \\ -a_{21} & (1-a_{22}) & 0 \\ -a_{31} & -a_{32} & -1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ Y_3 \end{bmatrix} = \begin{bmatrix} Y_1 + a_{13} X_3 \\ Y_2 + a_{23} X_3 \\ -(1-a_{33}) X_3 \end{bmatrix} \quad (1)$$

Equation (1) includes the average expenditure propensities (a_{ij}), final demands (Y_i), and the supply-determined output of the third sector (X_3).

Endogenous accounts that pertain to the SAM constructed for this paper include certain production sectors, factors of production, enterprises, households, and exports of forest products. Exogenous accounts are the pre-specified production sectors, government, capital formation, and exports of the endogenous sectors. Injections to the system include transfers to enterprises and households from government, and the rest-of-world. In addition, injections occur through final demands from government, capital formation, and exports from the endogenous production sectors. Leakages include taxes, savings, and imports.

In the simplified three-sector model, the forecasts of endogenous sector outputs (X_1 and X_2) and exports of the predetermined output sector (Y_3) are derived by taking the inverse of the coefficient matrix of equation (1) and multiplying by the right-hand vector of forecasted final demands of the endogenous sectors and the pre-determined output sector linkages as follows:

$$\begin{bmatrix} X_1 \\ X_2 \\ Y_3 \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} & 0 \\ \alpha_{21} & \alpha_{22} & 0 \\ \beta_1 & \beta_2 & -1 \end{bmatrix} \begin{bmatrix} Y_1 + a_{13} X_3 \\ Y_2 + a_{23} X_3 \\ -(1-a_{33}) X_3 \end{bmatrix} \quad (2)$$

Exogenous shocks imposed on this structure consist of changes in final demands plus the interaction of the sectors with the pre-specified X_3 sectoral output.

III. EMPIRICAL ANALYSIS

A SAM was constructed for McCurtain County, Oklahoma, base year 1985, using the previously described analytical structure. Land use in 1985 for McCurtain County was predominantly forest-based, with 850,000 out of 1.2 million acres (71 percent) classified as forested (USDA, Forest Service 1992). A majority

(600,000 acres) of the forested acreage was owned by industrial private owners; an additional 175,000 acres was owned by nonindustrial private forest owners; and 110,000 acres was public forest. This county, in 1985, had a population of roughly 36,000, with a workforce of 10,500 (USDC, Bureau of Economic Analysis; 1990). Compared to all of Oklahoma, this county was characterized by high unemployment–8.0 percent compared to 6.7 percent–and low per-capita income–$9,089 compared to $13,321 (Oklahoma Department of Commerce 1988).

Specific procedures used in constructing the model (Table 1) are fully described in companion articles (Marcouiller, Schreiner and Lewis 1993 and Marcouiller, Lewis and Schreiner 1996). Data sources used in the construction of the McCurtain County SAM included an IMPLAN (IMpact analysis for PLANning) hybrid input-output model (MIG, 1991), forest inventory data (USDA, Forest Service 1992), 1985 forest product prices (Norris 1985), household income distributions (Rose et al. 1988; USDC 1990), wage rates (USDL 1986), transfer payments (USDC 1990; Peterson 1991; Oklahoma Department of Agriculture 1992; USDA 1987), and factor shares (Koh 1991; Robinson et al. 1991; Marcouiller et al. 1996). The SAM was balanced using a current accounting framework which incorporated rest-of-world linkages.

Several characteristics of this region either justify or provide limitations to the use of a fixed-coefficient model to estimate changes to regional production activity. With respect to the market for final forest products, the region is very small relative to the rest-of-world. Increased commodity production of the regional wood processing industry would be expected to have very little, if any, impact on national market price for final forest products output. This justifies the assumption that demand for increased regional wood processing output would exist and be determined external to the model. Also, with respect to the linkage between regional raw material availability and wood processing expansion, transportation costs of roundwood and surrounding regional timber inventories justify a supply-constraint. With respect to factor markets, land and growing stock are constrained in the short run to their respective fixed quantities, given the length of time required to produce timber. Price change could indeed be significant, thereby leading to the need to model a price effect separately. An empirical question that needs further examination is whether or not the regional price effect would differ from national trends given the exogenous increases applied to the model. Certainly, fixed coefficients in labor markets provide important limitations to the empirical model. Incorporating different assumptions for supply/demand of regional labor resources and the resulting impact on regional wage rates would improve the analysis.

TABLE 1
Social Accounting Matrix for McCurtain County, Oklahoma (In thousands of 1985 dollars)

	Production Sectors						Factor Accounts						
	1.	2.	3.	4.	5.	6.	1a.	1b.	1c.	1d.	1e.	2	3
PRODUCTION SECTORS	(interindustry transactions)												
1. Agricultural Products	12,227	2,240	238	30,965	264	361							
2. Timber Prod. and Serv.	228	547	0	47	7,302	0							
3. Manufacturing	282	998	243	331	897	5,331							
4. Food/fiber process.	3	13	4	2,877	16	199							
5. Wood processing	19	1	1,009	137	31,660	78							
6. Services and gov't.	7,161	692	5,098	3,412	12,630	20,681							
FACTOR ACCOUNTS	(matrix of value added)												
1. Labor (total)													
a. Mgmt/Professional	1,532	539	3,410	3,167	6,612	29,649							
b. Tech/Sales/Admin. Supp.	614	224	2,284	2,855	5,360	35,719							
c. Service	148	54	141	389	524	12,213							
d. Farm/Forest/Fish	5,143	1,878	4	7	627	205							
e. Prod/Crafts/Repair	705	257	8,592	12,078	25,918	17,633							
2. Capital	6,947	2,088	12,399	5,622	16,193	82,156							
3. Land	10,797	3,656											
ENTERPRISES													
a. Forestry Complex							(institutional income distribution)						
1. NIPF							26	10	2	81	11	131	185
2. IPF							433	173	42	1,453	199	1,241	3,578
3. Public							32	13	3	108	15	-18	-13
4. Wood processing							5,804	4,685	458	548	22,652	13,851	
b. Non-Forestry Complex													
1. Agriculture							1,339	536	130	4,495	616	5,642	9,071
2. Non-Agriculture							40,101	34,308	10,127	174	36,214	85,901	
HOUSEHOLDS													
1. Low (<$15,000)													
2. Medium ($15-90)													
3. High (>$90,000)													
GOVERNMENT	(indirect business taxes)						(factor taxes)						
Government Revenue Sources	1,324	432	312	244	1,393	10,774	7,197	7,340	2,708	1,806	5,676	18,216	1,632
CAPITAL													
Savings													
REST-OF-WORLD	(imports)												
	86,957	4,992	28,442	75,395	31,673	31,958							
TOTAL	(total industry outlays)						(factory expenditure)						
	113,487	18,332	62,186	137,486	160,829	277,117	54,730	47,085	13,471	7,864	85,183	134,764	14,453

TABLE 1 (Continued)
Social Accounting Matrix for McCurtain County, Oklahoma (In thousands of 1985 dollars)

	Enterprises						Households			Government	Capital	Rest of World	Total
	a1.	a2.	a3.	a4.	b1.	b2.	1. low	2 .med	3. high				
PRODUCTION SECTORS							(household consumption demand)			(government demand)	(investment demand)	(commodity exports)	(commodity demand)
1. Agricultural Products							870	624	295	419	343	64,842	113,497
2. Timber Prod. and Serv.							80	52	16	0	0	9,857	18,332
3. Manufacturing							117	101	38	8,408	34,714	10,826	62,186
4. Food/fiber process							1921	2,051	1,100	36	558	128,742	137,486
5. Wood processing							99	37	14	123	765	126,921	160,829
6. Services and gov't.							43,057	36,190	14,838	37,799	2,787	92,772	277,117
FACTOR ACCOUNTS													(factor income)
1. Labor (total)													34,730
a. Mgmt/Professional													47,085
b. Tech/Sales/Admin Supp.													13,471
c. Service													7,969
d. Farm/Forest/Fish													65,185
e. Prod/Crafts/Repair													134,798
2. Capital													14,453
3. Land													
TOTAL													
ENTERPRISES										(transfers to institutions)			(institutional income)
a. Forestry Complex													
1. MIPF										35			478
2. IPF										0			7,119
3. Public										0			140
4. Wood processing										0			47,798
b. Non-Forestry Complex													
1. Agriculture										1,574			23,204
2. Non-Agriculture										0			206,825
HOUSEHOLDS	(household income distribution)									(transfers to households)		(unearned income)	(household income)
1. Low (<15,000)	-5	-33	-2	4,494	-284	11,306				37,916		3,149	56,551
2. Medium (15-40)	367	1,343	109	18,348	15,987	61,330				24,238		8,376	130,238
3. High (>40,000)	115	380	47	9,007	6,910	44,822				10,191		22,889	94,561
GOVERNMENT Government Revenue Sources							(household taxes) 3,053	13,230	15,758			(ROW Gov't transfers) 39,263	(government revenue) 151,358
CAPITAL Savings	(institutional depreciation) 0	731	0	12,339	592	45,229	(household savings) 1,508	7,309	7,795				(total savings) 75,702
REST OF WORLD	(institutional ROW transfer) 100	4,488	-15	3,411	0	44,118	(imports to consumption) 6,101	68,442	54,702	(gov't impt dmd) 30,398	(resource flows) 36,338		(total outflows) 327,636
TOTAL	(institutional expenditures) 478	7,119	140	47,798	23,204	206,826	(household expenditures) 56,551	130,238	94,561	(government expenditure) 151,358	(total investment) 75,702	(total inflows) 327,636	

Ex-Ante Timber Output Increases

The significant potential for increased timber production in Southeastern Oklahoma could lead to increased amounts of raw materials available for processing. The ex-ante analysis of this study takes the estimated potential volumes of timber production (Table 2) with proportional increases in processing and applies fixed-price SAM multiplier analysis. The Mid-South forest inventory (USDA, 1992) was used to identify silvicultural treatment opportunities. These treatments were identified as annual volume changes which could earn a four percent or greater rate of return on investment based upon work by Vasievich (1987) in the mid-1980s. Treatments are predominantly conversions of forest lands to even-age loblolly pine plantations. Such intensive timber production sites were identified for each of the three forest land ownerships[2]. The annual potential change in value from applying these silvicultural treatments amounted to roughly $16.3 million using 1985 prices (Table 2).

Forecasted real timber price changes for the period 1985 - 2020 (as identified in USDA 1988 and Lewis and Goodier 1991) were used to calculate real income changes, and the impacts of these changes were an additional component of the SAM multiplier analysis. The factor income change from a real price increase amounts to about $31 million in additional regional income (Table 2). Price in-

TABLE 2
Commodity Output and Price Changes in Timber Production from 1985–2020, McCurtain County, Oklahoma

Ownership	Annual Potential Growth[a] ($1,000)	Current Annual Removals[b] ($1,000)	Annual Potential Value Change[c] ($1,000)	Real Income Change[d] ($1,000)
NIPF	7,711	1,040	6,671	6,945
IPF	23,168	16,633	6,515	20,850
Public	3,417	331	3,086	3,074
Total	34,296	18,004	16,292	30,869

[a]Identified from USDA, Forest Service (1992) and Vasievich (1987) using 1985 prices (Norris, 1985).

[b]Identified from USDA, Forest Service (1992) using 1985 prices (Norris, 1985).

[c]Difference between *Annual Potential Growth* and *Current Annual Removals*.

[d]Difference between gross revenue change (annual potential growth multiplied by 2020 real price change) and annual potential output (calculated using 1985 prices).

creases on standing timber are assumed to be passed through to the processing stage and thus reflected in final processed product price. Price change effects were more heavily weighted toward industrial private landowners as compared to volume change effects. This is because industrial private forest owners had existing and potential growing stock levels more heavily weighted to higher valued products relative to nonindustrial private and public forests. Furthermore, many of the management techniques that capture potential productivity had already been implemented on industrial private forestlands and were accounted for in current timber inventories (volume effect) but are new sources of income from the price effect.

Regional Impact of Output Change

Volume effect. The impact of intensive timber production at constant prices was applied as an exogenous volume effect shock to the SAM. This shock included pre-specified timber production output change and wood processing change. No changes were made in the final demands of other sectors. Thus, impact results are solely from timber production volume change using 1985 prices and the forward linkages to wood processing.

The regional impacts of the potential 1985 - 2020 supply-determined timber and wood processing volume change are shown in Table 3. In the production account, the timber production and wood processing supply-determined sectors show, respectively, an 88.9 percent and 90.5 percent volume change (prices constant) over the 1985 base SAM output. The other endogenous sectors show marginal output changes for food/fiber processing (0.5 percent), agricultural production (1.7 percent), and manufacturing (3.2 percent) but a more substantial change for services (9.3 percent). Effects on other endogenous sectors are expected to be marginal because of the relatively small region and little sector interdependence except for services. The output multiplier of the timber complex (production and processing) for McCurtain County is approximately 1.20.

The factor account changes by $76,682,000, or 23.4 percent over the base 1985 SAM. Labor shows the largest change in the aggregate, at $48,412,000, or 25.7 percent. Capital and land rents change 19.8 percent and 24.4 percent, respectively. The fixed-price nature of the SAM-based multiplier analysis assumes perfectly elastic supplies of factor resources. However, land-intensive timber production is assumed to be supply-determined, with increased output from improved silvicultural technologies. Hence, no additional land is added to the timber production base, but the 24.4 percent increase in factor income to land comes from a proportional increase in timber production value added. The value-added multiplier for the forestry complex is about 1.33.

TABLE 3
Regional Impacts of Potential 1985–2020 Supply-Determined Timber and Wood Processing Volume Change, McCurtain County, Oklahoma (1985 Price Level)

Account	1985 ($1,000)	Regional Change ($1,000)	(percent)
Production			
Supply-Determined Sectors			
Timber Production	18,332	16,292	88.9
Wood Processing	160,829	145,552	90.5
Endogenous Sectors			
Agricultural Products	113,487	2,951	1.7
Food/Fiber Processing	137,487	716	0.5
Manufacturing	62,168	1,997	3.2
Services	277,117	25,881	9.3
Total	769,437	193,389	25.1
Factors			
Labor			
Mgmt./Professional	54,730	10,169	18.6
Technical/Sales Admin.	47,065	8,490	18.0
Services	13,471	1,674	12.4
Farm/Forestry/Fishery	7,864	2,390	3.0
Prod./Crafts/Repair	65,183	25,689	39.4
Capital	124,764	24,740	19.8
Land	14,453	3,530	24.4
Total	327,530	76,682	23.4
Enterprises			
Supply-Determined			
NIPF	478	2,841	594.4
IPF	7,119	2,797	39.3
Public Forest	140	1,306	932.9
Wood Processing	47,798	43,258	90.5
Endogenous			
Agriculture	23,264	5,265	22.7
Non-ag/Non-forestry	206,826	46,257	22.4
Total	285,565	101,724	35.6
Households			
Low income	56,551	3,753	6.6
Medium income	130,238	23,120	17.8
High income	94,561	14,372	15.2
Total	281,350	41,245	14.7
Regional Exports			
Timber production	9,857	8,994	91.2
Wood processing	126,921	116,846	92.1
Total	136,778	125,840	92.1

Regional change in enterprise income includes the potential increase in timber production for the three land ownership categories (nonindustrial private forest - NIPF, industrial private forest - IPF, and public forest lands) and the income derived from expansion of wood processing industries (Table 3). Public and non-industrial private forests show the most significant potential increases (932.9 percent and 594.4 percent, respectively). Industrial private forests show a 39.3 percent increase and wood processing a 90.5 percent increase[3]. The forestry complex enterprises (timber and wood processing) show a potential income increase of $90,202,000, or 90.4 percent increase over the 1985 base SAM. The endogenous non-forestry complex enterprises show an income increase of $51,522,000, or 23.4 percent. The forestry complex enterprise income multiplier is about 2.03.

Household income would increase by $41,245,000 or 14.7 percent from the potential increase in timber production and wood processing for McCurtain County. The largest increase in both absolute ($23,120,000) and percentage (17.8) is with the medium income households. The smallest increase is with low income households. As noted earlier, this is because low income households have high proportions of income transfers and low proportions of resources used in production activities. Of the $76,682,000 increase in factor incomes from the potential increase in output of the forestry complex, only $41,245,000, or 53.8 percent, is distributed to regional (McCurtain County) households. The remaining 46.2 percent is distributed to factor taxes, depreciation and retained earnings on the capital account, and factor outflows to rest-of-world. The latter is expected because of resource ownerships by institutions and households located outside the region.

The expected increase in regional exports of the forestry complex is about $125,840,000, or a 92.1 percent increase over the base exports. This is similar to the percentage increase in production of timber and wood products.

Real Price Effect. The supply-determined real price effect was calculated using the pre-specified real stumpage price change of $30,869,000 (Table 2). This change was applied directly to the capital factor input account as an exogenous infusion of factor returns. The assumption is that the real price increase does not affect wage income or bare land rents. Because timber and wood processing output cannot change from the supply-determined volume effect, the results of the real price change are estimated including the volume effect. The difference between the two is attributed to the real price effect.

The factor income increase because of higher timber prices results in the increase of capital income of $30,869,000, or a 24.7 percent increase in capital income (Table 4). This is distributed to forest land ownerships by existing output levels and the potential increases in output levels. Public lands and non-industrial private forest lands show the greatest increases in incomes. The total factor in-

TABLE 4
Regional Impacts of 1985–2020 Supply-Determined Timber Price Change, McCurtain County, Oklahoma

Account	1985 ($1,000)	Regional Change ($1,000)	Regional Change (percent)
Factors			
Supply-Determined			
Capital	124,764	30,869	24.7
Endogenous			
Labor	188,313	2,128	1.1
Land	14,453	17	0.1
Total	327,530	33,014	10.1
Enterprises			
Supply-Determined			
NIPF	478	6,945	1,452.9
IPF	7,119	20,850	292.9
Public Forests	140	3,074	2,195.7
Wood Processing	47,798	0	0.0
Endogenous			
Agriculture	23,204	1,469	6.3
Non-ag/Non-forestry	206,826	23,868	11.5
Total	285,565	56,206	19.7
Households			
Low income	56,551	1,652	2.9
Medium income	130,238	9,687	7.4
High income	94,561	6,380	6.7
Total	281,350	17,719	6.3

come increase of $33,014,000 results in an increase in regional household income of $17,719,000, or about 53.7 percent of the total. The remaining factor income increase results in increases in retained earnings and factor income outflows from the region.

Total effect. The volume and price effects of the potential increases from 1985–2020 of timber production and wood processing are summarized in Table 5. Regional value added is expected to increase by $109,696,000, or 33.5 percent for McCurtain County. The largest factor increase (44.6 percent) is for capital because of the price increase in timber products. However, labor income and land income are expected to increase by 26.8 percent and 24.5 percent, respectively, based on the assumptions of the SAM multipliers.

Forestry complex enterprise income is expected to increase 146 percent. However, non-forestry complex enterprise income is expected to increase 33.4 percent. Household income is expected to increase $58,964,000, or 21.0 percent.

TABLE 5
Summary Impact of Potential 1985 - 2020 Volume and Price Changes in Timber Production and Wood Processing; McCurtain County, Oklahoma

Account	1985 ($1,000)	Regional Change ($1,000)	Regional Change (percent)
Regional Value Added			
Labor	188,313	50,540	26.8
Capital	124,764	55,609	44.6
Land	14,453	3,547	24.5
Total	327,530	109,696	33.5
Enterprise Income			
Forestry Complex			
NIPF	478	9,786	2,047.3
IPF	7,119	23,647	332.2
Public Forests	140	4,380	3,125.6
Wood Processing	47,798	43,258	90.5
Non-Forestry Complex			
Agriculture	23,204	6,734	29.0
Non-ag/Non-forestry	206,826	70,125	33.9
Total	285,565	157,930	55.3
Households			
Low income	56,551	5,405	9.6
Medium income	130,238	32,807	25.2
High income	94,561	20,752	21.9
Total	281,350	58,964	21.0

Medium-income households are expected to have an income increase of about one-fourth, whereas low-income households will have a 10 percent increase in incomes.

This paper analyzed potential increases in regional value added resulting from increased usage of factor inputs in producing timber by means of a social accounting matrix. Whereas the results are important for addressing questions of forested region economic development, there are limitations to the analysis. While this study is limited to showing the impact of increased forest production on one county, increased productivity on all forested lands would undoubtedly cause aggregate timber supplies to grow and prices to decline, diminish effects of forward-linked wood processing, and reduce potential change in incomes of all forested regions. However, the forested regions of the southern United States forest are anticipated to gain disproportionately in income shares from future enhancements to forest land productivities.

IV. STUDY IMPLICATIONS AND CONCLUSIONS

Over the past 25 years, a significant increase in timber management intensity has occurred in McCurtain County, Oklahoma, and throughout the southern United States. The structure of national timber supply and demand has led to predictions of continued real price increases for timber stumpage. Forecasted real stumpage price increases will provide market incentives for further intensification of timber management, particularly on nonindustrial private forest landownerships throughout the South. The core question addressed in this paper deals with how intensification of timber management affects total regional income (direct, indirect, and induced) and how that income is distributed in a regional market economy.

The analysis presented here contributes to our understanding of natural resource-based economies in a regional context by tracking income flows while simultaneously accounting for the capital growing stock assets of forests and the underlying dynamics of forest land productivity. From an economic linkage perspective, timber production provides raw material to primary and secondary wood processing sectors. Expansion of primary and secondary processing in a region is limited by the availability of timber in the region. The analysis presented here is based on sustainable timber production potentials identified using both inventory data and investment criteria. The paper presents an analysis procedure and empirical case study to estimate the distribution of income resulting from a single land use alternative–increased timber production–and its forward economic linkages. The analysis integrates environmental and economic sustainability measures in assessing the economic implications of natural resource production change. Further work is required to assess alternative land uses, individual land use compatibilities and impacts of this strategy on other economic development strategies.

A social accounting matrix (SAM) was constructed for McCurtain County, Oklahoma, for the base year 1985. Potential timber productivity over the 1985–2020 period was assessed using a volume effect and a real price effect. The USDA Forest Service Mid-South inventory was used to identify forest land treatment opportunities for McCurtain County. A sustainability assumption was applied which constrained annual removals to current annual growth plus potential net annual increment resulting from more intensive timber management by three ownership groups. Prices for 1985 were used to assess a volume effect, and future forecasted prices were used to assess a real price effect. The SAM was modified to a mixed exogenous/endogenous accounting structure which supply-determined the timber production and wood processing sectors for assessing impact of the potential timber productivity increase on McCurtain County. Three types of

impacts were quantified, using a fixed-price SAM analysis including: (1) a volume change resulting from forest landowners taking advantage of treatment opportunities identified as returning a four percent real rate on investment in 1985 prices; (2) wood processing output change proportional to the increase in timber volume output; and (3) a real price change in timber stumpage over the 1985–2020 period. Several conclusions may be drawn from this analysis of forest land use on a small regional economy.

Regional impacts of the potential increase in timber production (1985 prices) are significant. Whereas the direct income of timber production is expected to increase by about $7 million, the direct increase in value added through wood-processing activities is expected to increase by about $43 million. The increase in value added from all direct and indirect sources is expected to be about $77 million from the volume change and about $33 million from the price change, for a total of $110 million, or a third larger than the 1985 base for the region.

The aggregate increase in regional household income is expected to be substantially less because of indirect business taxes and ownership of resources outside of McCurtain County. This is especially true for capital and land resources in the industrial private forest land ownership category. Regional household incomes are expected to increase by about $59 million, or a 21 percent increase over 1985. Because of the nature of fixed-price SAM multiplier analysis, most of this increase is assumed to accrue to new households established in the region through labor in-migration.

The analysis shows income distribution by forest land ownership, production sector, factor resource, and household income class size. Nonindustrial private forest and public forest lands show the greatest potential percentage increase in volume of timber output because the percentage of that land in the improved technologies is lower than for industrial private forest lands. However, the absolute increase in income by the industrial private forest land owners is about 63 percent of the total increase because of the price effect on their high existing base of timber output. Of the total income increase of about $38 million, $24 million would accrue to industrial private forest land owners.

The services sector shows modest direct and indirect linkages to timber and wood processing output. Regional agriculture, food/fiber processing, and manufacturing have little linkage to the forestry complex *or* to regional household consumption from a change in household income. These production sectors have a three percent or less change in regional output, with about a 90 percent change in forestry complex output.

Factor income shares vary, depending on whether the analysis accounts for a volume effect, price effect or combined volume and price effect. Factor income shares for the volume effect show labor with 63.1 percent, capital with 32.3 per-

cent, and bare land with 4.7 percent. The combined volume and price effects show factor shares as capital with 50.7 percent, labor with 46.1 percent, and bare land with 3.2 percent. High factor share for labor with the volume effect is because of the wood processing value-added activity. When the price effect is included, capital shows the highest factor share because it is evaluated as an increase over bare land value. Growing stock is included as a return to capital, and not to land. Distribution of factor share income is important from the standpoint of regional household income. Because a substantial part of capital and land ownership is from outside the region, factor incomes show high outflows of resources because of past investments and expected future investments in forestry complex industries.

Distribution of household income by income class size is revealing. Forested regions are characterized by relatively high numbers of households in low-income categories. It is frequently viewed that development of the forestry complex assists low-income groups. The base period income shares show that 20.1 percent of regional income accrues to low-income households, 46.3 percent to middle-income, and 33.6 percent to high-income. Because low-income households receive a significant part of their income as transfers and because the analysis assumes full employment of available labor resources, adding timber and wood processing activities adds little income to low-income households. The volume effect shows that in the aggregate, income changes for low-income groups by 6.6 percent, for middle-income groups by 17.8 percent, and for high income groups by 15.2 percent. The reasons for income change by income class size is related to ownership of resources used by the forestry complex industries. Middle- and high-income groups tend to have jobs and own capital and land resources used in the forestry complex activities.

There is a clearly identified need for further research that incorporates market-equilibrating mechanisms. Factor and commodity markets need to be better defined within the context of regional equilibrium market analysis. Factor supplies, particularly labor and land, need to be interpreted in the context of what it takes in terms of increased wages and land rents to significantly change available supplies. Similarly, service sectors produce basically non-tradable commodities, and thus commodity prices should be endogenously determined. One available method that extends the SAM analysis into more price-endogenous models that incorporate market-equilibrating mechanisms is contained in computable general equilibrium analysis. These analyses continue to suffer from a dearth of available data on supply/demand relationships. They do, however, provide a logical extension to fixed coefficient modelling frameworks.

Another area requiring further study includes extending the modeling framework to account for land use compatibilities. The study reported in this

paper emphasized timber production at the exclusion of other land uses and land-use compatibilities. Further research is needed to determine land-use compatibilities including production of non-market goods as well as the traditional market goods of timber and wood processing. For example, how does the existence of large tracts of land devoted to even-aged pine silviculture impact the attraction of regions for rural tourism? More generally, there is a need to incorporate the simultaneous production of goods not openly traded in the marketplace into regional analysis of this nature. The analysis contained in this paper does not address these important multiple-use values of forest land management and would benefit from their inclusion. There is an opportunity to extend the SAM framework into a more complete model that captures these non-market goods.

Finally, there is a need to better evaluate alternative economic development strategies with respect to distributional impacts. For example, how does a value added development strategy focused on forestry production compare to other development strategies? There is a need to compare forestry strategies with other agricultural strategies, tourism development, and other strategies that build on the comparative advantages of rural regions. An expanded SAM analysis that more fully specifies regional economic development alternatives would provide one way to obtain estimates of these comparative strategies.

Rural incomes departed from a path of convergence with urban incomes to a trend of divergence and increased incidence of rural poverty during the 1980s. The distribution of income follows the ownership of resources and the rates of return to resources in a market economy. Evidence from this study indicates that forested regions in the South will benefit from higher timber prices and more intensive silvicultural practices. However, most of these direct benefits will accrue to owners of productive forest lands that can absorb the additional capital inputs represented by growing stocks. Most low-income groups do not own significant amounts of productive forest lands nor do they have access to capital resources and the required management skills. Whereas industrial private forest (IPF) landowners have benefitted from improved silvicultural practices, non-industrial private forest (NIPF) landowners have the greatest potential for increased adoption of improved timber production technologies. It will require programs of extension and education to assist these land owners in technology adoption and improved management. It may also require additional sources of credit to assist owners in allowing growing stock to mature over longer time periods.

Evidence from this study does indicate that value-added activities of the forest industry complex and the services linked industries provide jobs that benefit low- and middle-income groups. The analysis used in this study may indeed underestimate the full impact from these linkages. Labor market analysis

that allows wage rates to increase may draw out more of the unemployed and under-employed in the low- and middle-income groups as well as allow in-migration of households that serve these labor markets. However, it is evident that value-added industries (wood processing) and services industries do create jobs and that these jobs are dependent upon supplies of raw materials from timber production.

ENDNOTES

1. This follows the mixed exogenous/endogenous variables analysis developed by Miller and Blair, also referred to as *supply-determined* or *predetermined* analysis. It is important to note that this type of analysis should be distinguished from the economy-wide supply side (driven) input-output models discussed and critiqued by Oosterhaven (1988 and 1989), Rose and Allison (1989), and Gruver (1989) and represents a method that addresses important constraints to expansion of natural resource-dependent industries.

2. Land-use compatibilities of productive forest lands are important, but little research is available to assist in quantifying these interactions. Results of the current study identify the regional potential impact of adopting more intensive silvicultural practices on industrial private forest (IPF), nonindustrial private forest (NIPF), and public forest lands. Further research is needed to address alternative land uses and respective compatibilities.

3. Public and nonindustrial forests have not been as intensively managed for timber compared to industrial private forests. This is evident in productivity potentials. To be sure, non-timber management objectives have played a part in creating this situation. Nevertheless, an understanding of the distributive impacts of potential production provides important perspectives on the economic development consequences of intensive timber management strategies on these landownerships. Increases in raw material availability creates the opportunity for wood-processing expansion. The authors understand that raw material availability is but one determinant of industry expansion. Due to relatively high transport costs and low value to volume ratios, however, this analysis assumes that increases in raw material availability will allow for a commensurate increase in wood-processing output.

REFERENCES

Adelman, I., and S. Robinson. "U.S. Agriculture in a General Equilibrium Framework: Analysis with a Social Accounting Matrix." *American Journal of Agricultural Economics*, 68 (1986): 1196-1207.

Alig, R.J., and D.N. Wear. "Changes in Private Timberland: Statistics and Projections for 1952 to 2040." *Journal of Forestry*, 90: (1992): 31-36.

Bottiroli Civardi, M., and R. Targetti Lenti. "The Distribution of Personal Income at the Sectoral Level in Italy: A SAM Model." *Journal of Policy Modeling*, 10 (1988): 453-468.

Boyd, R.G., and W.F. Hyde. *Forestry Sector Intervention: The Impacts of Public Regulation on Social Welfare*. Iowa State University Press, Ames, Iowa, 1989.

Cohen, S.I. "A Social Accounting Matrix Analysis for the Netherlands." *De Economist*, 136 (1988): 253-272.

Connaughton, K.P., P.E. Polzin, and C. Schallau. "Tests of the Economic Base Model of Growth for a Timber Dependent Region." *Forest Science*, 31 (1985): 717-725.

Cole, S., B. McLean, and M. Hadeshian. "Flexible Manufacturing and Economic Recovery–Wood Products in Western New York." *Technology Analysis & Strategic Management*, 1, (1989): 171-190.

Coxhead, I.A., and P.G. Warr. "Technical Change, Land Quality, and Income Distribution: A General Equilibrium Analysis." *American Journal of Agricultural Economics*, 73 (1991): 345-360.

Daniels, S.E., W.F. Hyde, and D.N. Wear. "Distributive Effects of Forest Service Attempts to Maintain Community Stability." *Forest Science*, 37 (1991): 245-260.

Davis, L.S., and K.N. Johnson. *Forest Management*. McGraw Hill, Inc., New York, NY, (1987).

Deavers, K.L. "1980's: A Decade of Broad Rural Stress." *Rural Development Perspectives*, 7, (1991): 2-5.

deMelo, J. "SAM-Based Models: An Introduction." *Journal of Policy Modeling*, 10, (1988): 321-325.

Eckaus, R.S., F.D. McCarthy, and A. Mohie-Eldin. "A Social Accounting Matrix for Egypt, 1976." *Journal of Development Economics*, 9 (1981): 183-203.

Esparza, A. "Defense Impact Analysis Within a Social Accounting Framework." *Growth and Change*, 20 (1989): 63-79.

Flick, W.A., and L.D. Teeter. "Multiplier Effects of the Southern Forest Industries." *Forest Products Journal*, 38 (1988): 69-74.

Gruver, G.W. On the Plausibility of the Supply-Driven Input-Output Model: A Theoretical Basis for Input-Coefficient Change. *Journal of Regional Science*, 29 (1989): 441-450.

Havinga, I.C., K. Sarmad, F. Hussain, and G. Badar. "A Social Accounting Matrix for the Agricultural Sector of Pakistan." *Pakistan Development Review*, 26 (1987): 627-639.

Haynes, R.W., and D.M. Adams. "The Timber Situation in the United States: Analysis and Projections to 2040." *Journal of Forestry*, 90 (1992): 38-43.

Johnson, T.G., and S.N. Kuishreshtha. "Exogenizing Agriculture in an Input-Output Model to Estimate Relative Impacts of Different Farm Types." *Western Journal of Agricultural Economics*, 7 (1982): 187-198.

Keuning, S.J., and W.A. deRuijter. "Guidelines to the Construction of a Social Accounting Matrix." *Review of Income and Wealth*, 34 (1988): 71-100.

Ko, S. "A Regional Computable General Equilibrium Model for Korea." Unpublished Ph.D. thesis, University of Illinois, Champaign, IL. 1985.

Koh, Y. "Analysis of Oklahoma's Boom and Bust Economy." Unpublished Ph.D. thesis, Oklahoma State University, Stillwater, OK. 1991.

Lewis, D.K., and J. Goodier. "The South's Fourth Forest–Oklahoma." Oklahoma State University Agricultural Experiment Station Miscellaneous Paper 130. 1990.

Marcouiller, D.W., D.F. Schreiner and D.K. Lewis. "Constructing a Social Accounting Matrix to Address Distributive Economic Impacts of Forest Management." *Regional Science Perspectives*, 23 (1993): 60-89.

Marcouiller, D.W., D.K. Lewis, D.F. Schreiner. "Timber Production Factor Shares by Forest Tenancy Group." *Land Economics* 72 (1996): 358-369.

MIG. 1991. Micro-IMPLAN version MI 91-09 and Oklahoma 1985 County Database. Available from the Micro IMPLAN Group, Inc., 5830 Blytrail Ave. No., Lake Elmo, MN 55042-9542.

Miller, R.M., and P.D. Blair. *Input-Output Analysis: Foundations and Extensions*. Prentice-Hall, Inc., Englewood Cliffs, NJ, 1985.

Norris, F. Timber-Mart South–Oklahoma. Stumpage prices published by Timber-Mart South, Inc., Highlands, NC, 1985.

Oklahoma Department of Agriculture, Forestry Services. Unpublished 1985 FIP Progress Report (by county) 1992.

Oklahoma Department of Commerce. Statistical Abstracts of Oklahoma. Center for Economic and Management Research, College of Business Administration, University of Oklahoma and Oklahoma Department of Commerce, Oklahoma City, Oklahoma, 1992.

Oosterhaven, J. On the Plausibility of the Supply-Driven Input-Output Model. *Journal of Regional Science*, 28, (1988): 203-217.

Oosterhaven, J. The Supply-Driven Input-Output Model: A New Interpretation But Still Implausible. *Journal of Regional Science*, 29, (1989): 459-465.

Pederson, L., D.E. Chappelle and D.C. Lothner. "The Economic Impacts of Lake States Forestry: An Input-output Study." USDA, Forest Service General Technical Report NC136, 1989.

Peterson, W.C. Transfer Spending, Taxes, and the American Welfare State. Kluwer Academic Publishers, Boston, MA, 1991.

Pyatt, G., and J.I. Round (eds.). *Social Accounting Matrices, A Basis for Planning*. The World Bank, Washington, DC, 1985.

Pyatt, G. "A SAM Approach to Modeling." *Journal of Policy Modeling*, 10, (1988): 327-352.

Richardson, H.W. "Input-Output and Economic Base Multipliers: Looking Backward and Forward." *Journal of Regional Science*, 25, (1985): 607-661.

Robinson, S., M. Kilkenny, and K. Hanson. "The USDA/ERS Computable General Equilibrium (CGE) Model of the United States." Staff Report No. AGES 9049, Agricultural and Rural Economy Division, ERS USDA 1991.

Rose, A., B. Stevens, and G. Davis. *Natural Resource Policy and Income Distribution*. The Johns Hopkins Press, Baltimore, MD, 1988.

Rose, A., and T. Allison. On the Plausibility of the Supply-Driven Input-Output Model: Empirical Evidence on Joint Stability. *Journal of Regional Science*, 29, (1989): 451-458.

Rowley, T.D., J.M. Redman, and J. Angle. "The Rapid Rise in State Per Capita Inequality in the 1980's: Sources and Prospects." USDA Economic Research Service, Staff Report AGES 9104, 1991.

Sartorius, P., and H. Henle. *Forestry and Economic Development*. Praeger Publishers, New York, NY, 1968.

Schuster, E.G. and E.L. Medema. "Accuracy of Economic Impact Multipliers: An appraisal for foresters." *Journal of Forestry*, 87, (1989): 27-32.

Skountzos, T. "Social Accounting Matrix Multipliers in a Developing Economy: the Case of Greece." *Economics of Planning*, 22, (1988): 57-71.

Task Force on Persistent Rural Poverty. *Persistent Poverty in Rural America*. Westview Press, Rural Studies Series, Boulder, CO, 1993.

Temple, S. "Is Forestry the Problem or the Solution?" *Woodland Management*, 14, (1993): 18-19.

USDA, Agricultural Stabilization and Conservation Service. Unpublished ACP and Price Support Payments from ASCS Enrollment Report for 1985, McCurtain County, 1987.

USDA, Forest Service. "The South's Fourth Forest: Opportunities to Increase the Resource Wealth of the South." USDA Forest Service Misc. Publication No. 1461, Washington, DC, 1988.

USDA, Forest Service. Southern Forest Inventory and Analysis Database. Oracle database of midsouth forest resource data, 1992.

USDC, Bureau of Economic Analysis. 1990 Personal Income by Major Sources and Transfer Payments by Type, Regional Economic Information System, 1992.

USDL, Bureau of Labor Statistics. "Employment and Wages: Annual Averages 1985." Bulletin 2272, U.S. Department of Labor, 1986.

Vasievich, J.M. "Summary of Timberland Investment Opportunities in Oklahoma." USDA FS, North Central Forest Experiment Station, St. Paul, MN, 1987.

VonGoethem, L. "Who Owns the National Forests and Why Can't They Agree?" *Northern Logger and Timber Processor*. 36, (1993): 16-17, 34-35, 44.