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USING SEVERANCE TAX DATA TO ESTIMATE ANNUAL TIMBER REMOVAL LEVELS FOR INVENTORY PROJECTION IN ALABAMA

XIAOPING ZHOU
LAWRENCE D. TEETER

ABSTRACT

The accuracy of timber inventory projections are affected by the estimates of future removal levels. Estimates of future removal levels are a function of current removal levels, current inventory, market demand factors, and forest-related policy effects. Most current regional inventory projections rely on the removals information provided by the Forest Inventory and Analysis (FIA) data, which are reported by the USDA Forest Service every 8 to 10 years for each state. The usefulness of this information is limited since only the total removals between survey periods and the average annual removals are reported. This paper describes how Alabama severance tax data were used with the FIA removals data to estimate actual removal levels each year between surveys and after the latest survey period. The estimated removal levels were used to project South Alabama timber inventories with the DPSupply model. Inventory projections made using the estimated removal levels were compared with projections using average annual removals to highlight the importance of combining the FIA data and severance tax data to provide more accurate inventory projections.

Forest inventory information is critical for forest industry decision making. There are several regional models available in the South to project timber inventory, e.g., SERTS (1), GRITS (2), and DPSupply (8). The basic data used for timber inventory projection are provided by the Forest Inventory and Analysis (FIA) research units of the USDA Forest Service. In most southern states, field surveys are conducted every 8 to 10 years by FIA, in which they gather information on forest area, volume, growth, and removals, among other things. These data are important, but the usefulness of the information is limited for inventory projection purposes since only the total and average annual removals between surveys are reported. Information on actual harvest level for each year is not available from FIA. Lacking data on annual removal levels from other sources, many modelers use the average annual removal data in FIA reports to project future timber inventories. This may not be realistic since harvests vary over time. In an expanding forest economy where harvests are increasing each year, average annual harvests overstate actual harvests for the early years of the inventory cycle and underestimate harvests in the last years of the cycle. The lack of information on harvests for each year may affect the estimation of coefficients in projection models as well as the future projections themselves. The availability of severance tax data in some states can help in determining annual harvest levels (5). In this paper, we examine the feasibility of using severance tax data to describe the annual pattern of removals during the survey period. We also demonstrate how using more representative removal estimates affects projection results using the DPSupply model for South Alabama.

THE DATA

In Alabama, severance tax is assessed at the point of first conversion of timber into products (such as lumber, chips, poles, etc.). The units of measure associated with these products must be converted to cubic feet to be comparable to data reported by FIA. The unit conversions are based on methodology used by the Alabama Forestry Commission and outlined in an annual report series.[1] When converted, the data can serve as a proxy for harvest. **Table 1** shows the converted severance tax data for South Alabama, which includes the Southeast, Southwest-South, and Southwest-North FIA survey units.

[1] The Alabama Forestry Commission produces the *Forestry Cash Receipt Report on Forest Products Harvested in Alabama* annual report series (3). In each report, equations supporting the conversion of final product measures to stumpage volumes are outlined in detail. They are too extensive to reproduce here. In this article, "severance tax removals" are actually the results of converting the final product measures to stumpage volumes by the Forestry Commission using the conversion equations in the *Cash Receipt Reports.*

The authors are, respectively, Research Associate and Associate Professor, School of Forestry, Auburn Univ., Auburn, AL 36849. Alabama Agri. Expt. Sta. J. Series No. 9-985952. This paper was received for publication in July 1997. Reprint No. 8701.

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According to the data, harvest levels varied substantially year-to-year between 1982 and 1995 in South Alabama. **Figure 1** represents the trend in harvests based on severance tax with the FIA average annual removals (7) shown as a level line. In South Alabama, softwood harvest increased 11.6 percent in the first 8 years while hardwood harvest increased by 73.3 percent in the same period. The upward trend in annual softwood harvests after 1989 (1990 to 1995) is much stronger. Based on severance tax reports (3,4), softwood harvests increased 31.7 percent from 1990 to 1995 (from 408.9 million cubic feet (MMCF) to 538.5 MMCF) or at an annual rate of 5.7 percent; hardwood harvests increased by 20.2 percent (an annual rate of 3.75%) during the same period in South Alabama (from 190.8 MMCF to 229.4 MMCF).

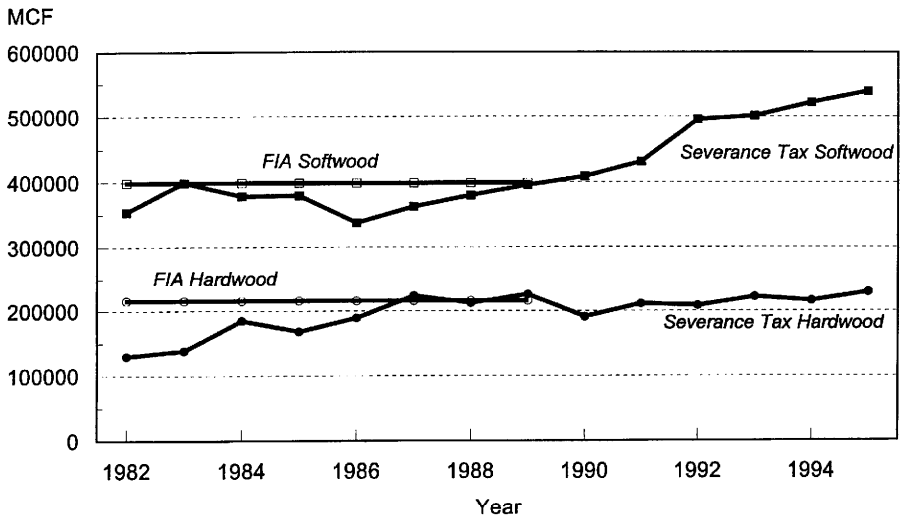

Figure 1. — Annual softwood and hardwood removal levels based on severance tax and FIA reports — South Alabama (1982 to 1995).

The severance tax data show the patterns of annual harvests, but the total harvest volumes by type (softwood or hardwood) or by product are quite different from the removal volumes in the FIA report. The patterns revealed by the severance tax reports are helpful in determining annual removals if the FIA estimates of total removals are accepted as correct.

Table 1 shows harvests based on severance tax for the 8-year reporting period 1982 to 1989. The FIA average survey period for plots measured in the 1982 (6) and 1990 (7) surveys was actually 8.82 years for South Alabama. **Table 1** also reports the total removals for the 8 calendar years (1982 to 1989) using eight times the annual removal in the FIA report (public land excluded) for comparison with the harvest totals for the 1982 to 1989 annual severance tax reporting period.

TABLE 1. — Removals data based on severance tax reports and the FIA report for South Alabama.

Severance tax removal data							
Year	Total	Softwood	Hardwood	Softwood pulpwood	Softwood sawtimber	Hardwood pulpwood	Hardwood sawtimber
	(MCF)						
1982	484,282	345,474	130,108	223,344	130,830	102,658	27,450
1983	537,960	399,330	138,630	233,786	165,544	107,480	31,150
1984	562,998	378,342	184,656	226,103	152,239	144,194	40,461
1985	547,208	379,485	167,724	213,556	165,928	132,958	34,765
1986	526,701	337,580	189,122	186,973	150,607	152,908	36,214
1987	586,269	362,575	223,694	205,617	156,958	177,184	46,510
1988	591,984	379,894	212,091	216,322	163,572	173,615	38,476
1989	620,898	395,397	225,501	229,032	166,366	186,877	38,625
Avg. annual	557,288	373,347	183,941	216,842	156,506	147,234	36,706
Total removal	4,458,301	2,986,777	1,471,524	1,734,733	1,252,044	1,177,873	293,651
FIA 1990 removal							
Avg. annual	614,860	399,090	215,770	86,120	312,970	84,160	131,610
Total removal	4,918,880	3,192,720	1,726,160	688,960	2,503,760	673,280	1,052,880

TABLE 2. — Adjustment rates using two adjustment approaches.

	Total	Softwood	Hardwood	Softwood pulpwood	Softwood sawtimber	Hardwood pulpwood	Hardwood sawtimber
	(MCF)						
Severance removal	4,458,301	2,986,777	1,471,524	1,734,733	1,252,044	1,177,873	293,651
FIA removal	4,918,880	3,192,720	1,726,160	688,960	2,503,760	673,280	1,052,880
Adj. rate (1)	1.1033	1.0690	1.1730	0.3972	1.9997	0.5716	3.5855
Adj. rate (2)				0.4177	1.9997	0.4793	3.5855

Figures 2 and **3** indicate the trends for softwood and hardwood harvests based on the severance tax reports and the FIA removals by product class for South Alabama. Our characterization of product volumes for FIA removals requires an estimation of total removal volumes by product class on the basis of tree size. For example, pulpwood removals estimates are based on the volumes of pulpwood size trees (e.g., 5- to 9-inch diameter at breast height (DBH) for softwood) removed. Using this characterization, a noticeable lack of correspondence exists between the harvest estimates based on severance tax and FIA removal levels for pulpwood and sawtimber.

Sawtimber harvests based on severance tax for both softwood and hardwood are lower than the sawtimber removals in the FIA report, while pulpwood harvest volumes are higher in the severance tax reports. The reason(s) for this may be among the following: 1) harvest volume and stumpage volume (for removals purposes) are not the same; pulpwood volumes may include some sawtimber residuals, and sawtimber harvest volumes may not recognize waste and residual pulpwood when the estimates are based on the final products volumes as in severance tax reports; 2) there is a problem of definitions: for example, FIA defines softwood sawtimber as 9 inches DBH and above, while conversion functions used to convert final products to sawtimber volumes may have been meant to represent larger DBH trees; 3) there may be other measurement units conversion problems, for example, board feet or tons to cubic feet.

DATA ADJUSTMENT

Although discrepancies exist between the severance tax data and FIA data as indicators of annual product level removals, the harvest *pattern* revealed by the severance tax data is helpful in determining annual removals. Our goal is simply to distribute the FIA total removal levels for the survey period to the individual years of the survey period according to the harvest patterns revealed by the severance tax data.

This research developed two ways to adjust the severance tax data and labeled them the "direct adjustment" approach and the "indirect adjustment" approach. **Table 2** shows the adjustment rates using these two approaches.

The direct adjustment approach simply calculates the adjustment rates A_{ij}:

$$A_{ij} = F_{ij}/S_{ij}$$

where:

A_{ij} = adjustment rate for species i and product j

i = species: $i = 1$ softwood; $i = 2$ hardwood

j = product: $j = 1$ pulpwood; $j = 2$ sawtimber

F_{ij} = total (survey period) removals in the FIA report for species i and product j

S_{ij} = total (survey period) harvest in the severance tax report for species i and product j

Then the adjusted removal for species i and product j in any particular year t will be:

$$R^t_{ij} = A_{ij} \times SR^t_{ij}$$

where:

SR^t_{ij} = harvest level based on severance tax in year t for species i and product j

R^t_{ij} = adjusted removal level in year t for species i and product j

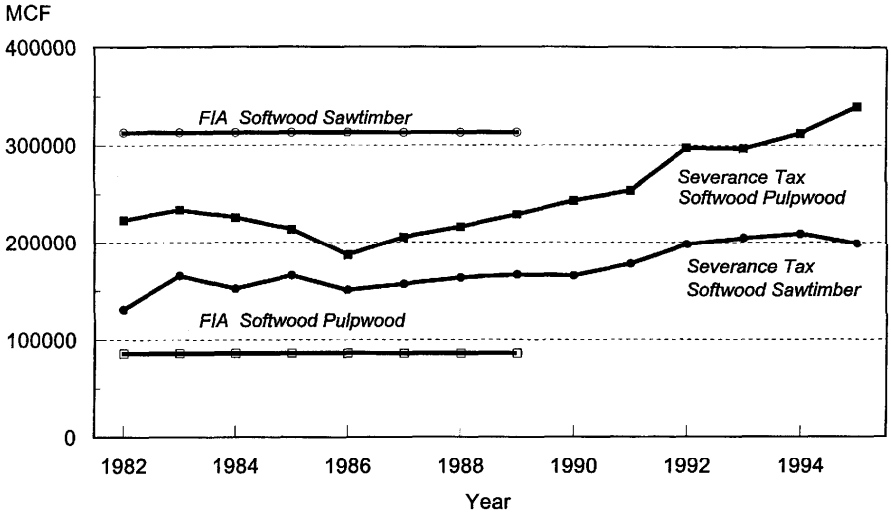

Figure 2. — Annual softwood removals based on severance tax and FIA reports by product class — South Alabama (1982 to 1995).

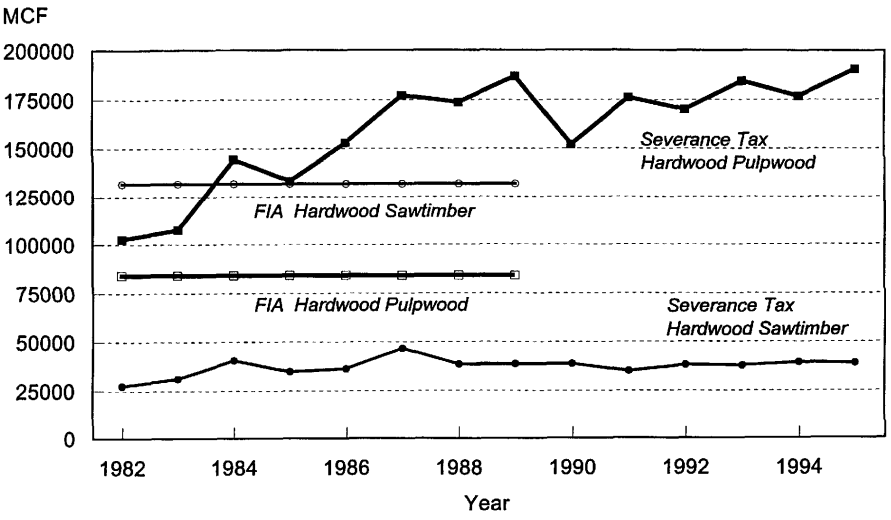

Figure 3. — Hardwood removals based on severance tax and FIA reports by product class — South Alabama (1982 to 1995).

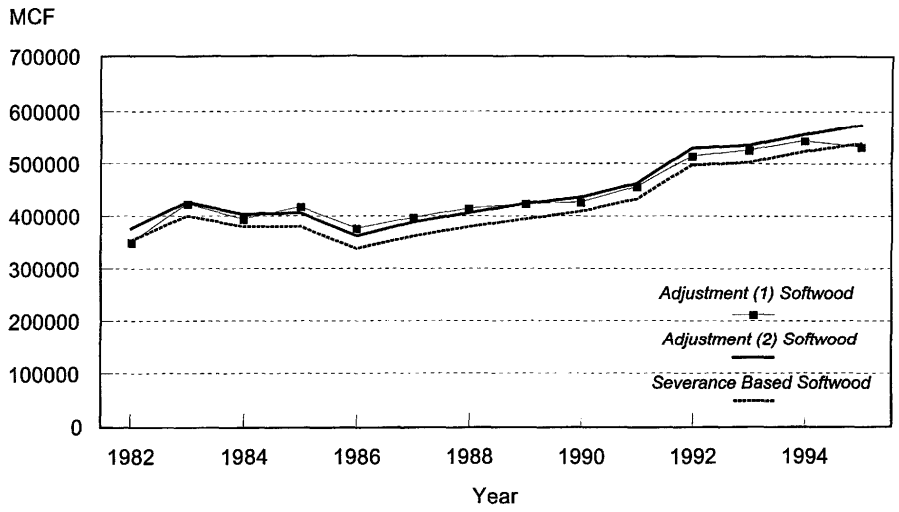

Figure 4. — Adjusted total softwood removal levels using different adjustment approaches — South Alabama (1982 to 1995).

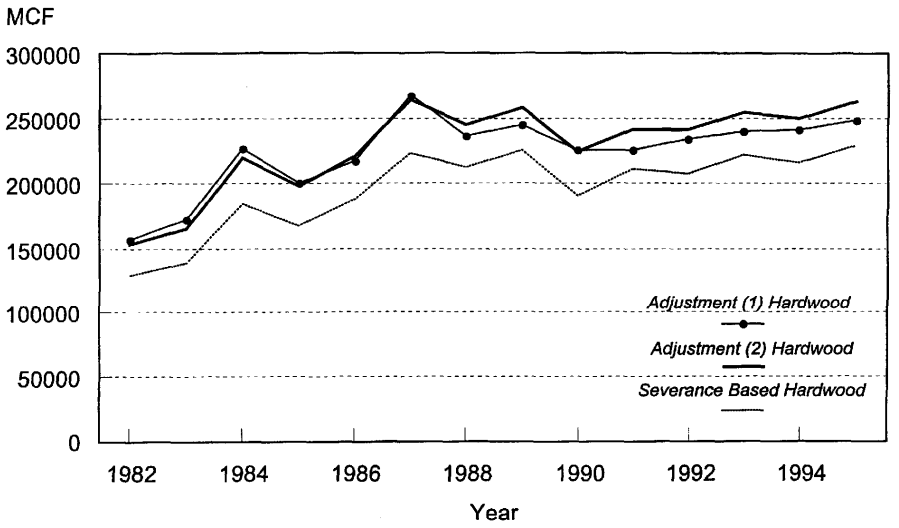

Figure 5. — Adjusted total hardwood removal levels using different adjustment approaches — South Alabama (1982 to 1995).

Total softwood sawtimber removals in the FIA report (7) are twice as high as the harvests in the severance tax report while pulpwood removals account for only 40 percent of the pulpwood volume on the severance tax reports from 1982 to 1989 (3,4). The difference must be due to a combination of several factors: 1) residual chips and tops from sawtimber trees are going to pulpwood; 2) sawtimber size trees are being used for pulpwood (either because of poor form or market competition); or 3) the volume of waste is not accurately reflected by the report. These reasons lead to the much higher harvest levels for pulpwood in severance tax reports as compared to the FIA volumes removed from the pulpwood size classes for both softwood and hardwood. Following the logic that sawtimber products must come from sawtimber trees, but pulpwood can come from trees of either size class, the pulpwood adjustment is a function of the sawtimber harvest level. The sawtimber indirect adjustment is the same as in the direct adjustment approach. The indirect adjustment rates are calculated as follows:

$$\text{Pulpwood: } A_{i1} = (S_{i1} - F_{i1})/(F_{i2})$$

$$\text{Sawtimber: } A_{i2} = F_{i2}/S_{i2}$$

Once the adjustment rates are obtained, they can be used to obtain the adjusted removals:

Indirect adjusted removals:

$$\text{Sawtimber: } R^t_{i2} = A_{i2} \times SR^t_{i2}$$

$$\text{Pulpwood: } R^t_{i1} = SR^t_{i1} - (A_{i1} \times R^t_{i2})$$

where:

SR^t_{i1} = pulpwood harvests in severance tax report at time t for species i

SR^t_{i2} = sawtimber harvests in severance tax report at time t for species i

R^t_{i1} = adjusted pulpwood removals at time t for species i

R^t_{i2} = adjusted sawtimber removals at time t for species i

Figures 4 and **5** show the different trends obtained by using these adjustment approaches. For both softwood and hardwood, the indirect adjustment approach (Adjustment (2) on the graph) better reflects the harvest pattern based on severance tax.

APPLICATION

Based on the results of tests such as those reported in **Figures 4** and **5**, we elected to use the indirect adjustment approach to convert the harvest data based on severance tax to an estimate of removals (and make it comparable to the FIA removals data). To demonstrate the usefulness of incorporating severance tax data in projections, two sets of projections for South Alabama were compared, one using adjusted removals based on severance tax and the other using FIA average annual removals. Two assumptions were made about removals: 1) that the severance tax data after 1990 should be converted in the same manner as the 1982 to 1989 data; and 2) that future (after 1995) removals will hold at 1995 levels. **Table 3** shows the removal levels by product class from 1982 to 1995 using the indirect adjustment approach. The DPSupply model (8) projected future timber inventories under each removals scenario starting from the most current survey (1990). The inventory projections using FIA 1990 average annual removal levels (7) and estimated actual removals after 1990 are shown in **Table 4** and **Figure 6**. The projection results are totally different for softwood and only slightly similar in trend (declining) for hardwood using these two specifications of removals. The projection shows that softwood inventory decreases by 27 percent while hardwood inventory decreases

TABLE 3. — Adjusted removal levels using the indirect adjustment rate for South Alabama.

Year	Total	Softwood	Hardwood	Softwood pulpwood	Softwood sawtimber	Hardwood pulpwood	Hardwood sawtimber
				(MCF)			
1982	529,605	375,694	153,911	114,067	261,626	55,489	98,421
1983	592,201	426,559	165,641	95,515	331,044	53,953	111,688
1984	623,164	403,383	219,741	98,946	304,438	74,668	145,073
1985	604,647	406,777	197,870	74,965	331,813	73,219	124,651
1986	582,877	362,652	220,524	61,178	301,175	90,679	129,845
1987	652,417	388,393	264,024	74,518	313,875	97,264	166,761
1988	652,254	406,799	245,454	79,697	327,102	107,500	137,954
1989	681,756	422,762	258,994	90,074	332,688	120,506	138,488
1990	660,388	436,075	224,313	105,113	330,962	85,572	138,741
1991	702,144	460,484	241,660	105,009	355,474	115,891	125,769
1992	769,384	528,110	241,274	132,202	395,908	104,622	136,652
1993	789,731	534,865	254,866	125,759	409,106	119,544	135,323
1994	806,217	556,112	250,105	137,612	418,500	109,175	140,930
1995	834,365	571,216	263,149	173,550	397,666	123,495	139,654

by 23 percent from 1995 to 2010 in South Alabama if adjusted removal levels are used. On the other hand, softwood inventory *increases* 20 percent and hardwood inventory decreases by 8 percent for the same period if average annual removals, reported in the FIA 1990 reports for South Alabama, are used instead.

CONCLUSION

FIA surveys provide invaluable information to researchers interested in projecting forest inventories. The data on aggregate growth, removals, and actual inventory at specific points in time are unavailable from any other source and are necessary components of model calibration efforts. However, the major weakness of the data is that they are not very useful for depicting trends over time (e.g., annually during and between surveys) for growth and particularly for removals. This trend information is crucial to accurately projecting inventories due to the dynamic nature of forest growth and the abrupt changes in harvest trends that may take place during the period subsequent to the last survey. Severance tax data or other related data collected by states may be a useful source of harvest trend information. The application described in this paper for South Alabama demonstrates the feasibility of using severance tax data in combination with FIA removals data to trace the removal levels each year between survey periods, thereby facilitating model calibration and inventory projection. Severance tax harvest records for years following the most recent survey can be used to help determine the most current removal levels more precisely and give a more accurate representation of inventory trends for the years between the most recent FIA survey and the next survey.

TABLE 4. — Inventory projection for South Alabama using different estimates of removals.

Year	Severance tax softwood	Severance tax hardwood	FIA softwood	FIA hardwood
		(MCF)		
1990	6,804,538	6,472,654	6,827,324	6,494,866
1991	6,831,069	6,497,805	6,910,192	6,554,206
1992	6,785,601	6,516,940	6,972,760	6,625,542
1993	6,713,348	6,527,992	7,021,869	6,699,652
1994	6,636,659	6,514,930	7,067,143	6,769,981
1995	6,520,046	6,501,683	7,160,229	6,757,397
1996	6,385,212	6,488,851	7,230,916	6,818,220
1997	6,281,564	6,434,314	7,330,079	6,815,580
1998	6,159,223	6,385,873	7,390,332	6,844,843
1999	6,028,865	6,332,345	7,448,787	6,869,982
2000	5,909,754	6,258,057	7,569,549	6,831,073
2001	5,808,331	6,158,880	7,660,886	6,821,657
2002	5,711,248	6,051,040	7,792,477	6,768,572
2003	5,551,352	5,997,389	7,877,474	6,752,632
2004	5,406,682	5,915,841	7,953,006	6,740,773
2005	5,281,474	5,800,461	8,079,310	6,669,290
2006	5,181,836	5,646,527	8,193,035	6,600,540
2007	5,077,335	5,492,445	8,315,515	6,523,144
2008	4,965,445	5,331,915	8,412,285	6,428,770
2009	4,859,106	5,144,693	8,537,012	6,293,588
2010	4,735,862	4,958,942	8,619,885	6,190,413

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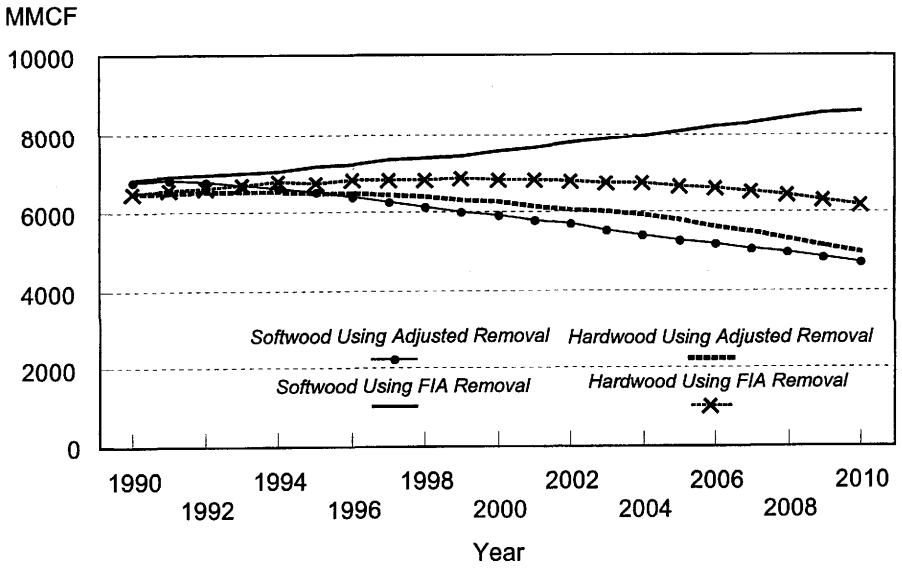

Figure 6. — Inventory projection using different methods for specifying removals — South Alabama (1982 to 1995).

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