Carbon Pools—Checking the Deep End, Before Diving In (The ME Experience)

K. M. Laustsen, Biometrician, Maine Forest Service, Department of Conservation, Augusta, ME

Abstract—*Maine's initial Greenhouse Gas (GHG) estimates of the Land Use Change and Forestry (LUCF) sub-accounts predicted that this account supplied 15 percent of the net emissions in 2000. The magnitude and direction of this estimate ran counter to internal assumptions and the recently published analysis on multiple and positive forest inventory changes for the period of 1995 to 2002. The major cause was the simple assignment and linkage of a forest soil's organic carbon level to a single specific forest type group. Carbon emissions were predicted as a result of changes in the forest type distribution over successive periodic and annual inventories (1980 to 2002). In general, plots transitioned from previous softwood to a new hardwood forest type group, creating an assumed and immediate diminution in the underlying soil's organic carbon level. Improved carbon flux estimations were obtained by: the use of a single forest-typing algorithm to ameliorate changes in the soil sub-account; incorporating regional and local biomass equations; utilizing FIA P3 DWM data; state level accounting of processed wood products and residues; and a structured analysis of land use coding for conversion and reversion rates.*

Introduction

In 2003, Maine's legislature charged the Department of Environmental Protection, Bureau of Air Quality, with a statutory requirement to produce an annual statewide Greenhouse Gas (GHG) emission inventory. The federal Environmental Protection Agency (EPA), through its contractor, and with input from the USDA Forest Service, developed a spreadsheet program to assist individual states in compiling their GHG inventories. The spreadsheet program has built-in default inventory data, with an option for users to input their own data in order to improve the prediction accuracy of various sub-accounts. The default inputs utilize Maine's 1995 USDA Forest Service Forest Inventory and Analysis (FIA) Periodic Inventory, without updating, to estimate forested conditions for the base year of 2000. The spreadsheet estimated that the "Land Use Change and Forestry" (LUCF) account provided 15 percent of the CO2 emissions (fig. 1). Both the magnitude and direction of this estimate were counter to recent annual inventory reports, released by the Maine Forest Service (MFS), estimating increased forestland coverage and biomass stocking over the period of 1995 to 2002 (Laustsen 2003).

Additional investigation and discussion determined that the soils carbon component represented nearly 60 percent of predicted emissions in the total forest carbon flux. For the initial base estimate, the 1990 Forest Carbon Flux uses updated estimates of Maine's 1982 FIA Periodic Inventory as reported in the 1987 Resource Planning Act Assessment (RPA). The ending base estimates a 2000 Forest Carbon Flux using Maine's 1995 Periodic Inventory as reported in the 1997 RPA. The inconsistent treatment and updating of the base estimates

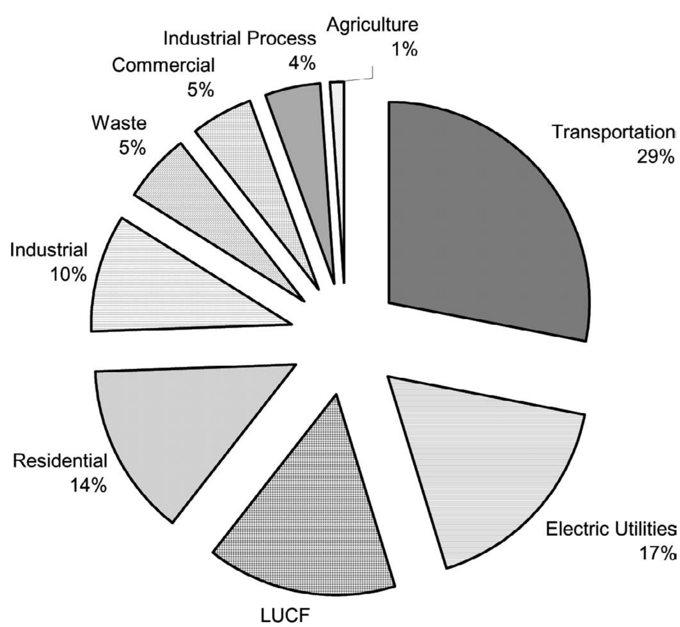

Figure 1. CO2 Emission Estimates, Maine, 200.

was further compounded with additional changes in classification techniques, sampling design, and FORCARB models.

In cooperation with the Durham, NH USDA Forest Service office, MFS was tasked with developing improved inventory and change estimates for the LUCF account (Smith and others, this proceedings).

Methods

An initial assessment provided a successful multi-staged approach to improved estimation techniques:

1. Since a single national equation treats a given species the same everywhere, but truly does not represent that species well anywhere, MFS offered to review additional sources. Published sources of biomass equations were offered in an effort to identify more species-specific regional and local volume equations to replace the imbedded National equations utilized in FORCARB2 for bole, sapling, seedling, and understory vegetation estimates (Chase and others 1978, Heath and others 2001, Honer and others 1983, Wharton and others 1998, Young and others 1980, Young and others 1967).
2. FIA Phase 3 data on down woody material (DWM) was incorporated to improve estimates of the forest floor and the down woody material (DWM) sub-account.
3. A repartitioning of harvested wood products, residue volumes, and import/export accounting was effected, based on historic MFS Wood Processor Reports. Further analysis was required in order to obtain improvement in the two remaining pieces of the forest carbon flux dynamics.
4. The forest soils sub-account proved to be the most difficult to enhance and refine. This sub-account is set up as a simple look-up matrix, in that a single soils carbon value is linked to a single forest type group (MFTYP), regardless of stand age, stocking, or average tree size. The typing algorithm, however, uses relative assessments of each plot's stocking, tree size, crown position, and species composition of primarily merchantable sized trees (5.0"+ d.b.h.) to assign MFTYP. The crux is that the forest typing algorithm and classification process underwent numerous alterations between the inventories of 1982, 1995, and 2003. These imbedded changes confound any trend analysis in trying to determine whether the plot truly underwent natural or management dynamics and had a real type change or rather the algorithm just remixed the classification metrics and assigned a new MFTYP (table 1). The example cited most often is that between the 1982 and the 1995 Periodic Inventories, Maine's Spruce-Fir MFTYP acreage decreased by approximately 2 million acres, with the bulk of the change showing up with increases in the Sugar Maple/Yellow Birch/Beech MFTYP. The associated soil carbon loss in this transition is over 50 tons per hectare and this change was simply averaged as a steady state 10-year emission.

The parties realized that changes in soil carbon are not that spontaneous, yet were very reluctant to imbed a no net soil carbon change. Some consideration was given

Table 1. Area of forestland by forest type group as originally published or current estimate, Maine.

Forest Type Group	Original & Published 1982 Forest Type Group (Forestland Acres)	Original & Published 1995 Forest Type Group (Forestland Acres)	Estimated 2003 Forest Type Group (Forestland Acres)
Aspen/W. Birch	1,504,900	2,249,600	2,341,937
Elm/Ash/Cottonwood	238,200	434,700	407,184
Other Forestland - Untyped	547,200	751,410	
Loblolly/Shortleaf	8,300	6,700	-
Maple/Beech/Y. Birch	5,000,900	6,408,800	7,055,581
Nonforested	2,229,400	2,064,200	2,033,849
Oak/Gum/Cypress	-	-	11,720
Oak/Hickory	306,500	453,200	320,044
Oak/Pine	36,200	127,600	334,384
Softwood Plantation	-	-	19,062
Spruce/Fir	7,770,500	6,011,200	5,819,039
White/Red/Jack Pine	2,194,700	1,245,900	1,359,302
Timberland - Nonstocked	-	-	49,293
Grand Total	19,836,800	19,753,310	19,751,394
Total Forestland	17,607,400	17,689,110	17,717,545
Total - Nonforested	2,229,400	2,064,200	2,033,849

to modeling a logarithmic type growth/decay function, that would systematically approach the real change over some period of time, but there was no research available to help that progressive transition.

By May 2004, the Northeastern Research Station FIA Unit had already completed the validation and classification of Maine's 1999 to 2003 Annual Inventory Panels using the new National Forest Typing Algorithm. That FIA unit had also completely rerun the plot sample from Maine's 1995 Periodic Inventory using the same algorithm for a determination of real trends and changes in stocking, stand size, and forest types over this 8-year period. MFS requested and received the continued extension of this reclassification, using the same identical algorithm, to the plot sample in Maine's 1982 Periodic Inventory. For the initial 1982 Periodic Inventory, this resulted in only 683 plots being retained and remeasured in the current 1999 to 2003 annualized inventory. The proposal was to use just the 683 remeasured plots as representative of the statewide transitions in carbon accounting.

Furthermore, ongoing MFS analysis raised suspicions about the validity of the 1995 tree level assessments of bole height and cull deduction. This lead to the decision to generate base estimates for 1982 and ending estimates for 2003 and derive average 20-year change components for all of the forest flux sub-accounts.

Another complication was that each of these three inventories used different county-level census acreage for their derived plot expansion factors. The MFS resolution was to utilize the current plot expansion factor (Census 2000) and 2003 Phase 1 stratum weights for both the base and final estimates, assuring additivity across time.

5. A better system of accounting for the conversion of forestland to non-forest and offsetting reversion of non-forest land uses to forestland was needed.

   FIA uses the term "condition class" to identify and map areas of discrete landscape and forest attributes that identify and define different strata on the plot. A condition class is a unique combination of condition status, land use, owner group, forest type, stand origin, stand size, reserve status, stand density, and a disturbance/treatment history. The identification, delineation, and assignment of condition class evolved between the 1982 and the 2003 inventories. Protocols for Maine's 1982 inventory were two-fold: newly established plots were forced to rotate until they represented a single condition class; while remeasured plots were assigned a single condition class based on the observed and encompassing attributes located at plot center.

   For Maine's 1999 to 2003 annualized inventory, condition classes are mapped, allowing multiple delineations on a single sub-plot (1/24th acre). The assignment of condition class #1 was still based on the qualifying attributes at the sub-plot #1's plot center. This sub-plot center is identical to the 1982 plot center for the 683 remeasured plots.

   MFS decided to analyze land use changes between 1982 and 2003 solely on the changes in the land use coding between the 1982 and 2003 inventories for condition class #1.

Results

The first step was to develop an initial forest type group transition table, based on the 683 remeasured plots. This table provided estimates of acres retained, lost, and gained over the 20-year period by specific MFTYP (table 2). For example, the Aspen/White Birch forest type group had a total estimated acreage of 2,245,685 acres in 1982 and 2,594,240 acres in 2003, indicating an overall acreage gain. Over the 20-year period; 863,532 acres remained unchanged; 1,730,708 acres were retyped into this group; and 1,382,153 acres converted to another forest type group, so that the derived annual change is an increase of 17,428 acres per year.

Of the eleven forest type groups, five had net gains (ranging from 1,220 to 53,411 acres per year) and six had net losses (ranging from –2,973 to –45,267 acres per year) (table 3). The average annual net change in table 3 is derived using just the 683 remeasured plots, while table 4 uses all available inventory plots at each measurement occasion. The estimated 1982 to 2003 rates of change are all in the same direction and are roughly of the same magnitude, except for the Oak/Hickory group, which flip-flopped from a 5,000 acre per year decline in table 3 to an estimated 1,500 acre per year increase in table 4.

The next apportionment was to adjust the 1982 individual MFTYP acres, such that they collectively summed to the current 2003 total forestland estimate of 19,751,394 acres (table 4). Table 4 also allows the comparison of this final 1982 reapportionment to three other 1982 estimates of MFTYP acreage.

The most meaningful check compares the "Restated 1982 MFTYP" column to the "Reapportionment of 1982 acres" column. Sugar Maple/Beech/Birch and Spruce/Fir represent 65 percent of the acres and each of their estimates are within 1 percent of the final 1982 reapportionment, Nonforested is within 5 percent, and Aspen/White Birch is within 8 percent. All in all, a pretty good indication that the original 683 plots are representative of the corrected 1982 forest type acreage

Table 2. Cross-tabulation of forest type group and all major land use changes (source 683 FIA plots measured in 1982 and remeasured in 1999-2003). Shaded Cells represent the intersection of acreage (2000 Census and 2003 Phase 1 weighting process) that did not change over the period. The other row values represent acres transitioning out to a new 2003 MFTYP, I.e. Aspen/W. Birch lost 641,975 acres to Maple/Beech/Birch by 2003. The other column values represent acres transitioning into a new MFTYP, I.e. Aspen/W. Birch gained 142,046 acres from Elm/Ash/Cottonwood by 2003.

1982 MFTYP	2003 MFTYP Aspen/W. Birch	Elm/Ash/Cottonwood	Maple/Beech/Y. Birch	Nonforested	Oak/Gum/Cypress	Oak/Hickory
Aspen/W. Birch	863,532		641,975	32,889		27,889
Elm/Ash/Cottonwood	142,046	171,762	157,470			
Maple/Beech/Y. Birch	376,806	73,152	3,893,692	116,942		66,388
Nonforested	231,008	13,139	296,135	1,226,891		
Oak/Gum/Cypress			10,411			
Oak/Hickory	53,924	27,845	28,480	14,296		94,920
Oak/Pine			117,793			
Softwood Plantation						
Spruce/Fir	735,255	108,301	1,263,258	284,873	34,809	
White/Red/Jack Pine	191,670	37,763	291,390	91,375		
Timberland - Nonstocked		34,809		51,256		
2003 MFTYP Totals	**2,594,240**	**466,770**	**6,700,603**	**1,818,522**	**34,809**	**189,196**

1982 MFTYP	2003 MFTYP Oak/Pine	Softwood Plantation	Spruce/Fir	White/Red/Jack Pine	Timberland - Nonstocked	1982 MFTYP Totals
Aspen/W. Birch	34,541		630,564	14,296		2,245,685
Elm/Ash/Cottonwood	11,805		43,140			526,223
Maple/Beech/Y. Birch	92,423	54,084	675,093	283,805		5,632,383
Nonforested	54,735		309,543	44,757		2,176,207
Oak/Gum/Cypress						10,411
Oak/Hickory	48,237		19,456			287,158
Oak/Pine	36,224			61,716		215,733
Softwood Plantation						
Spruce/Fir	68,736		4,353,149	131,285	17,134	6,996,800
White/Red/Jack Pine	87,834		60,517	680,085		1,440,633
Timberland - Nonstocked						86,064
2003 MFTYP Totals	**434,535**	**54,084**	**6,091,461**	**1,215,944**	**17,134**	**19,617,297**

Table 3. A summarized version of table 2, checking to ensure additivity across the assumed average 20-year period (1982 - 2001). Column labeled "Overall Net Change Direction" is a simple gain/loss indicator. Derived Annual Net Change is the calculated annual change (+/-) by MFTYP or land use.

MFTYP	Estimated 1982 Acres	Acres Gained 1982 - 2003	Overall Net Change Direction	Derived Annual Change (Acres/Year) for 20 Years	Acres Lost 1982 - 2003	Estimated 2003 Acres Net Change Summary
Aspen/W. Birch	2,245,685	1,730,708	+	17,428	1,382,153	2,594,240
Elm/Ash/Cottonwood	526,223	295,008	-	(2,973)	354,461	466,770
Maple/Beech/Y. Birch	5,632,383	2,806,912	+	53,411	1,738,691	6,700,603
Nonforested	2,176,207	591,630	-	(17,884)	949,316	1,818,522
Oak/Gum/Cypress	10,411	34,809	+	1,220	10,411	34,809
Oak/Hickory	287,158	94,277	-	(4,898)	192,238	189,196
Oak/Pine	215,733	398,311	+	10,940	179,508	434,535
Softwood Plantation	-	54,084	+	2,704	-	54,084
Spruce/Fir	6,996,800	1,738,311	-	(45,267)	2,643,651	6,091,461
White/Red/Jack Pine	1,440,633	535,859	-	(11,234)	760,548	1,215,944
Timberland - Nonstocked	86,064	17,134	-	(3,447)	86,064	17,134
Totals	**19,617,297**			**0**		**19,617,297**
Total Forestland	**17,441,089**			**17,884**		**17,798,775**
Total - Nonforested	**2,176,207**			**(17,884)**		**1,818,522**

distribution. To get an idea of the fluidity of the typing compare the Restated 1982 MFTYP column (current algorithm) to the Recalculated 1982 MFTYP column (old algorithm) (table 4).

The last step is a combined rubber sheeting and apportionment step, making the apparent type changes in and out of a given MFTYP to be totally additive to the current total of 19,751,394 acres. In doing this final adjustment, MFTYP acres that remained static over the 20-year period were not re-proportioned (table 5).

Table 6 provides the estimated annual change acreage of gains and losses within each MFTYP. Because of the step-wise reapportionment process, changes in the forest soil's organic carbon can now be linked to specific MFTYP changes. This enhanced capability results in soil carbon having a revised and minimal emission value, roughly just 10 percent of the previous estimate.

The same accounting and rebalancing process was conducted to look at specific trends in land use changes. The available land use codes for the 1982 data were limited to four broad land use classes (Forestland-Reserved, Forestland-Unproductive, Nonforested, and Timberland-Rural). These were matched to a full transition matrix identifying the current land use, a listing of 15 possible classes. Because of the limited identification in 1982, and the further restriction to just the land use coded for condition class #1 at sub-plot #1, some invalid transitions were estimated (table 7). An annual net loss of over 5,000 acres per year was estimated to occur from Reserved Forestland to a Timberland-Rural land use code. By FIA definitions, this transition is not allowed.

To minimize the impact of this specific incorrect estimate, Forestland-Reserved and Forestland-Other were recombined into a single 1982 land use class of Forestland. This still estimated a transition of 369 acres per year to a timberland land use, which could now, at least be feasibly attributed to unproductive land becoming productive over the 20-year period. The most frequent use of this table, for carbon flux estimation, is documenting conversions to nonforested uses and the offsetting reversions to forestland. The land use analysis should be re-processed to take into account the two noted problems. To do this, MFS would need to obtain the original 1982 field data. There was a full suite of land use codes, which would improve the transition on sub-plot #1 by allowing acreage to flow to all land uses currently identified on this sub-plot. With these enhancements, a more specific and accurate transition matrix can be produced.

Table 4. Reapportioned 1982 MFTYP, revised annual net change estimates, and 2003 MFTYP Acreage.

MFTYP	Informational Purposes ONLY: Original 1982 MFTYP (Acres) [Published]	Informational Purposes ONLY: Recalculated 1982 MFTYP (Acres) [82 Eastwide] (2,483 plots)	Restated 1982 MFTYP (Acres) (Current Typing Algorithm) (2,483 plots)	Reapportionment of 1982 MFTYP (Acres) (Current Typing Algorithm) (Sums to 2003 total)[2]	New Annual Net Change (Acres/Year) for 20 Years[3]	Current 2003 MFTYP (Acres)[1]
Aspen/W. Birch	1,504,900	1,603,555	2,449,254	2,261,035	4,045	2,341,937
Elm/Ash/Cottonwood	238,200	296,304	618,145	529,820	(6,132)	407,184
Noncommercial Forestland	547,200					
Loblolly/Shortleaf	8,300	4,277	4,277	-	-	-
Maple/Beech/Y. Birch	5,000,900	4,911,681	5,636,349	5,670,884	69,235	7,055,581
Nonforested	2,229,400	2,084,412	2,084,412	2,191,083	(7,862)	2,033,849
Oak/Gum/Cypress	-	12,238	56,522	10,482	62	11,720
Oak/Hickory	306,500	314,953	305,410	289,121	1,546	320,044
Oak/Pine	36,200	313,157	240,676	217,207	5,859	334,384
Softwood Plantation	-	-	-	-	953	19,062
Spruce/Fir	7,770,500	8,438,274	7,130,445	7,044,628	(61,279)	5,819,039
White/Red/Jack Pine	2,194,700	1,952,720	1,304,663	1,450,481	(4,559)	1,359,302
Timberland - Nonstocked	-	17,461	118,879	86,652	(1,868)	49,293
Grand Total	**19,836,800**	**19,949,032**	**19,949,032**	**19,751,394**	**0**	**19,751,394**
Total Forestland	**17,607,400**	**17,864,620**	**17,864,620**	**17,560,311**	**7,862**	**17,717,545**
Total - Nonforested	**2,229,400**	**2,084,412**	**2,084,412**	**2,191,083**	**(7,862)**	**2,033,849**

1 Actual 2003 Acres Column is the current 5-panel estimate by MFTYP, using the current typing algorithm
2 Adjusted 1982 Acres is a proportional construct to obtain additivity across the 20-year period, I.e. {(Table 3. 1982 Estimated 1982 acres/Table 3. 1982 Total acres) X (19,751,394)
3 New Annual Net Change by MFTYP or land use uses just values in Table 4.

Table 5. Rubber Sheeting and Proportionation of the Adjusted 1982 acres and aggregate change into respective Forest Type Groups. Assumed that Forest Type Group acres that remained static did not need any reapportionment. Adjusted remaining column cell values using their table 2 share of Forest type Group Acreage to the current 2003 Forest Type Acreage in table 4. For example, table 1 had Aspen/W. Birch gaining 142,046 acres from Elm/Ash/Cottonwood over the 20-year period. This has been re-proportioned to be only a 121,338 acre gain.

MFTYP	Aspen/W. Birch	Elm/Ash/Cottonwood	Maple/Beech/Y. Birch	Nonforested	Oak/Gum/Cypress	Oak/Hickory
Aspen/W. Birch	863,532	-	723,162	44,859	-	66,595
Elm/Ash/Cottonwood	121,338	171,762	177,385	-	-	-
Maple/Beech/Y. Birch	321,875	58,377	3,893,692	159,503	-	158,529
Nonforested	197,331	10,485	333,586	1,226,891	-	-
Oak/Gum/Cypress	-	-	11,728	-	-	-
Oak/Hickory	46,063	22,221	32,082	19,500	-	94,920
Oak/Pine	-	-	132,690	-	-	-
Softwood Plantation						
Spruce/Fir	628,069	86,426	1,423,017	388,554	11,720	-
White/Red/Jack Pine	163,728	30,135	328,241	124,631	-	-
Timberland - Nonstocked	-	27,778	-	69,910	-	-
2003 Total	**2,341,937**	**407,184**	**7,055,581**	**2,033,849**	**11,720**	**320,044**

MFTYP	Oak/Pine	Softwood Plantation	Spruce/Fir	White/Red/Jack Pine	Timberland - Nonstocked	New Proportioned 1982 Total
Aspen/W. Birch	25,856		531,744	18,121	-	2,273,869
Elm/Ash/Cottonwood	8,837		36,379	-	-	515,701
Maple/Beech/Y. Birch	69,184	19,062	569,294	359,731	-	5,609,246
Nonforested	40,972		261,032	56,731	-	2,127,029
Oak/Gum/Cypress	-		-	-	-	11,728
Oak/Hickory	36,108		16,407	-	-	267,300
Oak/Pine	36,224		-	78,226	-	247,140
Softwood Plantation						
Spruce/Fir	51,453		4,353,149	166,408	49,293	7,158,090
White/Red/Jack Pine	65,749		51,033	680,085	-	1,443,602
Timberland - Nonstocked	-		-	-	-	97,688
2003 Total	**334,384**	**19,062**	**5,819,039**	**1,359,302**	**49,293**	**19,751,394**
					Total Forestland	**17,624,365**
					Total - Nonforested	**2,127,029**

Table 6. MFTYP Annual Net Change. Suggested Use is calculating the Forest Soil's Organic Carbon flux by Forest Type Group. Need to read JUST down the column, looking at JUST the unshaded values, to avoid duplication. For example, on an annual basis, Aspen/W. Birch has gained 6,067 acre per year from Elm/Ash/Cottonwood and concurrently lost (20,064) acres to Maple/Beech/Birch.

	Annual Net Change (Acres/Year) estimated for the period of 1982 - 2003					
MFTYP	**Aspen/W. Birch**	**Elm/Ash/Cottonwood**	**Maple/Beech/Y. Birch**	**Nonforested**	**Oak/Gum/Cypress**	**Oak/Hickory**
Aspen/W. Birch		(6,067)	20,064	(7,624)	-	1,027
Elm/Ash/Cottonwood	6,067		5,950	(524)	-	(1,111)
Maple/Beech/Y. Birch	(20,064)	(5,950)		(8,704)	(586)	6,322
Nonforested	7,624	524	8,704		-	(975)
Oak/Gum/Cypress	-	-	586	-		-
Oak/Hickory	(1,027)	1,111	(6,322)	975	-	
Oak/Pine	(1,293)	(442)	3,175	(2,049)	-	(1,805)
Softwood Plantation	-	-	(953)	-	-	-
Spruce/Fir	4,816	2,502	42,686	6,376	586	(820)
White/Red/Jack Pine	7,280	1,507	(1,575)	3,395	-	-
Timberland - Nonstocked	-	1,389	-	3,496	-	-
Grand Total	**3,403**	**(5,426)**	**72,317**	**(4,659)**	**(0)**	**2,637**

MFTYP	**Oak/Pine**	**Softwood Plantation**	**Spruce/Fir**	**White/Red/Jack Pine**	**Timberland - Nonstocked**	**Aggregate MFTYP Net Change**
Aspen/W. Birch	1,293	-	(4,816)	(7,280)	-	3,403
Elm/Ash/Cottonwood	442	-	(2,502)	(1,507)	(1,389)	(5,426)
Maple/Beech/Y. Birch	(3,175)	953	(42,686)	1,575	-	72,317
Nonforested	2,049	-	(6,376)	(3,395)	(3,496)	(4,659)
Oak/Gum/Cypress	-	-	(586)	-	-	(0)
Oak/Hickory	1,805	-	820	-	-	2,637
Oak/Pine		-	(2,573)	624	-	4,362
Softwood Plantation	-		-	-	-	953
Spruce/Fir	2,573	-		5,769	2,465	(66,953)
White/Red/Jack Pine	(624)	-	(5,769)		-	(4,215)
Timberland - Nonstocked	-	-	(2,465)	-		(2,420)
Grand Total	**4,362**	**953**	**(66,953)**	**(4,215)**	**(2,420)**	**-**

Table 7. Final transition matrix annual land use changes (acres per year). For the period of 1982 – 2003.

1982 Land Use Class	Apportioned 1982 Acres (Sums to 2003 Total)	Overall Net Change Direction	Derived Annual Net Change (Acres/Year) for 20 Years	Current 5 Panel Estimate 2003 acres
Forestland - Reserved, Unproductive, Other	522,374	-	(369)	515,001
Nonforested	2,191,083	-	(7,862)	2,033,849
Timberland - Rural, Other, Urban	17,037,937	+	8,230	17,202,544
Grand Total	**19,751,394**			**19,751,394**
Total Forestland	**17,560,311**		**7,862**	**17,717,545**
Nonforested - Total	**2,191,083**		**(7,862)**	**2,033,84**

Discussion

The fine tuning and improved accounting of Maine's LUCF GHG flux was achieved by identifying the problem areas, finding references to improved estimations, trying approximations, and then having the wherewithal to reprocess and analyze the results. An asset to this process was Maine's continued high percentage of forestland, which minimizes some of the potential permutations that other regions are experiencing, particularly in land use changes. While the above described carbon estimation process will continue to be enhanced, the focus can now comfortably shift to finding and recommending forest management practices that realistically improve the current state of carbon fluxes and effect a reduction in GHG amounts both for the immediate short-term, (next 10 years) and for the long-term (20 plus years).

References

Chase, A. J.; H. R. Young. 1978. Pulping, biomass and nutrient studies of woody shrubs and shrub sizes of tree species. Life Sciences and Agriculture Experiment Station, University of Maine, Orono, Maine. Bulletin 749. 36 p.

Griffith, Douglas M.; Alerich, Carol L. 1996. Forest Statistics for Maine, 1995. Resource bulletin NE-135. Radnor, PA: U. S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Forest Inventory and Analysis Unit. 134 p.

Heath, L. S.; Chojnacky, David C. 2001. Down dead wood statistics for Maine timberlands, 1995. Research bulletin NE-150. Newtown Square, PA: U. S. Department of Agriculture, Forest Service, Northeastern Research Station. 80 p.

Honer, T. G.; Ker, M. F.; Alemdag, I. S. 1983. Metric Timber Tables for the commercial tree species of central and eastern Canada. Environmental Canada, Canadian Forest Service, Maritimes Forest Research Centre, Fredericton, New Brunswick. Information Report M-X-140. 140 p.

Laustsen, Kenneth M.; Griffith, Douglas M.; Steinman, James R. 2003. Fourth Annual Inventory Report on Maine's Forests. Augusta, ME: Department of Conservation, Maine Forest Service, Forest Health and Monitoring Division. 49 p. w/Appendices.

Northeast Field Guide, field manual version 1.4. 2000. U. S. Department of Agriculture, Forest Service, Northeastern Research Station, Forest Inventory and Analysis Unit.

Powell, Douglas S.; Dickson, David R. 1984. Forest Statistics for Maine 1971 and 1982. Resource bulletin NE-81. Broomall, PA: U. S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Forest Inventory and Analysis Unit. 194 p.

Wharton, Eric H.; Griffith, Douglas M. 1998. Estimating total forest biomass in Maine, 1995. Resource Bulletin NE-142. Radnor, PA: U. S. Department of Agriculture, Forest Service, Northeastern Research Station. 50 p.

Young, H. E.; Ribe, J.; Wainwright, K. 1980. Weight tables for tree and shrub species in Maine. Life Sciences and Agriculture Experiment Station, University of Maine, Orono, Maine. Miscellaneous Report 230. 84 p.

Young, H. E.; Carpenter, P. M. 1967. Weight, nutrient elements and productivity studies of seedlings and saplings of eight tree species in natural ecosystems. Maine Agriculture Experiment Station, University of Maine, Orono, Maine. Technical Bulletin 28. 39 p.