

## **Documentation of Methods for Producing the NY Biomass Extraction Rate Layer**

Eric K. Miller, Ecosystems Research Group, Ltd.

### **Purpose and Limitations**

This raster data layer was developed to provide a rough representation of the spatial distribution of recent biomass extraction rates<sup>1</sup> in New York. The New York analysis followed the same methods employed previously in the NEG/ECP project for the New England States (NEG/ECP 2001, Miller 2006). The process is documented here with examples from Vermont. The primary difference between the NY and VT data layer development was that timber removal data were retrieved directly from the USFS FIA system (<http://www.fia.fs.fed.us/tools-data/>) rather than provided by the state department of forestry. The biomass extraction rates are used together with localized biomass and nutrient content estimates (developed separately, see Pardo et al. 2005) to estimate the quantities of nutrients exported as the result of timber harvest. It is important to include this term of the nutrient mass balance equations in order to calculate critical loads that will adequately protect the working forest.

This is a highly generalized representation of recent biomass extraction rates. There are many limitations to the use of this data layer. This data layer is not intended to provide site-specific information. It is intended as a reasonable estimate of the spatial apportionment of the inferred harvest as a percentage of the estimated biomass inventory, accounting for differential extraction rates by county, land-ownership class, and forest type. There is no reason to expect that recent extraction rates are representative of the long-term average rates of extraction that would be most appropriate for steady-state critical loads modeling. Thus the end user of these data and of the critical loads assessment is advised to compare their knowledge of forest management in parcels or regions of interest with the estimates provided here. Improvements in local critical loads estimates can be made by recalculating the mass balances with better-constrained local data.

### **Forest Inventory and Harvest Data**

#### *New York Specifics*

Please note, the example method of development is described below with reference to VT. NY data were obtained directly from the USFS FIA system (<http://www.fia.fs.fed.us/tools-data/>). The period 2003-2006 was the most recent available survey period at the time of access.

#### *Vermont Example*

Bob DeGeus at the Vermont Agency of Natural Resources, Forests Parks and Recreation provided a data summary using NEFIA's forest inventory information and FP&R's Annual Harvest Report. The data were summarized by county, with Grand Isle County and Franklin County being combined, rather than calculated independently.

The data available were:

- The total estimated living biomass inventory on forests on all forest lands (1997).
- The annual harvest extraction of biomass from both public and private lands (averaged 1998-2000). Bob felt that the 1998-2000 period was reasonably representative of conditions today. These data were tabulated by "softwood" and "hardwood" extractions (Table 1).

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<sup>1</sup> In this document the term "extraction-rate" refers to the fraction of living biomass removed via harvesting activities per year.

**Table 1. Biomass inventory (1997), Annual Harvest (1998-2000) and Extraction Rates by County.**  
**Note: Grand Isle figures are included with Franklin County. From VTANR FP&R.**

NAME	ID	Inventory (living biomass Mg dry weight )		Harvest (Mg / year)		Extraction Rate (fraction of inventory / year)	
		softwood	hardwood	softwood	hardwood	softwood	hardwood
Franklin	1	2,684,869	6,707,139	23,174	27,550	0.0350	0.0056
Essex	2	2,597,486	8,212,467	45,196	37,368	0.0618	0.0070
Grand Isle	3						
Orleans	4	3,878,481	5,644,352	70,691	57,855	0.0491	0.0171
Lamoille	5	1,915,522	6,355,968	12,804	45,091	0.0260	0.0101
Caledonia	6	4,474,514	5,889,536	38,217	47,304	0.0214	0.0136
Chittenden	7	1,664,723	6,643,502	12,837	15,406	0.0315	0.0032
Washington	8	4,168,577	9,450,528	14,521	49,250	0.0110	0.0081
Addison	9	1,467,529	7,126,291	9,986	26,057	0.0314	0.0051
Orange	10	5,006,127	9,195,311	32,779	57,387	0.0181	0.0098
Windsor	11	5,680,496	17,230,321	34,605	71,890	0.0186	0.0063
Rutland	12	4,815,661	14,899,694	21,229	50,140	0.0164	0.0050
Bennington	13	1,311,881	14,526,637	9,939	39,074	0.0591	0.0038
Windham	14	7,016,060	14,538,831	23,714	41,274	0.0017	0.0006

### ***Spatial Data: Land-Ownership and Forest-Type Classifications***

#### ***New York Specifics***

GIS coverages of public land ownership was obtained from the NY State GIS Clearing House and classification was interpreted in terms of cut allowed and no cut areas following the NYDEC land classification system (<http://www.dec.ny.gov/outdoor/7811.html>). There was no state-wide coverage of private preserved lands available.

#### ***Vermont Example***

Sandy Wilmot (VTANR, FP&R) provided a GIS coverage identifying the West Mountain Core Preserve in the former Champion Lands. She also provided a layer of no-cut stream corridor buffer zones for the areas under management by Essex Timber. VMC provided a coverage for the Lye Brook Wilderness Area. All of these areas were considered “no-cut”.

VCGI provided a GIS-coverage of private preserved lands (subset of private conservation lands). These areas were considered “no-cut”. ERG analyzed the VT DEM to identify all areas above 2500 feet in elevation. These areas were considered to be “no-cut”.

VCGI provided a GIS-coverage identifying all public (State and Federal) lands as well as VT county boundaries.

The USGS/USEPA National Land Cover Data (NLCD) were used to identify softwood, hardwood, and mixed forest lands (to be consistent with ERG’s more specific forest-type coverage).

### ***Approach***

The no-cut areas were assembled into a single coverage.

The no-cut coverage was subtracted from the public-lands coverage. The remaining public areas were assumed to allow harvesting.

The no-cut and public lands coverages were subtracted from the full forest coverage. The remaining forest areas were assumed to be privately-owned lands potentially available for

harvesting.

The areas of each land-ownership (no-cut, public, private) by forest-type (softwood, hardwood, mixedwood) were determined by cross-tabulation (Table 2).

**Table 2. Forested land-area (ha) by ownership-forest-type class by county.**

NAME	ID	public and private preserve			private land subject to harvest			public land subject to harvest			total
		pres-hw	pres-mx	pres-sw	priv-hw	priv-mx	priv-sw	pub-hw	pub-mx	pub-sw	
Franklin	1	470.3	860.6	651.7	51717.7	31335.8	7655.0	738.4	261.7	83.3	93774.5
Essex	2	4216.9	3216.7	2203.4	72985.2	43351.6	17865.9	3247.0	1926.2	2003.8	151016.6
Grand Isle	3	0.0	0.0	0.0	5234.1	1330.8	743.0	306.6	117.0	22.0	7753.6
Orleans	4	1516.0	1188.3	1214.5	52400.3	42016.9	24948.6	2387.3	1356.8	767.0	127795.6
Lamoille	5	662.0	1227.2	1892.3	44387.8	30000.7	8159.1	7904.8	2729.3	567.7	97531.1
Caledonia	6	705.3	562.1	322.0	42208.5	49637.9	24550.0	9604.0	4148.0	1924.2	133662.1
Chittenden	7	763.4	1398.1	1399.7	40472.6	24429.7	6905.3	7644.2	3108.9	539.3	86660.9
Washington	8	1422.0	1941.4	2110.6	53241.6	50458.5	17295.8	13407.5	5001.0	1044.5	145922.9
Addison	9	2961.2	2567.0	1991.4	34567.9	15246.3	7296.6	31221.8	10115.7	3841.3	109809.2
Orange	10	358.2	238.1	51.4	60017.9	51962.9	23387.5	2716.7	1844.7	860.7	141438.2
Windsor	11	1389.8	353.0	239.6	97886.5	45306.0	40051.3	16405.2	4805.2	3875.5	210312.0
Rutland	12	6394.2	2065.6	2956.0	80447.8	12608.7	32902.3	30254.9	4735.9	6608.4	178973.8
Bennington	13	16718.9	2533.4	3782.8	46171.1	3059.7	5621.8	54206.3	6564.5	8431.7	147090.1
Windham	14	4202.4	794.1	884.3	63017.0	37508.3	32613.0	24195.7	5888.0	6330.5	175433.2
Total		41780.5	18945.5	19699.6	744755.9	438253.8	249995.1	204240.4	52602.9	36899.8	1807173.6

Because the extraction rates provided by VTANR FP&R are tabulated for 2 classes of wood (softwood and hardwood) and the forest land area is classified into three classes (softwood, hardwood, and mixed wood), it was necessary to apportion the mixed wood areas into fractions of softwood and hardwood. For lack of better information, the mixed wood areas were assumed to be 50% hardwood and 50% softwood.

Both the biomass inventory and annual harvest were then apportioned according to the percentage of forested area by type (softwood or hardwood) and ownership-class within each county (Table 3). The preserve or no-cut class was assigned its portion of the forest inventory, but no portion of the harvest. Bob DeGeus at the Vermont Agency of Natural Resources, Forests Parks and Recreation indicated that extraction rates on public lands are 1/2 to 1/3 the rate of extraction on private lands. In order to account for this known differential, the harvest rate on public land was taken to be 1/2 the rate over all land ownership classes (because private lands represent the vast majority of the total harvestable land area). The harvest rate for privately held lands was increased appropriately so that the total harvest from public and private land areas equaled the known county harvest.

**Table 3. Fraction of forested area by ownership-forest-type class. Note: Grand Isle figures are included with Franklin County.**

NAME	ID	preserve		private		public	
		hardwood	softwood	hardwood	softwood	hardwood	softwood
Franklin	1	0.008871	0.010657	0.721821	0.243591	0.012158	0.002902
Essex	2	0.038573	0.025240	0.626825	0.261837	0.027878	0.019646
Grand Isle	3						
Orleans	4	0.016511	0.014152	0.574423	0.359614	0.023989	0.011310
Lamoille	5	0.013080	0.025694	0.608915	0.237457	0.095041	0.019813
Caledonia	6	0.007380	0.004512	0.501469	0.369357	0.087370	0.029913
Chittenden	7	0.016875	0.024217	0.607972	0.220631	0.106145	0.024160
Washington	8	0.016397	0.021116	0.537756	0.291421	0.109016	0.024294
Addison	9	0.038655	0.029824	0.384222	0.135869	0.330388	0.081042
Orange	10	0.003374	0.001205	0.608035	0.349050	0.025729	0.012606
Windsor	11	0.007447	0.001978	0.573146	0.298149	0.089428	0.029851
Rutland	12	0.041498	0.022287	0.484720	0.219064	0.182277	0.050155
Bennington	13	0.122276	0.034329	0.324298	0.048621	0.390839	0.079638
Windham	14	0.026217	0.007304	0.466110	0.292802	0.154701	0.052866

With this apportionment, extraction rates were calculated by forest-type and ownership class within each county (Table 4). The mixed wood extraction rate was taken to be the inventory-weighted average of the softwood and hardwood extraction rates.

**Table 4. Percentage of living biomass inventory removed by harvest by ownership-forest-type class and county. Note: Grand Isle and Franklin Counties were lumped for analysis and therefore have the same rates of extraction.**

NAME	ID	Private Timberland			Public Timberland		
		softwood	hardwood	mixedwood	softwood	hardwood	mixedwood
Franklin	1	3.52%	0.56%	0.92%	1.75%	0.28%	0.41%
Essex	2	6.41%	0.71%	1.38%	3.09%	0.35%	0.85%
Grand Isle	3	3.52%	0.56%	0.92%	1.75%	0.28%	0.41%
Orleans	4	4.99%	1.75%	2.72%	2.46%	0.86%	1.25%
Lamoille	5	2.71%	1.09%	1.26%	1.30%	0.50%	0.55%
Caledonia	6	2.23%	1.48%	1.75%	1.07%	0.68%	0.76%
Chittenden	7	3.32%	0.35%	0.60%	1.58%	0.16%	0.24%
Washington	8	1.15%	0.89%	0.94%	0.55%	0.40%	0.42%
Addison	9	4.07%	0.73%	0.96%	1.57%	0.26%	0.32%
Orange	10	1.84%	1.01%	1.21%	0.91%	0.49%	0.58%
Windsor	11	1.95%	0.68%	0.86%	0.93%	0.31%	0.38%
Rutland	12	1.82%	0.60%	0.76%	0.82%	0.25%	0.30%
Bennington	13	10.74%	0.60%	0.74%	2.95%	0.19%	0.24%
Windham	14	1.14%	0.60%	0.72%	0.09%	0.03%	0.04%

The county-aggregate extraction rates by land-ownership class and forest type were then assigned to cover the full county area (Figure 1: example using publicly owned hardwood rates).

To remove the hard edges (large apparent differentials in extraction rates) at county boundaries, the following process was employed. This process was undertaken to try to represent a more gradual transition in harvesting practices across county lines. Such a transition might be more similar to the situation on the ground than the hard-bounded county aggregate data. This estimate is clearly arbitrary, as we lack information at higher spatial resolutions.

However, it is common sense that the extraction rates do not change abruptly at the county boundaries.

1. Four-hundred systematic sample points were used to sample the extraction rates on a regular grid across the VT image.
2. These sample point values were interpolated using the 6-nearest neighbors with a distance-weighting exponent of 1.0 at a resolution of 167x312 (10X less than the native image resolution). This produced a reasonably smooth interpolated image with minor artifacts (Figure 2).
3. A 7x7 mean (low-pass) filter was applied to produce the final image (Figure 3).
4. These images were resampled to 30x30m resolution for combination with the land-ownership x forest-type class masks.

The smoothed/filtered extraction rate images were multiplied by the corresponding mask for each land-ownership x forest-type class. These images were then concatenated (sequentially overlaid) to form the full regional biomass extraction-rate layer (Figure 4).

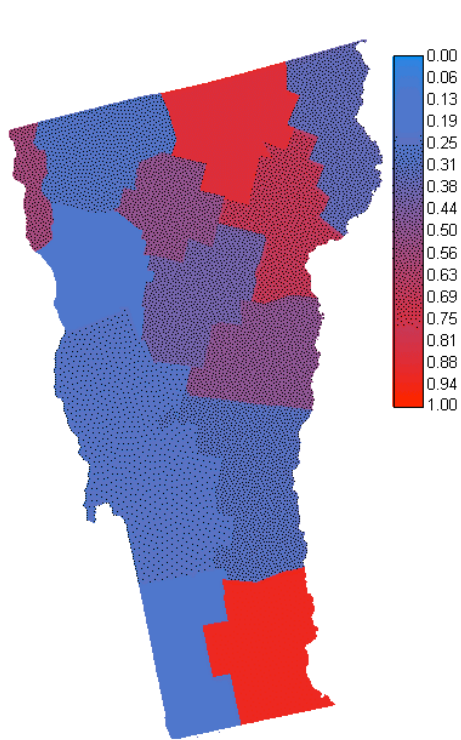
#### ***Tests for consistency of the regionalized ownership-forest-type generalizations with the FP&R survey and USFS FIA data***

A simple test was conducted to be sure the regionalized ownership-forest-type generalization did not seriously distort the state-wide biomass extraction rate as indicated by the FP&R survey data.

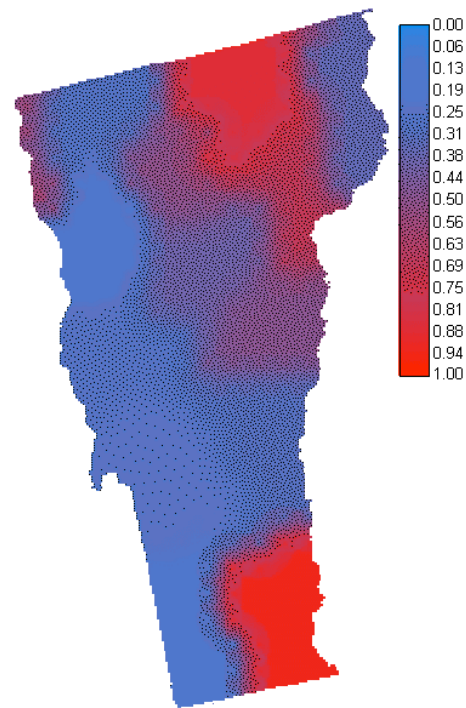
The state-wide average biomass extraction rate determined from the FP&R survey data (after excluding the inventory we estimated to be associated with “no-cut” preserve areas) is 0.93%. This value was determined by summing the softwood and hardwood harvest and dividing by the total living biomass inventory (excluding the no-cut inventory) for the whole state.

The average fractional biomass extraction rate computed from the regionalized ownership-forest-type generalization was 0.90%. This value was determined by taking the spatial average of all the values in figure 4. The spatial representation in figure 4 appears to be in good agreement with underlying data and no serious distortion was introduced by the spatial generalization process.

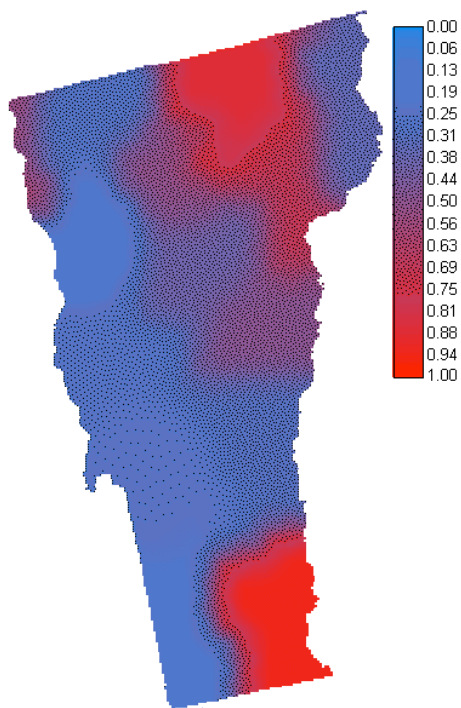
The amount of timberland area estimated using the 1991-1993 NLCD was 3.5% less than FIA's estimate of timberland area for 1997. The 1997 FP&R inventory figures are 6.0% less than an estimate using the NLCD timberland area and the mean above-ground biomass densities for softwoods and hardwoods for the Northeast-FIA region of Smith et al. (2002). Considering the differences in methodology and dates related to these estimates, they are in reasonable agreement. FIA is not currently publishing harvest estimates for Vermont.



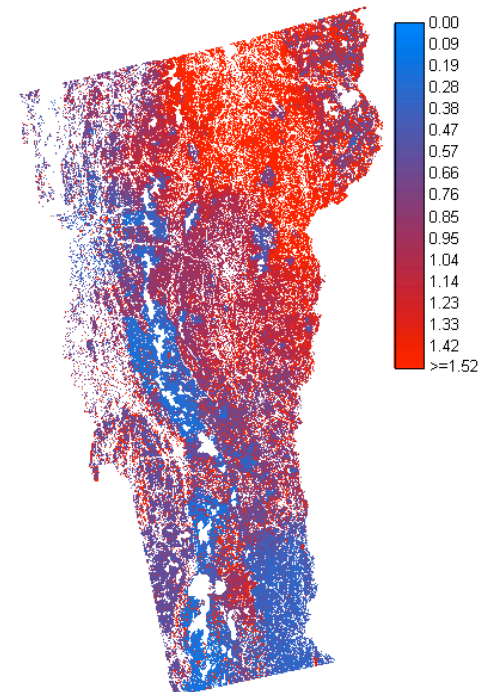
**Figure 1. Biomass extraction (% inventory per year) of hardwoods on publicly-owned lands by county.**



**Figure 2. Interpolated surface representing biomass extraction (% inventory per year) of hardwoods on publicly-owned lands by county.**



**Figure 3. Low-pass filter of figure 2.**



**Figure 4. Biomass extraction (% inventory per year) apportioned by ownership-class and forest-type.**

***Extracted biomass apportionment by tree component***

A forester stakeholder group and individual consultations indicated that tree component utilization is difficult to assess. The general sense of those consulted is that practices and market conditions in Vermont (in 2000) were heavily weighted to saw-log only extraction. For the purposes of the study we assumed all of the biomass extracted is in the form of saw-logs (including bark) and therefore will be extracted from the live bole and bark biomass inventory for the purpose nutrient export calculations. The utilization scheme could be improved in subsequent work. Future scenarios involving significant utilization of slash to be chipped for biomass fuel would result in different (likely higher) nutrient extraction rates.