

Estimation of Forest Conversion Rates from FIA and Remote Sensing Data

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FSC Controlled Wood Standard

Considered low risk if: 4.1 There is no net loss AND no significant ^{gross?} rate of loss (>0.5% per year) of natural forests and other naturally wooded ecosystems such as savannahs taking place in the eco-region in question.

FSC-STD-40-005 (Version 2-1) EN

The intent of this category is to avoid wood coming from regions where there is a significant occurrence of deforestation of natural and semi-natural forests.

Uncertainties about FSC wording

- No net loss is clear
- No significant rate of loss ($>0.5\%$ per yr) is unclear
 - *This is interpreted (by ncasi) to mean gross loss cannot exceed 0.5% per year
 - *We can only think of 2 kinds of loss: net or gross
- Procuring wood from an ecoregion that exceeds either loss limit would be problematic
 - Not clear what happens, but likely to be costly

Define gross and net loss

Gross loss = f_{2n} (forest to non-forest)

- Includes loss, but not gain

Net loss = $f_{2n} - n_{2f}$

- Includes loss and gain

*Loss expressed as annual percentages.

*A negative net loss is a gain in forest area

*Beware of studies that only report gross loss

Quantification of global gross forest cover loss

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Abstract

[Proceedings of National Academy of Sciences, 2010](#)

A globally consistent methodology using satellite imagery was implemented to quantify gross forest cover loss (GFCL) from 2000 to 2005 and to compare GFCL among biomes, continents, and countries. GFCL is defined as the area of forest cover removed because of any disturbance, including both natural and human-induced causes. GFCL was estimated to be 1,011,000 km² from 2000 to 2005, representing 3.1% (0.6% per year) of the year 2000 estimated total forest area of 32,688,000 km². The boreal biome experienced the largest area of GFCL, followed by the humid tropical, dry tropical, and temperate biomes. GFCL expressed as the proportion of year 2000 forest cover was highest in the boreal biome and lowest in the humid tropics. Among continents, North America had the largest total area and largest proportion of year 2000 GFCL. At national scales, Brazil experienced the largest area of GFCL over the study period, 165,000 km², followed by Canada at 160,000 km². Of the countries with >1,000,000 km² of forest cover, **the United States exhibited the greatest proportional GFCL and the Democratic Republic of Congo the least**. Our results illustrate a pervasive global GFCL dynamic. However, GFCL represents only one component of net change, and the processes driving GFCL and rates of recovery from GFCL differ regionally. For example, the majority of estimated GFCL for the boreal biome is due to a naturally induced fire dynamic. To fully characterize global forest change dynamics, remote sensing efforts must extend beyond estimating GFCL to identify proximate causes of forest cover loss and to estimate recovery rates from GFCL.

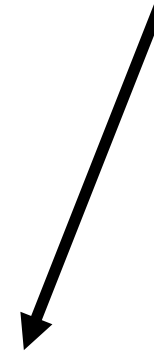
Conversion rates from NLCD

- National land cover data derived from Landsat
- Used the NLCD 2006 change product
 - *16-class land cover classification scheme
 - *NCASI further reduced this to forest and non-forest
- Computed net and gross loss statistics for Bailey's ecoregions and the lower 48 states

NLCD Change Product Classes

- 1) Unclassified
- 2) Open Water
- 3) Perennial Ice/Snow
- 4) Developed, Open Space
- 5) Developed, Low Intensity
- 6) Developed, Medium Intensity
- 7) Developed, High Intensity
- 8) Barren Land
- 9) Deciduous Forest
- 10) Evergreen Forest
- 11) Mixed Forest
- 12) Shrub/Scrub
- 13) Grassland/Herbaceous
- 14) Pasture/Hay
- 15) Cultivated Crops
- 16) Woody Wetlands
- 17) Emergent Herbaceous Wetlands

4 Options to reclassify into forest



Option 1: Only Forest classes are forest

Option 2: Shrub/Scrub and Forest classes are forest

Option 3: Wetlands and Forest classes are forest

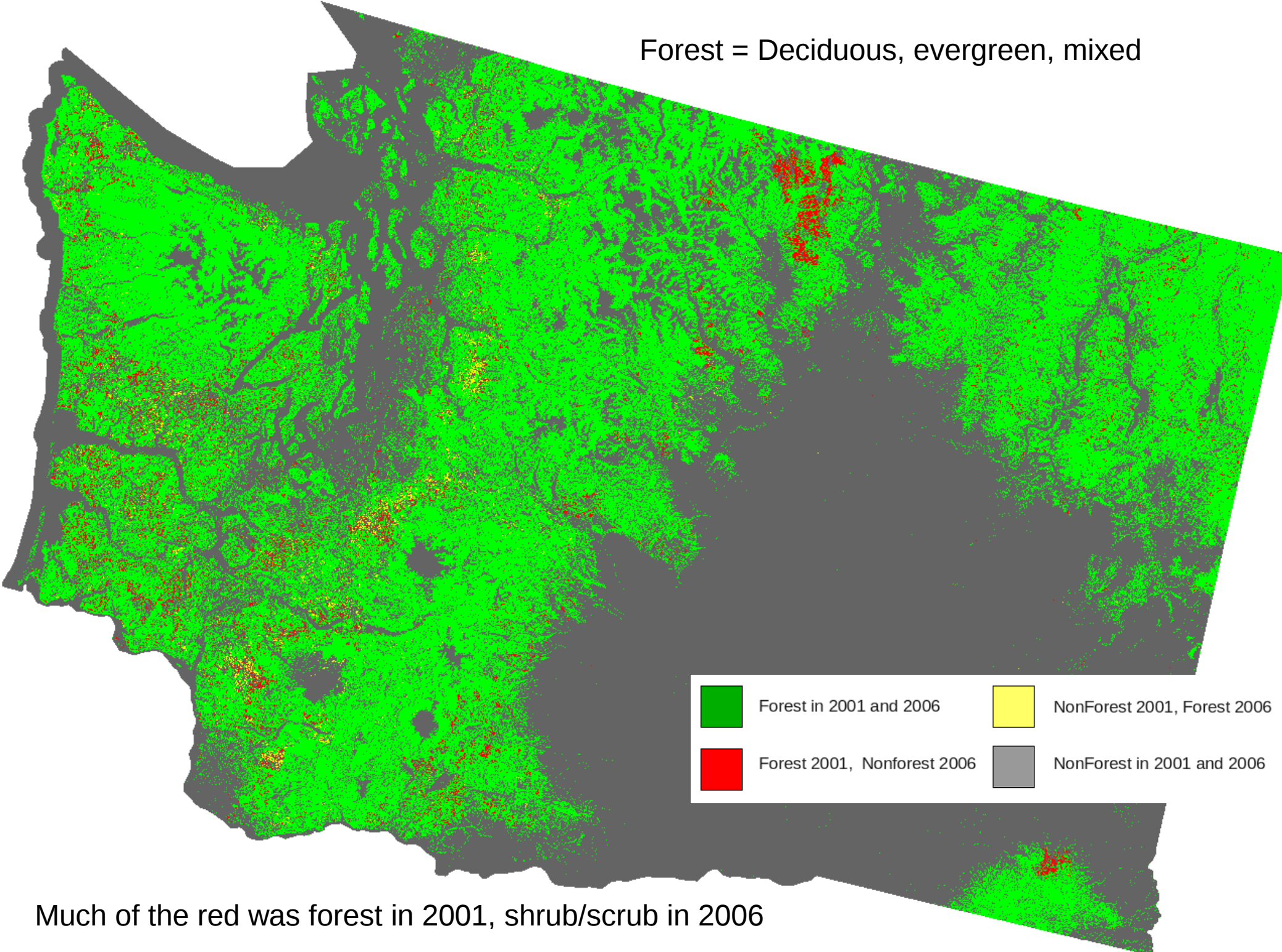
Option 4: Wetlands and Shrub/Scrub and Forest classes are forest

NLCD Conversion Rates for Washington

Option	Gross Loss	Net Loss	FIA Acres	NLCD Acres
Forest Only	0.845	0.637	22,344,000	17,835,467
Forest + Wetlands	0.833	0.621		18,358,416
Forest + Shrub/Scrub	0.258	-0.022		28,831,709
Forest+Wetlands+ Shrub/Scrub	0.256	-0.020		29,354,656

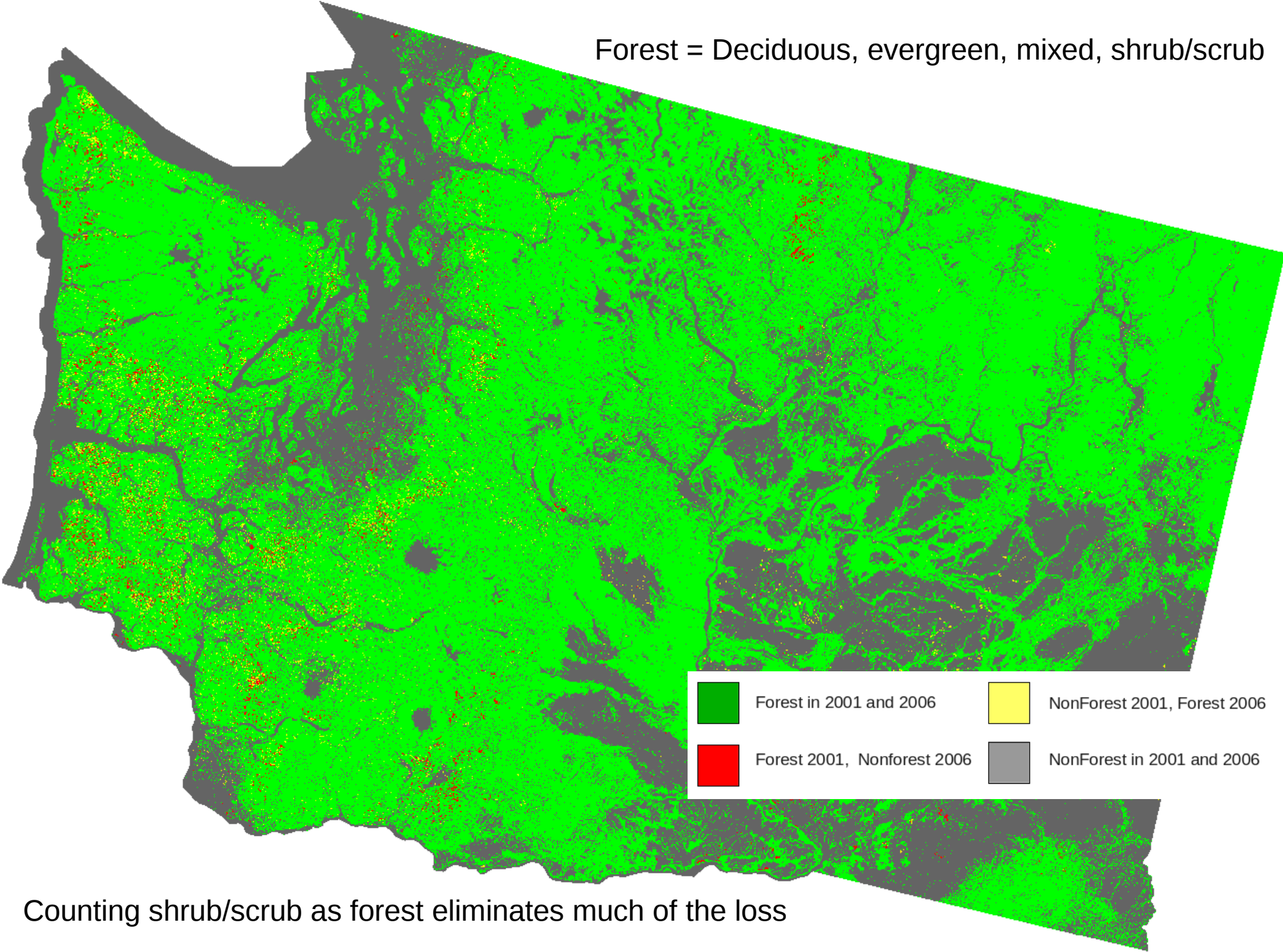
*Loss is annual percent
Negative net loss is a forest gain

Forest = Deciduous, evergreen, mixed



Much of the red was forest in 2001, shrub/scrub in 2006

Forest = Deciduous, evergreen, mixed, shrub/scrub

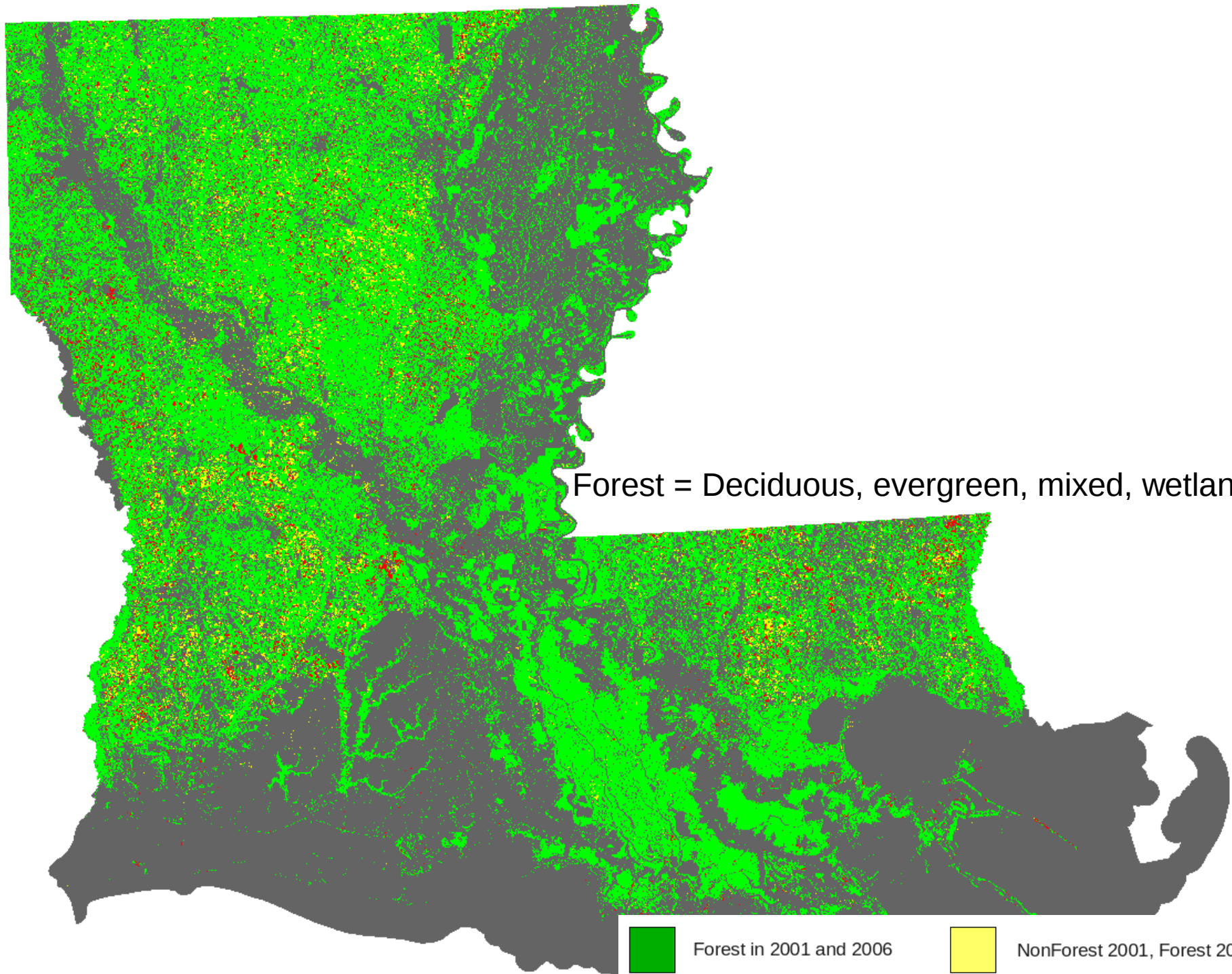


Counting shrub/scrub as forest eliminates much of the loss

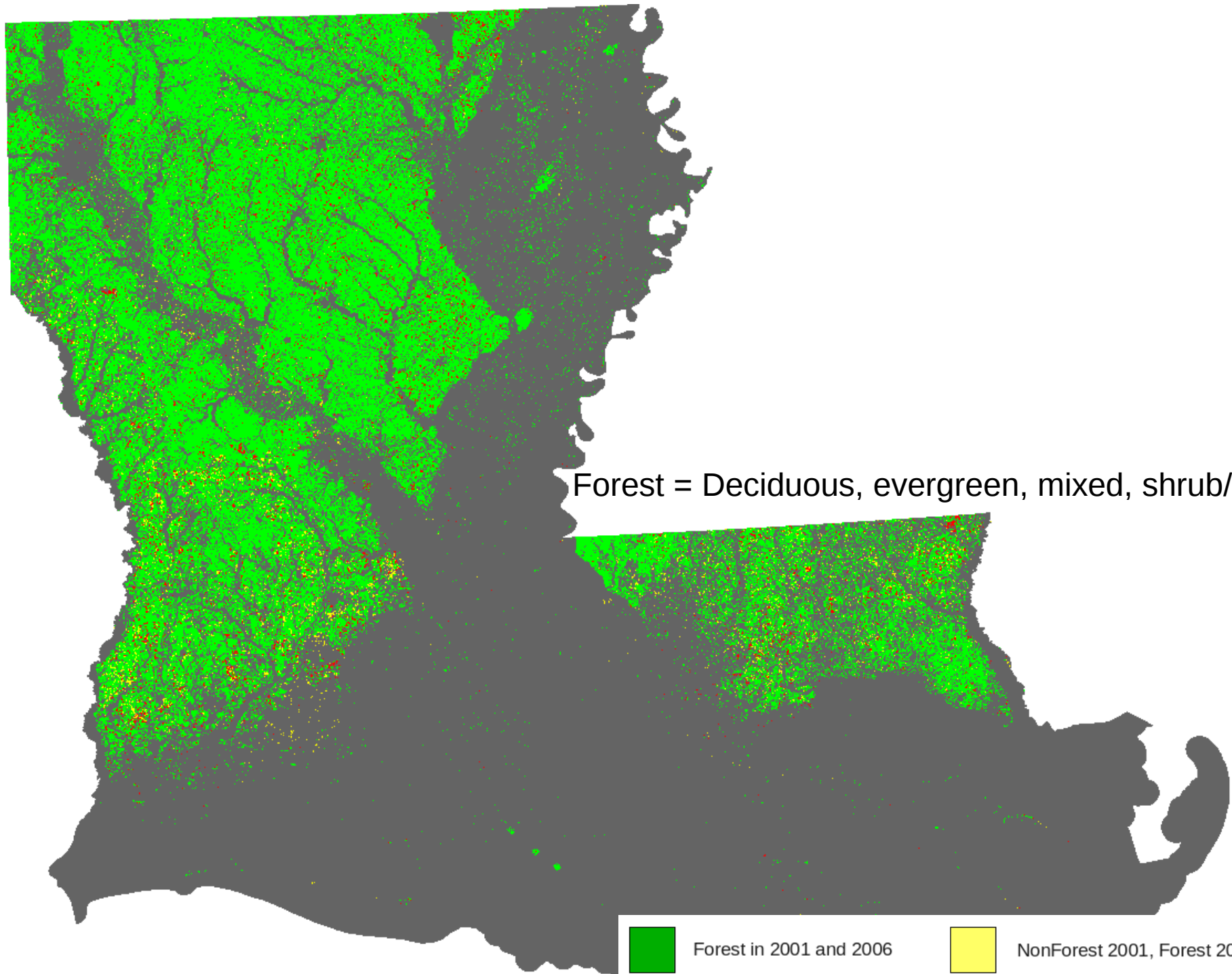
NLCD Conversion Rates for Louisiana

Option	Gross Loss	Net Loss	FIA Acres	NLCD Acres
Forest Only	1.616	-0.15	14,373,390	6,462,172
Forest + Wetlands	0.944	-0.136		12,866,640
Forest + Shrub/Scrub	0.903	0.347		8,444,743
Forest+Wetlands+ Shrub/Scrub	0.534	0.148		14,849,211

*Loss is annual percent
Negative net loss is a forest gain



Forest gain with this classification option



Forest loss with this classification option

Conversion rates from FIA data

- FIA data removes uncertainty due to classification of forest and non-forest
- NLCD is wall-to-wall, but FIA is a sample
- Estimates from samples are prone to errors
 - *Type I – accepting H_0 when false
 - *Type II – rejecting H_0 when true
 - Power = $1 - \text{Type II}$
 - Control Type II error with sample size
- FSC controlled wood involves 2 hypotheses
 - *gross loss < 0.5 and net loss < 0
 - *should adjust Type I error to account for this

A study to determine the sample size required to test for Gross loss < 0.5 and net loss < 0

RESEARCH ARTICLE

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measurement

Estimating Forestland Area Change from Inventory Data

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Simple methods for estimating the proportion of land changing from forest to nonforest are developed. Variance estimators are derived to facilitate significance tests. A power analysis indicates that 400 inventory plots are required to reliably detect small changes in net or gross forest loss. This is an important result because forest certification programs may require additional precautions when wood from areas where forestland area loss is occurring is harvested or purchased. Net and gross forest area loss must be clearly differentiated to avoid confusion. Estimates of gross forest cover loss from satellite data should not be equated with net forest area

harvested from those that have moved into a nonforest use. FIA defines forestland as land that is at least 10% stocked with trees of any size or that formerly had such tree cover and is not currently developed for a nonforest use. The minimum area for classification of

Table 3: Binomial Type I and Type II errors for $n = 200$ and $n = 400$, where $H_0 : p = 0.02$ and $H_a : p = 0.05$. The Type I and II error columns are derived from eq (B.2) and eq (B.3). The critical value, n_c , is the number of plots going from forest to non-forest.

n_c	n=200			n=400		
	Type I	Type II	Power	Type I	Type II	Power
1.0000	0.9937	0.0000	1.0000	1.0000	0.0000	1.0000
2.0000	0.9613	0.0004	0.9996	0.9995	0.0000	1.0000
3.0000	0.8785	0.0023	0.9977	0.9975	0.0000	1.0000
4.0000	0.7385	0.0090	0.9910	0.9903	0.0000	1.0000
5.0000	0.5617	0.0264	0.9736	0.9722	0.0000	1.0000
6.0000	0.3840	0.0623	0.9377	0.9353	0.0001	0.9999
7.0000	0.2359	0.1237	0.8763	0.8730	0.0002	0.9998
8.0000	0.1307	0.2133	0.7867	0.7832	0.0006	0.9994
9.0000	0.0656	0.3270	0.6730	0.6700	0.0017	0.9983
10.0000	0.0300	0.4547	0.5453	0.5437	0.0042	0.9958
11.0000	0.0126	0.5831	0.4169	0.4170	0.0094	0.9906
12.0000	0.0048	0.6998	0.3002	0.3018	0.0190	0.9810
13.0000	0.0017	0.7965	0.2035	0.2060	0.0355	0.9645
14.0000	0.0006	0.8701	0.1299	0.1328	0.0614	0.9386
15.0000	0.0002	0.9219	0.0781	0.0808	0.0990	0.9010
16.0000	0.0001	0.9556	0.0444	0.0466	0.1499	0.8501
17.0000	0.0000	0.9762	0.0238	0.0254	0.2145	0.7855
18.0000	0.0000	0.9879	0.0121	0.0132	0.2912	0.7088
19.0000	0.0000	0.9942	0.0058	0.0065	0.3771	0.6229
20.0000	0.0000	0.9973	0.0027	0.0030	0.4680	0.5320

For n=200, 10 plots must be converted to get type I < 0.05. The power is too small for a reliable test.

For n=400, 16 plots must be converted to get type I < 0.05. The power is sufficient for a reliable test.

FIA data for conversion rates: Conclusions

- No state that had remeasured annual inventory data had statistically significant net or gross forest loss
- Can't get reliable estimates with less than 400 remeasured plots
 - *1 plot per 6000 acres X 400 plots = 2.4 million acres
 - Lake states have 1 plot per 3000 acres

Summary

- Gross loss and net loss can be used to summarize forest change.
- Gross loss by itself can be deceptive
- It's difficult to differentiate bare land from forest with remote sensing
 - *Hence gross loss but not net loss can be estimated from satellite data
- Sample size is critical when estimating conversion rates from FIA data