Emerging trends in the management of Maine's forest: Where are we headed and can it be modeled?

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New Trends?

Forests in Maine

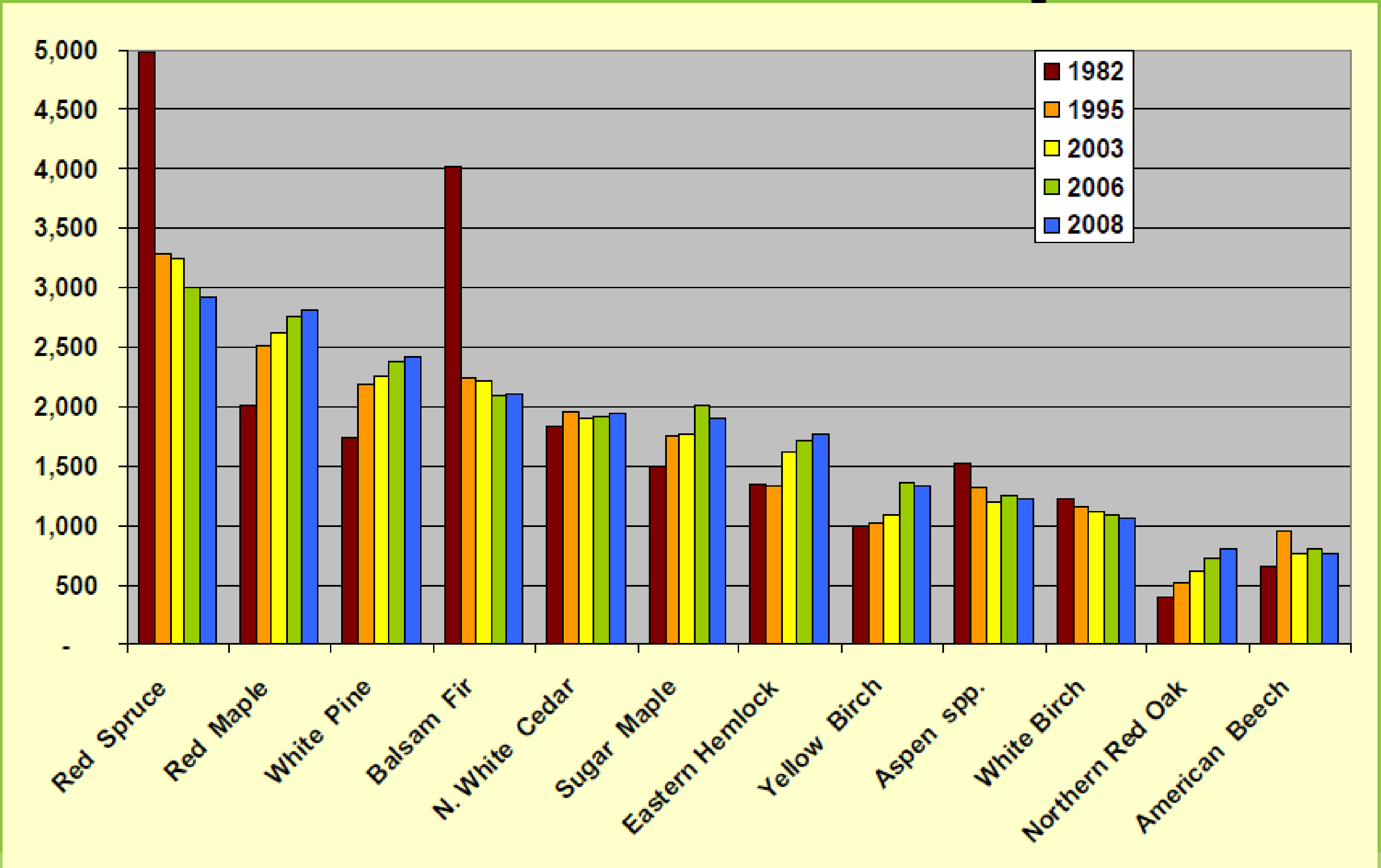
- **Most** forested state in the US
  - 7.3 million ha - 90% of land area
- Forest product industry contributes an annual **$2.2 billion** to the state's economy,
- Largest contiguous block of privately owned commercial forest in US (**4 million ha)**

Introduction

	ALL FORESTS			PRIVATELY-OWNED FORESTS		
	Contribution to GDP-- All Forests		Percentage of State GDP	Contribution to GDP-- Private		Percentage of State GDP
TOTALS	**$**	**115,191,955,000**	**1.20%**	**$**	**102,126,114,970**	**1.06%**
Northeast	**$**	**6,434,118,000**	**0.55%**	**$**	**6,071,694,440**	**0.52%**
Maine	$	2,270,550,000	4.90%	$	2,247,844,500	4.85%
New Hampshire	$	526,807,000	0.94%	$	489,930,510	0.87%
New York	$	3,228,979,000	0.31%	$	2,938,370,890	0.28%
Vermont	$	407,782,000	1.65%	$	395,548,540	1.60%
Appalachia	**$**	**15,188,101,000**	**1.07%**	**$**	**13,514,477,130**	**0.96%**
Kentucky	$	2,620,482,000	1.79%	$	2,568,072,360	1.75%
Maryland	$	848,107,000	0.34%	$	814,182,720	0.32%
Ohio	$	4,521,293,000	1.01%	$	3,843,099,050	0.86%
Pennsylvania	$	6,439,337,000	1.27%	$	5,537,829,820	1.09%
West Virginia	$	758,882,000	1.36%	$	751,293,180	1.35%

Forestry still matters in Maine

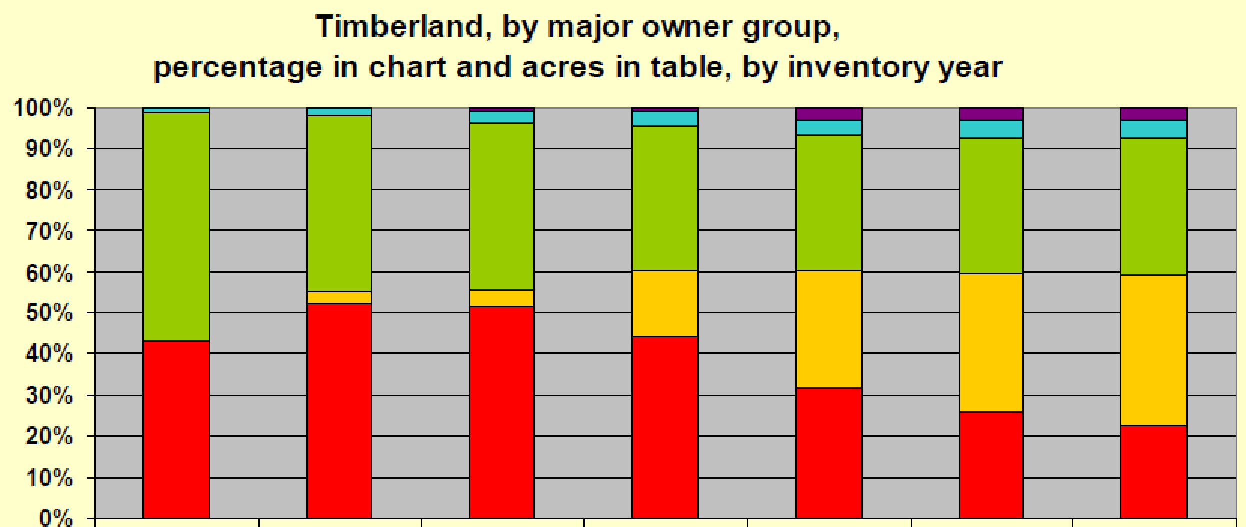
Current forest composition



Laustsen (2010)

Reductions in red spruce and balsam fir; increases in red maple and white pine

Forest Ownership Patterns

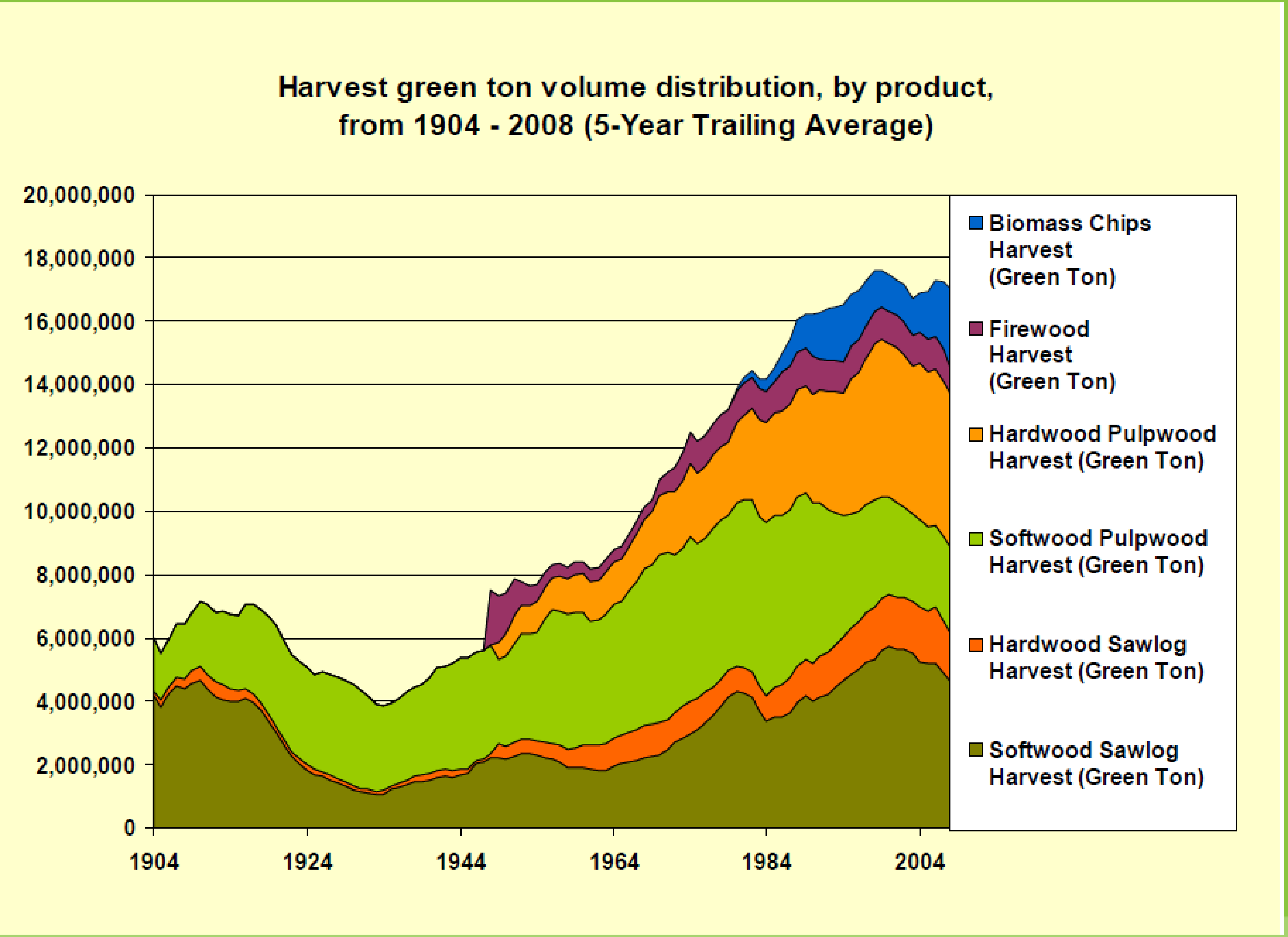


	1959	1971	1982	1995	2003	2005	2006
Misc. Large Private	-	-	118,153	100,399	475,208	509,081	504,061
Public	216,000	311,500	495,746	627,957	743,542	756,707	771,236
Family Forests	8,440,000	6,797,200	6,579,406	5,935,261	5,648,088	5,700,469	5,705,685
Corporate Investor	-	408,500	656,756	2,702,735	4,865,170	5,751,145	6,302,971
Forest Industry	6,521,000	8,255,000	8,286,336	7,446,258	5,470,094	4,443,205	3,865,592

Laustsen (2010)

Corporate inventors are the predominant owner of forests now

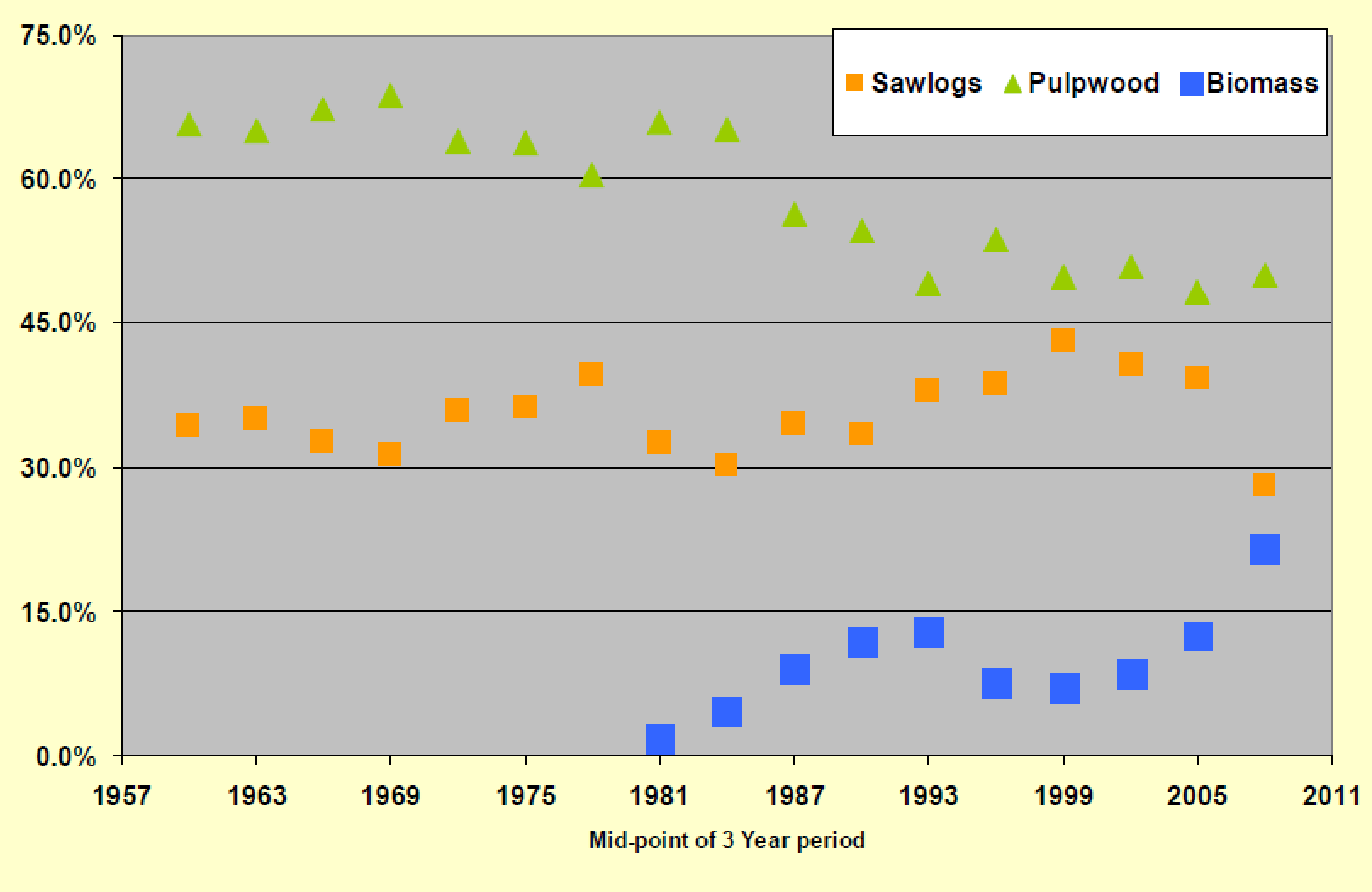
Forest Harvest Patterns



Laustsen (2010)

Harvest levels remain near historic highs

Forest Harvest Patterns

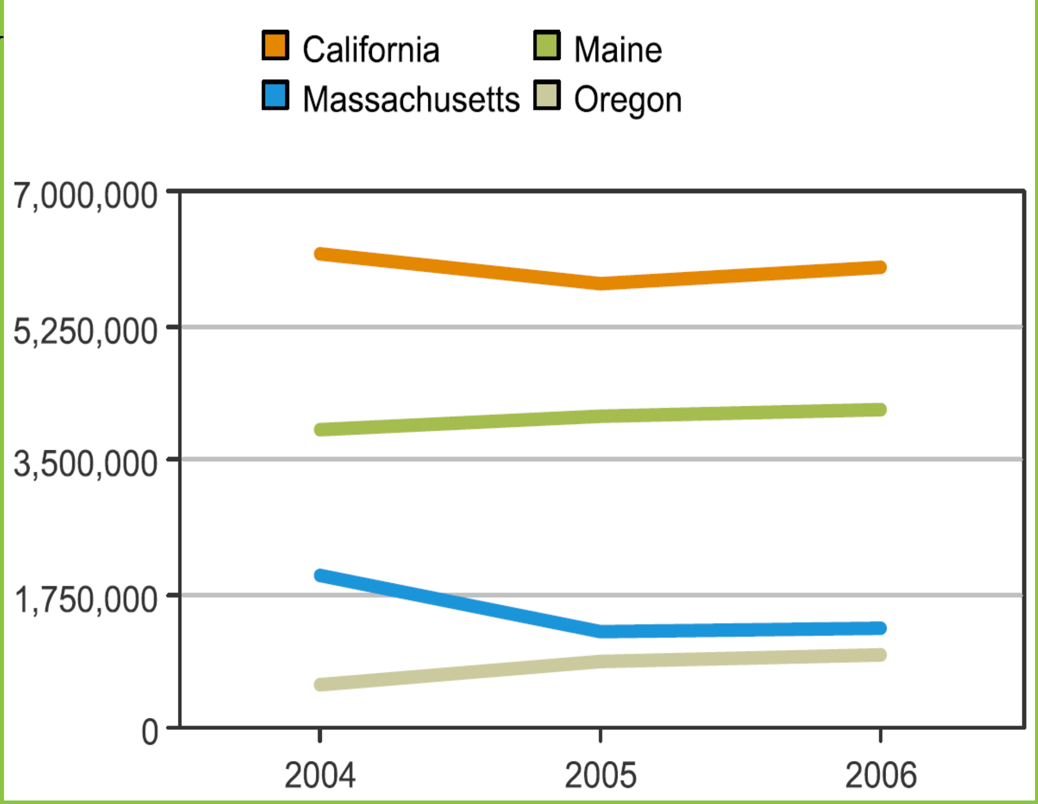


Laustsen (2010)

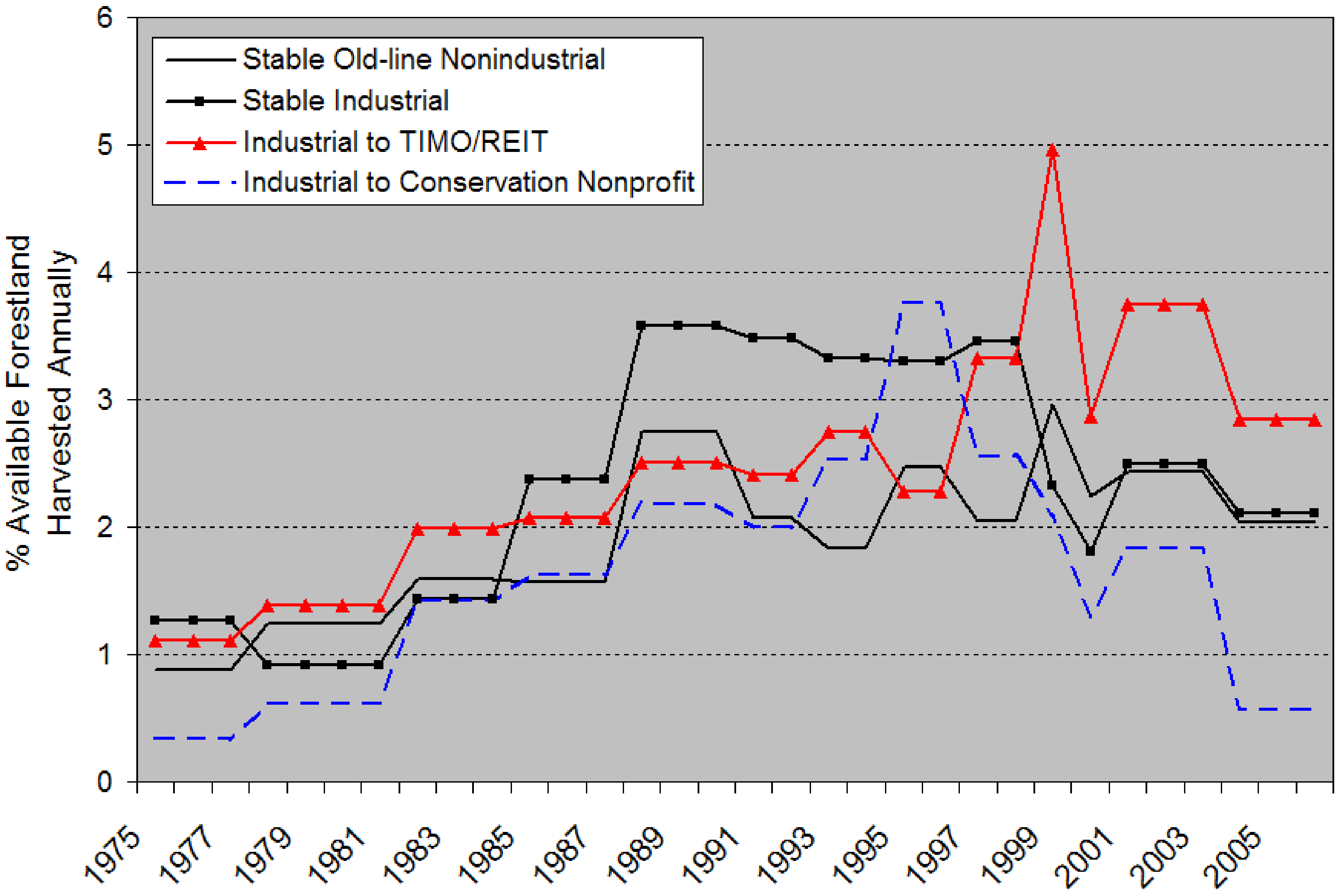
Biomass is becoming a significant contributor to the total harvest

Biomass & Bioenergy?

- Currently 7 woody biomass power plants in Maine
  - Supply 25% of Maine's energy
  - 3rd highest production in US
  - Federal subsidize for woody biomass electricity just went into effect
- 3 wood pellet mills
- Significant interest in renovating old paper mills for bioethanol production



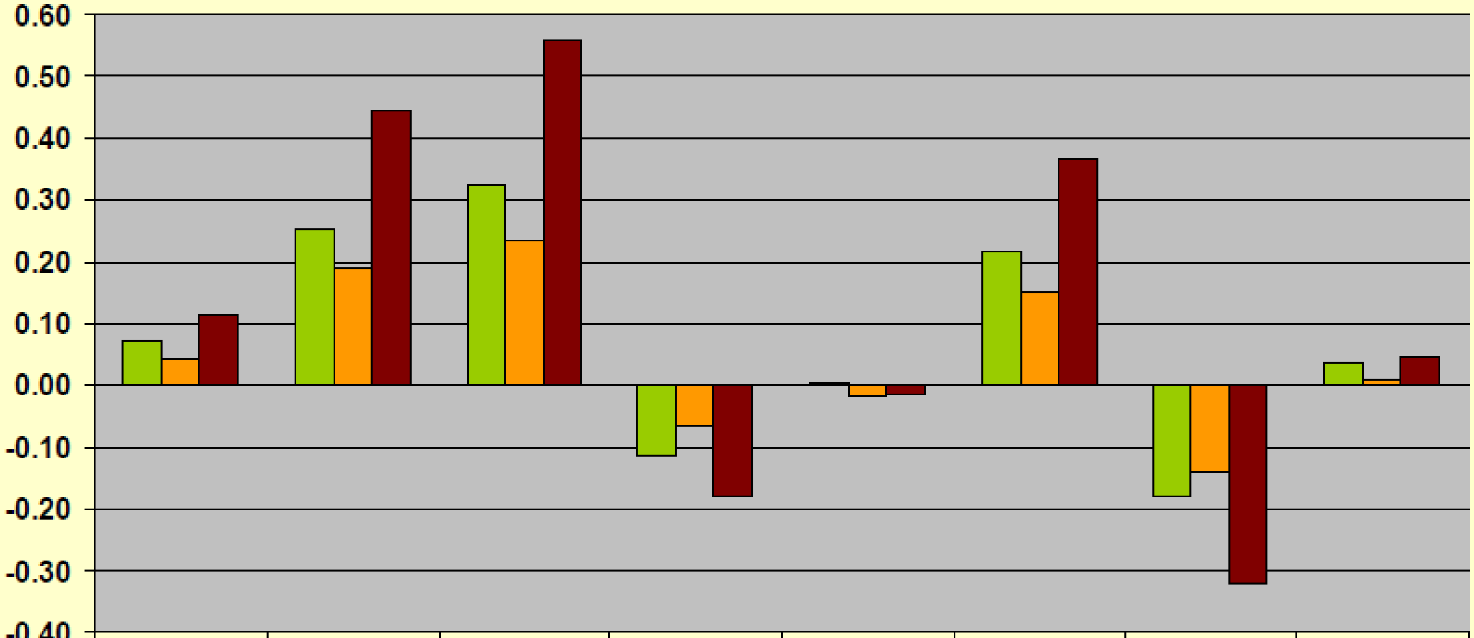
Who’s harvesting what?



Sader et al. (2005)

Corporate investors are harvesting at elevated rates

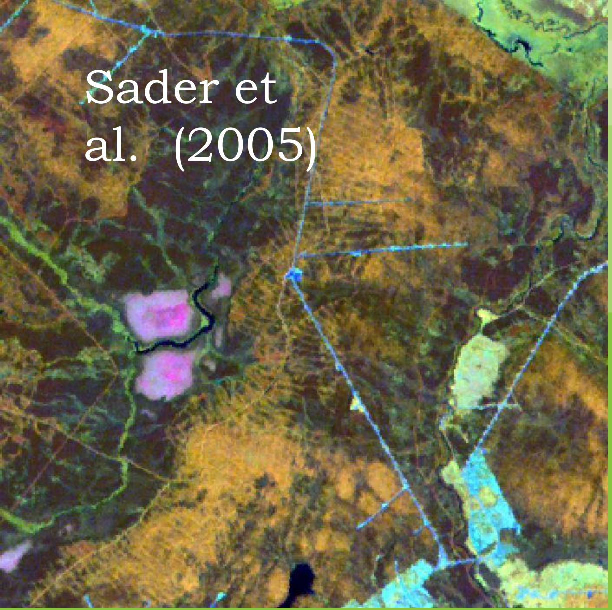
Sustainable?



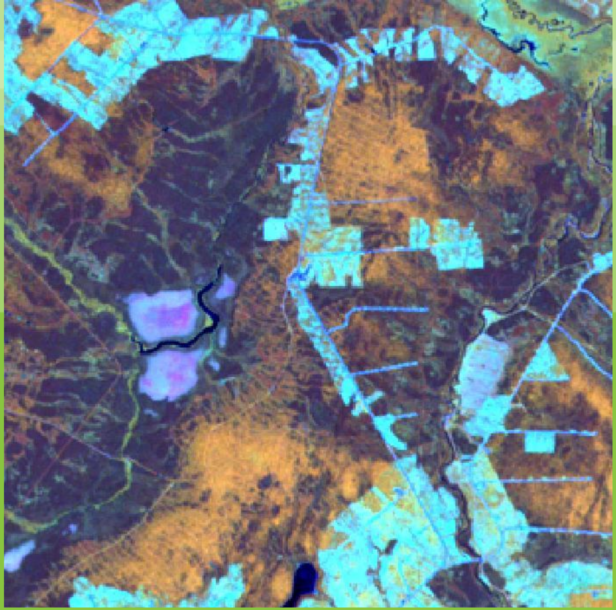
	Ingrowth	Accretion	Gross Growth	Mortality	Net GS Increment	Net Growth	Total Removals	Net Change
All Softwoods	0.07	0.25	0.32	-0.11	0.00	0.22	-0.18	0.04
All Hardwoods	0.04	0.19	0.23	-0.07	-0.02	0.15	-0.14	0.01
Statewide	0.11	0.44	0.56	-0.18	-0.01	0.37	-0.32	0.05

Laustsen (2010)

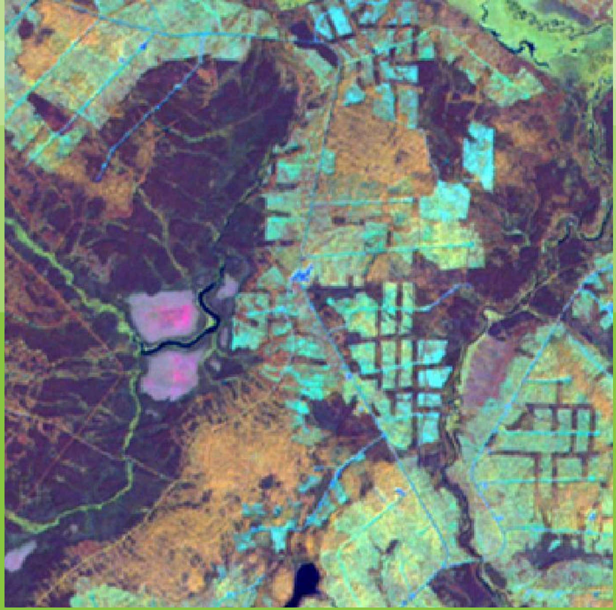
Growth still exceeds mortality and removals, but for how long?



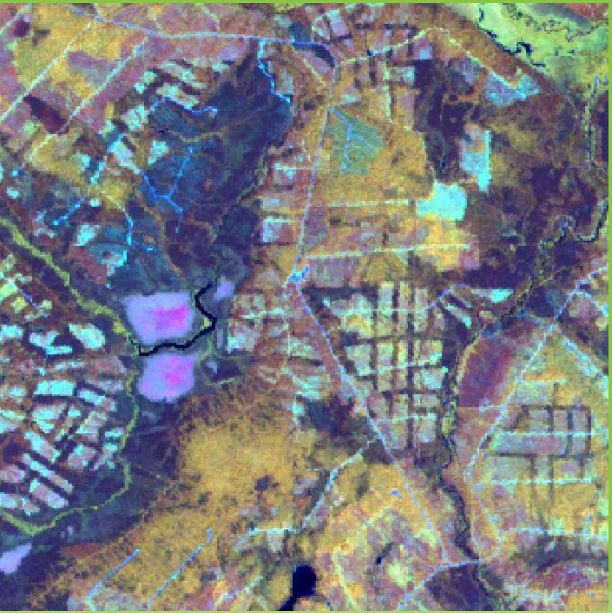
1988



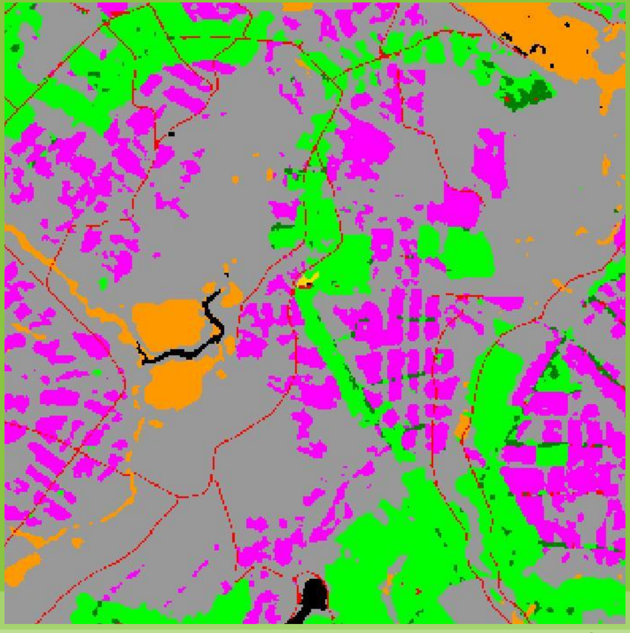
1991



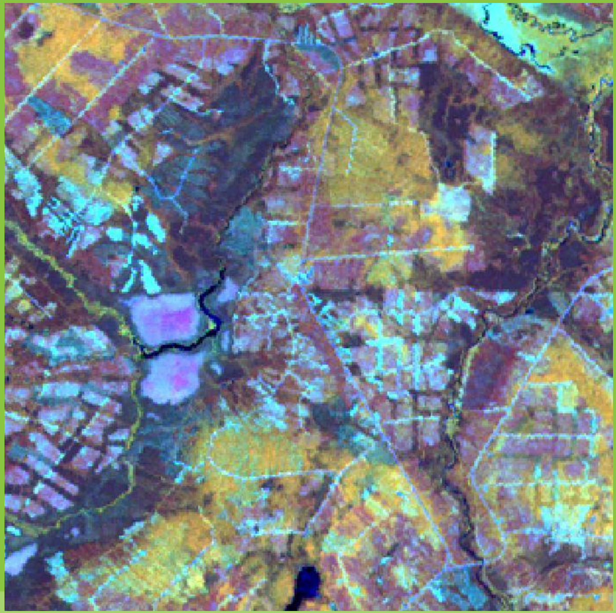
1993



2000

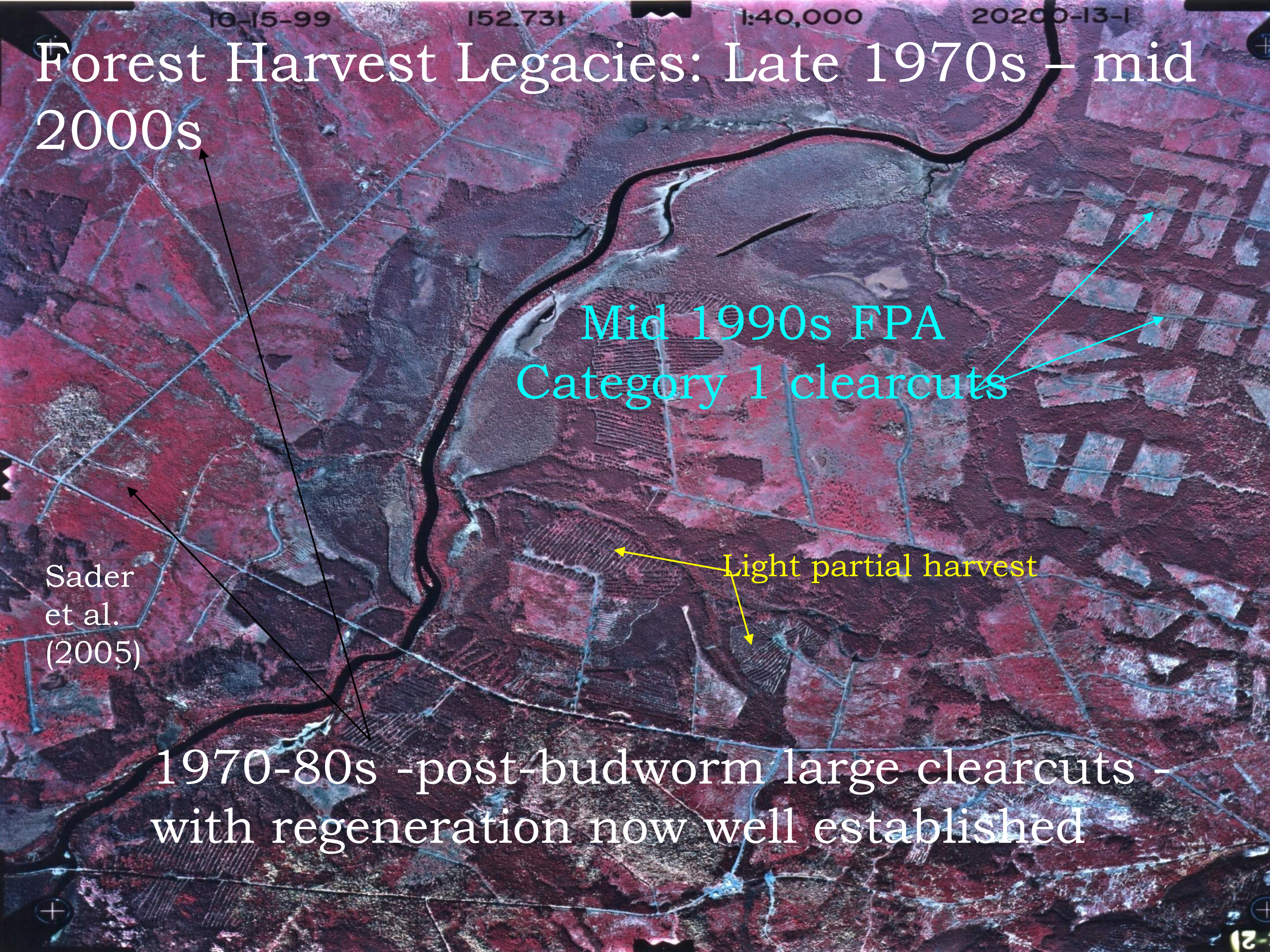


1991-2000 Forest Change

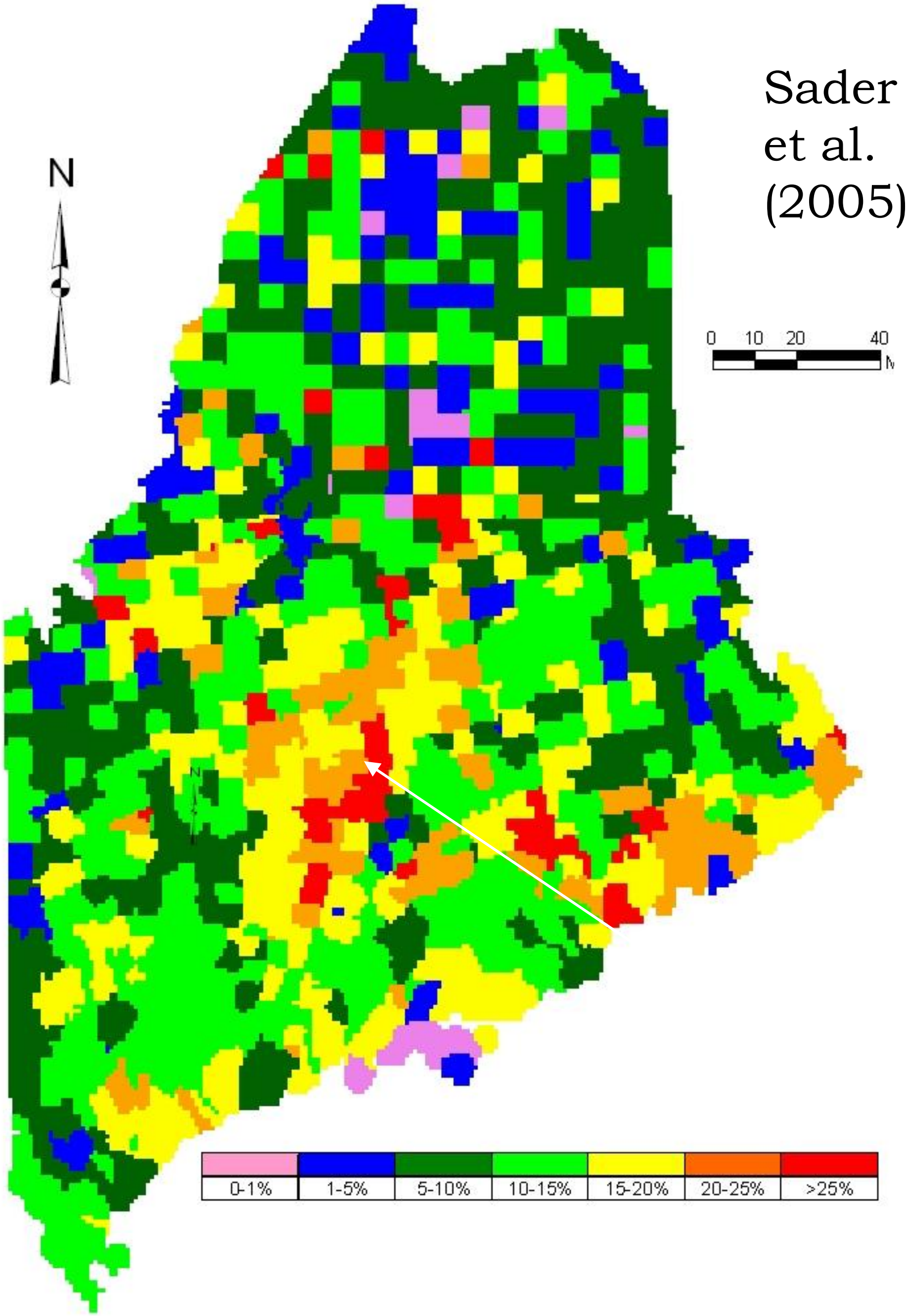


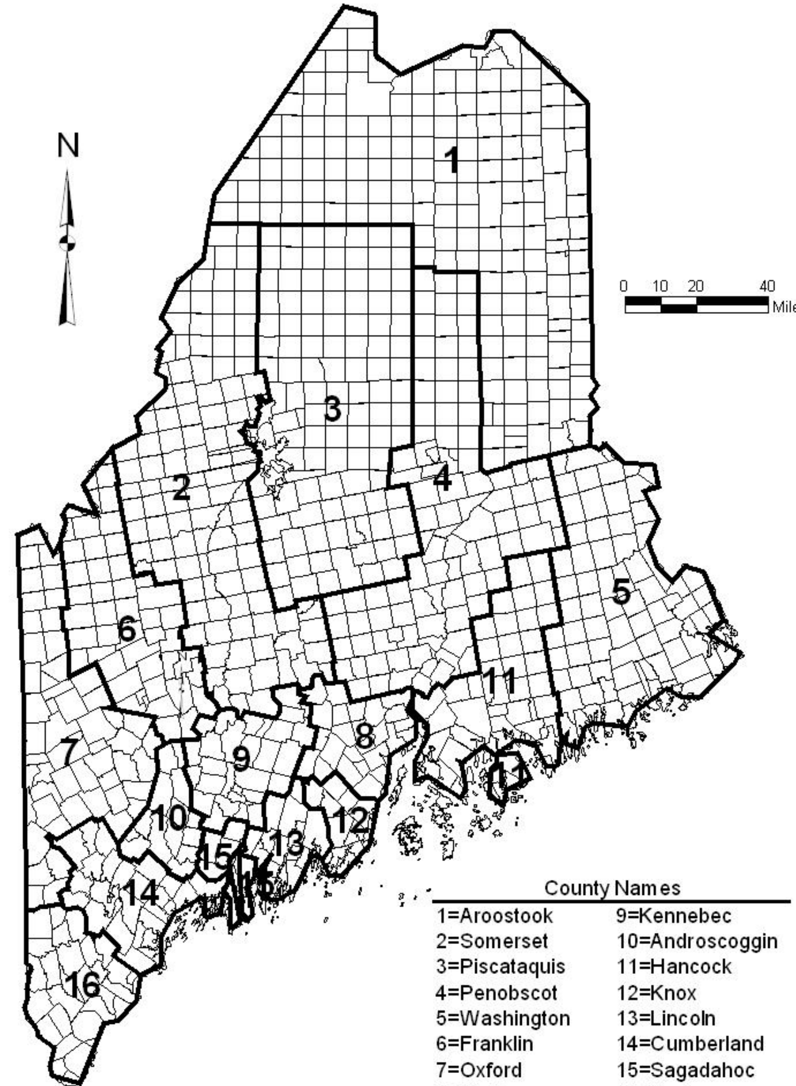
2004

Forest Harvest Legacies: Late 1970s – mid 2000s



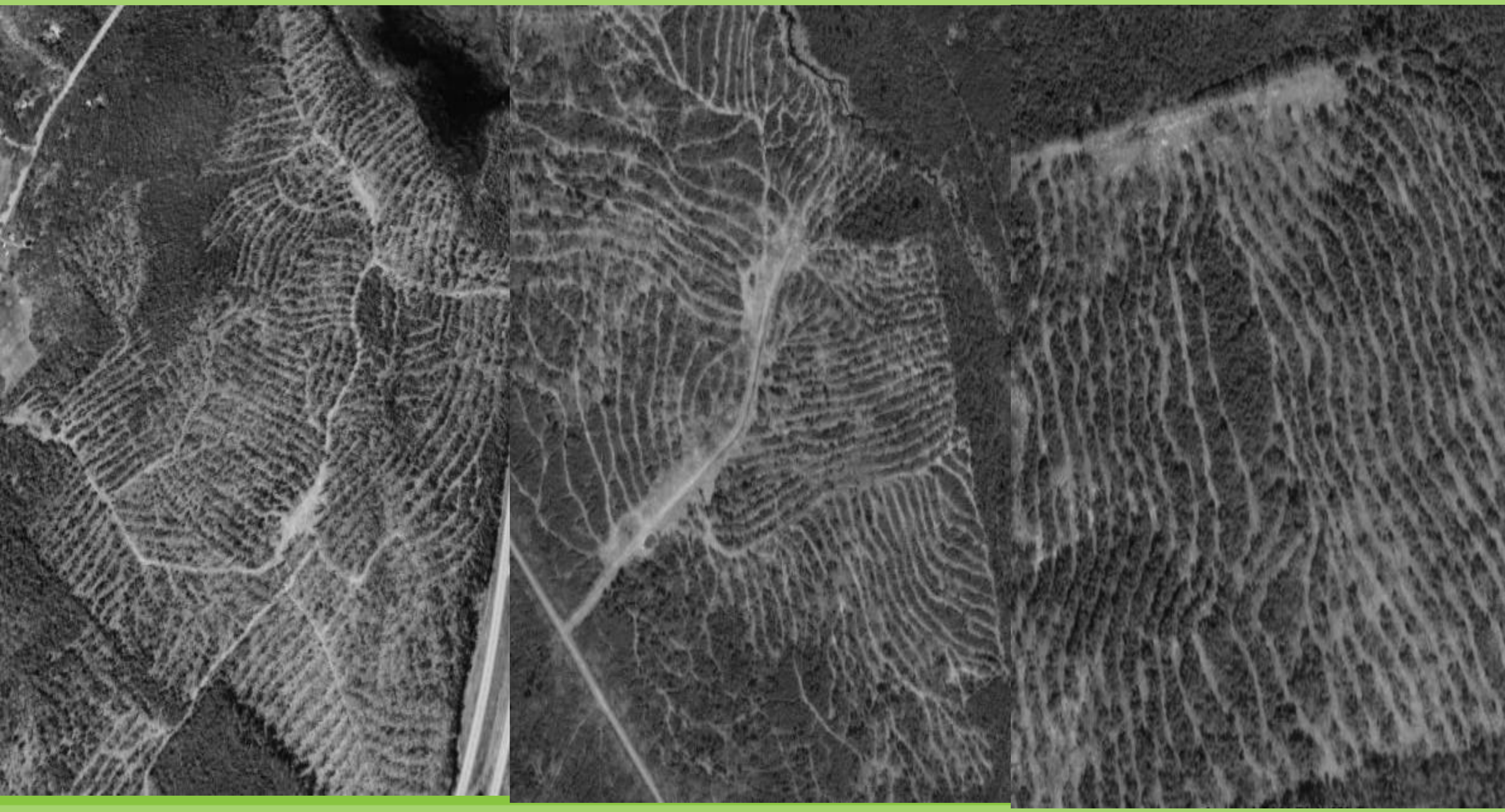
Sader et al. (2005)





Forest Disturbance Index (1991-2000) - Percentage per Maine Township

Partial Harvests



Predominant and distinctive harvest patterns

Emerging Questions

- Multiple questions about the future of the forest
  - Changing ownership
  - Increasing utilization of biomass
  - Partial harvests
  - Spruce budworm
  - Climate change
  - Habitat availability

Biomass Harvest Guidelines

	Missouri (CWM ≥ 6")	Wisconsin (CWM ≥ 4")	Minnesota (CWM ≥ 6")	Pennsylvania (CWM ≥ 6")	Maine (MFS-FSS)*
Residue	Leave 1/3 of all treetops from roundwood harvest as FWM and 1/3 of the small cut trees	Leave 10% of the FWM of all harvested trees plus all incidental FWM breakage (10-15%)	Leave 1/3 of the FWM on site (intentionally leave 20% plus 10-15% from breakage)	Leave 15-30% of total harvested biomass as CWM	
Large Logs			Retain 2-5 down logs/acre ≥ 12 inches		Retain 3 down logs/acre ≥ 15 inches and 1 ≥ 21 inches
Snags	Leave 3-6 snags/acre ≥ 10"	Leave ≥ 3 snags/acre ≥ 12", preferably ≥ 18"		Leave 1-5 snags/acre (any size)	Leave 3 snags/acre ≥ 15" and 1 per acre ≥ 21"

* Draft

Bredis (2009)

Impacts of biomass harvesting

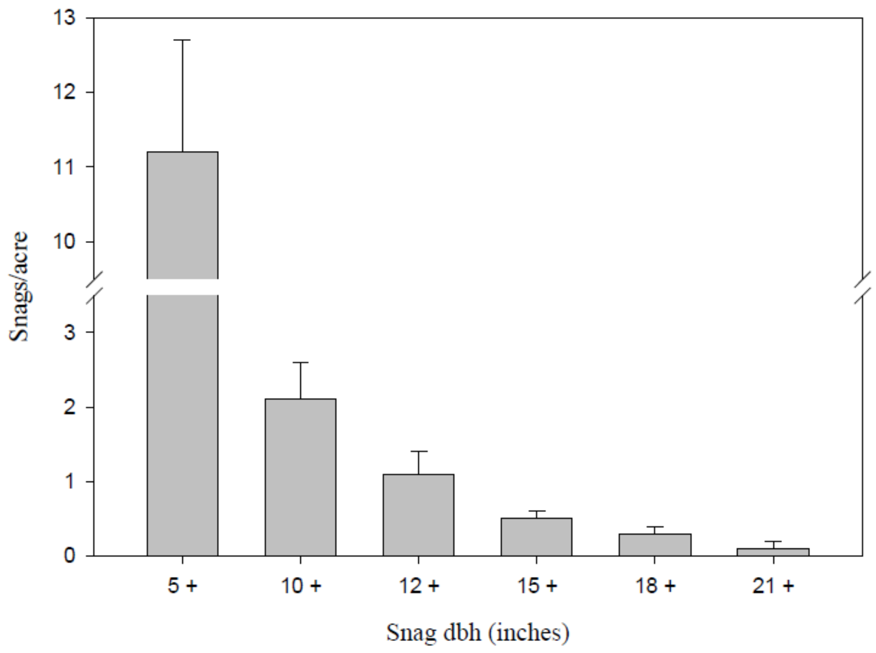
Location	Percent of total residue	Percent of total harvest
A	44.5	15.8
B	51.3	15.3
C	44.0	13.7
D	57.4	19.7
E	34.2	9.6
F	43.2	22.4
G	40.9	12.2
Avg.	45.1± 2.8	15.5 ± 1.6

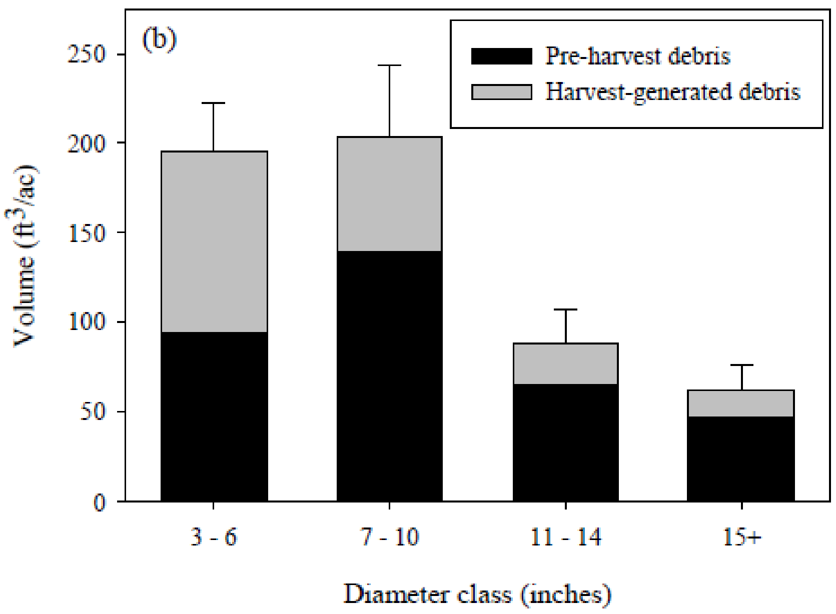
Bredis (2009)

Significant amount of biomass is left on site

Impacts of biomass harvesting

Bredis (2009)





Snags and coarse woody debris being generated by harvests, but larger piece sizes are limited

Impacts of partial harvests

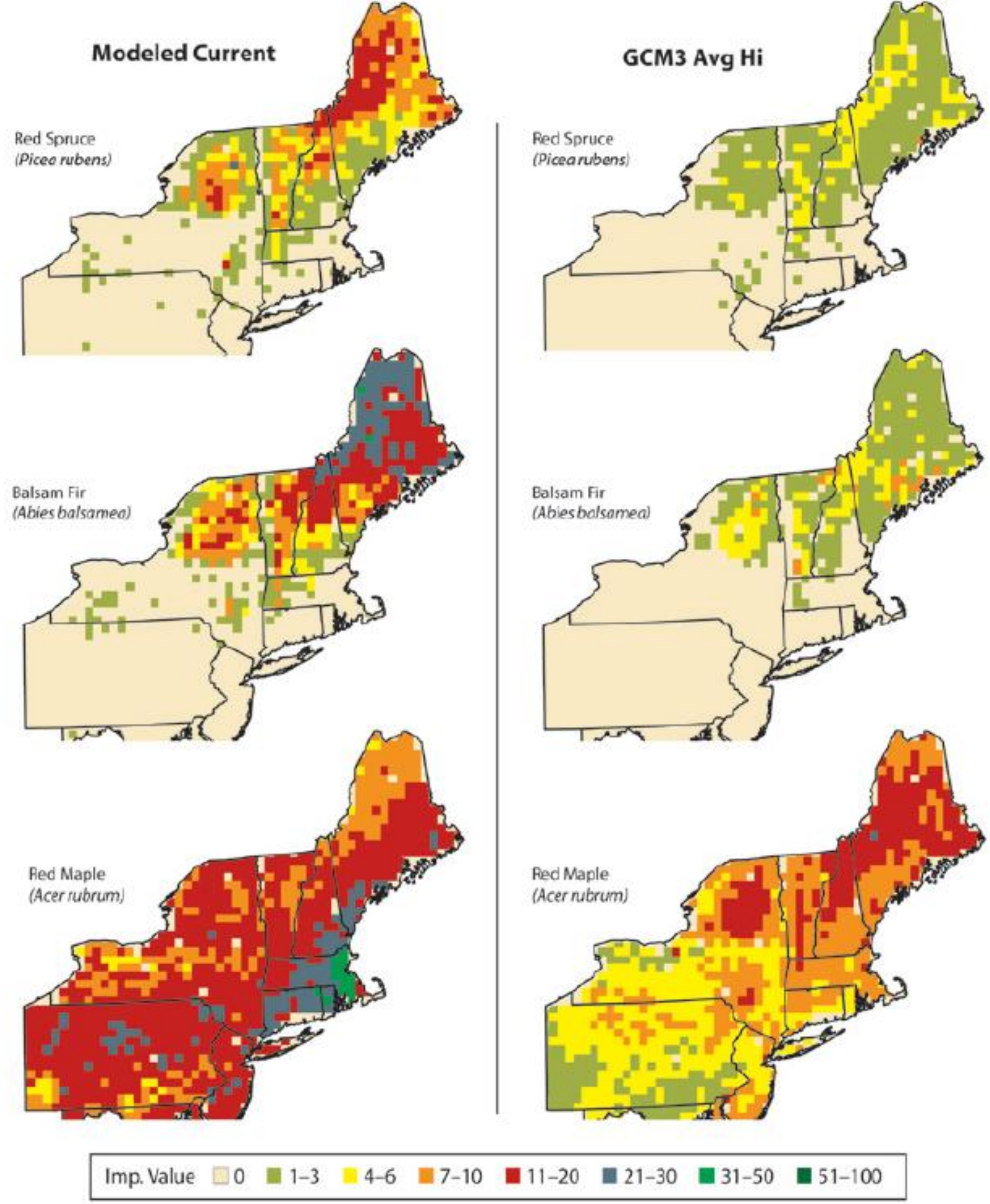
- Significant increase of area in trails
  - 23% on average
- *Rubus* overtops regeneration in trails
- Forested areas have a greater proportion of undesirable hardwoods

Greeno et al. (2010)

Climate change

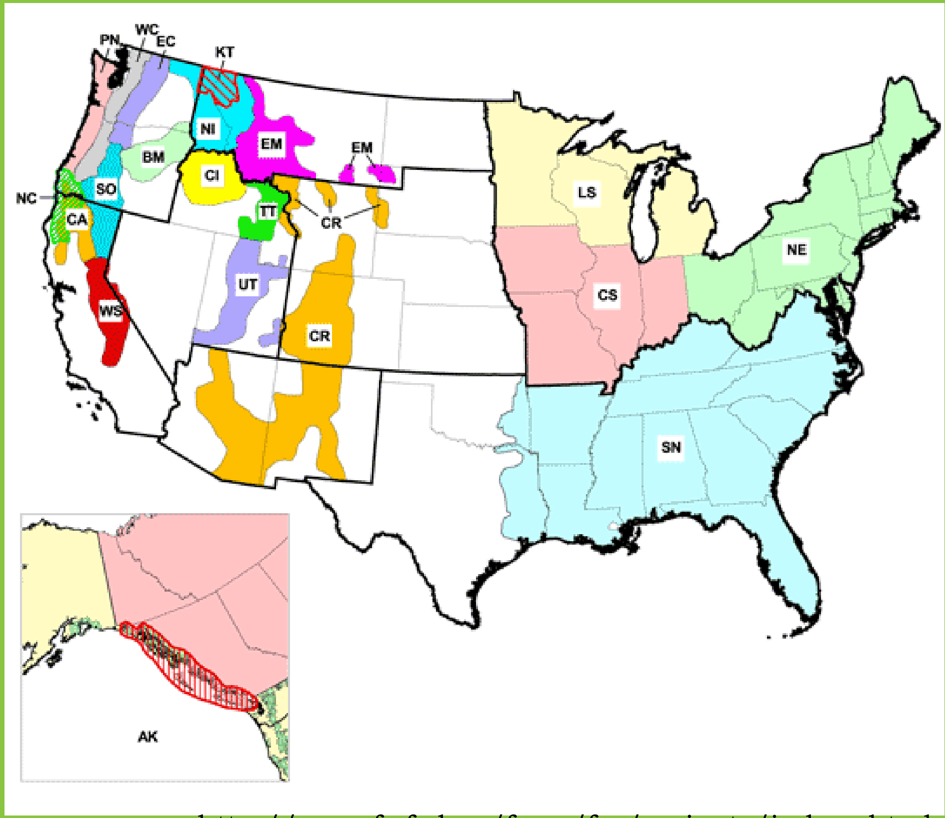
- Increased temperature and greater precip.
- Balsam fir and red spruce decrease
- Red maple increases

Iverson et al. (2008)



Predicting the future?

- Growth and yield models widely used:
  - Project inventories forward
  - Compare alternative management regimes
  - Simulate alternative futures
  - Test hypotheses
- Forest Vegetation Simulator (FVS) widely used in Maine
  - Individual tree, distance-independent empirical model
  - Northeast (NE) variant covers broad geographic area



http://www.fs.fed.us/fmsc/fvs/variants/index.shtml

Does FVS work?

- FVS doesn't explicitly model influence of management
  - Thinned stands grow like unthinned ones of the same density
- Based on long-term simulations, FVS has been found to be highly biased
  - *Underpredicts* response to thinning (-173 to -206%)
  - *Overpredicts* growth in unmanaged stands (64-67%)

Table 1- Percent errors for Forest Vegetation Simulator – Northeast Variant (FVS-NE) growth model in predicting diameter growth of red spruce and balsam fir from regional long-term thinning experiments (Saunders et al. 2007).

Tree species	Commercial Thinning	Precommercial Thinning	No Thinning
Balsam fir	yes	-206%	-13%
	no	-26%	+64%
Red spruce	yes	-173%	+4%
	no	-25%	+66%

Saunders et al. 2007

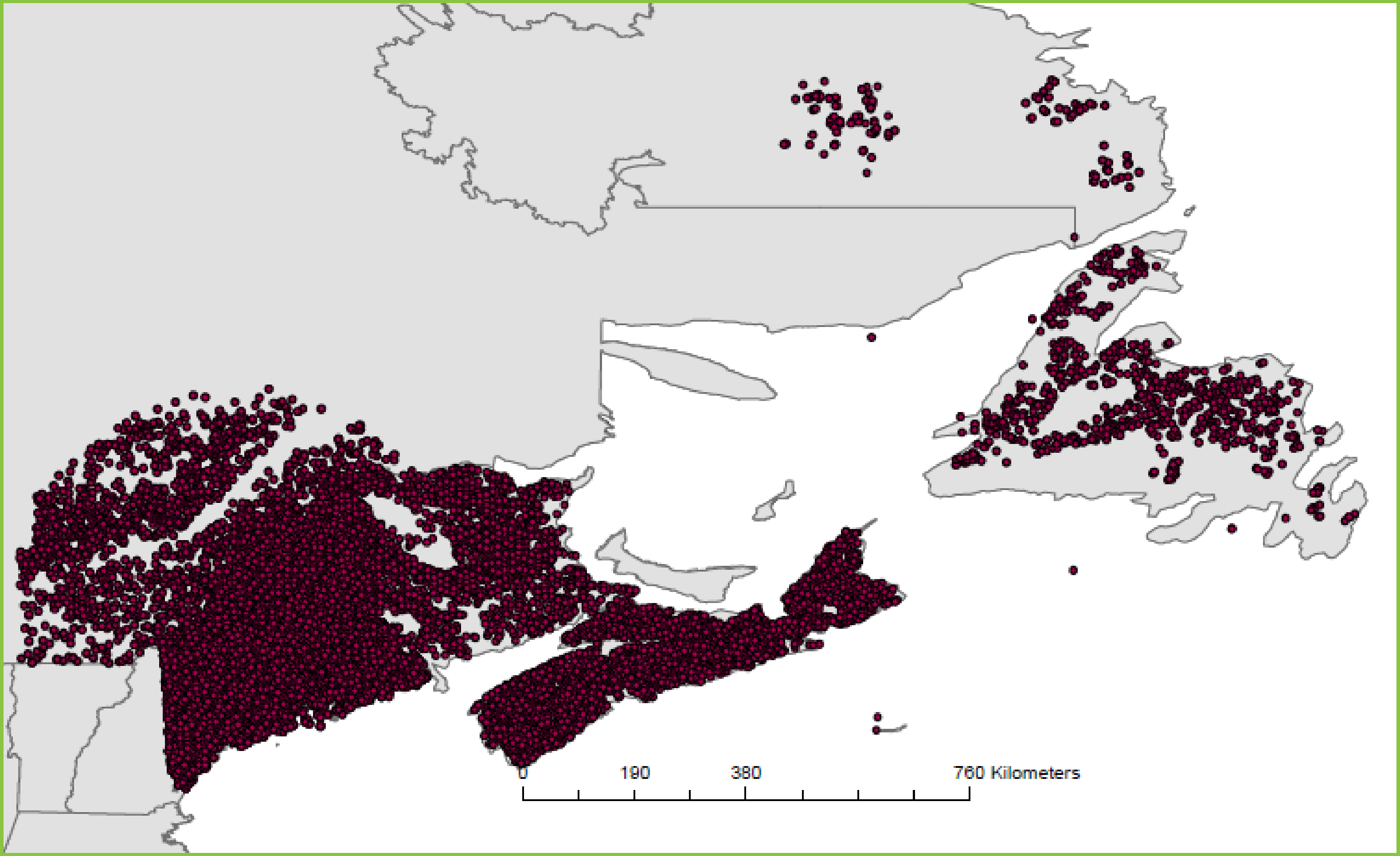
How do currently available models stack up?

	GNY	FIBER	FVS-NE	SaMARE	STAMEN
Individual tree	Stand-level	Size class	✓	✓	Size class
Forest management	✓	No modifiers	No modifiers	✓, selection cutting	No modifiers
All size classes		>4.5 inches	✓, separate equations	✓, ingrowth and overstory	
Distance-independent	✓	✓	✓	✓	✓
Flexible	Nova Scotia only	Relies on habitat type	Requires site index	Québec only; Requires climate data	New Brunswick only
Model interface	✓	✓	Unstable	✓, SAS & CAPSIS	
State of art		Developed >25 years ago	Old data and poor performance	✓, emphasis on northern hardwoods	Needs constant calibration

What to do?

- Empirical models only as good as the data used to construct them
- Compile regional growth and yield data
- Refit equations
  - Allometric (height, crown ratio, crown width, volume)
  - Diameter increment
  - Height increment
  - Mortality

The Data



Extensive database from Maine and several Canadian provinces compiled

The Data

Species	DBH (cm)					HT (m)				
	N	Mean	StDev	Min	Max	N	Mean	StDev	Min	Max
Balsam fir	958,162	11.1	6.3	2.1	94.0	518,947	8.72	4.26	0.10	28.99
Black spruce	339,278	10.6	5.9	0.5	99.0	224,090	7.81	4.06	0.10	30.47
Red spruce	303,937	15.8	7.8	2.8	118.6	213,586	11.78	4.00	0.60	35.35
Red maple	259,252	14.8	8.1	2.8	82.0	149,397	12.83	3.83	0.10	30.19
Paper birch	161,343	12.9	7.5	0.5	72.0	84,504	11.24	4.84	0.10	30.19
Sugar maple	118,852	16.8	9.7	3.3	106.2	55,153	14.41	3.88	0.55	33.90
White spruce	102,486	16.0	7.9	15.2	68.9	74,184	10.68	4.21	0.60	30.17
Northern white cedar	99,653	16.8	8.4	27.9	99.9	36,999	10.92	2.91	1.22	29.56
Yellow birch	76,809	17.0	10.7	5.6	98.0	37,609	13.03	3.87	1.00	31.49
Eastern hemlock	70,420	17.4	12.0	1.2	88.6	21,932	12.40	4.20	1.49	31.19
American beech	65,334	16.2	8.5	0.4	66.8	27,133	12.34	4.11	1.22	31.51
White pine	48,054	20.8	13.5	13.7	110.7	25,638	13.91	5.39	0.60	39.00
Quaking aspen	26,214	17.1	8.4	5.3	67.6	9,642	14.54	5.41	0.60	33.89
Overall	2,629,794	15.6	8.8	0.4	118.6	1,478,814	11.9	4.2	0.1	39.0

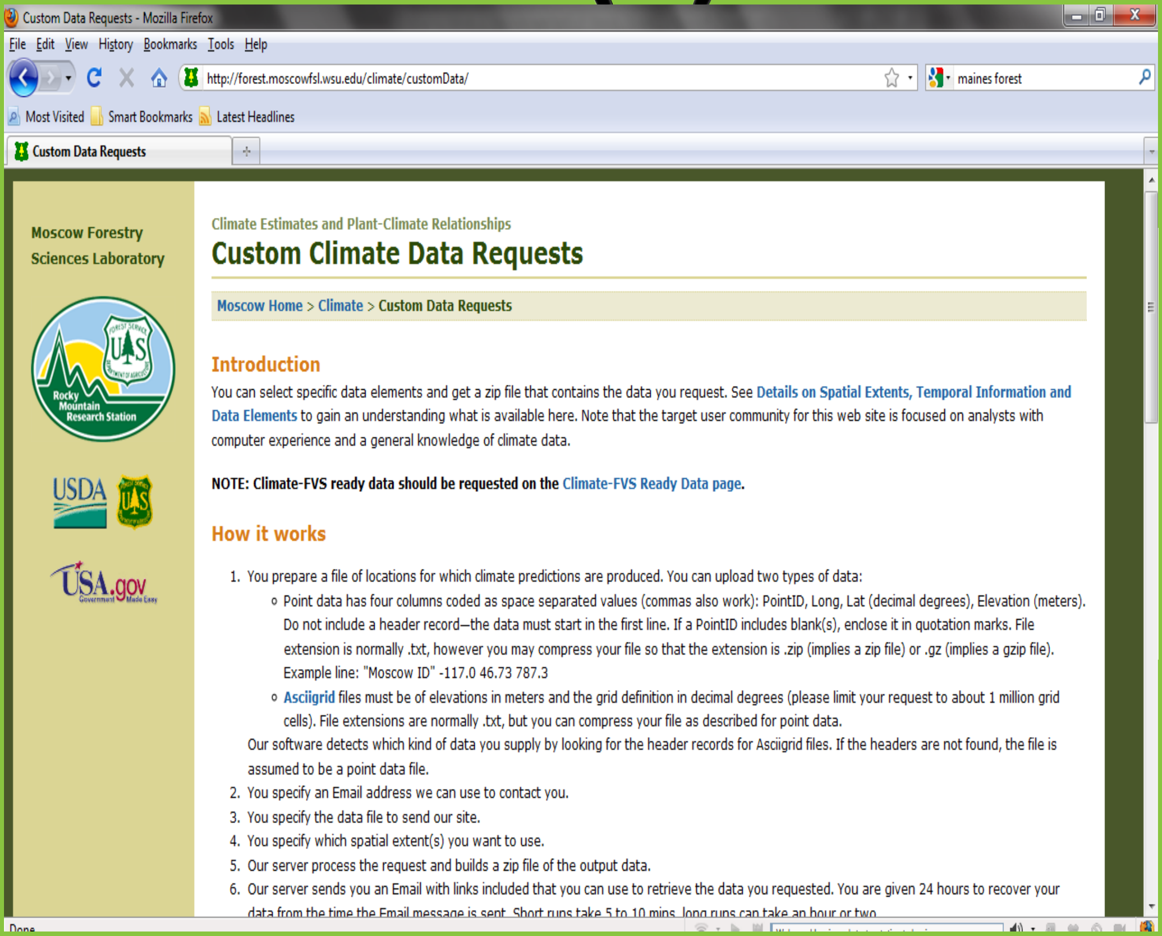
Major species are well represented, even at the extremes

Problems

- Lack of a good measure of site productivity
  - >95% of data does not have age information
  - Inconsistent climate and soils information
- Lack of site history information
  - Long history of selection harvests
- Data from over 65 individual species

Potential Solutions (?)

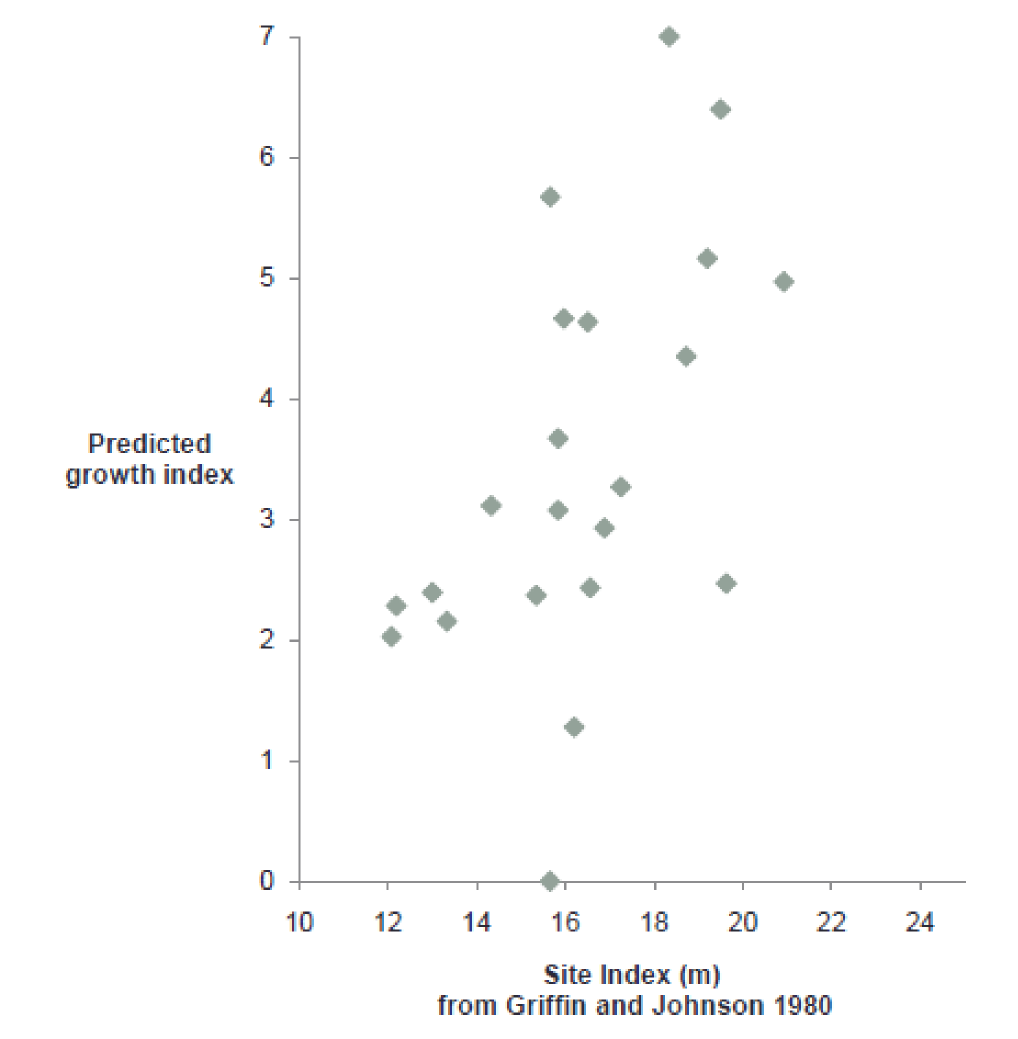
- With USFS, developed high resolution climatic surfaces for North America
  - Dependent on Lat, Long, and Elevation
  - Past & future climate
  - Easily queried via web
- Using existing algorithms, creating detailed GIS layers
  - Topographic position
  - Soil drainage



http://forest.moscowfsl.wsu.edu/climate/customData

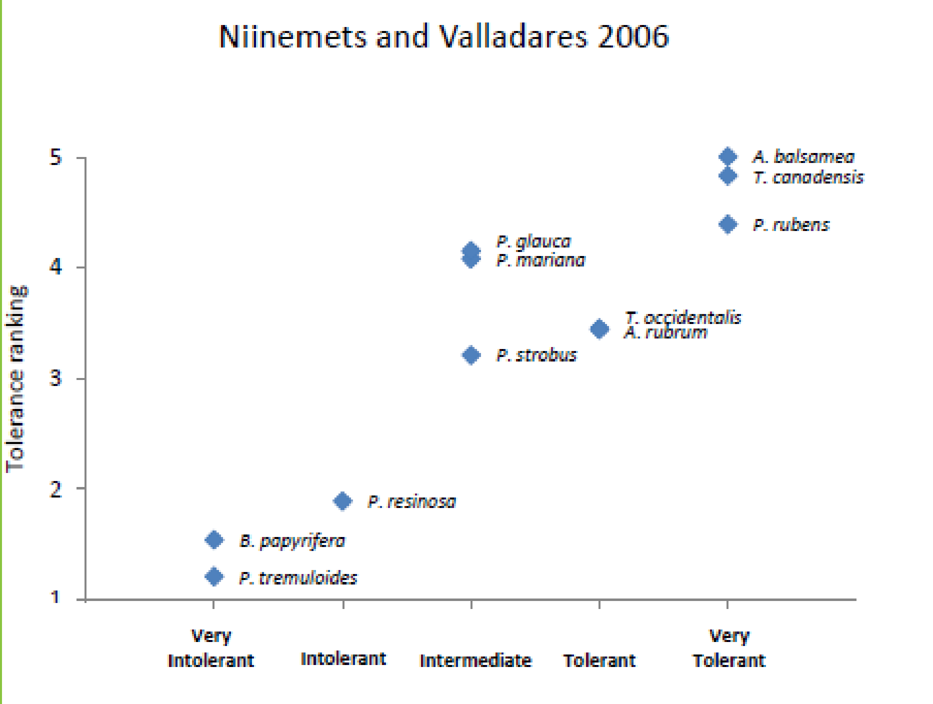
Potential Solutions (?)

- Use growth as an indicator of potential productivity
  - Both stand- and tree-level shown to be effective
  - Relate measure to climate and soil factors
  - Map relationship at high resolution
- Initial results show a reasonable relationship with observed site index



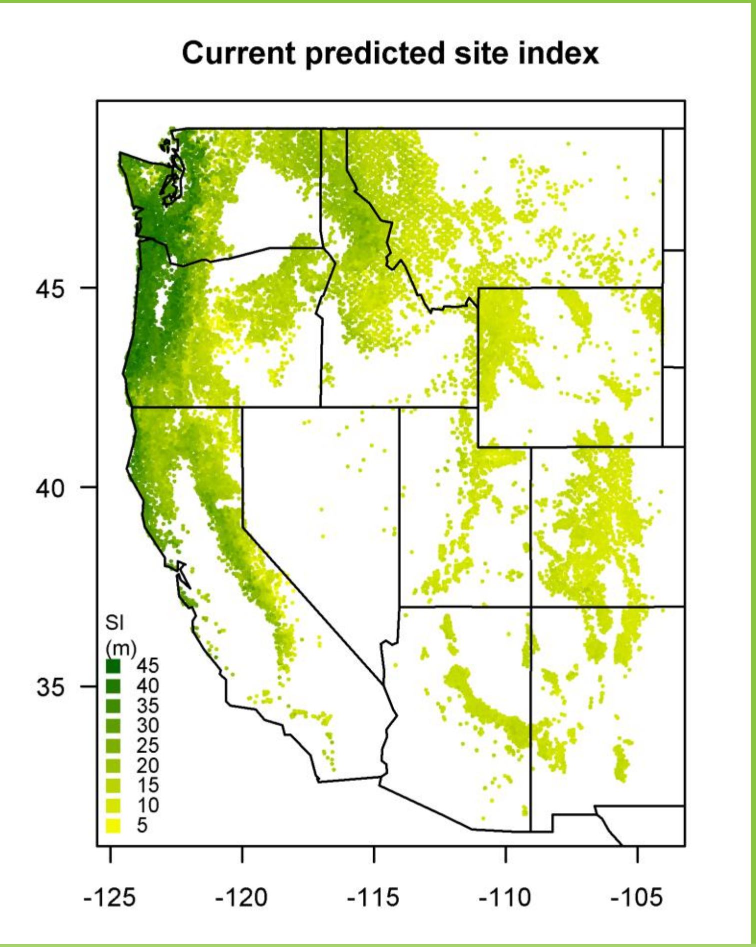
Potential Solutions (?)

- Avoid fitting species specific equations
- Quantify species differences in allometry and growth
- Initial results are promising
  - individual tree diameter growth are accounting for ~**70% of the variation** of observed growth when a unified equation (all species) is used

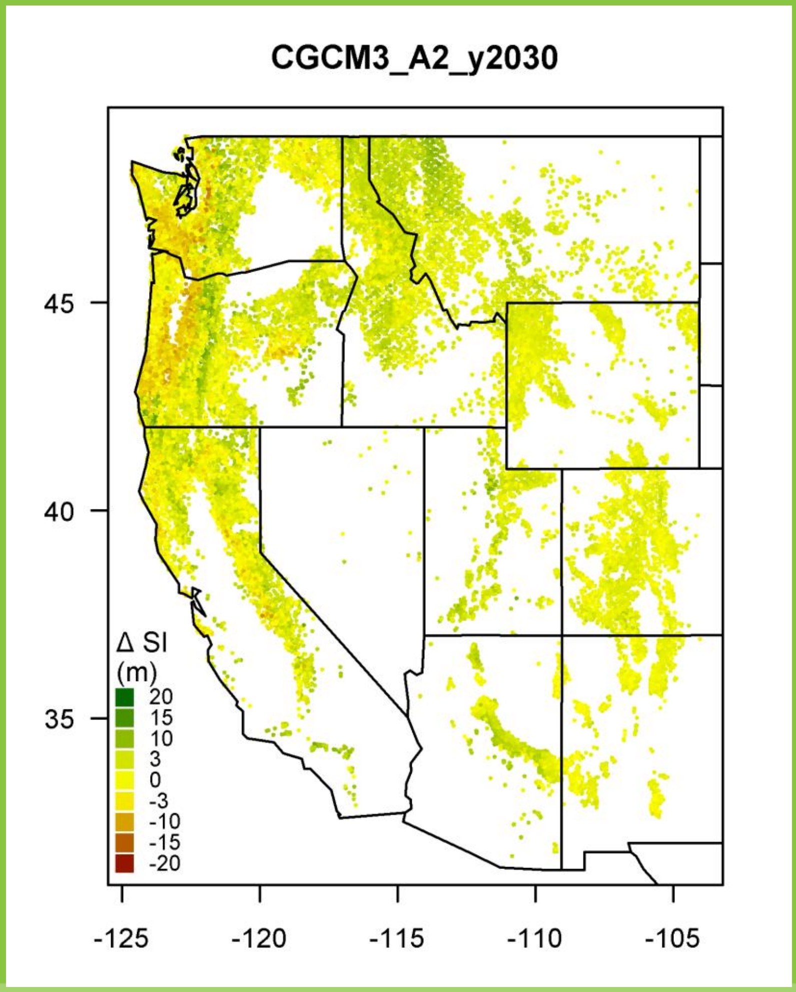


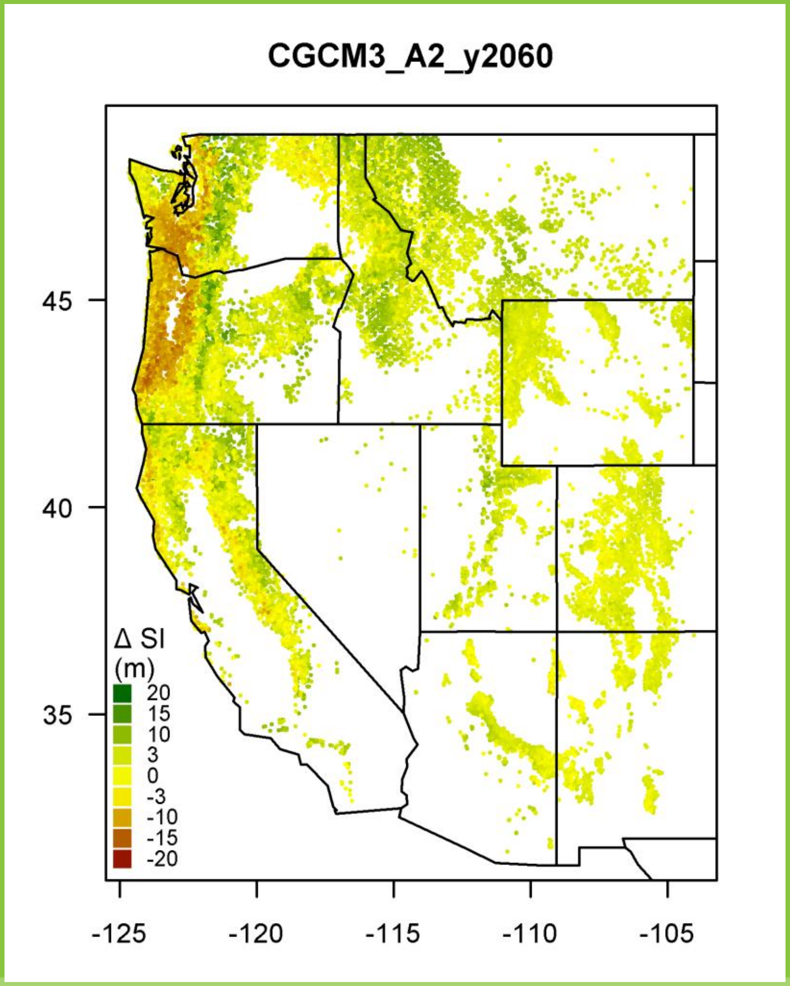
Climate Change

- Used a non-parametric regression technique and high resolution climate data
  - Explained over 73% in observed site index using 2 variables across 11 states in western US
- Mapped relationship across western US
  - Current climate
  - Future climates



Climate Change

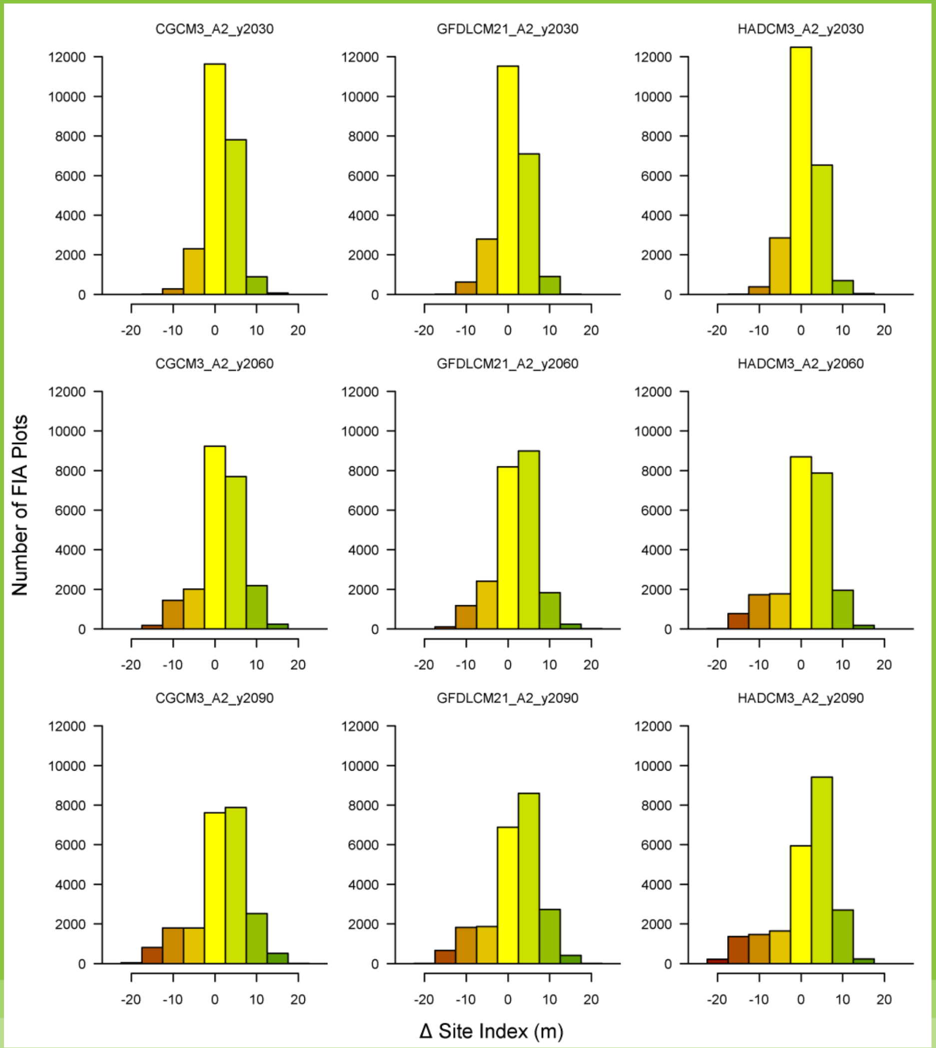




Significant changes in site index that vary by location

Climate Change

- Most areas will see a slight increase in site index of 0-5 m
- Significant reductions in some areas of 5 of 15 m
  - Coastal Pacific Northwest
- General agreement between general circulation models
  - Most of the change occurs after 2030
  - Change most drastic under Hadley Center model



Summary

- Forestry in Maine faces many complex issues
- High uncertainty on the long-term influence of current practices
- Growth models will continue to play a big part in shaping management decisions
- Preliminary results are promising, but much more work needs to be done

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Questions/Comments