U.S. LUC Analyses in RPA National Assessments and Interfaces with the Forest and Agriculture Sector Optimization Model-Green House Gases (FASOMGHG)—Linkages Across the Land Base

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Western Forest Economics Meeting—May 5, 2009

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Sources of Support

USDA Forest Service
USEPA

Outline of Talk

- **Land Conservation Policy Issues**
- **RPA Assessments and Total Land Base**
- **RPA and FASOM-GHG Modeling Ties**
- **Preliminary Results**
- **Summary and Wrap-Up**

Preventing GHG Emissions Through Avoided Land-Use Change

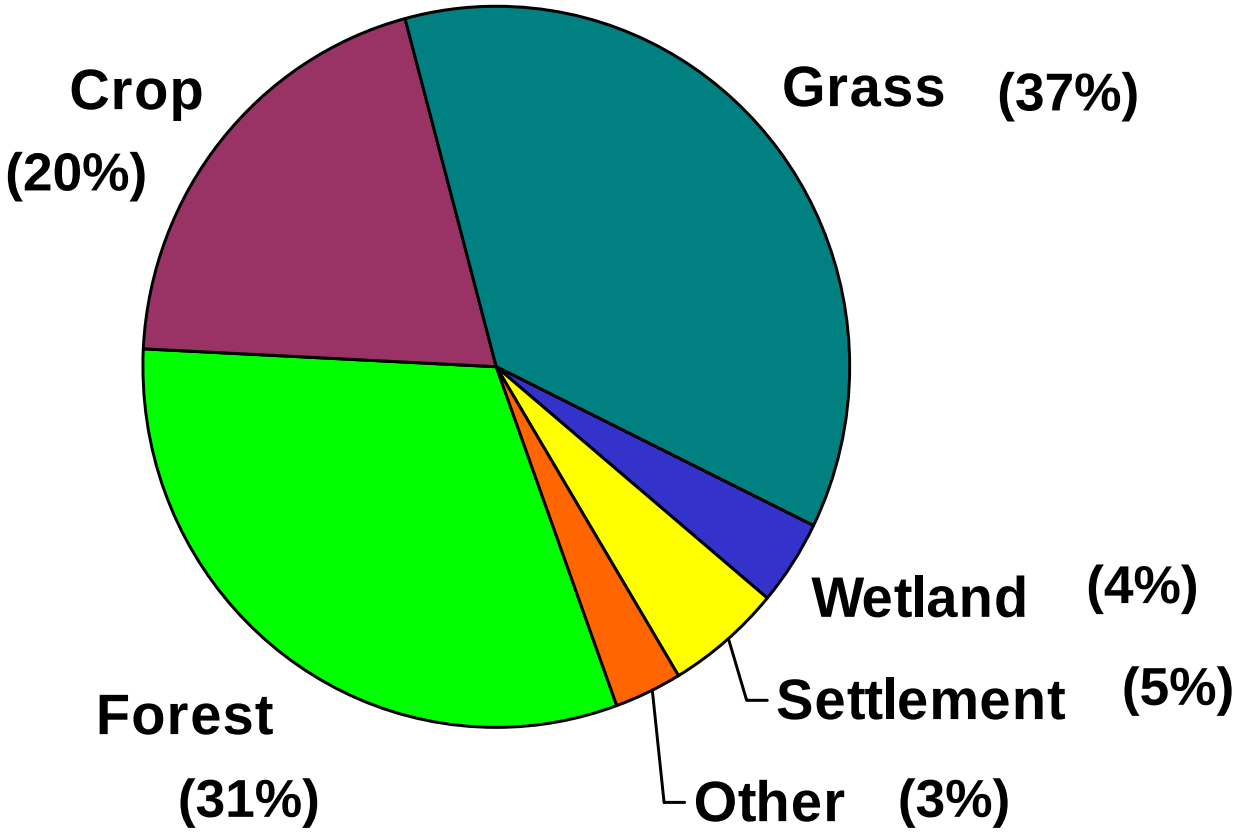
- April/May 2008: Society of American Foresters Task Force on Climate Change
- Globally, 1/3 of total carbon-related emissions between 1850 and 1998 due to forestland conversions
- Tools for Forest Retention or “Keeping Forests in Forests,” e.g., conservation easement
- Market-related effects for certain forest retention scenarios

Background

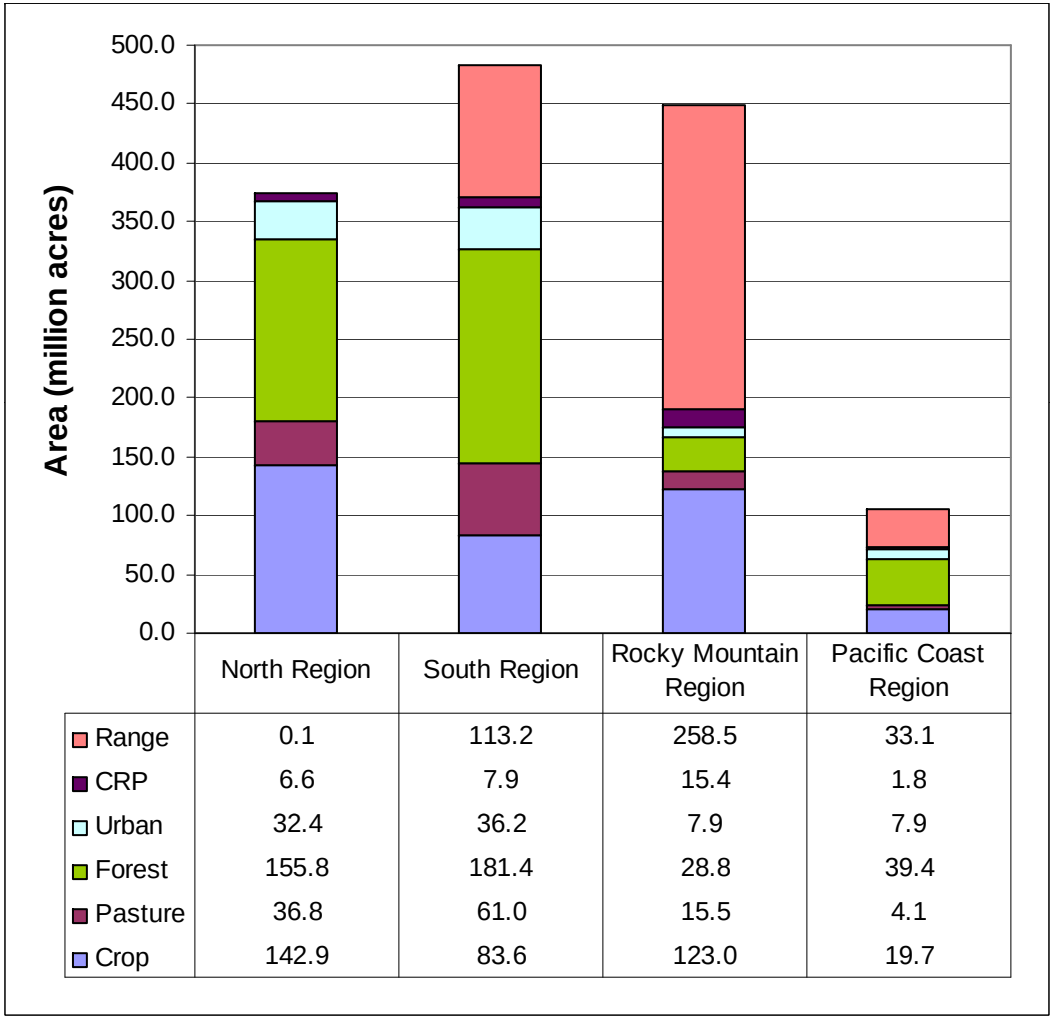
- Recent Trend: Two million acres of U.S. nonfederal rural land converted annually to developed uses
- Largest source is forest of land converted to developed uses; with approximately one million acres per year of deforestation
- Other land withdrawals for land protection
- Tech. change affects demand for land, e.g., Green Revolution reducing pressure to convert forestland
- Demand for land for bioenergy production

US land uses, 2006

Source: **Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2006, www.epa.gov/climatechange/emissions/index.html#inv**



Allocation of nonfederal land by major use by region for the U.S., 2002



	North Region	South Region	Rocky Mountain Region	Pacific Coast Region
Range	0.1	113.2	258.5	33.1
CRP	6.6	7.9	15.4	1.8
Urban	32.4	36.2	7.9	7.9
Forest	155.8	181.4	28.8	39.4
Pasture	36.8	61.0	15.5	4.1
Crop	142.9	83.6	123.0	19.7

Data source: NRI

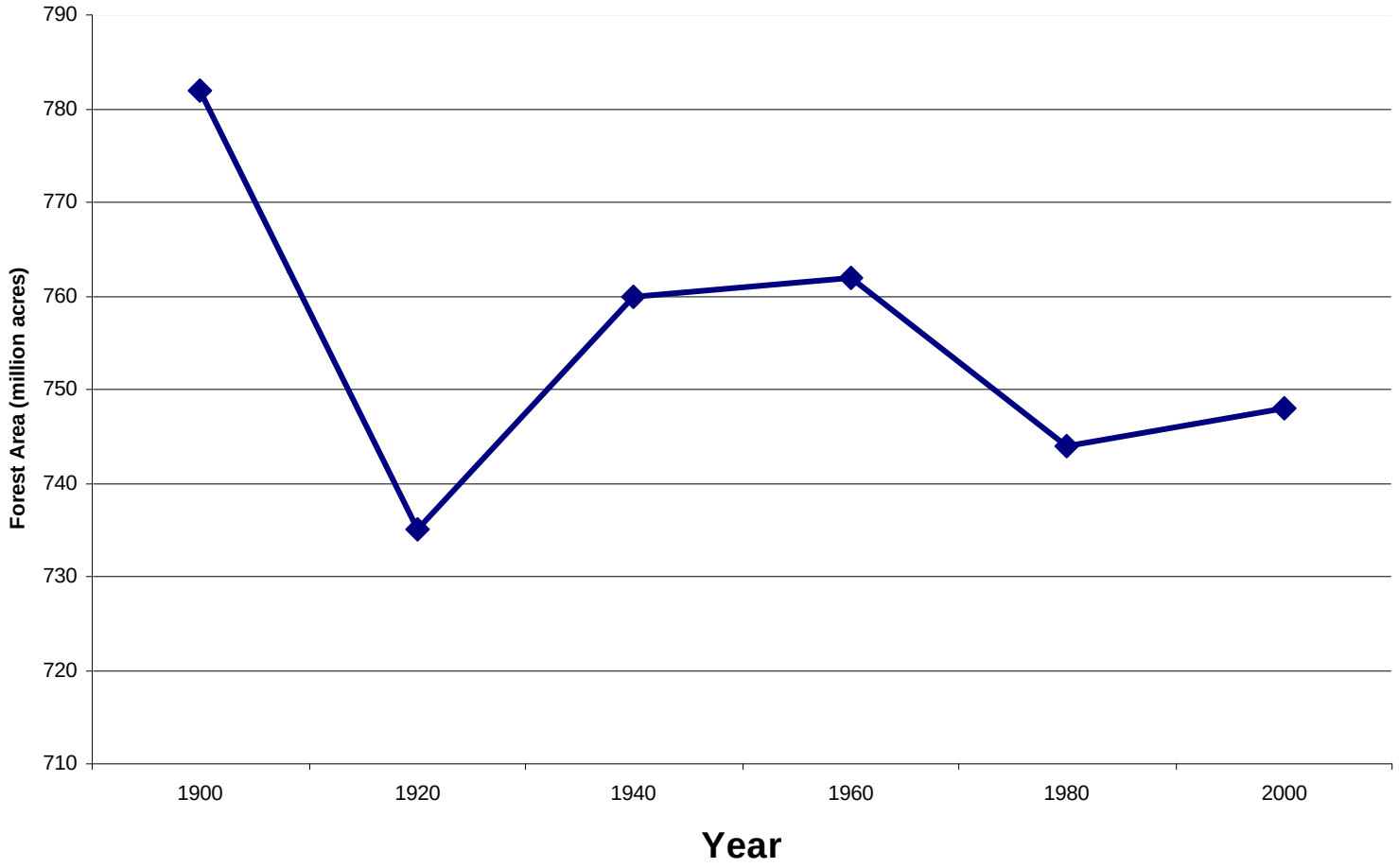
Parcelization—many private forested acres changing ownership

- **19 million acres of forest changed hands in 5 years (Mike Clutter, U of Georgia, WFE)**
- **Growth in area owned by Timberland Investment Management Organizations (TIMOs) and Real Estate Investment Trusts (REITs) since 1987 was 22% per year (Hancock Timber Resource Group)**
- **HBU spin-offs and “tidying up”**

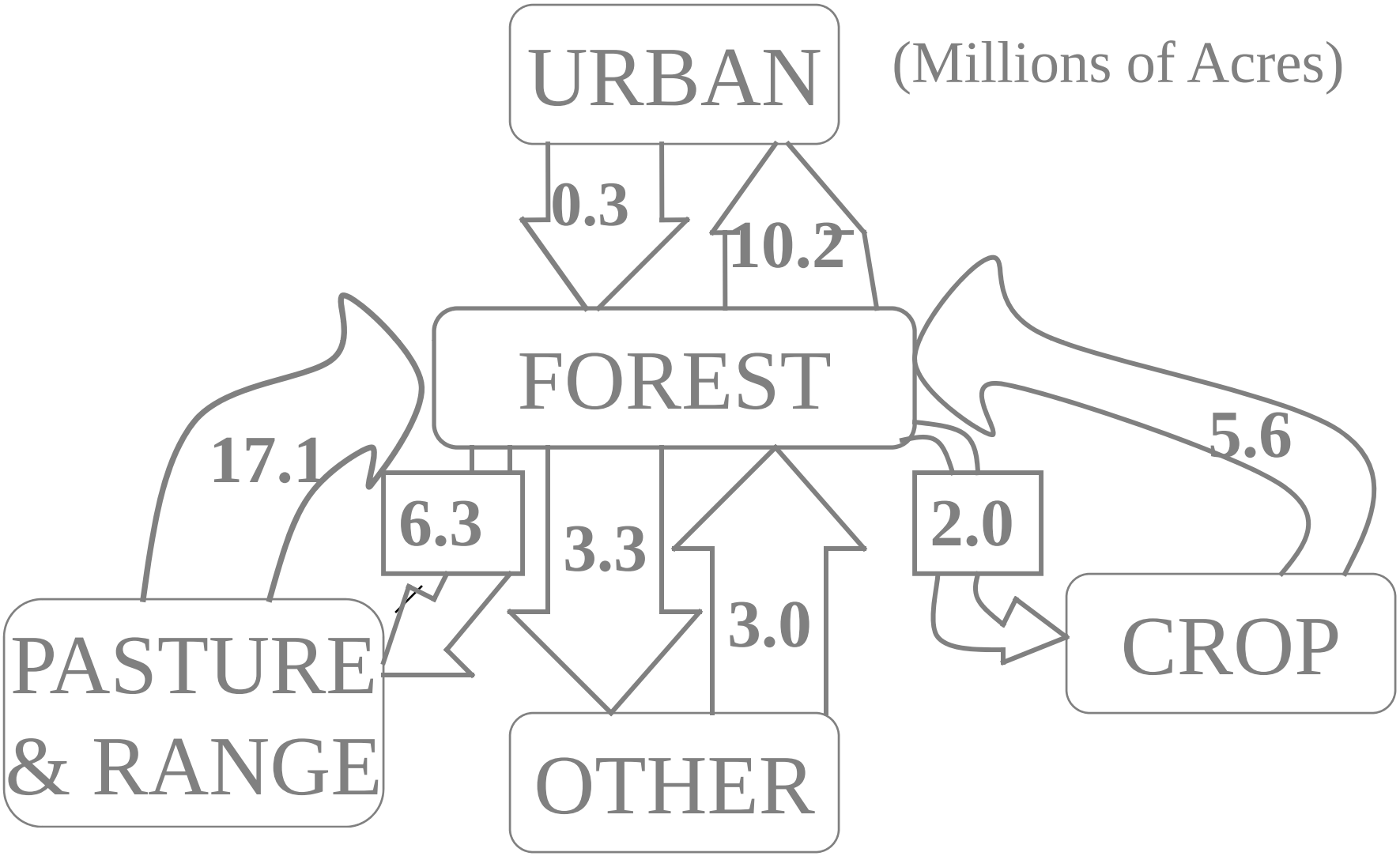
Land-use Data

- FIA, NRI: latter has two-way flows vs. net changes
- Land productivity: ground surveys
- National consistent set of data
- Forestry: existing timber stocks, site productivity, forest types, age class (region, owner, forest type, existing or new, age class, site class, etc.)

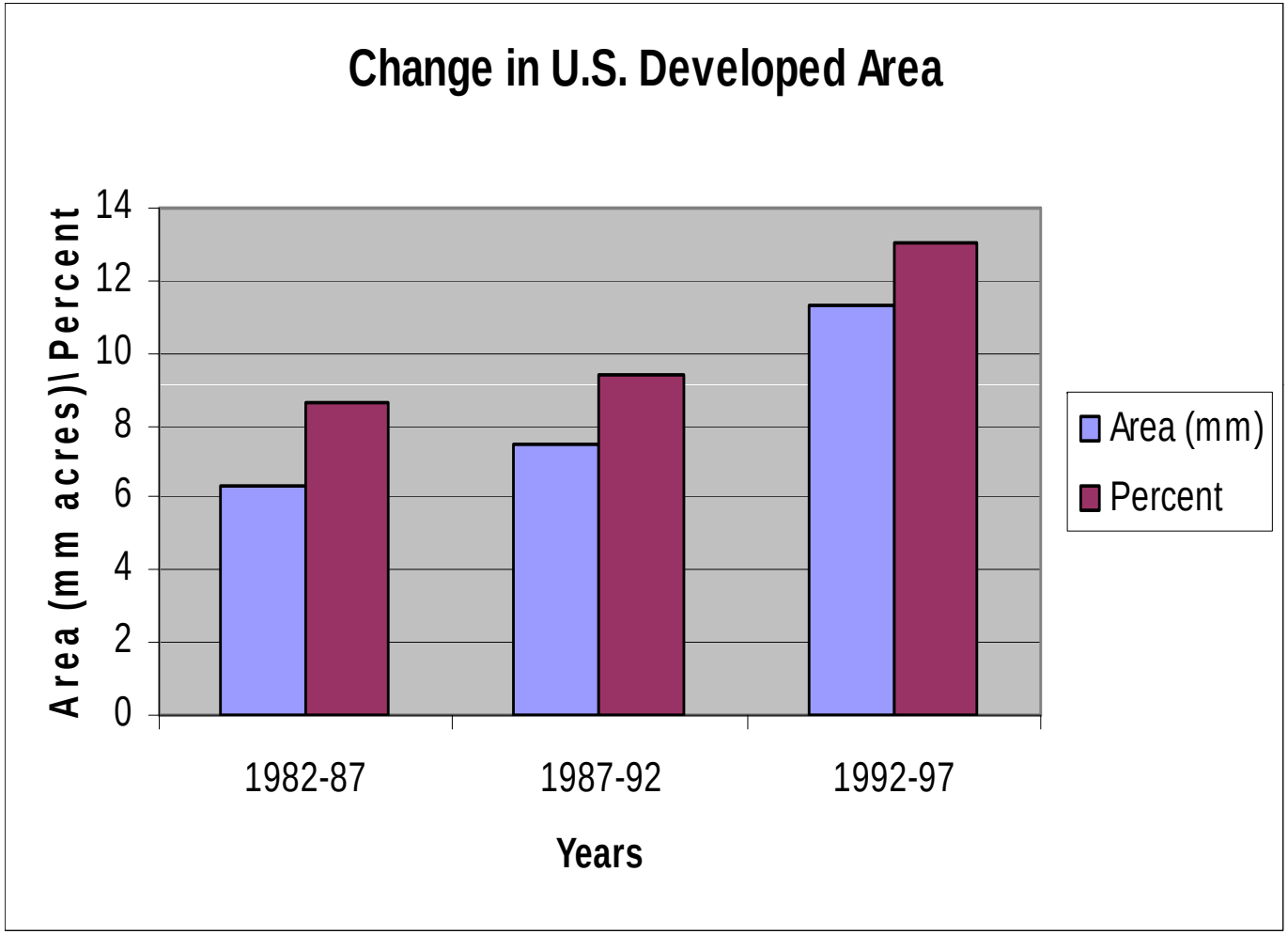
Trends in U.S. Forest Area, 1900-2000 (source: RPA\FIA)

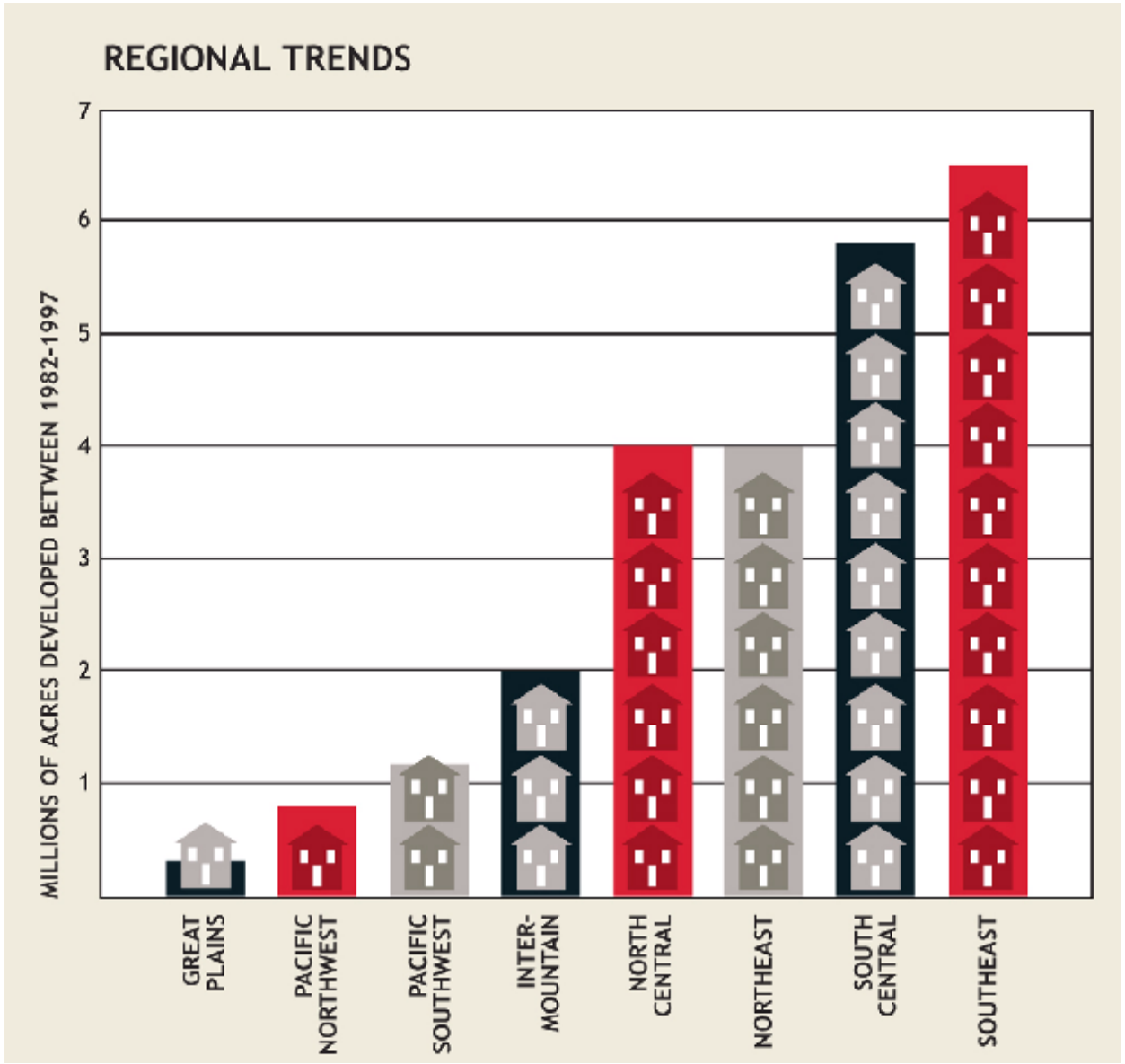


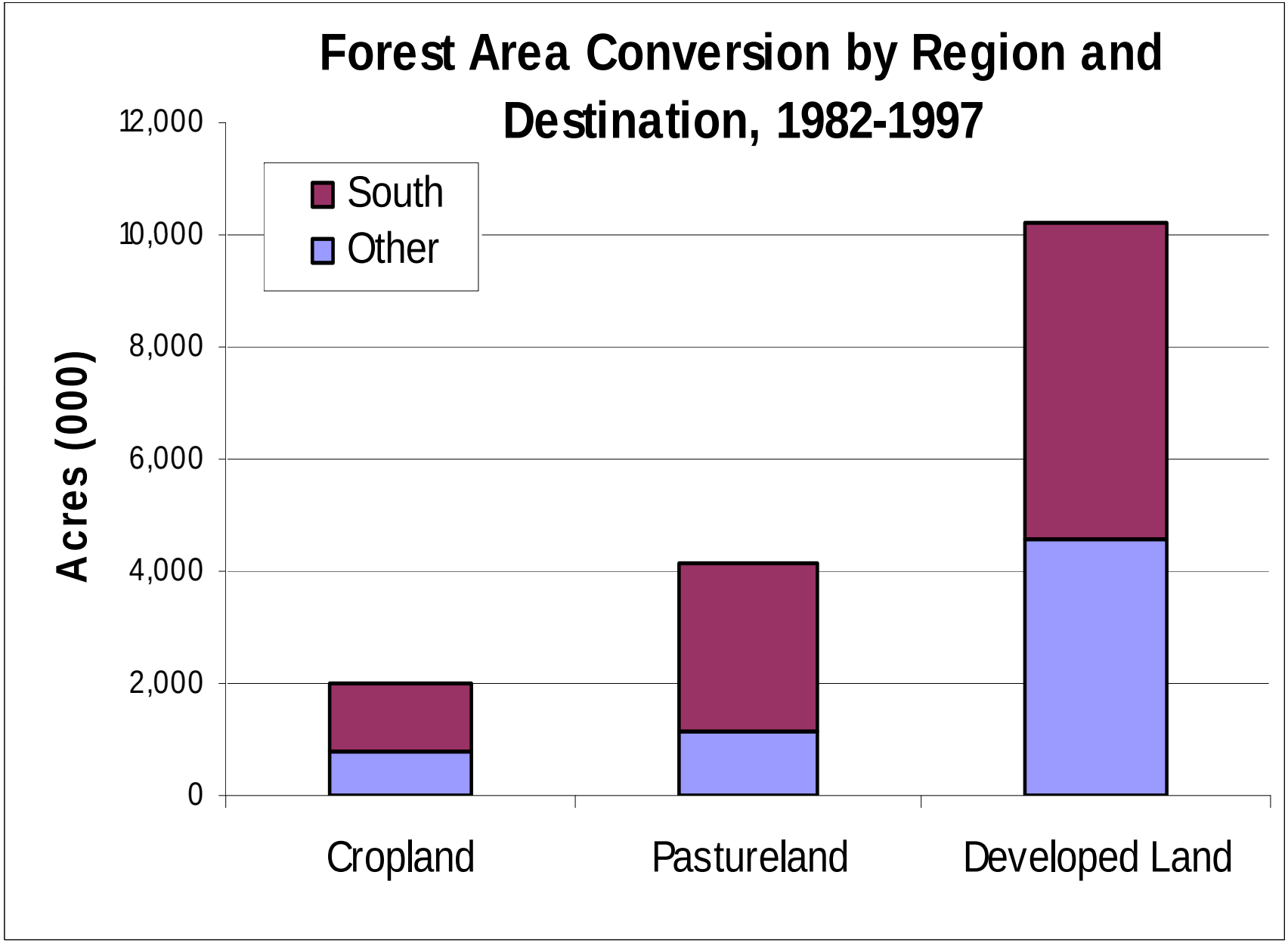
Sources and Sinks of U.S.Forestland, 1982-1997



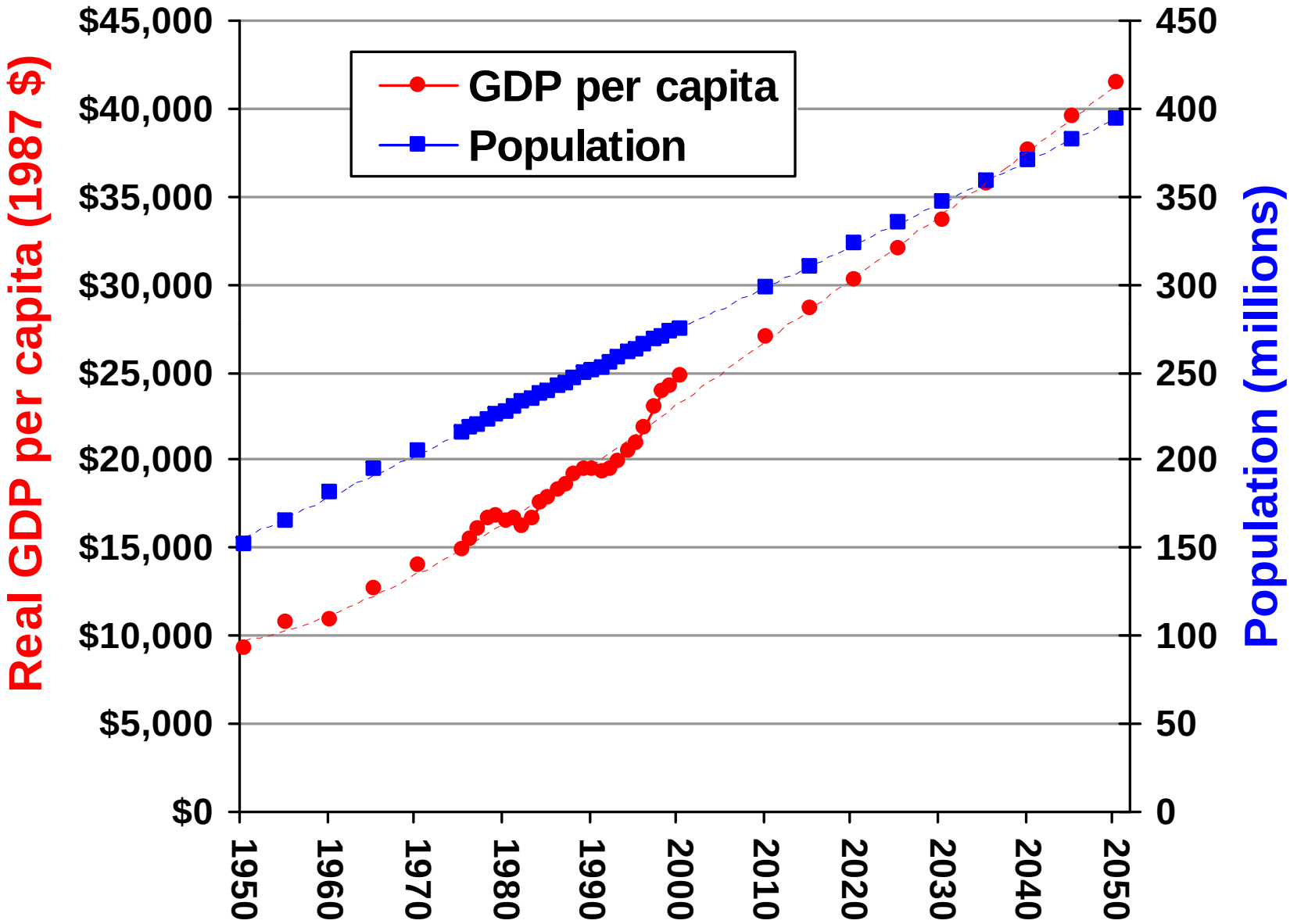
Source: USDA NRCS, NRI


Change in U.S. Developed Area
Area (mm acres)\ Percent
14
12
10
8
6
4
2
0
1982-87
1987-92
1992-97
Years
Area (mm)
Percent


REGIONAL TRENDS
MILLIONS OF ACRES DEVELOPED BETWEEN 1982-1997
7
6
5
4
3
2
1
GREAT PLAINS
PACIFIC NORTHWEST
PACIFIC SOUTHWEST
INTER-MOUNTAIN
NORTH CENTRAL
NORTHEAST
SOUTH CENTRAL
SOUTHEAST


Forest Area Conversion by Region and Destination, 1982-1997
Acres (000)
12,000
10,000
8,000
6,000
4,000
2,000
0
South
Other
Cropland
Pastureland
Developed Land

U.S. Population and real GDP per capita



More Changes in Demand For Land-Projections

- World population to grow from 6 to 9 billion by 2050
- National population to grow by 120 million: ~40% increase
- Regional (West) population to grow by 5 million ~70% increase
- Higher average personal incomes
- Increased demand for land to produce biofuels

Resources Planning Act Assessments

- 1979: expert opinion
- Early 1980s—Southern area model, tested in Special Study of "South's 4th Forest"
- Other regional, econometric models of land-use change
- National econometric model
- 2010 RPA Assessment, IPCC scenarios

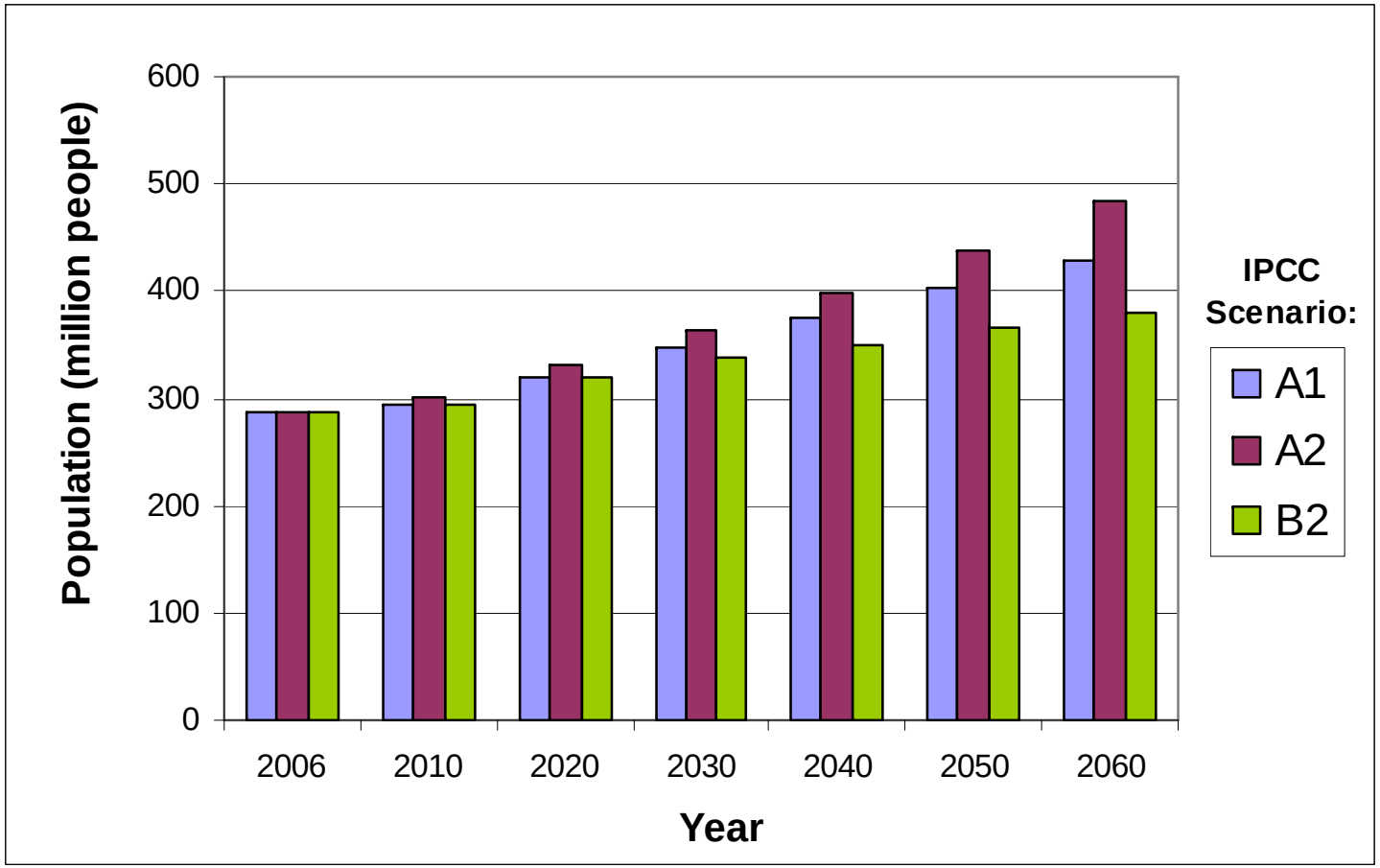
U.S. National Econometric Model of Land Use: RPA Applications

- Ruben Lubowski's PhD work at Harvard
- Collaboration with Andrew Plantinga, Oregon State University
- Application in the 2010 Resources Planning Act Assessment: Projections of areas for major land uses, such as for developed land, for nonfederal land, at county level

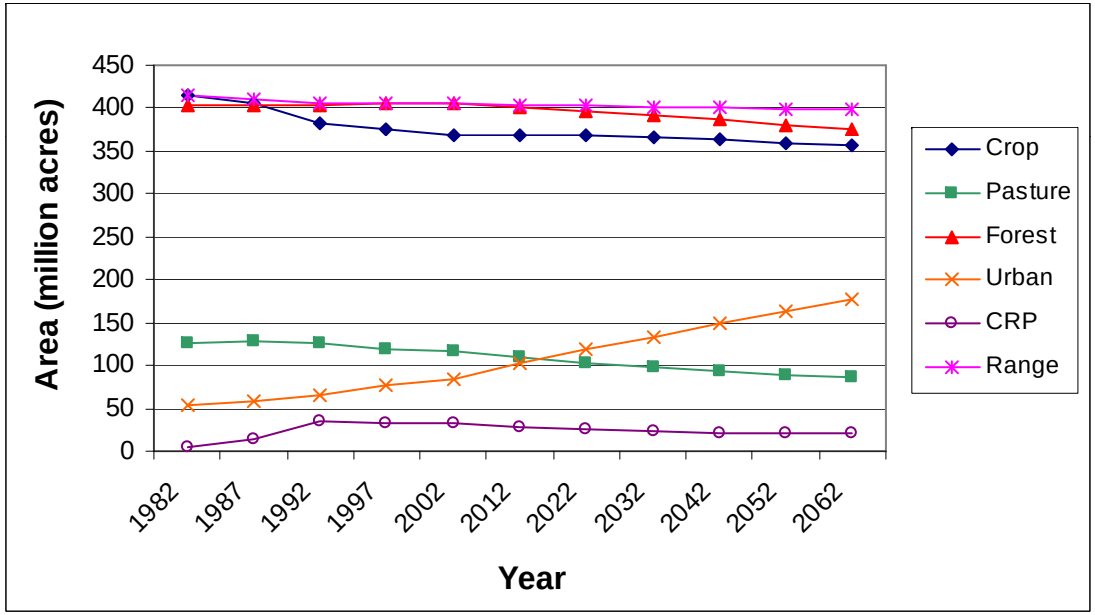
2010 RPA

- North, South, Rocky Mountains, Pacific Coast
- Forest, Crop, Pasture, Range, Urban, CRP
- Projections to 2062
- Acres Transitioning Among Major Uses (NRI data basis)

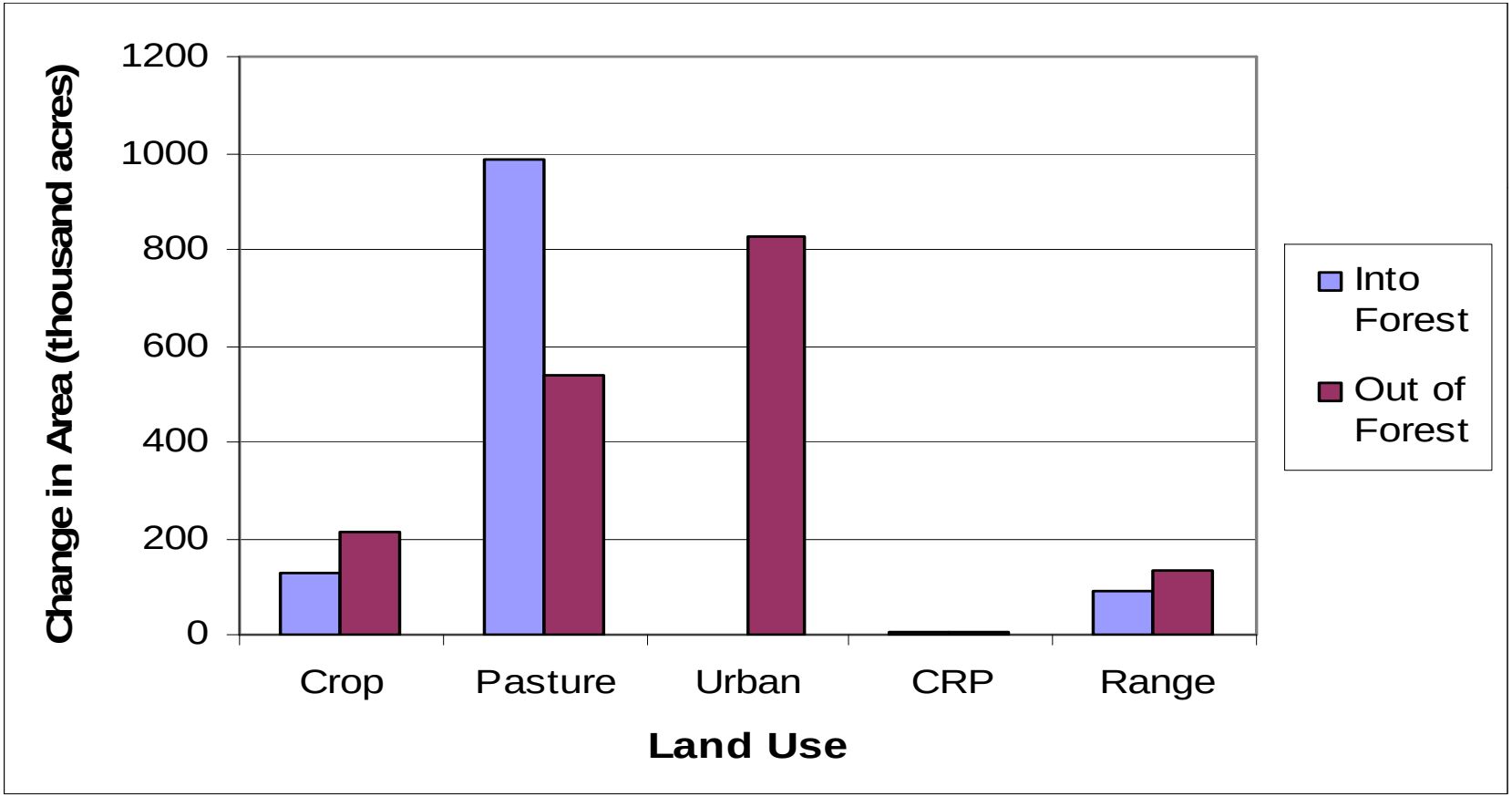
IPCC population projections for the U.S., 2006 to 2060.



Historical and projected land-use trends on nonfederal land in the U.S., 1982 to 2062



Projected average annual transitions involving forest area on nonfederal land in the U.S., 2002 to 2062, under initial conditions.



Forest-Ag Modeling

- Forest land viewed as reservoir of potential cropland (CARD)--1979
- USDA Basic Assumptions Working Group—ERS's NIRAP, FS's model of urban and developed land (Alig and Healy)
- SE CARD Model with Forest Sector
- RPA Total Land Base Model
- FASOM

Forest and Agricultural Sector Optimization Model (FASOM)-GHG

- Unique features:
  - Links forest and ag commodity markets,
  - Connects those markets to private land use decisions (for crops, pasture, forest)
- 5-year time step for optimization, typically 80-100 year time horizon
- CO_2, methane, and nitrous oxide emissions
- Underlying biophysical yields for ag, forest (including long-term forest growth process)
  - Can be adjusted to reflect projected impacts of climate change

FASOM-GHG GHG Accounting

- Comprehensive for forestry and agriculture, and carbon on developed land
- Forest pools: standing stock, understory, below ground
- Carbon in wood products (Ken Skog)
- Soil carbon dynamics with land use change between forestry and agriculture

FASOM Application

- EPA's policy question (1995)—expand area of southern pine plantations, effects on carbon seq. and timber and ag markets
- Leakage—countervailing land transfers
- Other unintended consequences

FASOM-GHG research examples

- What may be the socio-economic impacts of climate change on the U.S. forest sector and recreation?
  - National climate change assessment: Irland, Adams, Alig, et al. (2001) *Bioscience*
- What may be the impacts of climate change on U.S. forest and ag. sectors and carbon budgets?
  - Alig et al. (2002) *Forest Ecology and Management*
- What is the economic potential for forestry and agriculture to supply GHG mitigation? (EPA, 2005)
- What is the magnitude of leakage from forest carbon sequestration projects/programs?
  - Alig et al. (1997) *Environmental and Resource Economics*
- How competitive would biomass-fueled energy be?
  - McCarl, Adams, Alig, et al. (2000) *Annals of Operations Research*

PROJECTIONS USING FASOM-GHG MODEL

- FASOM-GHG MODEL: 2008 Version
- Model runs by GREG LATTA and BRUCE MCCARL
- 80-year model runs, focus on first 50 years of projections in talk
- Funding assistance by EPA

Scenarios: FOREST TO DEVELOPMENT

- 2X BASE amount
- No loss of timberland to developed uses

Carbon Price Scenarios

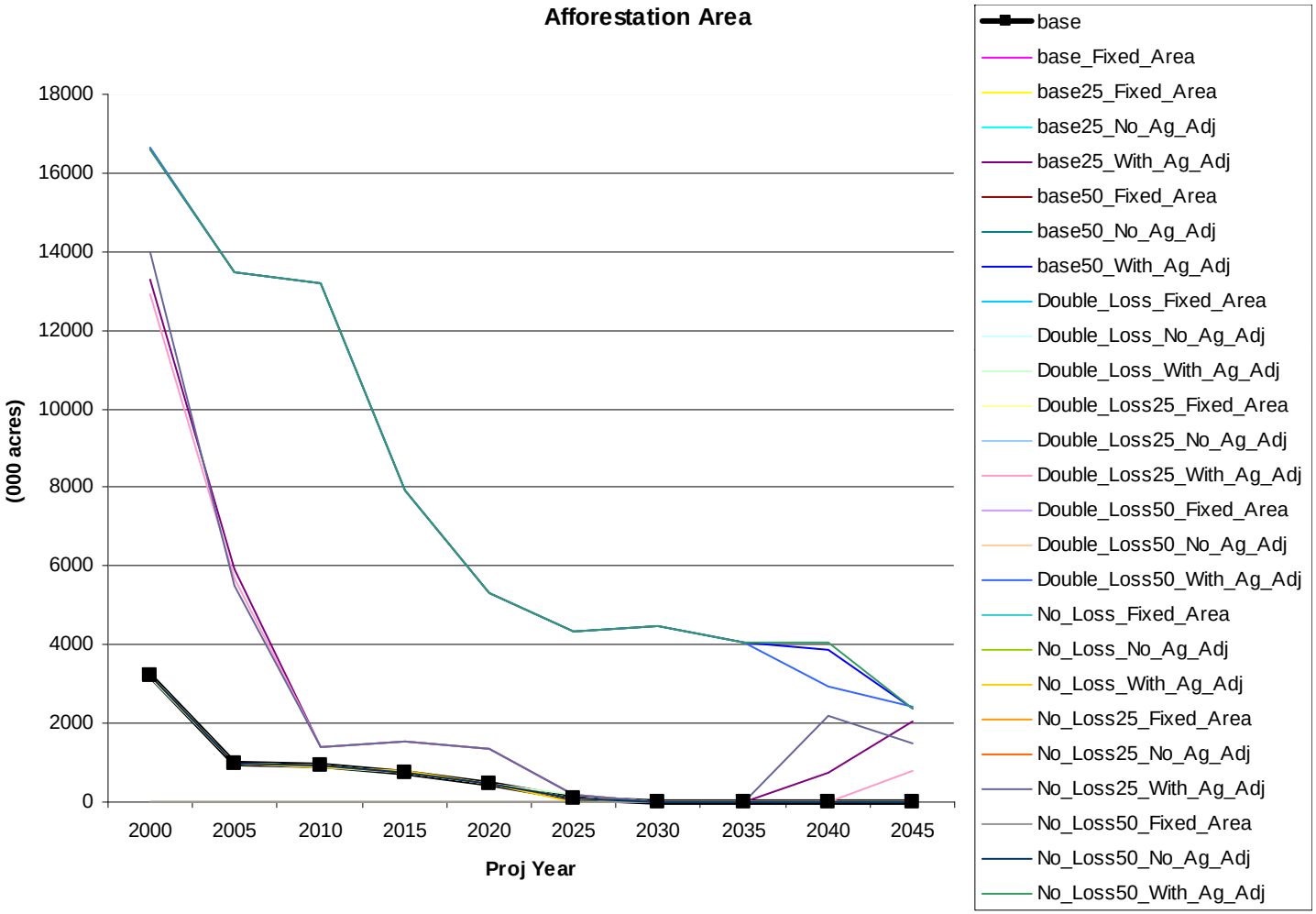
- $25 and $50 per tonne (CO2 equivalent)
- Constant prices used in this analysis
- Reflected in FASOM-GHG objective function

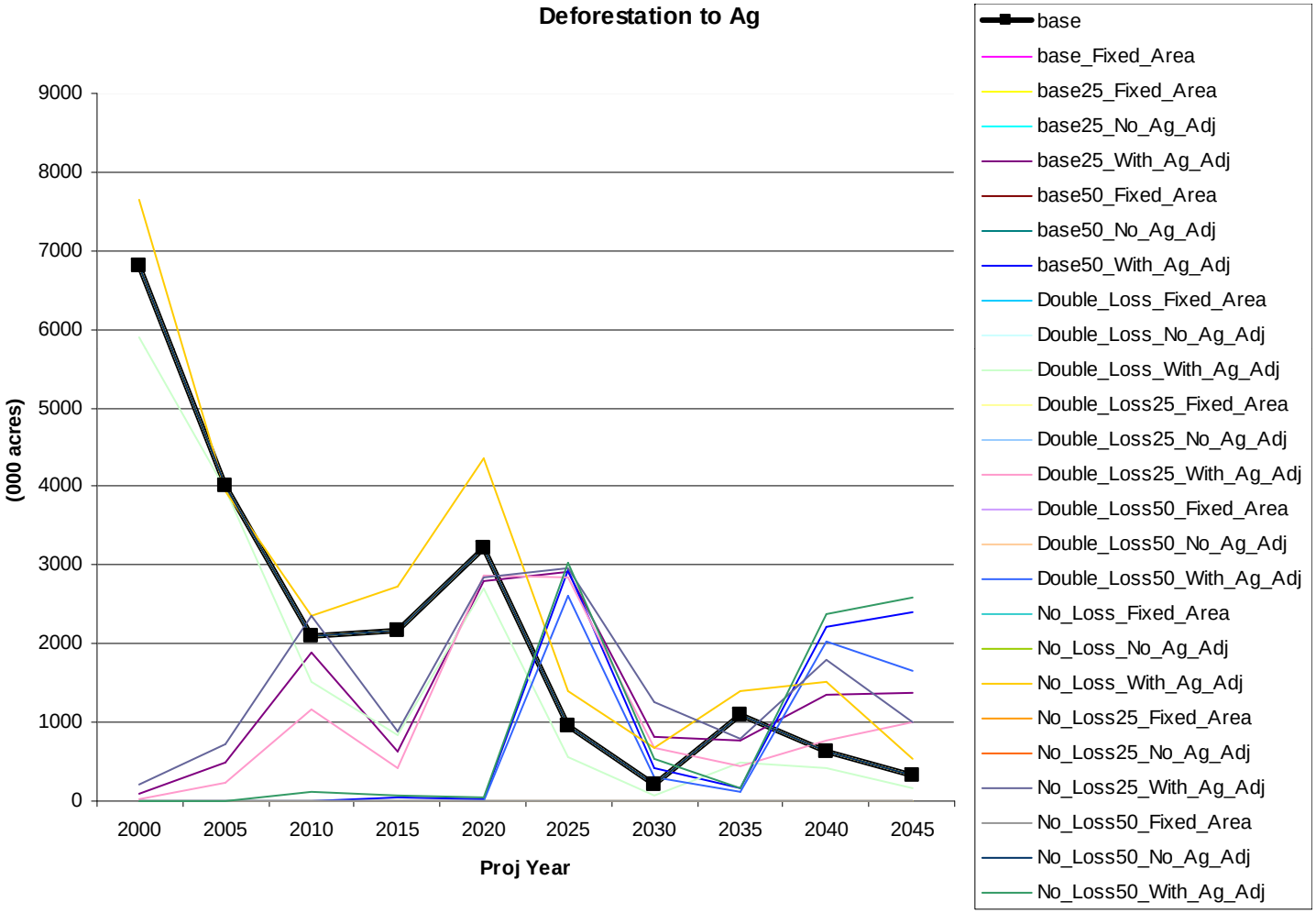
Scenarios About Responses by Agricultural Sector

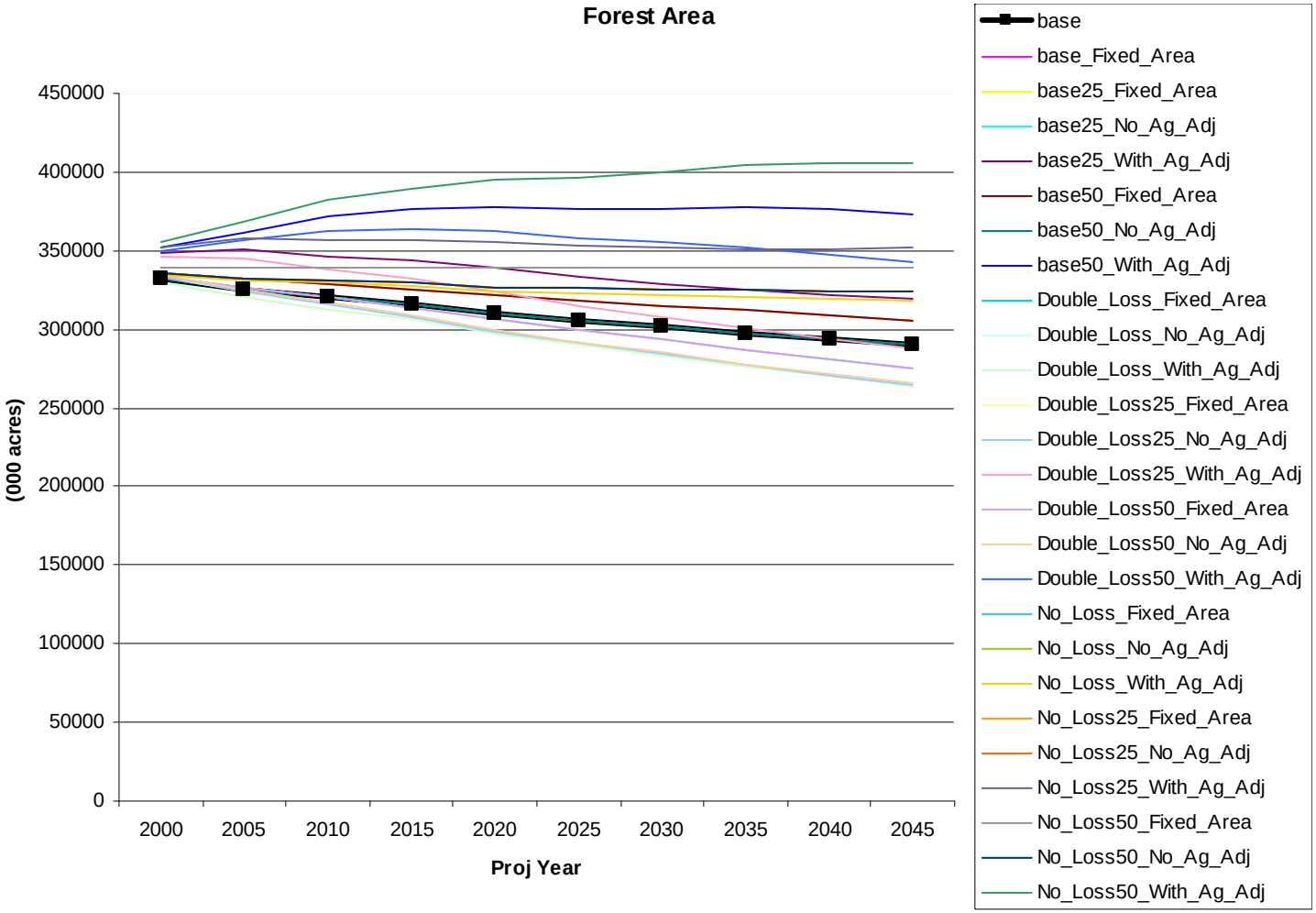
- Intersectoral land transfers (Fully endogenous)
- Intersectoral land transfers fixed at base run levels
- No transfers of land between forest and ag. sectors, such that timberland area is fixed except for transfers of timberland to developed uses

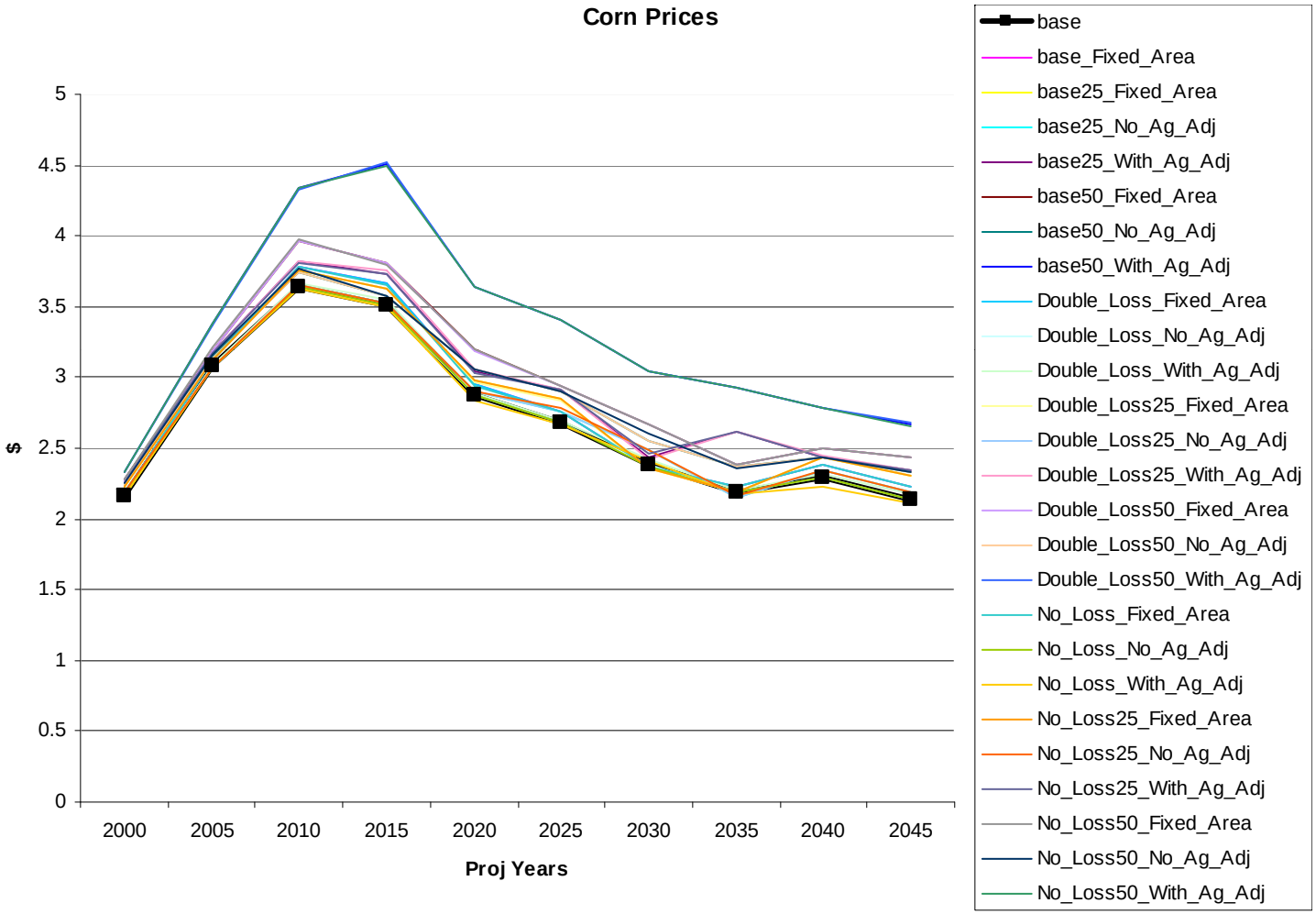
COMBINATIONS

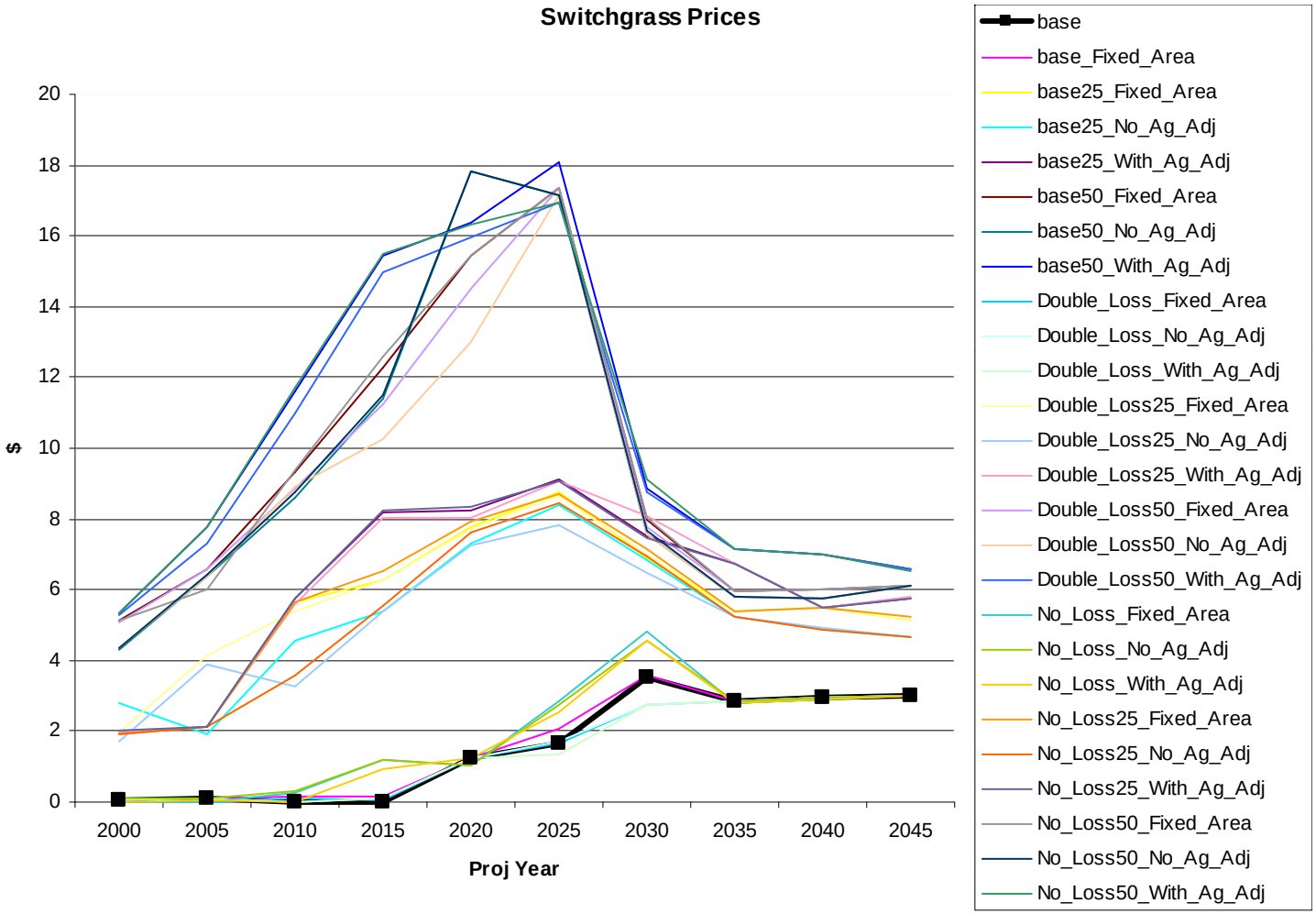
1. Timberland loss to development (Base, No Loss, Double Loss)
2. Carbon Price (0, $25, $50)
3. Intersectoral land transfers (Fully endogenous; Fixed at base run levels “limited ag adjustment;“ no transfers of "No land between forest and ag sectors"

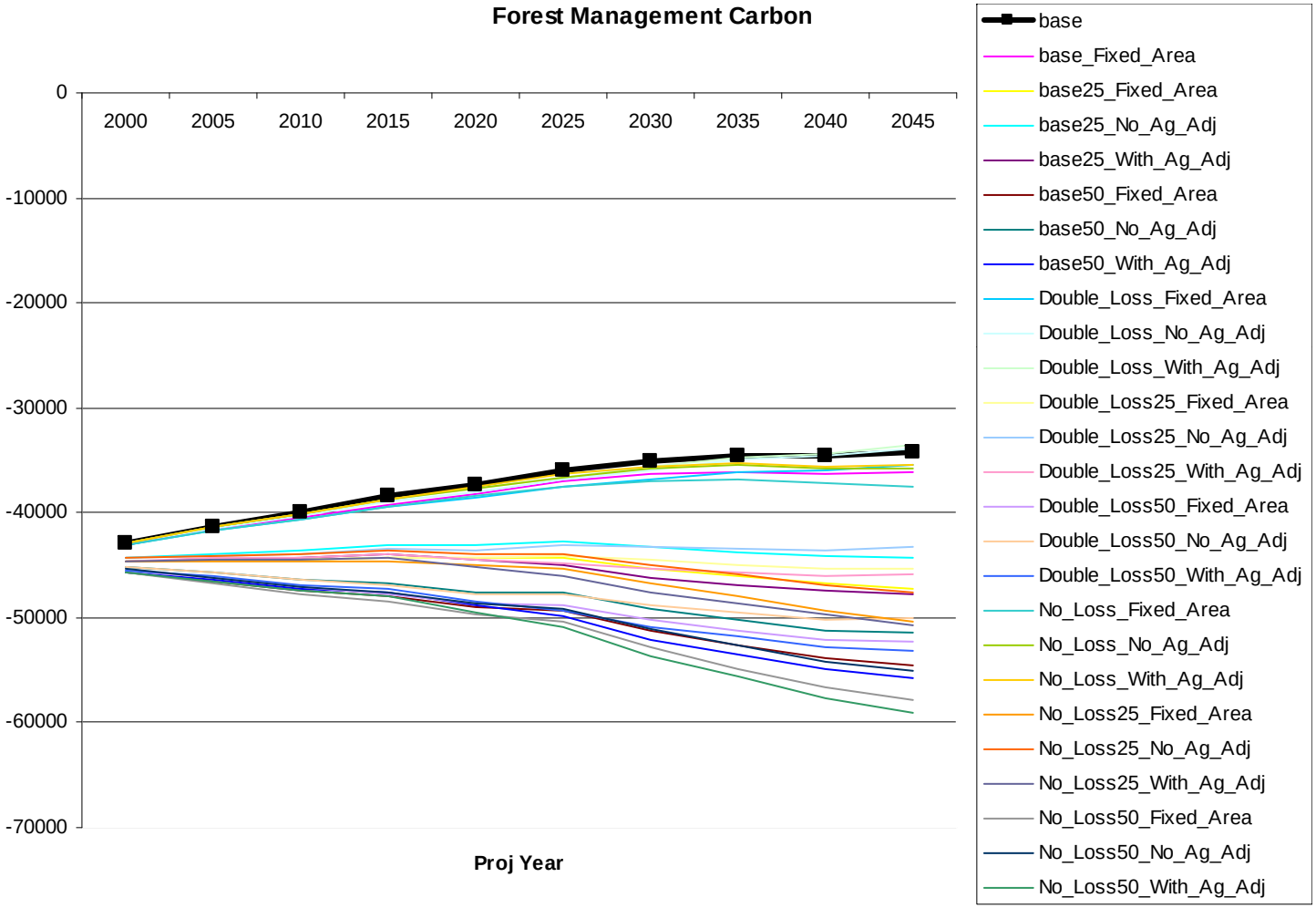

Afforestation Area
(000 acres)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
Proj Year
base
base_Fixed_Area
base25_Fixed_Area
base25_No_Ag_Adj
base25_With_Ag_Adj
base50_Fixed_Area
base50_No_Ag_Adj
base50_With_Ag_Adj
Double_Loss_Fixed_Area
Double_Loss_No_Ag_Adj
Double_Loss_With_Ag_Adj
Double_Loss25_Fixed_Area
Double_Loss25_No_Ag_Adj
Double_Loss25_With_Ag_Adj
Double_Loss50_Fixed_Area
Double_Loss50_No_Ag_Adj
Double_Loss50_With_Ag_Adj
No_Loss_Fixed_Area
No_Loss_No_Ag_Adj
No_Loss_With_Ag_Adj
No_Loss25_Fixed_Area
No_Loss25_No_Ag_Adj
No_Loss25_With_Ag_Adj
No_Loss50_Fixed_Area
No_Loss50_No_Ag_Adj
No_Loss50_With_Ag_Adj

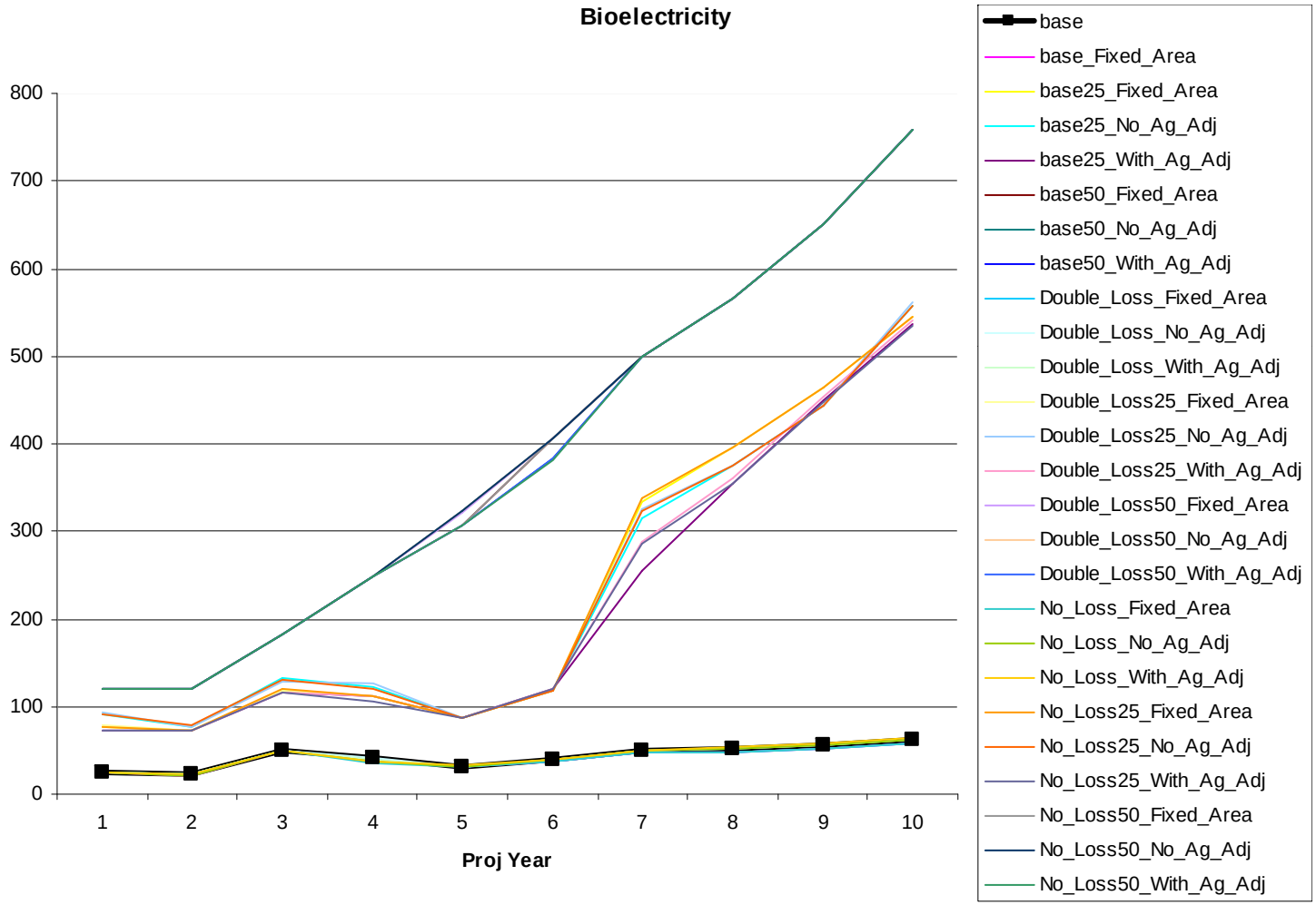

Deforestation to Ag
(000 acres)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
Proj Year
base
base_Fixed_Area
base25_Fixed_Area
base25_No_Ag_Adj
base25_With_Ag_Adj
base50_Fixed_Area
base50_No_Ag_Adj
base50_With_Ag_Adj
Double_Loss_Fixed_Area
Double_Loss_No_Ag_Adj
Double_Loss_With_Ag_Adj
Double_Loss25_Fixed_Area
Double_Loss25_No_Ag_Adj
Double_Loss25_With_Ag_Adj
Double_Loss50_Fixed_Area
Double_Loss50_No_Ag_Adj
Double_Loss50_With_Ag_Adj
No_Loss_Fixed_Area
No_Loss_No_Ag_Adj
No_Loss_With_Ag_Adj
No_Loss25_Fixed_Area
No_Loss25_No_Ag_Adj
No_Loss25_With_Ag_Adj
No_Loss50_Fixed_Area
No_Loss50_No_Ag_Adj
No_Loss50_With_Ag_Adj


Forest Area
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
(000 acres)
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
Proj Year
base
base_Fixed_Area
base25_Fixed_Area
base25_No_Ag_Adj
base25_With_Ag_Adj
base50_Fixed_Area
base50_No_Ag_Adj
base50_With_Ag_Adj
Double_Loss_Fixed_Area
Double_Loss_No_Ag_Adj
Double_Loss_With_Ag_Adj
Double_Loss25_Fixed_Area
Double_Loss25_No_Ag_Adj
Double_Loss25_With_Ag_Adj
Double_Loss50_Fixed_Area
Double_Loss50_No_Ag_Adj
Double_Loss50_With_Ag_Adj
No_Loss_Fixed_Area
No_Loss_No_Ag_Adj
No_Loss_With_Ag_Adj
No_Loss25_Fixed_Area
No_Loss25_No_Ag_Adj
No_Loss25_With_Ag_Adj
No_Loss50_Fixed_Area
No_Loss50_No_Ag_Adj
No_Loss50_With_Ag_Adj

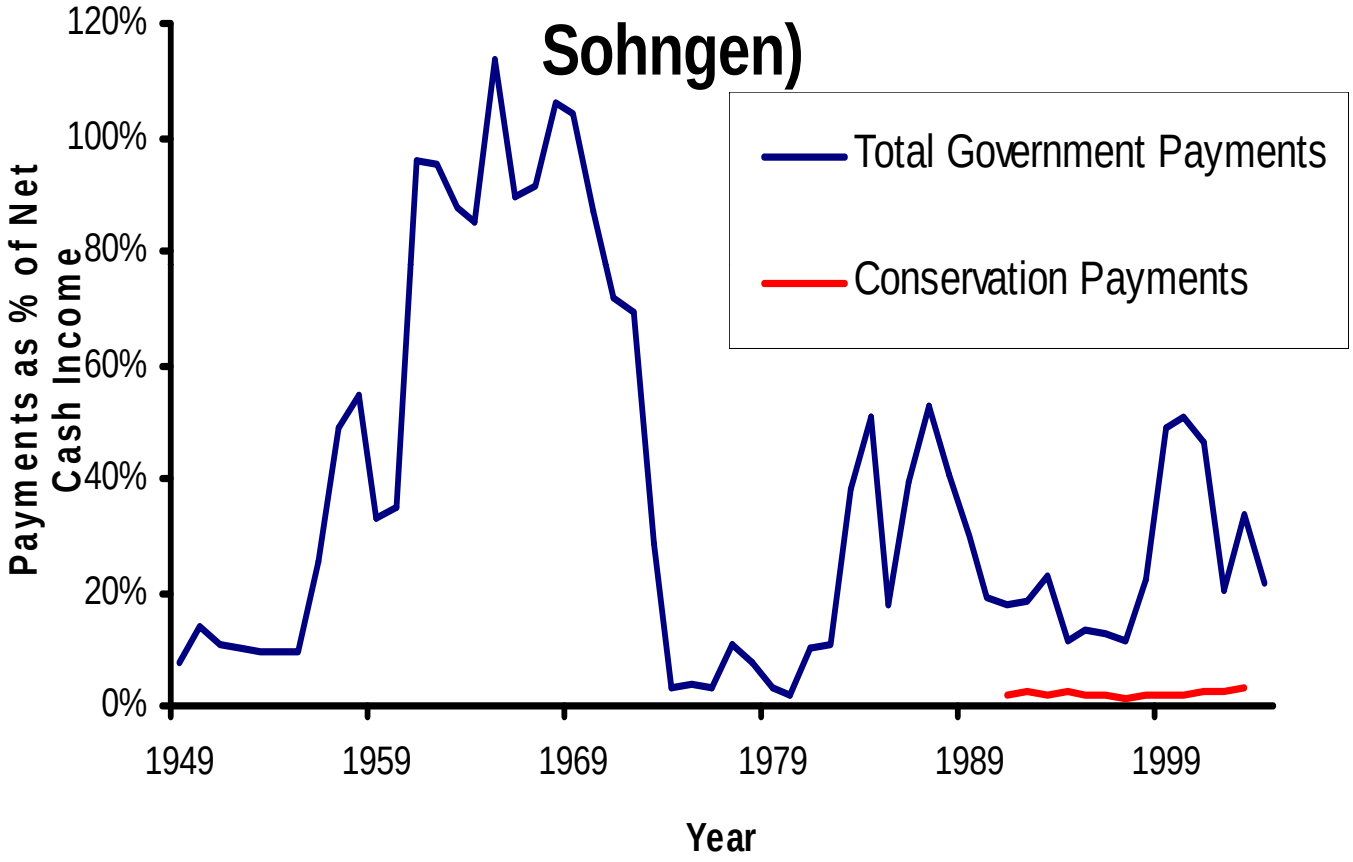

Corn Prices
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
$
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
Proj Years
base
base_Fixed_Area
base25_Fixed_Area
base25_No_Ag_Adj
base25_With_Ag_Adj
base50_Fixed_Area
base50_No_Ag_Adj
base50_With_Ag_Adj
Double_Loss_Fixed_Area
Double_Loss_No_Ag_Adj
Double_Loss_With_Ag_Adj
Double_Loss25_Fixed_Area
Double_Loss25_No_Ag_Adj
Double_Loss25_With_Ag_Adj
Double_Loss50_Fixed_Area
Double_Loss50_No_Ag_Adj
Double_Loss50_With_Ag_Adj
No_Loss_Fixed_Area
No_Loss_No_Ag_Adj
No_Loss_With_Ag_Adj
No_Loss25_Fixed_Area
No_Loss25_No_Ag_Adj
No_Loss25_With_Ag_Adj
No_Loss50_Fixed_Area
No_Loss50_No_Ag_Adj
No_Loss50_With_Ag_Adj


Switchgrass Prices
$
20
18
16
14
12
10
8
6
4
2
0
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
Proj Year
base
base_Fixed_Area
base25_Fixed_Area
base25_No_Ag_Adj
base25_With_Ag_Adj
base50_Fixed_Area
base50_No_Ag_Adj
base50_With_Ag_Adj
Double_Loss_Fixed_Area
Double_Loss_No_Ag_Adj
Double_Loss_With_Ag_Adj
Double_Loss25_Fixed_Area
Double_Loss25_No_Ag_Adj
Double_Loss25_With_Ag_Adj
Double_Loss50_Fixed_Area
Double_Loss50_No_Ag_Adj
Double_Loss50_With_Ag_Adj
No_Loss_Fixed_Area
No_Loss_No_Ag_Adj
No_Loss_With_Ag_Adj
No_Loss25_Fixed_Area
No_Loss25_No_Ag_Adj
No_Loss25_With_Ag_Adj
No_Loss50_Fixed_Area
No_Loss50_No_Ag_Adj
No_Loss50_With_Ag_Adj

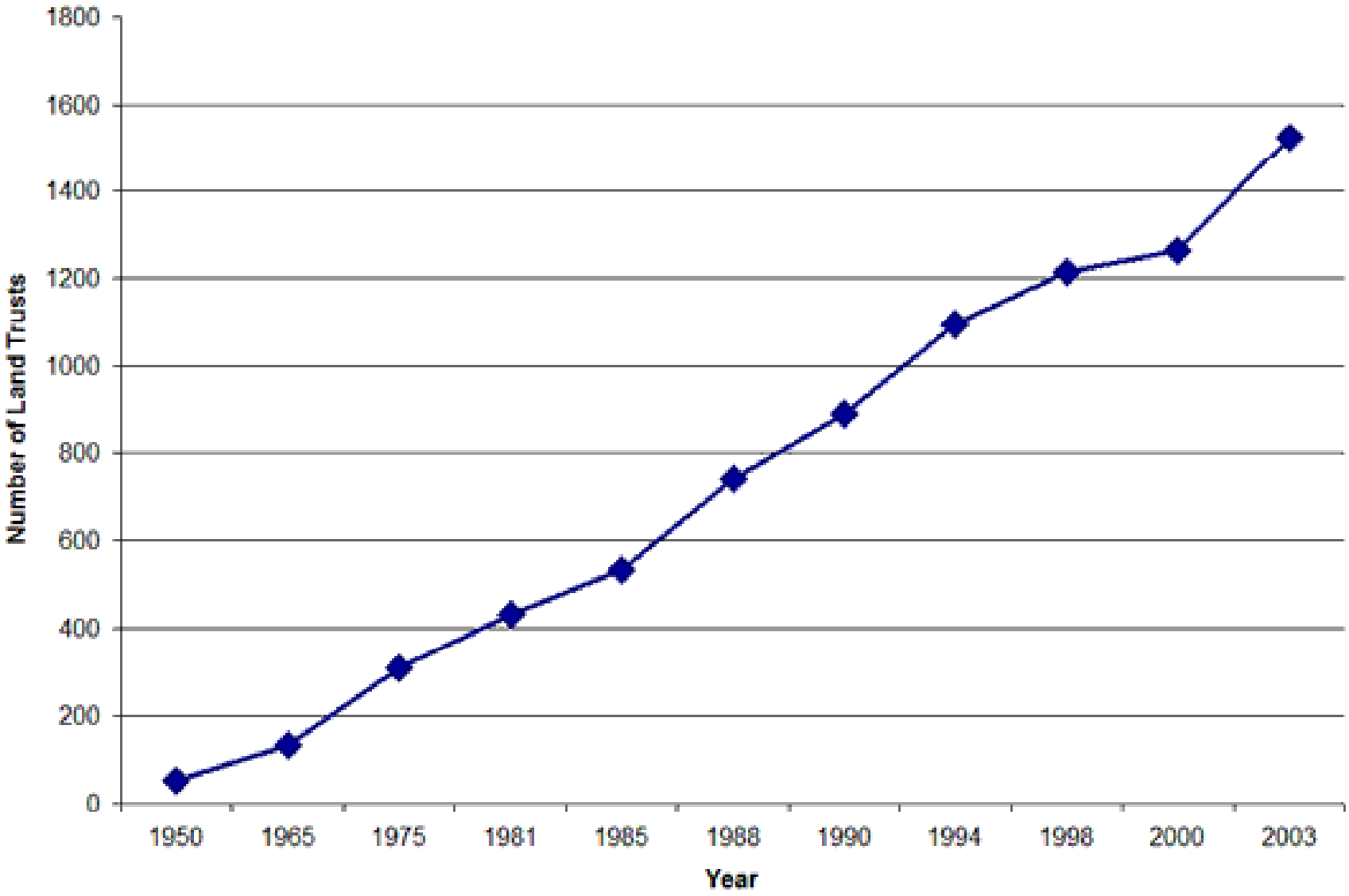

Forest Management Carbon
0
-10000
-20000
-30000
-40000
-50000
-60000
-70000
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
Proj Year
base
base_Fixed_Area
base25_Fixed_Area
base25_No_Ag_Adj
base25_With_Ag_Adj
base50_Fixed_Area
base50_No_Ag_Adj
base50_With_Ag_Adj
Double_Loss_Fixed_Area
Double_Loss_No_Ag_Adj
Double_Loss_With_Ag_Adj
Double_Loss25_Fixed_Area
Double_Loss25_No_Ag_Adj
Double_Loss25_With_Ag_Adj
Double_Loss50_Fixed_Area
Double_Loss50_No_Ag_Adj
Double_Loss50_With_Ag_Adj
No_Loss_Fixed_Area
No_Loss_No_Ag_Adj
No_Loss_With_Ag_Adj
No_Loss25_Fixed_Area
No_Loss25_No_Ag_Adj
No_Loss25_With_Ag_Adj
No_Loss50_Fixed_Area
No_Loss50_No_Ag_Adj
No_Loss50_With_Ag_Adj


Bioelectricity
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
Proj Year
base
base_Fixed_Area
base25_Fixed_Area
base25_No_Ag_Adj
base25_With_Ag_Adj
base50_Fixed_Area
base50_No_Ag_Adj
base50_With_Ag_Adj
Double_Loss_Fixed_Area
Double_Loss_No_Ag_Adj
Double_Loss_With_Ag_Adj
Double_Loss25_Fixed_Area
Double_Loss25_No_Ag_Adj
Double_Loss25_With_Ag_Adj
Double_Loss50_Fixed_Area
Double_Loss50_No_Ag_Adj
Double_Loss50_With_Ag_Adj
No_Loss_Fixed_Area
No_Loss_No_Ag_Adj
No_Loss_With_Ag_Adj
No_Loss25_Fixed_Area
No_Loss25_No_Ag_Adj
No_Loss25_With_Ag_Adj
No_Loss50_Fixed_Area
No_Loss50_No_Ag_Adj
No_Loss50_With_Ag_Adj

Farm Program Payments Can Reduce Forest Area (slide from Brent Sohngen)



NUMBER OF LAND TRUSTS IN THE UNITED STATES, 1950 to 2003



Source: Land Trust Alliance

Summary

- 2010 RPA Assessment: Projections under review
- RPA Assessments foundation of forest sector modeling supporting FASOM-GHG development
- Carbon Price Has Relatively Large Influence on FOR-AG interactions in FASOM-GHG for Prices Examined--$25 and $50
- With large land base, U.S. deforestation can be largely accommodated in terms of aggregate effects
- Land transfers between forestry and agriculture are important in climate change mitigation options involving forestry, including when carbon prices are in effect

Summary (con’t)

- Timing of ag crop peak prices influenced by Renewable Fuels Standard, with corn price peaking around 2015-2020, and more reliance on switchgrass in subsequent decades and switchgrass prices peaking about 10 years later
- Amount of afforestation is frontloaded in projections, as is deforestation to ag
- Amount of bioelectricity from cellulosic sources is notably higher with $50 carbon price

Documentation

- FASOM-GHG: Bruce McCarl's web site at Texas A&M; Ralph Alig's team web site (Land Use and Land Cover Dynamics)
- RPA Land Base Assessment—Gen. Tech. Report available for review