

Projected response of the agriculture and forest
sectors to national and regional renewable
electricity standards

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Research Question

What is the response of the U.S. agriculture and forest sectors to increased demand for bioelectricity?

Types and regional distribution of feedstock use?

Changes and intensification in land use?

Changes in greenhouse gas flux?

Scenarios

Baseline—2010 AEO projection for bioelectricity consumption in the electric power sector

Renewable electricity standards

--National-level:

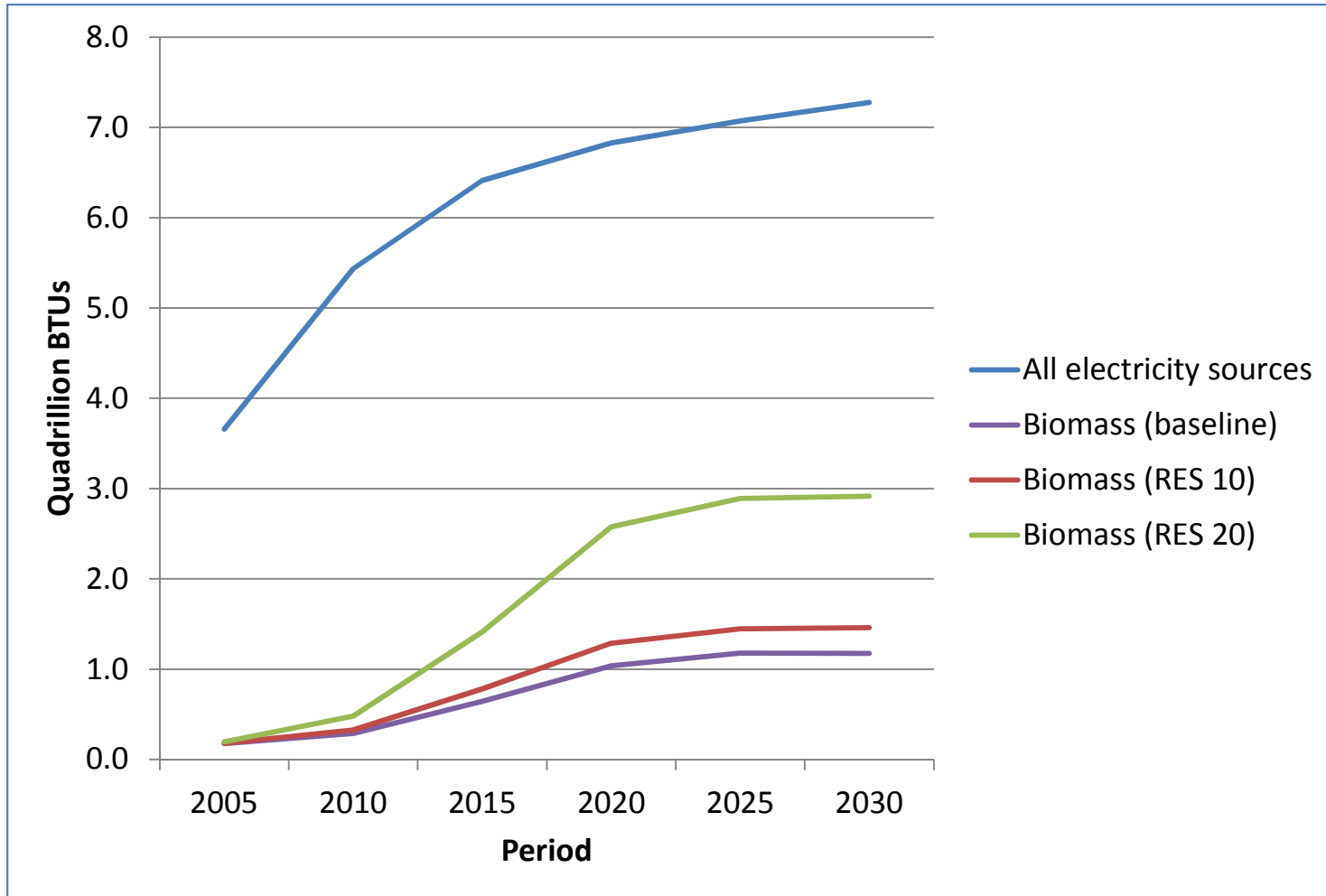
10% of electrical power sector consumption by 2020

20% of electrical power sector consumption by 2020

--Regional-level (Northeast)

doubling of AEO projected bioelectricity consumption

National-level Scenarios (electricity only)



Scenarios

BTU levels for bioelectricity consumption under the baseline and policy scenarios entered as minimum targets

Ethanol and biodiesel produced in amounts projected in the 2010 AEO outlook

In regional runs, national level bioelectricity consumption held at national baseline production

No carbon prices included

No storage costs

FASOM-GHG

Linked model of U.S. agriculture and forest sectors

Utilizes a dynamic optimization approach to simulate markets for agriculture and forest products

Regionally-explicit

Tracks a variety of agriculture and forestry resource conditions and management actions

Includes a bioenergy sector

Includes GHG accounting

FASOM-GHG



Feedstock	Higher heating value (BTUs)	Assumed moisture content
Agriculture residues		
Barley residue	14,883,920	10.3%
Corn residue	9,226,139	11.9%
Oats residue	14,883,920	10.3%
Rice residue	11,109,200	15.0%
Sorghum residue	11,917,456	11.9%
Wheat residue	15,055,891	8.9%
Energy crops		
Energy sorghum	13,749,781	11.9%
Switchgrass	13,749,781	11.9%
Bagasse	10,276,632	31.0%
Pulpwood/milling residues		
Hardwood pulpwood	10,666,667	33.0%
Softwood pulpwood	12,000,007	33.0%
Hardwood milling residues	10,666,667	0.0%
Softwood milling residues	12,000,007	0.0%
Logging residues		
Hardwood logging residues	10,666,667	33.0%
Softwood logging residues	12,000,007	33.0%
Short-rotation woody crops		
Willow	14,153,995	33.0%
Hybrid poplar	11,492,271	31.0%
Other residues		
Lignin, nonforest	18,222,001	33.0%
Lignin, hardwood	21,239,991	33.0%
Lignin, softwood	22,679,998	33.0%
Sweet sorghum pulp	11,406,208	11.9%

Bioelectricity Production

Direct firing 100 MW plants—assumed plant heat rate of 14,000 btu per kWh of generated electricity

Co-firing (with coal)—heat rates of 10,587 to 11,645 btus:

5%, 10%, 15%, and 20%

Improved efficiency with co-firing relative to direct firing
–76% to 83% of feedstock relative to direct-fired plant

All plant efficiencies are assumed to improve over time,
reducing feedstock requirements

Plants operate 75% of the year

Greenhouse Gas Accounting

GHG reductions from—

Avoided emissions that would have resulted from using coal to produce the same amount of electricity

625,515 tonnes avoided coal emission CO₂ per 100 MW dedicated bioelectricity plant

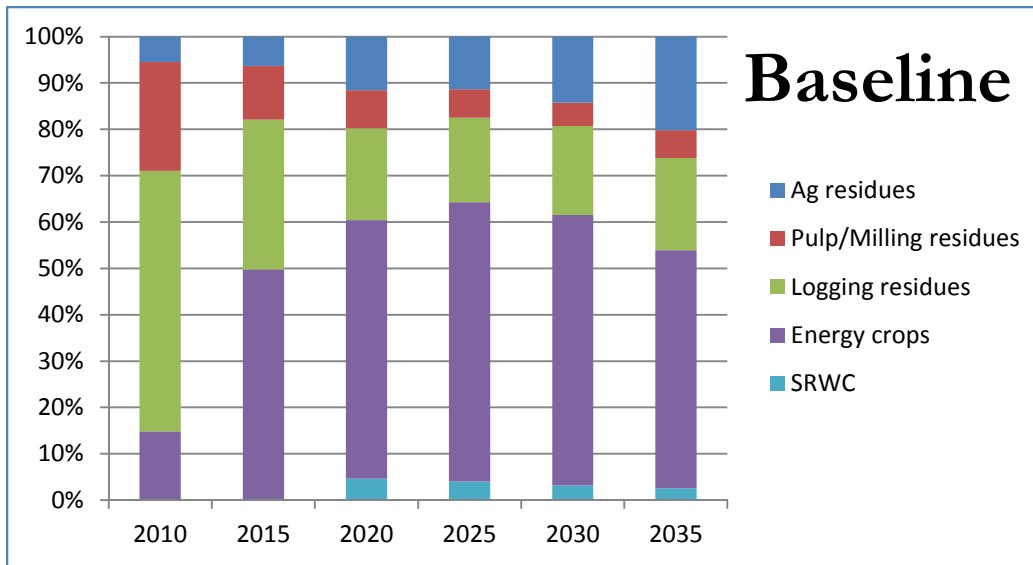
GHG emissions from—

Production, harvest, collection, and processing of biomass

Account for emissions associated with land conversion and intensification of agriculture land

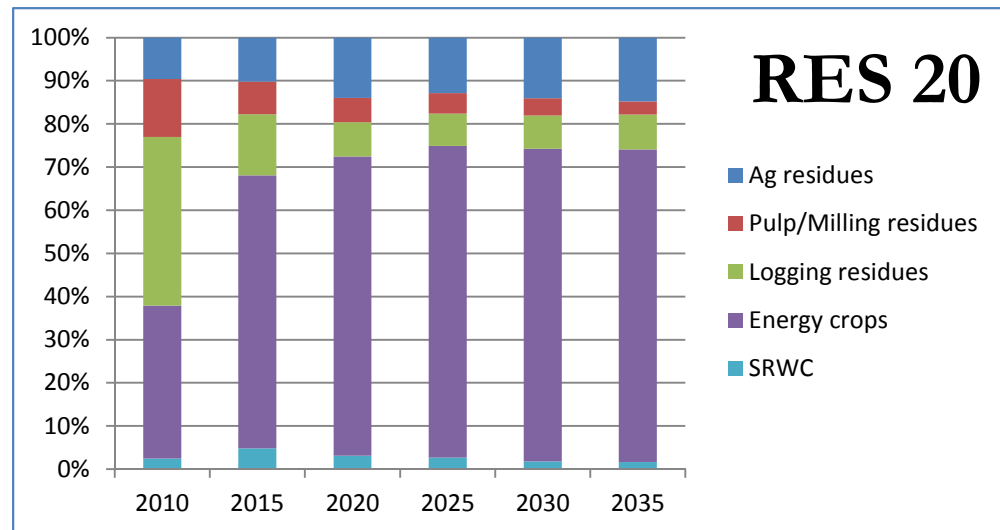
National RES Results

Feedstock Consumption



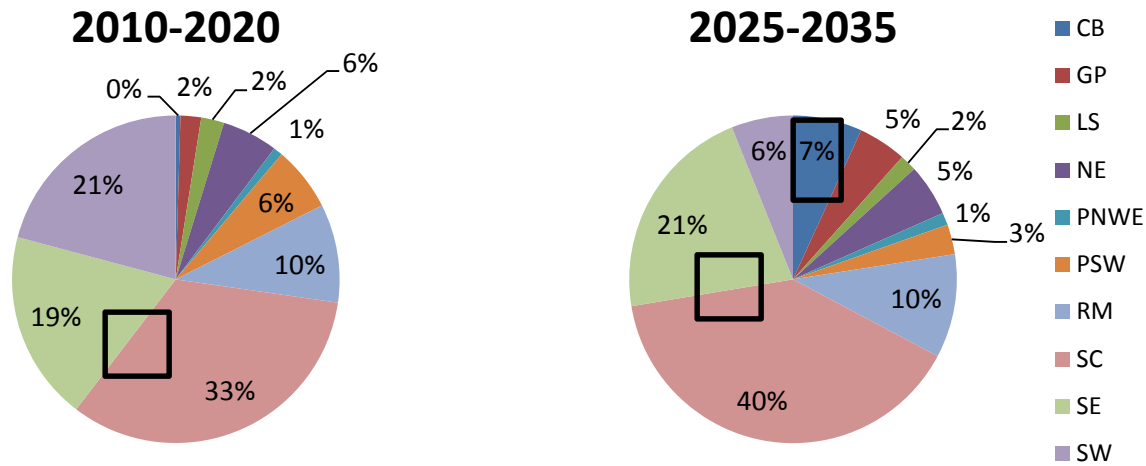
Feedstock (2010-2035)	Dry tons
Ag residues	12,300,000
Pulp/milling residues	43,200,000
Logging residues	23,400,000
Energy crops	79,400,000
SRWC	1,900,000

Feedstock (2010-2035)	Dry tons
Ag residues	56,200,000
Pulp/milling residues	79,900,000
Logging residues	30,300,000
Energy crops	402,900,000
SRWC	4,000,000

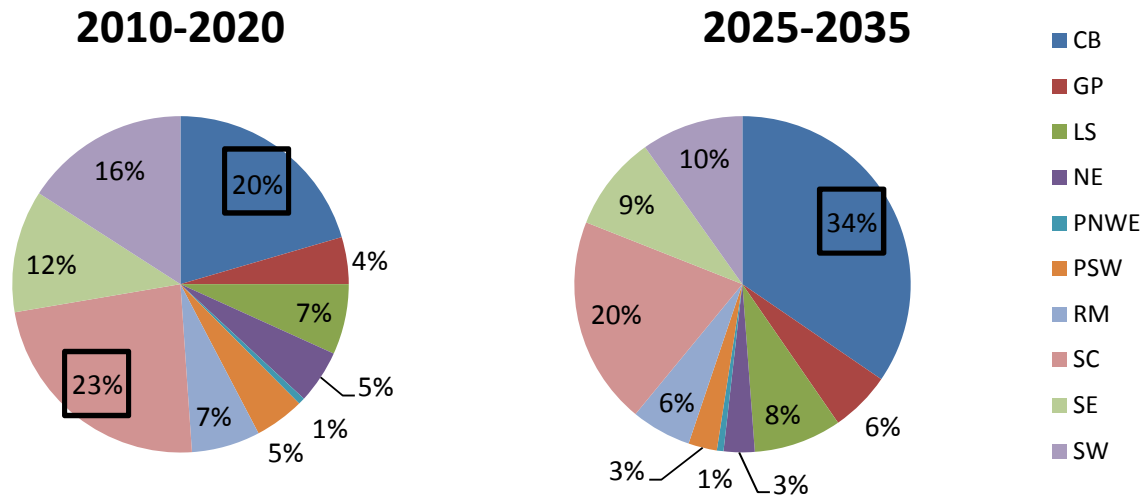


Feedstock Consumption Regional Distributions

Baseline



RES 20

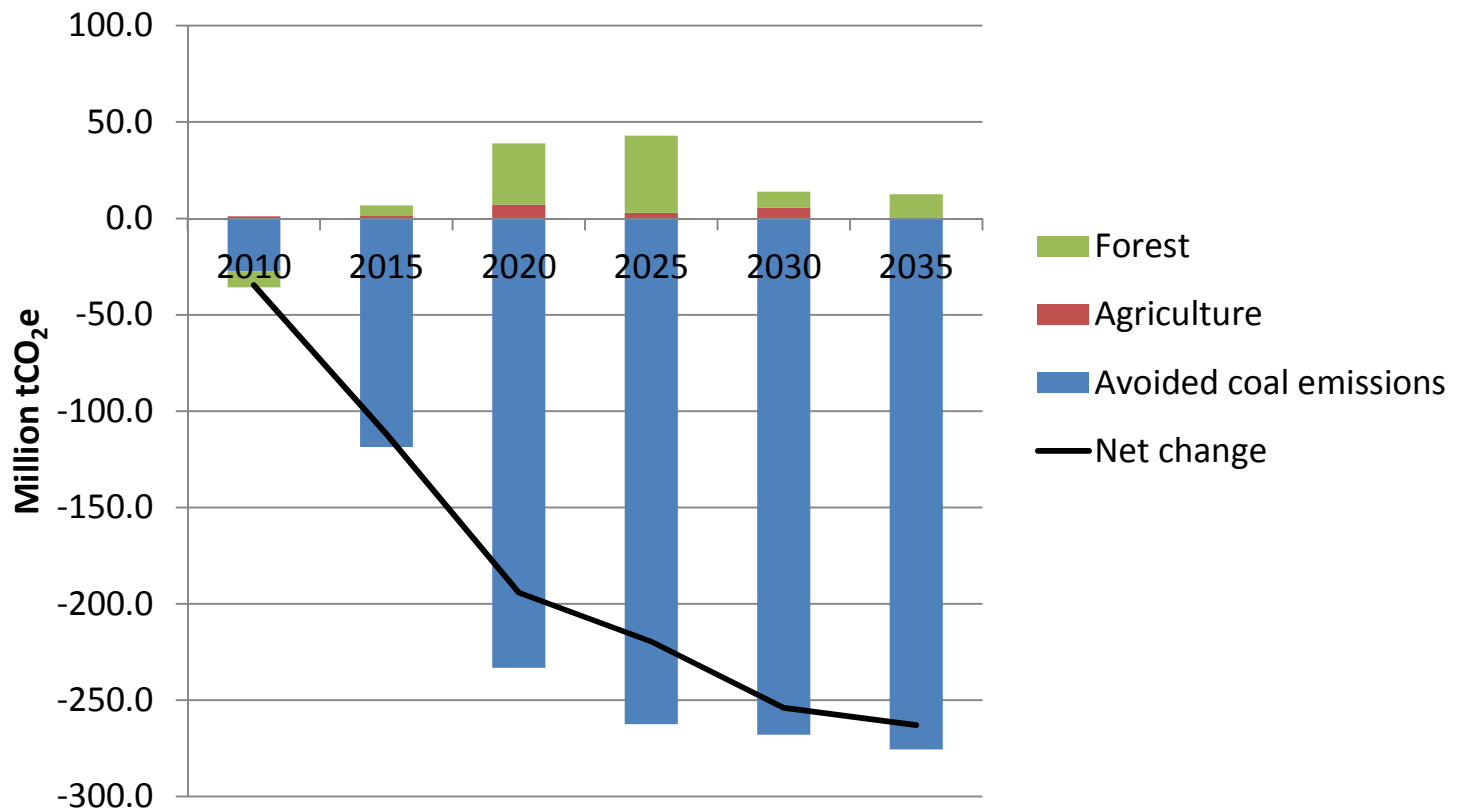


Deforestation/Afforestation

Deforestation	Base	RES 20 (change)
Corn Belt	1,194	-6
Lake States	2,442	0
Northeast	1,035	+153
Rocky Mountains	0	+4
Pacific Southwest	0	0
PNWE	55	0
South-Central	4,891	+2,449
Southeast	1,425	+1,089
Sum	11,042	+3,690
Afforestation	Base	RES 20 (change)
Corn Belt	1,854	+283
Lake States	132	0
Northeast	1,231	-31
Rocky Mountains	2,461	+98
Pacific Southwest	160	+5
PNWE	0	0
South-Central	4,087	-126
Southeast	1,600	-195
Sum	11,525	+34

National GHG Flux, RES 20 Scenario

Change from Baseline

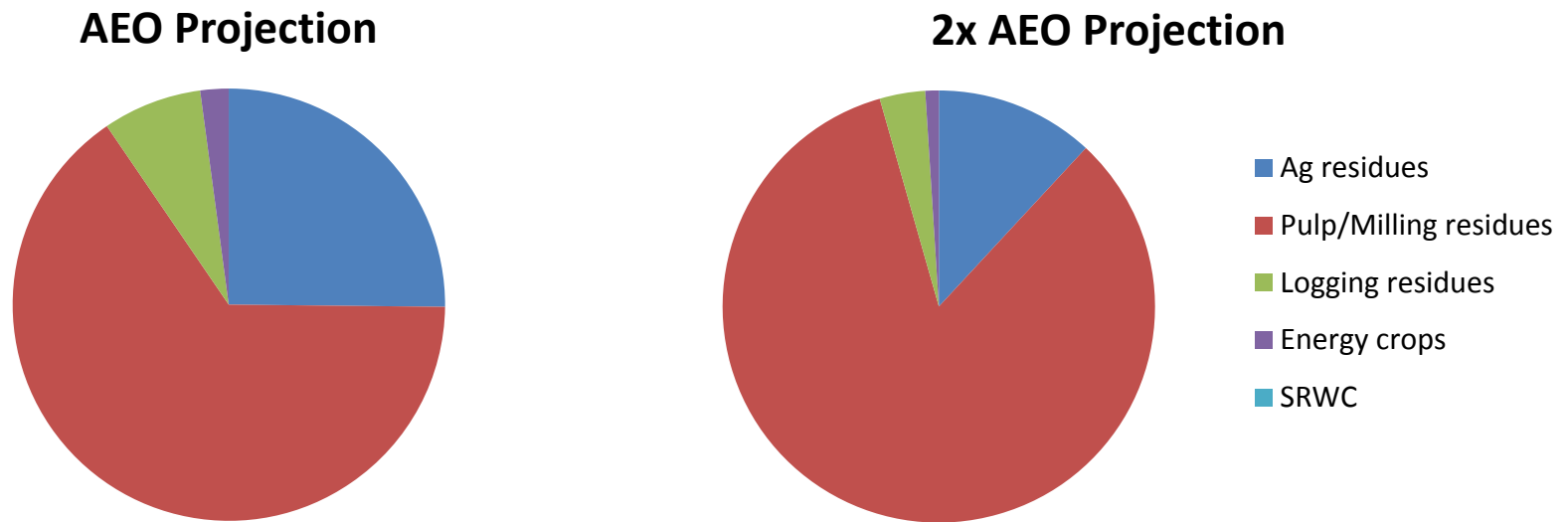


National GHG Flux, RES 20 Scenario

- The establishment of an RES yields large GHG improvements from avoided coal emissions and relatively small increases in emissions from the forest and agriculture sectors.
- In the RES 20 scenario, increased net deforestation post 2020 leads to the most significant deterioration in GHG flux in the forest sector.
- Net change in GHG flux, counting avoided emissions is greatest in the 2030 and 2035 period, when bioelectricity production is greatest

Regional RES Results

Feedstock Consumption

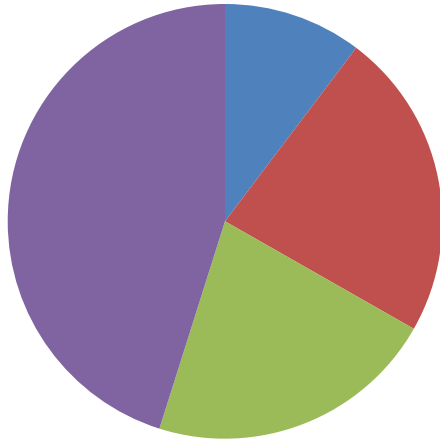


- NE region exhibits a greater reliance on dedicated biomass plants—leading to greater feedstock consumption.
- Pulp and milling residues more important feedstock in the Northeast relative to other regions.
- Despite reliance on P/M residues, the Northeast projected to employ several feedstocks to meet targets.

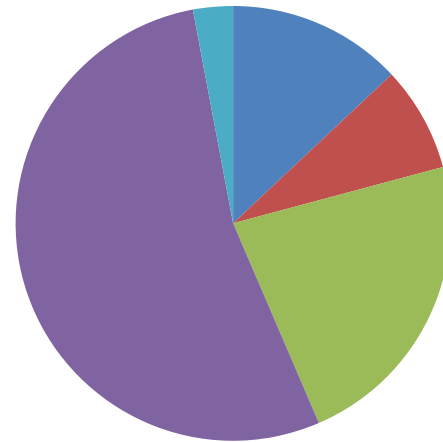
Feedstock Selection and Concentration

Base

Northeast



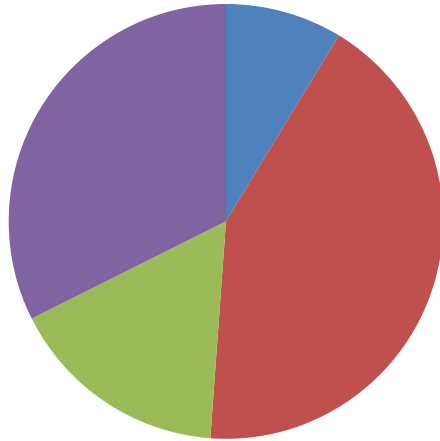
National



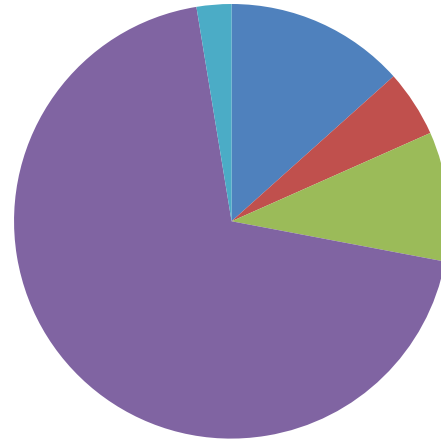
- Ag residues
- Pulp/Milling residues
- Logging residues
- Energy crops
- SRWC

RES

Northeast



National



- Ag residues
- Pulp/Milling residues
- Logging residues
- Energy crops
- SRWC

Land Use

Northeast—

Harvest of existing stands increase and age of forested stands decreases

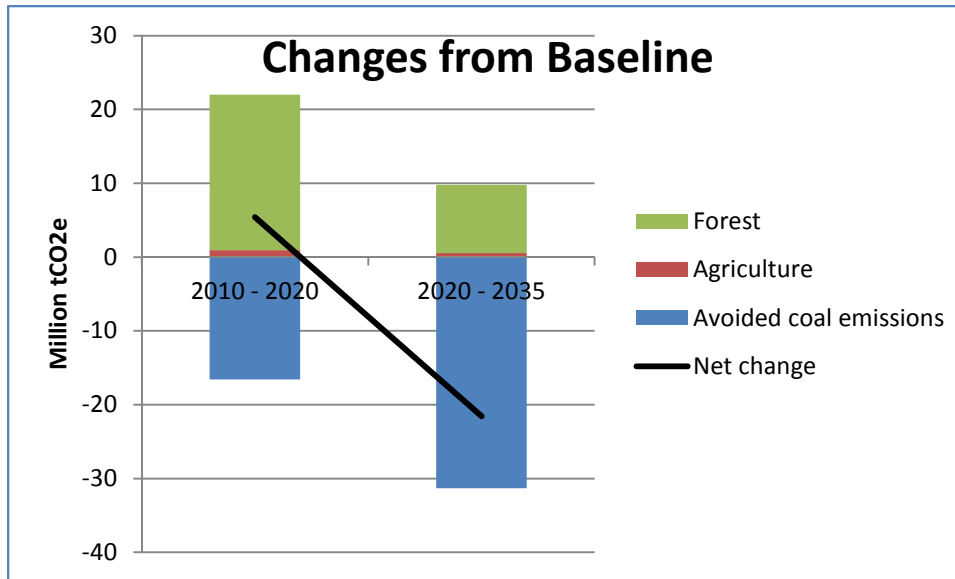
Afforestation increases by about 600,000 acres and deforestation to agriculture is roughly unchanged.

Greater land in crops and less in pasture between 2010 and 2025, but approaches baseline thereafter

ROTUS—

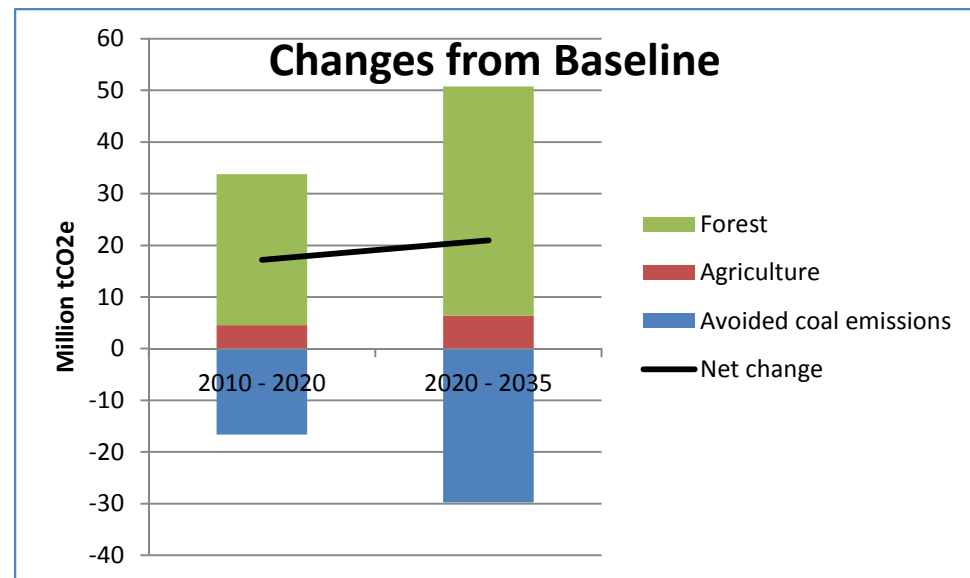
Results for the ROTUS are driven by changes in the existing forest resource base in the Northeast and Lake States regions

RES GHG Flux, Change from Base



Northeast

Nation
(including Northeast)



Conclusions

Forest sector residues are the earlier provider of biomass feedstock followed later by agriculture energy crops

Increased demand for renewable electricity increases the importance of energy crops

The South and the Corn Belt are the key providers of biomass feedstock

Significant land use change is projected only under the highest levels of renewable electricity demand

Future Directions

Examine commonalities and differences in bioenergy production resulting from standards and carbon markets

Consider alternate co-firing systems, and combined heat and power operations

Incorporate a broader representation of electric generation technologies into FASOM-GHG

Use update land use information to characterize the existing landscape and parameterize land use transitions