Understanding a Regional Biomass Inventories

Marc McDill, PSU School of Forest Resources

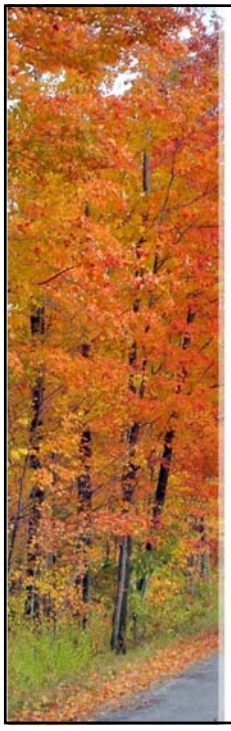
Cellulosic Supply Chains For BioEnergy
November 11, 2010

There's a lot of wood in them thar woods…

- Between 1953 and 2007 the estimated net volume of growing stock on forestland in the northern US more than doubled, from 103.7 billion cu ft to 248.0 billion cu ft
- Between 1963 and 2007 the estimated net volume of growing stock on forestland in the northeastern region increased from 76.9 billion cu ft to 136.6 billion cu ft – a 78% increase
- Pennsylvania's forests alone contain 1,146 million green tons of biomass

Outline

- Introduction: Estimating Agricultural Biomass Supplies
- Estimating Woody Biomass Supplies
- Case Study: Estimating Forest Biomass Supply in the Chesapeake Bay Watershed



A Simple Agricultural Biomass Supply Model

- **Supply = Area x Yield**

$$Supply = Area \times Yield$$

- **Multiple Site Classes**

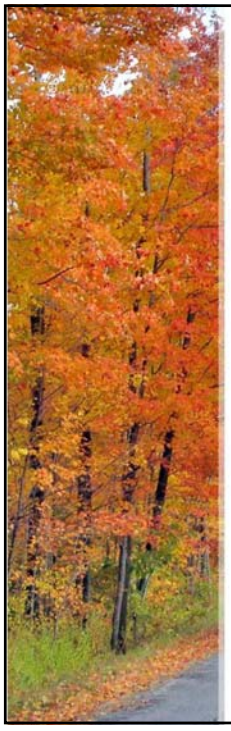
$$Supply = \sum_{i \in Sites} Area_i \times Yield_i$$

- **Multiple Crops**

$$Supply = \sum_{j \in Crops} \sum_{i \in Sites} Area_{ji} \times Yield_{ji}$$

A Simple Agricultural Biomass Supply Model

- The problem is to determine:
  - How much area is there in the region in each site class that could be used to grow the biomass crop?
  - How much area is there in the region in each site class that will be used to grow the biomass crop?
  - What is the yield of crop j on site class i?

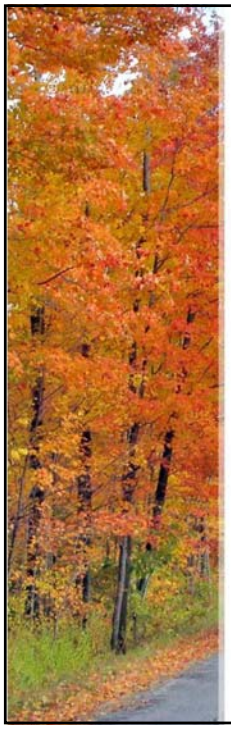


Geography & Logistics

- What is the region of interest?
  - For policy-makers, the region is typically determined by political boundaries
    - Delivered prices are based on average or maximum transport costs
  - For a potential biomass user, the region is determined by the point of use and the maximum distance a supplier can afford to transport the biomass

Geography & Logistics

- Maximum haul distance depends on:
  - Transportation infrastructure
  - Transportation mode
  - Preprocessing options



The Role of Price

- Higher biomass prices…
  - Increase the amount of land where growing biomass dominates the alternative land uses
  - Increase the amount of inputs that can be used to increase yields
  - Increase the distance suppliers can afford to go to get biomass

Factors Affecting of Forest Biomass Supplies

- Physical Supply
  - Area, volume (inventory), growth
  - Stocks vs. flows (i.e., inventory vs. growth)
    - « Bathtub model »
- Logistics
  - Harvest and transportation costs
    - Harvest costs depend on parcel area, volume/acre, tree size, slope, type of harvest, access
    - Transportation costs are more predictable
- Availability
  - Ownership objectives & attitudes
  - Environmental constraints

Factors Affecting of Forest Biomass Supplies

- Markets
  - Substitutes and competing uses of the raw material
  - What form do you want the woody biomass to be in?
    - Roundwood, dirty vs clean chips, mulch, moisture content, species composition
- Policies
  - RPS's, REC's, REGGI, etc.
  - Local ordinances
- Growth rates are hard to change…

Estimated reductions in wood availability from family forests of the northern US

Constraint	Reduction
Slope (≥50%)	3.2%
Physiographic class	2.3%
Site productivity	0.3%
Tree size (≤5 in)	2.2%
Cumulative reduction for biophysical constraints	**7.6%**

Source: Butler et al. 2010. Social vs biophysical availability of wood In the Northern US. N. J. Appl. For. 27(4):151-159.

Estimated reductions in wood availability from family forests of the northern US

Constraint	Reduction
Size of forest holdings (≤ 20 ac)	13.7%
Road distance (≥ 1 mile)	0.2%
Riparian buffers (≤ 100 ft)	3.8%
Population density (≥ 100 people/sq mi)	2.6%
Population gravity index	4.6%
Owner attitude index	52.8%
Cumulative reduction due to social constraints	**59.6%**
Cumulative reduction due to both biophysical and social constraints	**61.9%**

Source: Butler et al. 2010. N. J. Appl. For. 27(4):151-159.

Estimating Forest Biomass Supply in the Chesapeake Bay Watershed

Source: Wikimedia Commons

Physical Supply

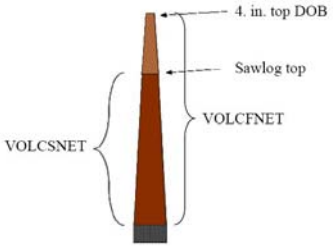
- Based on USDA Forest Inventory and Analysis (FIA) Data
  - Used GIS to identify subset of plots in each state in that are in the watershed
- Estimate biomass potentially available for biofuels (stock)
  - Oven dry tons (ODT)
- Estimate growth rates (flow)
  - Since growth is available in cubic feet, estimate growth as a percentage rate for each state
  - Apply percentage rate to biomass inventory to get biomass growth

Potentially Available Biomass

- "Commercial" and "Non-commercial" Biomass
  - "Non-commercial" biomass =
    All live biomass (includes branches & stump)
    - merchantable ("commercial") biomass (ODT)
    - stump biomass (too costly to harvest)
  - "Commercial" biomass =
    Pulpwood biomass (ODT)
    + Sawtimber biomass (ODT)
    - Commercial biomass is not broken out into pulpwood and sawtimber, but we assumed that sawtimber biomass would not be available for biofuels (it's too valuable in other uses)
    - So, we removed the sawtimber portion…

Estimating Pulpwood Biomass

- Pulpwood Biomass (ODT) =
  [Pulpwood Vol (cuft)/(Sawtimber Vol (cuft)]
  × Total Commercial Biomass (ODT)



- Sawtimber vol = VOLCSNET (cuft)
- Pulpwood vol = VOLCFNET (Total commercial vol (cuft))
  – VOLCSNET (cuft)

Estimating Biomass Growth

- Calculate volume growth for each state and use that growth rate to calculate biomass growth
  - Biomass Growth = Biomass Inventory × Volume Growth Rate
- Still based on FIA data
  - For plots in the watershed boundary

Physically Available Forest Biomass Inventory and Growth

States	Pulpwood Biomass (MODT)	Non-comm Biomass (ODT)	Total Biomass (MODT)	Growth Rate (Percent)	Plpwd Biomass Growth (MODT)	Non-Comm Biomass Growth (MODT)	Total Biomass Growth (MODT)
PA	149.6	118.1	267.7	2.3%	3.5	2.7	6.2
DE	3.0	2.7	5.6	3.7%	0.1	0.1	0.2
NY	44.4	32.7	77.1	2.4%	1.0	0.8	1.8
WV	28.8	20.4	49.2	1.6%	0.4	0.3	0.8
VA	141.9	110.3	252.2	3.0%	4.3	3.3	7.6
MD	35.8	32.6	68.4	3.3%	1.2	1.1	2.2
Total	403.5	316.8	720.3	avg=2.6%	10.5	8.3	18.8

- Note: inventory is about 38 times as large as growth.

Estimating "Available & Willing" Biomass Growth

- From pulpwood biomass, subtract current pulpwood use
  - Based on a combination of Timber Products Output (TPO) data and FIA removals
- From non-commercial biomass, subtract a percentage representing slash left in the woods for nutrient cycling
- Result is "potentially available" forest biomass
- Multiply this by a "willingness to manage factor"

Estimating Current Pulpwood Use

- Timber Products Output (TPO) database gives pulpwood use estimate by county for each state
- FIA database also gives a removals estimate (Sawt. & Pulpw.), which was adjusted using TPO data to estimate pulpwood removals
- Total pulpwood use (including composite products and fuelwood) was calculated for the counties that are (mostly or completely) in the watershed
  - Used an average of FIA removals and TPO use
- The ratio of pulpwood use relative to pulpwood inventory gives an estimate of the use rate as a percentage of the inventory in the region

Estimating Current Pulpwood Use as a Percentage of Inventory

State	FIA Pulpwood Inventory (MCuFt)	TPO Pulpwood Use (MCuFt)	FIA Removals / TPO Use	Adjusted (TPO-FIA) Puplwood Use (MCuFt)	Adjusted PWood Use/ FIA Pulpwood Inventory
PA	7,146	65.9	98%	65.2	0.9%
DE	169	3.6	139%	4.3	2.5%
NY	2,127	21.8	NA	21.6	1.0%
WV	1,286	1.2	241%	2.0	0.2%
VA	5,972	139.0	136%	163.9	2.7%
MD	1,901	25.1	83%	23.0	1.2%

Potentially Available Pulpwood Biomass Growth

States	Pulpwood Biomass (MODT)	Growth Rate (Percent)	Adjusted PWood Use/ FIA Pulpwood Inventory	Growth-Commercial Use	Potentially Available Pulpwood Biomass Growth (MODT)
PA	149.6	2.3%	0.9%	1.4%	2.10
DE	3.0	3.7%	2.5%	1.1%	0.03
NY	44.4	2.4%	1.0%	1.3%	0.60
WV	28.8	1.6%	0.2%	1.4%	0.40
VA	141.9	3.0%	2.7%	0.3%	0.38
MD	35.8	3.3%	1.2%	2.1%	0.74
Total	403.5				4.25

Slash Retention

- Assumed that 30% of non-commercial biomass was left in the woods for slash retention

Total Potentially Available Biomass Growth

States	Non-Comm Biomass (MODT)	Growth Rate (Percent)	Slash Retention (Percent)	Potentially Available Non-Comm Biomass Growth (MODT)	Potentially Available Plpwd Biomass Growth (MODT)	Total Potentially Available Biomass Growth (MODT)
PA	118.1	2.3%	30%	1.91	2.10	4.01
DE	2.7	3.7%	30%	0.07	0.03	0.10
NY	32.7	2.4%	30%	0.54	0.60	1.14
WV	20.4	1.6%	30%	0.22	0.40	0.62
VA	110.3	3.0%	30%	2.33	0.38	2.71
MD	32.6	-1.6%	30%	0.74	0.74	1.48
Total	316.8			5.82	4.25	10.06

Willingness to Manage Factors

- For Pennsylvania, New York and West Virginia:
  - "high willingness" = 45%
  - "low willingness" = 15%
- For Virginia and Delaware:
  - "high willingness" = 60%
  - "low willingness" = 25%
- "Willingness factors" can represent social willingness and/or economic availability

Annually Available "Willing" Forest Biomass Growth

States	Total Annually Available Forest Biomass (MODT)	Low Willingness to Manage for Biomass	Total Annually Available "Willing" Biomass (MODT) - Low Estimate	High Willingness to Manage for Biomass	Total Annually Available "Willing" Biomass (MODT) - High Estimate
PA	4.01	15%	0.60	45%	1.81
DE	0.10	25%	0.02	60%	0.06
NY	1.14	15%	0.17	45%	0.51
WV	0.62	15%	0.09	45%	0.28
VA	2.71	25%	0.68	60%	1.62
MD	1.48	15%	0.22	45%	0.67
Total	10.06		1.79		4.95

Discussion

- There's a lot subsumed in the "willingness factors"
  - Social availability
  - Logistics (access, harvest & transport)
- But the estimate is probably accurate within ±50%
- The low estimate (1.79 MODT) is enough to generate about 1.7% of Pennsylvania's electricity demand
- The high estimate (4.95 MODT) is enough for about 4.7% of Pennsylvania's electricity demand

Discussion

- The estimates are based on growth
- Current inventories (720.3 MODT) could be used at much higher rates for at least a couple decades before growth would become relevant

Questions?