# Modeling Forest Management and Carbon: a Tool for State-Wide Planning and Action

## Forest-Climate Working Group
## 2021-2022 Learning Exchange Series

May 4, 2022

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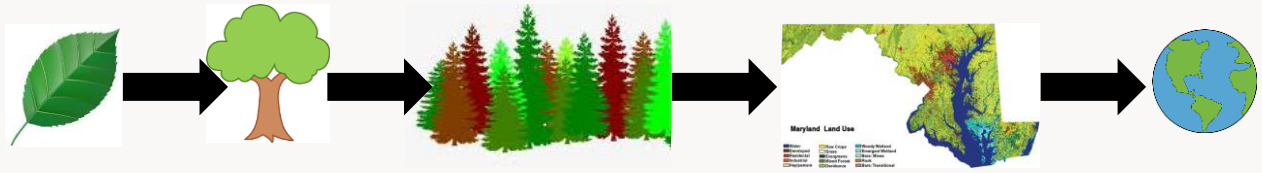
# Agenda

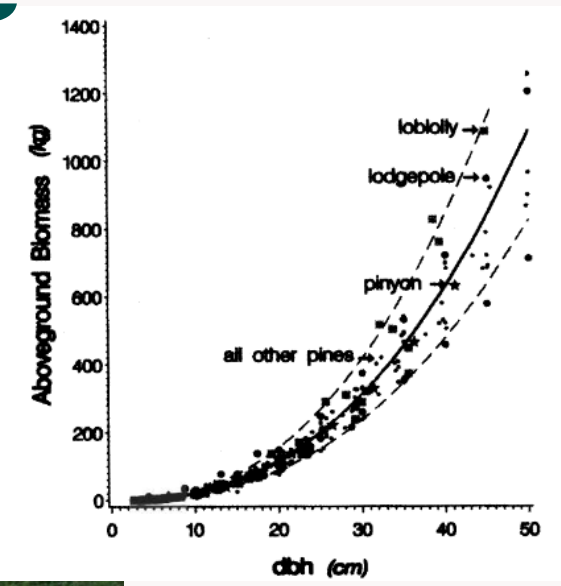
- Forest carbon modeling
- Our model: The CBM-CFS3
- Integrating FIA and US data into the CBM-CFS3

- Modeling carbon impacts of forest management and wood utilization
- Uses in state-wide planning and action

- Q&A

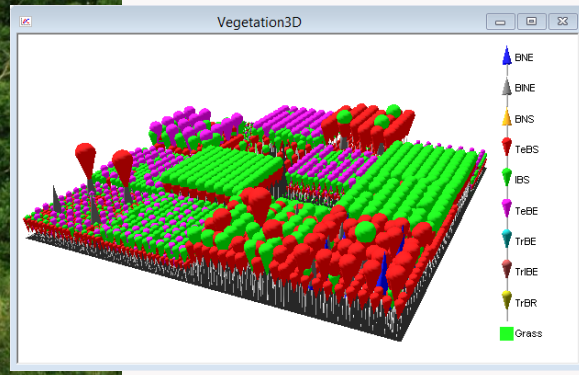
# Forest Carbon Modeling Landscape



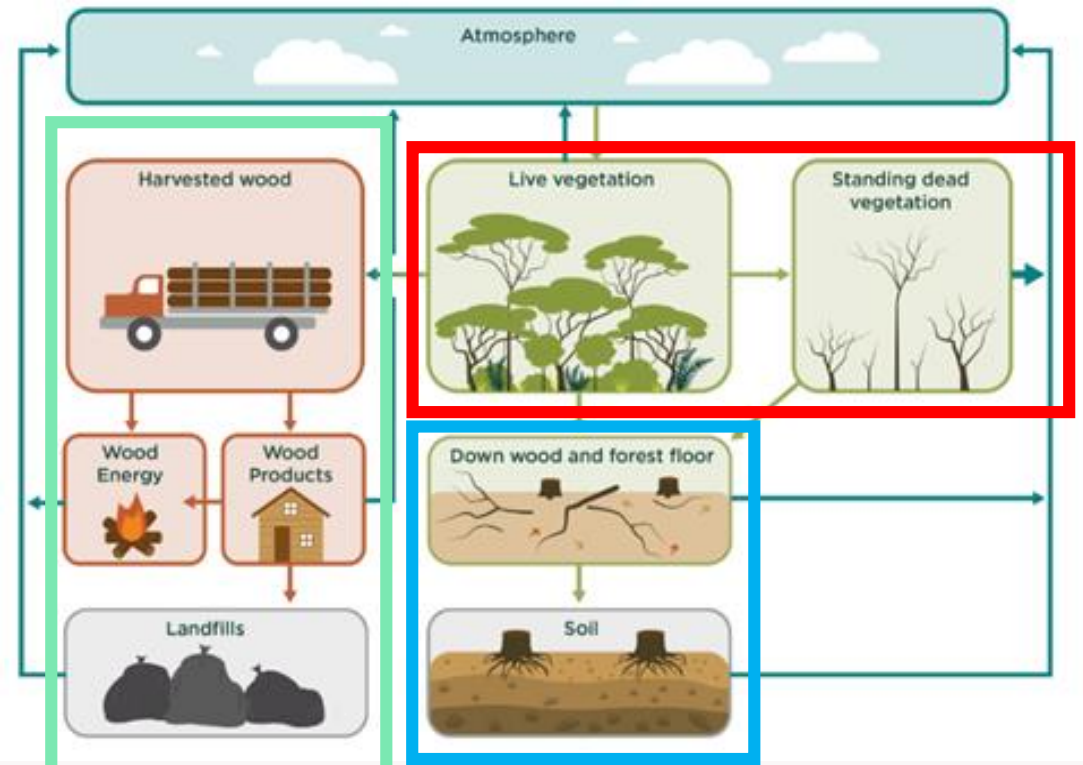




Two types of models

1. Estimate carbon from empirically-derived data (statistical models)
2. Estimate carbon from photosynthetic processes (process-based models)



# Hybrid simulation models: benefits and challenges



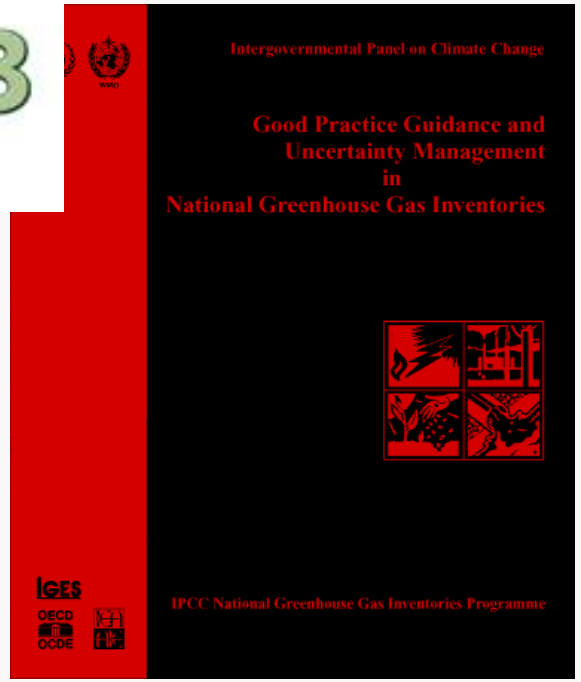

Benefits

- Empirical data lends strength to poorly constrained parameters in process models
- Simulating using process-based elements allows for advantages in projections
- Hybrid models can utilize the same data as operational foresters

Challenges

- Complex forest dynamics
- Both empirical models and process-based models can be poorly constrained
- Linkages to finance and HWP models

# CBM-CFS3: a tool for state-wide planning and action



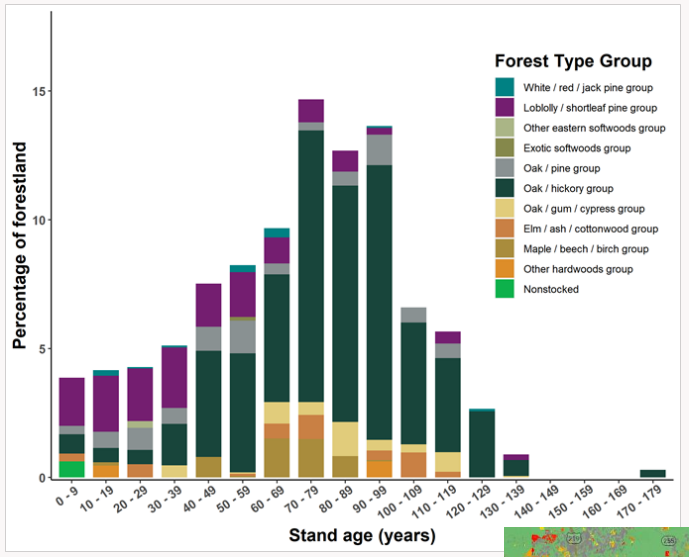

Carbon Budget Model of the Canadian Forest Sector

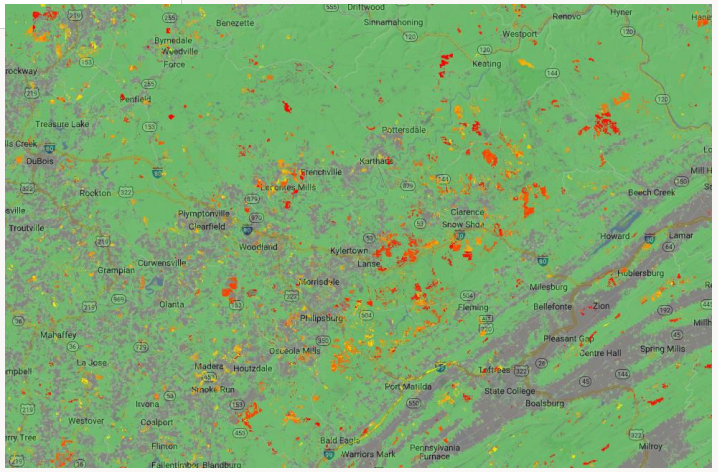
- Combines strengths of both empirical and process-based modeling approaches
- IPCC Compliant: Tier 3 methods:
  - "One inventory plus change" method
  - The CBM-CFS3 tracks 10 biomass and 11 DOM C pools
  - Easy aggregation into IPCC pools for reporting
  - Spatially referenced model (GCBM for spatially explicit modeling)
  - Ease of data availability with data inputs

# CBM-CFS3: a hybrid modeling framework to quantify forest carbon dynamics


Representation of Forest Disturbance
- Harvest
- Natural
- Land-use change

# CBM-CFS3: Data inputs and model structure



## Data Inputs

- Detailed forest inventory
  - Stands characteristics described by classifiers
- Empirically-derived growth-yield relations
- Disturbance representation
  - Harvest / management information
  - Natural disturbances
  - Land-use change

## Model structure

- Volume to biomass conversions
- Process-based models for turnover
  - Climate / soil dependent

# Forest Inventory and Analysis database at a glance

- National system for monitoring forests and forest change
  - 1999 revisions to methods and design
- Emerging applications:
  - rFIA
  - Advances in small area estimation
  - Advances in temporal queries
  - Improvements to carbon / biomass estimation

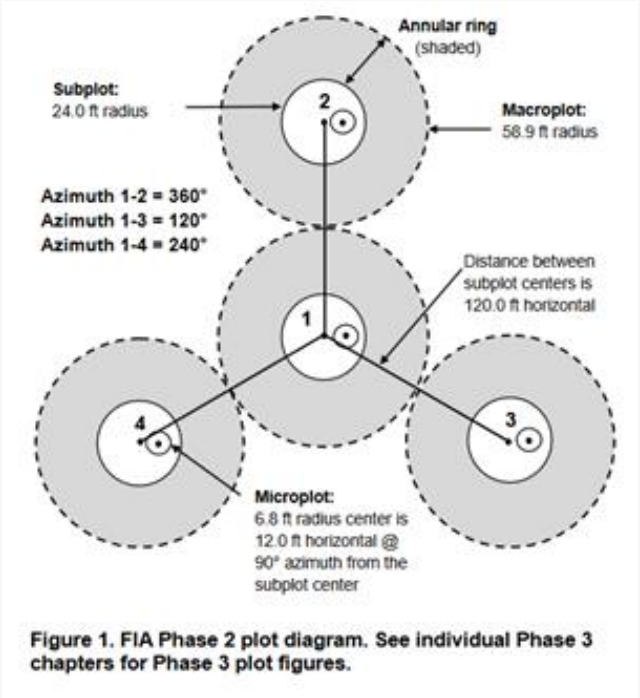
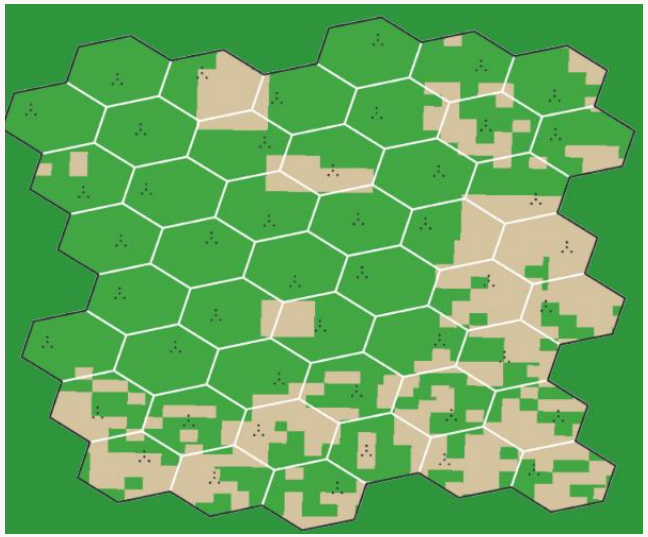
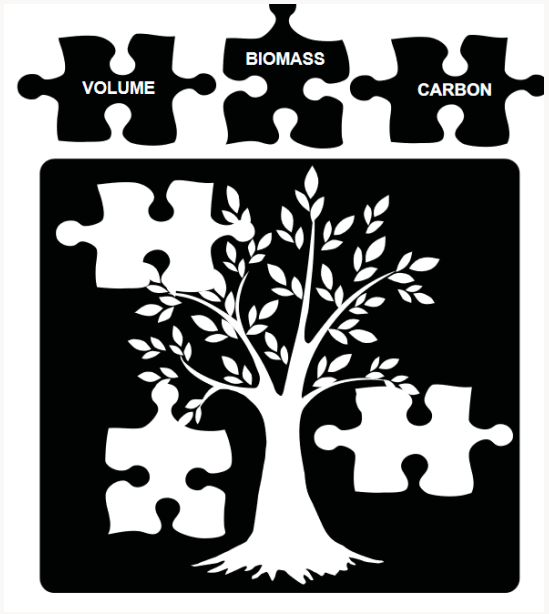
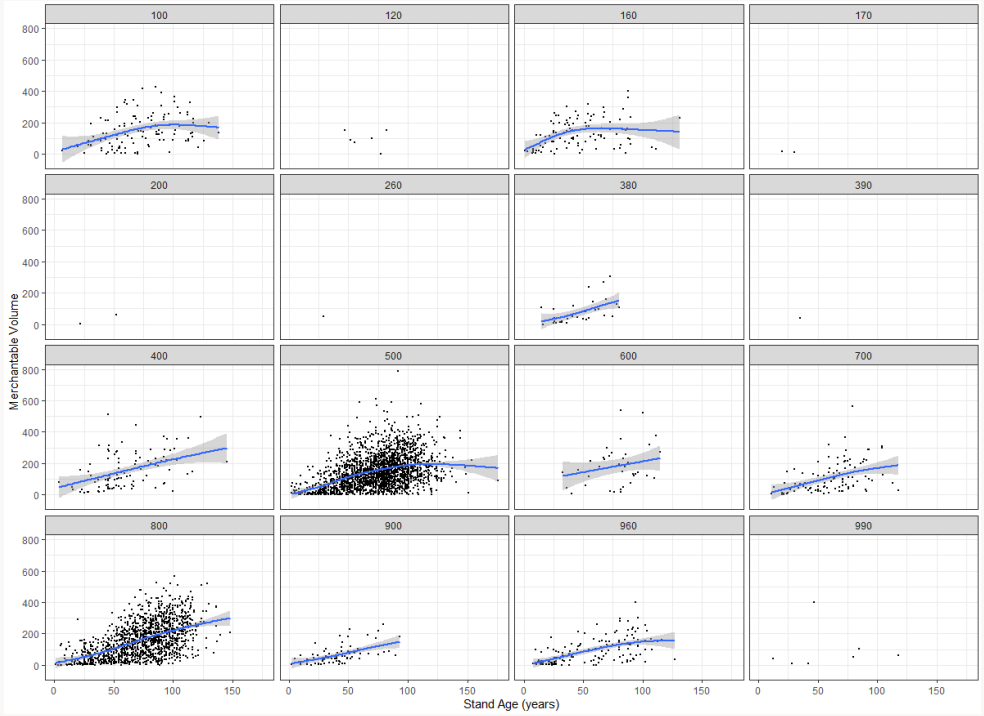


Figure 1. FIA Phase 2 plot diagram. See individual Phase 3 chapters for Phase 3 plot figures.

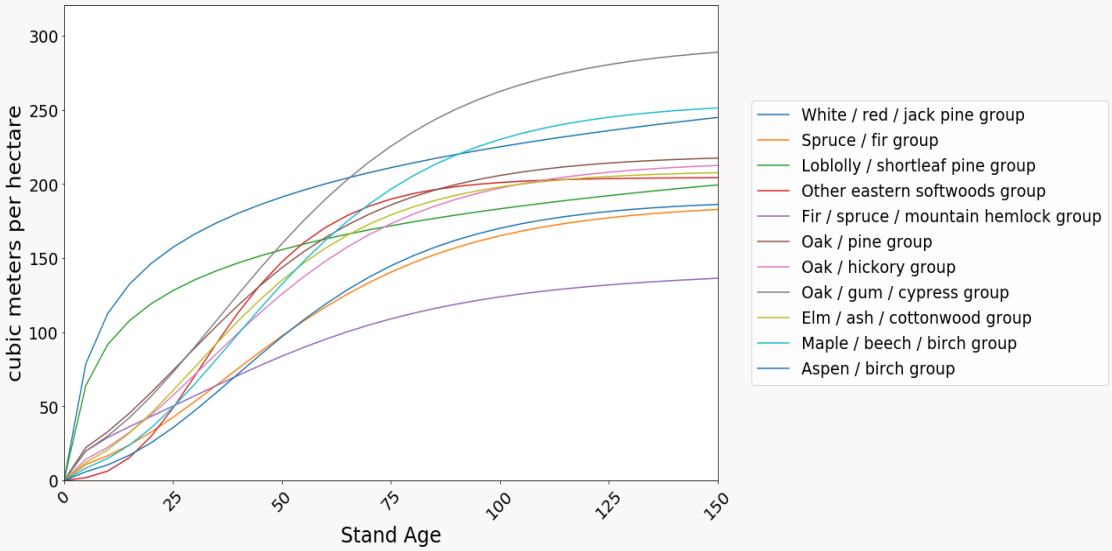




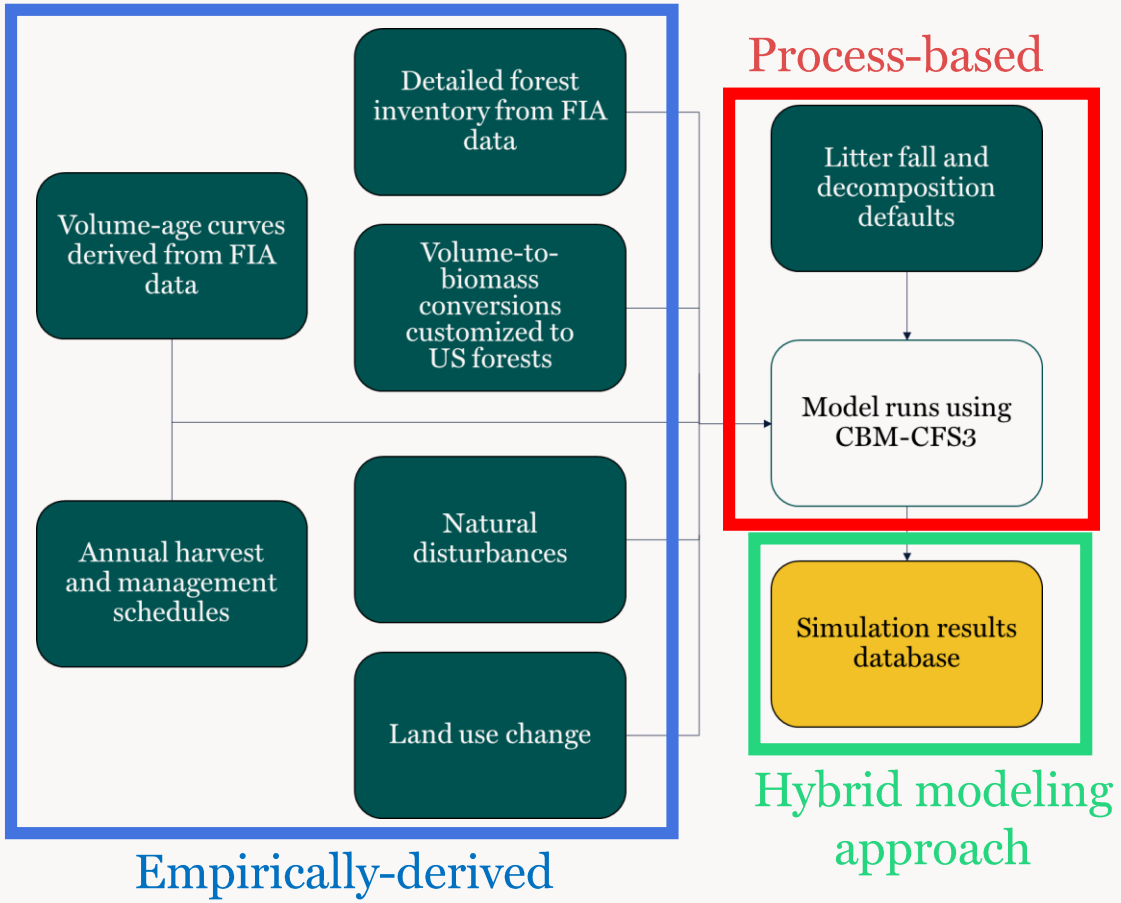
# Deriving empirically-based estimates from FIA data




- Applying estimators to generate age-based forest inventories
  - Bechtold, Patterson, et al. 2005
- Applications of plot-level estimates for growth-yield model derivation



# Integration and applications of US inventory data with the CBM modeling framework




- Streamline process of empirical data estimates, remotely-sensed metrics, and disturbance intensity data
- Flexibility in data inputs
  - i.e., disparate data sets can be utilized
- Customizable volume-to-biomass conversions
- Ease in post-processing results
  - User feedback
- Key linkages to both HWP and finance models
  - CBM-HWP modeling framework

# Modeling carbon impacts of forest management

American Forests™ NIACS Northern Institute of Applied Climate Science

Forest Carbon and Climate Program
Department of Forestry
MICHIGAN STATE UNIVERSITY

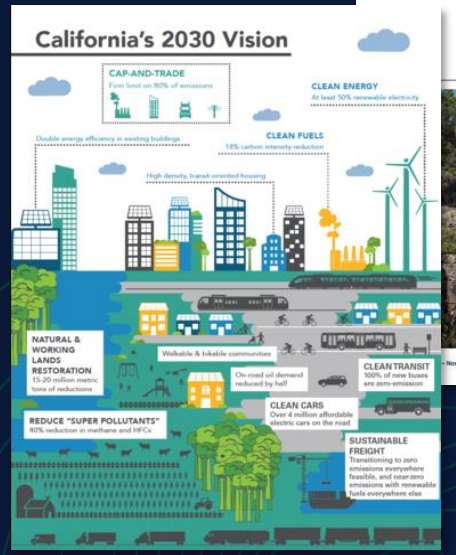
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Canada
Natural Resources Canada
Canadian Forest Service

✓Partners in 7 states (MD, PA, MN, MI, WI, OR, & CA)

## Objectives:

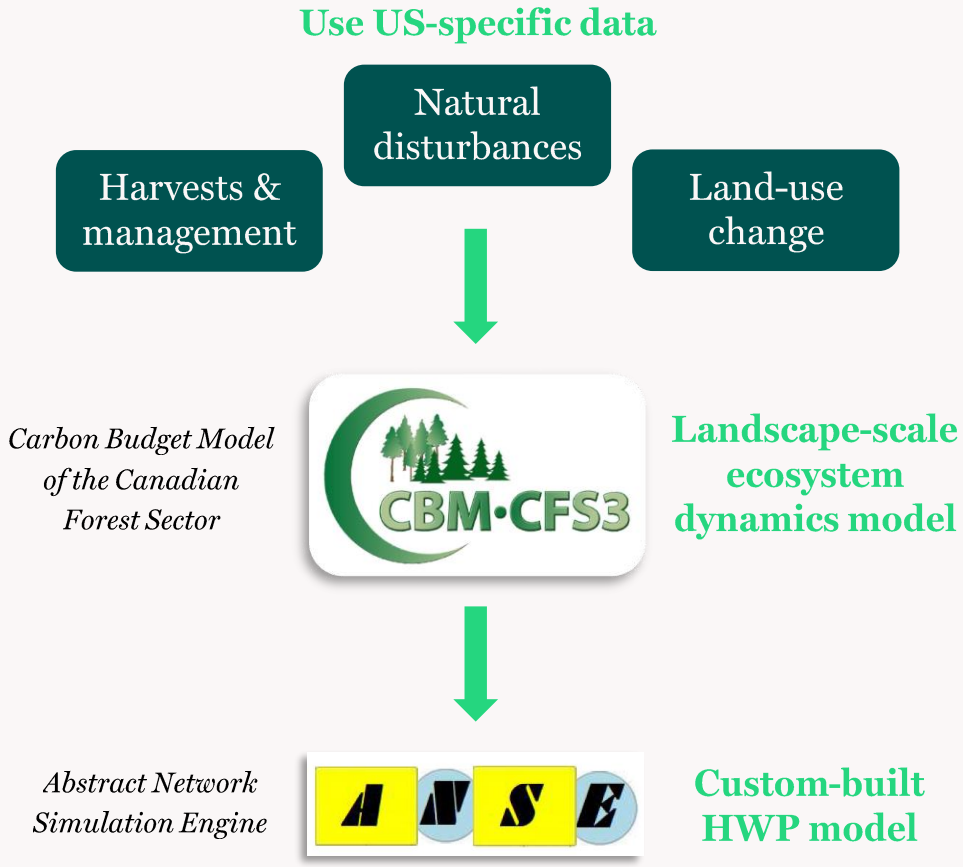
- Model carbon impacts of forest management and wood utilization scenarios
  - Ecosystem + wood products + substitution + economics
- Understand climate mitigation potential of scenarios/practices
- Integrate carbon in forest management and planning
- Integrate forests as natural climate solutions in state climate planning




# Modeling Scenarios

✓ Compare business-as-usual to broad range of forest management & wood utilization scenarios, such as:

- Extending rotations
- Controlling deer browse & promoting natural regeneration
- Optimizing stocking levels
- Timber stand improvements & resilience/restoration treatments
- Afforestation & silvopasture
- Reducing high grading & reducing deforestation
- No harvest activities
- Creating more mass timber or long-lived wood products
- Using woody biomass for energy or transportation fuels



# Uses of model outputs and results

Our outputs provide various tools for state-wide planning:

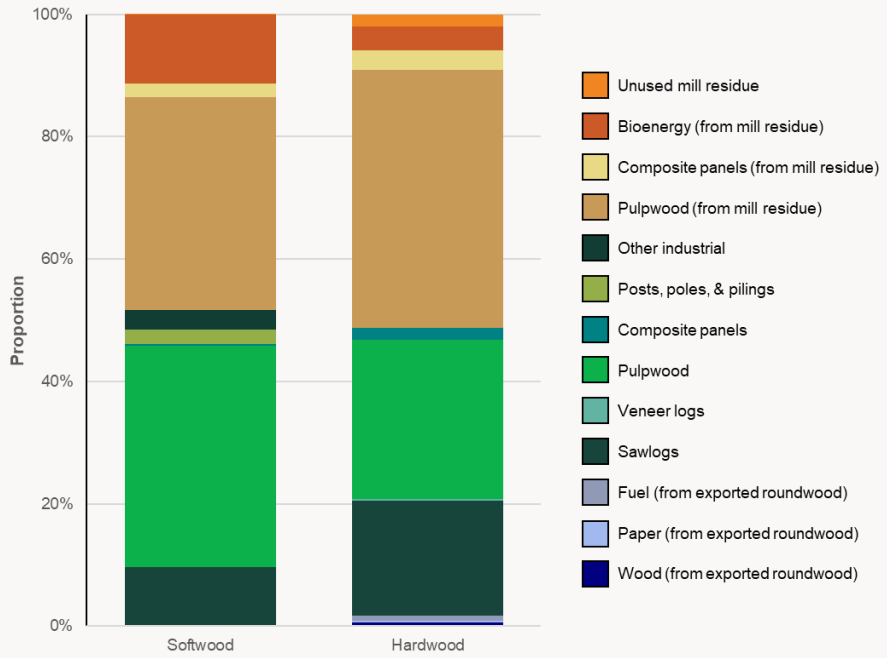
- Current practices for all ownerships
- Yield curves for all forest types and age classes
- Projected trends under business-as-usual scenario
- Comparisons of scenario performance/potential
- Assessments of state-wide restoration & reforestation needs
- Assessments of projected future climate impacts

Potential policy targets and actions:

- Acreage targets to meet carbon goals
- Most effective practices for meeting forest and climate goals
- Consider current state capacity, funding, and programs to incentivize practices

# Current Practices: Maryland

- Derived from FIA, RPA, TPO, NLCD, MTBS, Canham et al. 2013, and state-level data




*Proportion of harvested wood distributed to various product categories in Maryland*

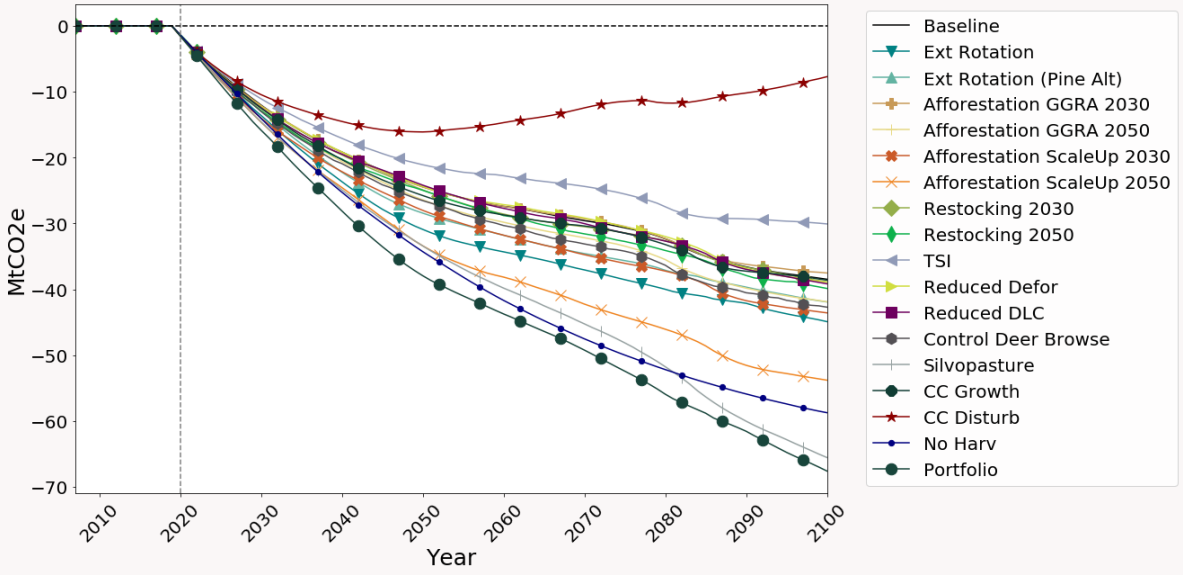
**Maryland business-as-usual baseline parameters**

| Event | Classifiers | Practice | Intensity | Historical average, 2007-2019 |
|---|---|---|---|---|
| Land-use change | - | Forest loss | - | -7,386 acres/year |
| | - | Forest gain | - | +6,909 acres/year |
| Natural disturbance | - | Wildfire | Low intensity | 436 acres/year |
| | - | Insect defoliation | Low intensity | 9,809 acres/year |
| | - | Insect mortality | | 372 acres/year |
| | - | Disease | | 28,090 acres/year |
| | - | Abiotics | Low intensity | 6,562 acres/year |
| Forest management | - | Prescribed fire | ~40% understory consumption | 384 acres/year |
| | State forests | Clearcut | 90% removal | 13,245 mt C/year<br>1,949,194 cu ft/year |
| | | Shelterwood cut (HW only) | 50% removal | 190 mt C/year<br>25,415 cu ft/year |
| | | Group selection/overstory removal (HW only) | 30% removal | 11,187 mt C/year<br>1,495,537 cu ft/year |
| | | Thinning | 30% removal | 923 mt C/year<br>135,833 cu ft/year |
| | Private forests | Clearcut | 90% removal | 31,520 mt C/year<br>4,638,660 cu ft/year |
| | | Seed tree cut (HW only) | 70% removal | 32,390 mt C/year<br>7,507,083 cu ft/year |
| | | Diameter limit cut (HW only) | 70% removal | 23,839 mt C/year<br>7,589,854 cu ft/year |
| | | Shelterwood cut (HW only) | 50% removal | 84,136 mt C/year<br>3,013,165 cu ft/year |
| | | Group selection/overstory removal (HW only) | 30% removal | 10,842 mt C/year<br>3,068,538 cu ft/year |
| | | Thinning | 30% removal | 19,384 mt C/year<br>2,267,534 cu ft/year |

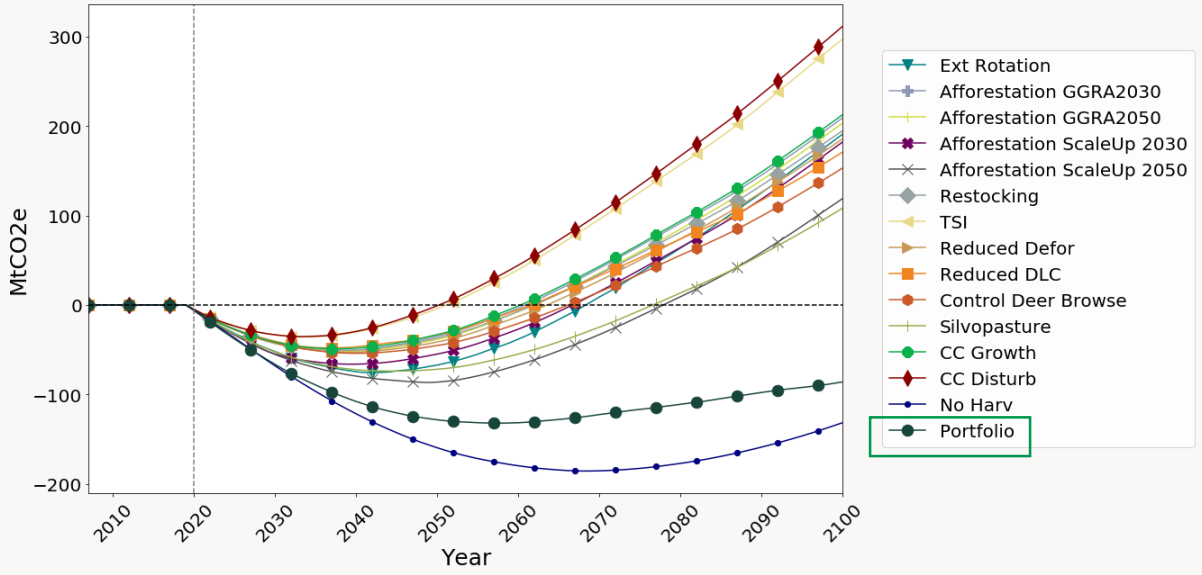
# Mid-Atlantic modeling results

- Projections show whether forests will stay a net carbon sink or become a net carbon source over time
- Scenarios demonstrate how various practices can alter this trajectory

**Maryland**




**Pennsylvania**




Cumulative annual emissions (ecosystem+HWP) from 2020-2100. **Negative numbers represent additional carbon sequestered (a net carbon sink).**

*Forests + HWP projected to remain a net carbon sink in BAU by 2100*

*Forests + HWP projected to become a net carbon source in BAU by 2100*

# Mid-Atlantic scenario comparisons

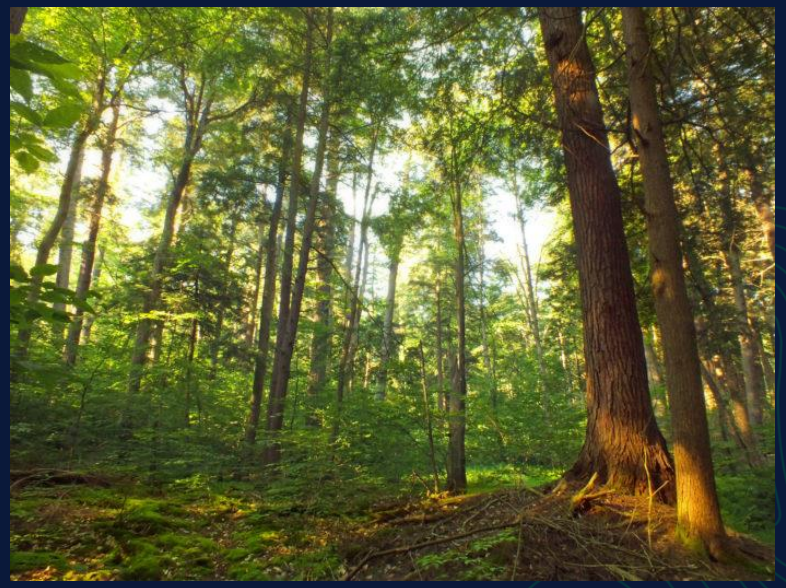
| | Rank | MARYLAND | | PENNSYLVANIA | |
|---|---|---|---|---|---|
| | | Carbon **Stocks** per Acre | Carbon **Fluxes** per Acre per Year | Carbon **Stocks** per Acre | Carbon **Fluxes** per Acre per Year |
| 2020-2030 | 1 | No harvest activities | Silvopasture | No harvest activities | Afforestation |
| | 2 | Extended rotations | Afforestation | Extended rotations | No harvest activities |
| | 3 | Reduce diameter limit cuts | Extended rotations | Restocking understocked stands | Silvopasture |
| | 4 | Control deer browse | Restocking understocked stands | Reduce diameter limit cuts | Extended rotations |
| | 5 | Afforestation | Control deer browse | Afforestation | Control deer browse |
| | 6 | Restocking understocked stands | No harvest activities | Control deer browse | Reduce deforestation |
| | 7 | Reduce deforestation | Reduce diameter limit cuts | Reduce deforestation | Restocking understocked stands |
| | 8 | Timber stand improvements | Reduce deforestation | Silvopasture | Timber stand improvements |
| | 9 | Silvopasture | Timber stand improvements | Timber stand improvements | Reduce diameter limit cuts |
| 2020-2050 | 1 | No harvest activities | Silvopasture | No harvest activities | No harvest activities |
| | 2 | Extended rotations | Afforestation | Extended rotations | Afforestation |
| | 3 | Control deer browse | Extended rotations | Restocking understocked stands | Silvopasture |
| | 4 | Afforestation | Control deer browse | Control deer browse | Extended rotations |
| | 5 | Reduce diameter limit cuts | Restocking understocked stands | Reduce diameter limit cuts | Control deer browse |
| | 6 | Restocking understocked stands | No harvest activities | Afforestation | Reduce deforestation |
| | 7 | Reduce deforestation | Reduce diameter limit cuts | Reduce deforestation | Restocking understocked stands |
| | 8 | Timber stand improvements | Reduce deforestation | Timber stand improvements | Reduce diameter limit cuts |
| | 9 | Silvopasture | Timber stand improvements | Silvopasture | Timber stand improvements |
| 2020-2100 | 1 | No harvest activities | Silvopasture | No harvest activities | Silvopasture |
| | 2 | Extended rotations | Afforestation | Extended rotations | Afforestation |
| | 3 | Control deer browse | Control deer browse | Control deer browse | Control deer browse |
| | 4 | Afforestation | Extended rotations | Restocking understocked stands | No harvest activities |
| | 5 | Restocking understocked stands | Reduce diameter limit cuts | Reduce diameter limit cuts | Reduce diameter limit cuts |
| | 6 | Reduce diameter limit cuts | Restocking understocked stands | Afforestation | Restocking understocked stands |
| | 7 | Reduce deforestation | Reduce deforestation | Reduce deforestation | Reduce deforestation |
| | 8 | Timber stand improvements | Timber stand improvements | Timber stand improvements | Extended rotations |
| | 9 | Silvopasture | No harvest activities | Silvopasture | Timber stand improvements |

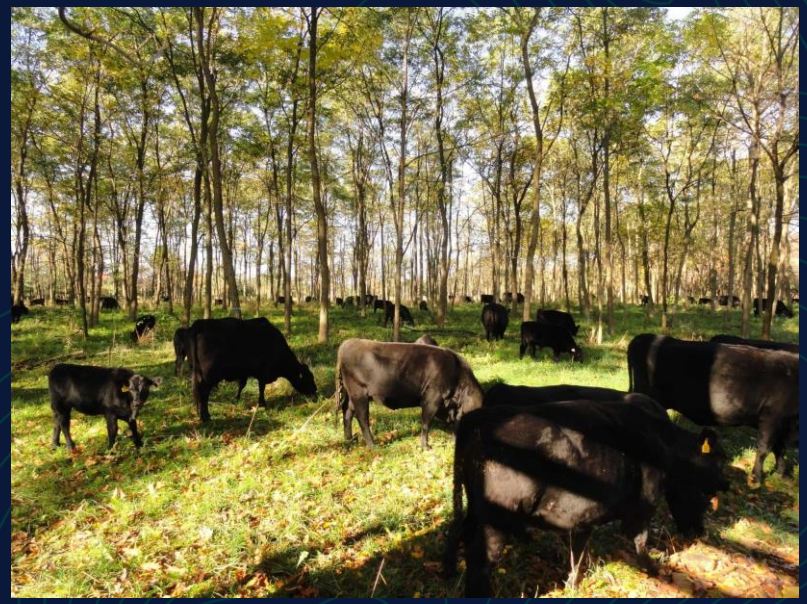
*Color coding based on scenario rank for carbon **stocks** per acre – note reordering of scenarios when ranking by carbon **fluxes** per acre per year. Bolded scenarios (above dotted lines) have higher carbon stocks/fluxes than the BAU scenario.*

- Ranking scenarios by relative performance can help identify effective practices for meeting carbon goals
- Rankings differ when considering:
  - Carbon stocks vs carbon fluxes
  - Timeline

# Opportunities and takeaways for Mid-Atlantic forests

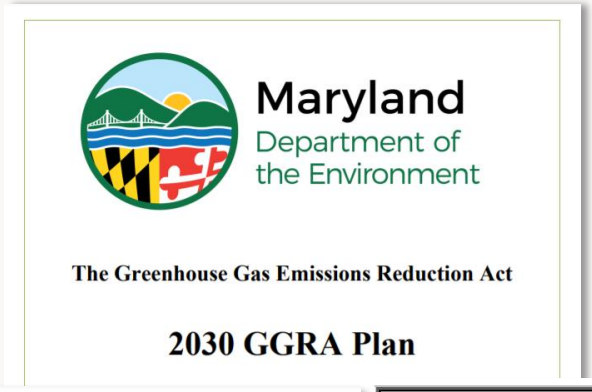
- Prioritize forest health and structure, rebalancing age distribution; focus on protecting natural regeneration
- Scale up ambition for tree planting
- Expand adoption of silvopasture
- Incentivize more sustainable management practices on private lands
- Prepare for potential negative impacts of climate change, especially from more pests and disease



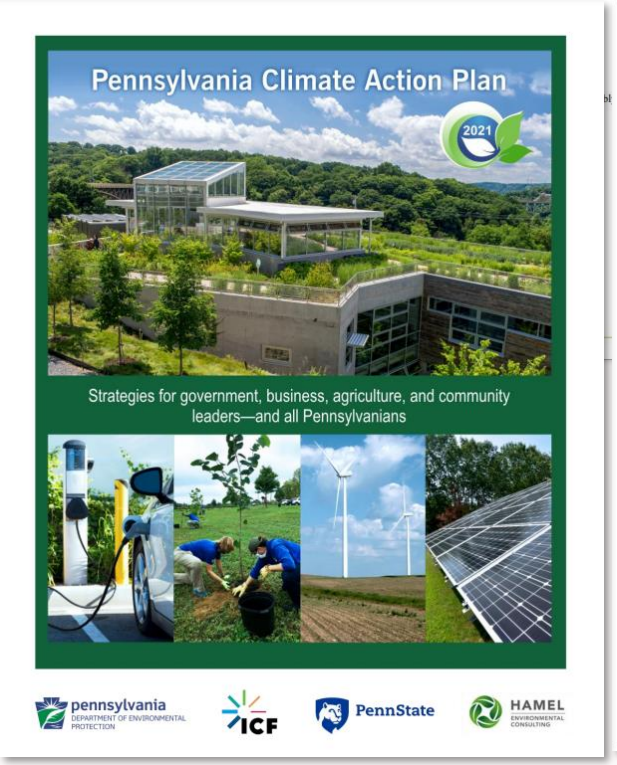


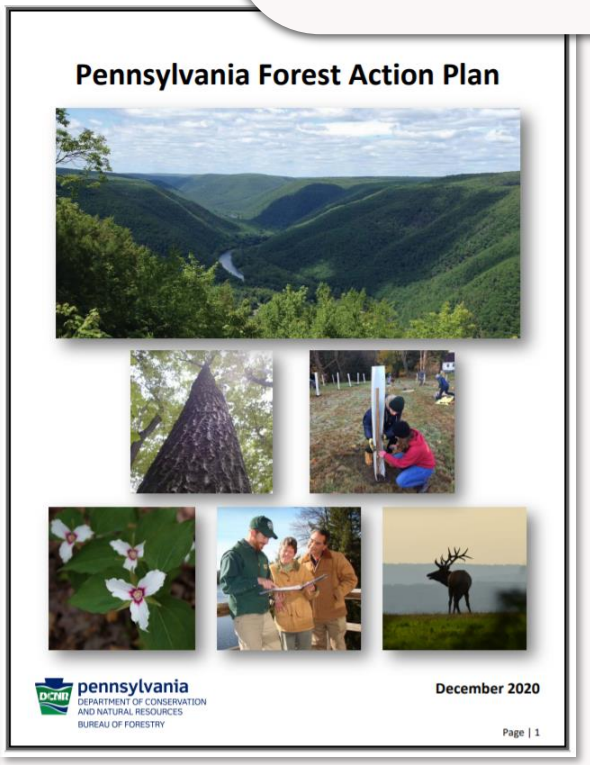
# Policy applications for the Mid-Atlantic

- Maryland's 2045 net zero goal
- Maryland Conservation Finance Act of 2022
- Maryland Tree Solutions Now Act of 2021
- RGGI & carbon markets
- Pennsylvania Climate Change Advisory Committee
- Pennsylvania Climate Action Plan
- Pennsylvania Forest Action Plan




CLIMATE SOLUTIONS NOW ACT of 2022



# Questions?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