Bringing forest management into Earth system models: Insights from observations and theory

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AMS 4th Biogeosciences / 33rd AgForMet Talk 3.1
May 14, 2018
MANangement and Disturbance in FORest Ecosystems

NSF EF-1241860; EF-1702835, (Macrosystems Biology)

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What is forest management?

- And how do current Earth system models represent it?
Unexpectedly large impact of forest management and grazing on global vegetation biomass

Karl-Heinz Erb\textsuperscript{1}, Thomas Kastner\textsuperscript{1,2*}, Christoph Plutzar\textsuperscript{1,3*}, Anna Liza S. Bais\textsuperscript{1}, Nuno Carvalhais\textsuperscript{4,5}, Tamara Fetzel\textsuperscript{1}
We know forest age determines NEP.
We know carbon management practices have significant potential.

US forests annually sequester the equivalent of 10% of US carbon dioxide emissions from burning fossil fuels.

Forestry activities could remove another 100 to 200 Tg C/yr.

But we really don’t know how to map, observed, and simulate forest management to understand continental to global scale effects of these activities on climate and ecosystems.

So let’s review some attempts
Can we better map management?
Age structure and disturbance legacy of North American forests

Y. Pan¹, J. M. Chen², R. Birdsey¹, K. McCullough¹, L. He², and F. Deng²

Pan et al.,
Biogesices, 2011
Management Functional Types

- **Production Forestry** maximizes wood or pulp production.

- **Preservation Forestry** maintains a baseline state to preserve species, ecosystem services, recreation, and aesthetic value.

- **Ecological Forestry** uses ecological principles to balance wood production with habitat and ecosystem services.

- **Passive Management** may be exploited for timber but lacks any active management practice other than desultory harvest.

References:

- Becknell et al., *Bioscience*, 2015
- OR BLM
- RJ Peterson
- TJ Gehling
Central North Carolina

2000
Private plantation landscape

25 km
2 M.

North Florida

2010
All January

Forest Trajectories
- Non-forest
- Recent regrowth
- Forest regrowth
- Deforestation
- Harvest regrowth
- Recent harvest
- Stable forest

M. Binford
MODIS time-series: Enhanced Vegetation Index
Normalized Spectral Entropy of VI
BFAST (Breaks For Additive Season and Trend)
Ownership, Forest Type, other ancillary data
overlay and zonal analysis
Ecological Passive

Total forest area: 61,345,169 ha

Variable Importance for Random Forest Classification
PNW forest management map

Total forest area: 28,988,131 ha

Area of forest classes by percentage:
- Ecological: 12%
- Passive: 51%
- Total: 100%

Variable Importance for Random Forest Classification

Kilometers

Legend:
- Red: Ecological
- Blue: Passive
- Yellow: Preservation
- Green: Production
What are the effects of management on the atmosphere?
Stoy et al, Nature Clim Change, 2018
Impacts of forest harvest on cold season land surface conditions and land-atmosphere interactions in northern Great Lakes states

Matthew Garcia¹, Mutlu Özdogan¹, and Philip A. Townsend¹
Let’s thin a forest!
New studies in the tropics

C. Deshmukh
APRIL

- National/global importance

Pristine peatswamp forest

Land use change

Plantation forestry

Mixed land cover
So how do we model forest management?
Desai et al., 2007

Climate only
Harvest only
Both
Control

NEE (gC m² yr⁻¹)

Full No_For No_CO2 No_For/CO2
Ecosystem Demography 2 Model
Preliminary Results
Implications and paths forward
Socioecological Linkages

Ecological Structure and Function

Sink or Source Products (Intermediate Services)

Assessment of Modeling and Monitoring data

Policy and Management

Final Ecosystem Services
Final thoughts

- Forest management is more than clear-cutting
- We can map it
- We can define management function in a relatively simple manner
- We are incorporating into ecosystem models
- And comparing it to real world experiments with alternative harvesting practices
- And testing hypotheses on ecological scaling and atmospheric feedbacks
- Thanks!