# Cross-scale integration of coupled human-environment models of land-use and land-cover change: Process based vs. data limitations

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## Big issues:

- Desire to link socioeconomic drivers of LULCC to LULCC to effects on key ecosystem services
- Relevant processes, and therefore models of them, often operate on different variables of interest at different spatial and temporal scales
- Data often available/collected for independent process models -> matching problem
- Data availability constraints

## Big questions:

To what extent can the challenges of coupled-HE models for this purpose be improved by:

- Better process models vs...
- Better data?

In short, what investments should we target and why?

## Focusing the question: 3 research applications

- Residential household level best management practices, storm water runoff, and water quality in the Potomac Gorge
- Residential landscaping and carbon sequestration in ex-urban Michigan, USA
- Timber management decisions and carbon sequestration in US Eastern deciduous forests

## A preview of the main issues

- Process-based limitation: the biophysical dimensions of the ecosystem service of interest are not the central drivers of the land management decisions (dependent variable, not scale mismatch)
- Data-based limitations:
  - collection costs
  - confidentiality and other institutional constraints
  - lack of field studies to link social behavior to inputs of biophysical models

## *Residential development and water quality (Potomac Gorge)*

- Residential land use contributes to decreased water quality through increased nutrient loadings and changes in hydrology (flow)
- Main research question: What linkages exist between residential land use in the Potomac Gorge watershed (DC area) and the degradation of water quality in tributary streams (a primary threat to rare and endangered species in the Gorge)
- Planned pilot project elements: water quality/nutrient modeling, land manager behavior model, participatory front-end

## *Water quality changes: Sources and impacts*


## *Residential development and carbon sequestration*

- Landscaping choices in existing and new developments may have dramatically different carbon profiles
- Main research question: Will ex-urban development in Southeastern Michigan produce a landscape-scale source or sink of carbon, given observed landscaping strategies of developers and landscaping preferences of residential agents?
- Collaboration with UM (Dan Brown et al.) to extend Project SLUCE

## *Residential development and landscape change*


## *Sources of environmental impacts: Behavior of resident land managers*

Land managers are not homogeneous. Water quality and carbon profiles depend on:

- Landscaping preferences and practices
  - Tree, turf, and horticultural choices
  - Fertilizer and pesticide use
  - Management of organic matter and debris
- Willingness to adopt BMPs:
  - Green roofs
  - Rain gardens
  - Pervious pavers
- Evidence from human ecology/environmental sociology/economics that these two factors vary with agent resources, information, attitudes, beliefs, and values & neighborhood influences

## *PoGo WQ model: Dep. Var mismatch issue*

- Households care about economics cost, social implications, transaction costs, flood risk reduction when thinking about WQ BMPS
- They may not know about, and rarely consider, off-site WQ impacts

## *PoGo WQ model: Scale issues*

- WQ models: coarse spatial scale (watershed); calibrated with fine temporal scale data for few locations
- Social science models (adoption of rain barrels, rain gardens, pervious pavers): fine spatial scale (parcel level), coarse temporal scale (10 years for RS land cover data, annual for parcel data)
- Institutional/juristictional boundaries cross watersheds: zoning, parcel sizes, setbacks, WQ regulations, etc.

## *PoGo WQ model: Data issues*

- *Coefficients to translate BMP assumptions into nutrient reductions for WQ models are sparse or missing
- Lack of time series of land cover data
- Lack of access to/expense of obtaining parcel-level land use data
- Institutional constraints on data collection
- Concern about time and attention demands of surveys

## *SLUCE II model: Dep. Var mismatch issue*

- Households stick to initial landscape design, care about aesthetics, imitate neighbors, and consider economic cost, social standing, local regulations, when thinking about residential landscaping
- They may not know about, and rarely consider, the carbon sequestration impacts of their landscaping

## *SLUCE II model: Scale issues*

- Landscaping decisions are fine-grained in time and space
- Existing carbon model designed to run on a coarser scale
- Problems could be solved with time, money, and computing power

## *SLUCE II model: model: Data issues*

- *Coefficients to translate landscaping decisions into biomass changes for carbon model are sparse or missing
- Other data constraints less binding due to long-term nature and resources of the project
- Cost limitations limit number of in-depth interviews/field surveys
- Complicated sample stratification due to desire to stratify by development type, LULCC history, and biophysical conditions
- Concern about time and attention demands of surveys

## *Timber management decisions and carbon sequestration in US Eastern deciduous forests*

- Carbon dynamics in mixed-stand deciduous forests are poorly understood; stands are reaching maturity, land manager motivations and strategies are diverse
- Main research question: How might the ability of central hardwood forests to store C change in the future under current conditions? Under alternative policy and economic regimes?
- Collaboration with West Virginia University (Amy Hessl et al.) with PhD student Sean Donahoe

## Experimental field work for model calibration

## *Timber model: Dep. Var mismatch issue*

- Harvesters make timber harvest considering only 2-3 high-value species, using various harvest heuristics (diameter limit cuts, clear cuts, etc.) They may or may not consider future biomass, but do not consider carbon
- Carbon model wants consistent and uniform data about species composition and corresponding canopy cover.

## *Timber model: Scale issues*

- Like SLUCE II, scale issues are not conceptually high hurdles--both models could run at a parcel scale
- Problems could be solved with time, money, and computing power

## *Timber II model: model: Data issues*

- *Compromises needed to be made on dependent variable (total biomass removal vs. timber harvest strategy) due to data quality issues
- Design of FIA database was good (gathers data on both management type and intent and biophysical measurements of growth and harvest
- But, sampling strategy was too sparse and data quality too poor to meet all of our goals for parcel level analysis (data collection was designed for aggregation)
- Confidentiality constraint on ownership type and location; could be solved with more time and money

## Conclusions and recommendations: Dependent/state variables

- More conceptual work needed on the problem of mismatch of dependent variables between models; socioeconomic and biophysical models have different state variables due to incentive problems
- We also need to consider whether models and developed under mismatched incentives will still be valid under a regime of corrected incentives (i.e., carbon markets)

## Conclusions and recommendations: Scale issues

- I see these as less important than I did in 2007!
- Many can be solved by time, money and computing power
- However, scale-related process and data matching issues should be considered when designing data collection protocols

## Conclusions and recommendations: Data issues

- Improved field studies and survey data to develop technical linkages between land management behavior and biophysical model inputs is the highest priority
- Coupled modeling needs should be considered when designing public data collection protocols
- Issues of privacy and time cost for survey respondents will continue to be important

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