The Role of Remote Sensing in LCLUC Future Scenarios

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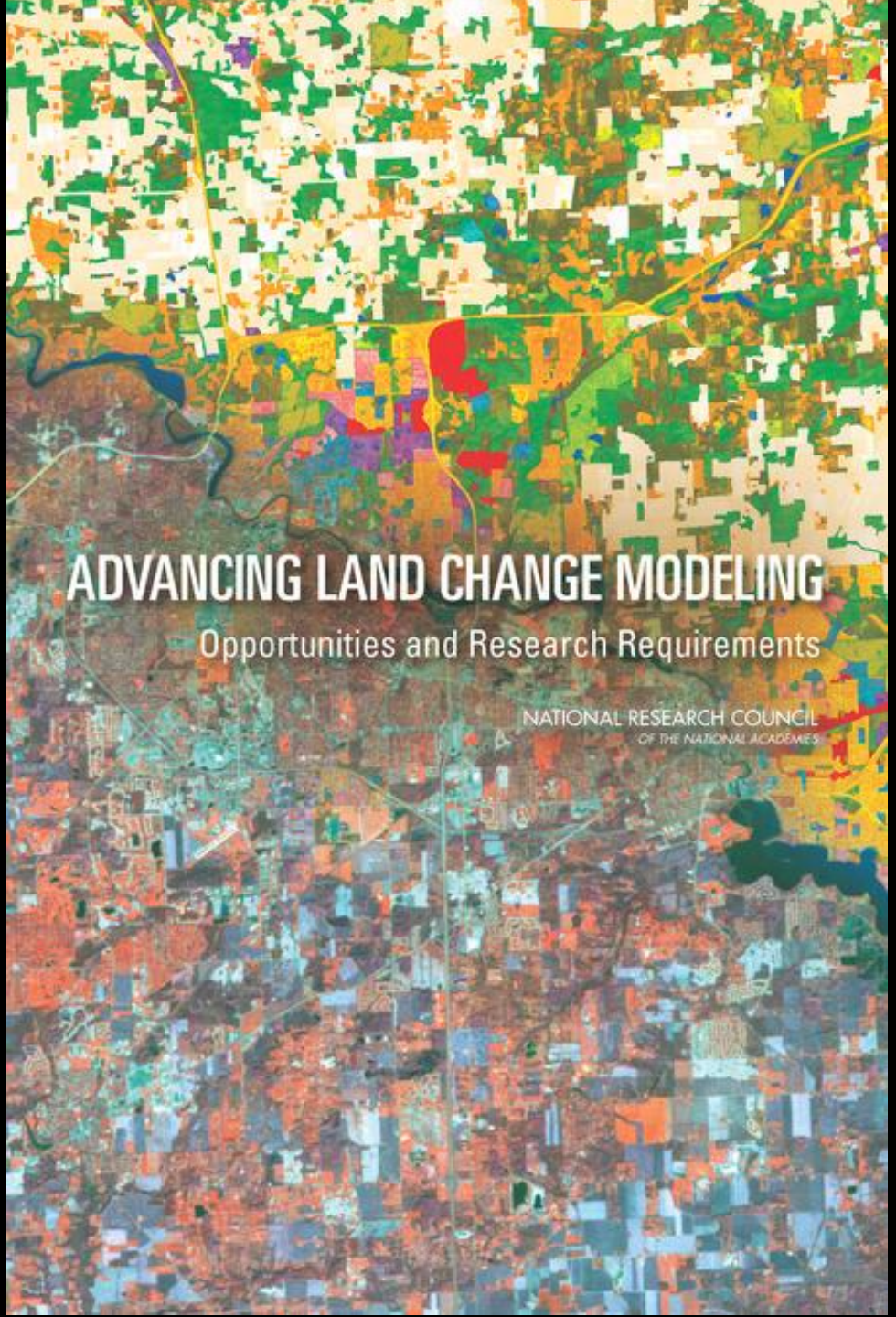
ADVANCING LAND CHANGE MODELING
Opportunities and Research Requirements
NATIONAL RESEARCH COUNCIL
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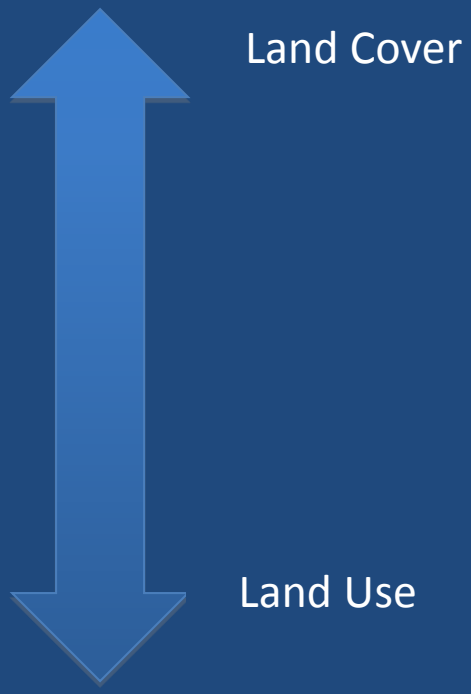
Modeling Approaches

Five overlapping approaches and hybrids were identified to evaluate their analytical capabilities and science and policy applications

- Machine learning & Statistical
- Cellular
- Economic
  - Sector-based
  - Spatially disaggregated
- Agent-based



Some Relevant General Themes

- Expanding variety and availability of remote sensing products creates new opportunities.
- Information needs will best be met through integration of remotely sensed information with other sources of data
- Need for more human process knowledge and land-use process models to complement Earth system models

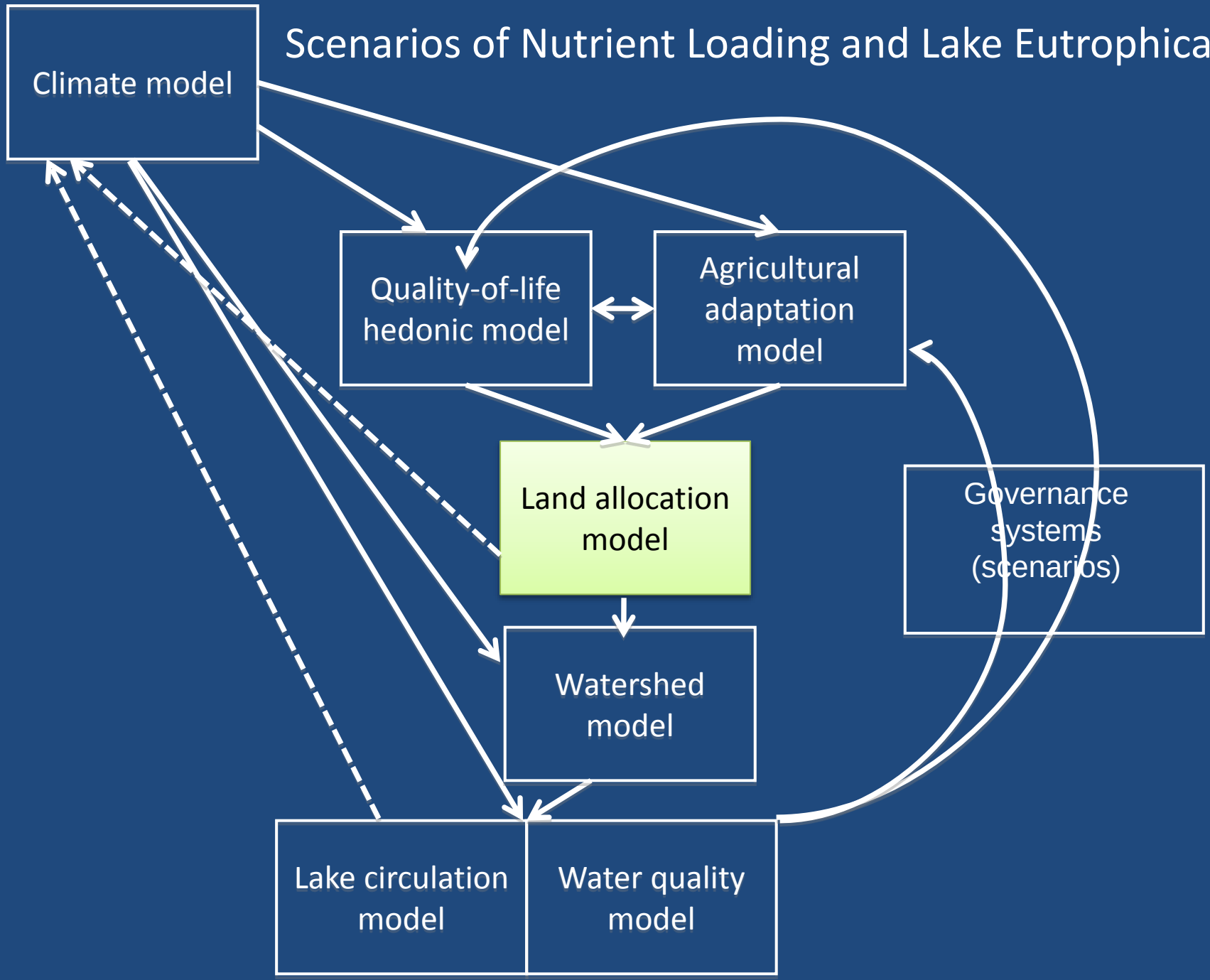
Roles of Remote Sensing

1. Establishing baseline and boundary conditions
   - Examples: Nutrient runoff, Russian Far East Forests
2. Expanding variables and measures
   - Examples: Object-based land use classification
3. Enhancing land-change process knowledge
   - Examples: Mongolia, Southeast Michigan

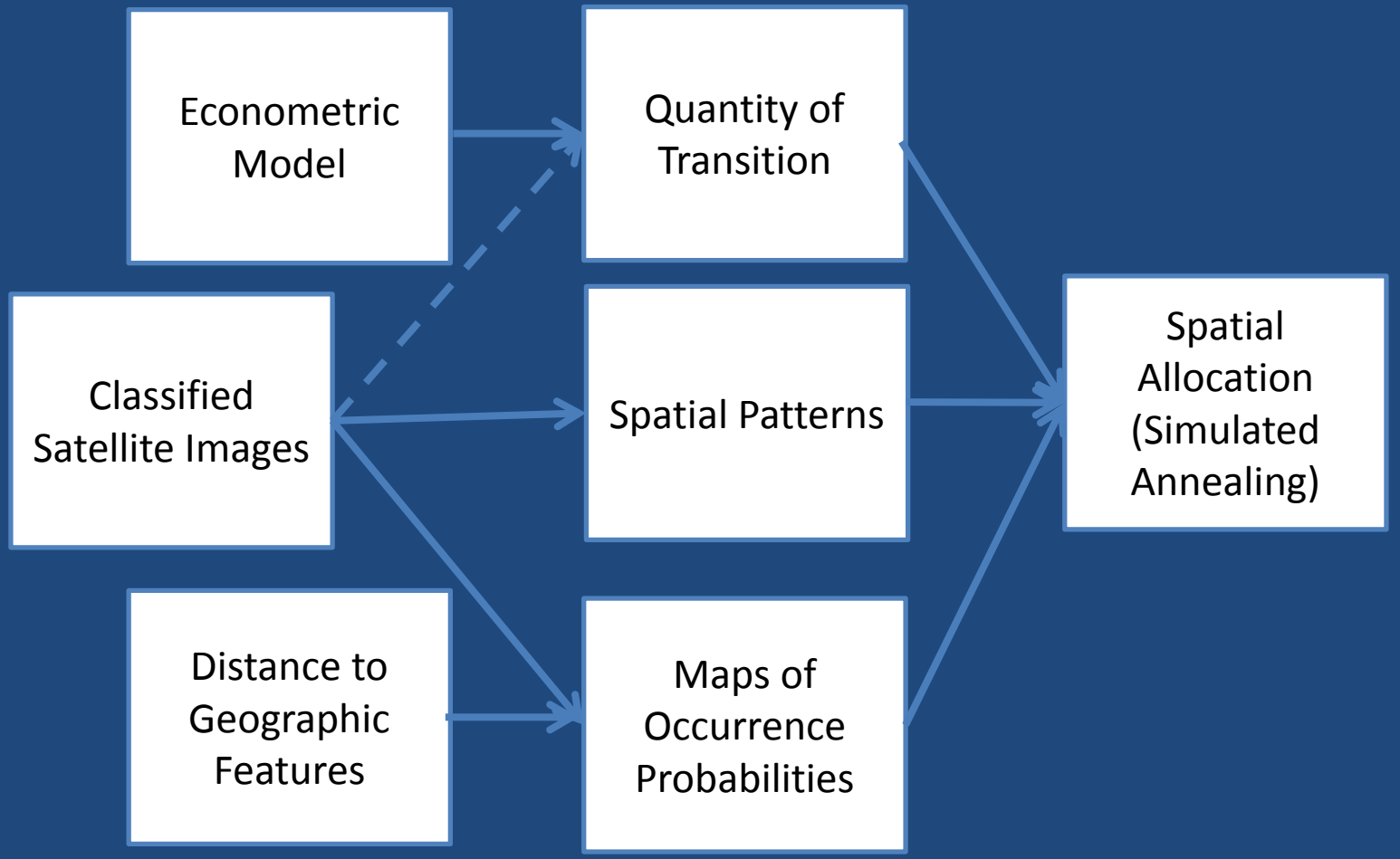
1. Establishing baseline and boundary conditions

- Remote sensing provides data used to establish model relationships, starting conditions, and other inputs.
- Spatially explicit, wall-to-wall, and temporally consistent nature of RS observations critical to modeling practice.

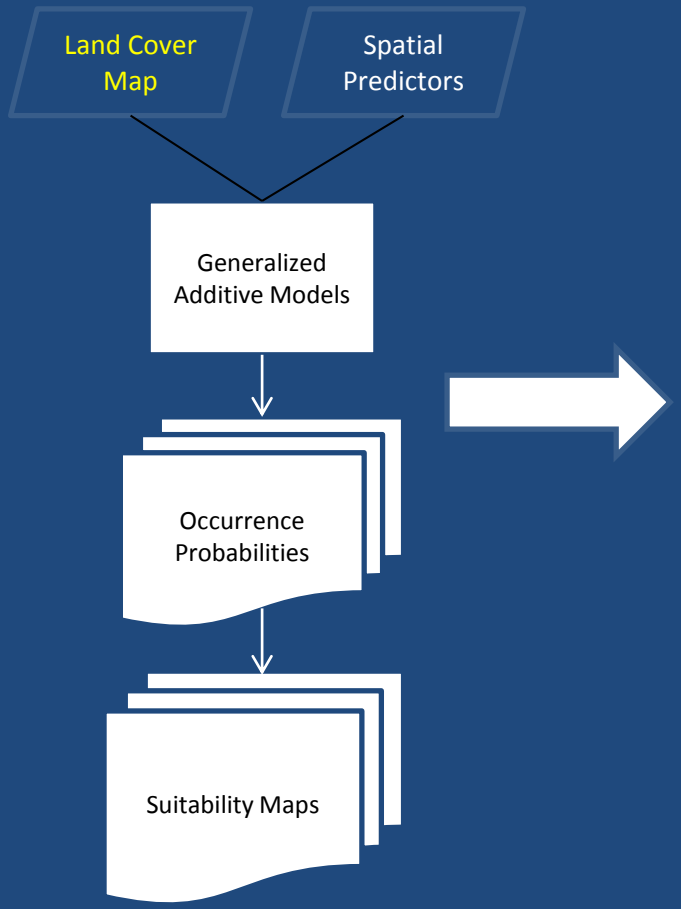
Scenarios of Nutrient Loading and Lake Eutrophication

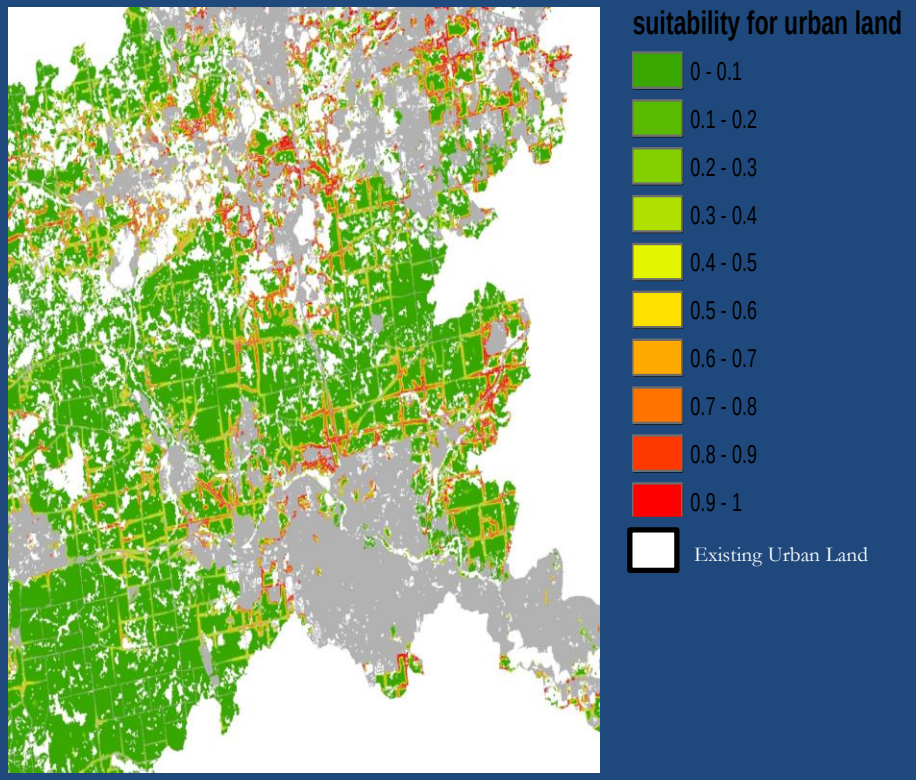


Spatial Land-Change Model



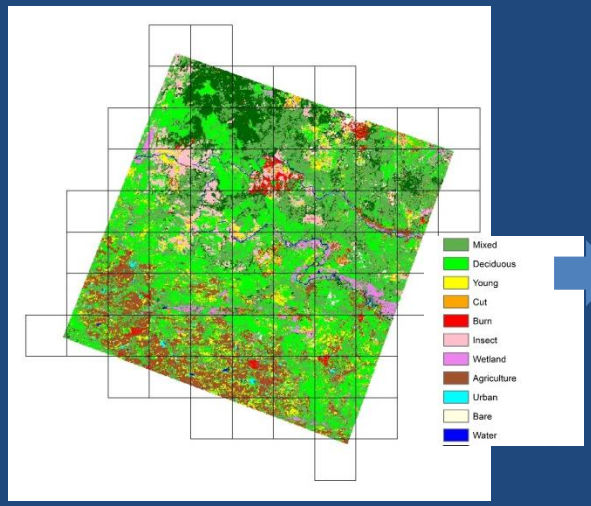
Example: Estimating Occurrence Probabilities

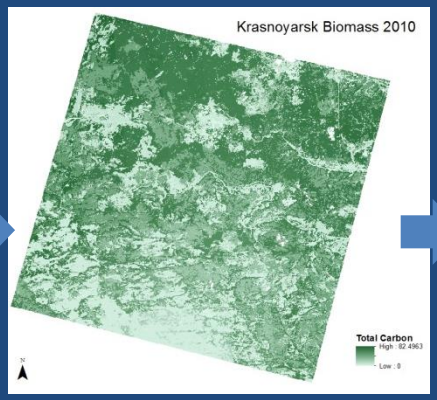




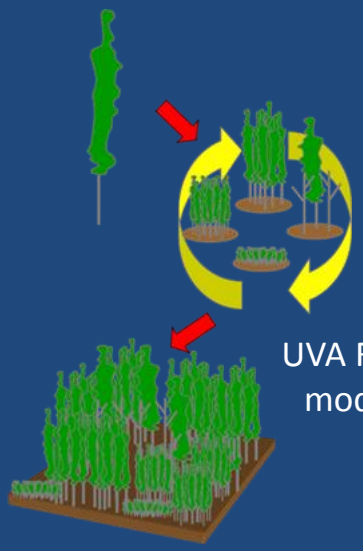
Scenarios for Forests of Russian Far-East

Initialize UVAFME Model to "current age and biomass" incorporating Landsat- or MODIS-derived forest-age map





Model simulation under current and future climate, fire and harvest scenarios



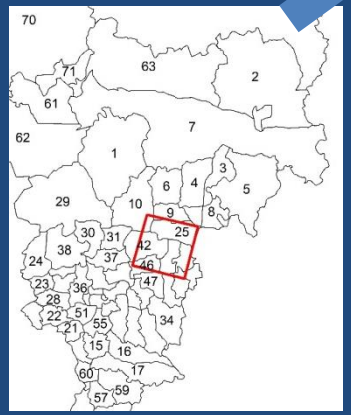
UVA FME model

Scenarios

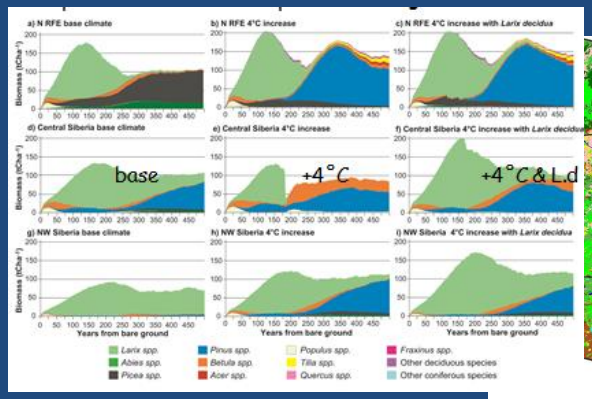
Harvest: based on actual harvest rates by management unit, and potential future rates

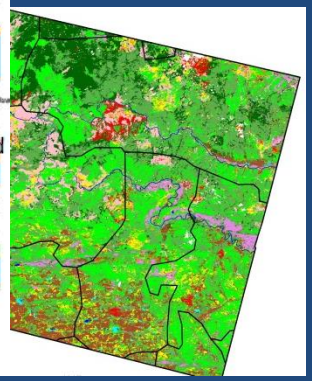
Fire: based on fire return intervals and potential future intervals

Climate: based on outputs of climate models



Output detailed composition and biomass change by scenario as well as mapped future landscapes



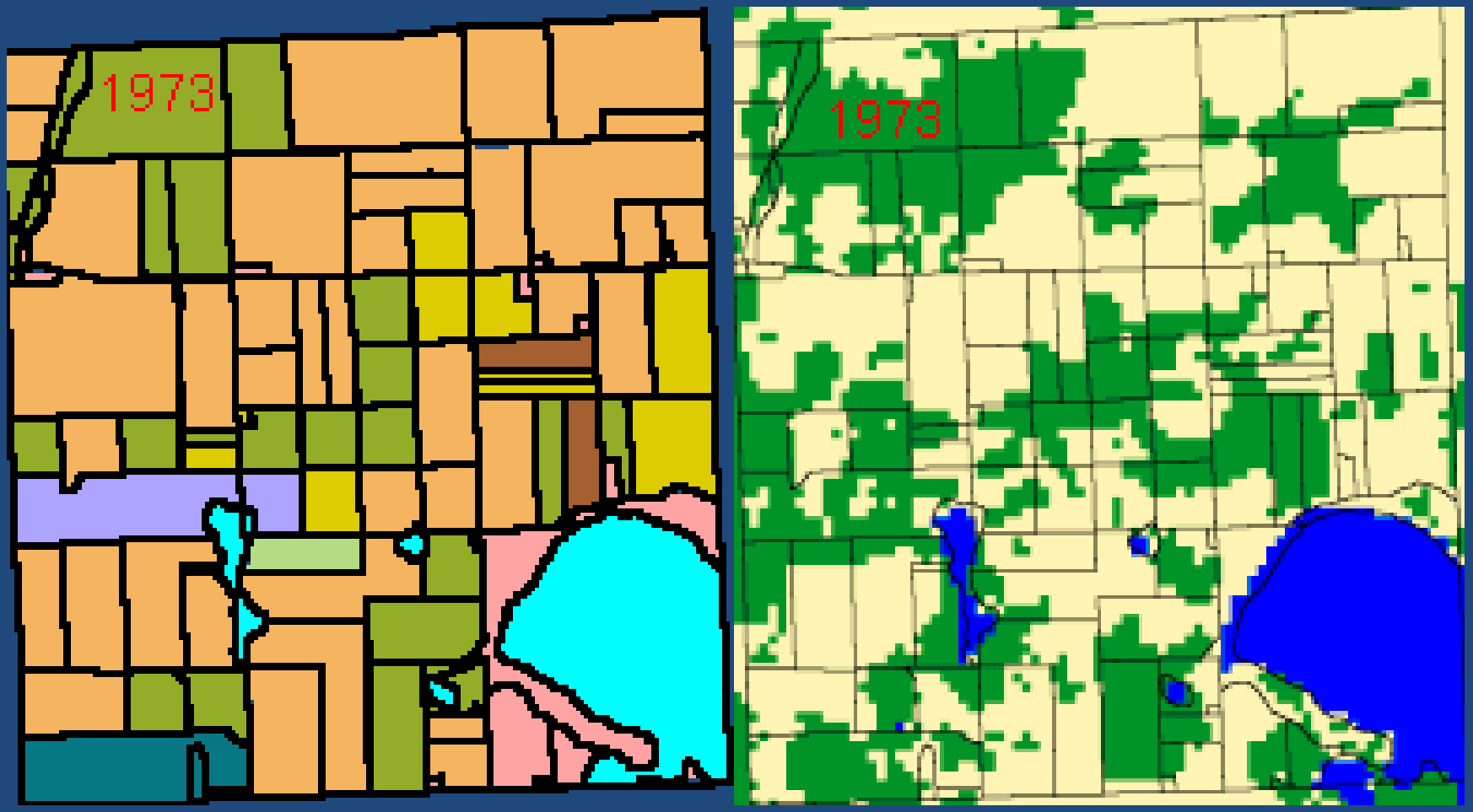


Figures courtesy of K. Bergen, U. Michigan and J. Shuman, U. Virginia

2. Expanding variables and measures

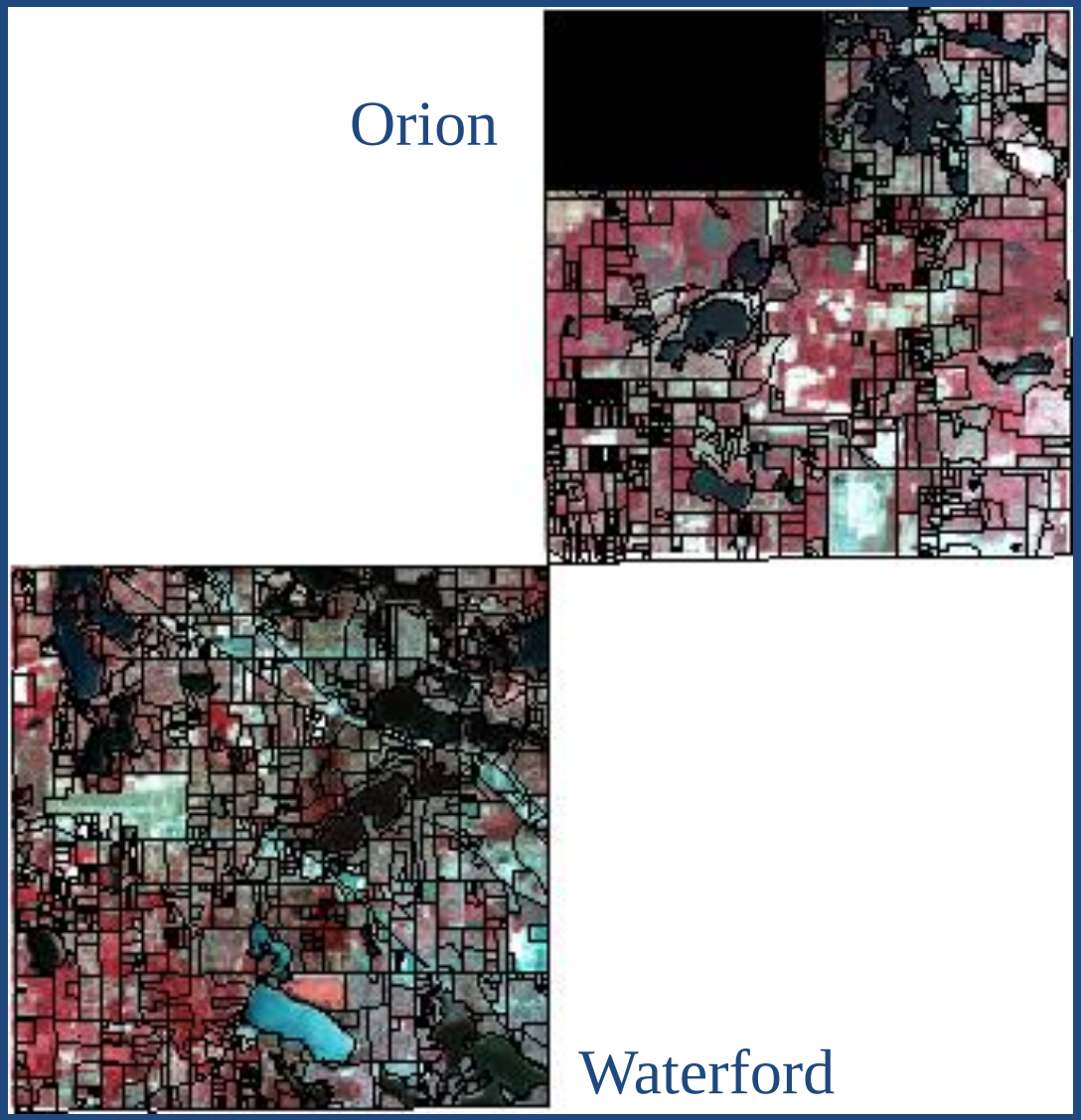
- Models and scenarios can use existing variables (e.g., land cover), but sometimes require additional information.
- Mapping land use and management should be a key goal for the community.
  - Requires integration with other types of information.

Land Cover and Land Use



Brown, D.G. (2003) *Landscape Ecology*, 18(8): 777-790.

Can we automate land-use classification?

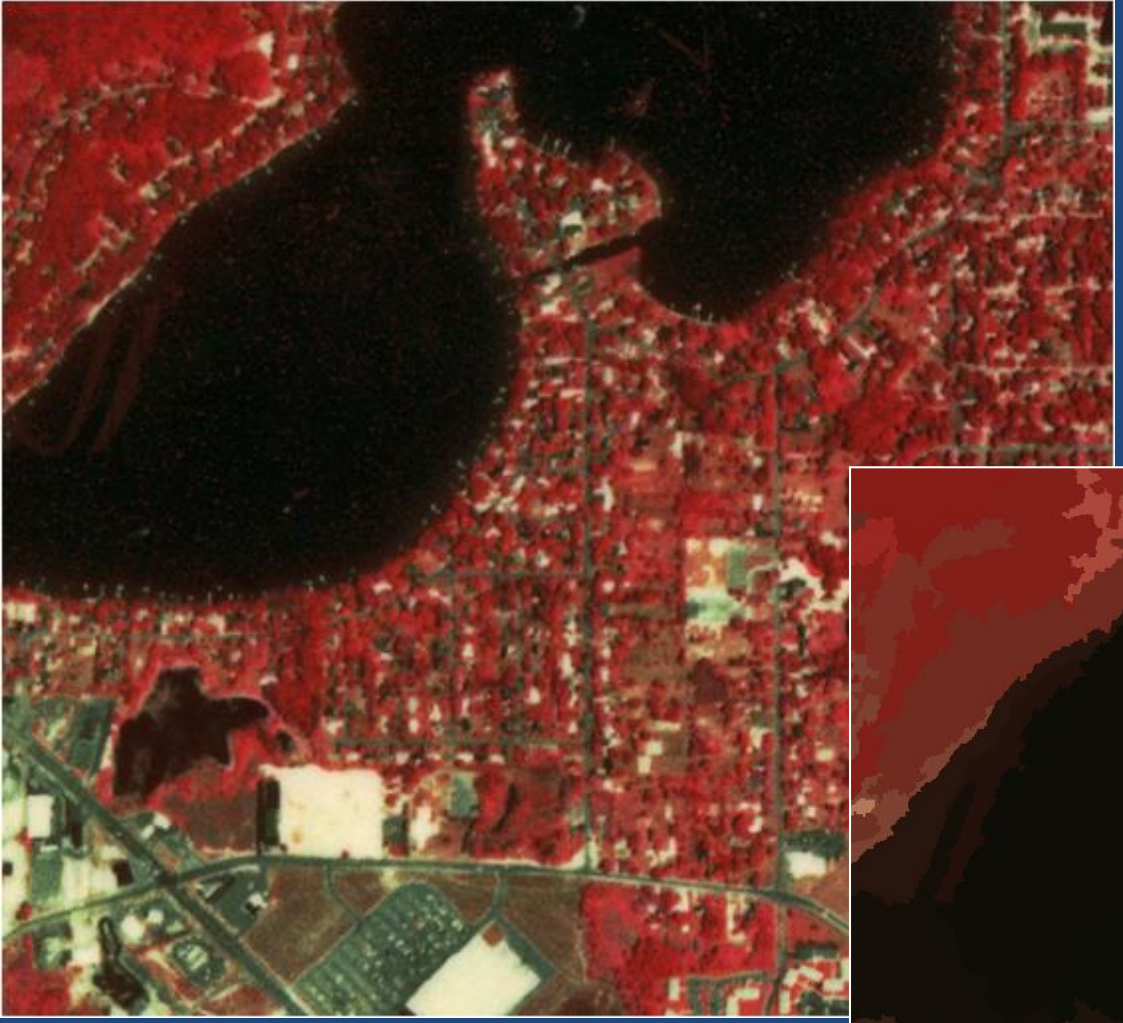


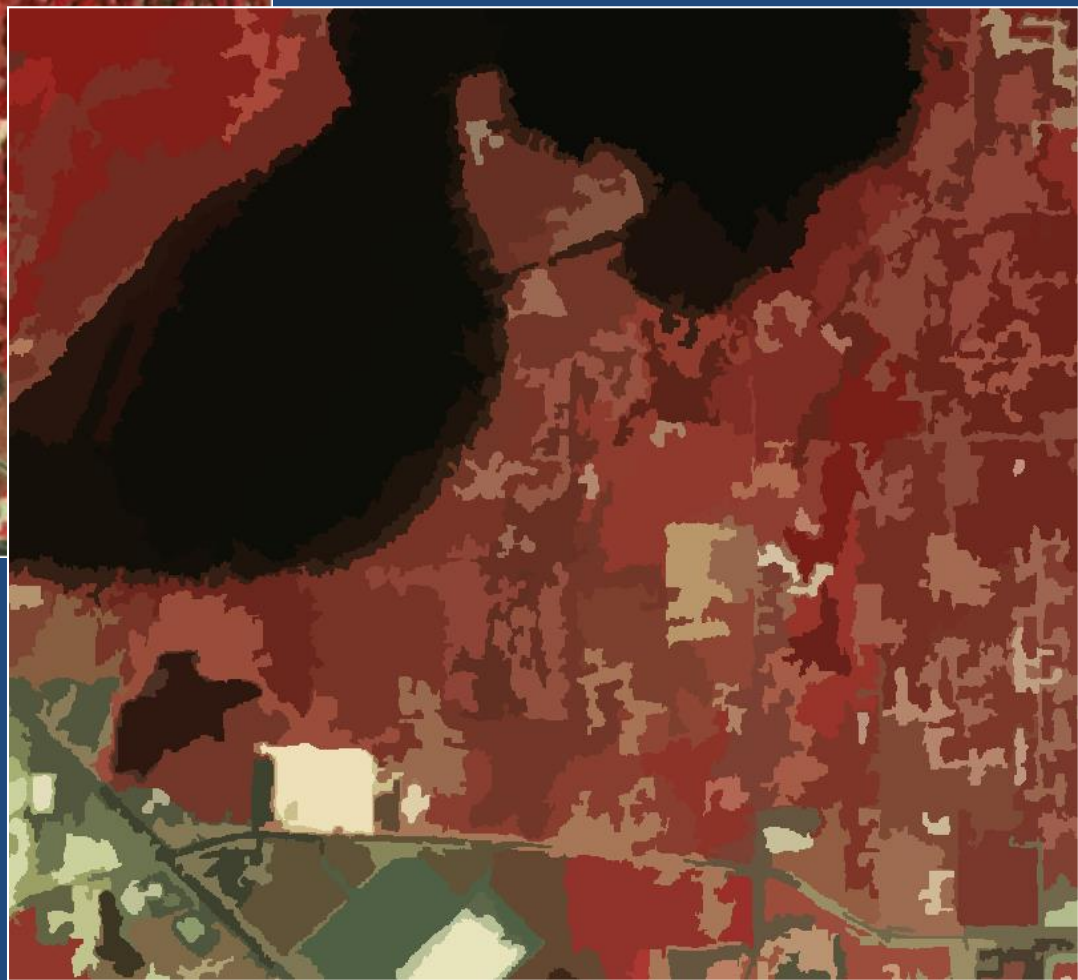
We want to classify parcels by land use:

- Residential (R)
- Commercial (C)
- Institutional (I)
- Agriculture (A)
- Open/Grassland (G)
- Successional Field (S)
- Forest (F)
-Water (W)
-Wetland (We)

Addink and Brown, unpublished manuscript

Image Segmentation





- Identifies spectrally homogenous *and* spatial contiguous patches.
- Differs from standard per-pixel approach.

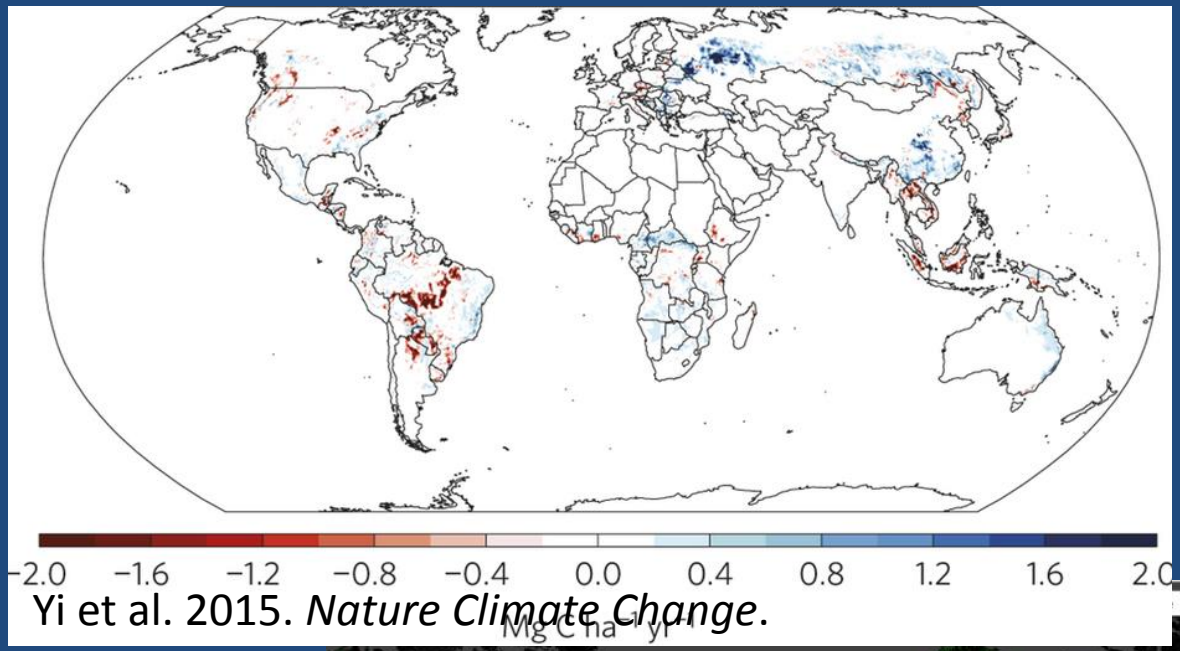
Land-Use Classification using Objects

- 56 variables used to describe *parcels* and *segments* within parcels by (a) spectral characteristics, (b) form (i.e., size and shape) and (c) relationship to neighbors.
- We used classification trees to describe relationships between parcel characteristics and image objects and land-use code.
- Overall accuracy was 65%, compared to 39% for per pixel classification.

3. Enhancing land-change process knowledge

- Understanding land-change processes (driven by both human and natural dynamics) requires a focus on change and time dynamics
- Increasing temporal depth and multi-sensor comparability (including cross-platform) facilitates observations of change
- Use of remote sensing in quasi-experimental, statistical, and econometric analyses helps in identification of mechanisms.

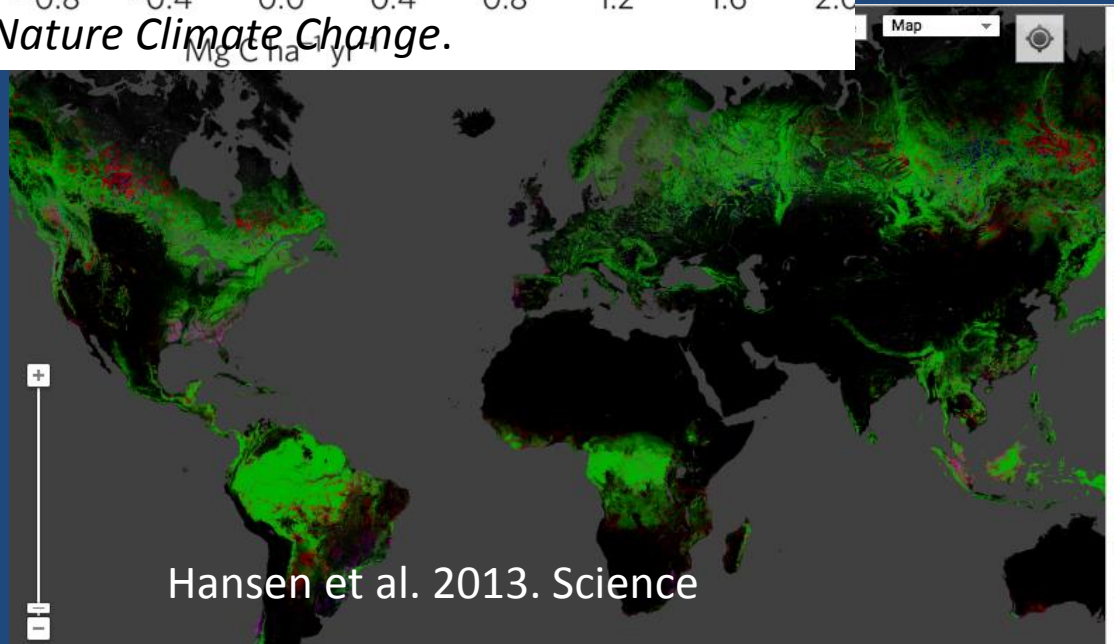
Change Information



Yi et al. 2015. *Nature Climate Change*.

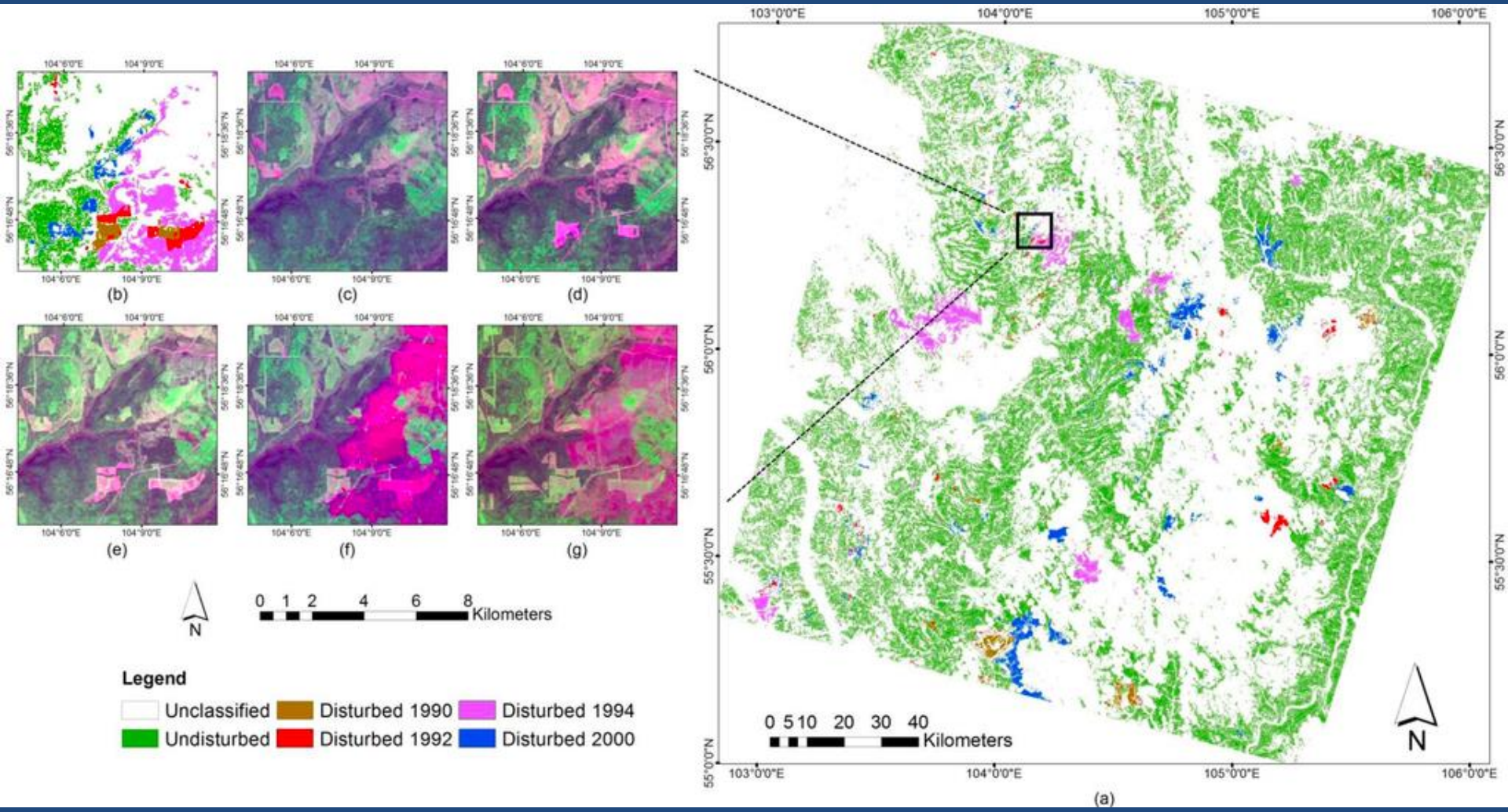
Change in Biomass from Passive Microwave

Forest Cover Change from Landsat



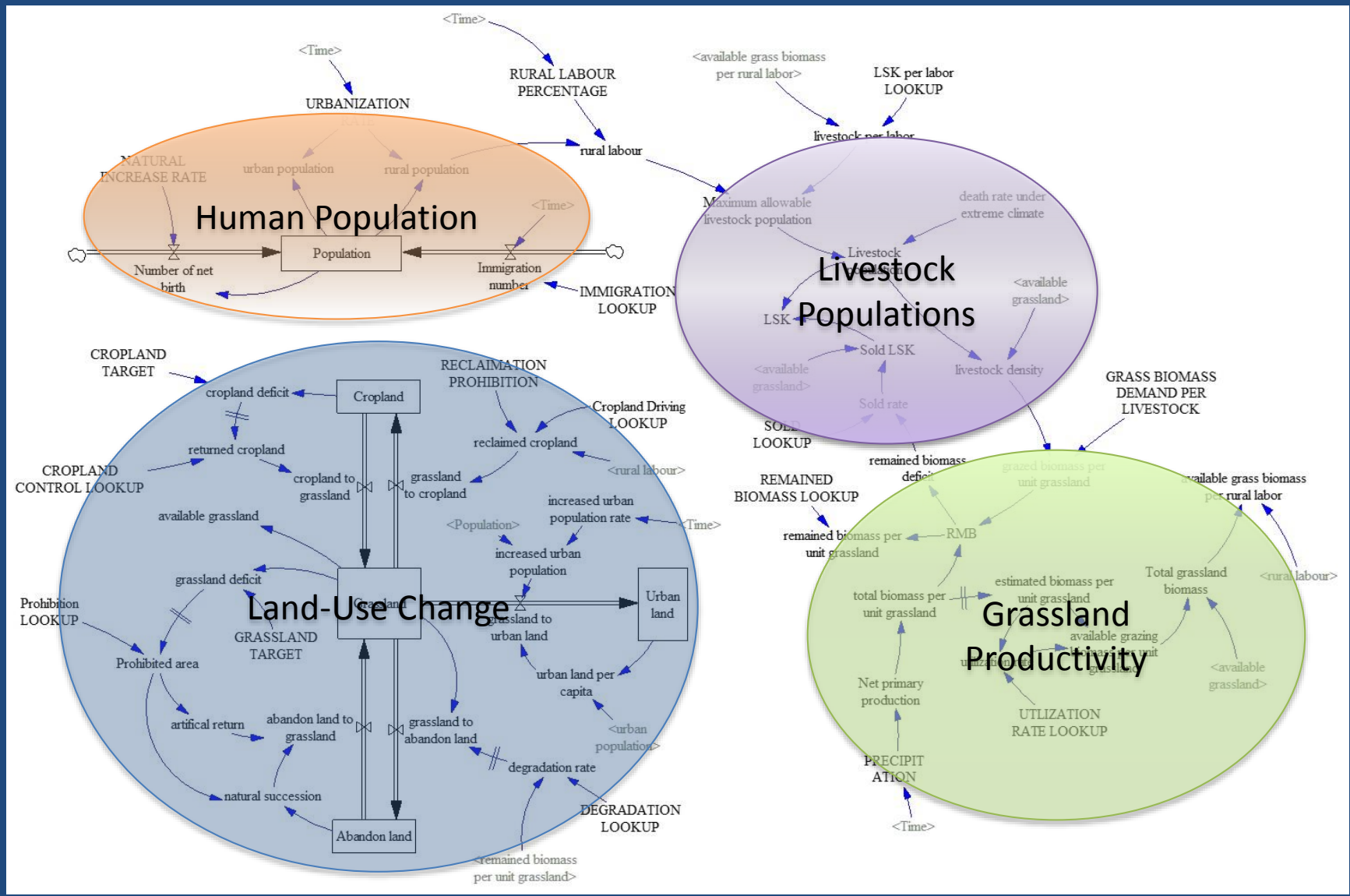
Hansen et al. 2013. Science

Timing of Disturbance and Forest Age



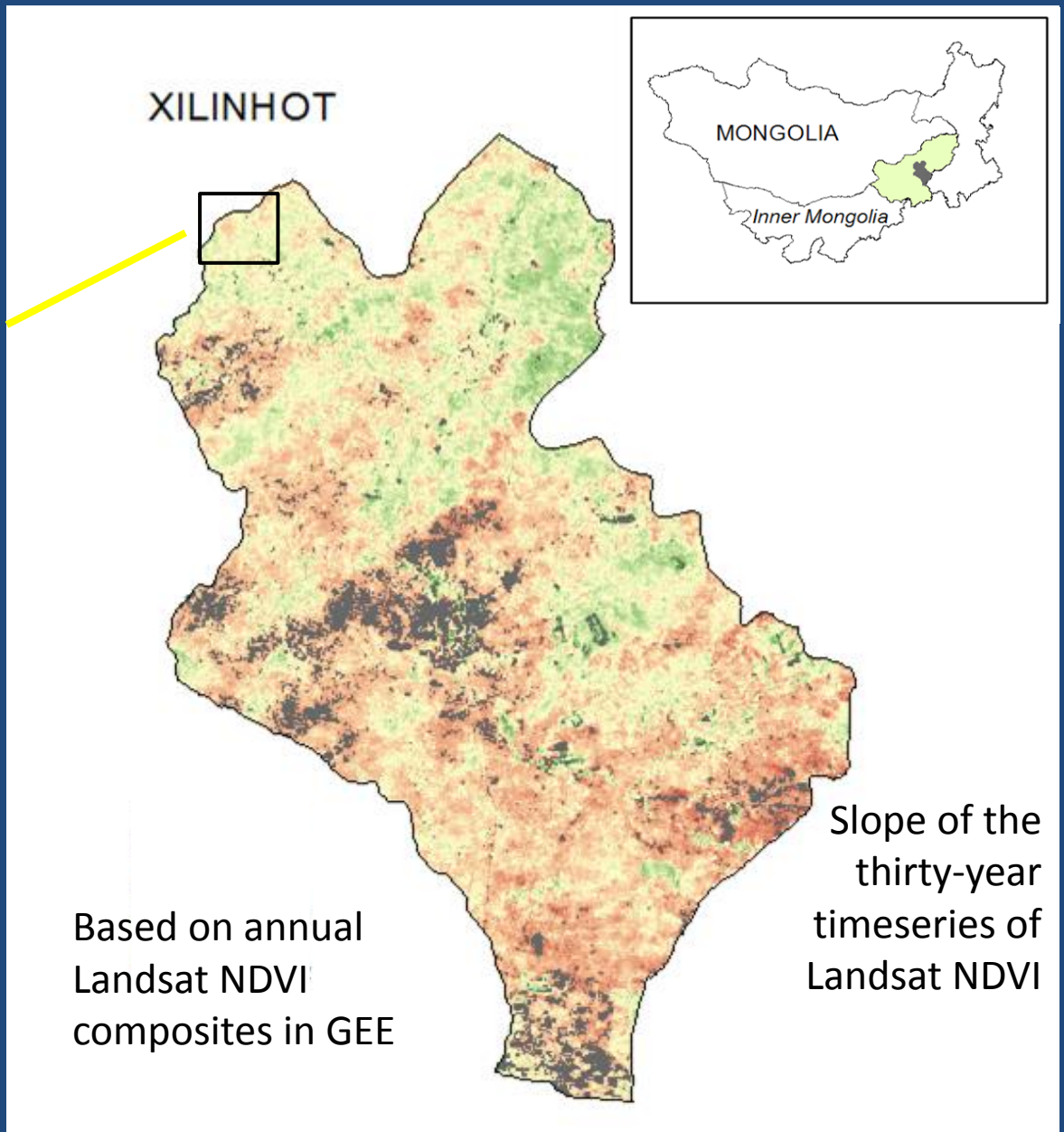
Chen, D., Loboda, T., et al. 2014. *Remote Sensing*, 6(7), 6020-6038.

System Dynamics Model for Mongolian Plateau

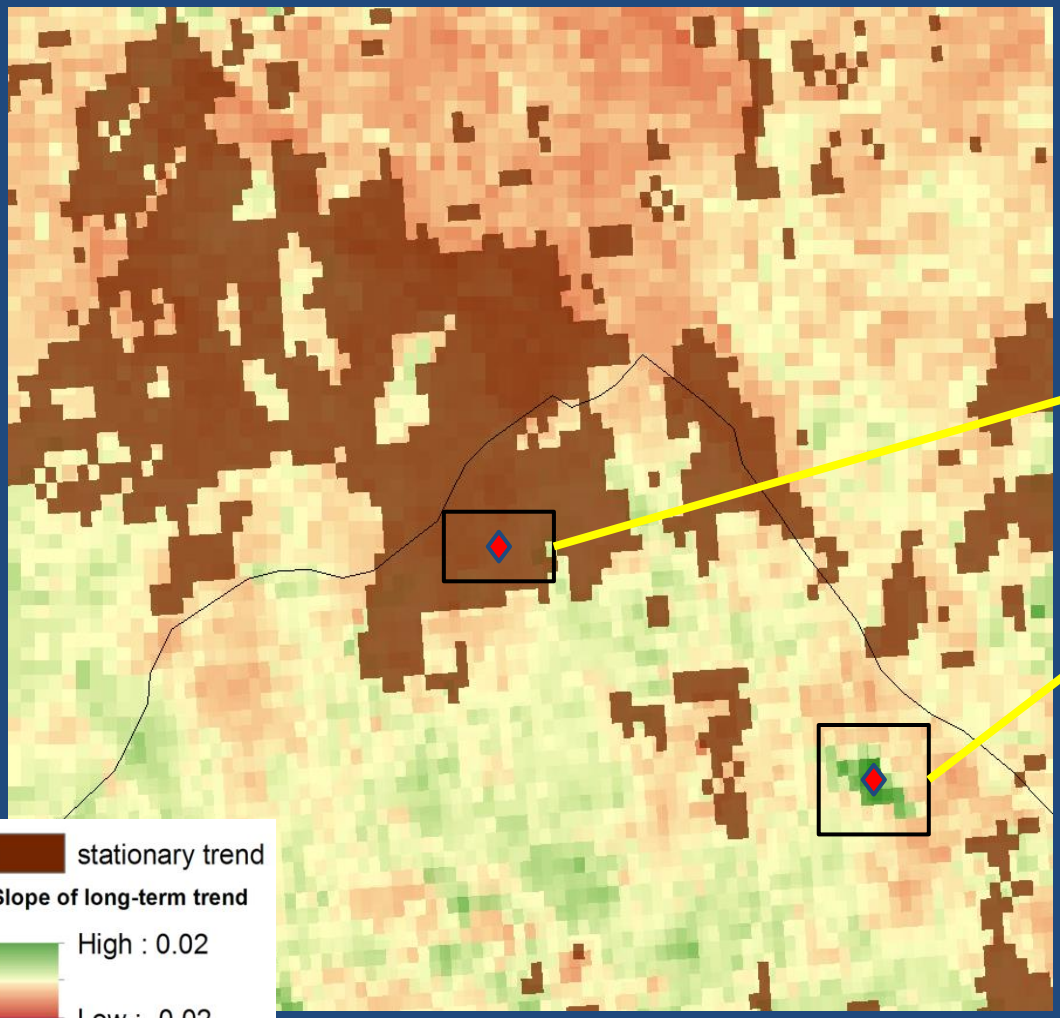


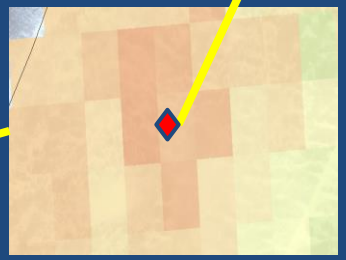
How To Identify Dynamics in Grassland Ecosystems?

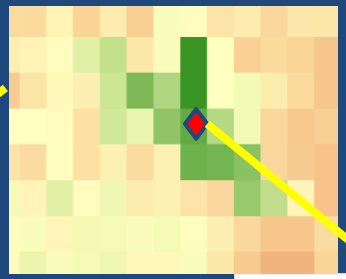
area enlarged on next slide

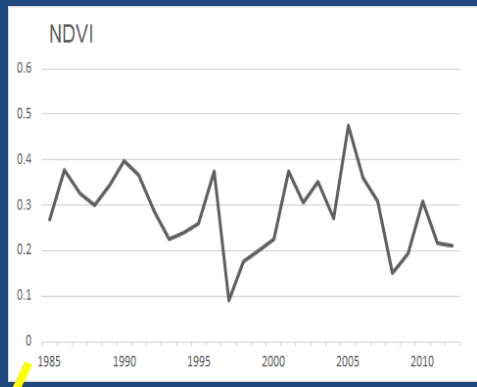


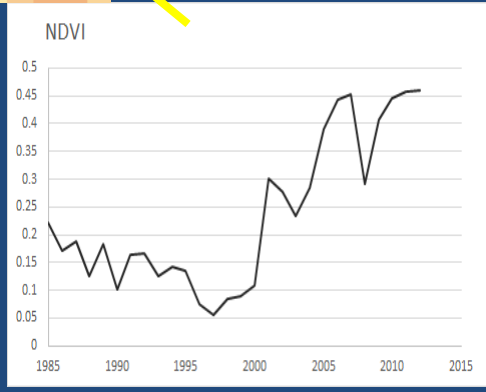
Testing for and Classifying Change





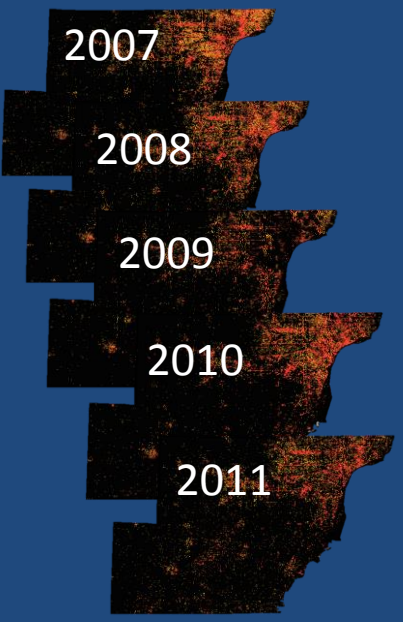






Slope of Impervious Surface Area vs Time

Annual Composites



pre-Recession (2001-2005)

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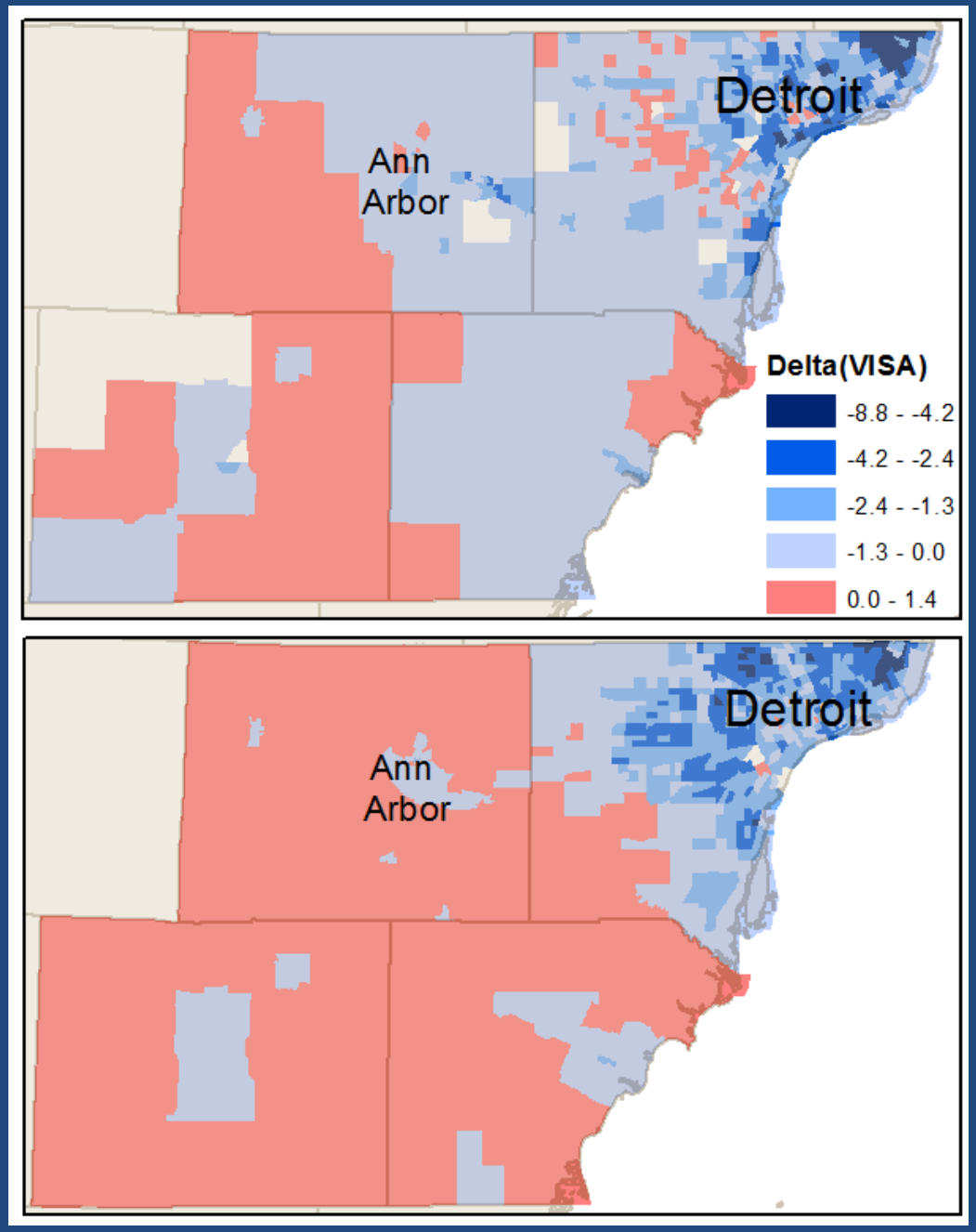
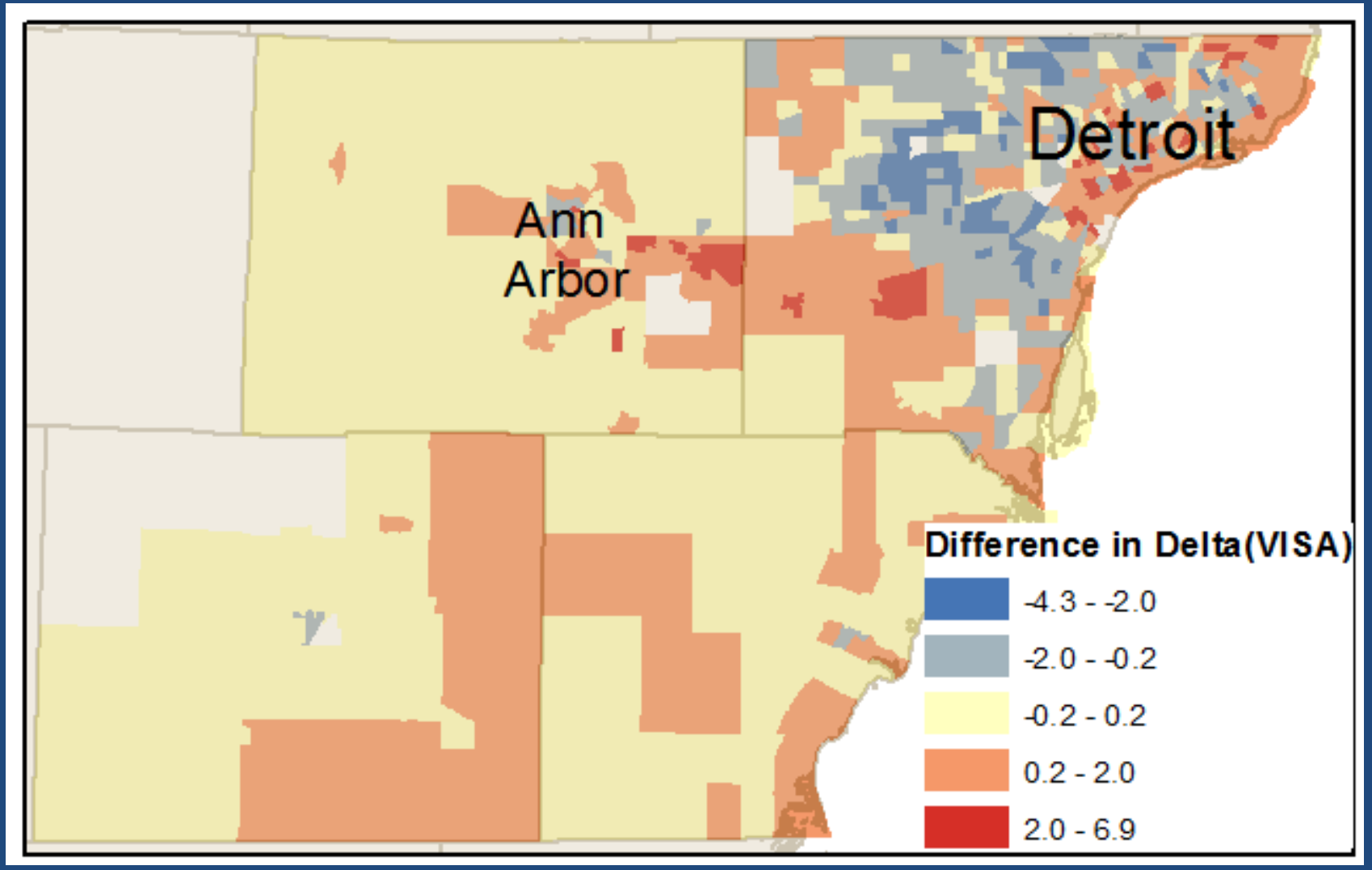
post-Recession (2007-2011)



Wilson and Brown 2015. *Population and Environment.*

Difference in Rates of Change



Concluding Remarks

- Lessons from the design, structure, and application of land-change models help identify data needs from remote sensing.
- RS data are often needed in coordination with other environmental and social observations.
- Land change models need to transition toward more process-based (structural) designs.