Biodiversity, Land Use, and Climate: Evolution of Three LCLUC-Funded Projects

Andrew Hansen
Montana State University

Jack Liu
Michigan State University

Volker Radeloff
University of Wisconsin

NASA Land Cover Land Use Change Annual Meeting

April 4-6 2007

LCLUC HIstory

- Started in mid 1990's.
- Focused on the causes and consequences of land change.
- Novel in integrating natural and social sciences.
- Eclectic group of geographers, sociologists, economists, ecologists.
- Regional case studies relying on first satellite-based land change detection
- In retrospect, extremely innovate and groundbreaking.

Topics

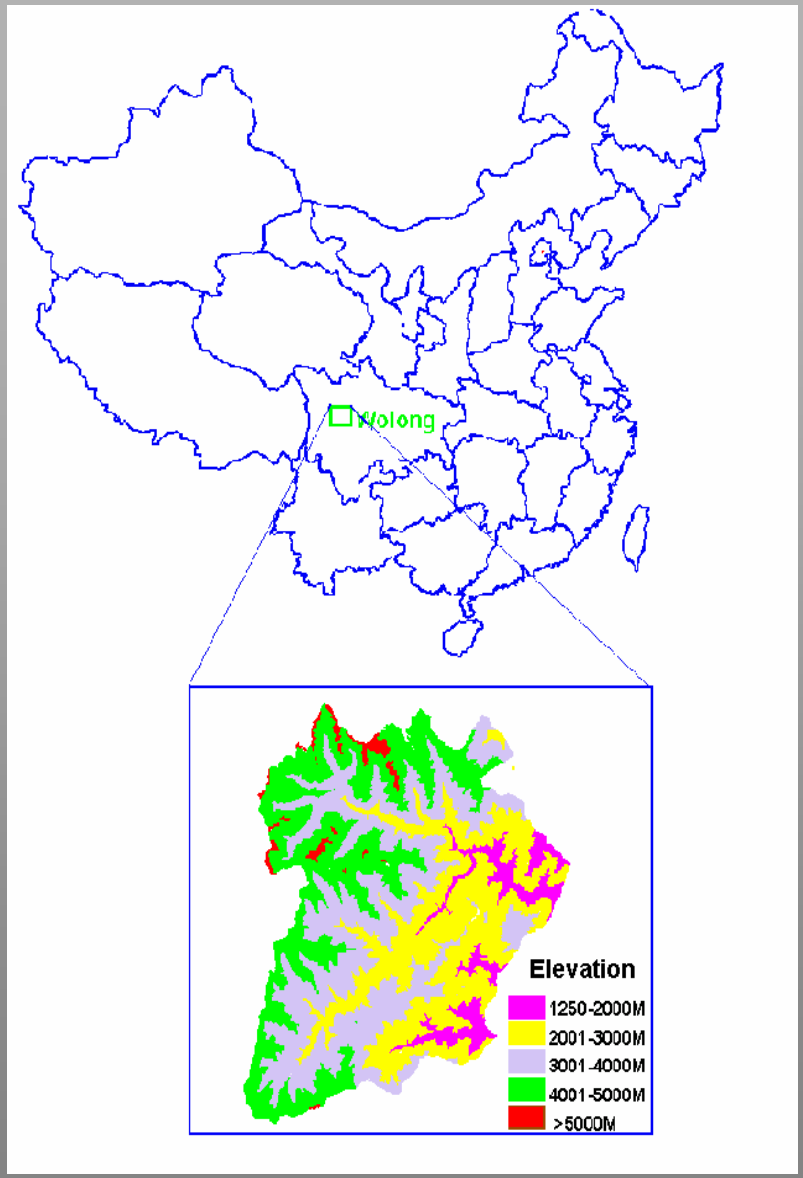
A tale of three LCLUC biodiversity P.I.s

- **Jack Liu – Human consumption as a driver of biodiversity impact**
- **Andy Hansen – Biophysical influences on biodiversity and land use**
- **Volker Radenoff – National sociopolitical system influence on biodiversity**

Human Impacts on Panda Habitat

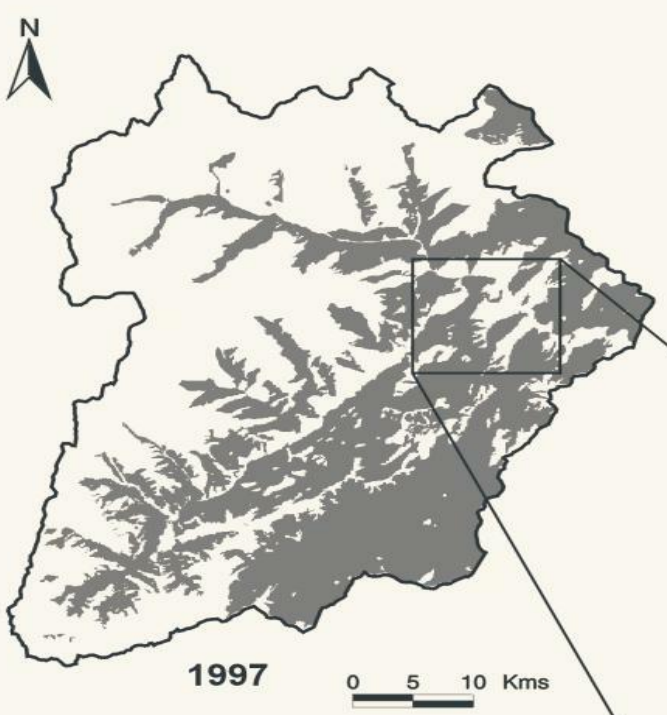
Jianguo (Jack) Liu (PI)
(with many collaborators)

Center for Systems Integration and Sustainability
Michigan State University
http://www.csis.msu.edu

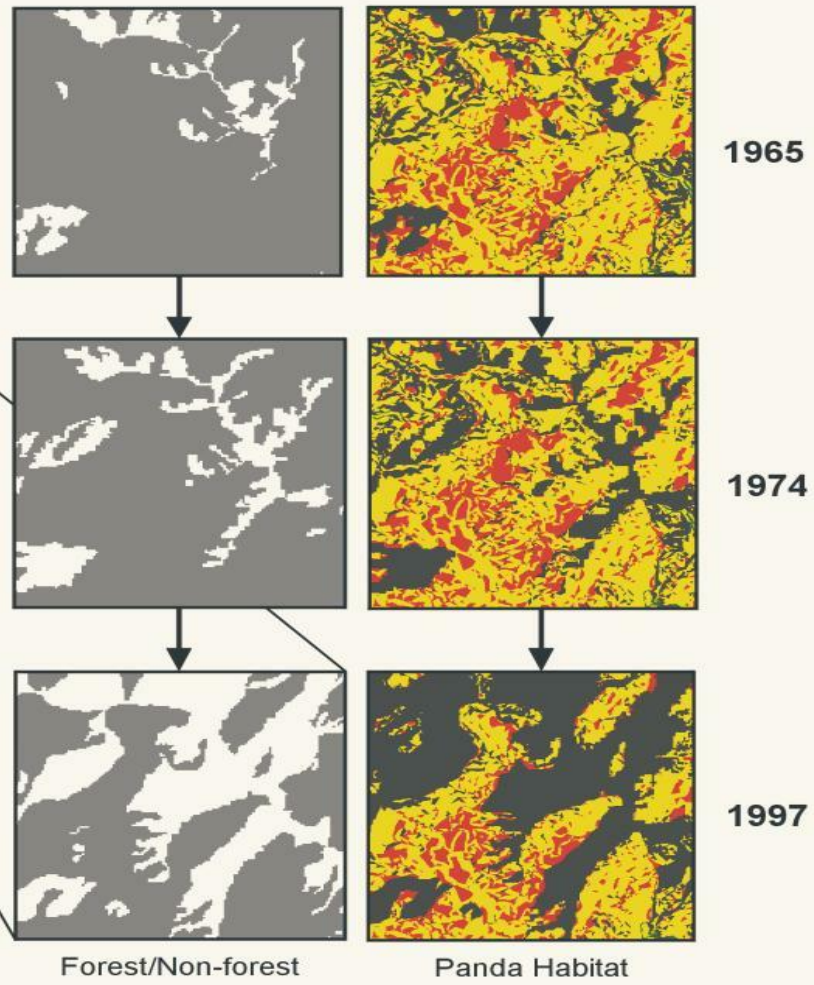


Wolong Nature Reserve

- One of the largest (200,000 ha)
- 10% of wild pandas (~1,600)
- Local residents (> 4,500)



Forest Distribution in 1997



Changes in Forest and
Panda Habitat in an Example Area

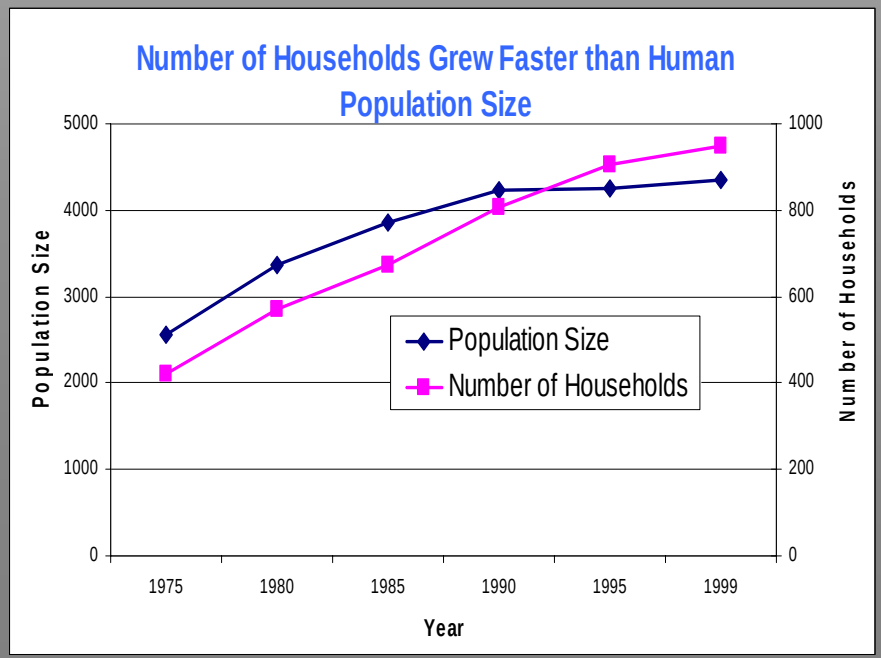
Highly suitable habitat declined from 14,000 ha to 12,000 ha

(Liu et al., 2001, Science)

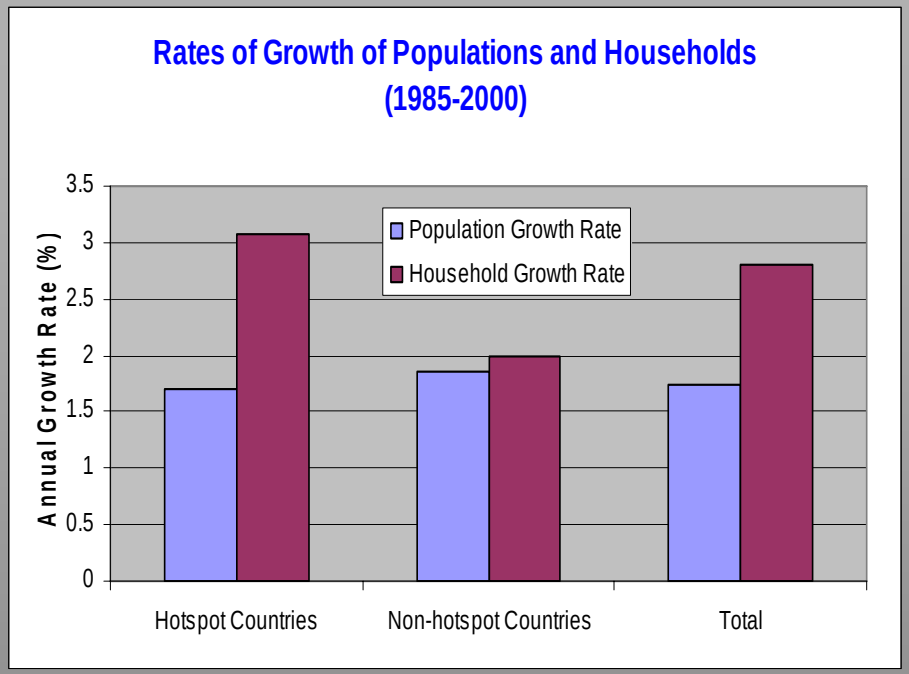
Why?

Household Production and Consumption as an Important Driving Force behind Habitat Degradation

Housing, fuel wood, agriculture

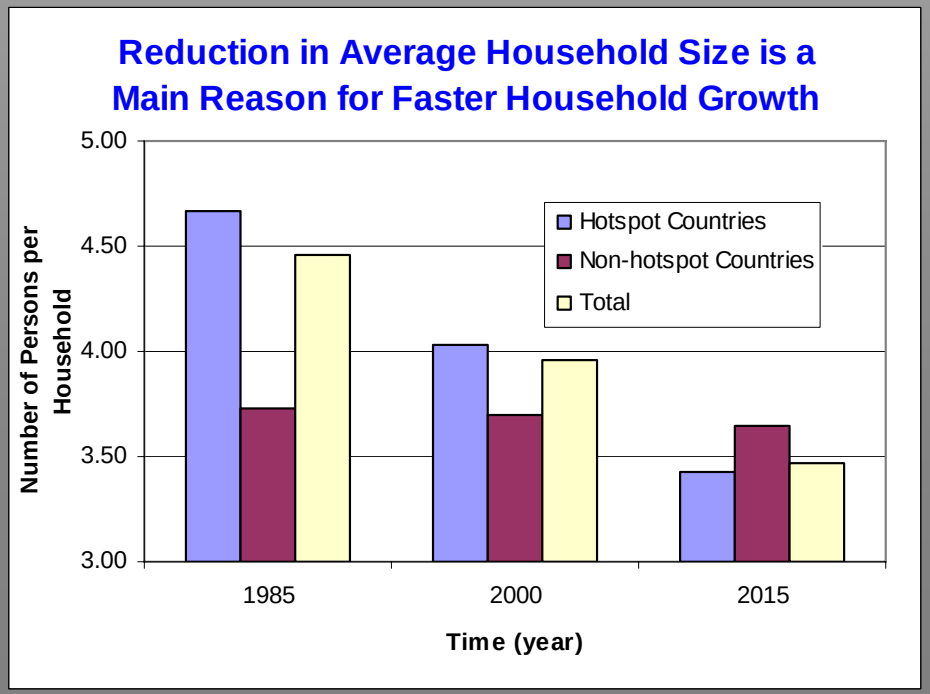


Extend Findings to Other Areas



- Do households increase faster than human population sizes at national and global levels?

Liu et al. 2003



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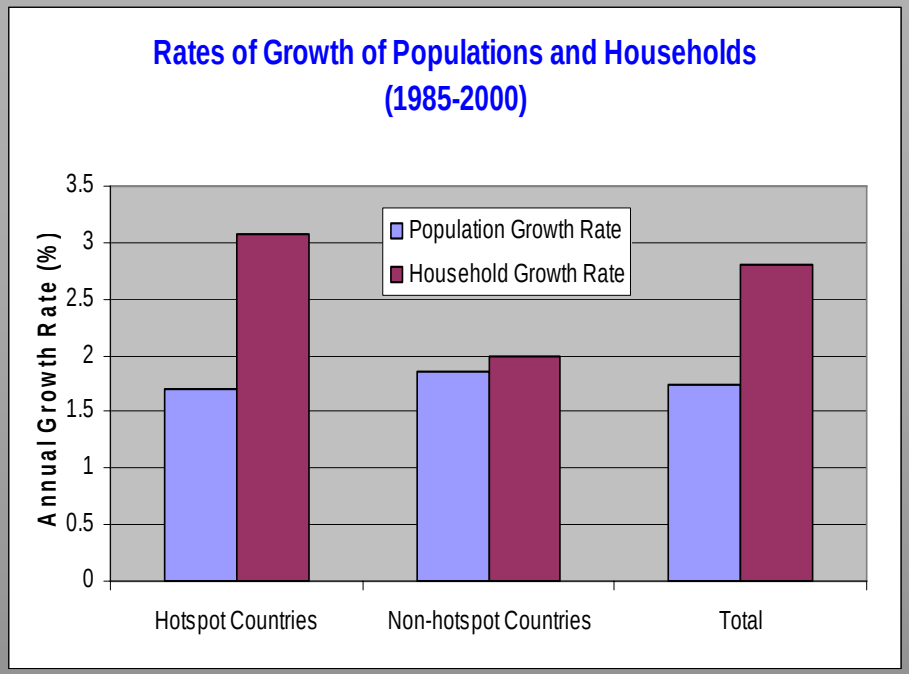
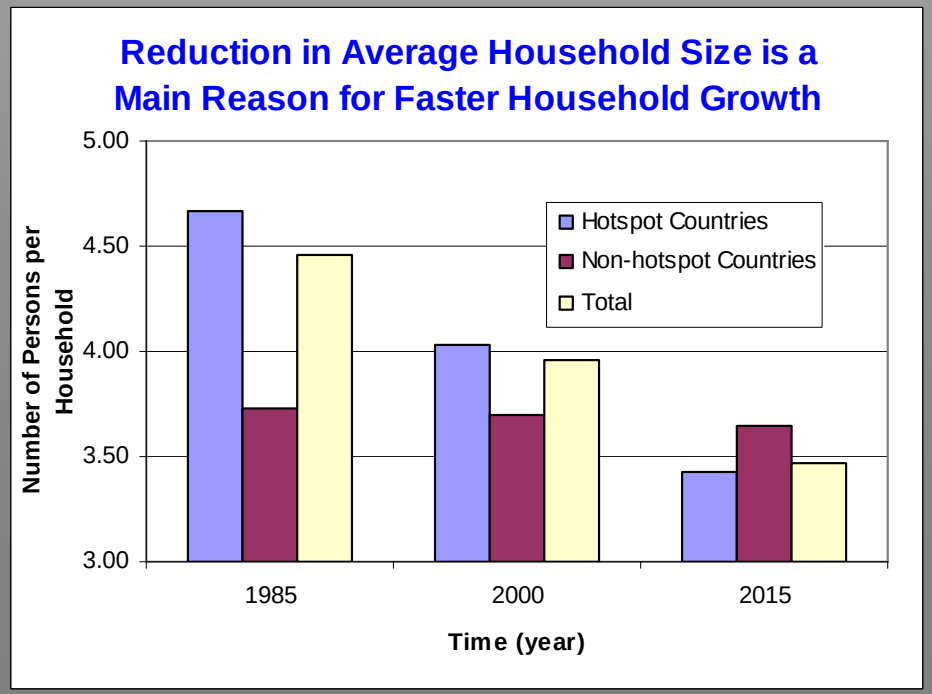


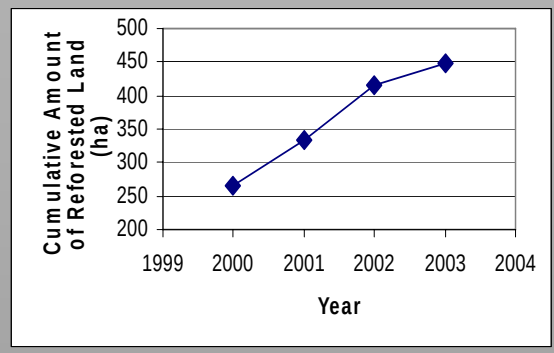
- Do households increase faster than human population sizes at national and global levels?

What are the implications of growth of population x consumption for sustaining biodiversity??

Liu et al. 2003



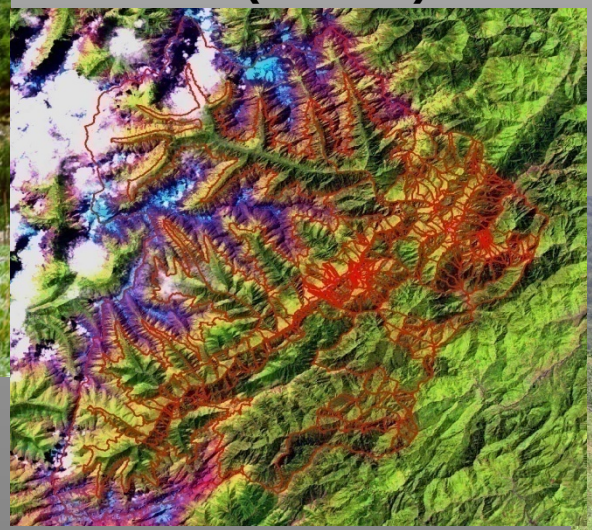
Policies Enacted to Protect and Restore Habitat



Eco-hydropower Plant (2002 →)

To eliminate fuelwood consumption

Natural Forest Conservation (2001→)



To prevent illegal harvesting

Grain-to-Green (2000→)

To return cropland to forest

Policies Enacted to Protect and Restore Habitat

Eco-hydropo
(2002

- Local case study leads to better understanding of global trends

- Lcluc change analysis allows society to visualize change and enact policy

- Improved local sustainability – led to advances in global sustainability?

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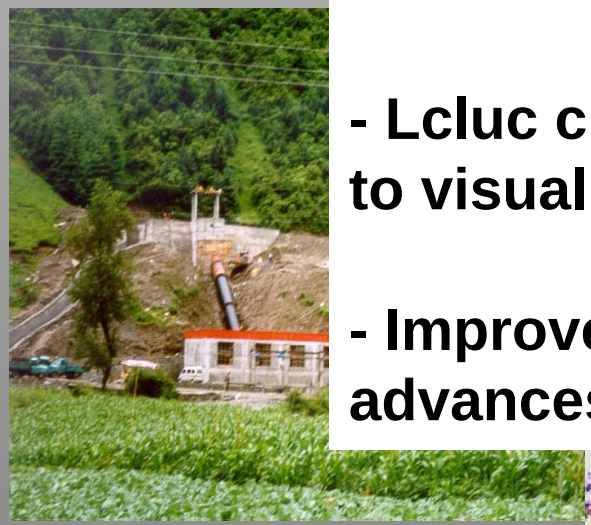
)



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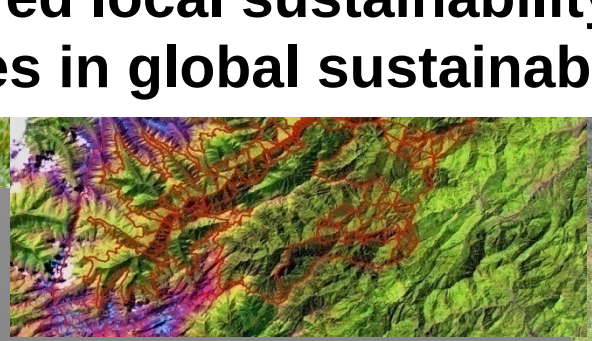
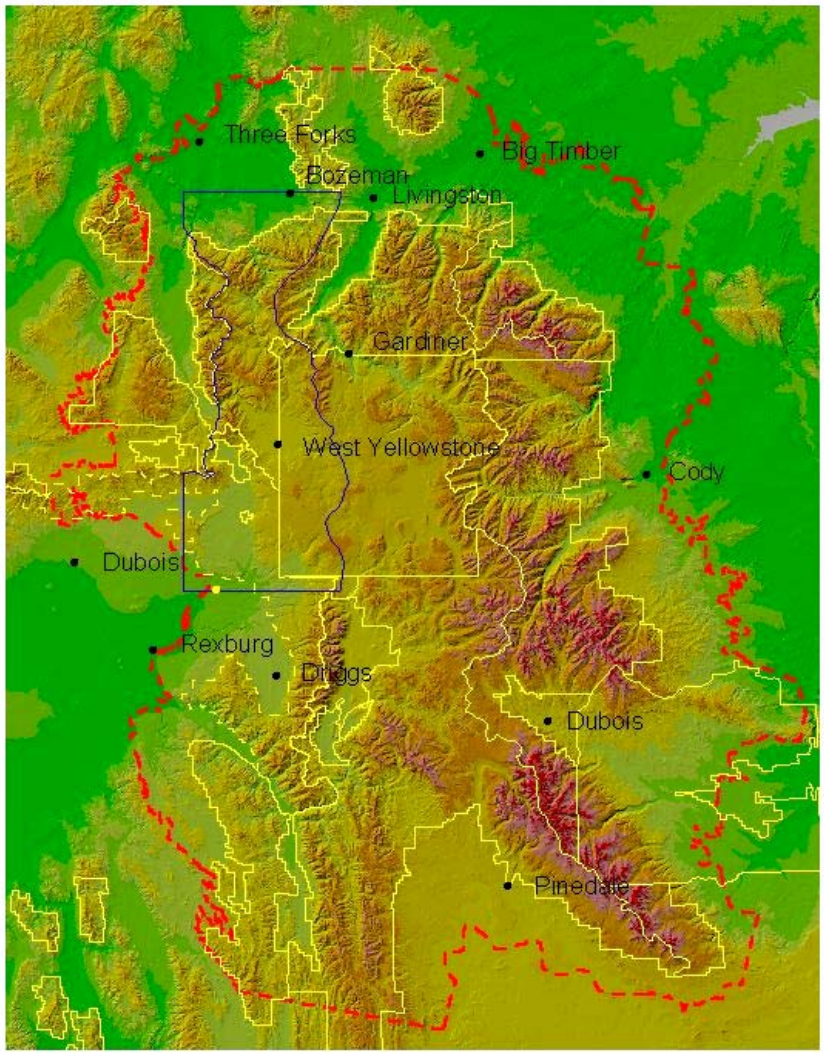


To prevent illegal harvesting

To return cropland to forest

Ecology and Socioeconomics in the New West: A Case Study from Greater Yellowstone.

Hansen et al. 2002. BioScience.



1. 25-Year History of GYE: Exurban growth largest land use change.

2.Causes and Consequences:
•Biophysical factors limit high biodiversity to hot spots;
•Biophysical factors also limit exurban development to same landscape locations with negative impacts on biodiversity ;
•Natural amenities drive of exurban growth;

3. Risk: Future growth can be placed to reduce impacts on biodiversity.

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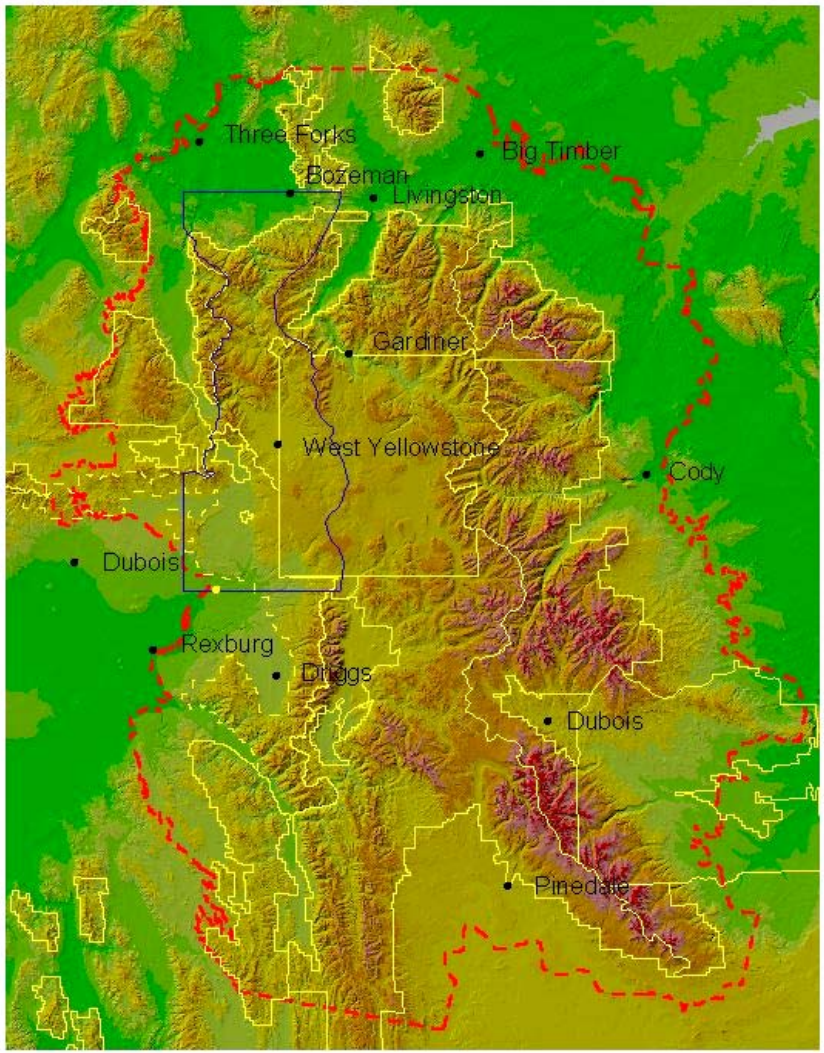

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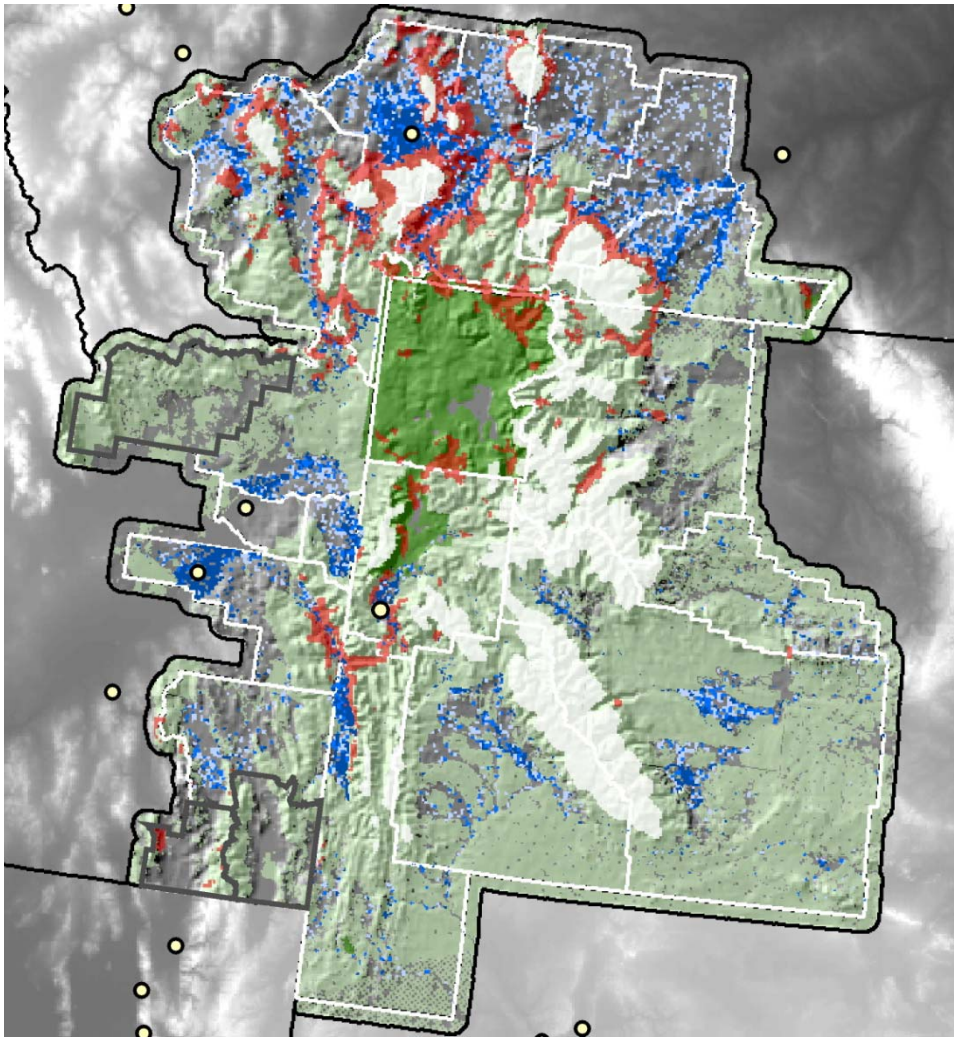

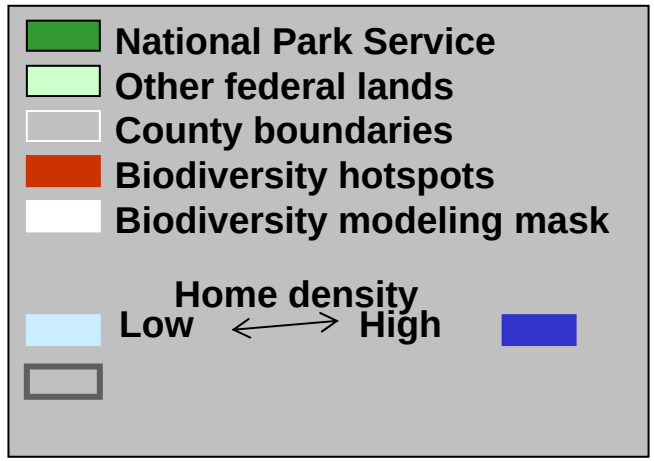

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Ecological Applications
Volume 15, Number 6 December 2005

Land Use Change Around Protected Areas and Consequences for Biodiversity

Greater Yellowstone Ecosystem, US

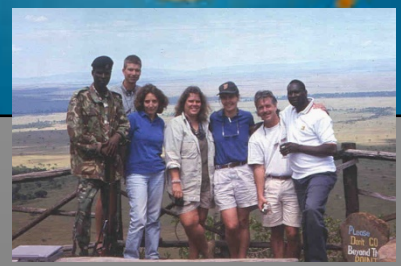
Yucatan, Mexico

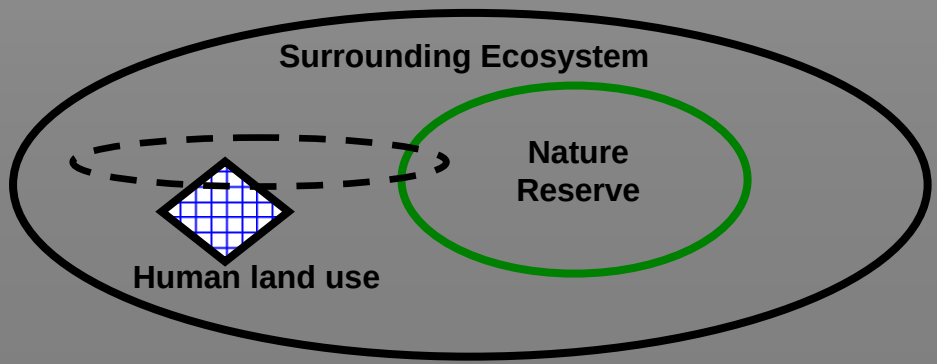
Santarém, Brazil

East Africa

Wolong, SW China

Borneo, Indonesia





Ecological Applications Invited Feature: Land Use Change around Protected Areas

In Press

Hansen, A.J. and R. DeFries. Land use change around protected areas: Implications for sustaining biodiversity.

Hansen, A.J. and R. DeFries. Ecological mechanisms linking nature reserves to surrounding lands.

Vester, H., D. Lawrence, R. Eastman, B.L. Turner II, S. Calme, R. Dickson, C. Pozo, and F. Sangermano. Land change in the Southern Yucatan and Calakmul Biosphere Reserve: Implications for habitat and biodiversity.

Gude, P., A.J. Hansen, and D. Jones. Biodiversity consequences of alternative future land use scenarios in Greater Yellowstone.

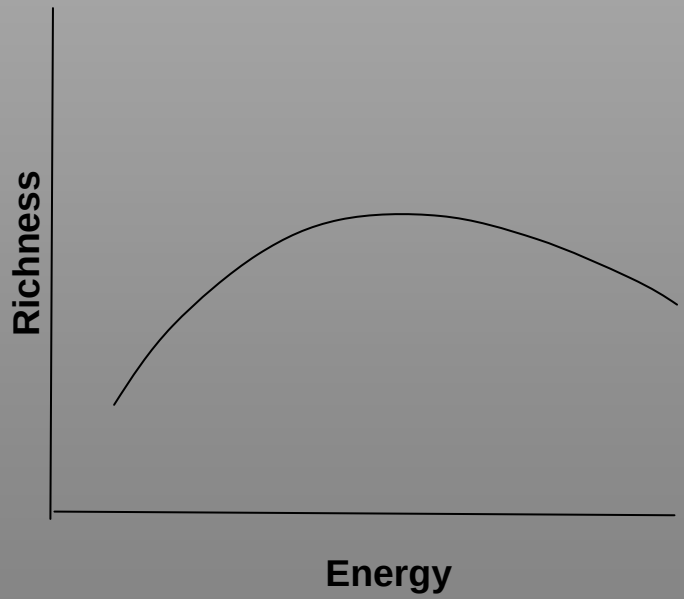
Vina, A., S. Bearer, C. Xiaodong, H. Guangming, M. Linderman, L. An, H. Zhang, Z. Ouyang, and J. Liu. Temporal changes in connectivity of giant panda habitat across the borders of Wolong Nature Reserve (China).

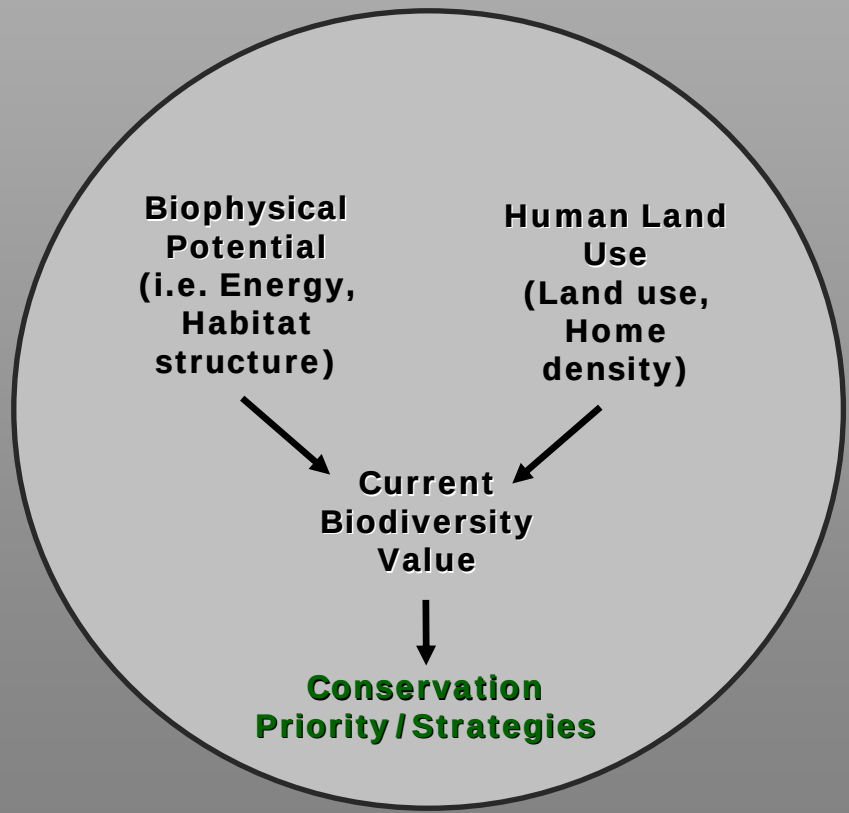
DeFries, R., A. Hansen, R. Reid, B. Turner, L. Curran, J. Liu, E. Moran. Towards scientific principles for regional management of landscapes surrounding nature reserves.

Biophysical and Land-use Controls of Biodiversity: Regional to Continental Scales

Andrew Hansen and Linda Phillips
Montana State University

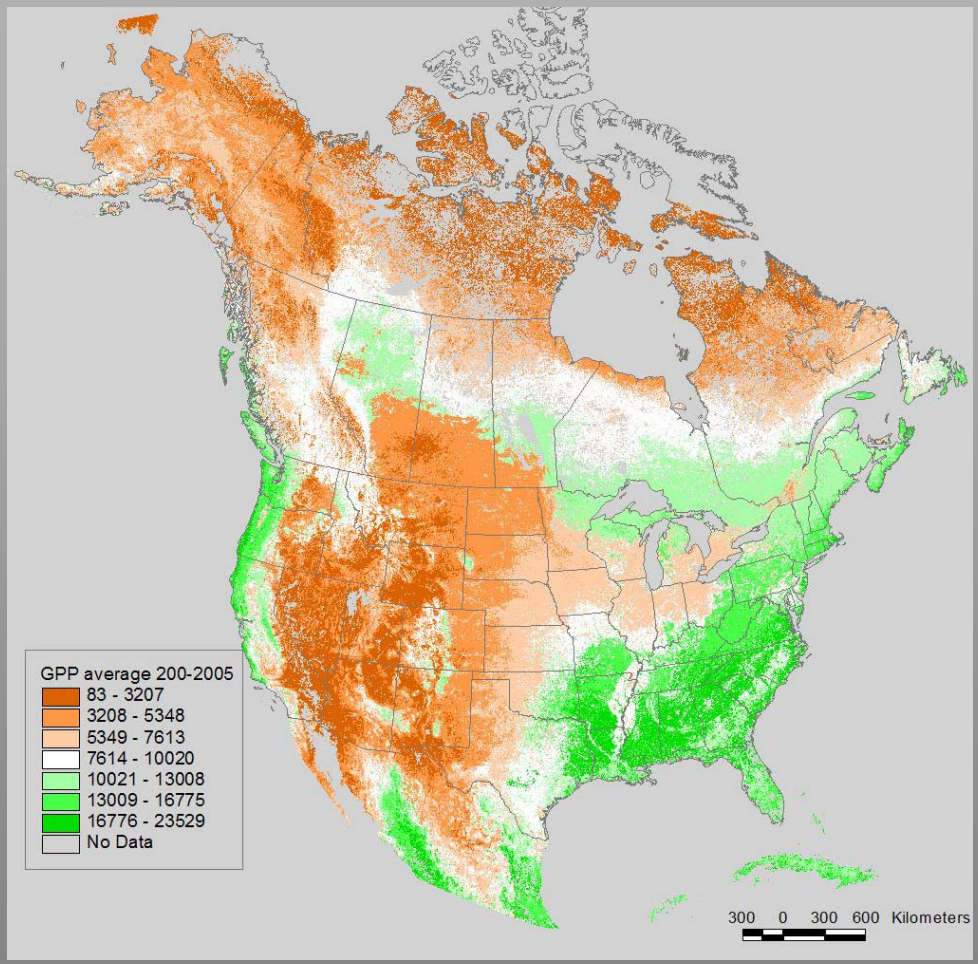
Curt Flather
Colorado State University

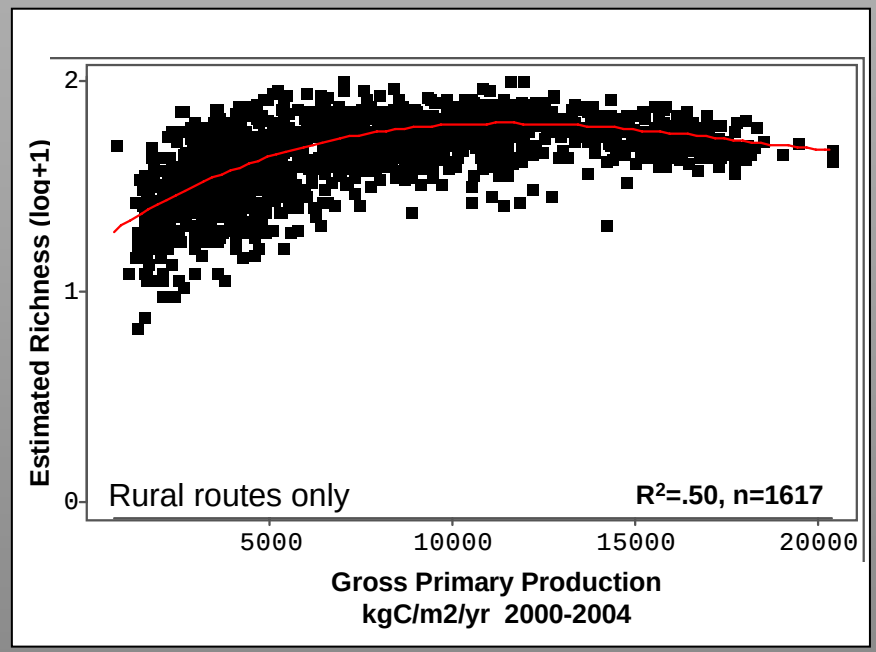




NASA EOS

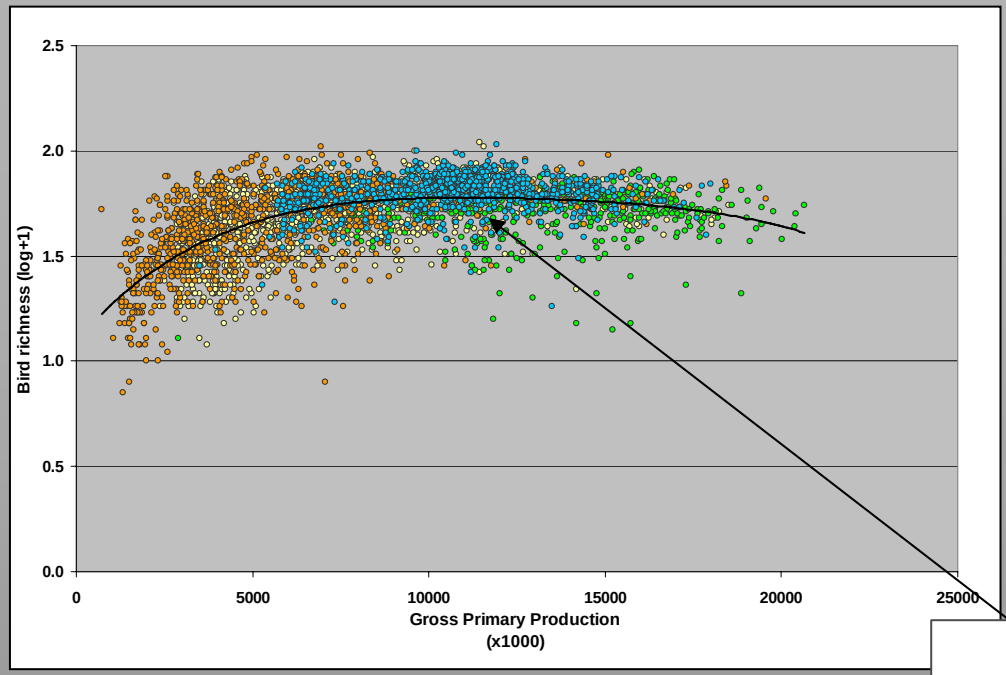
MODIS Products and Bird Diversity

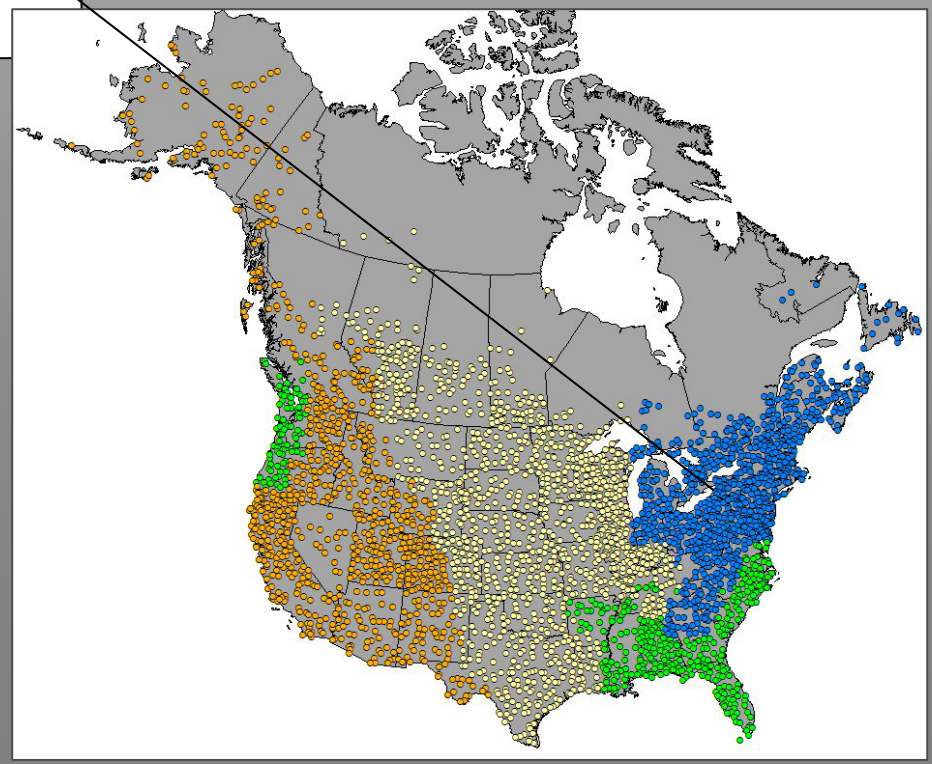




Bird diversity is related to ecosystem energy.

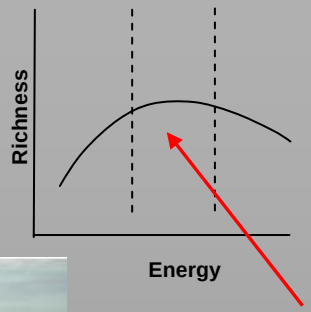
Spatial Distribution of Energy/bird Relationship

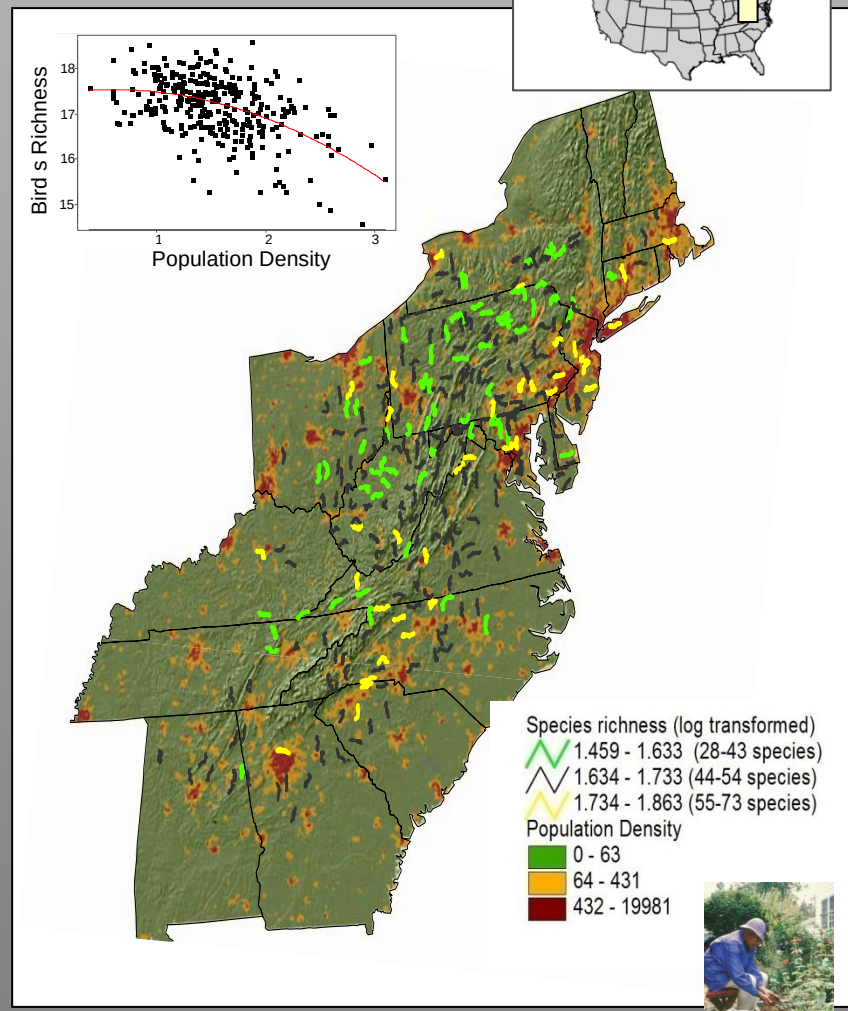




Ecoregions lie on different portions of the unimodal relationship.

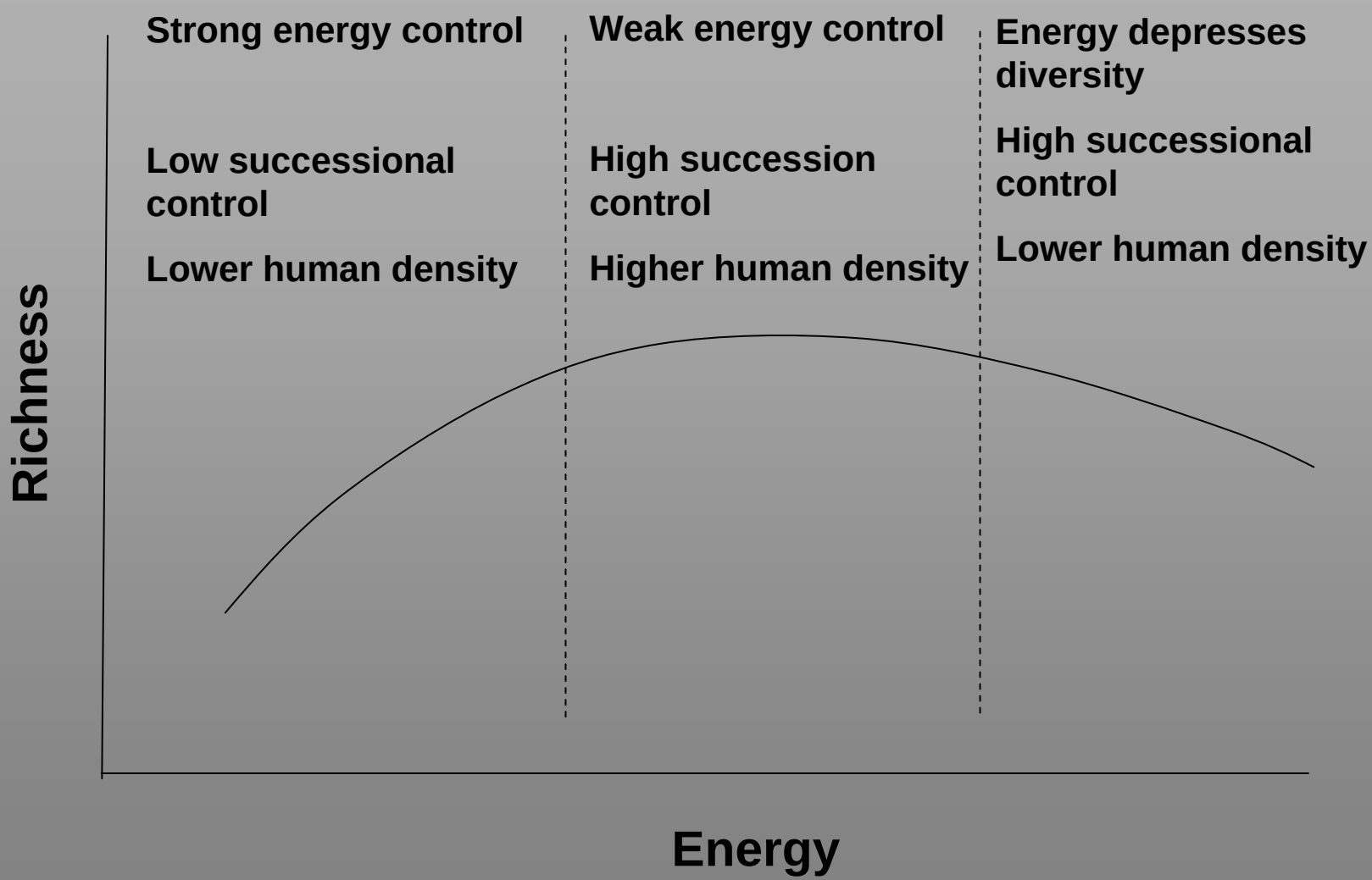
Mid-Energy Ecoregions: Appalachians





BACKYARD CONSERVATION
It'll grow on you.

Managing along Biophysical Gradients



Managing along Biophysical Gradients

Conservation Category	Low Energy	Medium Energy	High Energy
Conservation Zones	Protect high energy places	Protect more natural areas	Protect low energy places
Disturbance	Use fire, flooding, logging judiciously in hotspots	Similar to “Descending”	Use disturbance to break competitive dominance
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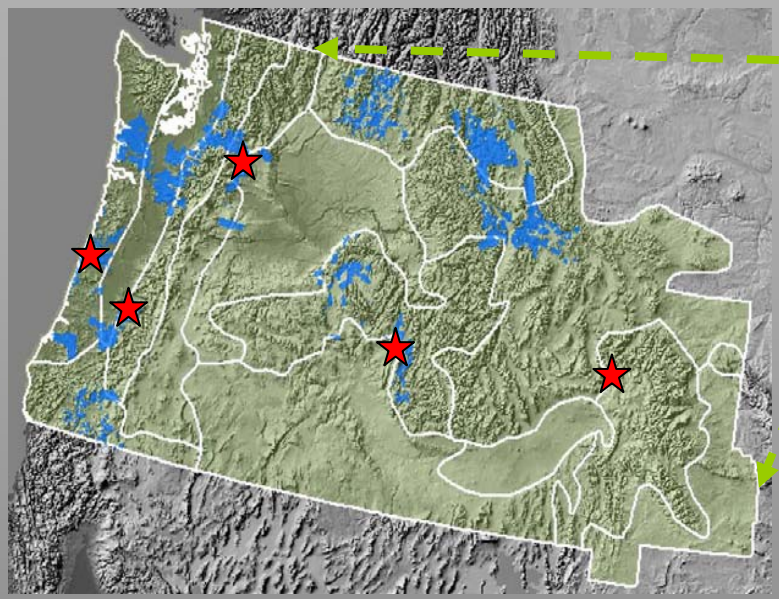
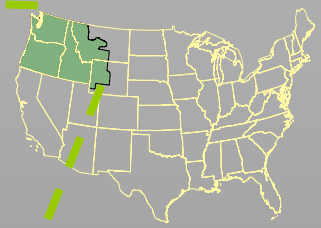
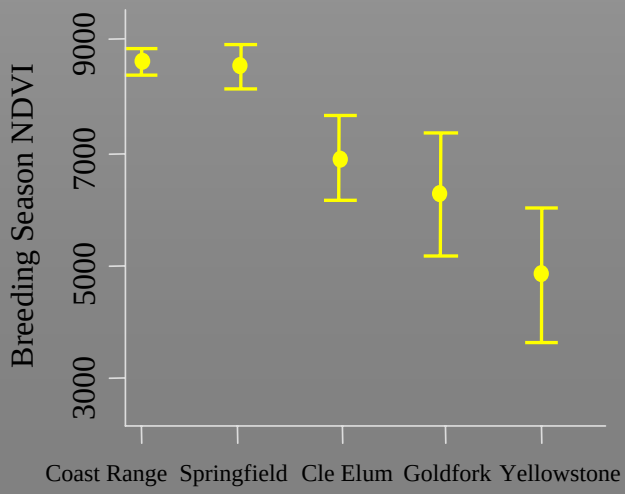
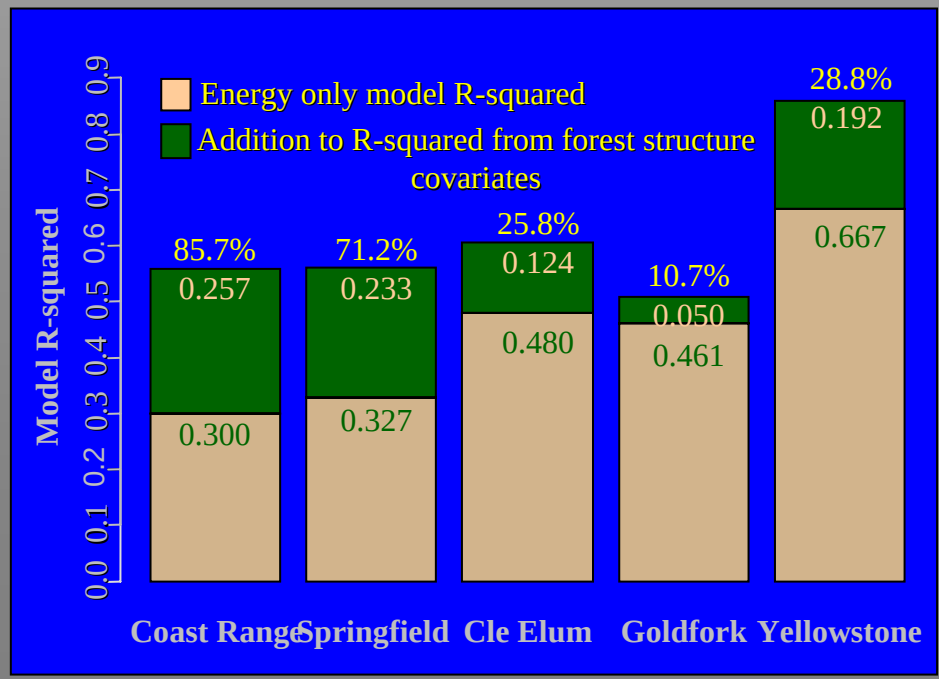
Does Ecosystem Productivity Modify Vegetation Structure Effects on Biodiversity?

Verschuyl et al. in prep.









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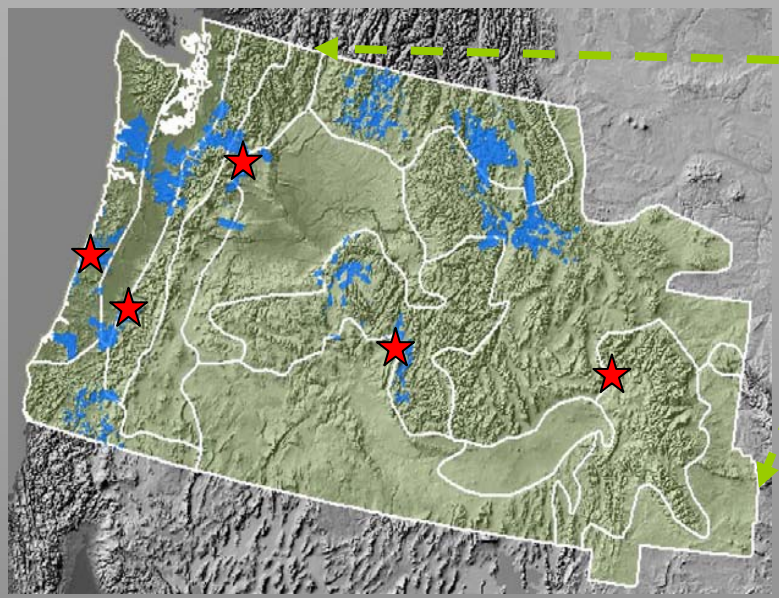
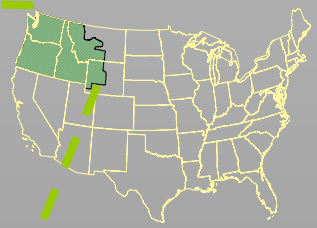
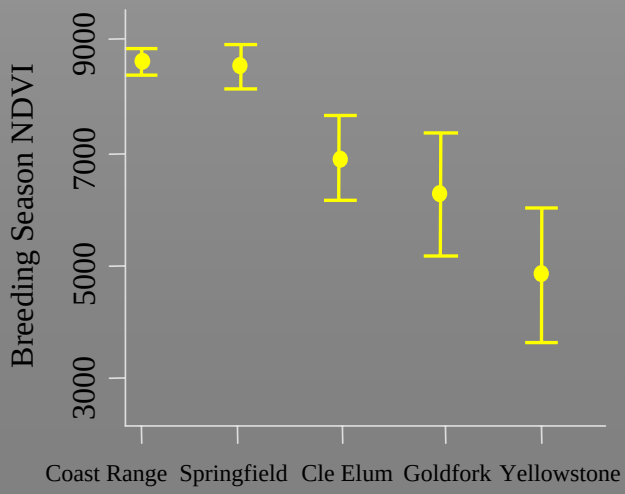
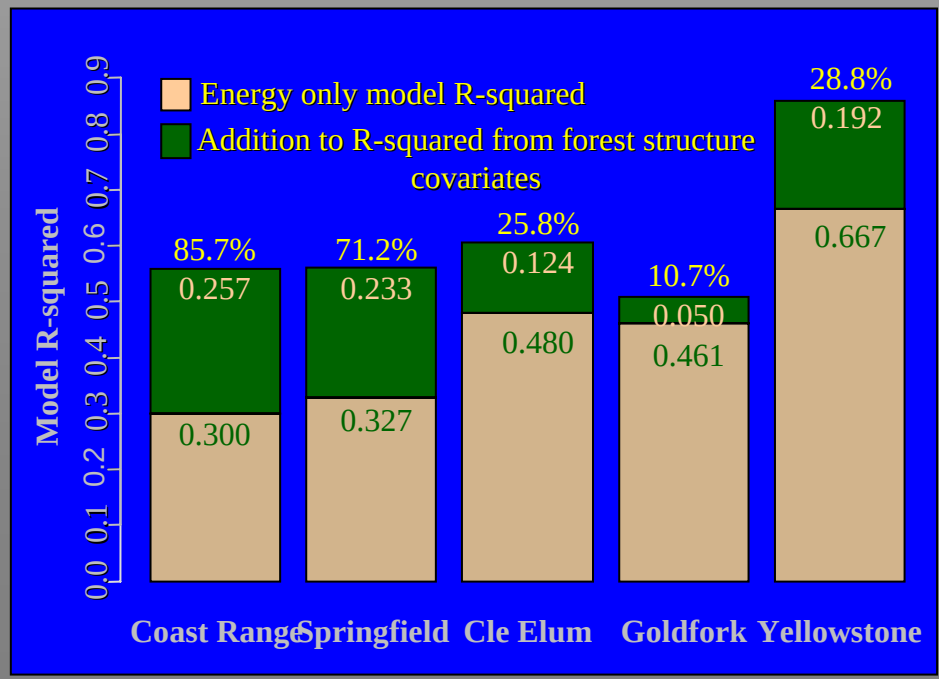


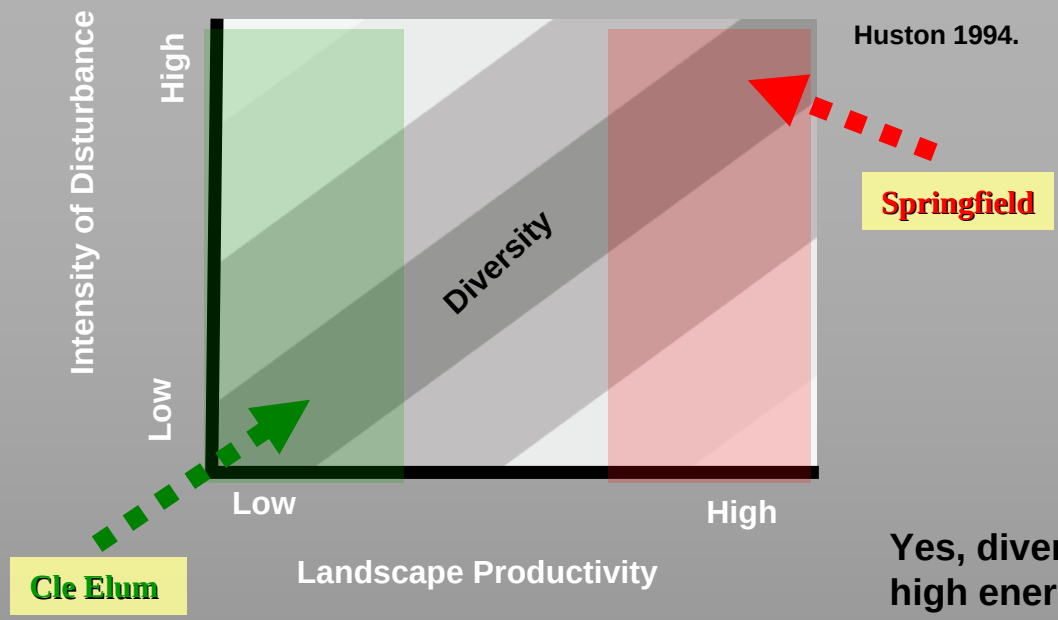


Yes, structure is most limiting in high energy systems.

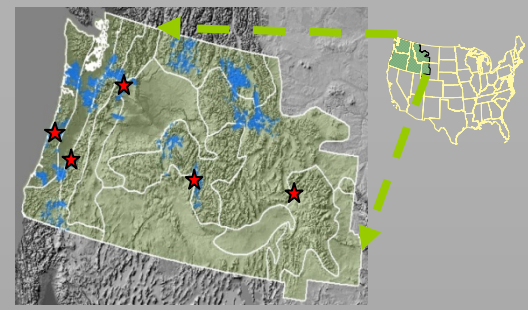




Does Ecosystem Productivity Modify Disturbance Effects on Biodiversity?

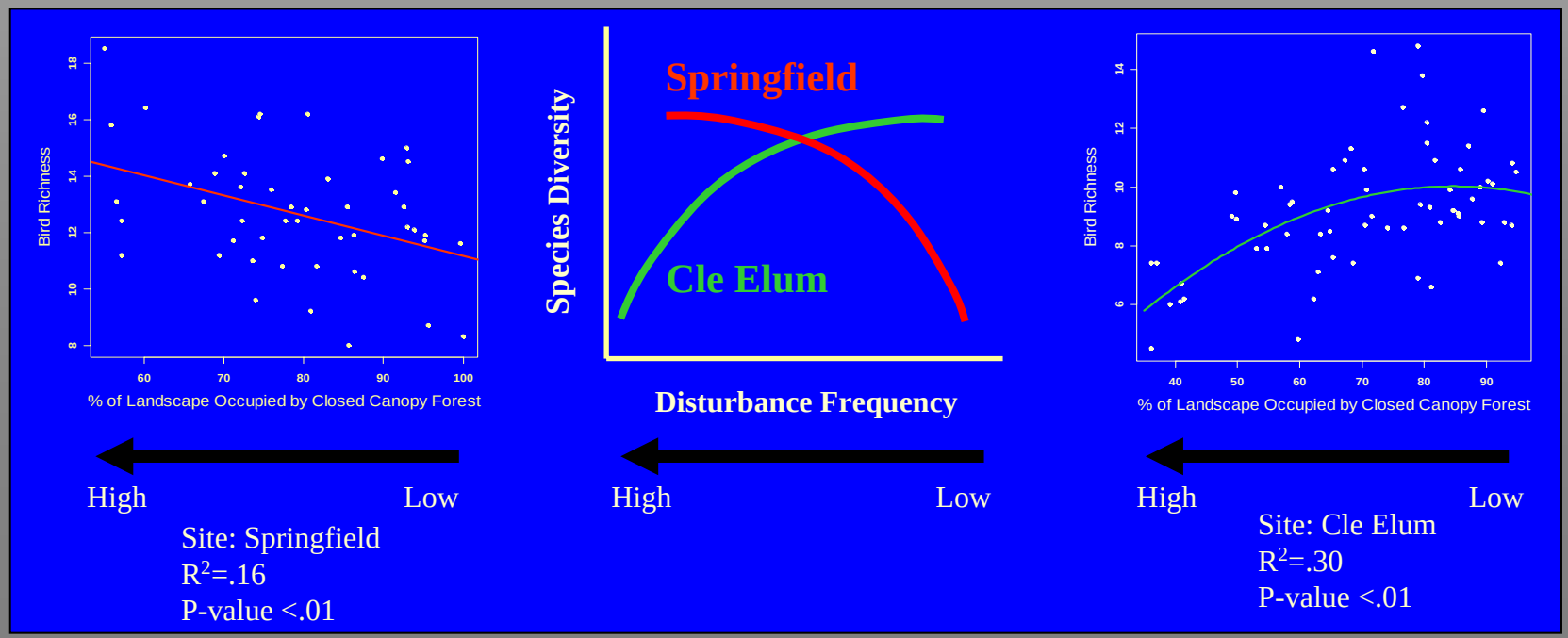


Huston 1994.



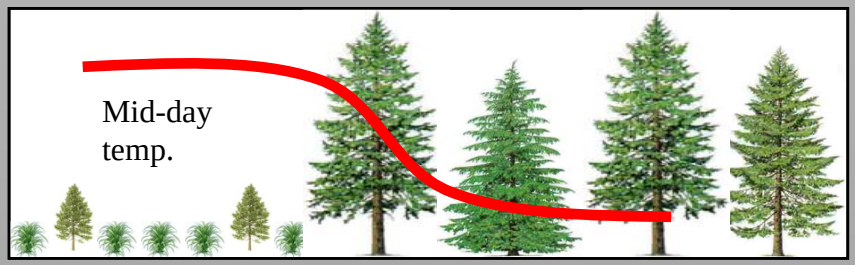
McWethy et al. in prep.

Yes, diversity increases with disturbance under high energy and decreases under low energy.

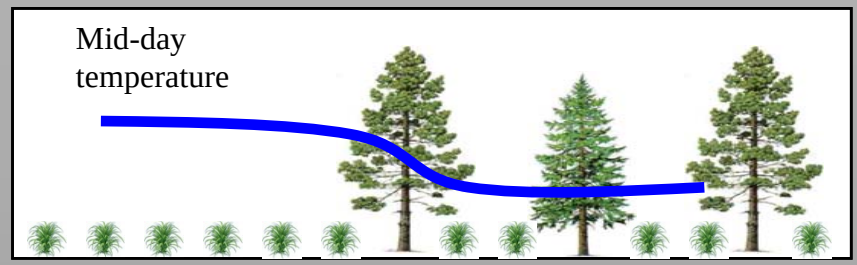


Does Ecosystem Productivity Modify Fragmentation Effects on Biodiversity?

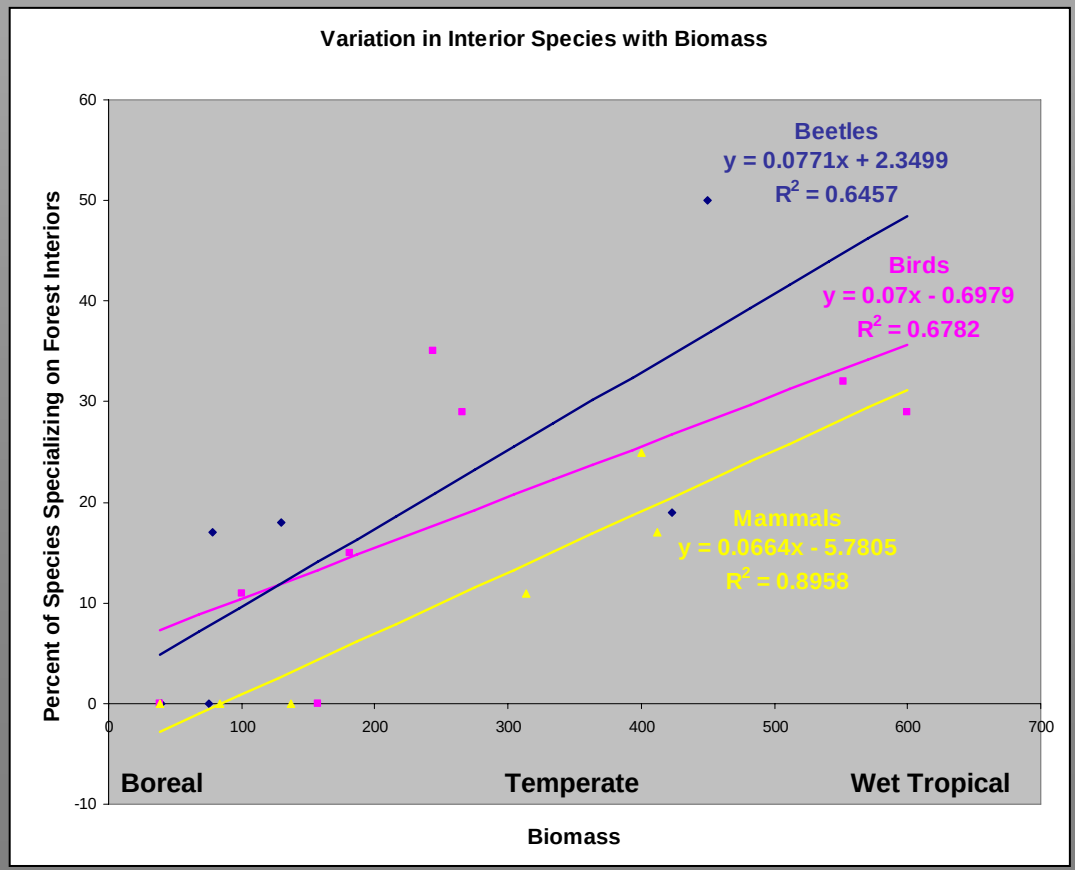
Hypothesis: Edge effects are more pronounced in high energy environments



High Biomass System



Low Biomass System



Yes, more species respond to edges in the more productive systems.

Hansen et al. in prep. Data from published studies

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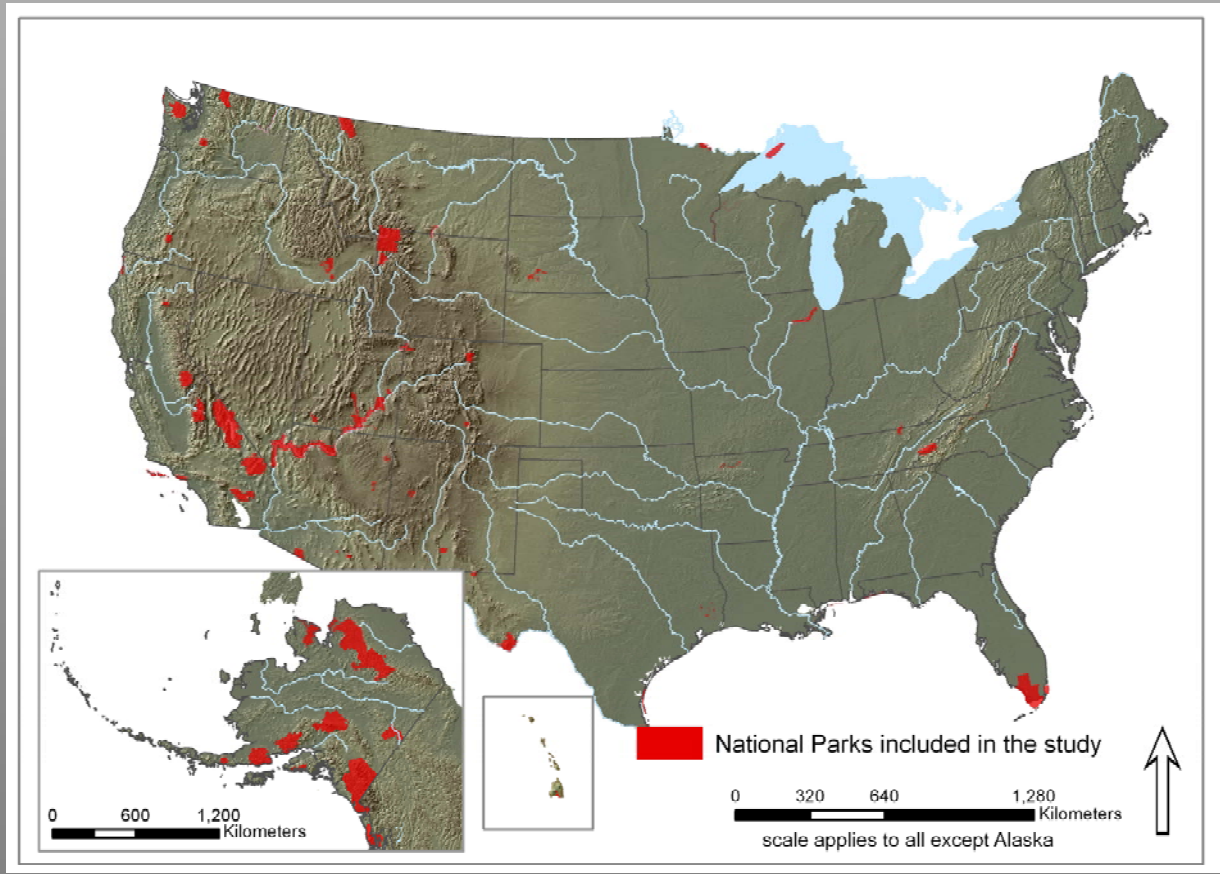
Vulnerability of US National Parks to Land Use and Climate Change and Variability

Andrew Hansen
Montana State University

Steve Running
University of Montana

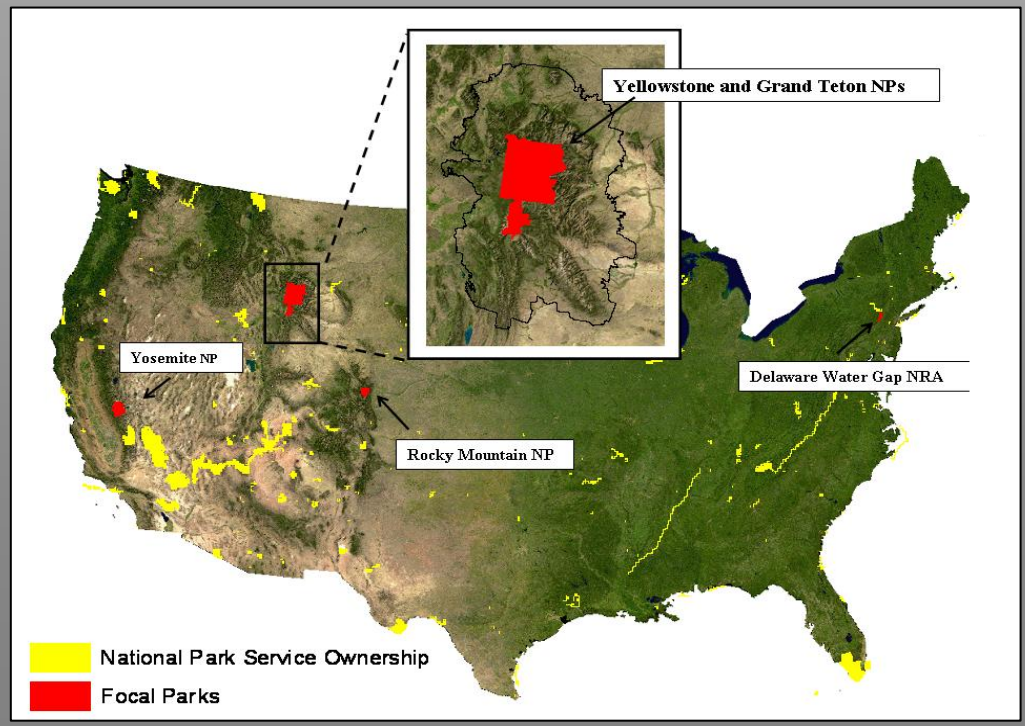


Ecological Conditions of US National Parks: Enabling Decision Support Through Monitoring, Analysis, and Forecasting

NASA Applications Program: Decision Support through Earth-Sun Science Research Results Project

And

NPS I&M Program



Pilot national parks

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Sensitive Species	Many species with large home		Forest interior species
Exotics			
Protected Area Size			
Land Use			

Regional case study

Theory

Continental-global tests

Revise conservation strategies

Improve monitoring to inform management

Land cover change in Eastern Europe and resulting effects on biodiversity

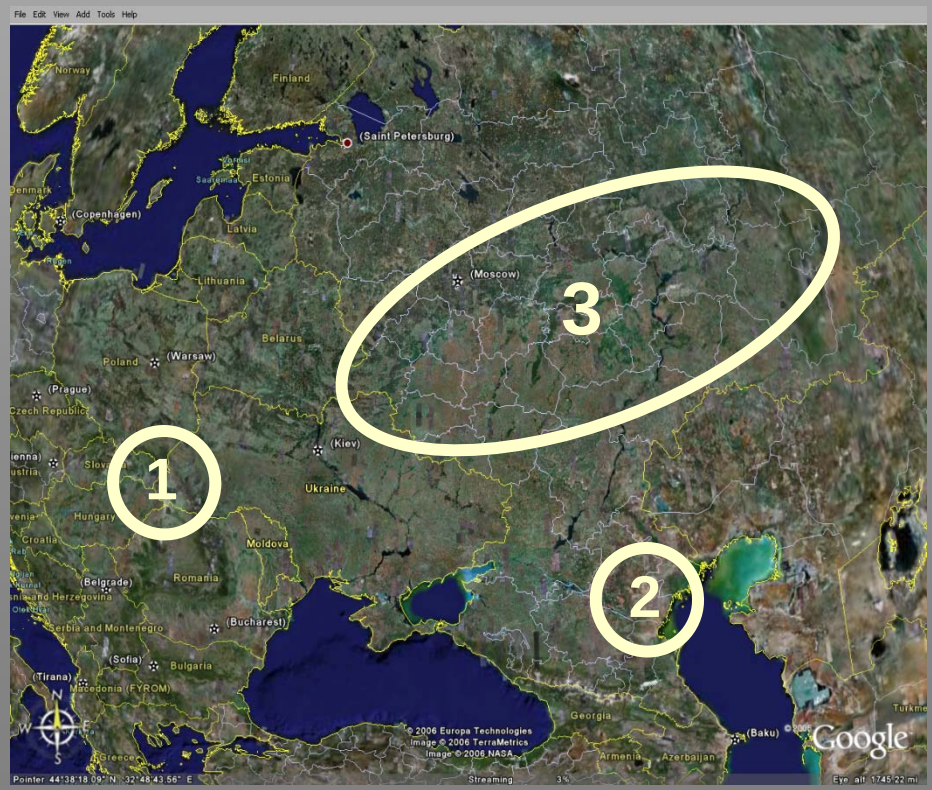
Volker C. Radeloff, M. Dubinin, A . Prishchepov, C. Alcantara
University of Wisconsin-Madison

L. Baskin, and A. Lushchekina Russian Academy of Sciences
K. Perzanowski Polish Academy of Sciences
P. Hostert, and T. Kuemmerle Humboldt University, Germany

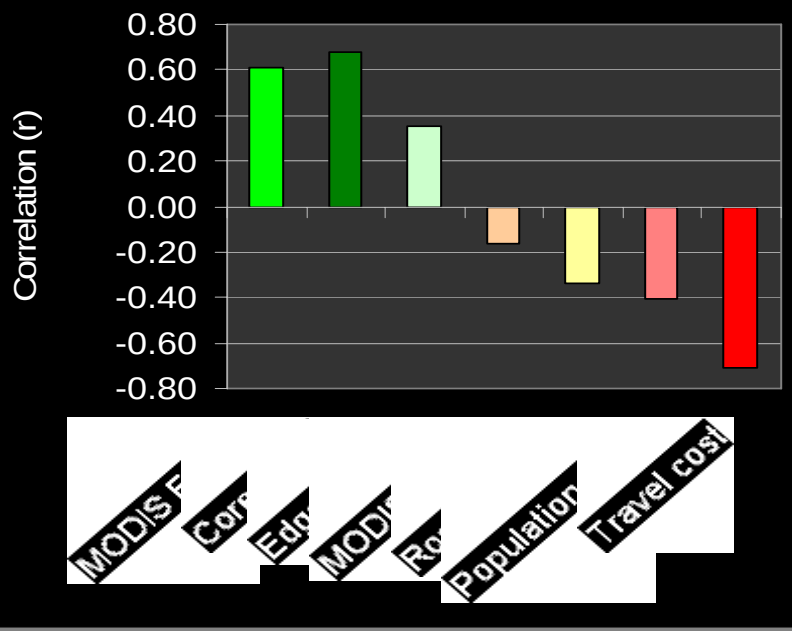
A NASA-LCLUC and NEESPI Project

Introduction

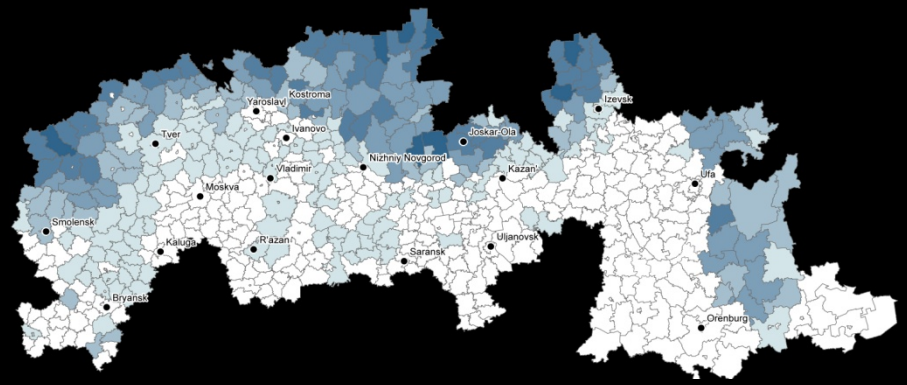
- In 1990, the Soviet Union broke down, and with it's control on eastern Europe
- How did this socioeconomic change affect LCLUC, and thus biodiversity?



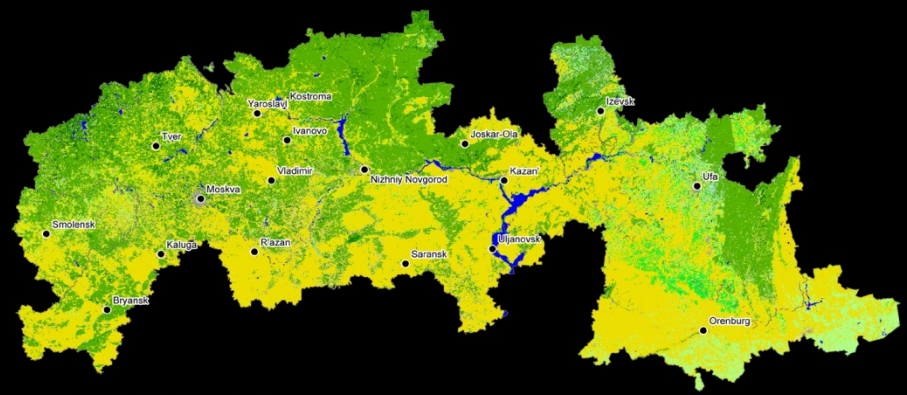
Brown bears in European Russia



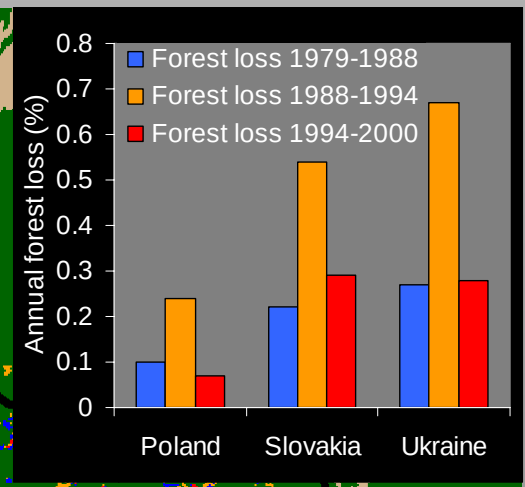
Bear density in 2000

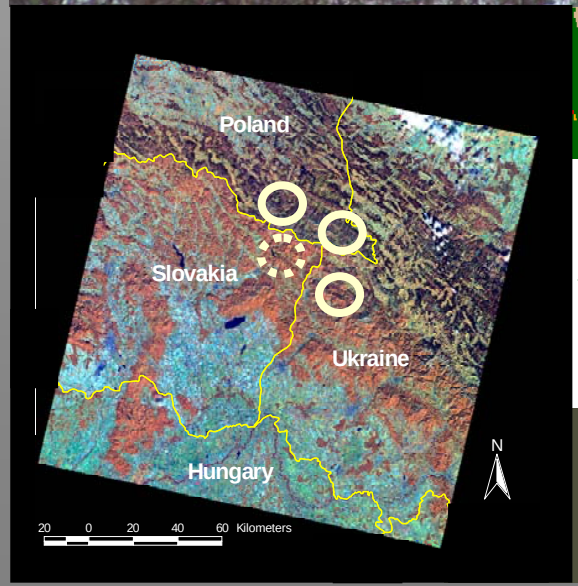


MODIS Landcover



European Bison in the Carpathians

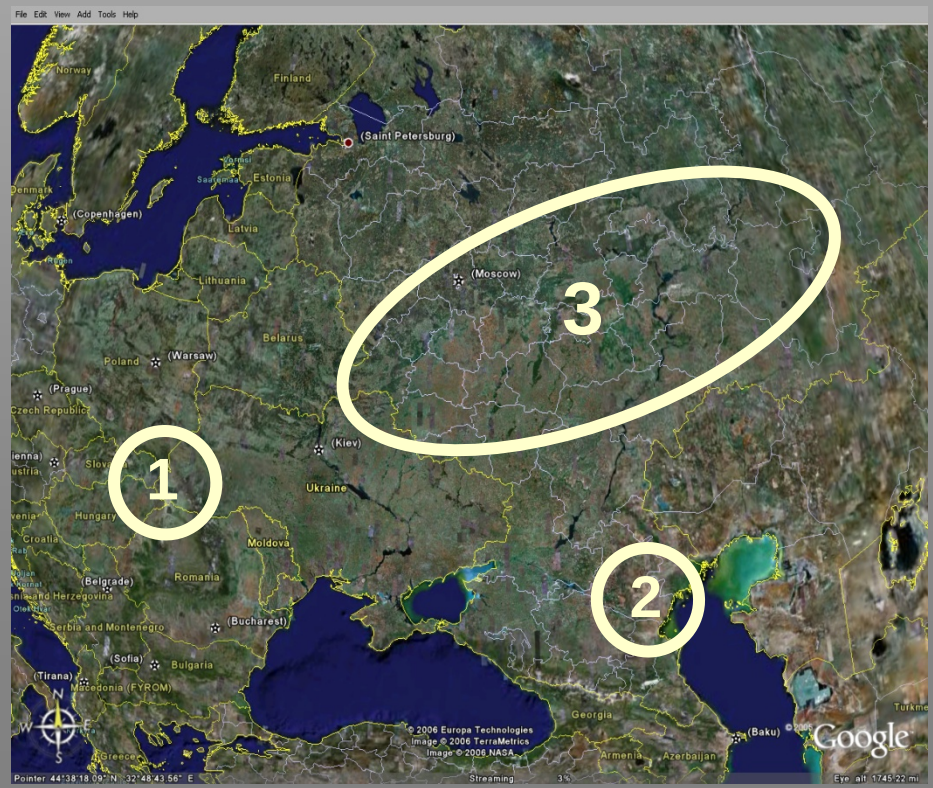




Kuemmerle et al. 2006. *Remote Sensing of Environment, 103:449-464*
Kuemmerle et al. 2007. *Ecological Applications, in press*
Kuemmerle et al. 2007. *Remote Sensing of Environment, in review*

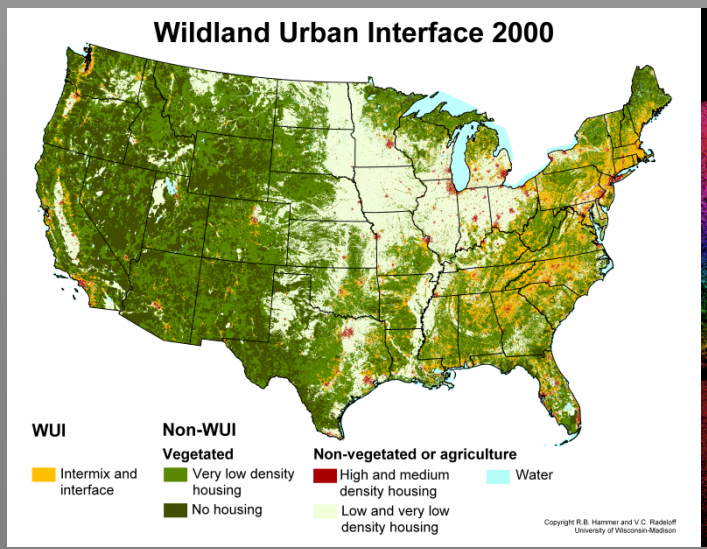
Eastern Europe LCLUC

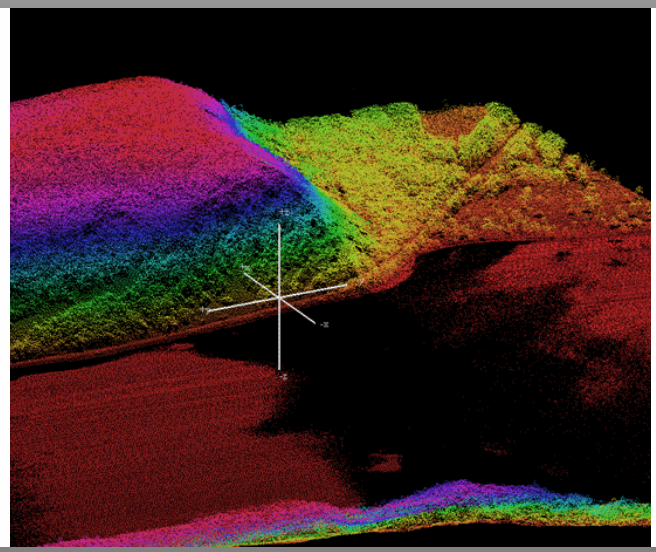
- Parts of Eastern Europe are re-wilding
- Land use intensity is decreasing
- Remote sensing is great for habitat analysis and biodiversity science
- Important to identify conservation threats and opportunities

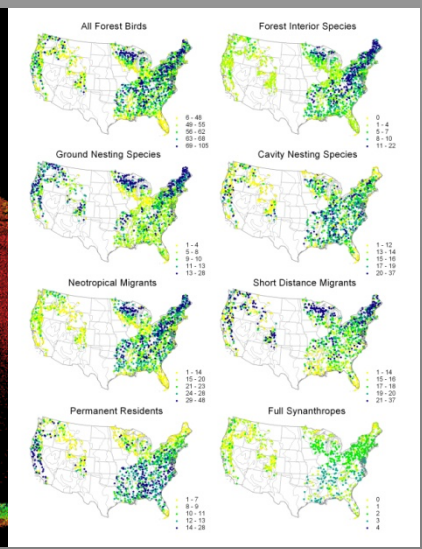


LCLUC/biodiversity projects in the U.S.

- NASA-Biodiversity: Remote sensing and avian biodiversity patterns in the United States
- NASA-IDS: Disturbance effects on avian biodiversity
- DoD-SERDP: Habitat monitoring for migratory birds
- US Forest Service: The wildland-urban interface in the U.S.
- Park Service: LCLUC near Pictured Rock and Indiana Dunes
- WI-DNR: LIDAR based forest bird habitat assessment







Conclusions

- **Highlighted development three labs under funding by LCLUC biodiversity.**

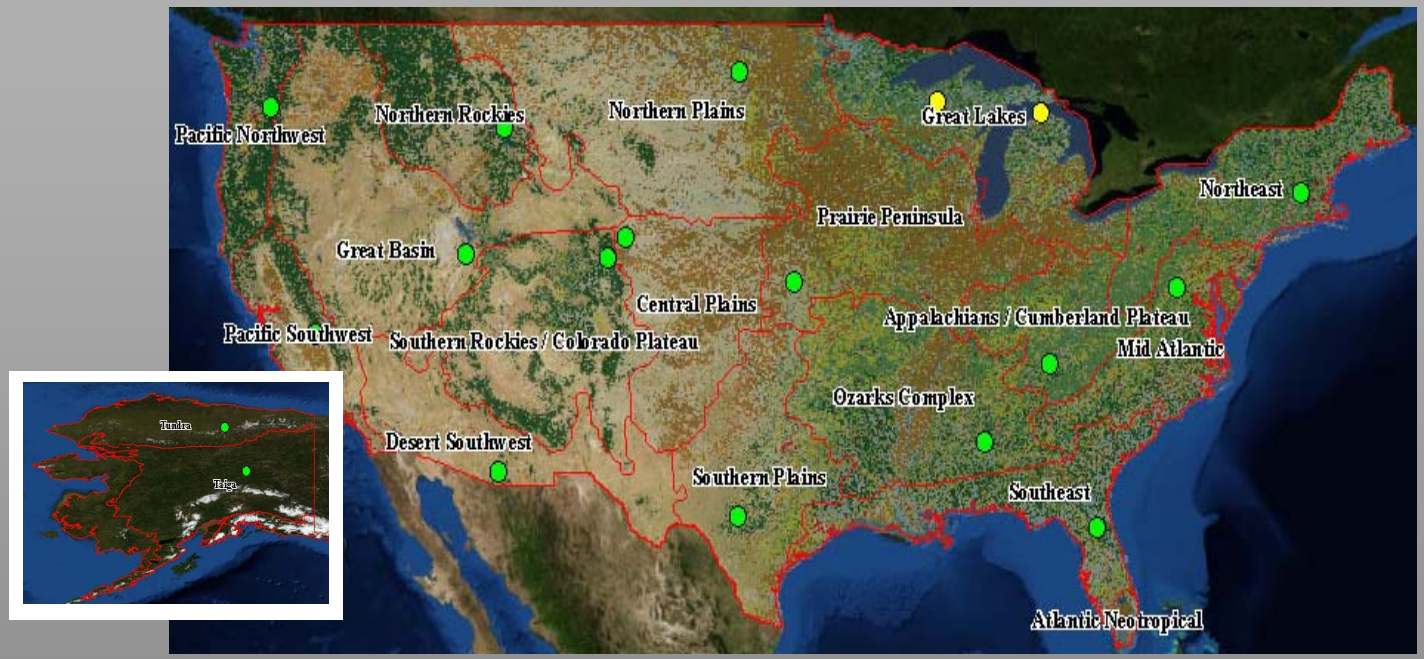
- **Stages of development:**
  - **Local case studies**
  - **Theory**
  - **Continental to global tests**
  - **Conservation and management**

- **This is true for many NASA P.I.s.**

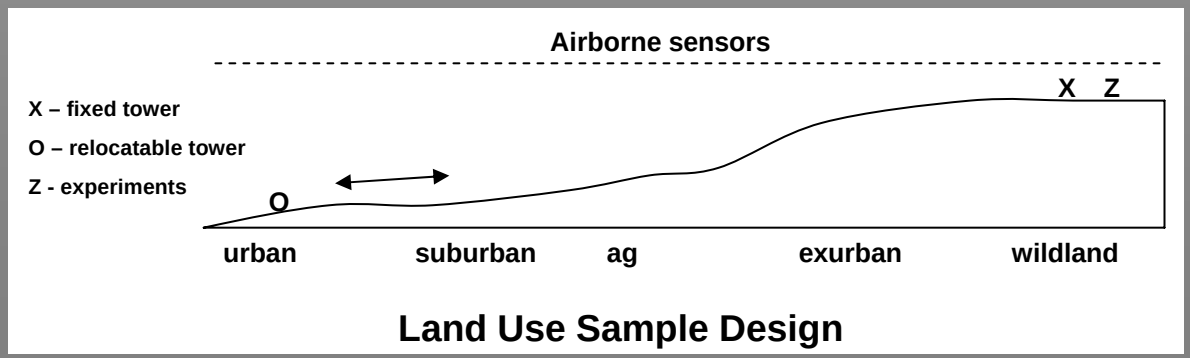
- **LCLUC has also have strong positive impact on other programs: NSF Biocomplexity, USDA Managed Forests Ecosystems, most recently – NSF NEON.**

National Ecological Observatory Network

How will ecosystems and their components respond to changes in natural- and human-induced forcings such as climate, land use, and invasive species across a range of spatial and temporal scales?



NEON puts the LCLUC regional studies into a national design for long term study



Land Use Sample Design

Future Directions for LCLUC Biodiversity?

- Making conservation biology spatial
  - Habitat structure vs productivity as drivers
  - Spatial variation in biophysical potential for biodiversity, land use, and biodiversity responses;
  - Use this to develop locally effective conservation and management

- Human population and consumption
  - (e.g., US is encouraging rapid population growth without evaluation of consequences)
  - Socioeconomic and ecological consequences of population size and consumption habitats
  - Managing natural amenities-based economies

Future Directions for LCLUC Biodiversity?

- Unpredicted thresholds of change in land use (e.g., soviet union)
  - Due to climate change?
  - Due to human sociopolitical systems

- LCLUC past, present, alternative futures
  - Elevate land use to level of climate change in public and policy discussions.
  - Evaluate the range of creative new land use designs now being employed

- Partner with NEON