Energy as a Framework for Prioritizing Conservation Vulnerabilities and Management Strategies

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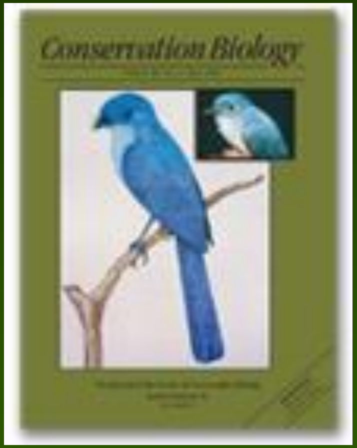
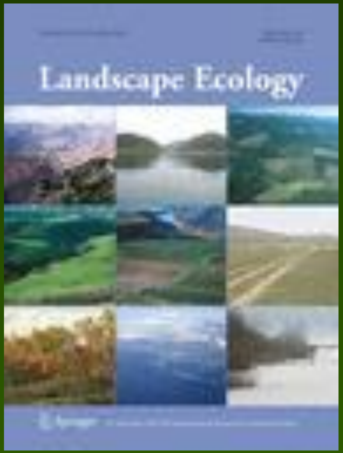
Advancement in Conservation Biology and Landscape Ecology



Conservation Biology



Landscape Ecology

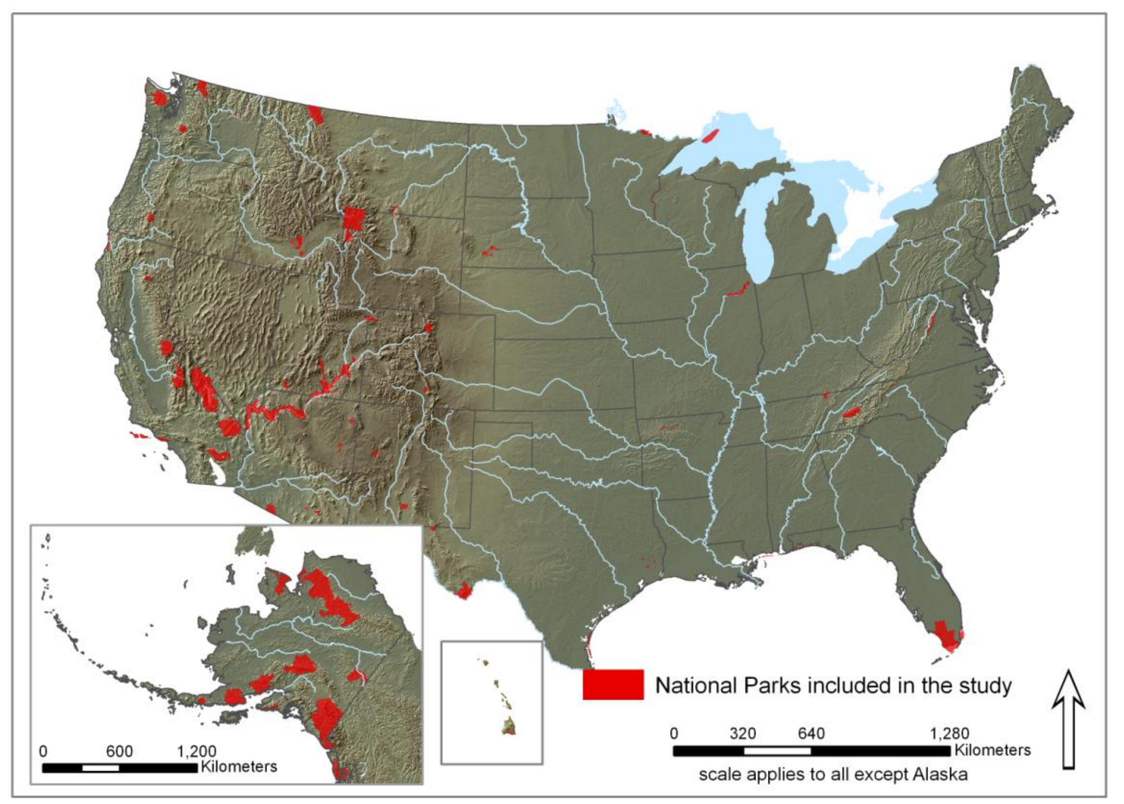
- great progress in identifying the many ways that ecological systems may be vulnerable to human activities.

Headache for Managers?

-difficult for managers to crystallize key conservation priorities for their particular place.

- habitat fragmentation
- natural disturbance
- sensitive species
- invasive species
- disease
- loss of top predators
- connectivity
- metapopulation dynamics
- dangerous wildlife
- protected areas
- other issues?

70 Largest US National Parks

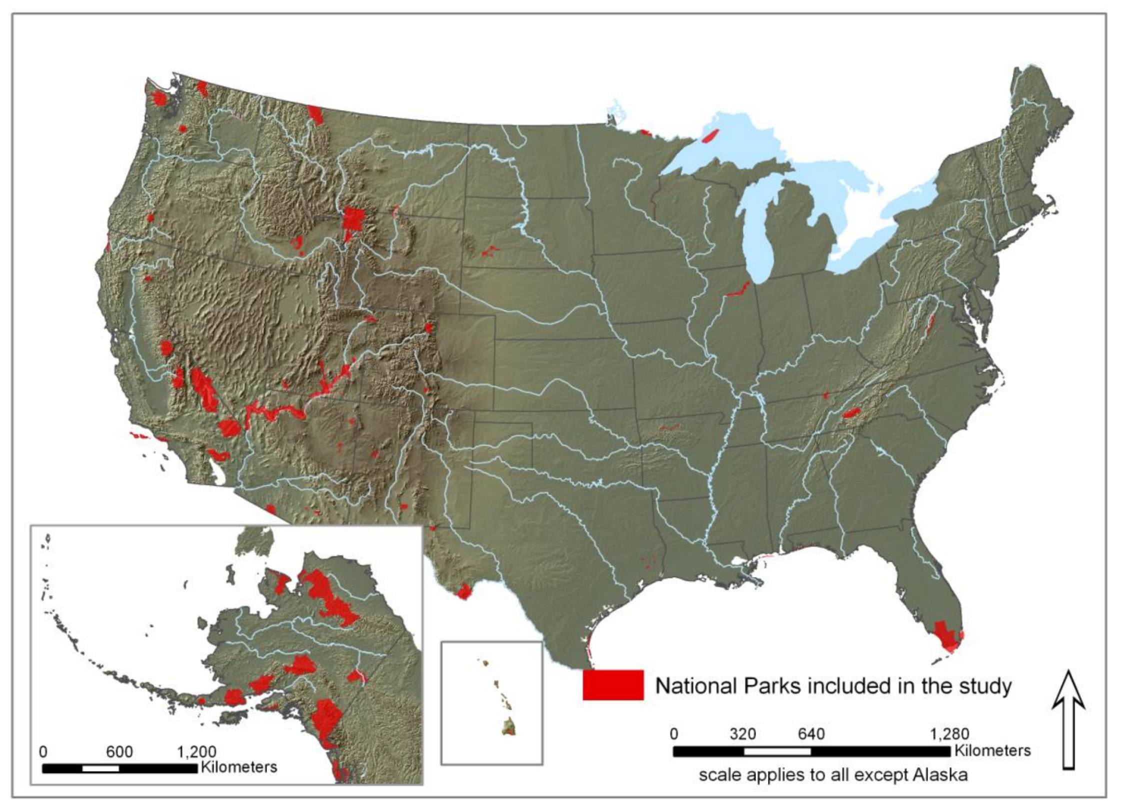


Advancement in Management?

-difficult for manager to crystallize key conservation priorities for their particular place.

70 Largest US National Parks

- habitat fragmentation
- natural disturbance
- sensitive species
- invasive species
- disease
- exurban development
- backcountry recreation
- protected areas
- other issues?



We know that place matters.

Advancement in Management?

-difficult for manager to crystallize key conservation priorities for their particular place.

- **habitat fragmentation**
- **natural disturbance**
- **sensitive species**
- **invasive species**
- **disease**
- **exurban development**
- **backcountry recreation**
- **protected areas**
- **other issues?**

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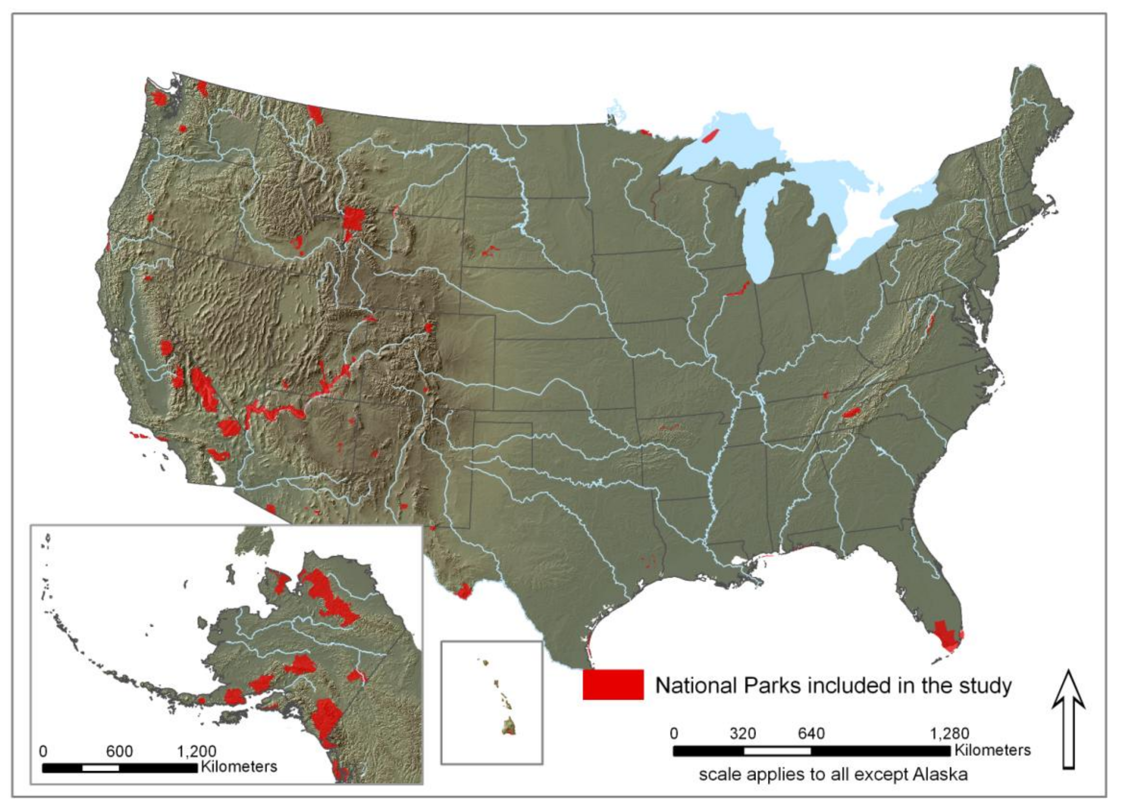

In different places, the interactions among abiotic variables, ecological processes, species, and humans are known to play out differently.

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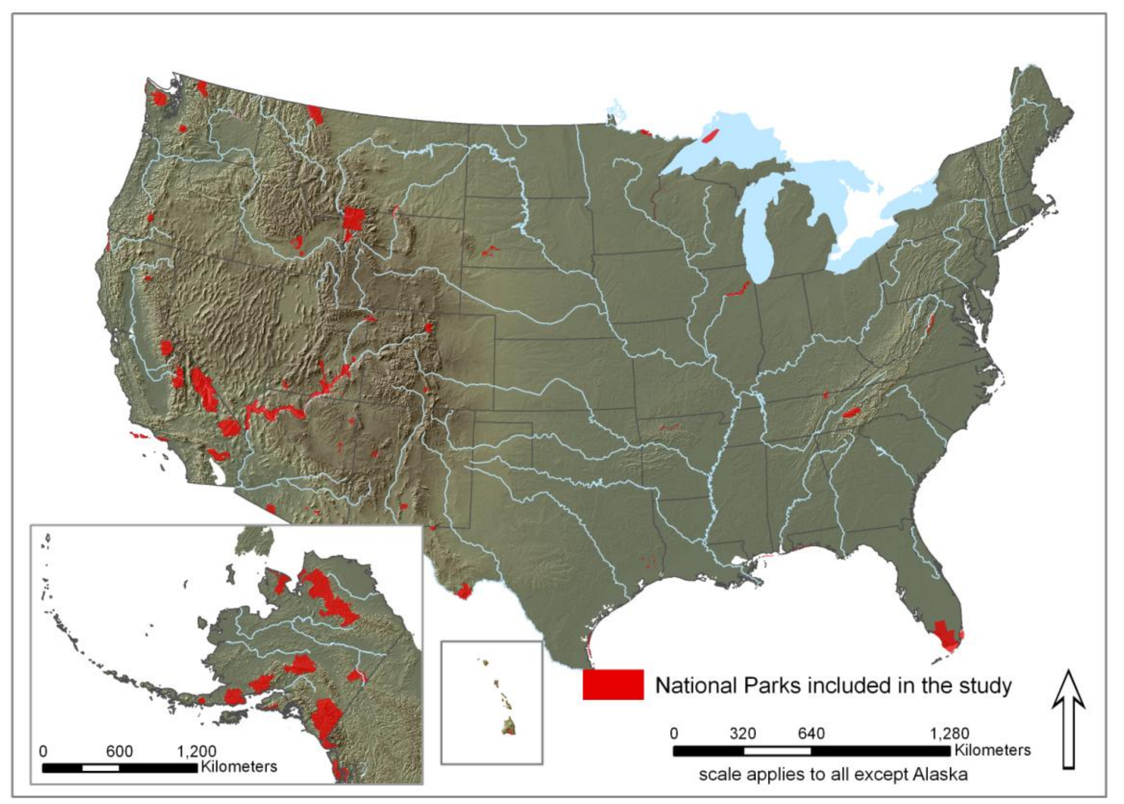

Are there general properties of ecosystems that, if recognized, could be used to set conservation goals more effectively?

Theoretical Roots of Conservation Biology

Hutchinson (1959), “What factors limit the number of species in a place”?

- **habitat heterogeneity**
- **habitat area**
- **trophic structure**
- **evolutionary processes**
- **available energy.**

Theoretical Roots of Conservation Biology

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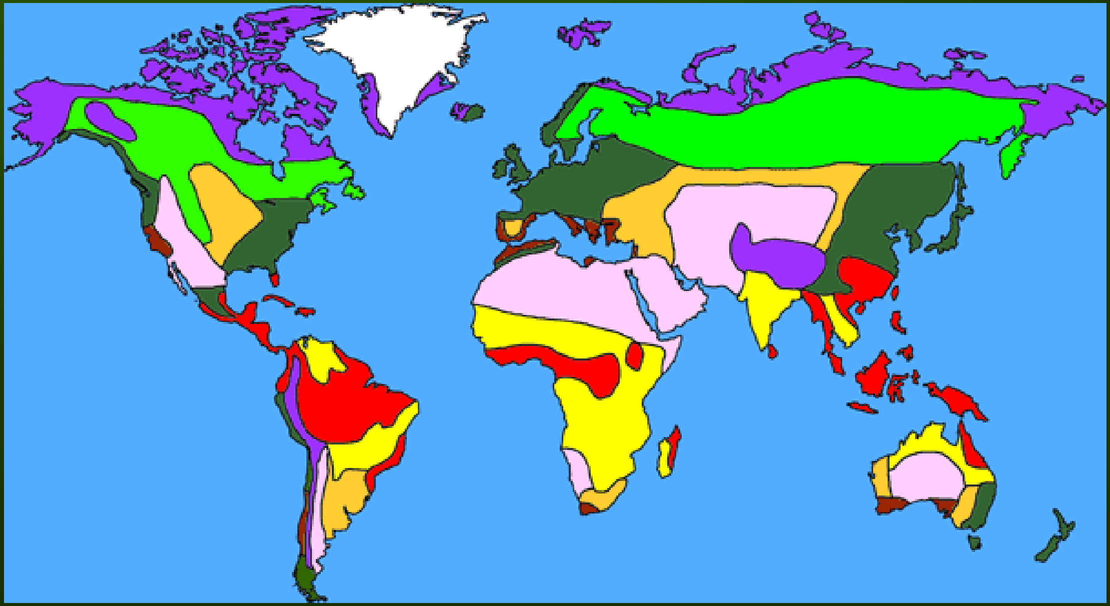
Topics

- A framework to grouping ecological systems based on ecosystem energy and habitat heterogeneity;
- Management strategies for each group;
- Illustrative case studies

Can we group ecosystems to better set conservation priorities?



Earth's Terrestrial Biomes

Generalizations on Traits of Ecosystems

Traits

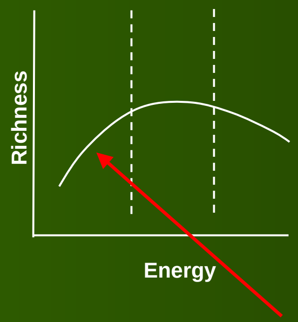
Habitat Heterogeneity	Low, Variable		Intermediate		High	
High geomorphic complexity and/or high natural seral diversity	Low population growth rates, small population sizes, higher extinction rates Large home ranges Migratory mammal populations Spatially explicit population dynamics S_K relatively low but increases with energy High stress following disturbance Weak competitive exclusion Weak response to vegetation structure or patch edge *Possibly low invasive species* *Top down effects possibly more likely* Low human density Lower land use intensity but concentrated in local hotspots	Very strong spatially explicit population dynamics S_K Increased by higher habitat heterogeneity	Moderate population growth rates, population sizes, extinction rates Some migratory mammal populations S_K is relatively high, but not strongly related to energy within the interval Moderate response to vegetation structure or patch edge Very high human density High land use intensity (esp. agriculture) widely distributed throughout landscape Top predators may be extripated allowing expanded mesocarnivore populations *Possibly high invasive species*	S_K Increased by higher habitat heterogeneity	Higher population growth rates, larger population sizes, lower extinction rates except where limited by poor soils Few migratory mammal populations S_K moderate to high and may decrease at the highest energy levels Rapid recovery following disturbance except where limited by soils Strong competitive exclusion High forest biomass and strong response to vegetation structure or to patch edge *Bottom up effects possibly more likely* Possibly high invasive species Human density and land use intensity moderate except where soils are fertile	S_K Increased by higher habitat heterogeneity *Very high invasiveness*
Low geomorphic complexity and/or low natural seral diversity		Very low S_K due to low energy and low habitat heterogeneity *Possibly very low invasive species richness due to lack of disturbance*		S_K decreased by lower habitat heterogeneity		S_K decreased by lower habitat heterogeneity *Possibly moderate invasive species richness* Very high forest biomass and strong response to vegetation structure or to patch edge

Primary Productivity

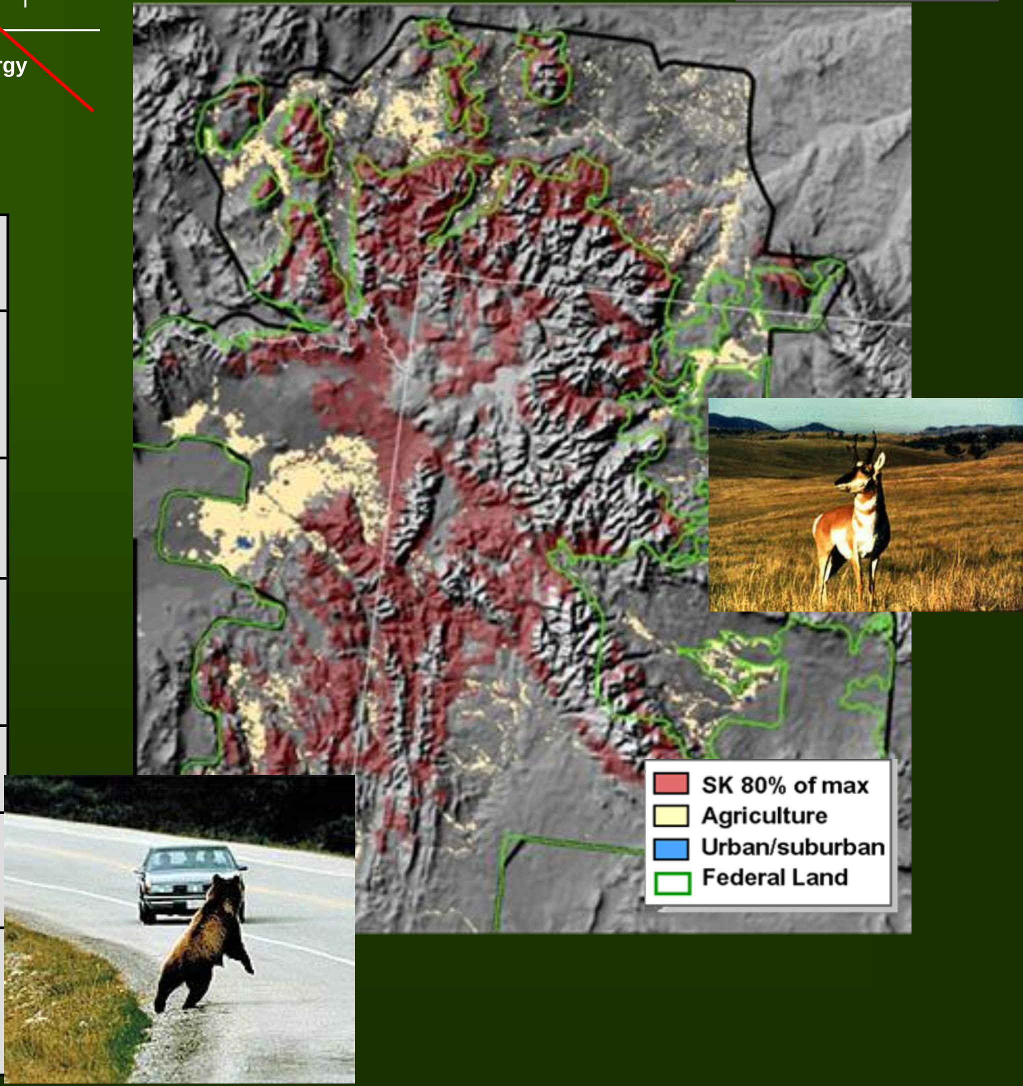
Framework for Prioritizing Management

Conservation Category	Ecosystem Energy Level		
	Low Energy	Medium Energy	High Energy
Individual species			
Sensitive Species			
Invasive Species			
Ecological processes			
Disturbance			
Productivity			
Landscape composition			
Biophysical gradients			
Source and sink habitats			
Seral Stages			
Within-stand structure			
Landscape cofiguration			
Connectivity			
Patch size/edge			
Biotic interactions			
Trophic cascades			
Competitive exclusion			
Land Use			
Protected areas			
Matrix			
Restoration			
Public education			
Overarching conservation priorities			

Low-Energy Ecoregions: Greater Yellowstone

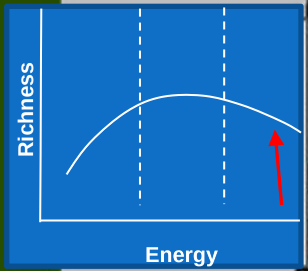


Conservation Category	Low Energy
Sensitive Species	Focus on species at risk due to low population sizes, large home requirements, migratory habits, source/sink dynamics
Disturbance	Manage to reduce disturbance in settings where high post-disturbance stress puts native species at risk
Landscape Pattern	Manage for large areas of habitat and well connected habitat for species with small populations and large home ranges, and/or migratory habits
Protected Areas	Should be larger and include representative biophysical gradients
Land Use	Focus conservation easements on high energy places and migration corridors Discourage development in hotspots
Overarching Priorities	Maintain large, well connected natural landscapes that include the full gradient of biophysical conditions and provide for wildland species needing large areas



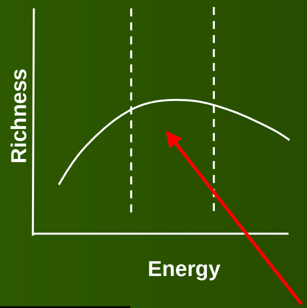
High-Energy Ecoregions: Pacific Northwest

Conservation Category	High Energy
Sensitive Species	Focus on seral stage, vegetation structure, and patch edge or interior specialist species
Disturbance	• relatively high rates in some locations to break competitive dominance and favor early seral species; • relatively low rates in some locations to maintain late seral species. • Maintain high levels of structural complexity in all seral stages. • Reduce erosion and leaching associated with disturbance.
Landscape Pattern	Manage for diverse range of patch sizes and spatial configurations
Protected Areas	Can be smaller but should include disturbance initiation and runout zones.
Land Use	Focus conservation easements on: • Low energy hotspots • places with high natural disturbance.
Overarching Priorities	Manage disturbance and vegetation pattern to maintain the large number of microhabitat specialists and high potential species richness.

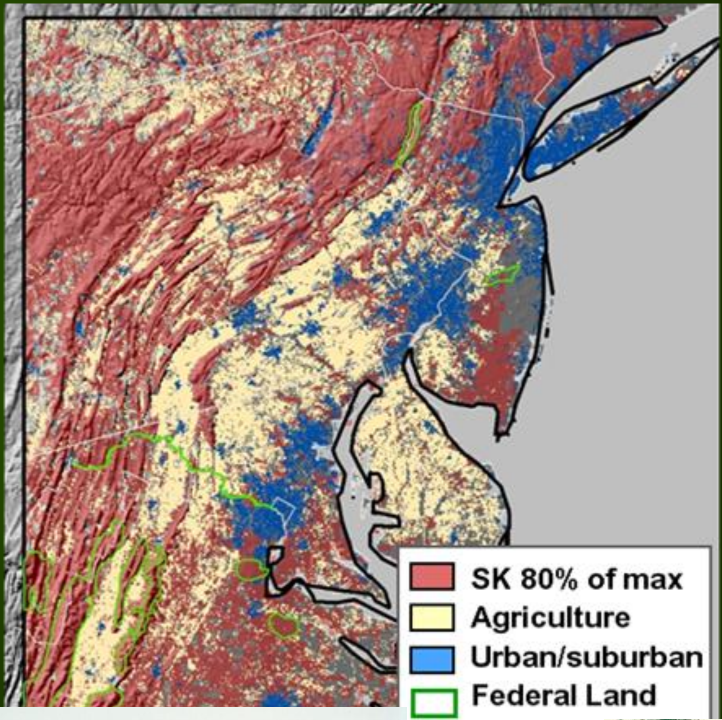


🟥 SK 80% of max
🟨 Agriculture
🟦 Urban/suburban
🟩 Federal Land

Mid-Energy Ecoregions: Mid-Atlantic



Conservation Category	Medium Energy
Sensitive Species	Focus on species sensitive to human impacts
Invasive Species	Manage to reduce the high level of introductions of exotics due to intense land use
Disturbance	Similar to High Energy
Landscape Pattern	Similar to High Energy
Protected Areas	Manage to buffer protected areas from surrounding human influence.
Land Use	- Focus conservation easements on remaining natural areas - and discourage development in remaining natural areas. - Emphasize restoration of degraded places - Educate citizens on “backyard” conservation
Overarching Priorities	Mitigate the heavy human influence in these systems which have the potential to be global hotspots for biodiversity.



BACKYARD CONSERVATION
It'll grow on you.

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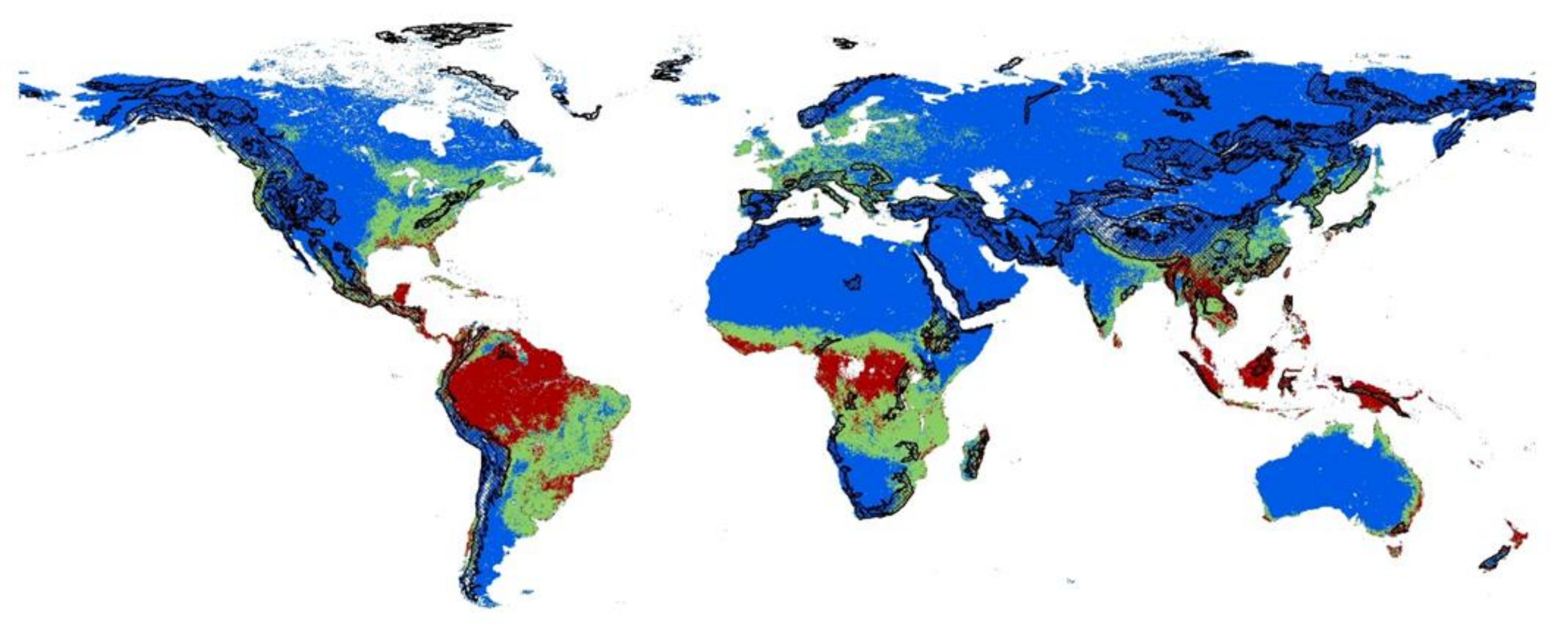
Public education			
Overarching conservation priorities			

Global Distribution of Ecosystem Types



🟦 Low Productivity
🟩 Intermediate Productivity
🟥 High Productivity
▨ High Topographic Complexity

Conclusions

- Can conservation biology become a more predictive science and help managers to identify up front the biggest problems in their place?
- Are there general properties of ecosystems that, if recognized, could be used to set conservation goals more effectively?
- Ecosystem productivity (the forgotten factor) and habitat heterogeneity are candidates.
- Will we get to the point that each conservation biology text book opens with a table of ecosystems grouped by vulnerabilities?