Use of NASA Technologies for Monitoring Park Condition: Integration of Four Case Studies

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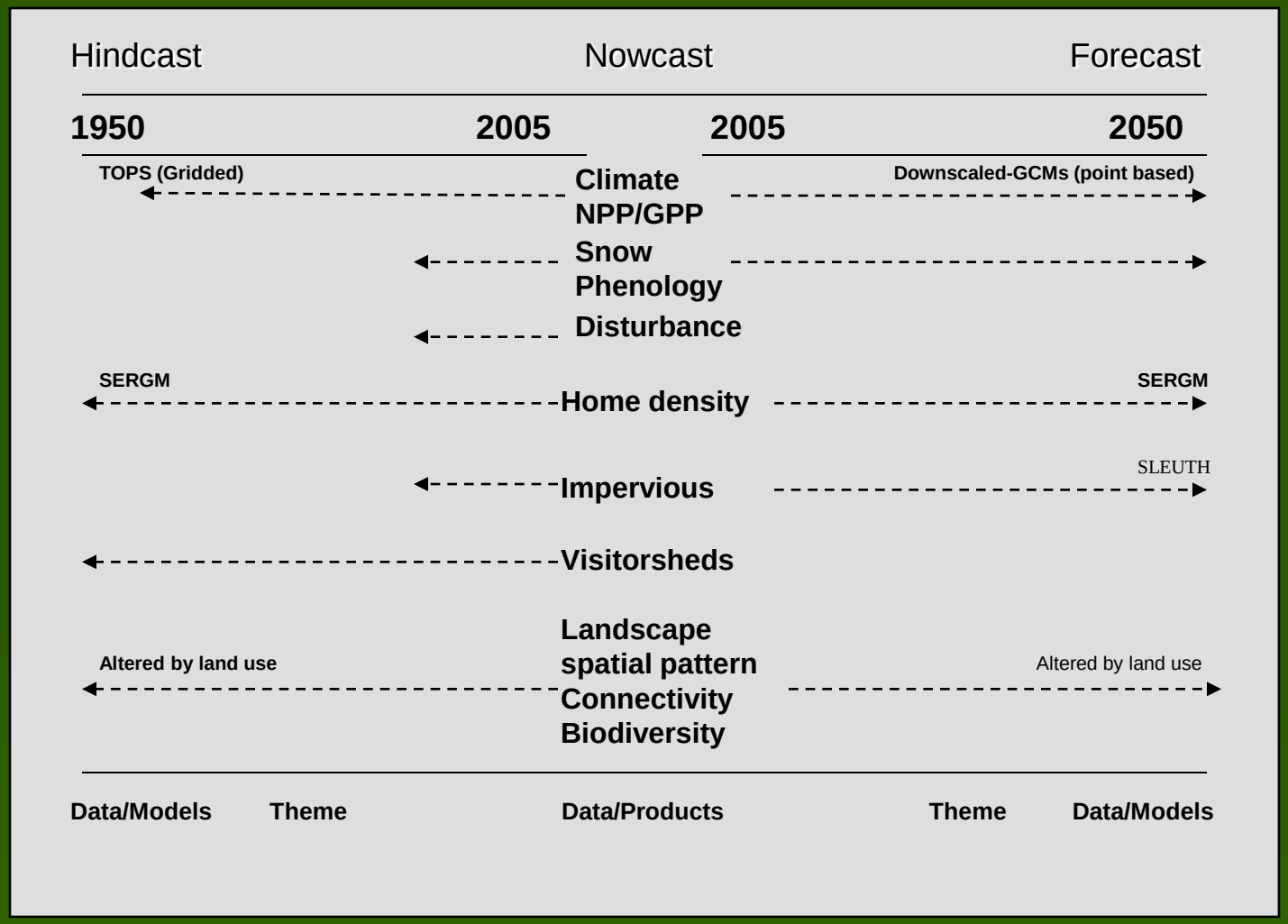
NASA Applications Sciences Program: Decision Support through Earth Science Research Results (DECISIONS)

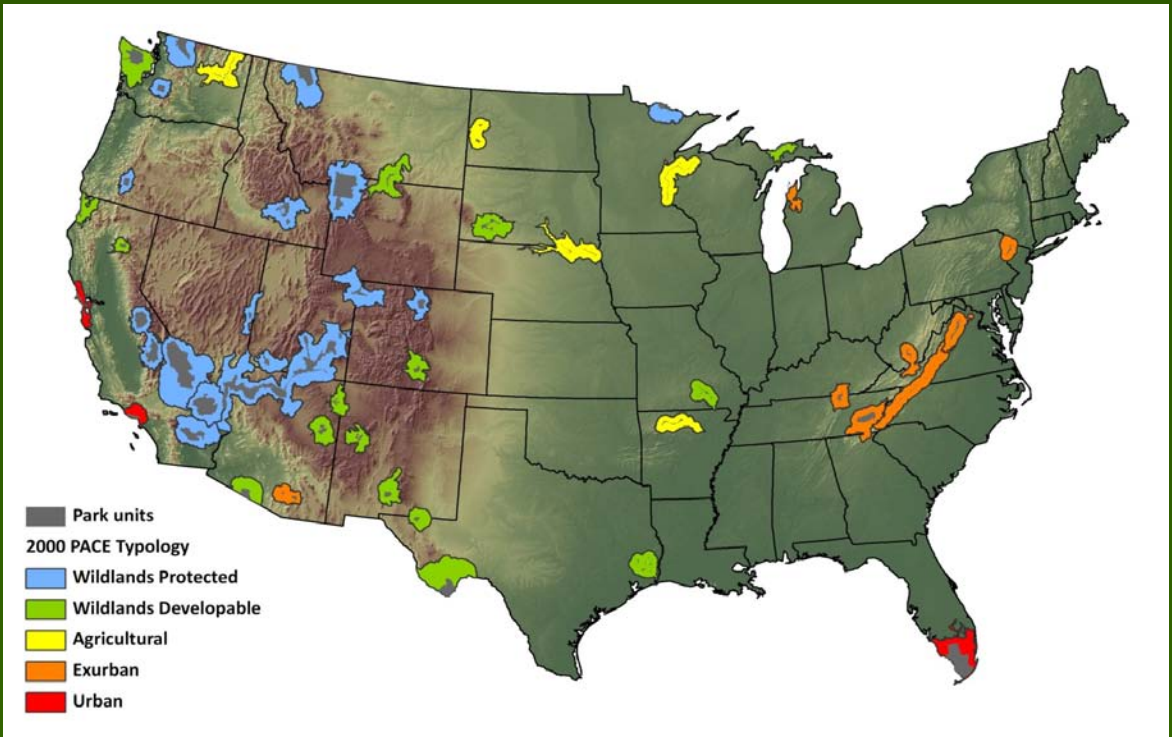
NPS I&M Program

Goal: Enhance park monitoring and management by use of NASA data and products



Topics

- Tell “stories” of park trends relevant to management
- Look at the where the case-study parks fit into a typology of US Parks based on land use change.



Case-Study Parks and NPS I&M Collaborators

GRYN Network
Tom Olliff,
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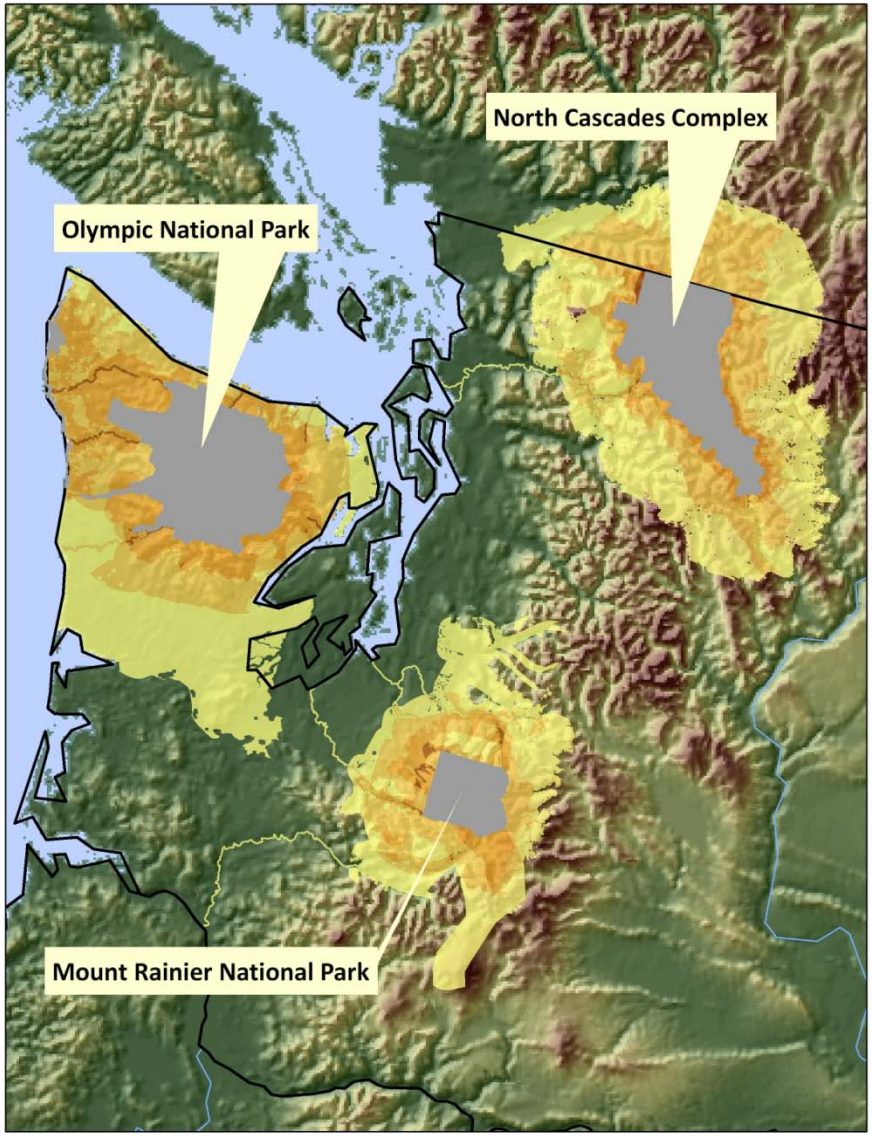
Mike Story

Protected Area Centered Ecosystems (PACEs)

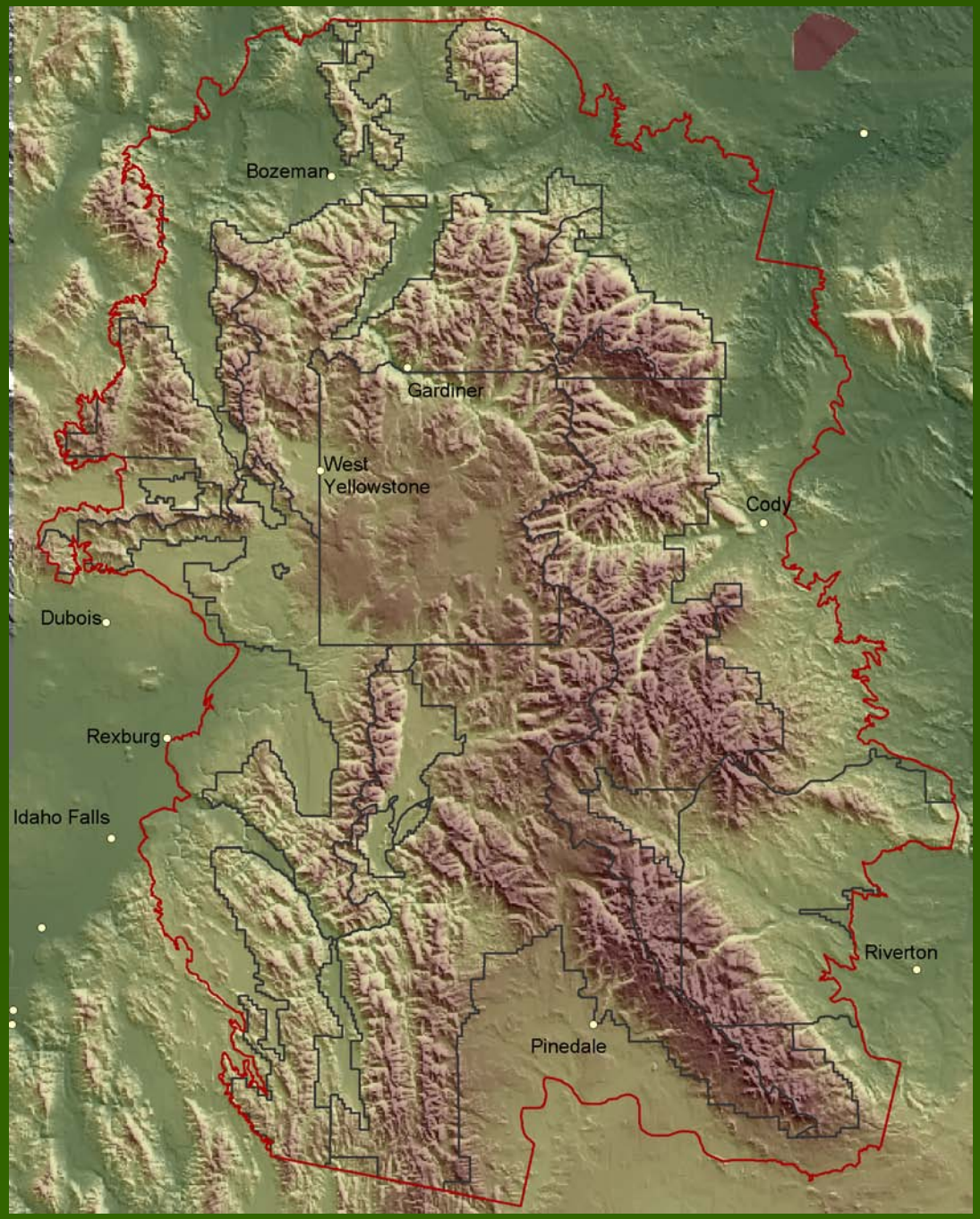
The area essential to maintaining natural processes and native populations within each park.

Merge data on five criteria:

1. **Contiguity of surrounding natural habitat**
2. **Watershed boundaries**
3. **Extent of human edge effects**
4. **Disturbance initiation and run-out zones**
5. **Crucial habitats outside the park**

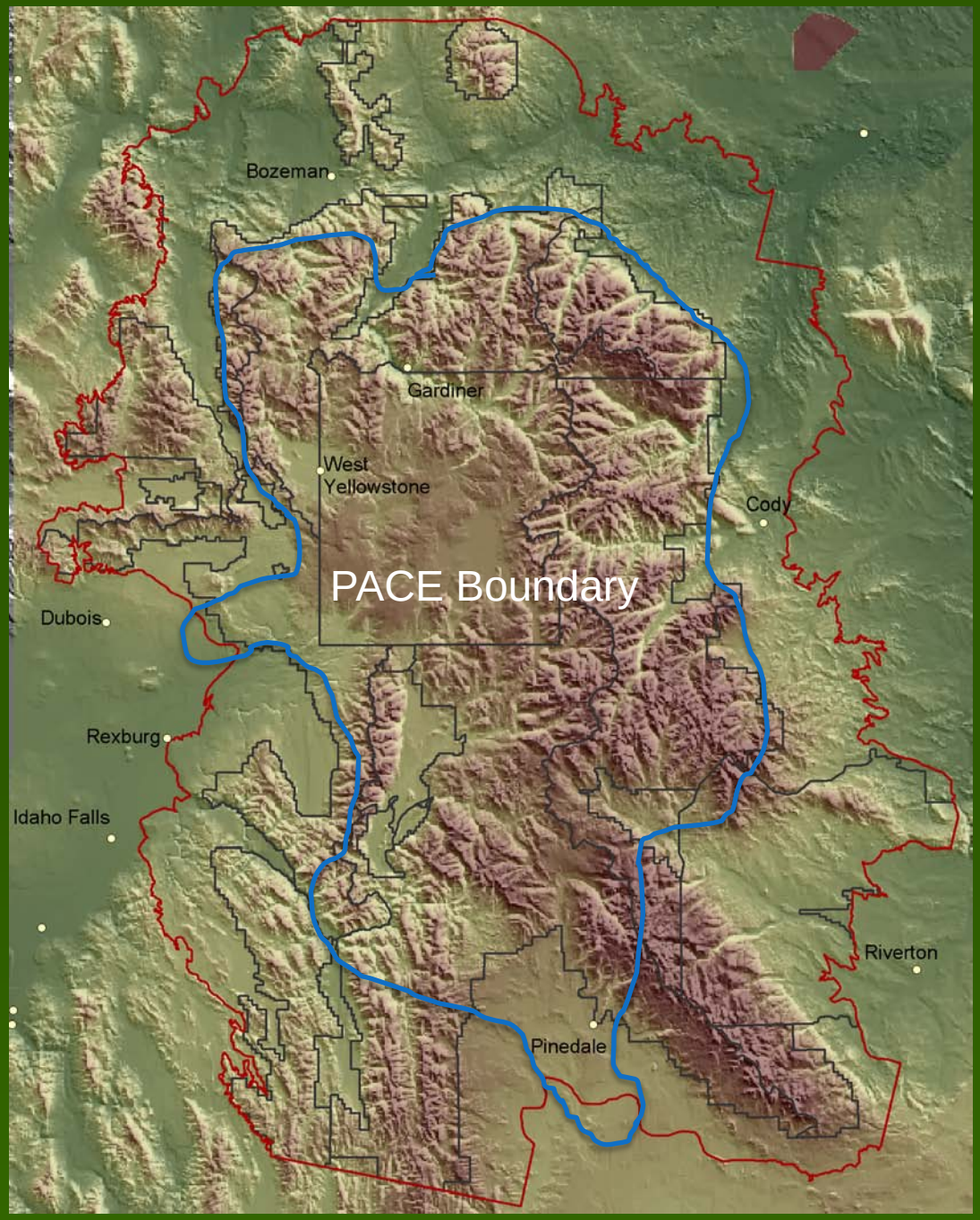


Hansen, A.J. et al. 2011. Delineating the Ecosystems Containing Protected Areas for Monitoring and Management. *BioScience*. May.



Yellowstone and Grand Teton National Parks

Thomas Moran Hayden Expedition 1871



Yellowstone and Grand Teton National Parks

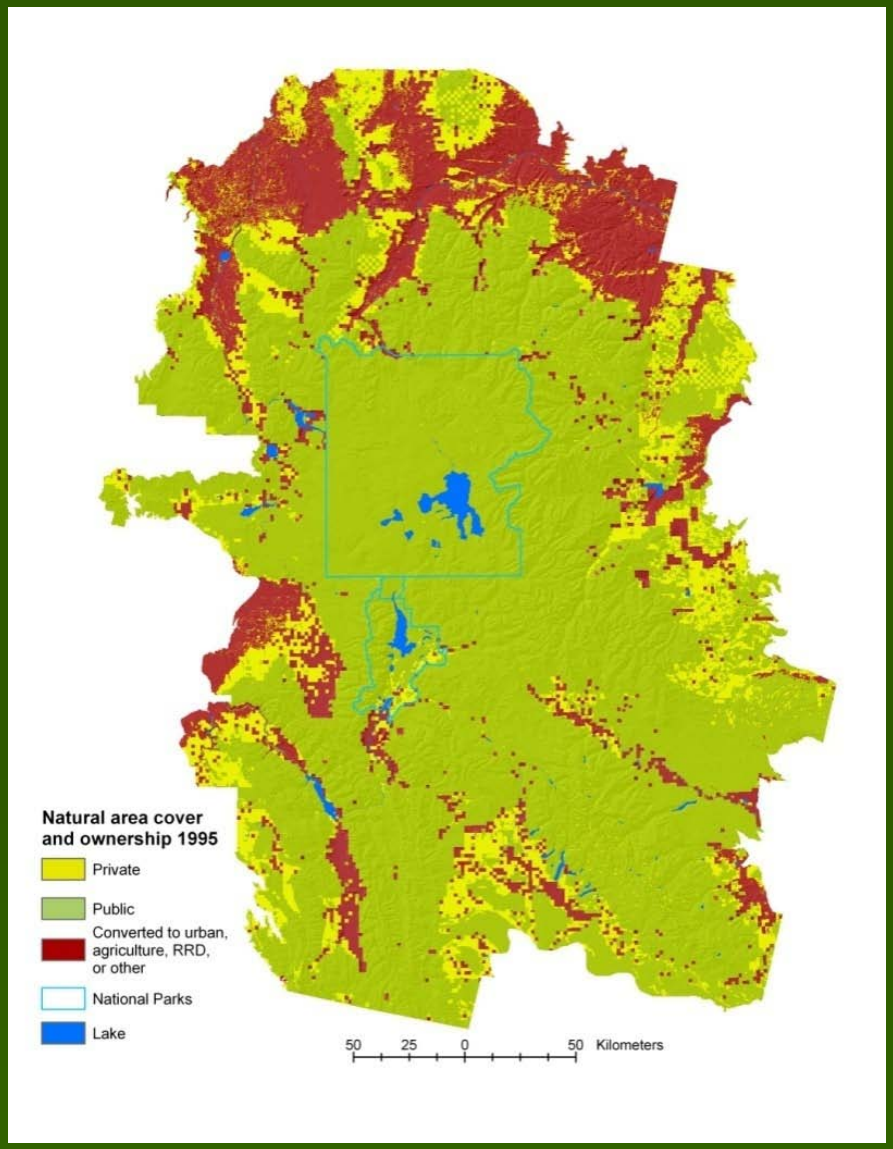
Percent public lands: 94%

Private land undeveloped: 73%

Yellowstone and Grand Teton National Parks

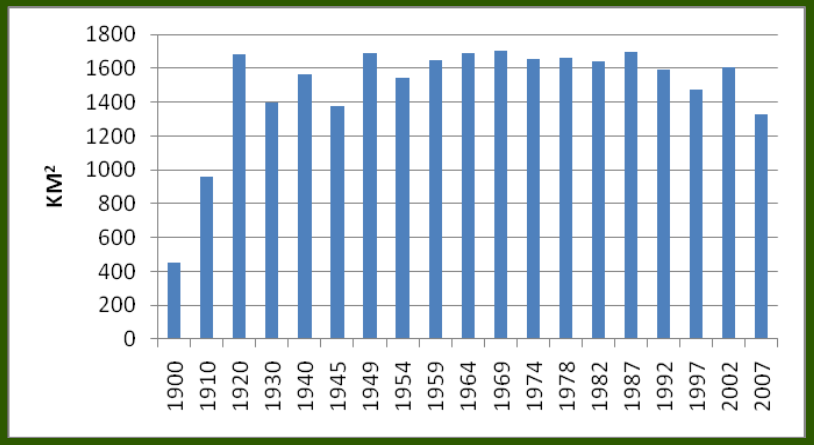
Wilderness Wildlife

Greater Yellowstone Ecosystem

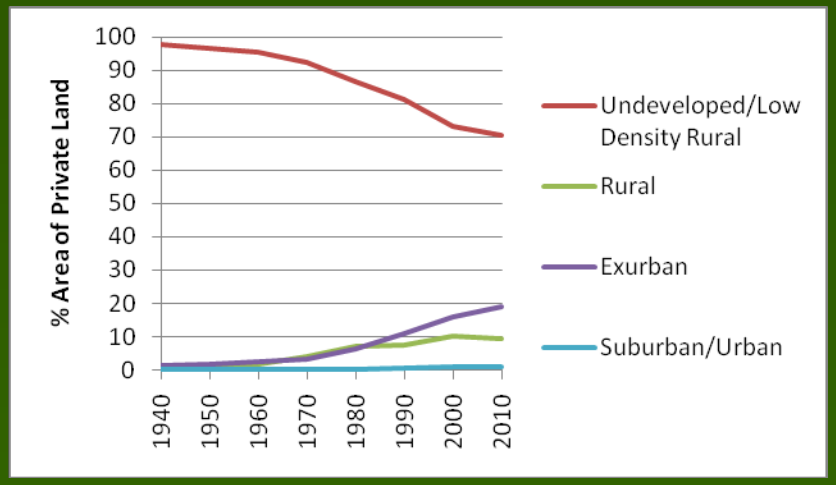


Private Lands in Agriculture, Exurban, Urban Classes

Land Use on Private Lands



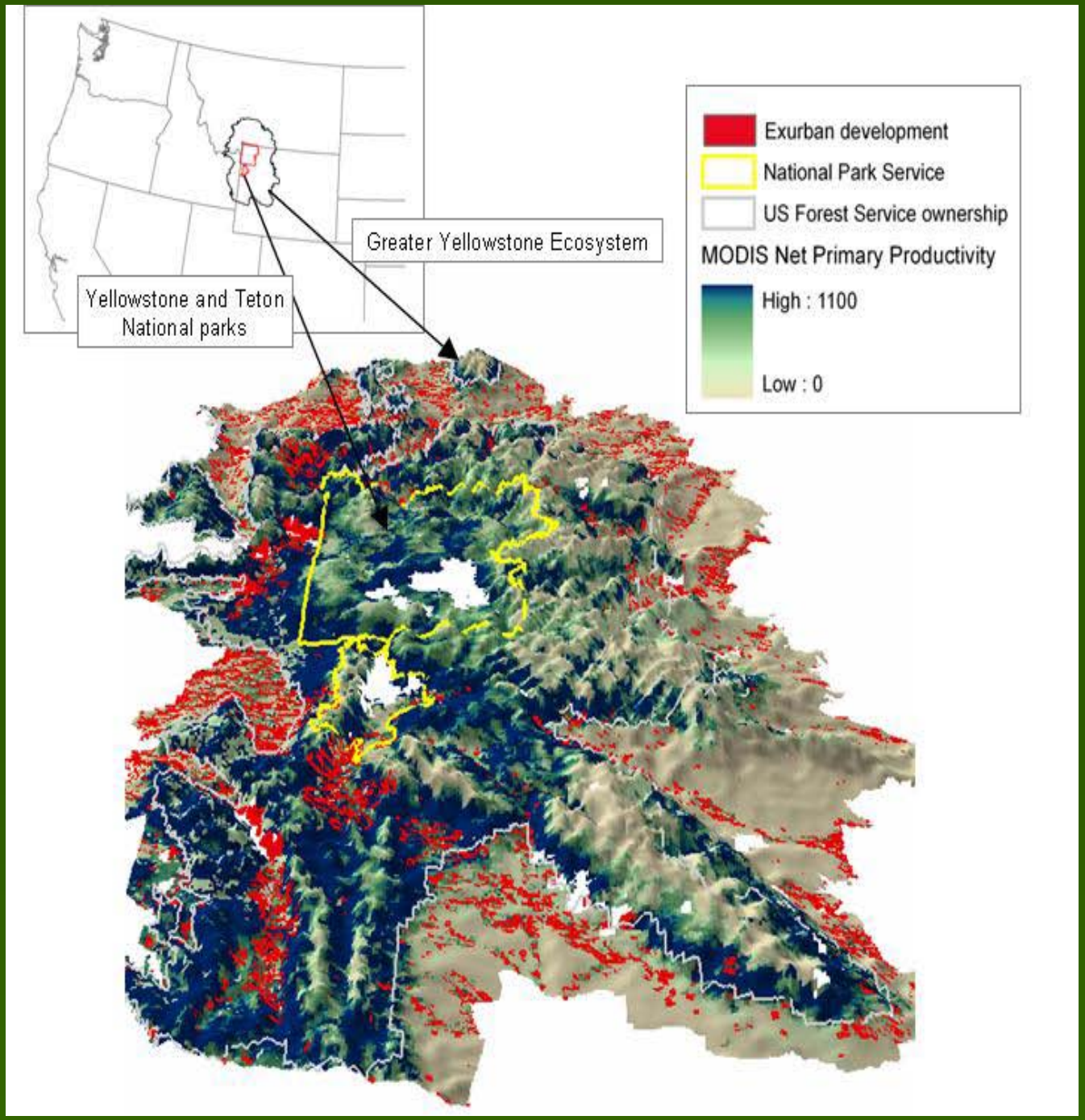
Area in Agriculture



Land Use Type based on Housing Density

Davis et al. in review.

Yellowstone and Grand Teton National Parks



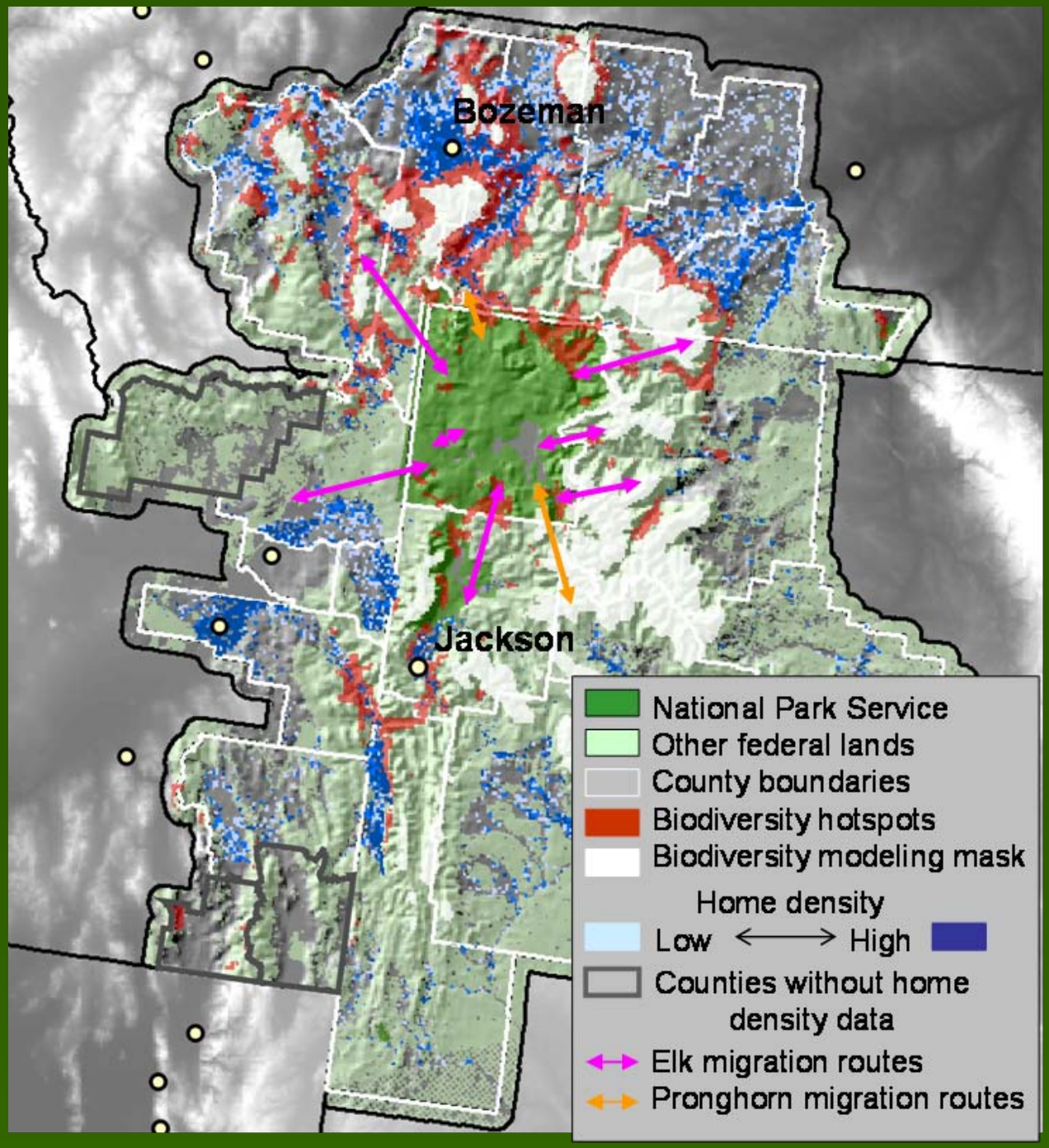
Biophysical Patchiness

Yellowstone and Grand Teton National Parks

Exurban Development,

Biodiversity Hotspots

Migration Paths



Greater Yellowstone Ecosystem

Reduction in Crucial Habitats

	Human Impacted Land		
	1980	1999	*2020
Pronghorn Range	2.00%	3.35%	5.83%
Moose Range	2.73%	5.49%	7.96%
Grasslands	2.99%	5.57%	8.36%
Grizzly Bear Range	3.13%	5.98%	8.52%
Douglas-fir	2.91%	6.01%	8.85%
Elk Winter Range	2.36%	6.26%	9.98%
Aspen	5.55%	13.92%	19.53%
Bird Hotspots	8.42%	16.91%	23.20%
Riparian Habitat	10.22%	17.30%	23.64%
Potential Corridors	8.89%	18.79%	24.43%
Irreplaceable Areas[1]	11.41%	23.15%	29.61%
Integrated Index[2]	11.80%	23.24%	29.93%

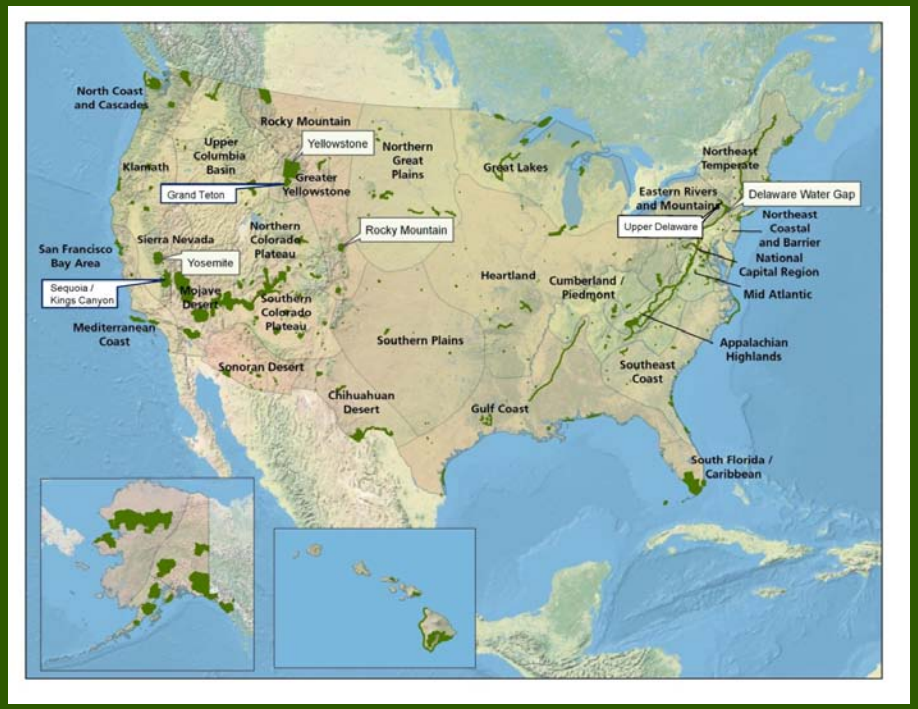
*projected impact under Status Quo scenario

Gude et al. 2007

Yellowstone and Grand Teton National Parks

Humanizing Wilderness

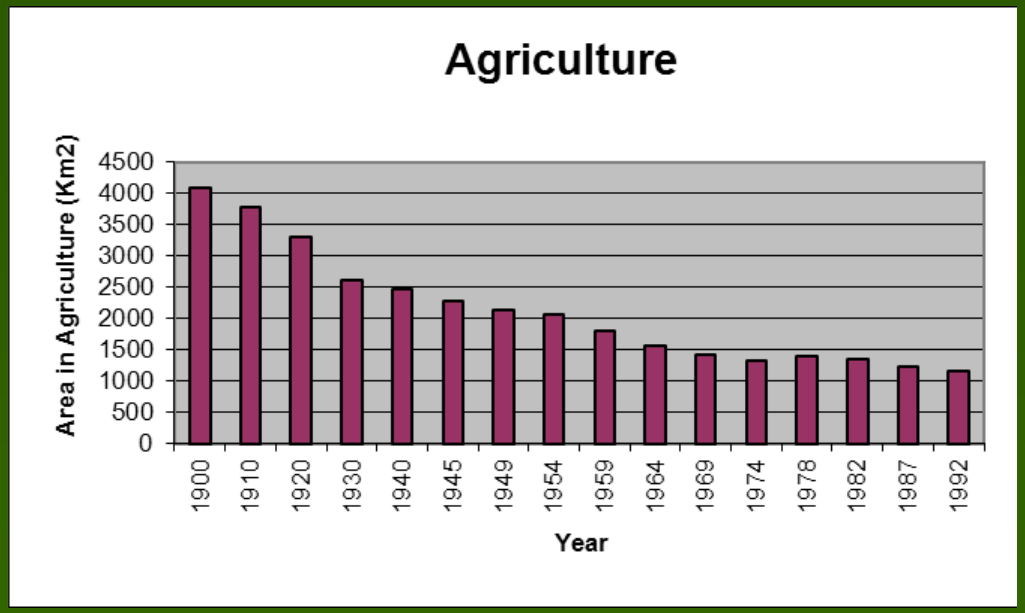
Delaware Water Gap and Upper Delaware



PACE is 32 times larger than the park areas

Delaware Water Gap and Upper Delaware

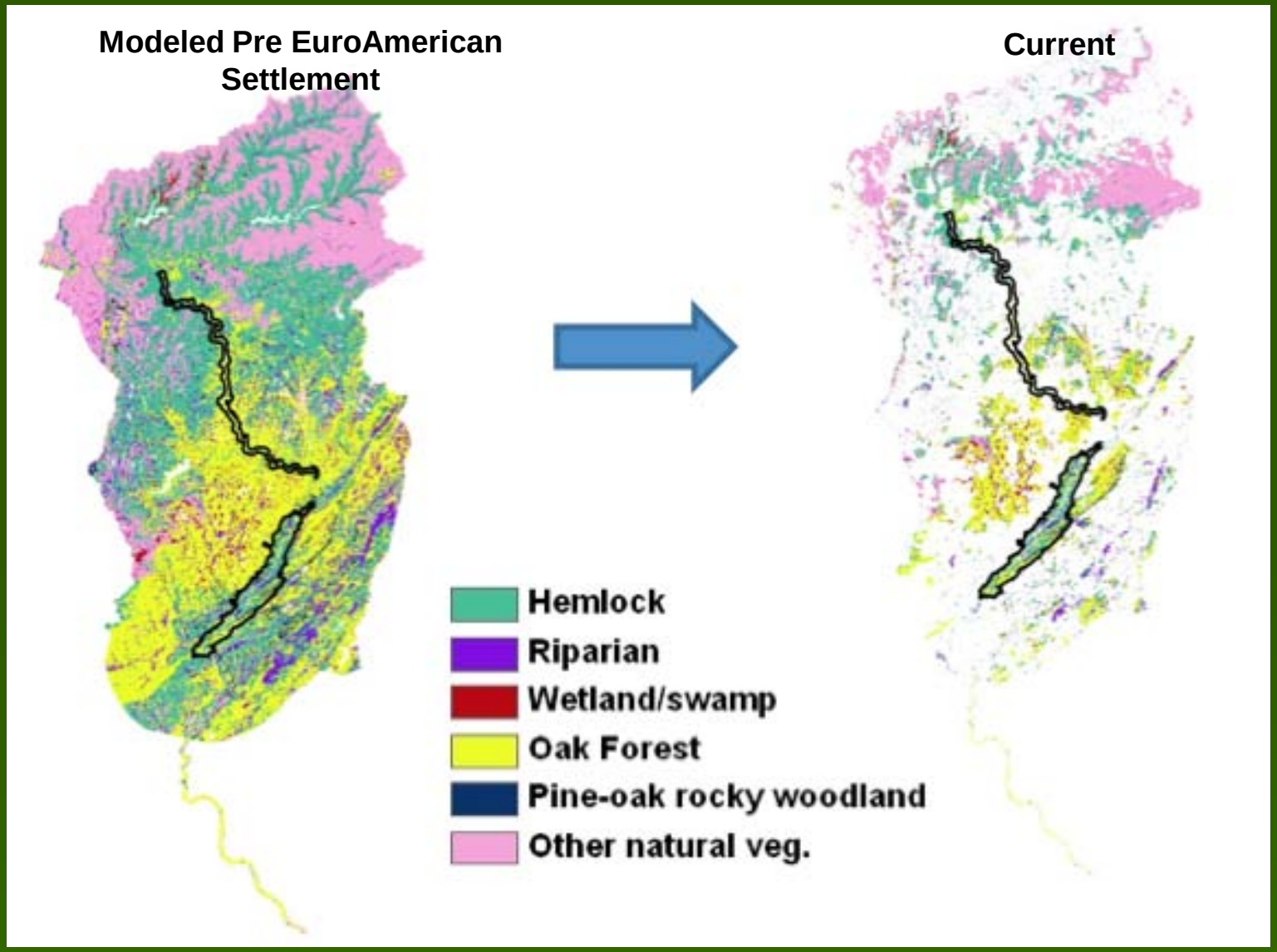
The area was mostly farmland till 1960.



DEWA was created in 1978.
It is largely reforested, but some ag fields are maintained in the park.

Delaware Water Gap and Upper Delaware

Ecosystem Type Composition

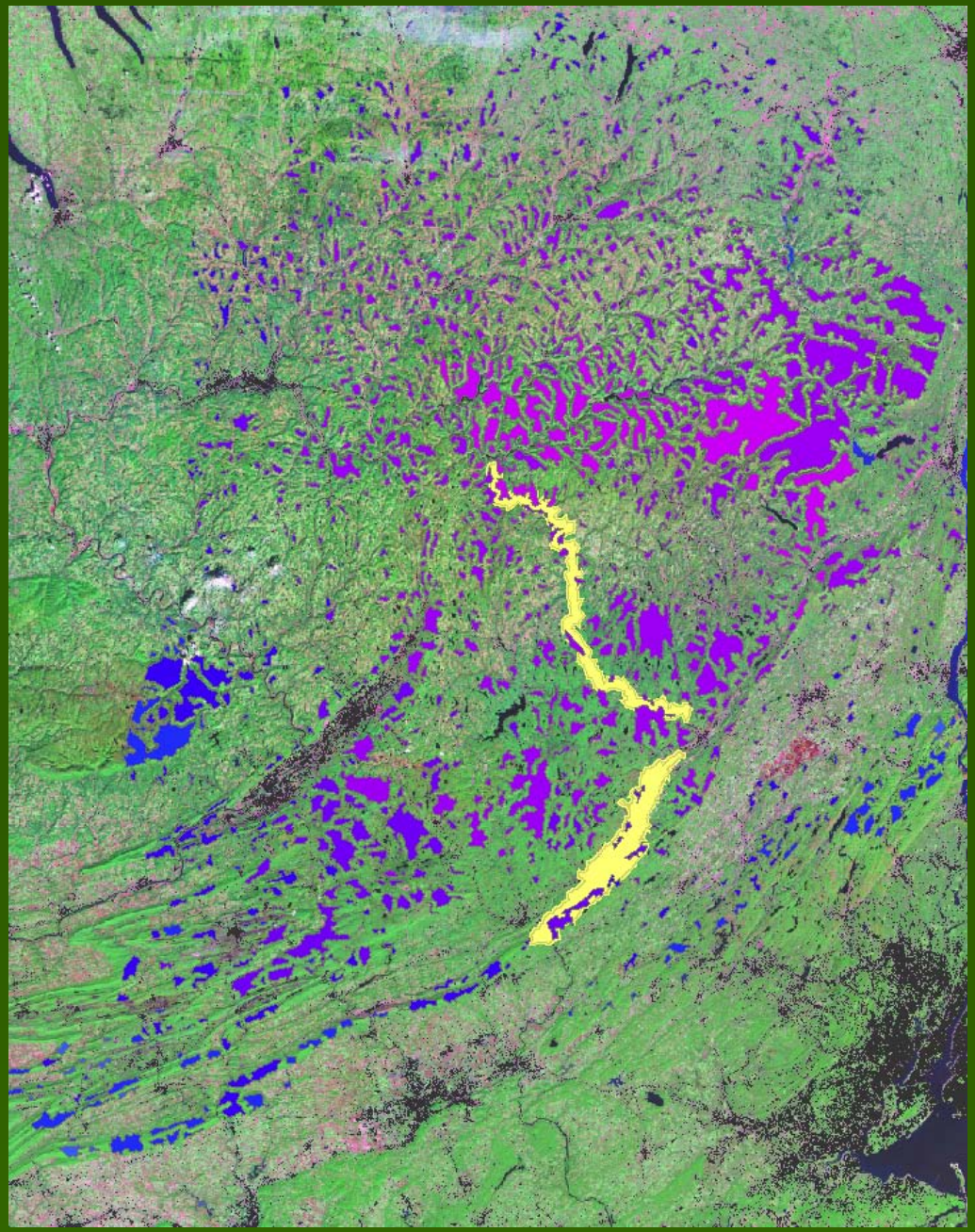


- hemlock (–74%)
- oak (-71%)
- riparian floodplain (-68%)
- wetland (-59%)

Piekielek et al. in prep

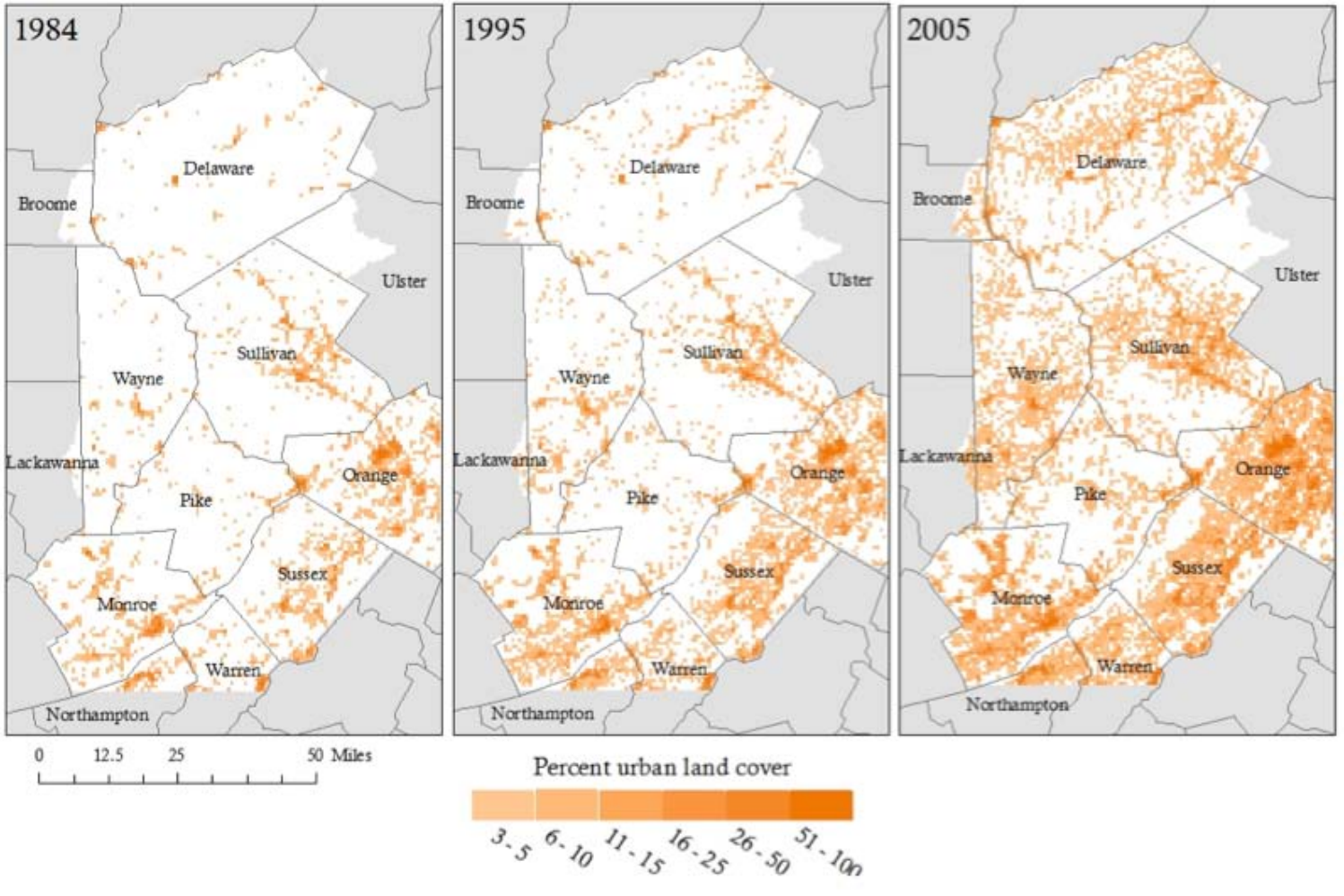
Delaware Water Gap and Upper Delaware

Connectivity of Core Habitat Areas around UPDE / DEWA

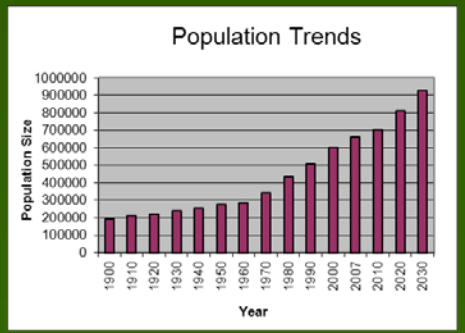


Goetz et al. 20xx

Delaware Water Gap and Upper Delaware

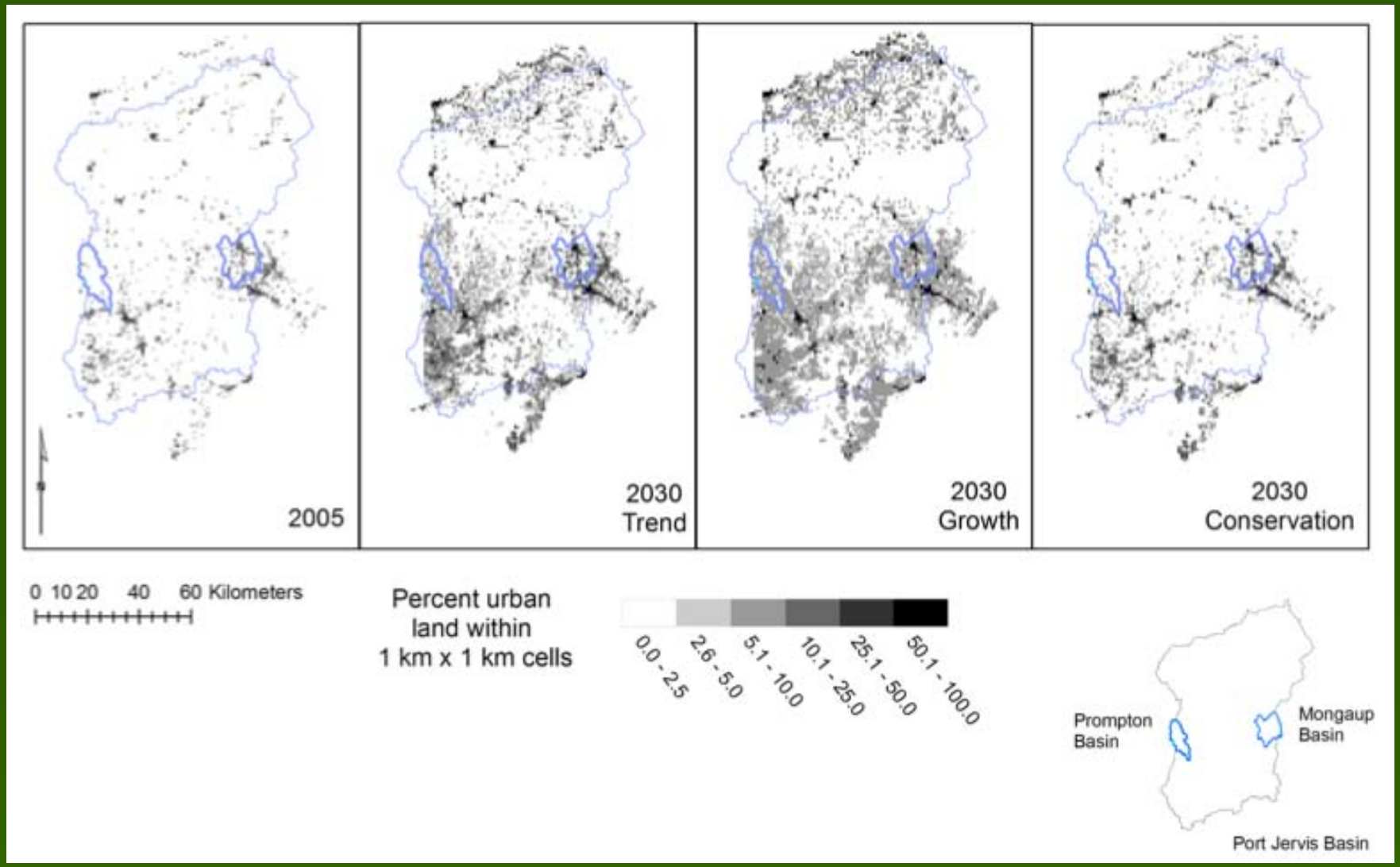


Impervious Cover Change.
Based on Landsat image analysis and interpretation.
Jantz et al. 2008).



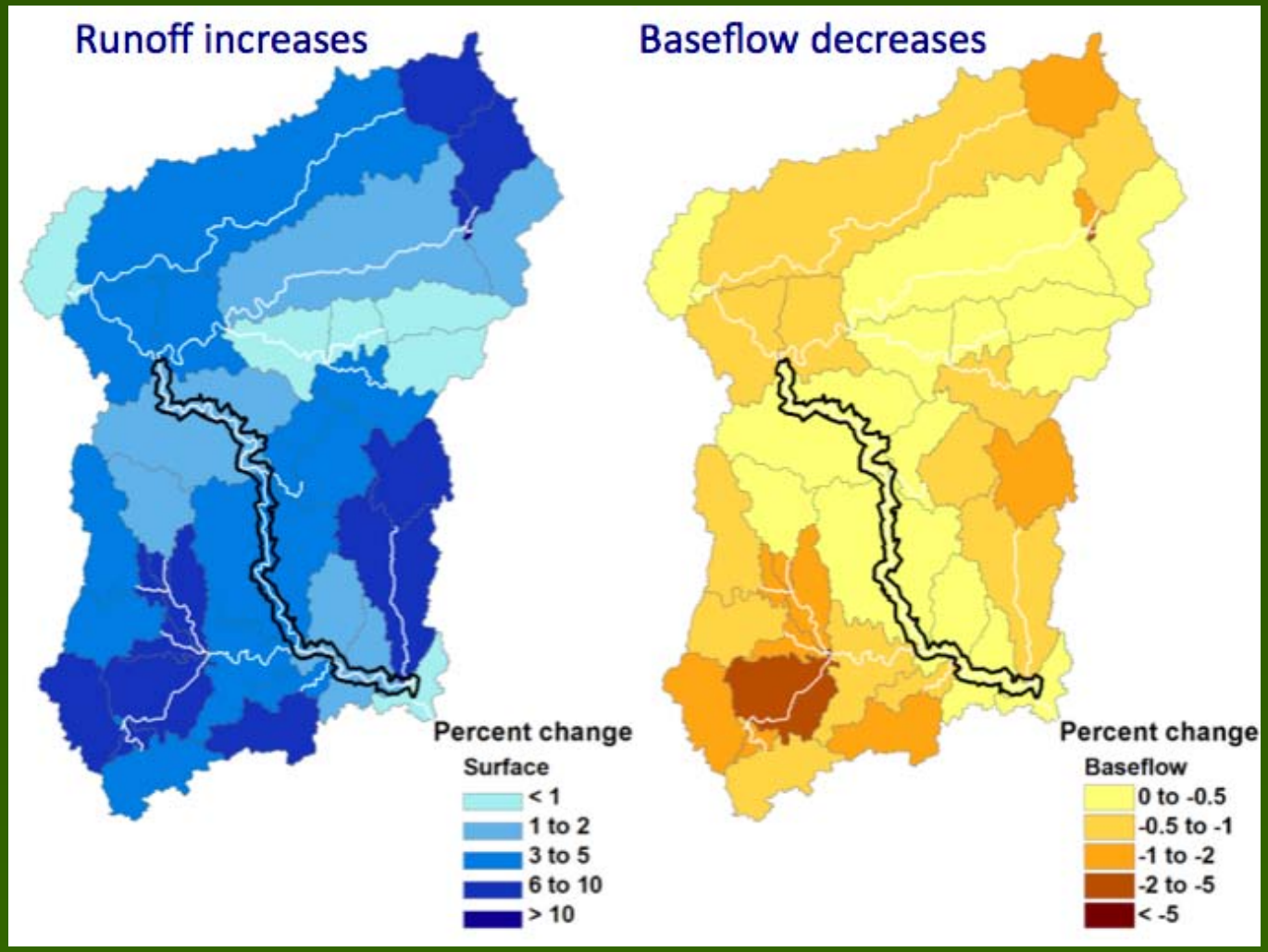
Delaware Water Gap and Upper Delaware

Current and Predicted Urbanization



Delaware Water Gap and Upper Delaware

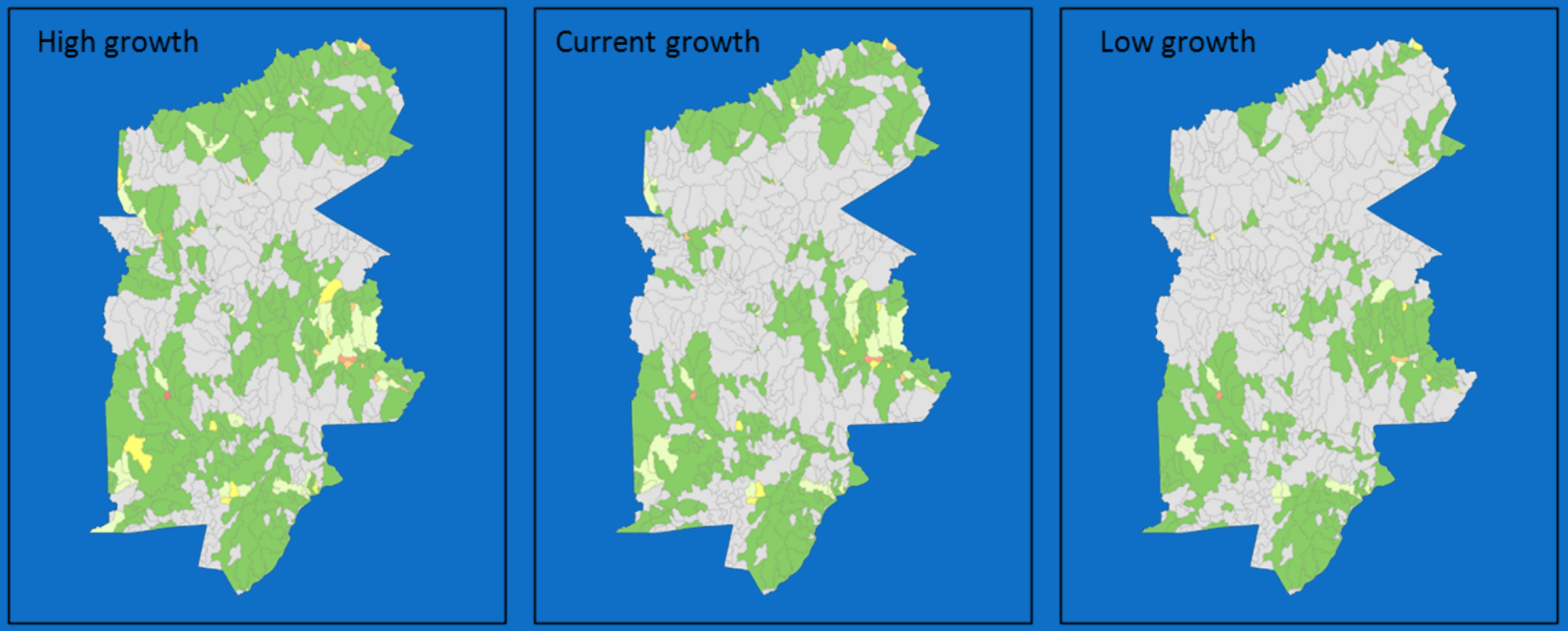
Hydrology: Change from Present to 2030 Growth Scenario



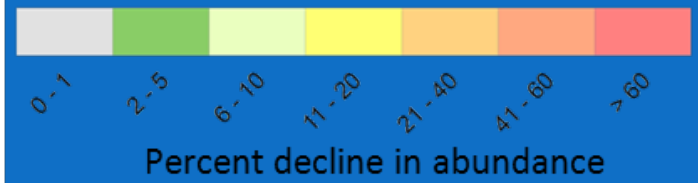
Results are from SWAT model calibrated with for a precipitation and river gauge data from 1981-2006.

Delaware Water Gap and Upper Delaware

Sensitive Stream Invertebrate Taxa

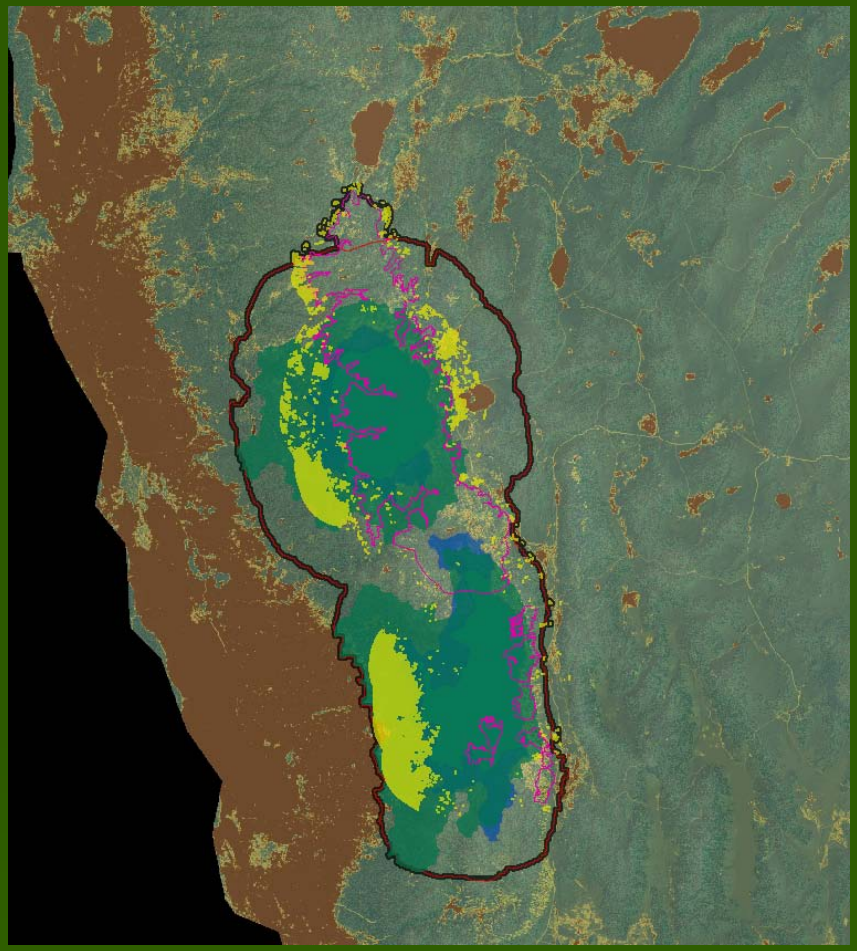


Predicted declines (%) in the abundance of sensitive stream species under three scenarios of urbanization: high growth, current trend of growth, and conservation oriented growth. Each scenario decreases stream biotic integrity, but the impacts vary by watershed.



Goetz and Fiske 2010

Yosemite and Sequoia and Kings Canyon National Parks



YOSE/SEKI PACE showing the areas included under each of the PACE classification criteria.

- % of PACE public: 80
- % of private lands developed: 65

Yosemite and Sequoia and Kings Canyon National Parks

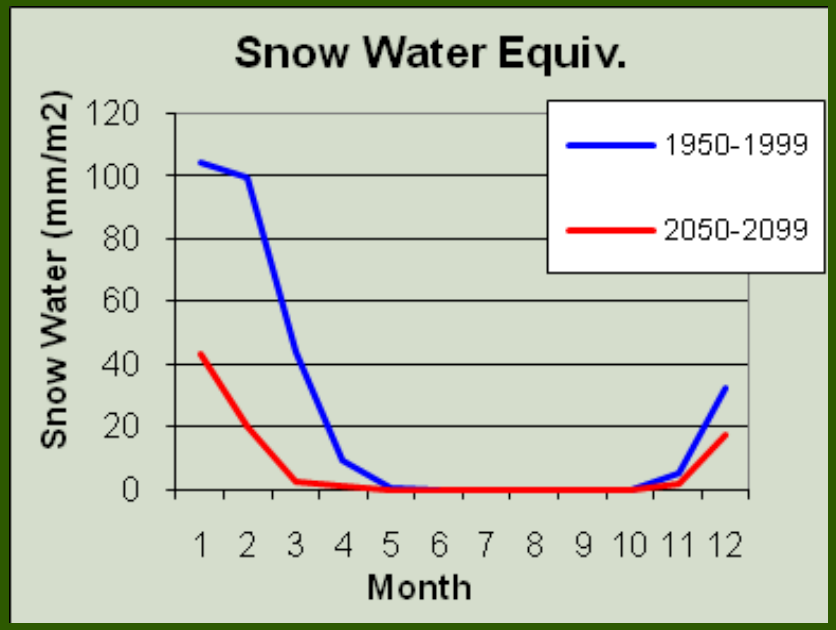
Climate Change

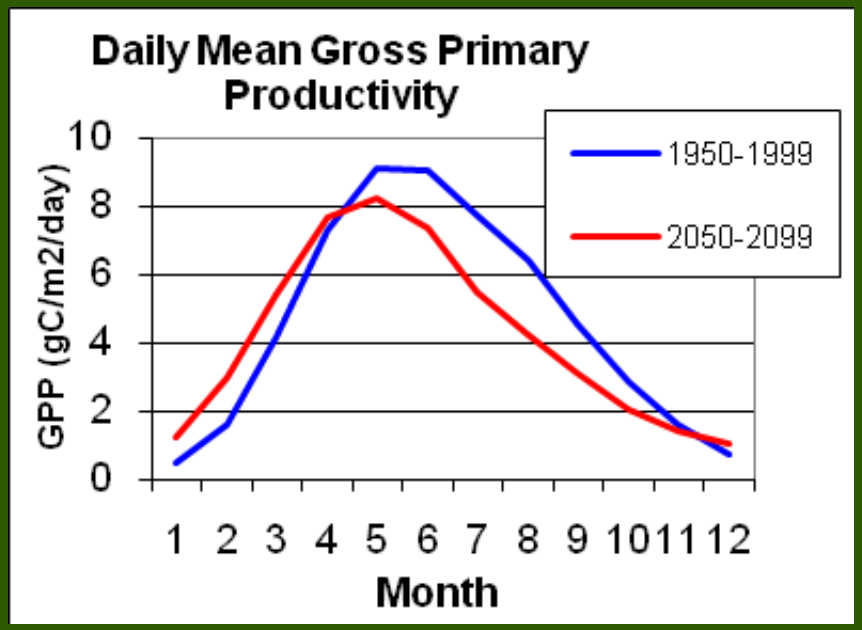
Average annual temperature increase since the 1900: 1.1 ^{0} C

Projected increase for the southwestern US including the SIEN PACE by 2100: 2.2 – 5.5^{0} C

Yosemite and Sequoia and Kings Canyon National Parks

Climate Change Impacts

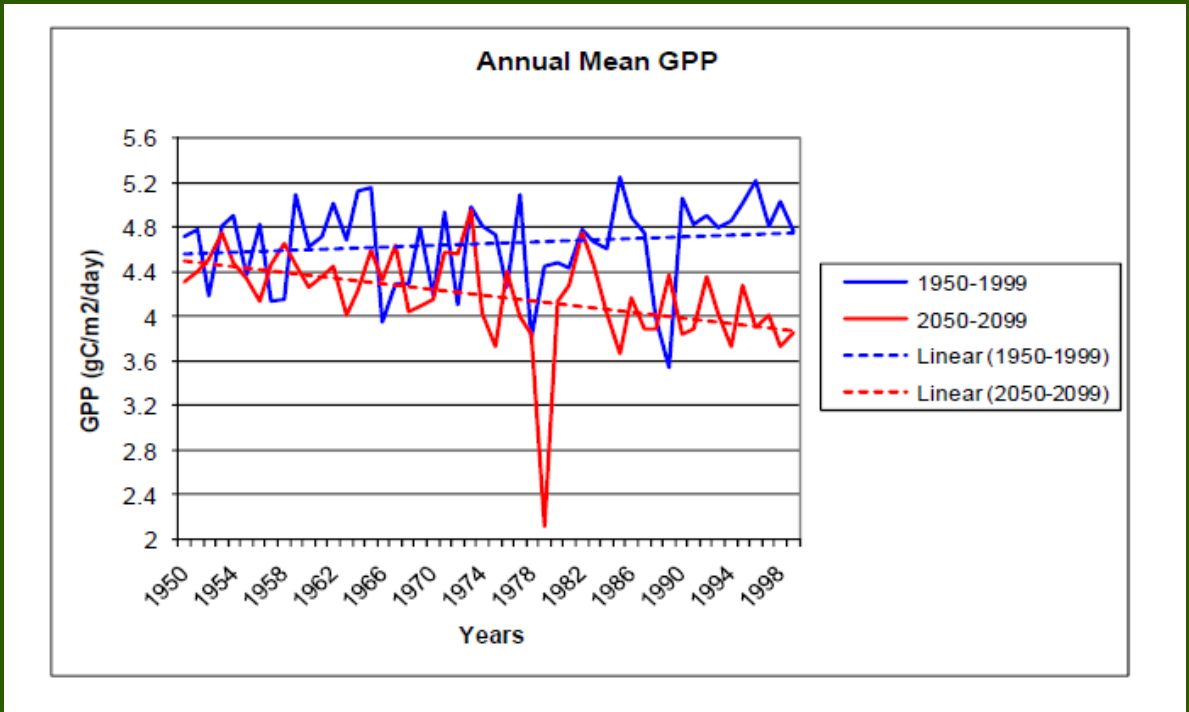




Predicted reductions in snow water equivalent and mean gross primary productivity in Yosemite from simulations using TOPS.

Yosemite and Sequoia and Kings Canyon National Parks

Climate Change Impacts



TOPS Forecasted Trends in GPP for 2050-2099, Yosemite Valley

Rocky Mountain National Park

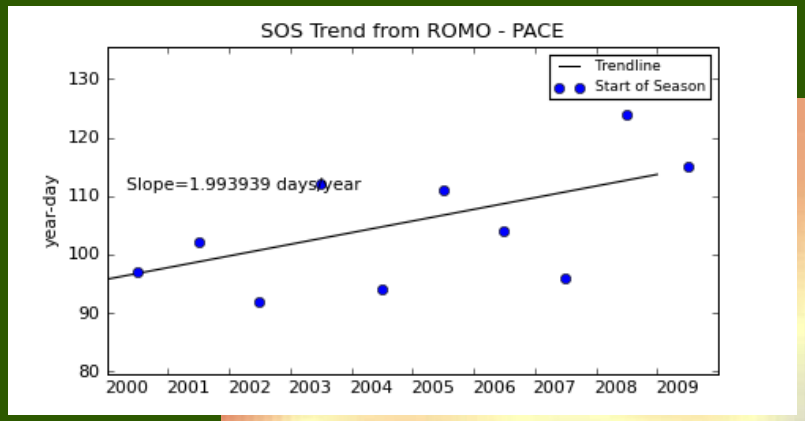
Climate Change

Average annual temperature increase since the 1900: 2.0^0 C

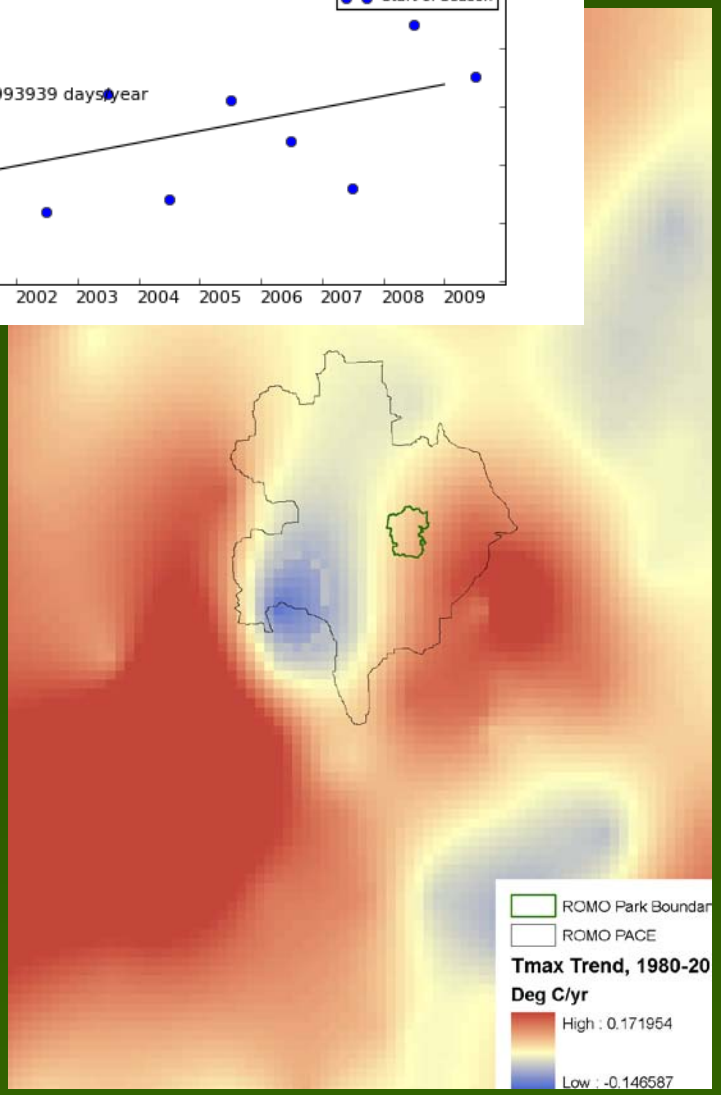
Largest increase among 60 park units in 48 US States.

Haas et al. 2010

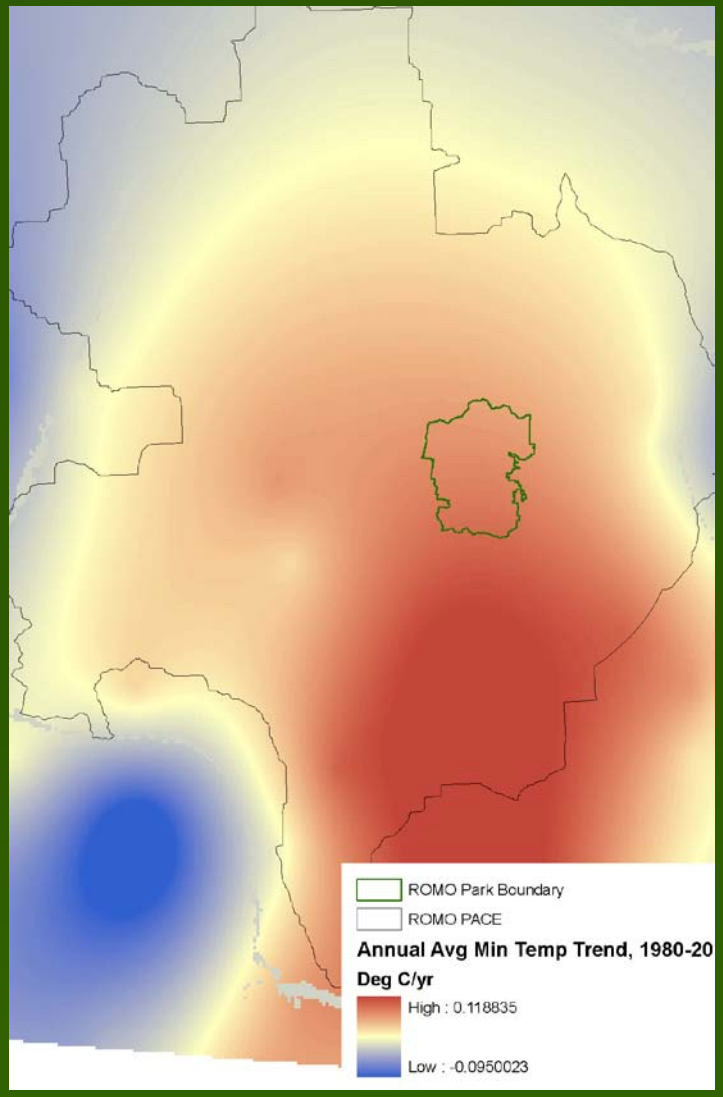
Rocky Mountain National Park



Climate Change



Annual average daily maximum temperature

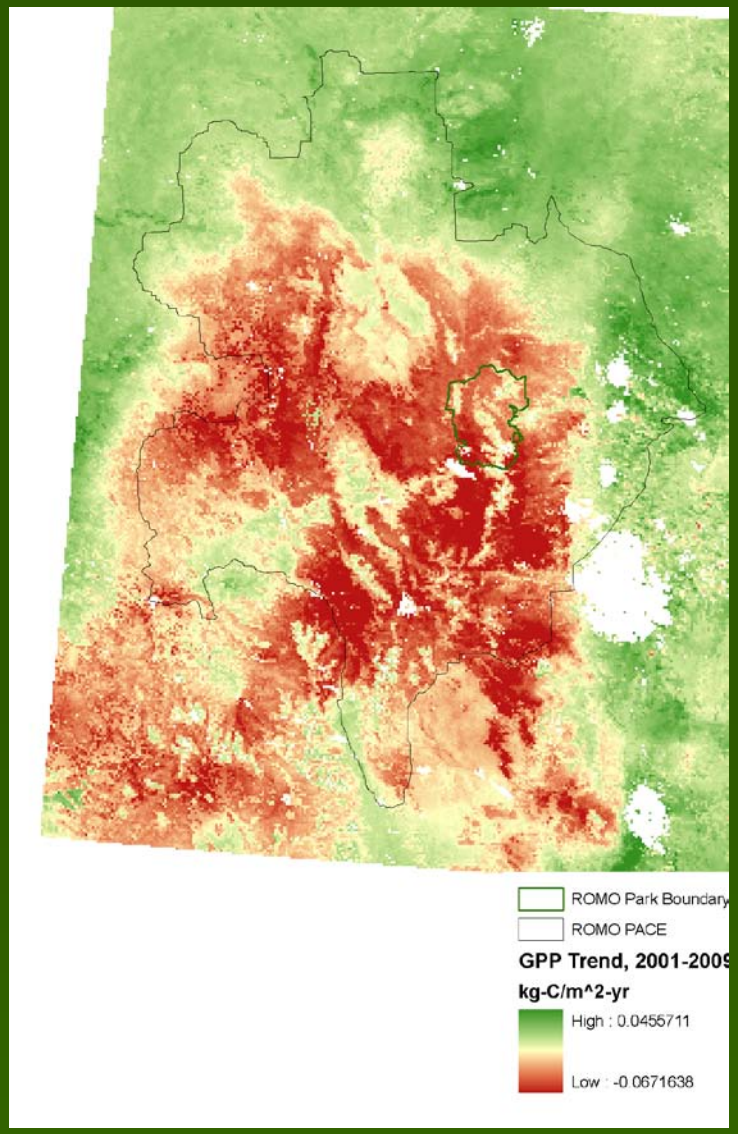


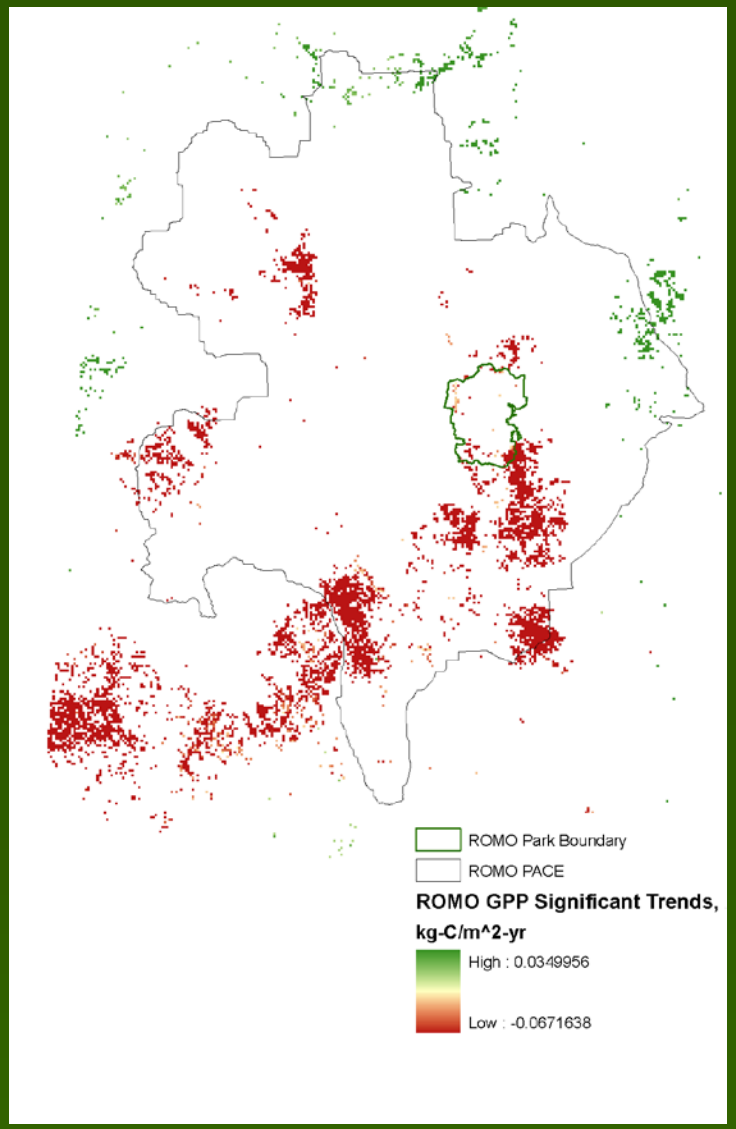
Annual average daily minimum temperature

Gridded Climate (1980-2009)

Rocky Mountain National Park

Climate Change Impacts





Gross Primary Productivity

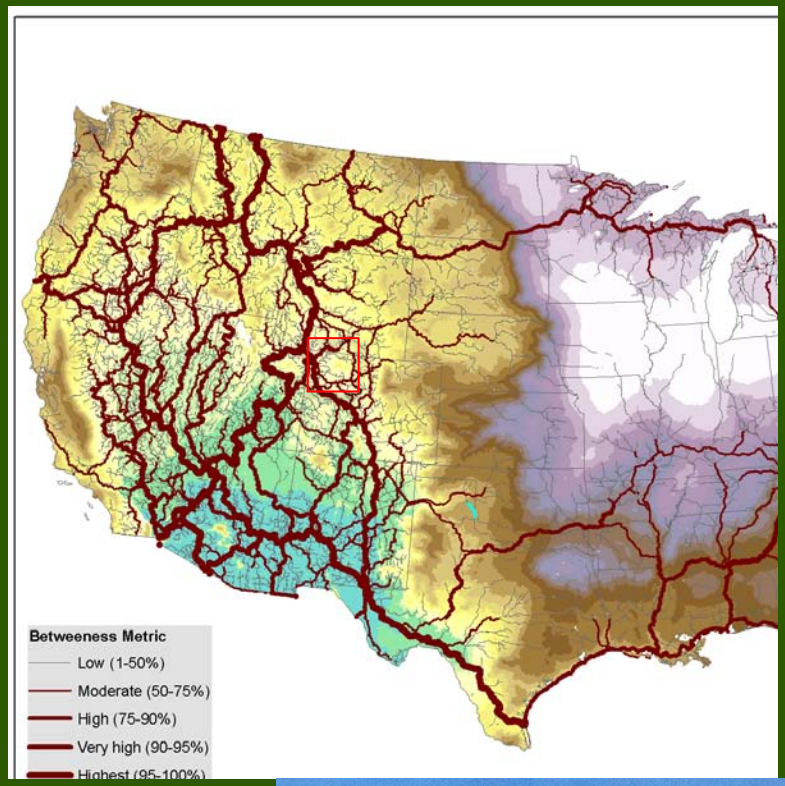
Rocky Mountain National Park

Climate Change Impacts

Reduction in GPP partially due to beetle kill?

Rocky Mountain National Park

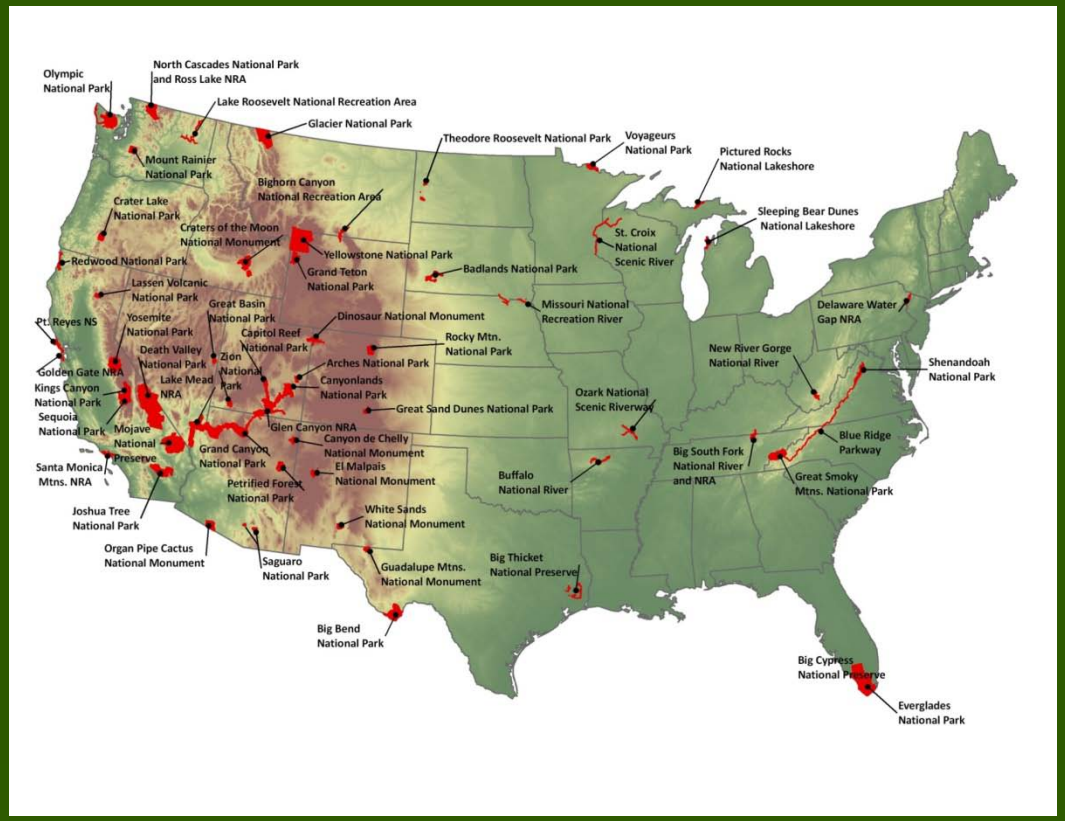
Reestablishment of extirpated wilderness wildlife?



Connectivity

Theobald and Reed 2010

Land Use Typology of US National Park Units



60 larger NPS Units in the Contiguous US.

Present metrics:

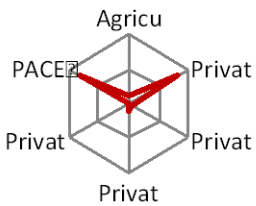
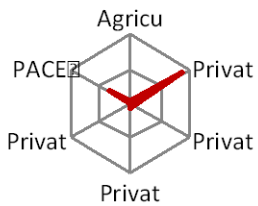
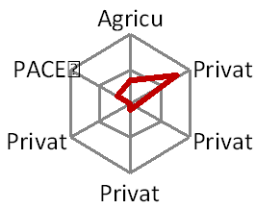
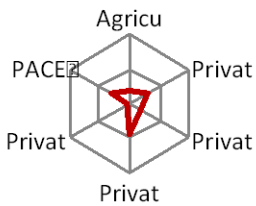
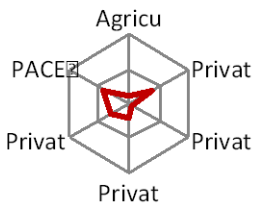
- Population density
- Housing density
  - Undeveloped/low density
  - Rural
  - Exurban
  - Suburban/urban
- Land allocation (public vs. private)
- Land in agriculture
- Area of impervious surface
- Percent developed
- (roads, housing, agriculture)

Change-over-time metrics:

- Population density (1900 – 2007)
- Housing density (1940 – 2000)
- Land in agriculture (1900 – 2005)

Davis and Hansen in review

Land Use Typology of US National Park Units

Wildland Protected	Wildland Developable	Agricultural	Exurban	Urban
1. > 65 % public	1. < 65% public 2. private > 60% undeveloped 3. private < 16% agriculture	1. < 65% public 2. private > 60% undeveloped 3. private > 16% agriculture	1. < 65% public 2. private < 60% undeveloped 3. private dominated by exurban or urban < 15%	1. < 65% public 2. private < 60% undeveloped 3. private dominated by urban or urban > 15%
				

Davis and Hansen in review

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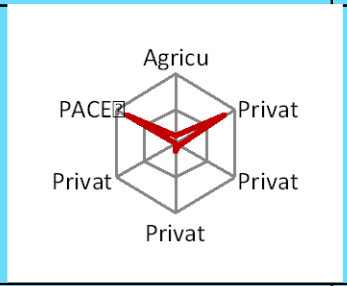
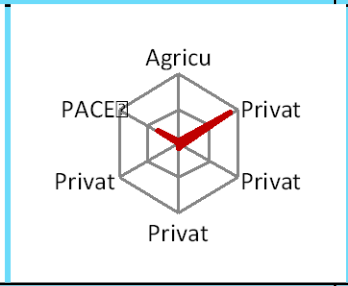
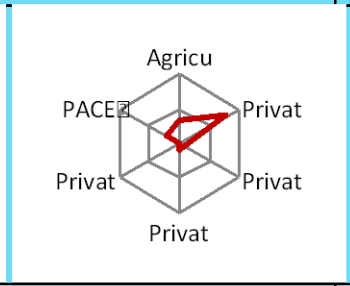
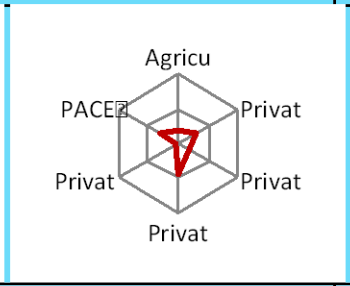
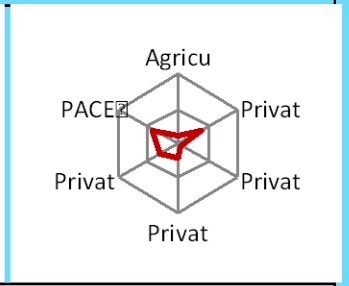
				
Arches Colorado River parks Crater Lake Craters of the Moon Death Valley Dinosaur Glacier Great Basin Joshua Tree Mojave Mount Rainier North Cascades Rocky Mountain Voyageurs Yellowstone/Grand Teton Yosemite/Kings Canyon-Sequoia Zion	Badlands Big Bend Big Thicket Bighorn Canyon Canyon de Chelly El Malpais Great Sand Dunes Guadalupe Mtns. Lassen Volcanic Olympic Organ Pipe Cactus Ozark Petrified Forest Pictured Rocks Redwood White Sands	Buffalo River Lake Roosevelt Missouri River Saint Croix Theodore Roosevelt	Big South Fork Blue Ridge Parkway Delaware Water Gap Great Smoky Mtns. New River Gorge Saguaro Shenandoah Sleeping Bear Dunes	Everglades/Big Cypress Point-Reyes/Golden Gate Santa Monica Mtns.

Davis and Hansen in review

Land Use Typology of US National Park Units

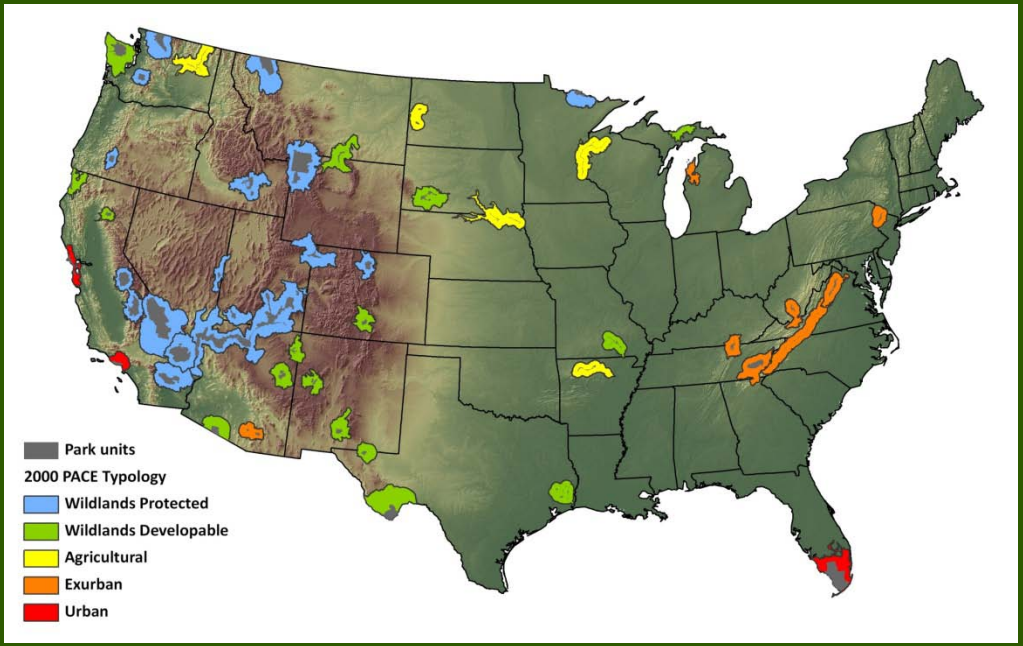
Type 1: Wildland Protected

<u>Characteristics:</u>

- Majority public land
- Little agriculture
- Private mostly undeveloped but exurban increasing
- Mostly located in western US

<u>Potential conservation issues:</u>

- Maintenance and/or restoration of wildland species
- Mammal-human conflicts
- Protection of private land "hotspots"
- Climate Change
- Resource extraction on public lands



Davis and Hansen in review

Land Use Typology of US National Park Units

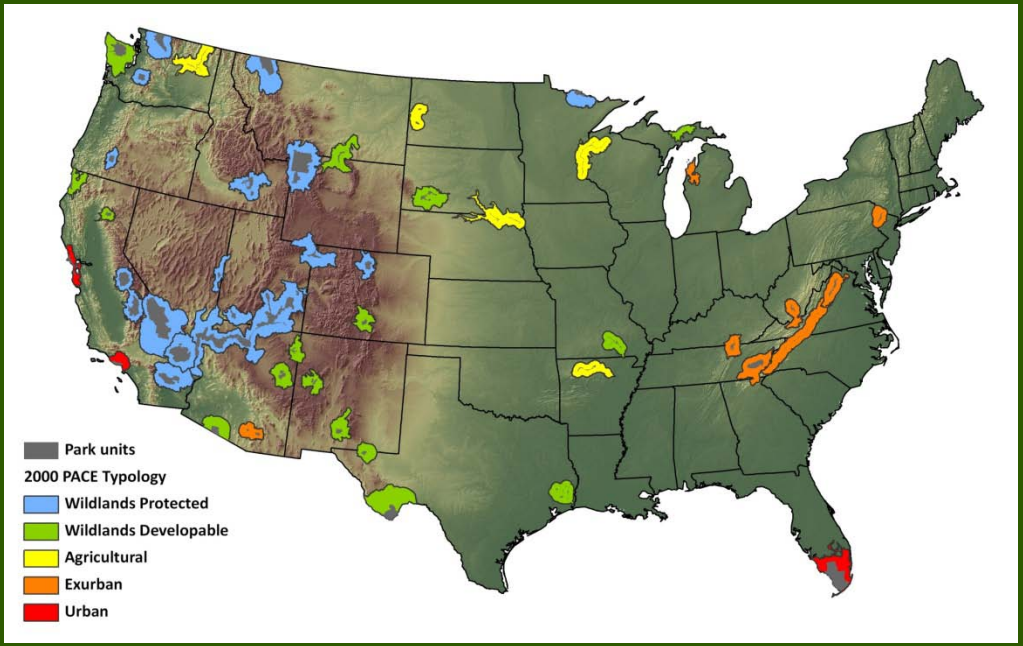
Type 4: Exurban

Characteristics:

- Majority private land
- Private mostly developed
- Rapidly increasing exurban and urban
- Mostly located in eastern US

Potential conservation issues:

- High road density leads to fragmentation of remaining natural lands
- High exurban development leads to loss of connectivity
- High levels of recreation disturbance in remaining natural lands
- Mesopredator release following loss of apex predators
- Wildlife interactions with pets and or disease
- Invasive species introductions and spread through roads and development



Davis and Hansen in review

Acknowledgements

Cathie Jean, Greater Yellowstone Network
Robert Daley, Greater Yellowstone Network
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Matthew Marshall, Eastern Rivers & Mountains Network
Leslie Morelock, Eastern Rivers & Mountains Network
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NPS I&M Program
NASA Applied Sciences Program

Next Project

Using NASA resources to inform climate and land use adaptation: Ecological forecasting, vulnerability assessment, and evaluation of management options across two US DOI Landscape Conservation Cooperatives

NRA: NNH10ZDA001N – BIOCLIM

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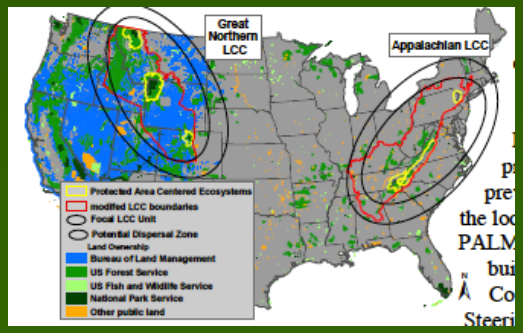
Project Period: March 2011 – February 2014