HOW to do proactive conservation planning at the LCC scale in light of landscape changes?

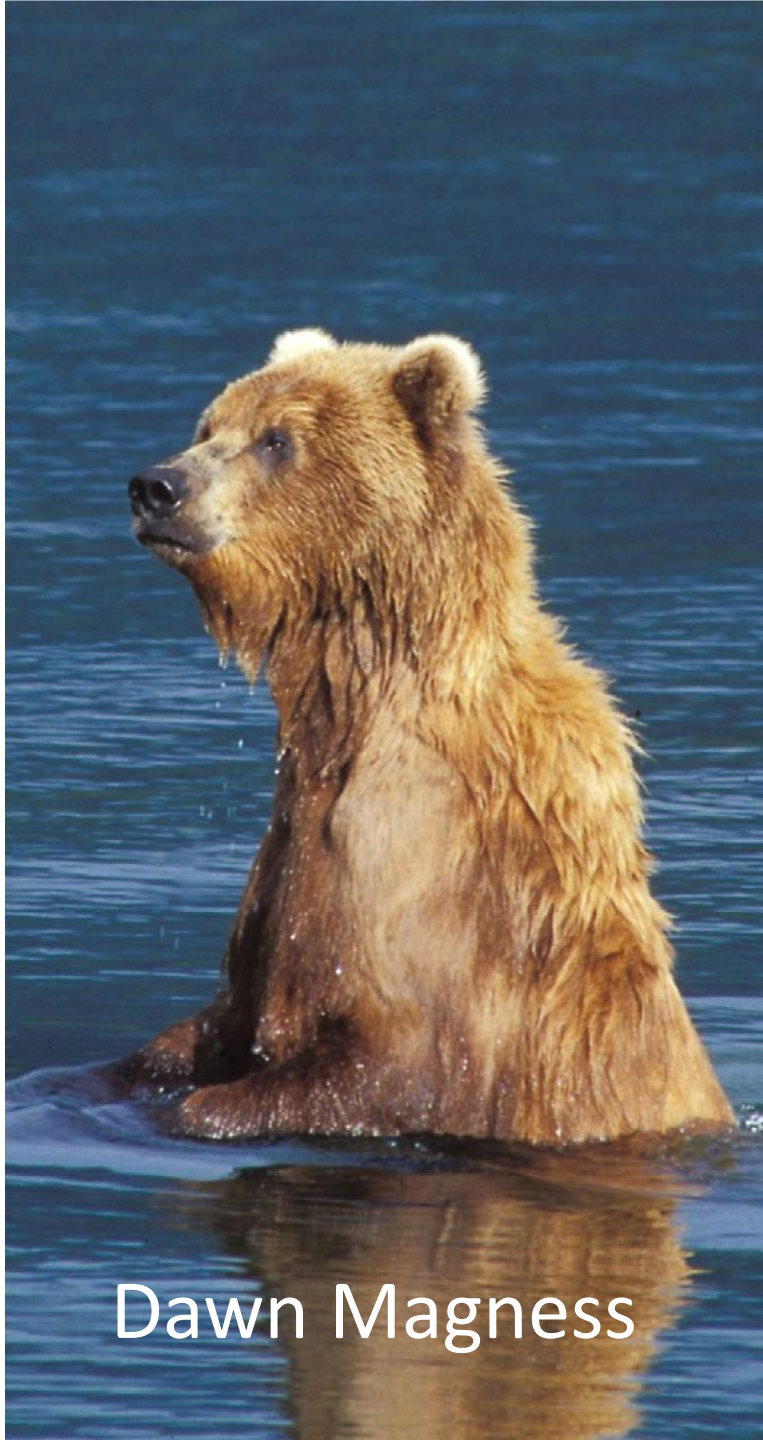
Welcome to Day 2!

HOW to:

- **Assess Vulnerability and Identify Trajectories of Change (2 hours)**
- **Explore Proactive Strategies to Address Directional Change (3 hours)**
- **Embrace and Reduce Uncertainty (2 hours)**
- **Plan for Resilience and Adaptation (45 minutes)**

Climate Change Vulnerabilities and Impacts

- Vulnerability Assessments
  - What Vulnerability Is
  - Types of Assessments
  - How It Informs Action



Vulnerability

Exposure: *character (e.g. variability, extremes), magnitude, and rate of climate change likely to be experienced.*

Sensitivity: *degree to which system or species is dependent on the prevailing climate.*

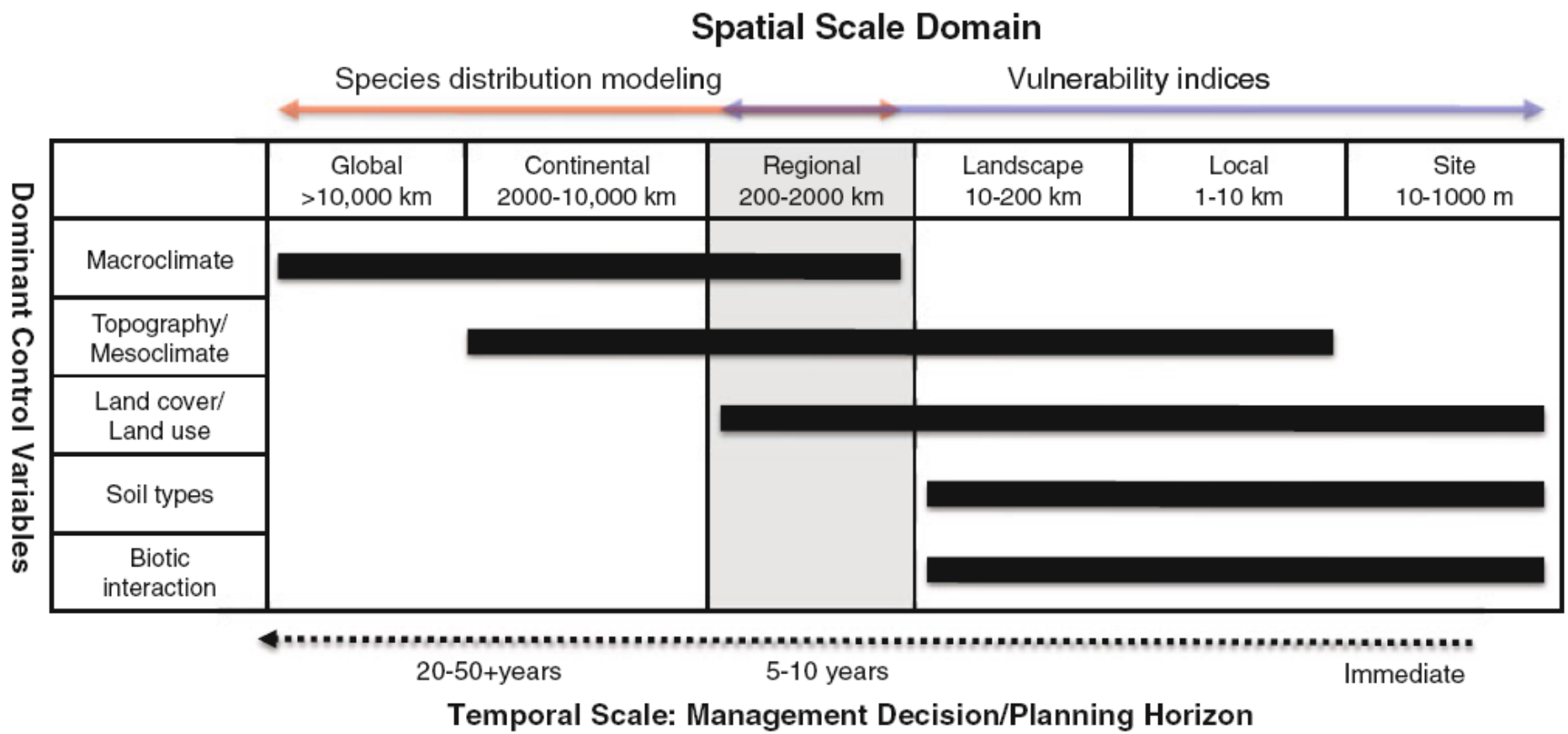
Adaptive Capacity: *the ability to adjust to climate change; to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.*

Examples of Vulnerability

	Exposure	Sensitivity	Adaptive Capacity
Species	• Sea level rise • Hazards (e.g. Floods) • Temp change • Temp extremes • Precip. Change	• Life history dependent on climate	• Dispersal Ability
Generalized Landscape		• Biome edge • Vegetation uniqueness	• Topographic diversity • Connectivity
Ecological System		• Spatial Extent	• Biological Diversity
Social System		• Dependence on single or few species	• Economic Diversity • Capital • Social Learning

Assessment Approaches

- Geographic Shifts
  - Paleo/Current empirical evidence
  - Species Distribution Models
- Relative Indices of Vulnerability
- Conceptual Models of Social-ecological Systems



Rowland, E.L, J.E. Davison and L.J. Graumlich. 2011. Approaches to evaluating climate change impacts on species: a guide to initiating the adaptation planning process. Environmental Management 47: 322- 337

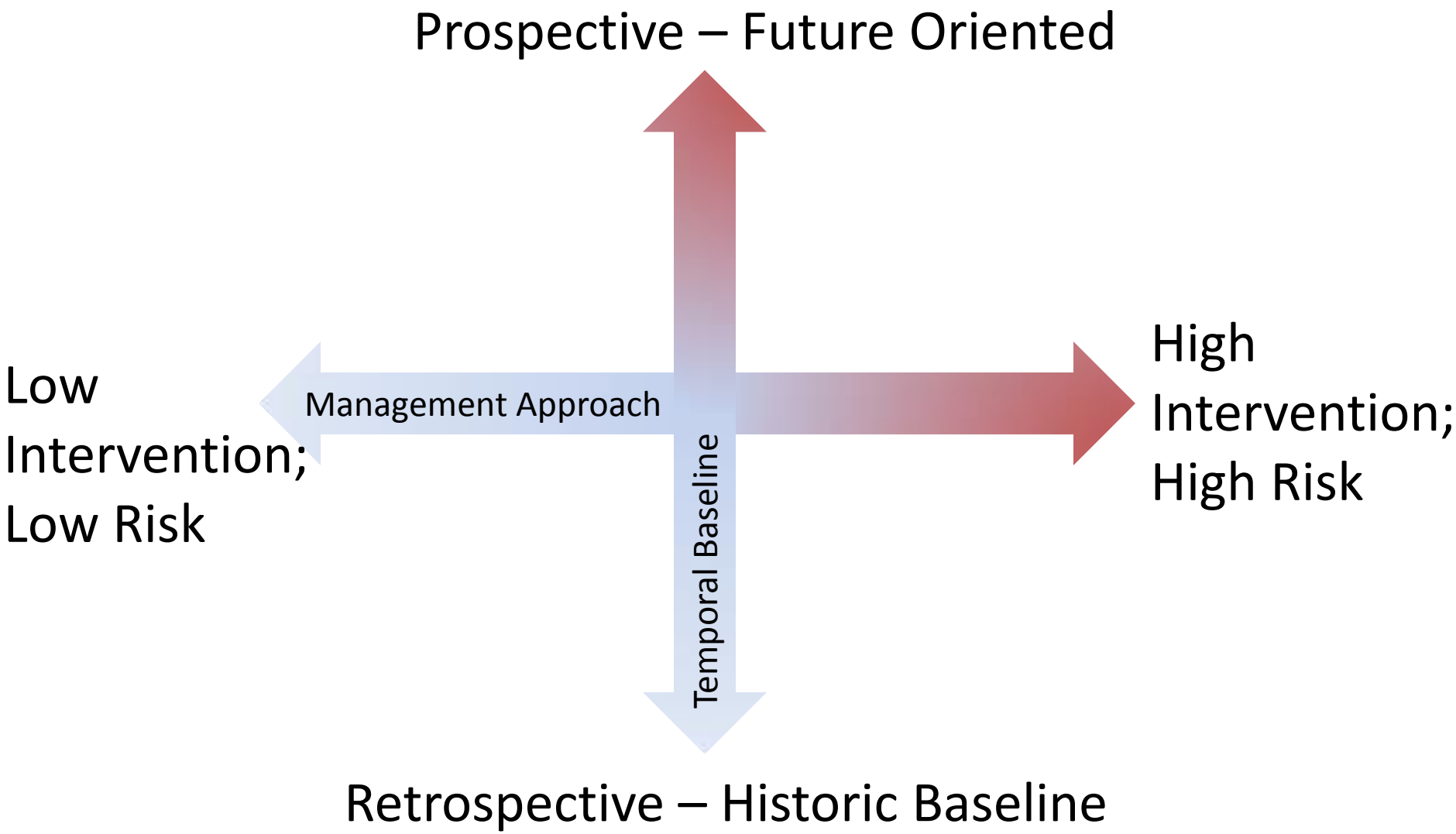
Analysis Dependent on Needs

- Spatial Scale
- Temporal Scale
- Target (Species, Ecosystem, Region)
- Aspatial (Ranking, Identifying Drivers) / Spatial (Leveraging geography: Bet-hedging, experimentation across range)

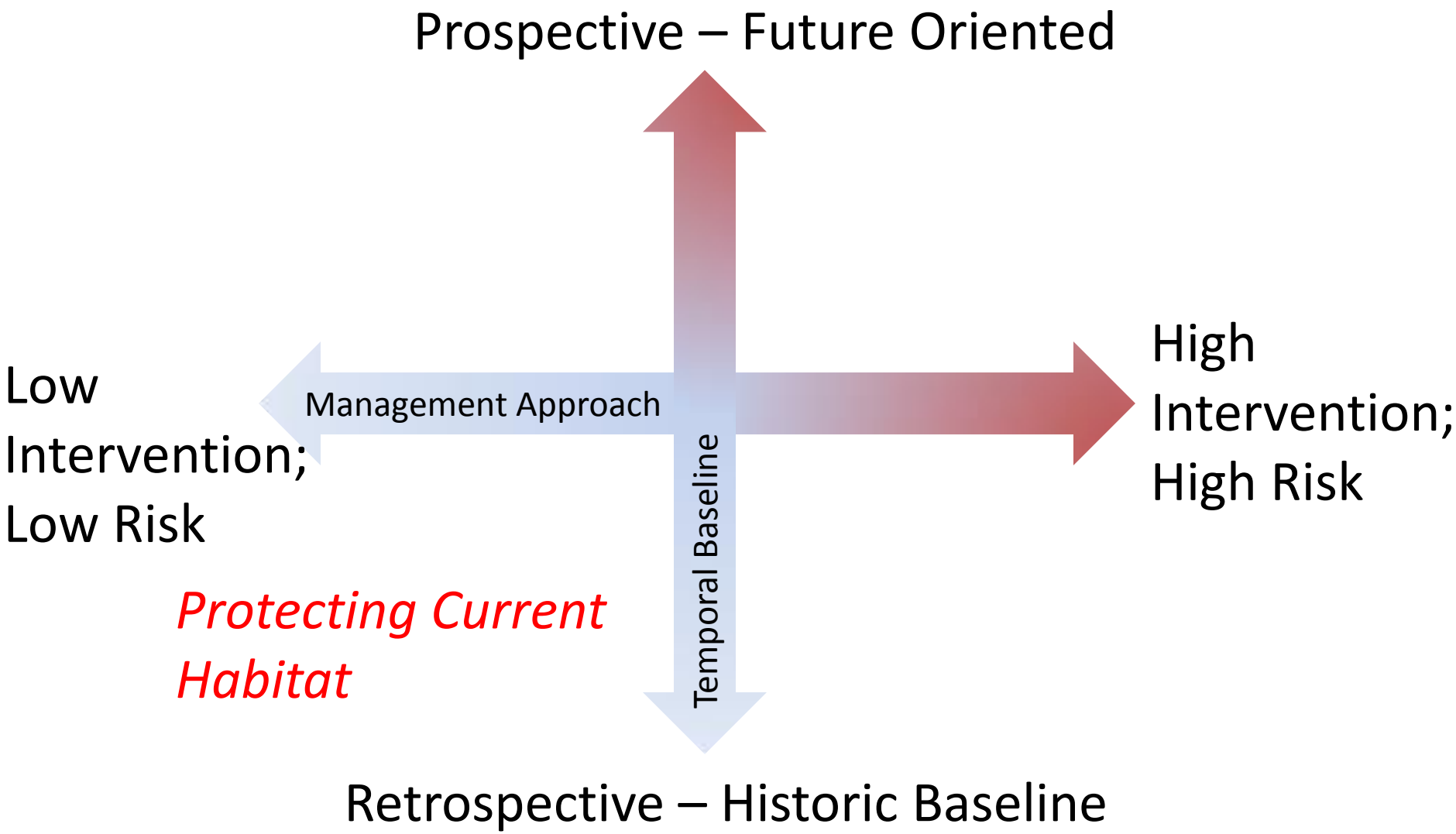
Vulnerability Assessments Can:

- Change Expectations
  - Identify What May be Resilient
  - Identify Possible Trajectories of Change
- Problem Identification
  - New or Emerging Problems
  - Help Prioritize
- Identify Where, When and How to Act

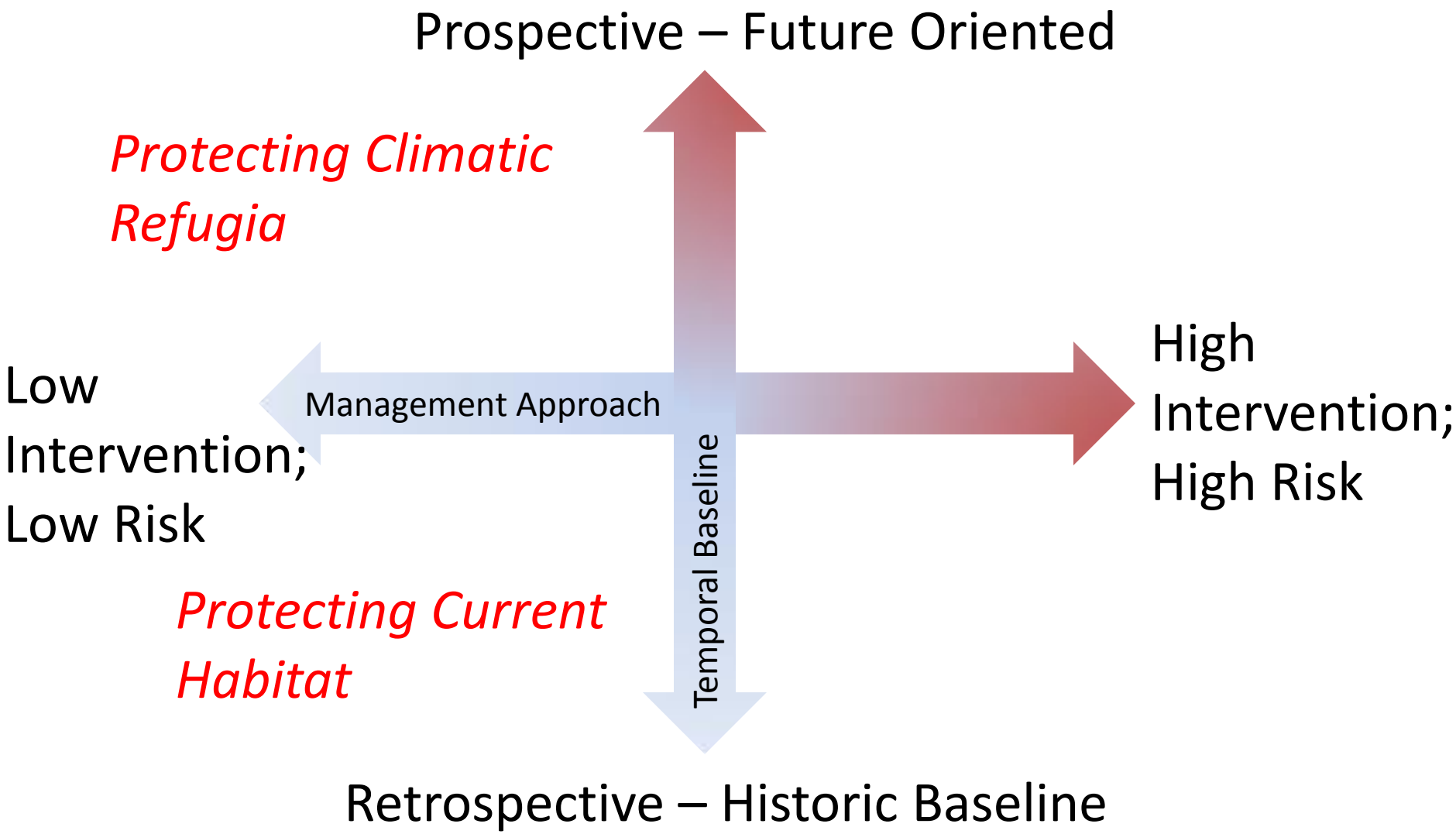
Linking Vulnerability to Actions



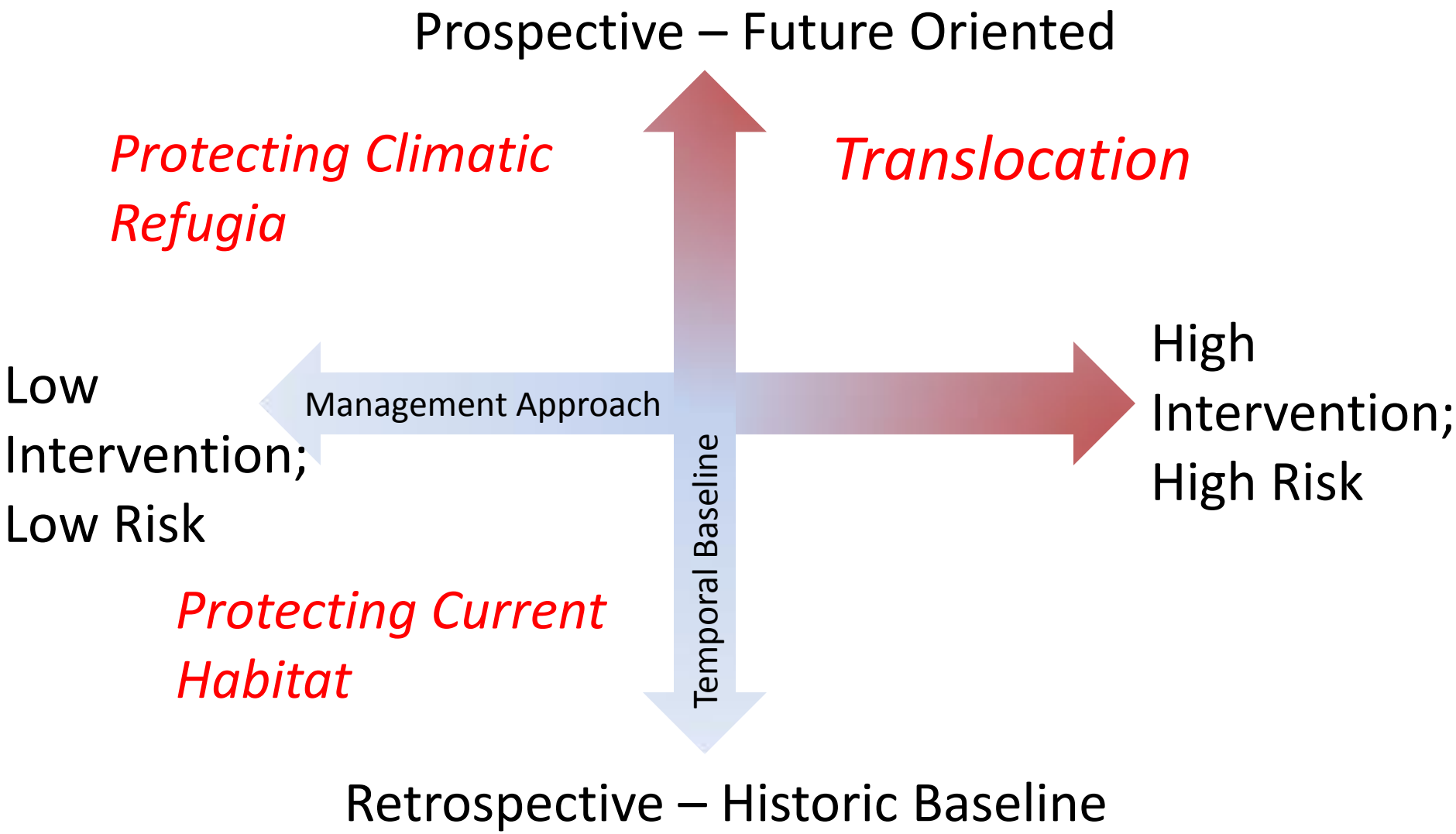
Linking Vulnerability to Actions



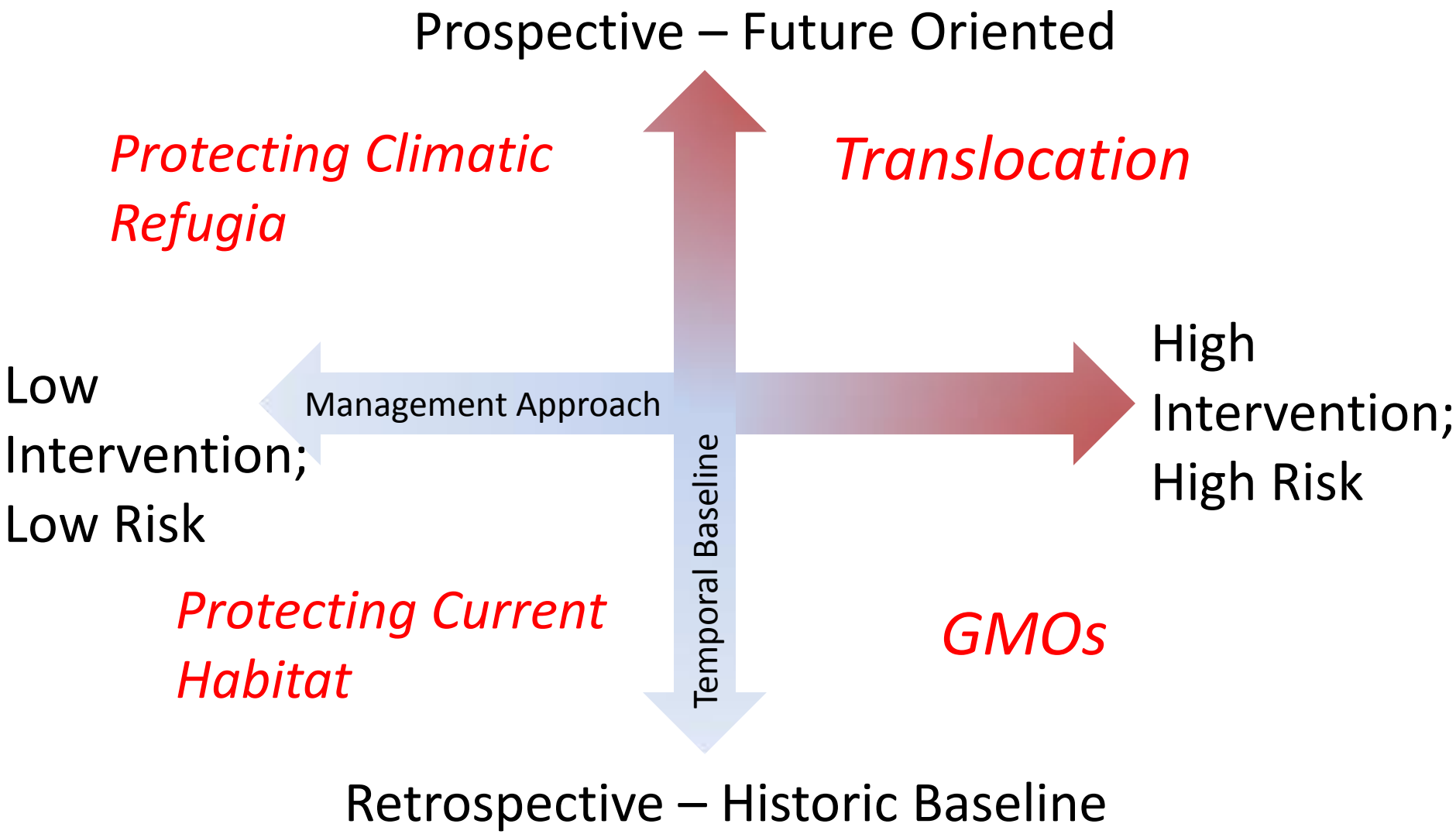
Linking Vulnerability to Actions



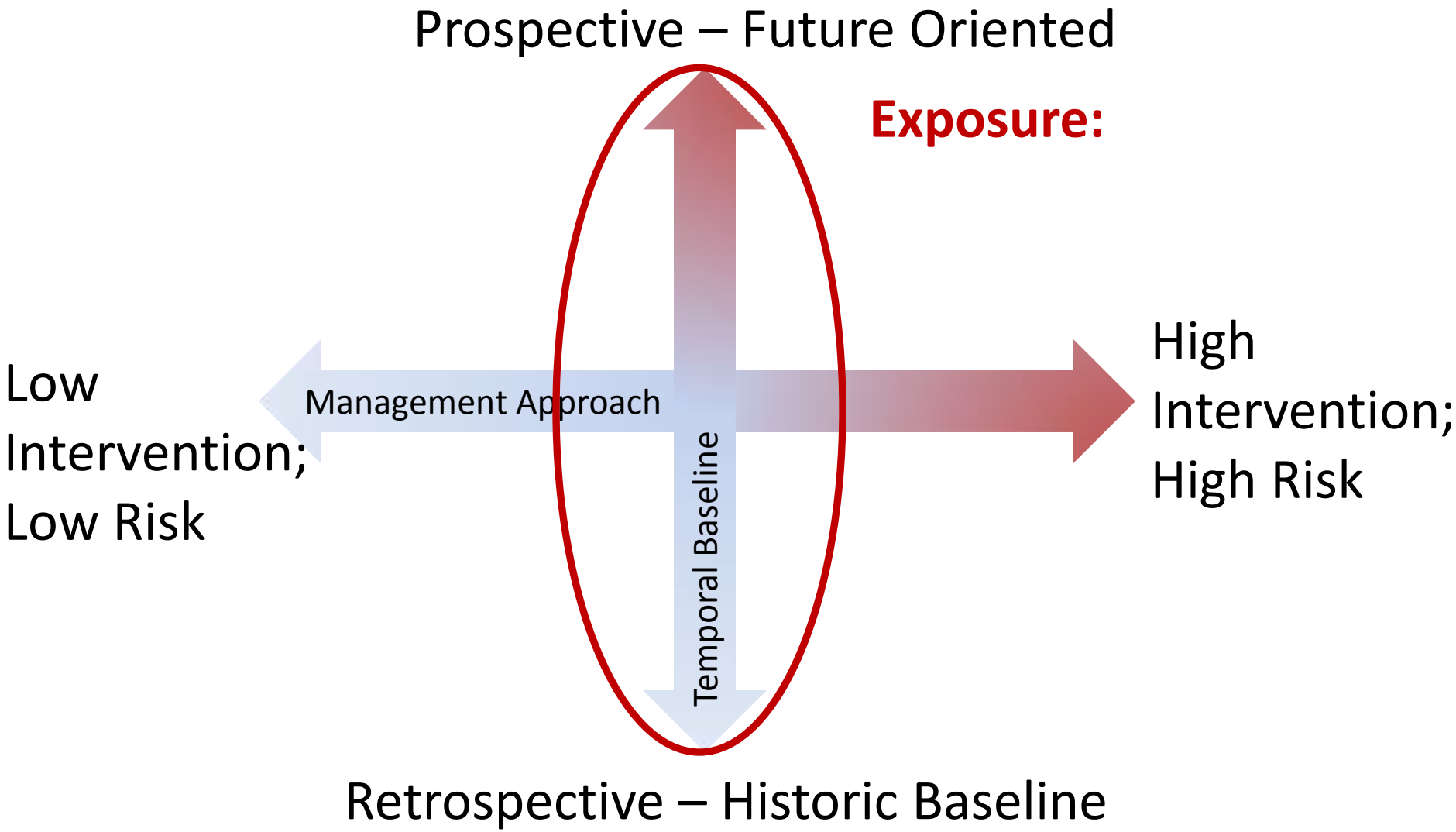
Linking Vulnerability to Actions



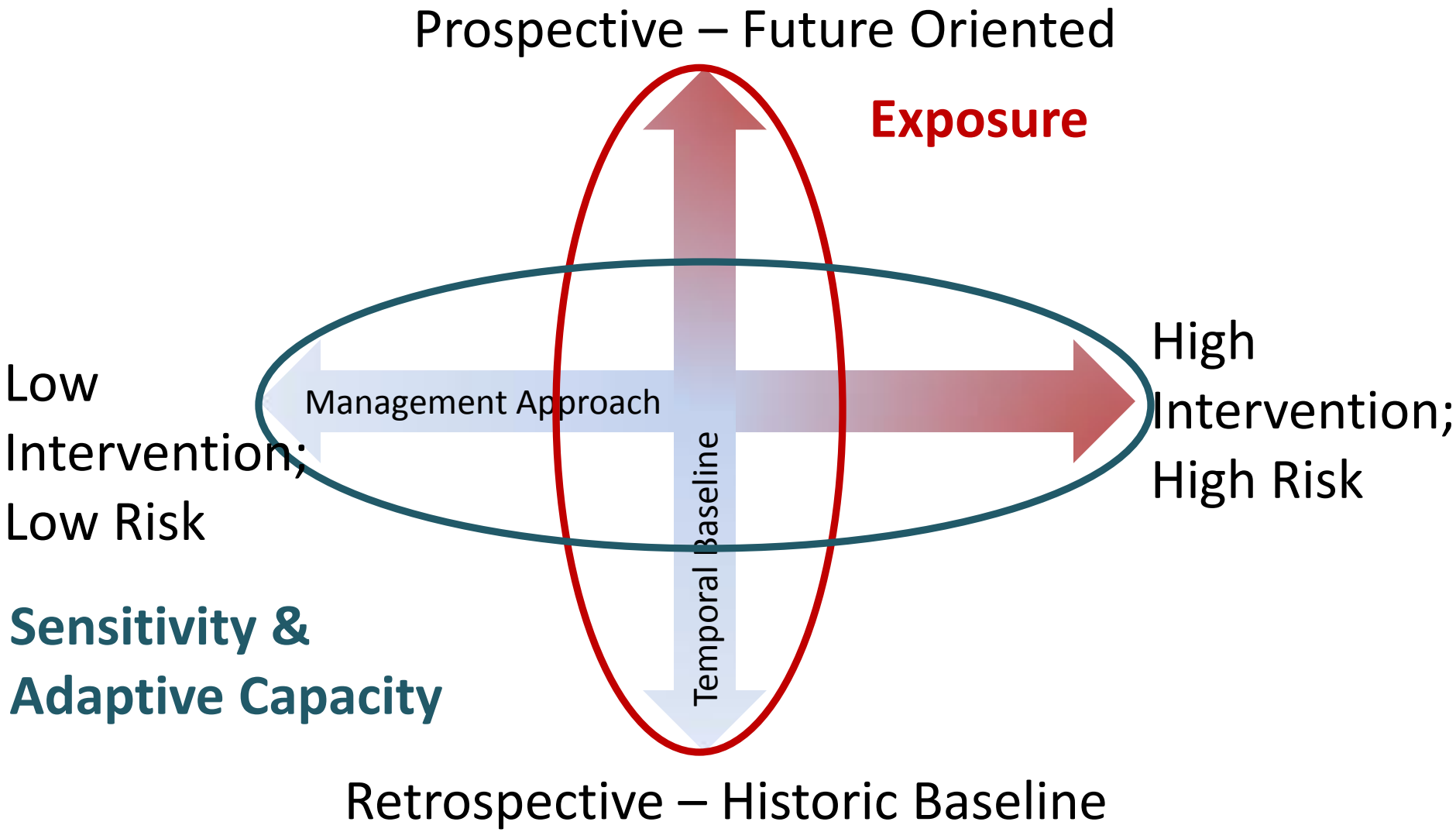
Linking Vulnerability to Actions



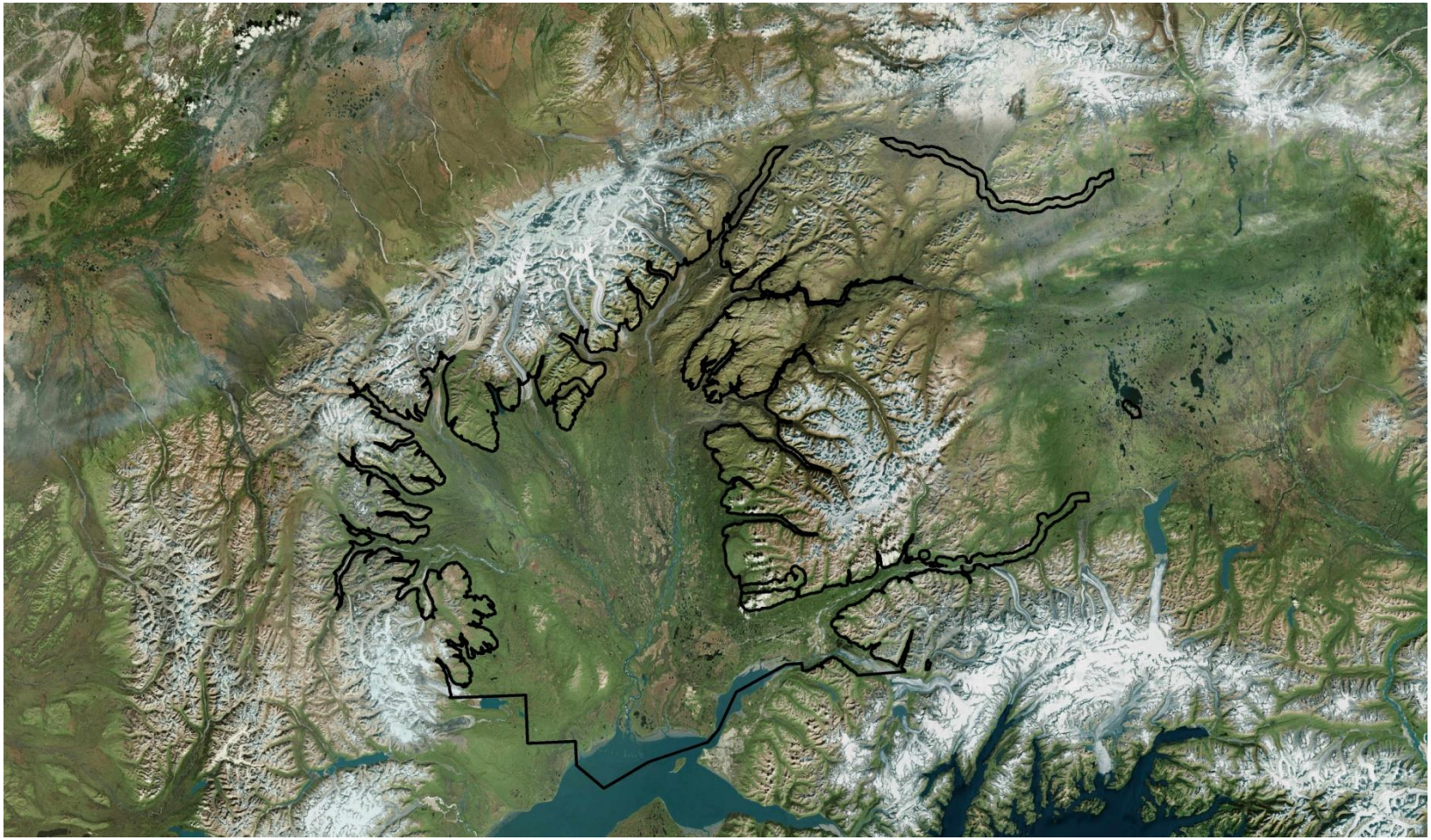
Linking Vulnerability to Actions



Linking Vulnerability to Actions



How can we add a climate change lens to current parcel prioritization?



Geography of Vulnerability

Exposure High

- Buy in one quadrant?
- Have different land buying strategies in different quadrants

Low Adaptive Capacity + High Sensitivity = **Low Landscape Resilience**

High Adaptive Capacity + Low Sensitivity = **High Landscape Resilience**

Exposure Low

Metrics

- Landscape Resilience = Anthropogenic Footprint
  - Road Density / Highway Present
  - Proportion Protected Land

- Climate Change Exposure
  - Forecast 2060 July Temperature in Non-glacial sub-basins (Proxy for Salmon Stream Temperature)
  - Forecast 2060 Cliome Change

Metrics

Exposure High

Low Adaptive Capacity + High Sensitivity = **Low Landscape Resilience**

- Road Density > 12m/h or Highway Present or Proportion Protected Land < 25%
- Proportion Biome Shift > 50% or non-glacial July T >15°C

- Road Density < 12 m/ha and No Highway Present and Proportion Protected Land > 25%
- Proportion Biome Shift > 50% or non-glacial July T >15°C

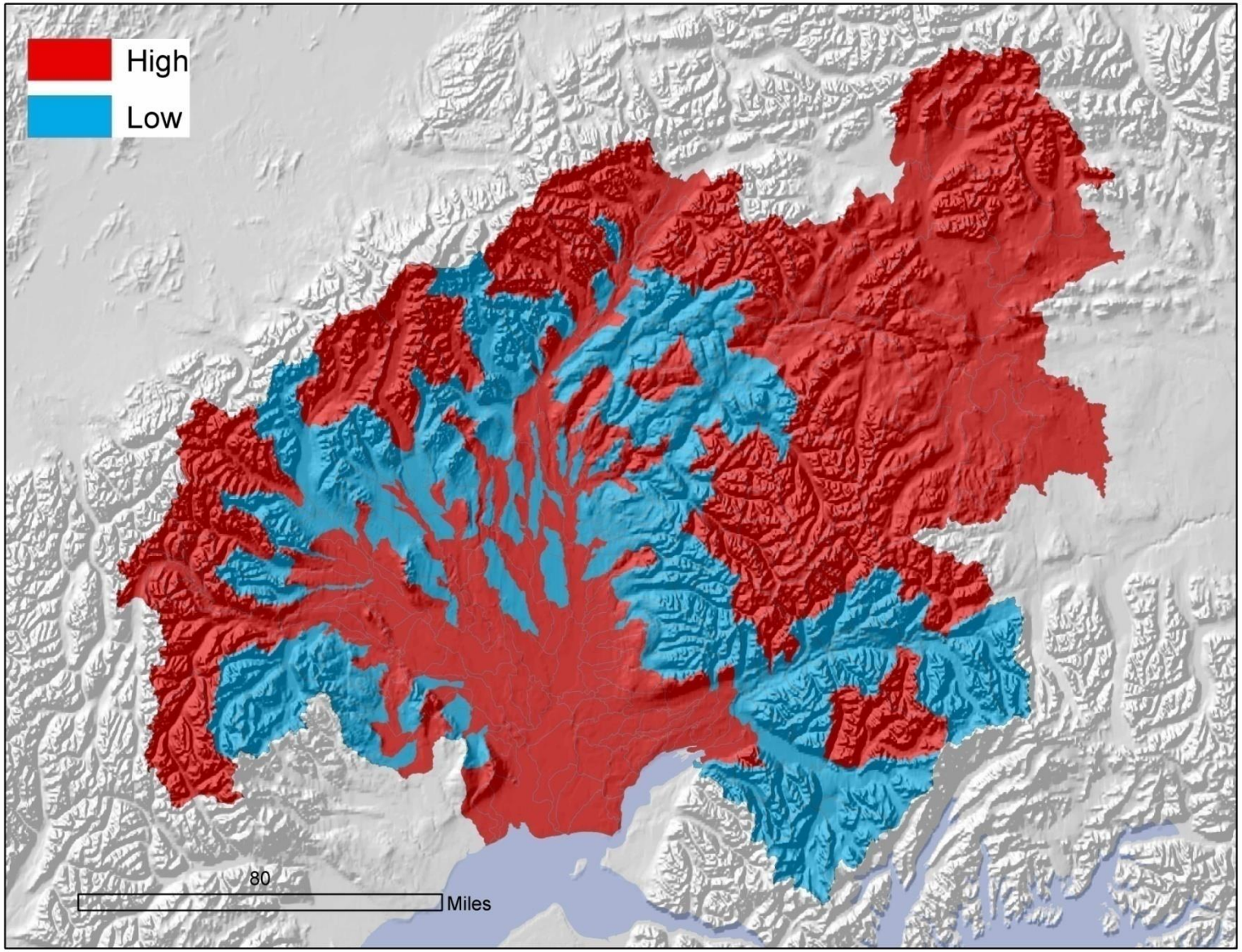
High Adaptive Capacity + Low Sensitivity = **High Landscape Resilience**

- Road Density > 12m/h or Highway Present or Proportion Protected Land < 25%
- Proportion Biome Shift < 50% and non-glacial July T < 15°C

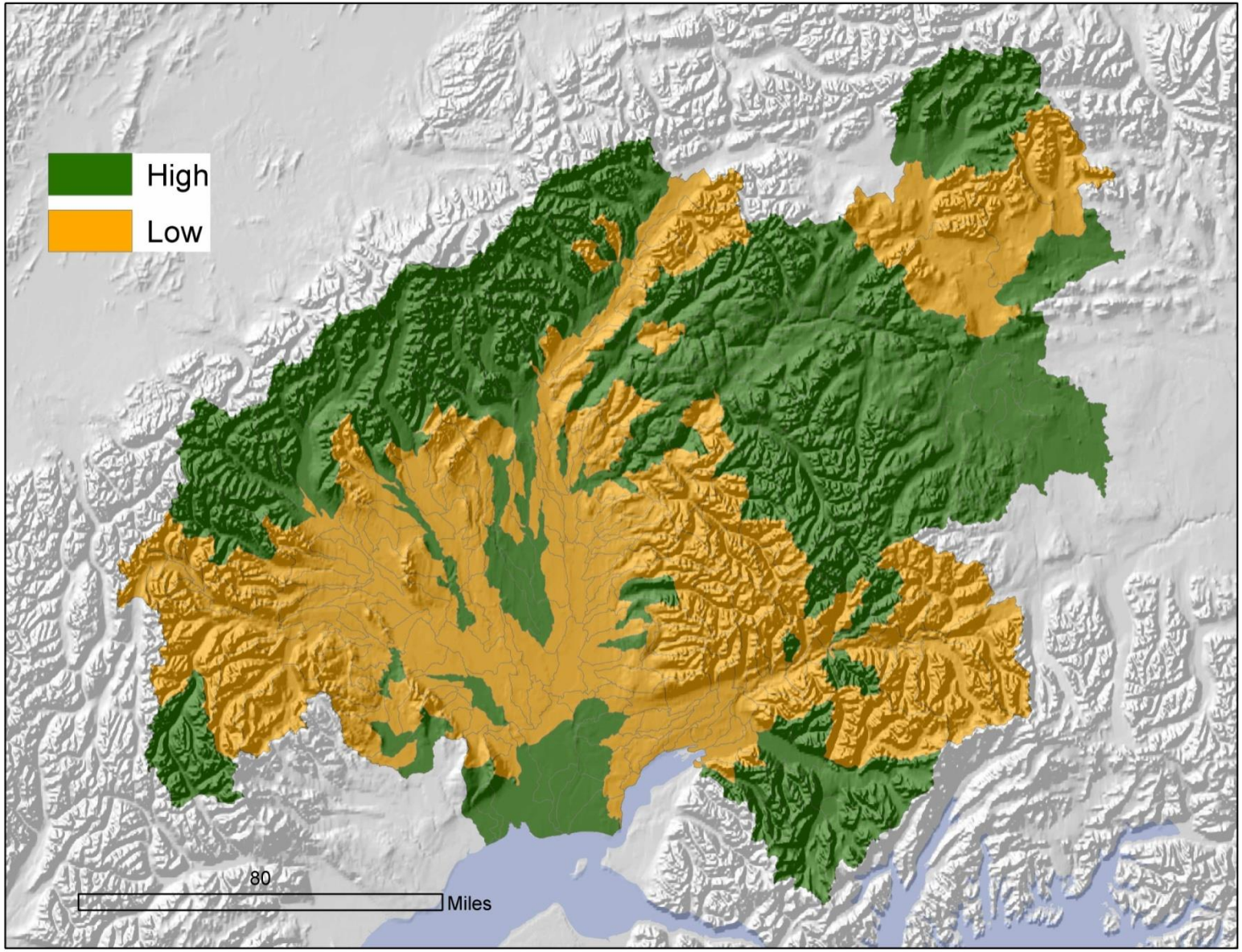
- Road Density < 12 m/ha and No Highway Present and Proportion Protected Land > 25%
- Proportion Biome Shift < 50% and non-glacial July T < 15°C

Exposure Low

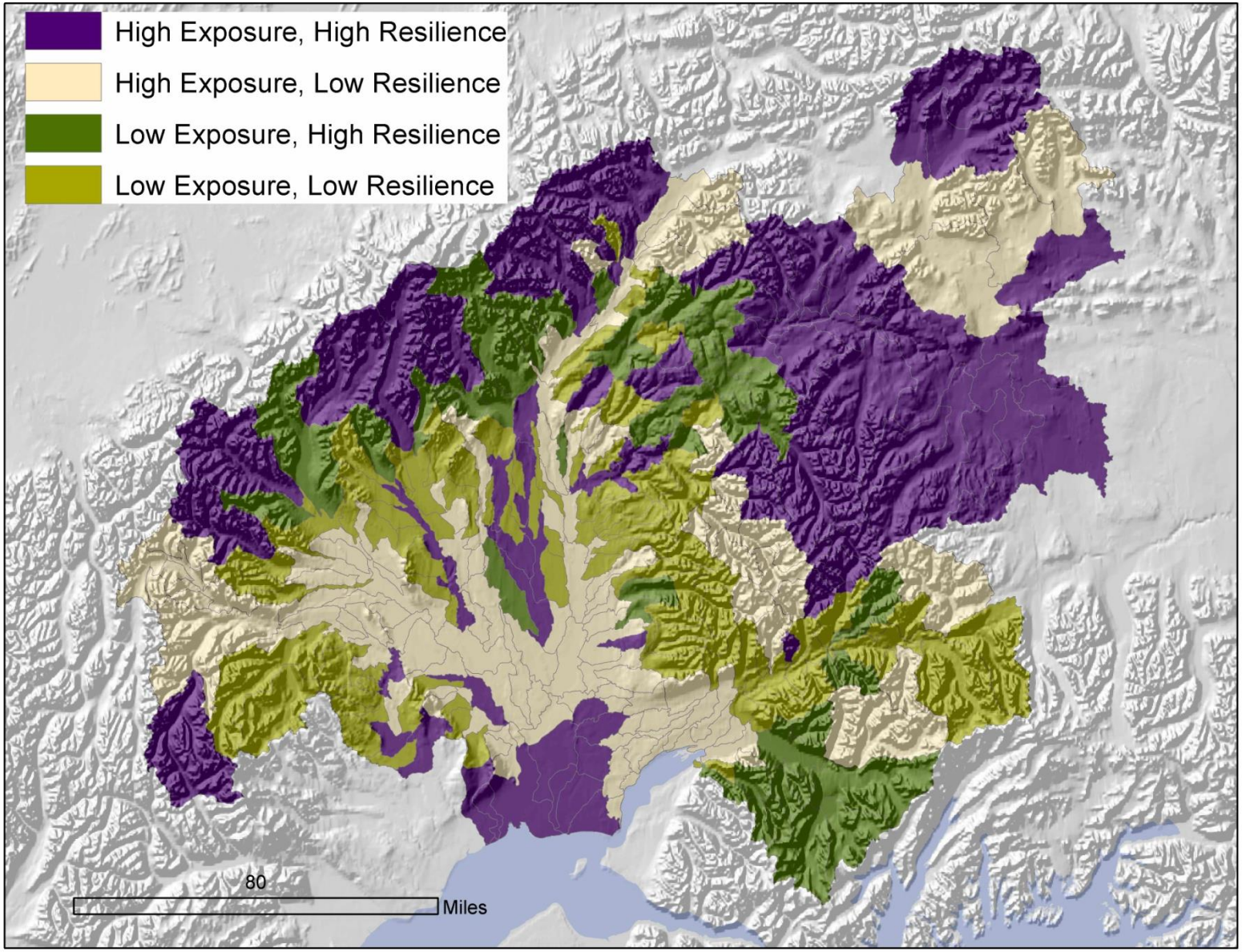
Exposure



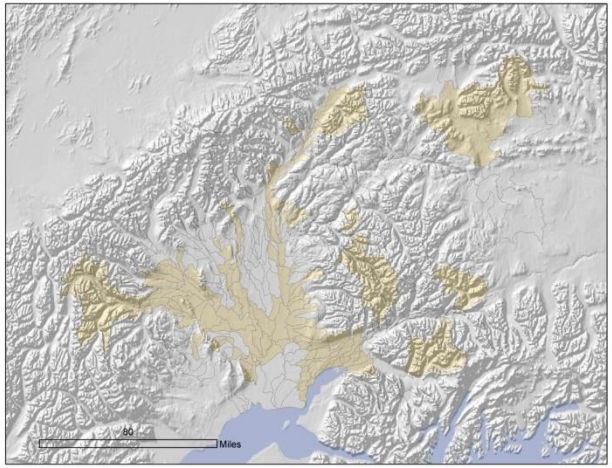
Resilience

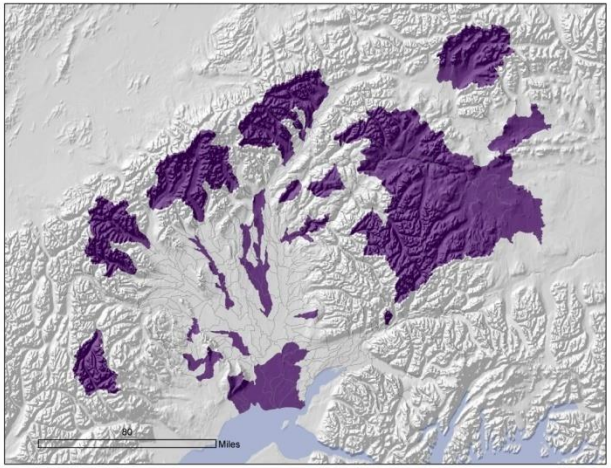


Exposure & Resilience



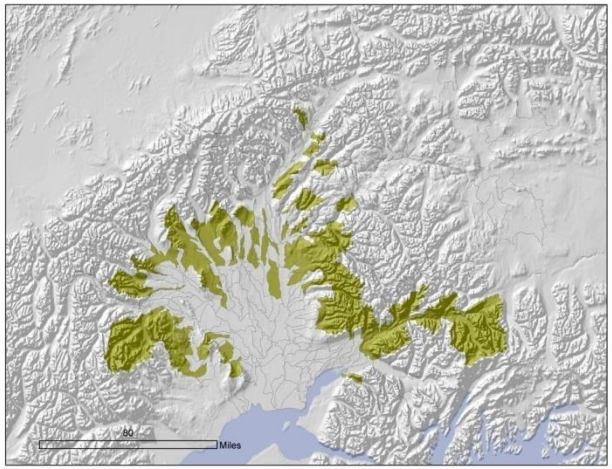
Exposure High

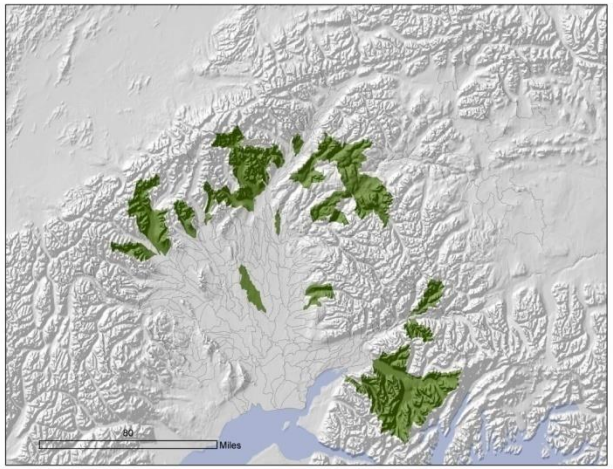




Landscape Resilience Low

Landscape Resilience High





Exposure Low

Exposure High

- Protect lands with non-glacial anadromous streams – provide shading
- De-emphasize buying lands based on current habitat conditions

- focus on locally important green areas based on land-use and community needs (parks, trail linkages, riparian)

- focus on maintaining regional landscape networks based on topography and other non changing factors (easements, subdivision planning,
- Consider buying lands in road-less areas before development raises cost

Landscape Resilience Low

Landscape Resilience High

- Focus on protecting current habitats that are important

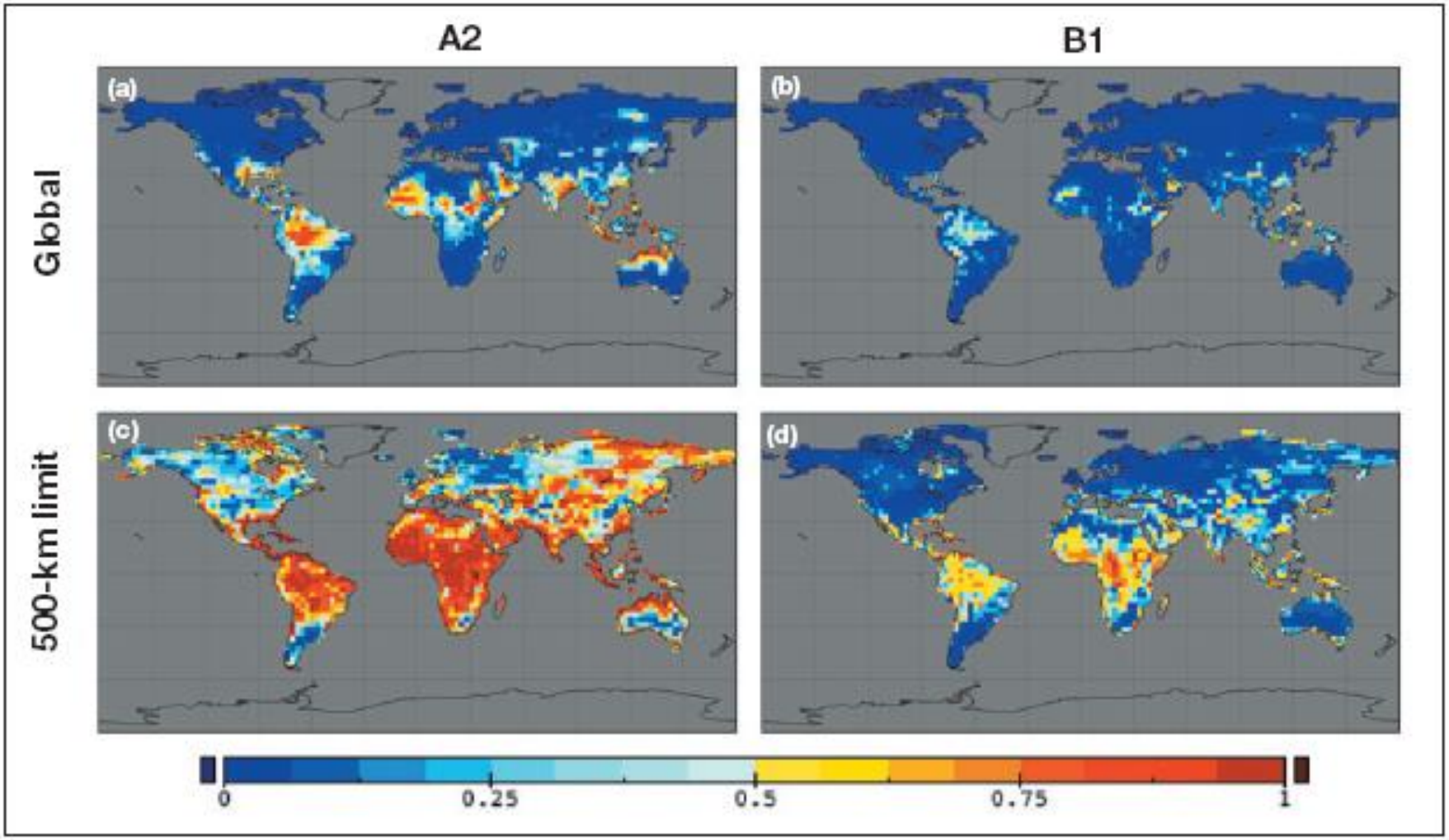
- focus on locally important green areas based on current habitat, linking current habitat, land-use, trail linkages, and riparian corridors

- Link the conservation estate at the regional scale
- Buffer conservation estate
- Consider buying lands in road-less areas before development raises cost

Exposure Low

Geographic Shifts - Vegetation Vulnerability

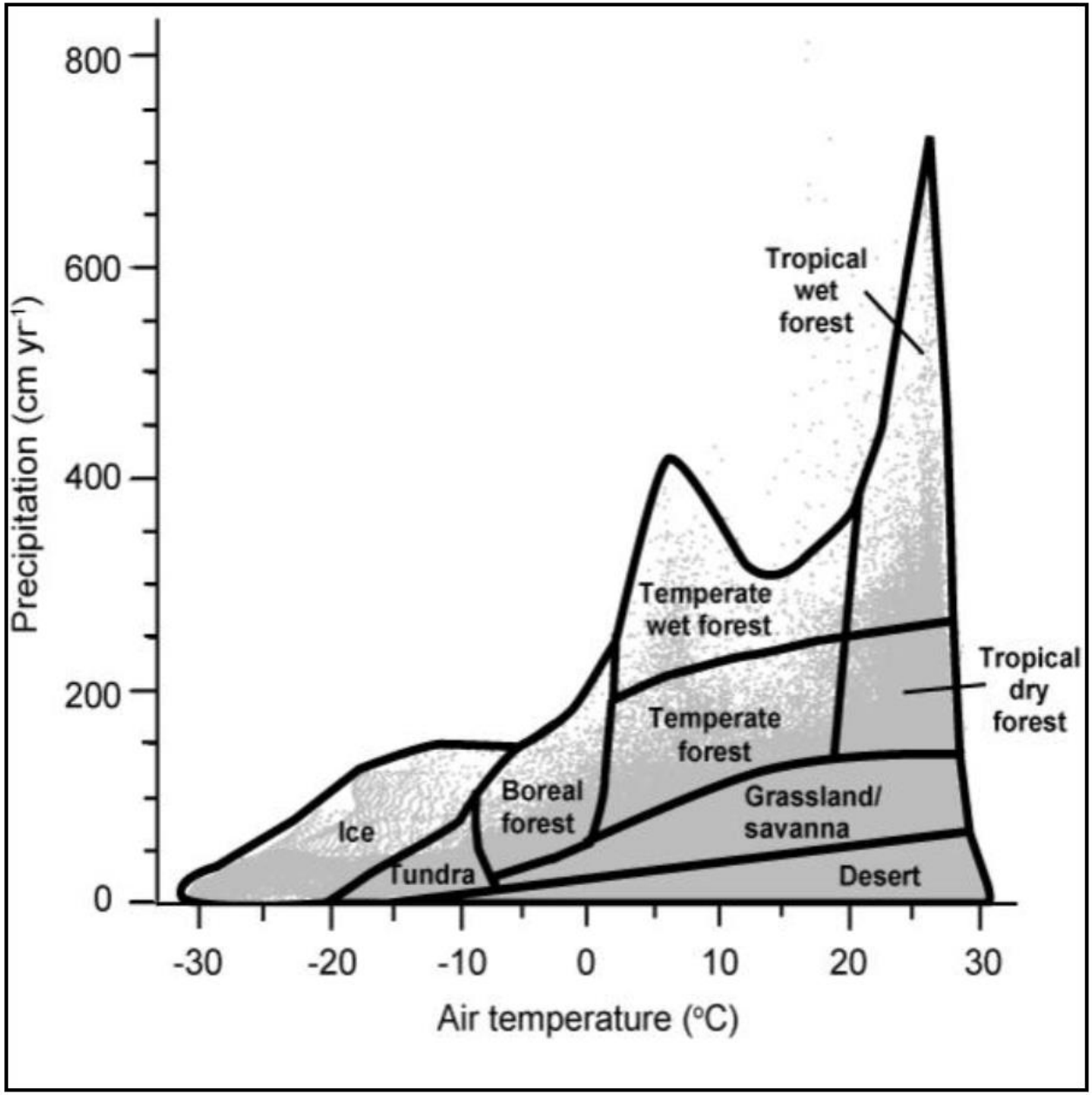
- Biome
- SNAP’s Cliome Models
- Land cover Climate Envelope
- Tree Species



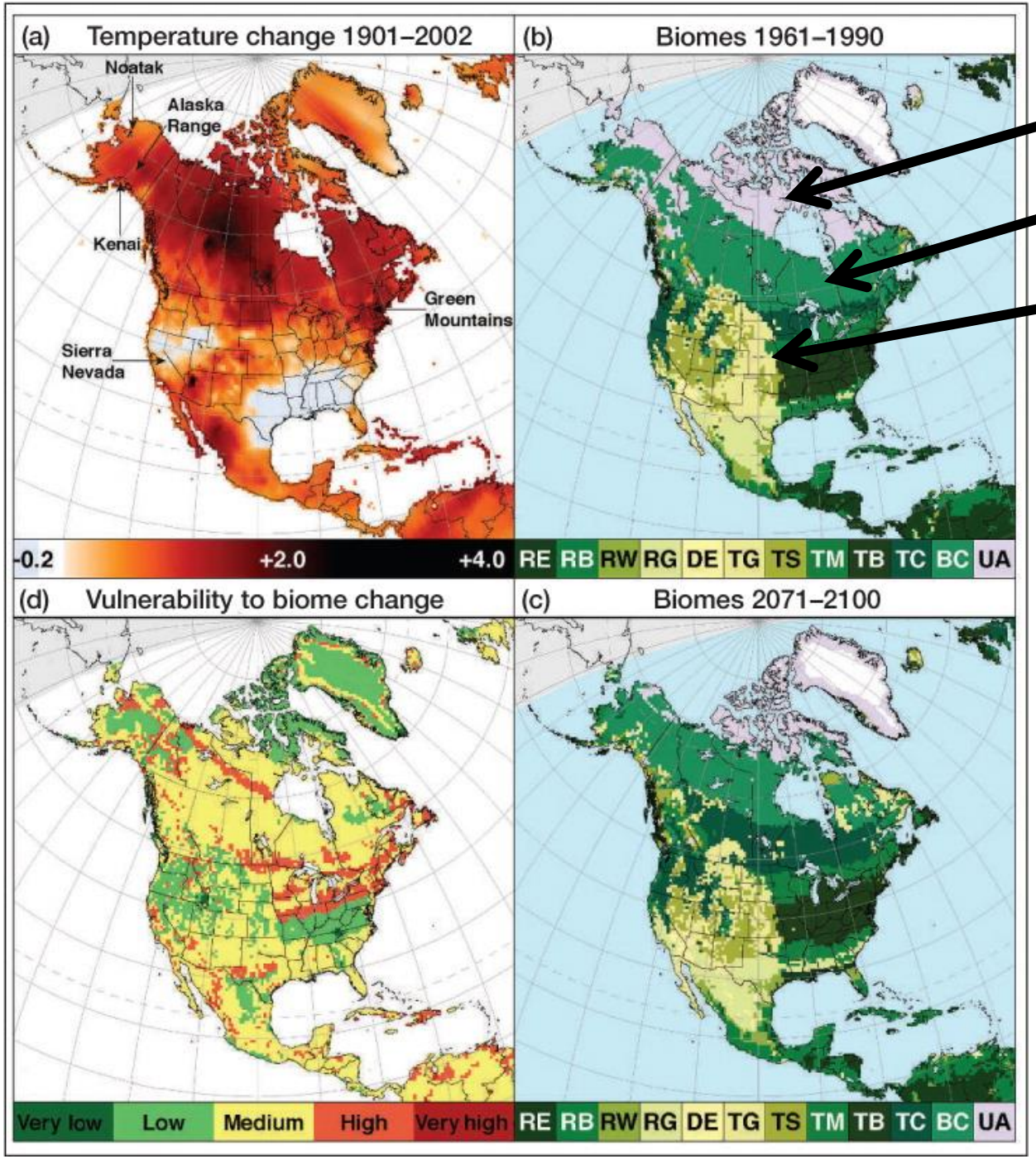
(a), (b) novel globally

(c), (d) novel regaionally (500km2)

Williams, J. W., Jackson, S., and Kutzbach, J. (2007). Projected distributions of novel and disappearing climates by 2100 AD. *Proceedings of the National Academy of Science* 104: 5738-5742.



Staudinger, M.D., N. B. Grimm, A. Staudt, S. L. Carter, F. S. Chapin III, P. Kareiva, M. Ruckelshaus, B. A. Stein. 2012. Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment.



Tundra and Alpine (UA)

Boreal Conifer Forest (BC)

Temperate Grassland (TG)

Geographic Shift

Low Confidence for Our Area

Gonzalez P, Neilson RP, Lenihan J M,and Drapek RJ. 2010. Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change. *Global Ecol Biogeogr* **19**: 755–68.

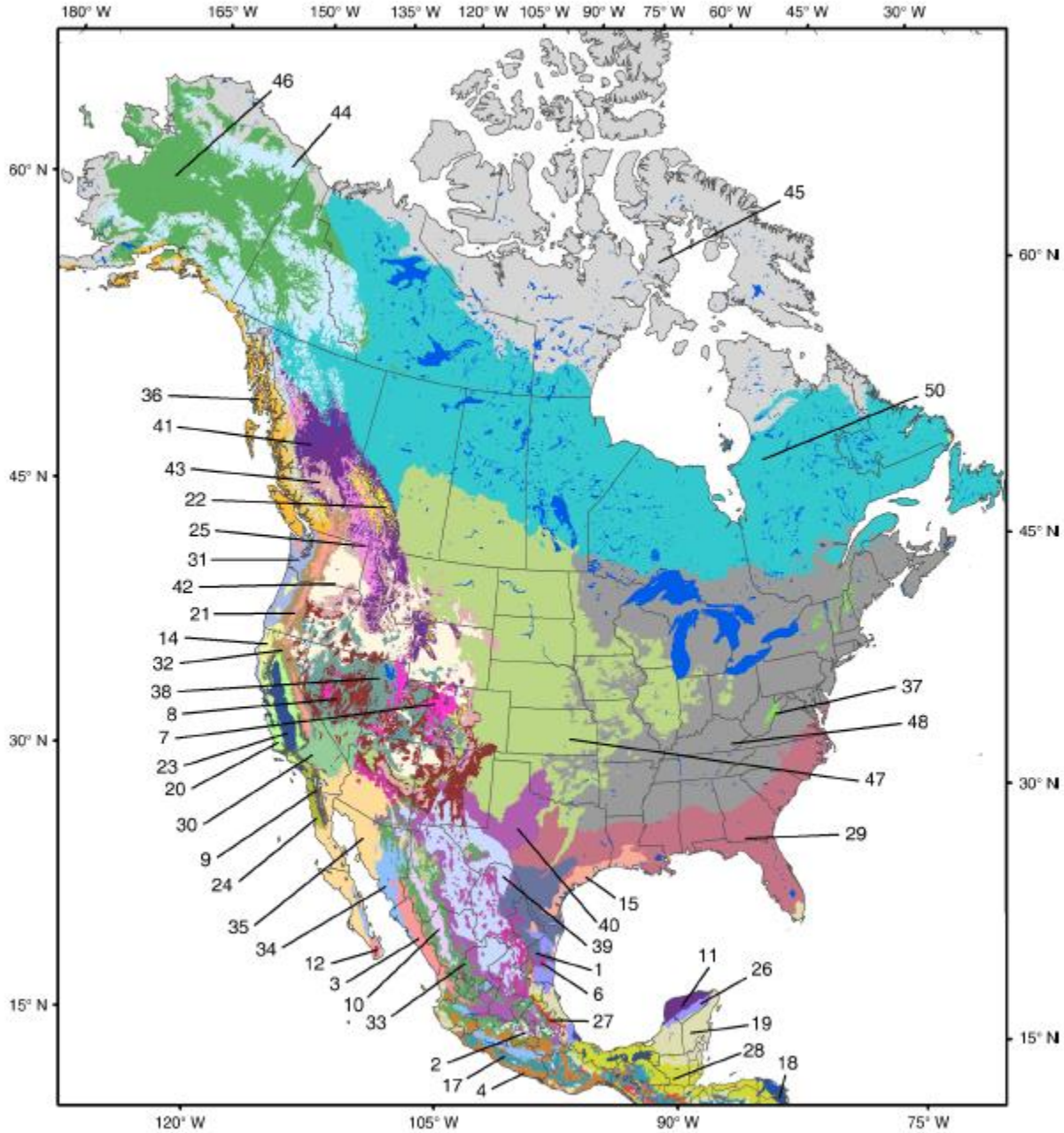
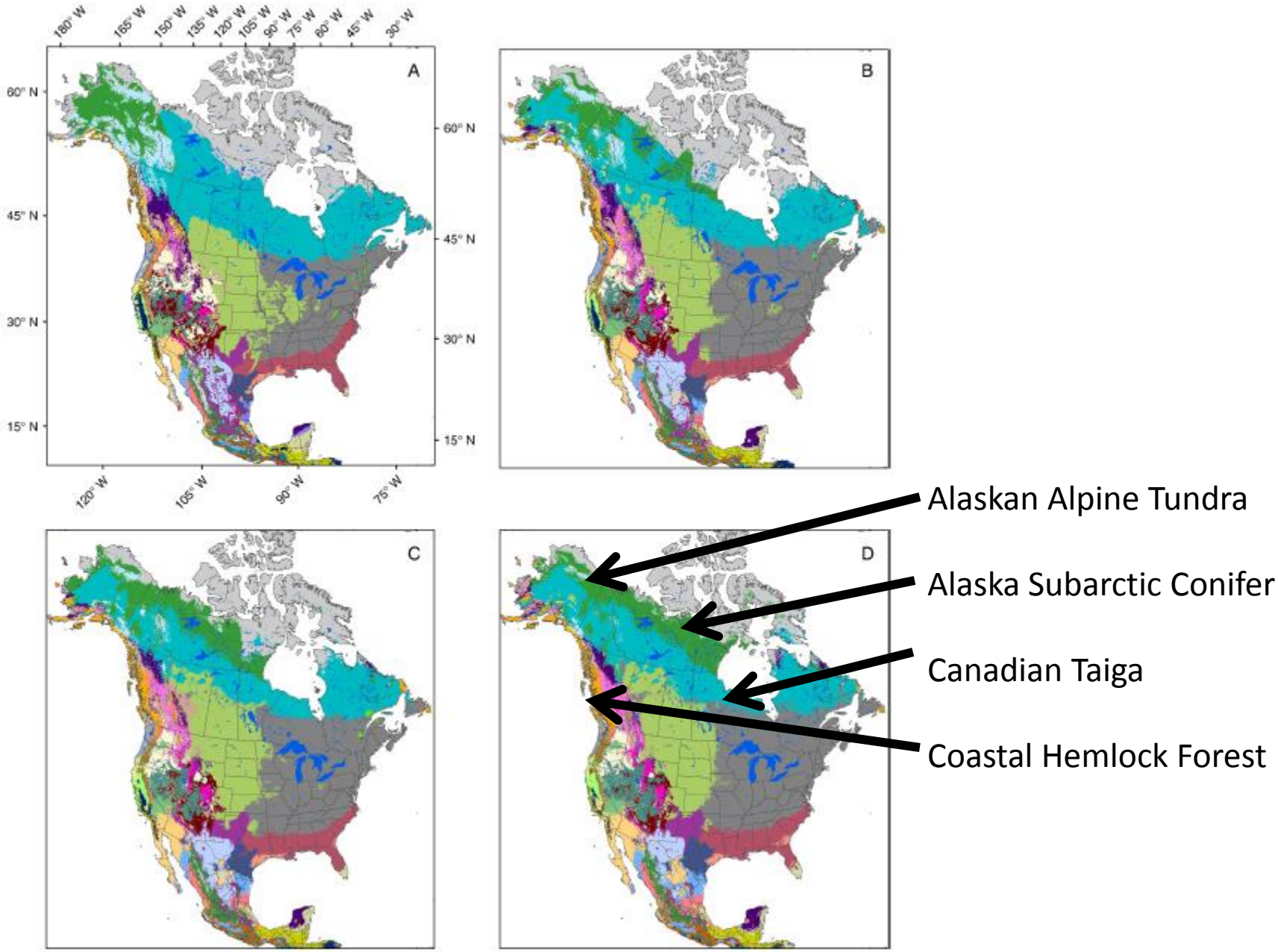
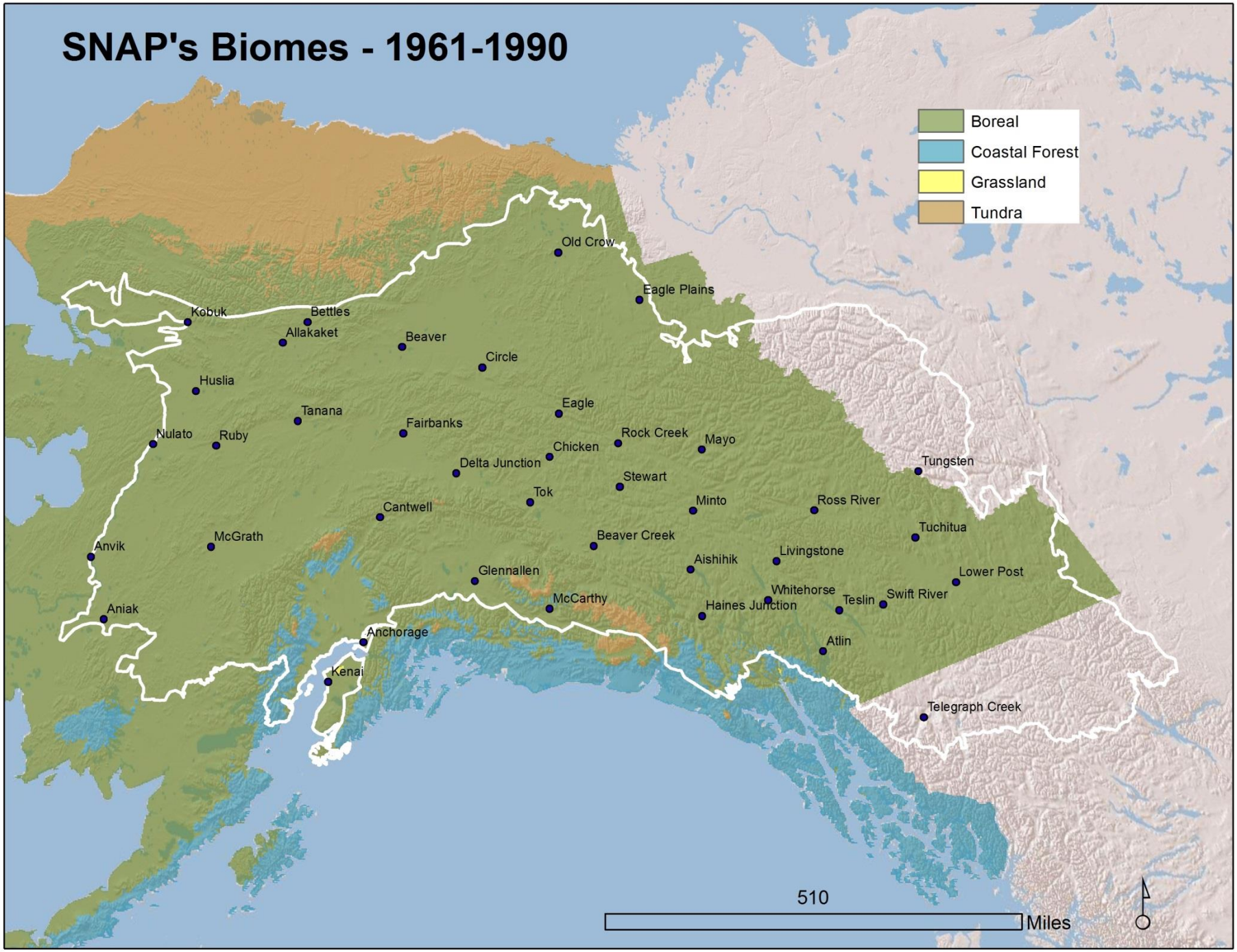
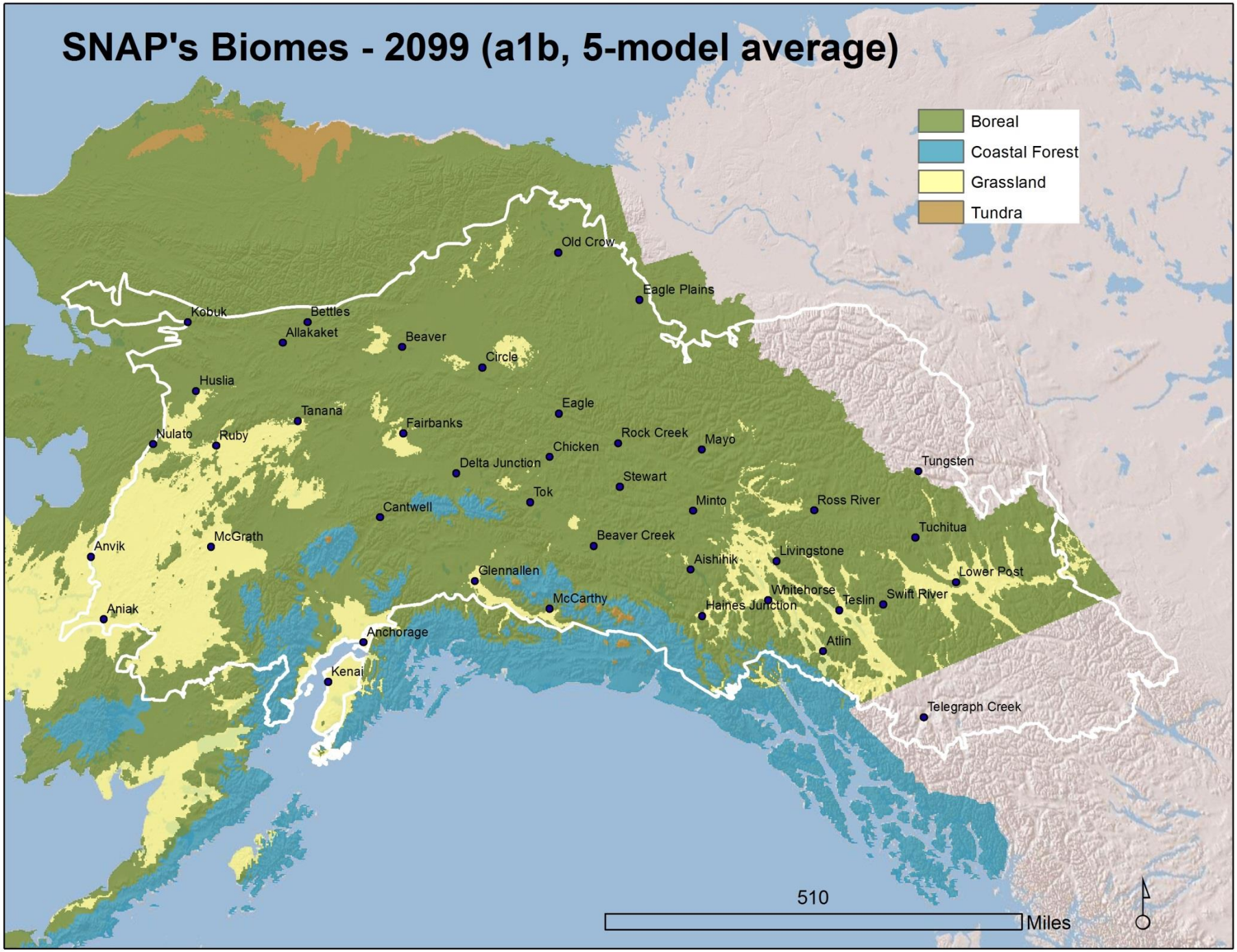


FIG. 1. Predicted contemporary distribution of 46 North American biomes. Biome code numbers are keyed to Table 1.

Gerald E. Rehfeldt, Nicholas L. Crookston, Cuauhtémoc Sáenz-Romero, and Elizabeth M. Campbell 2012. North American vegetation model for land-use planning in a changing climate: a solution to large classification problems. Ecological Applications 22:119–141. http://dx.doi.org/10.1890/11-0495.1


180° W
165° W
150° W
135° W
120° W
105° W
90° W
75° W
60° W
45° W
30° W
60° N
45° N
30° N
15° N
A
B
C
D
Alaskan Alpine Tundra
Alaska Subarctic Conifer
Canadian Taiga
Coastal Hemlock Forest


SNAP's Biomes - 1961-1990
Boreal
Coastal Forest
Grassland
Tundra
Old Crow
Eagle Plains
Kobuk
Bettles
Allakaket
Beaver
Circle
Huslia
Tanana
Eagle
Fairbanks
Nulato
Ruby
Rock Creek
Mayo
Chicken
Delta Junction
Tungsten
Stewart
Tok
Minto
Ross River
Cantwell
Tuchitua
McGrath
Beaver Creek
Anvik
Livingstone
Aishihik
Glennallen
Lower Post
Whitehorse
Teslin
Swift River
McCarthy
Haines Junction
Aniak
Anchorage
Atlin
Kenai
Telegraph Creek
510
Miles


SNAP's Biomes - 2099 (a1b, 5-model average)
Boreal
Coastal Forest
Grassland
Tundra
Old Crow
Eagle Plains
Kobuk
Bettles
Allakaket
Beaver
Circle
Huslia
Tanana
Eagle
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Atlin
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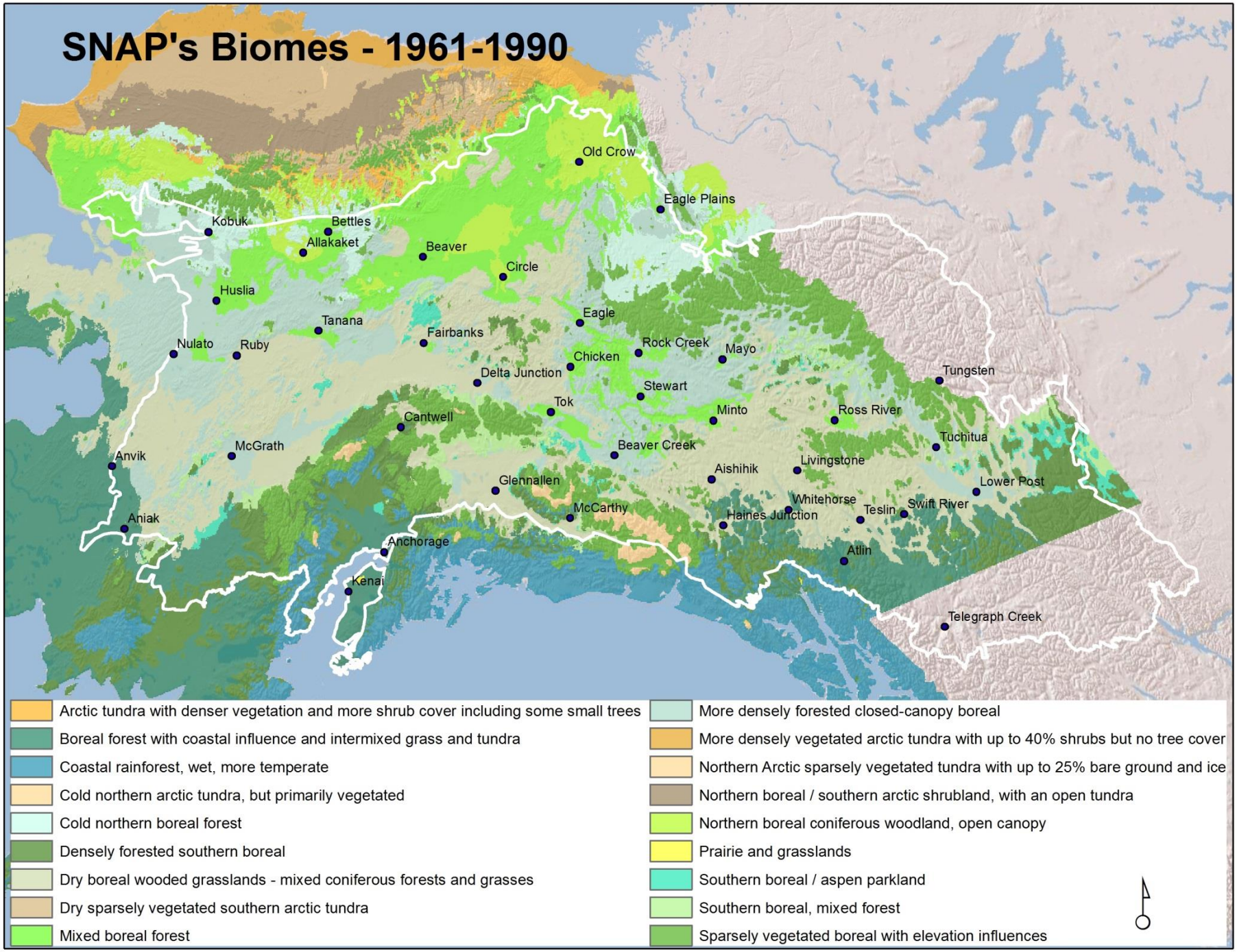
Telegraph Creek
510
Miles


SNAP's Biomes - 1961-1990
Old Crow
Eagle Plains
Kobuk
Bettles
Allakaket
Beaver
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Huslia
Tanana
Eagle
Fairbanks
Nulato
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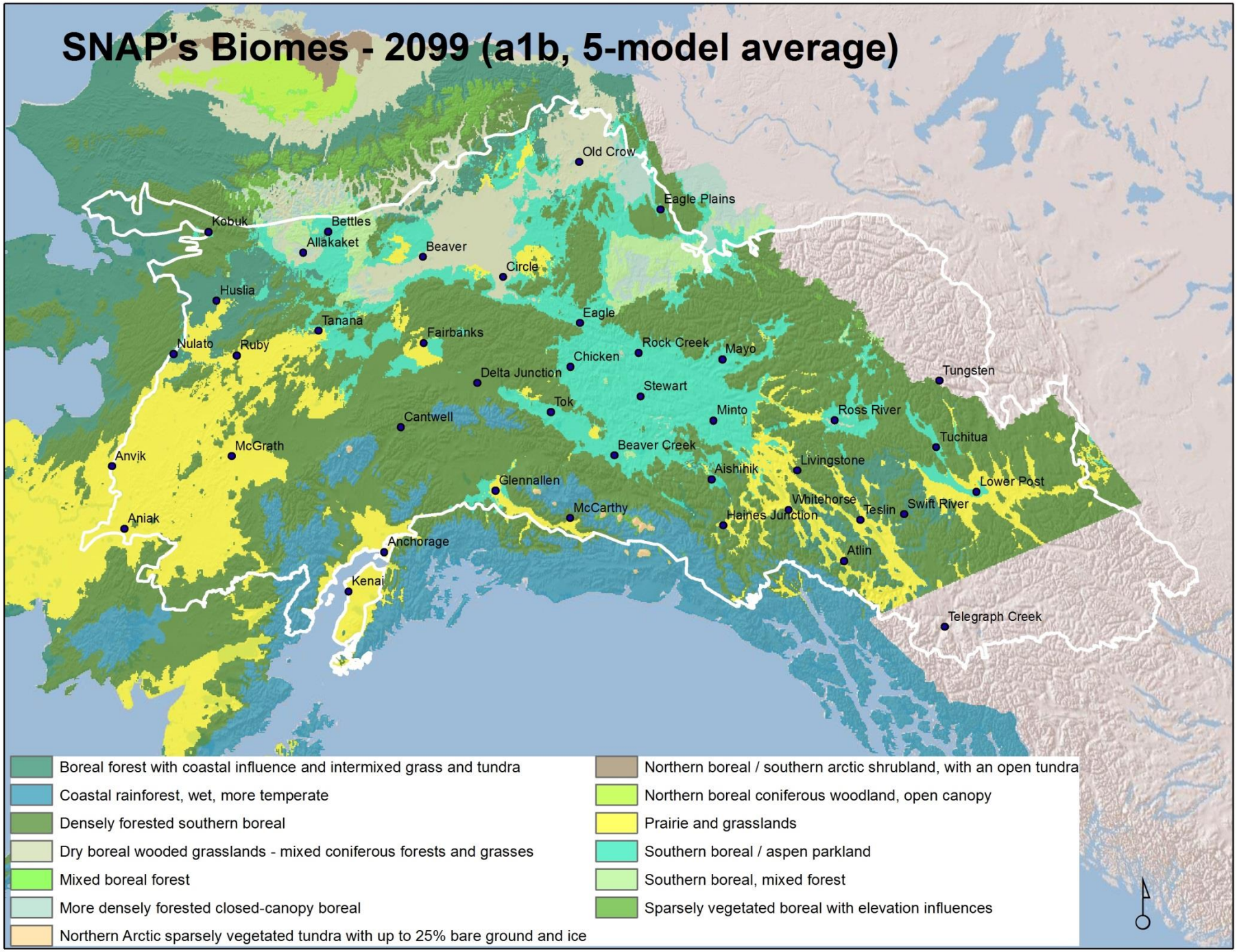
Aishihik
Glennallen
Lower Post
Whitehorse
Swift River
McCarthy
Teslin
Haines Junction
Aniak
Anchorage
Atlin
Kenai
Telegraph Creek
Arctic tundra with denser vegetation and more shrub cover including some small trees
Boreal forest with coastal influence and intermixed grass and tundra
Coastal rainforest, wet, more temperate
Cold northern arctic tundra, but primarily vegetated
Cold northern boreal forest
Densely forested southern boreal
Dry boreal wooded grasslands - mixed coniferous forests and grasses
Dry sparsely vegetated southern arctic tundra
Mixed boreal forest
More densely forested closed-canopy boreal
More densely vegetated arctic tundra with up to 40% shrubs but no tree cover
Northern Arctic sparsely vegetated tundra with up to 25% bare ground and ice
Northern boreal / southern arctic shrubland, with an open tundra
Northern boreal coniferous woodland, open canopy
Prairie and grasslands
Southern boreal / aspen parkland
Southern boreal, mixed forest
Sparsely vegetated boreal with elevation influences


SNAP's Biomes - 2099 (a1b, 5-model average)
Old Crow
Eagle Plains
Kobuk
Bettles
Allakaket
Beaver
Circle
Huslia
Tanana
Eagle
Fairbanks
Nulato
Ruby
Rock Creek
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Haines Junction
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Anchorage
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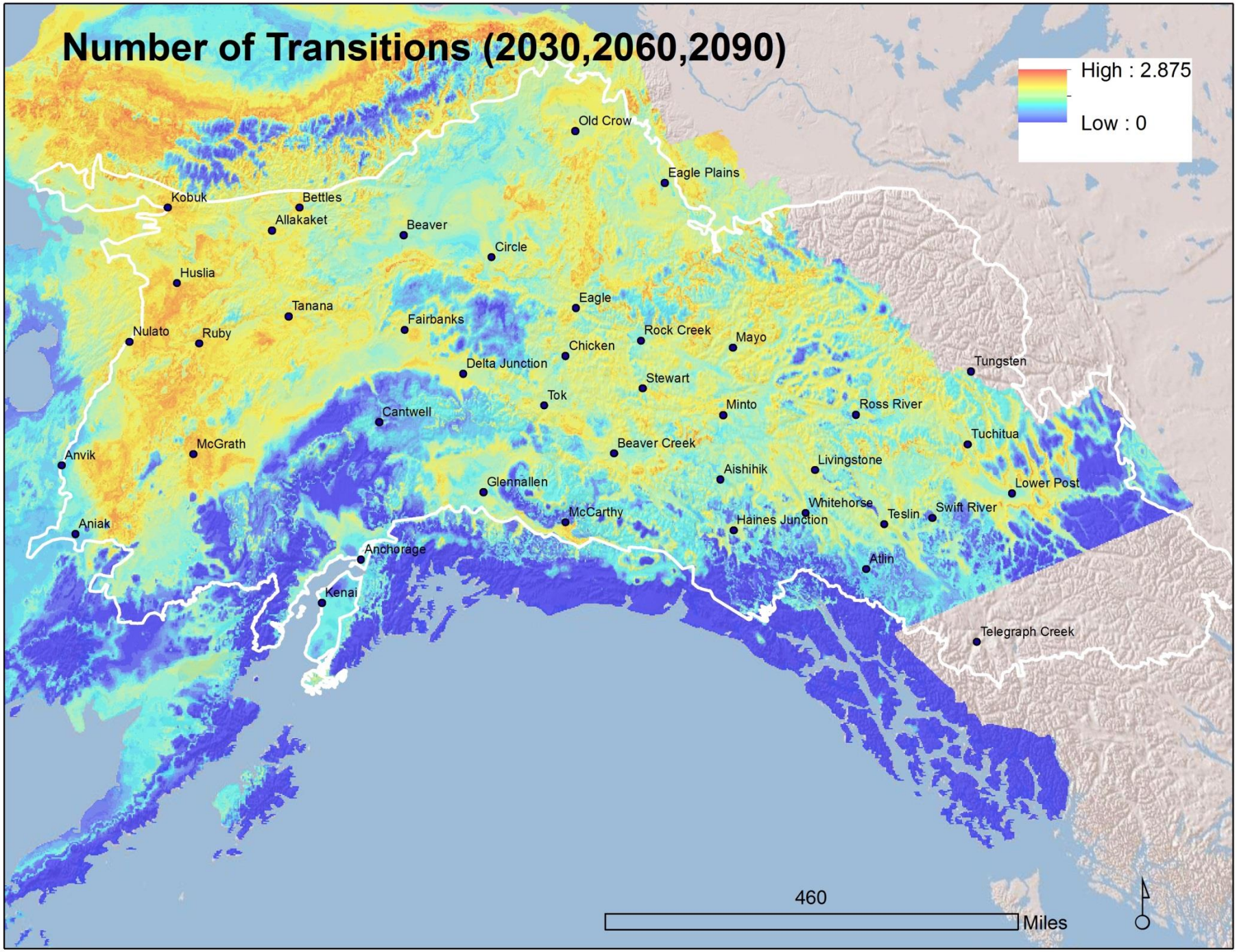
Number of Transitions (2030,2060,2090)
High : 2.875
Low : 0
Old Crow
Eagle Plains
Kobuk
Bettles
Allakaket
Beaver
Circle
Huslia
Tanana
Eagle
Fairbanks
Nulato
Ruby
Rock Creek
Mayo
Chicken
Delta Junction
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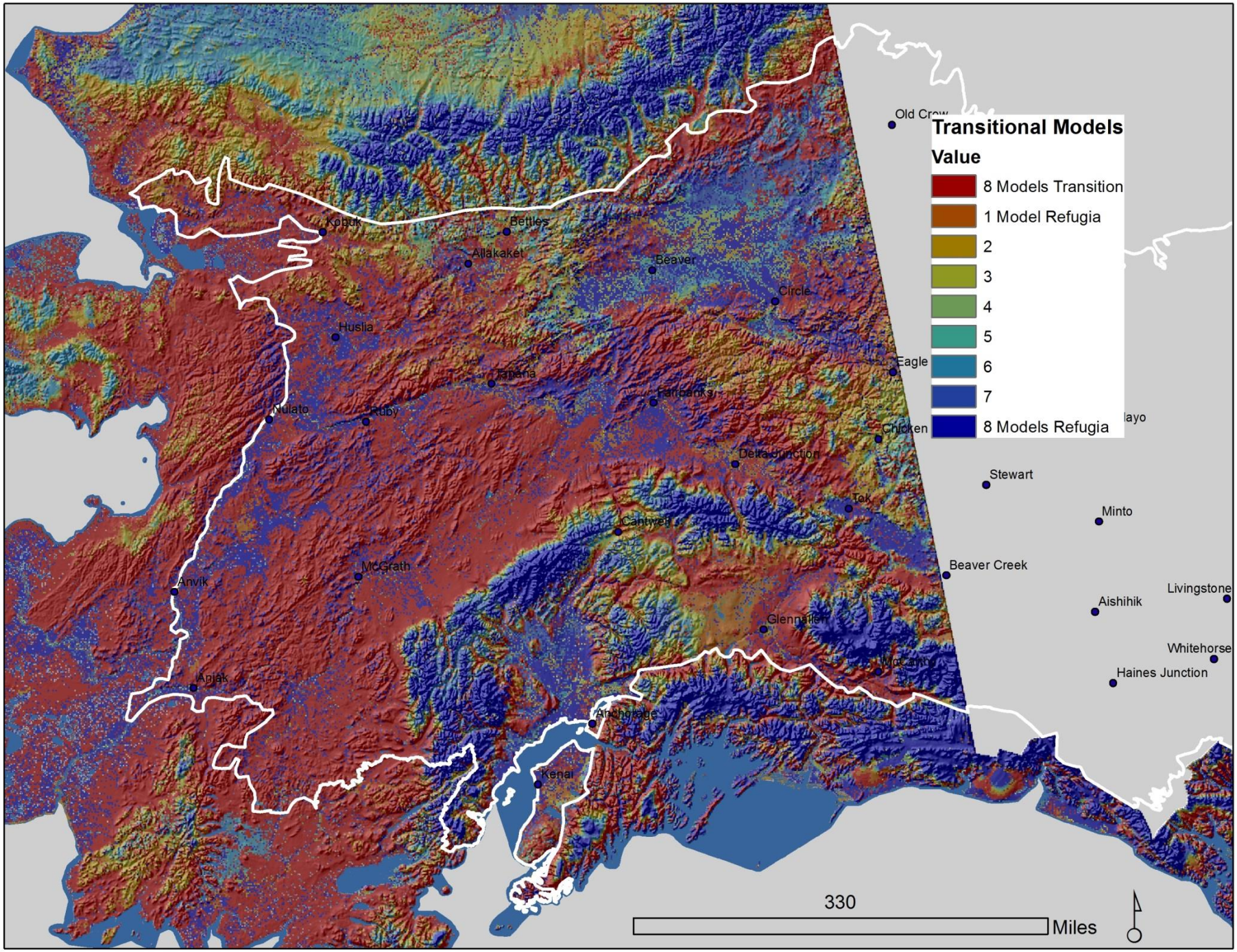
Haines Junction
Aniak
Anchorage
Atlin
Kenai
Telegraph Creek
460
Miles


Transitional Models
Value
8 Models Transition
1 Model Refugia
2
3
4
5
6
7
8 Models Refugia
Old Crow
Kobuk
Bettles
Allakaket
Beaver
Circle
Huslia
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Tanana
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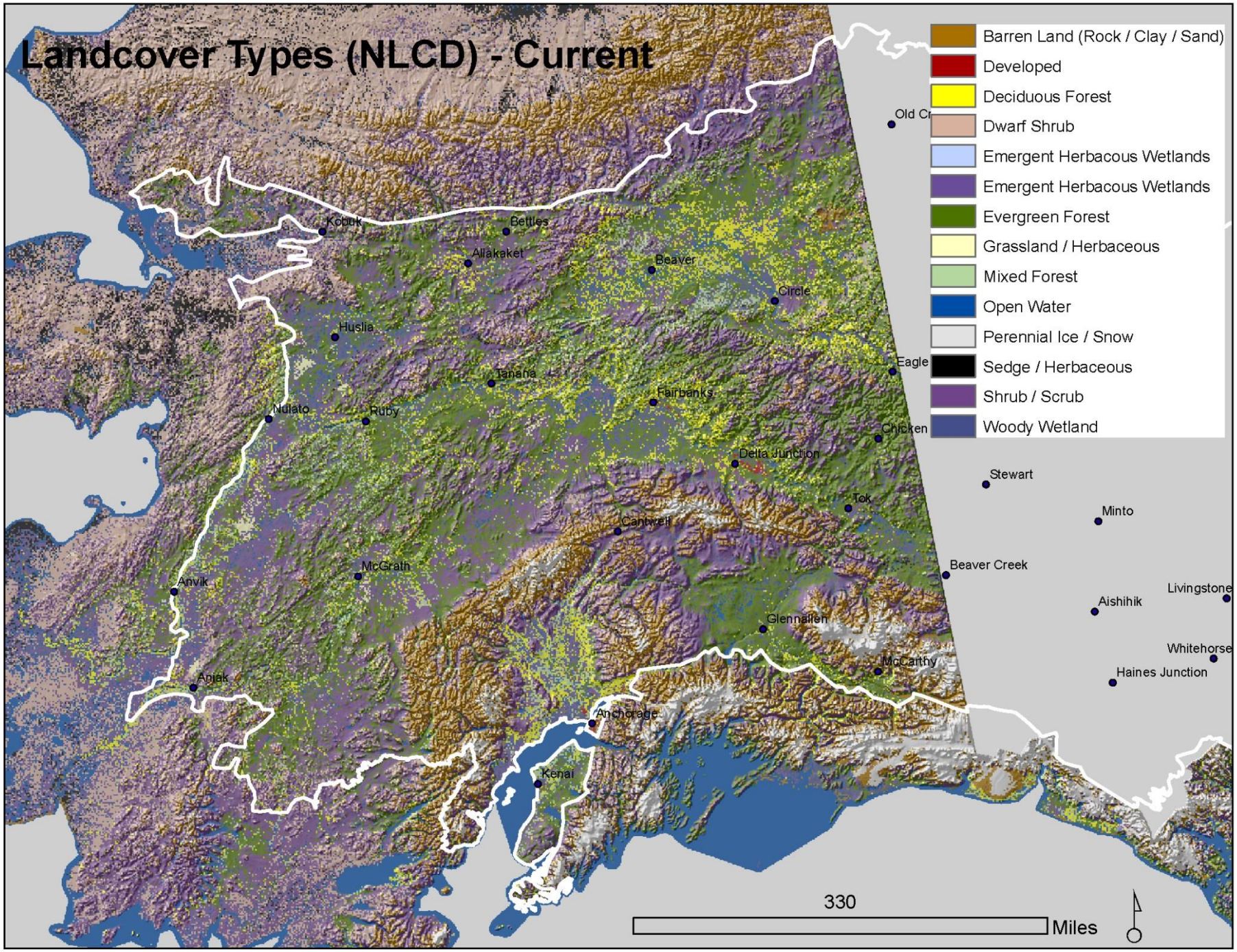
Anchorage
Kenai
330
Miles


Landcover Types (NLCD) - Current
Barren Land (Rock / Clay / Sand)
Developed
Deciduous Forest
Dwarf Shrub
Emergent Herbacous Wetlands
Emergent Herbacous Wetlands
Evergreen Forest
Grassland / Herbaceous
Mixed Forest
Open Water
Perennial Ice / Snow
Sedge / Herbaceous
Shrub / Scrub
Woody Wetland
Old Cr
Kobuk
Bettles
Allakaket
Beaver
Circle
Huslia
Eagle
Tanana
Fairbanks
Nulato
Ruby
Chicken
Delta Junction
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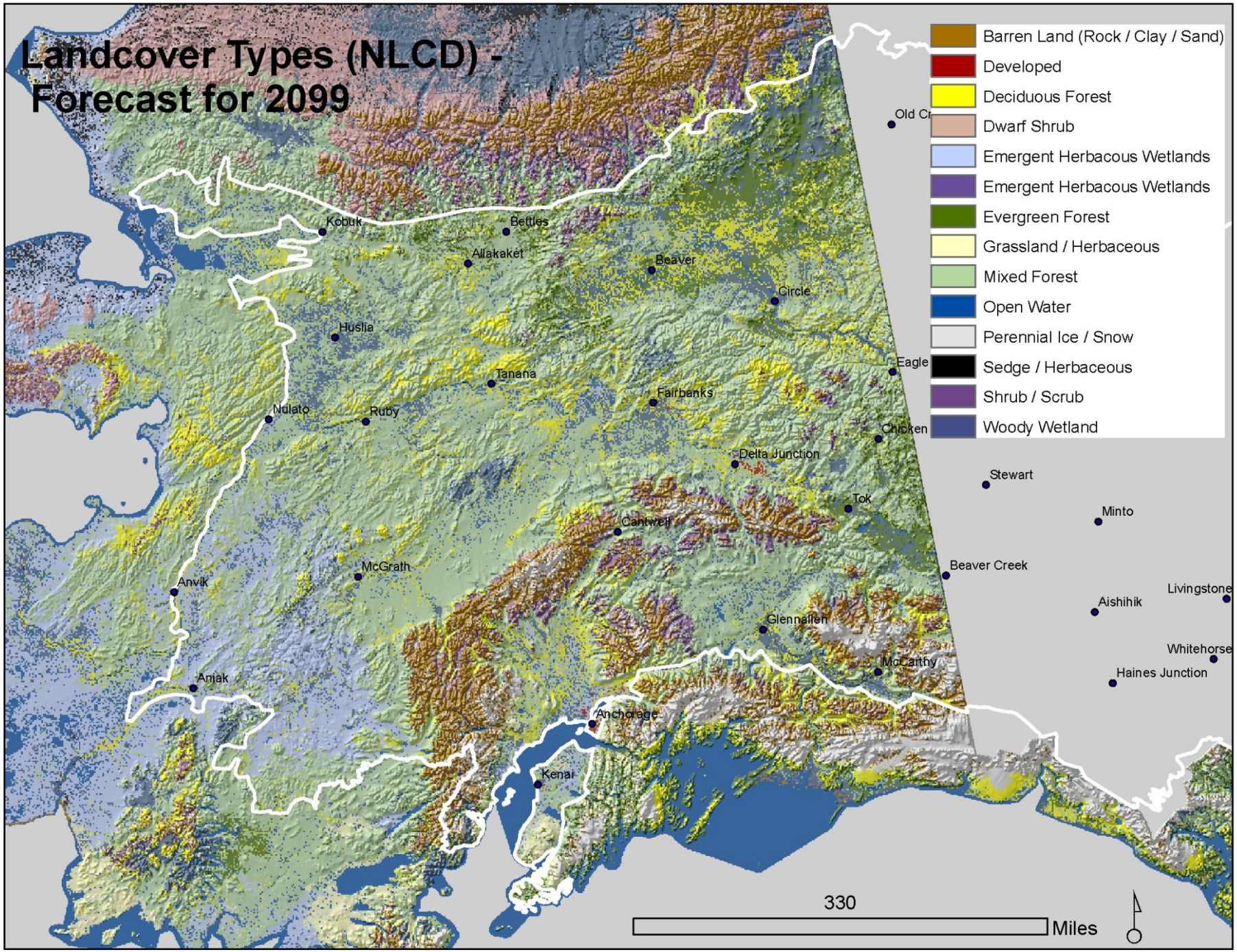
330
Miles


Landcover Types (NLCD) - Forecast for 2099
Barren Land (Rock / Clay / Sand)
Developed
Deciduous Forest
Dwarf Shrub
Emergent Herbacous Wetlands
Emergent Herbacous Wetlands
Evergreen Forest
Grassland / Herbaceous
Mixed Forest
Open Water
Perennial Ice / Snow
Sedge / Herbaceous
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Livingstone
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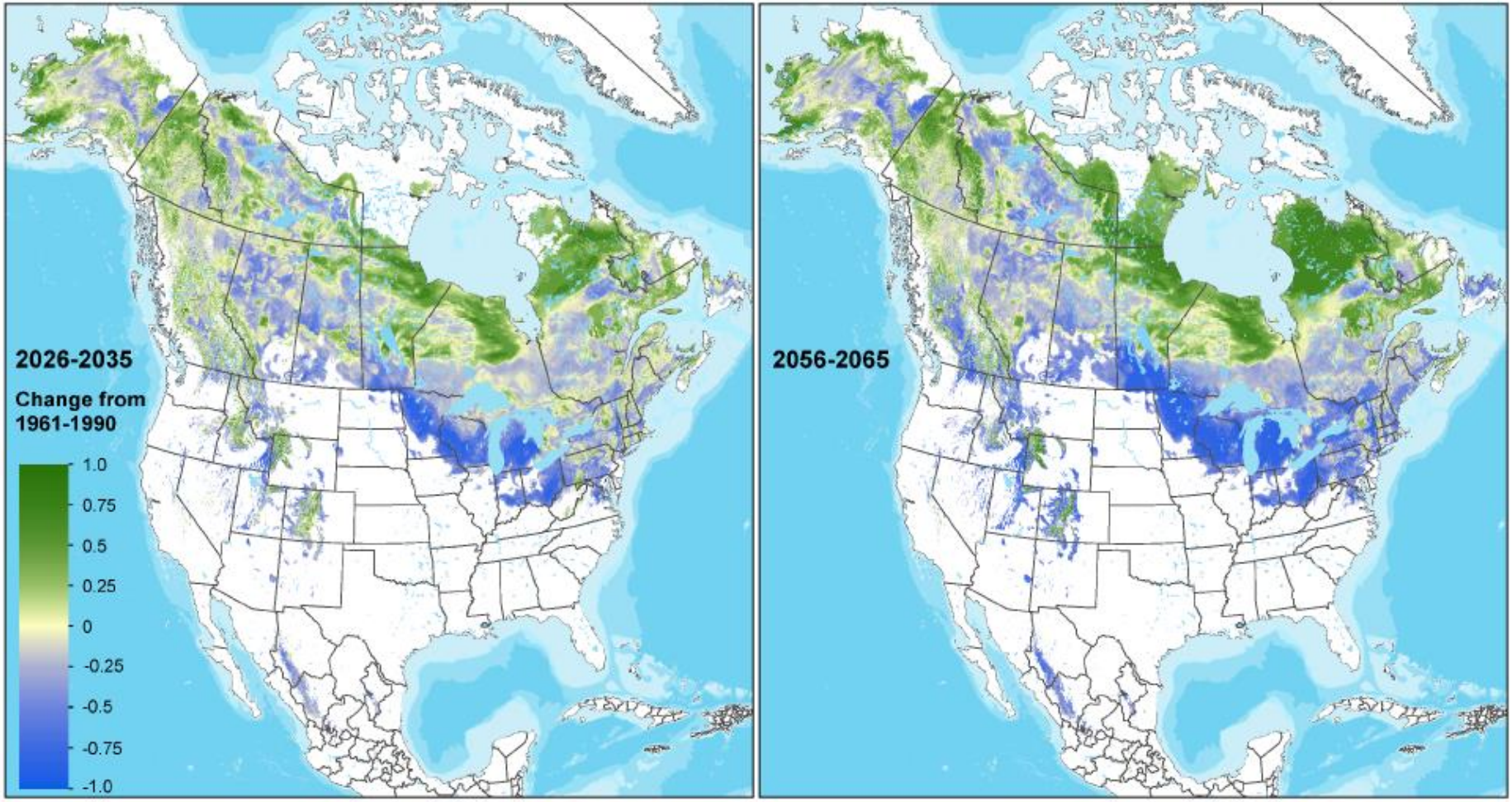
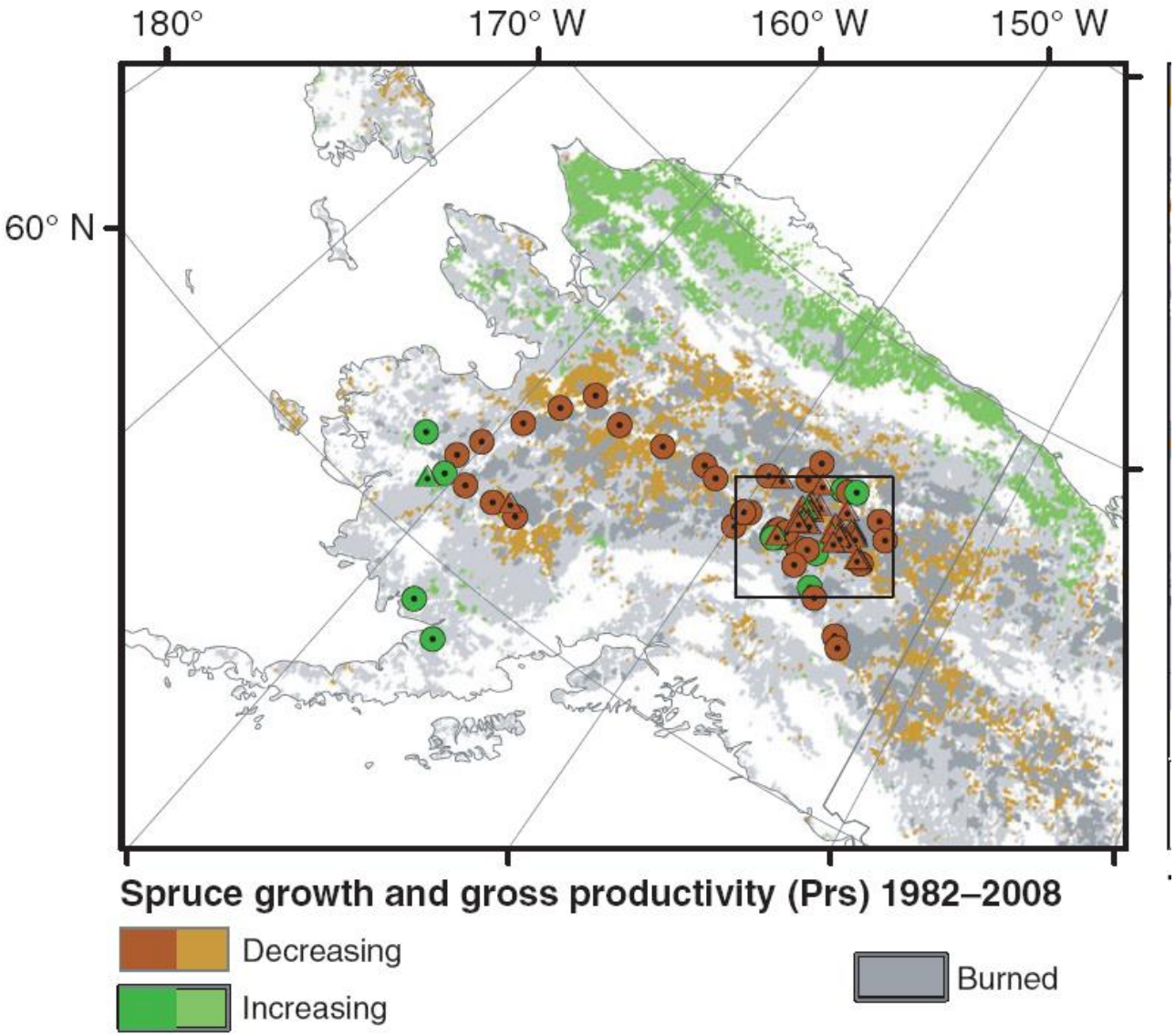
Glennallen
Whitehorse
McCarthy
Haines Junction
Anjak
Anchorage
Kenai
330
Miles



Worrall, J.J., Rehfeldt, G.E., **Hamann, A.**, Hogg, E.H., Marchettia, S.B., Michaelian, M., Gray, L.K. 2013. Recent declines of *Populus tremuloides* in North America linked to climate. *Forest Ecology and Management* **299**: 35–51.



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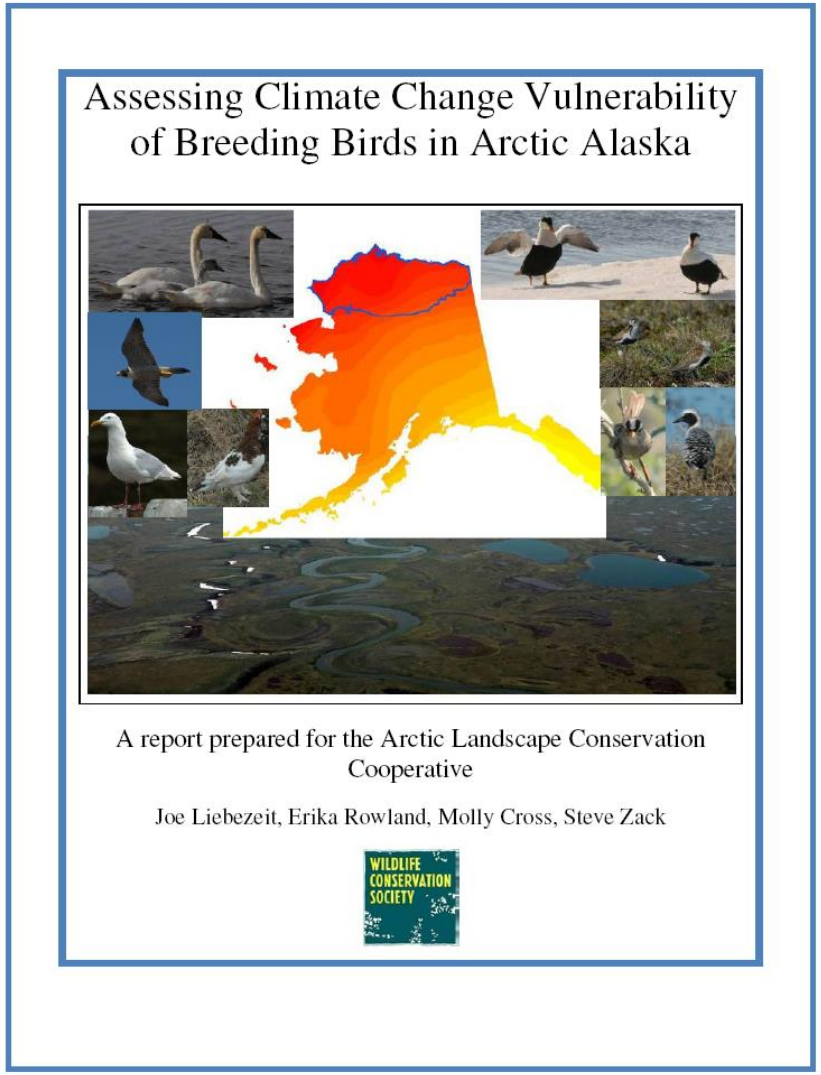
Relative Index

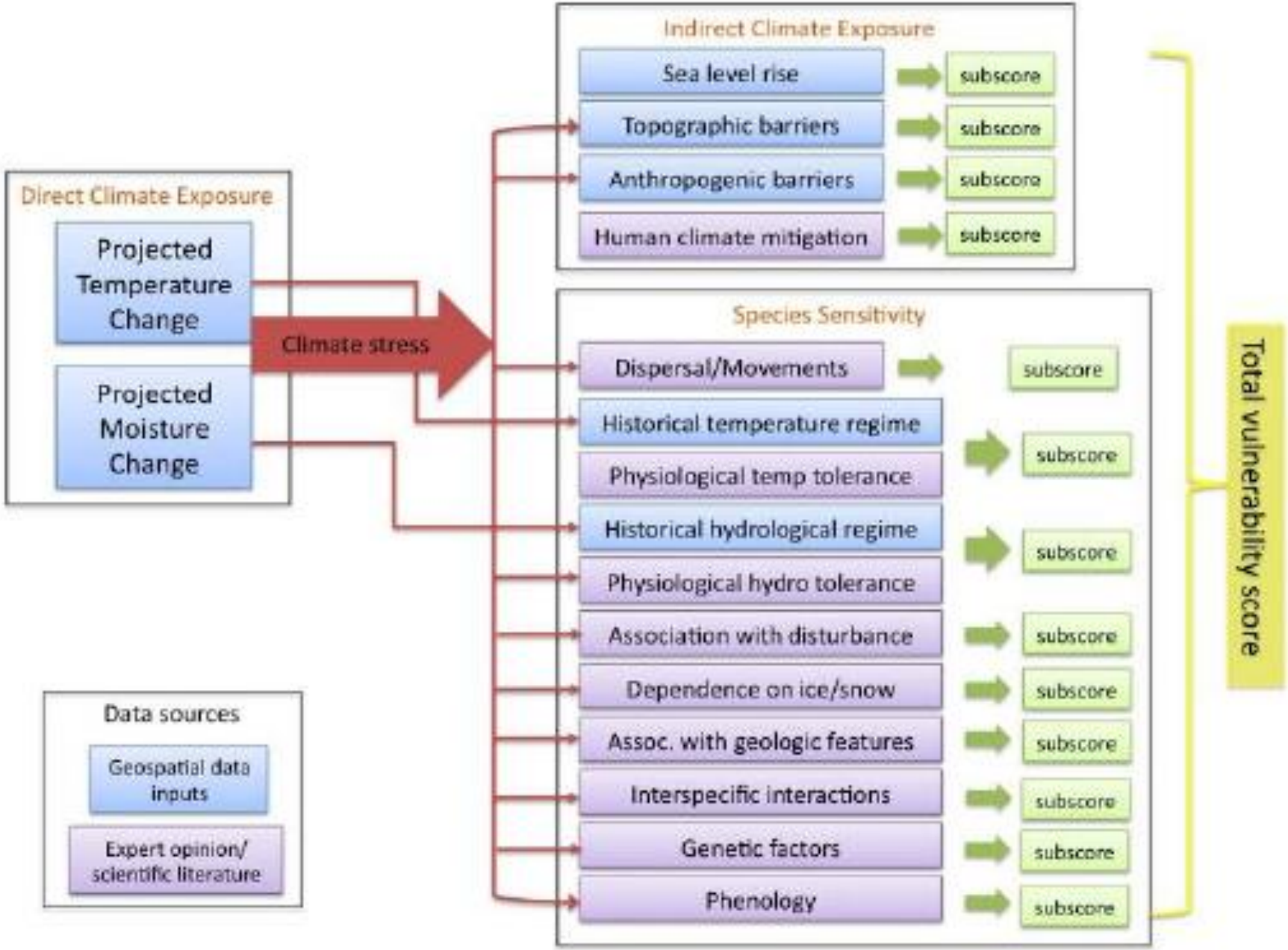

Assessing Climate Change Vulnerability of Breeding Birds in Arctic Alaska

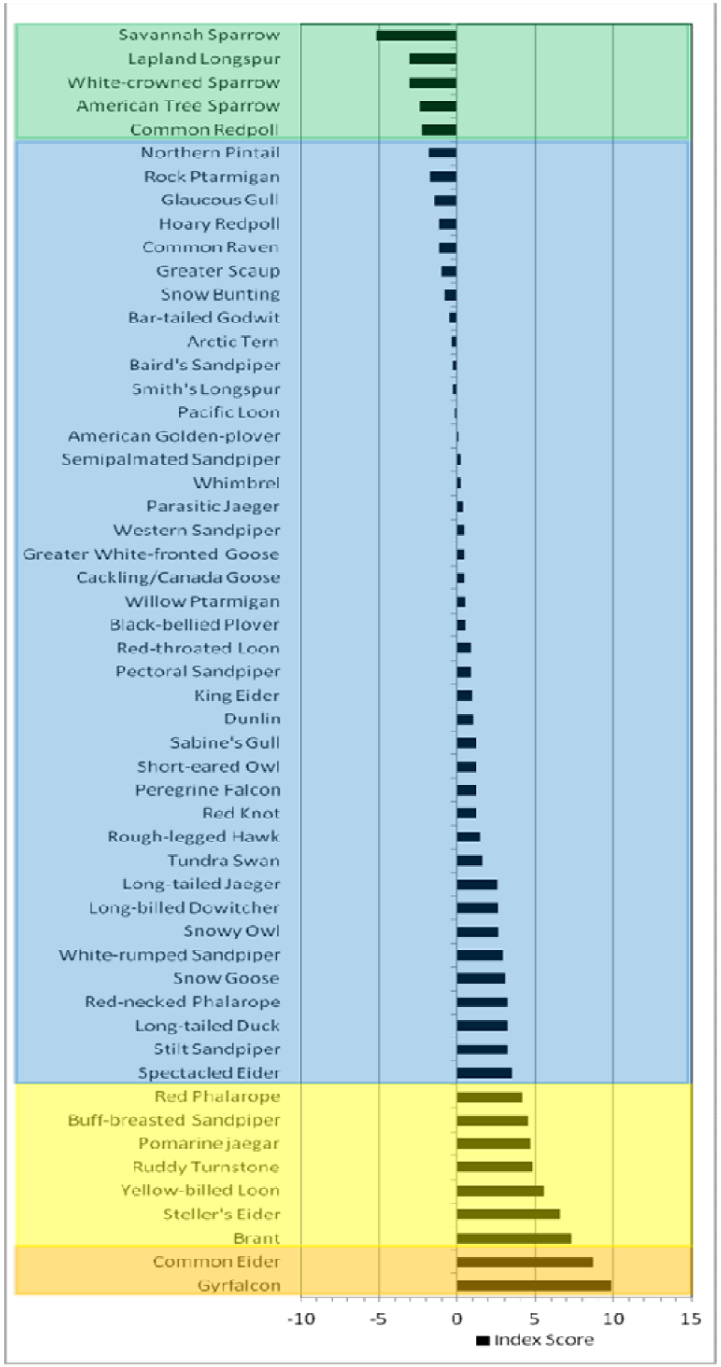
A report prepared for the Arctic Landscape Conservation Cooperative

Joe Liebezeit, Erika Rowland, Molly Cross, Steve Zack

WILDLIFE CONSERVATION SOCIETY

- 54 Species
- Regional
- Aspatial
- **Goal- Rank Species; Identify Sources of Vulnerability**


Indirect Climate Exposure
Sea level rise
subscore
Topographic barriers
subscore
Anthropogenic barriers
subscore
Human climate mitigation
subscore
Direct Climate Exposure
Projected Temperature Change
Projected Moisture Change
Climate stress
Species Sensitivity
Dispersal/Movements
subscore
Historical temperature regime
Physiological temp tolerance
subscore
Historical hydrological regime
Physiological hydro tolerance
subscore
Association with disturbance
subscore
Dependence on ice/snow
subscore
Assoc. with geologic features
subscore
Interspecific interactions
subscore
Genetic factors
subscore
Phenology
subscore
Total vulnerability score
Data sources
Geospatial data inputs
Expert opinion/ scientific literature



Index Score	*Vulnerability Category*
>10.0	Extremely vulnerable (red)
7.0-9.9	Highly vulnerable (orange)
4.0-6.9	Moderately vulnerable (yellow)
-2.0-3.99	Presumed stable (blue)
<-2.0	Increase likely (green)

Liebezeit, J., E.L. Rowland, M. Cross and S. Zack. 2012. Assessing climate change vulnerability of breeding birds in Arctic Alaska. A report prepared for the Arctic Landscape Conservation Cooperative. Wildlife Conservation Society, North America Program, Bozeman, MT. 167pp

Greater White-fronted Goose (*Anser albifrons*)

Vulnerability: **Presumed Stable** Confidence: High

Vulnerability Factors	D	SD	N	SI	I	GI	Unknown or N/A
B1. Sea level rise			*				
B2a. Natural barriers			*				
B2b. Anthropogenic barriers			*				
B3. Human response to CC			*	*			
C1. Dispersal/Movement			*				
C2ai. Historical thermal niche (GIS)			*				
C2aii. Physiological thermal niche		*	*				
C2bi. Historical hydro niche (GIS)			*				
C2bii. Physiological hydro niche				*	*	*	
C2c. Disturbance regime		*	*	*			
C2d. Ice & Snow habitats			*				
C3. Physical habitat restrictions		*					
C4a. Biotic habitat dependence			*	*			
C4b. Dietary versatility			*				
C4d. Biotic dispersal dependence			*				
C4e. Interactions with other species			*	*			
C5a. Genetic variation			*				
C5b. Genetic bottlenecks			*				
C6. Phenological response		*	*	*			*
D1. CC-related distribution response			*				*

D=Decrease vulnerability, SD=Somewhat decrease vulnerability, N=Neutral effect, SI=Slightly increase vulnerability, I=Increase vulnerability, GI=Greatly increase vulnerability.

Brant (*Branta bernicla*)

Vulnerability: **Moderately Vulnerable** Confidence: Moderate

Vulnerability Factors	D	SD	N	SI	I	GI	Unknown or N/A
B1. Sea level rise				*			
B2a. Natural barriers				*			
B2b. Anthropogenic barriers			*				
B3. Human response to CC			*	*			
C1. Dispersal/Movement			*				
C2ai. Historical thermal niche (GIS)			*				
C2aii. Physiological thermal niche			*	*			
C2bi. Historical hydro niche (GIS)						*	
C2bii. Physiological hydro niche				*	*	*	
C2c. Disturbance regime		*	*	*	*		
C2d. Ice & Snow habitats			*				
C3. Physical habitat restrictions		*	*				
C4a. Biotic habitat dependence			*	*			
C4b. Dietary versatility			*	*			
C4d. Biotic dispersal dependence			*				
C4e. Interactions with other species			*	*			
C5a. Genetic variation							*
C5b. Genetic bottlenecks			*				
C6. Phenological response		*	*	*			*
D1. CC-related distribution response			*				

D=Decrease vulnerability, SD=Somewhat decrease vulnerability, N=Neutral effect, SI=Slightly increase vulnerability, I=Increase vulnerability, GI=Greatly increase vulnerability.

Relative Index

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Identifying the World's Most Climate Change Vulnerable Species: A Systematic Trait-Based Assessment of all Birds, Amphibians and Corals

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Abstract

Climate change will have far-reaching impacts on biodiversity, including increasing extinction rates. Current approaches to quantifying such impacts focus on measuring exposure to climatic change and largely ignore the biological differences between species that may significantly increase or reduce their vulnerability. To address this, we present a framework for assessing three dimensions of climate change vulnerability, namely sensitivity, exposure and adaptive capacity; this draws on species' biological traits and their modeled exposure to projected climatic changes. In the largest such assessment to date, we applied this approach to each of the world's birds, amphibians and corals (16,857 species). The resulting assessments identify the species with greatest relative vulnerability to climate change and the geographic areas in which they are concentrated, including the Amazon basin for amphibians and birds, and the central Indo-west Pacific (Coral Triangle) for corals. We found that high concentration areas for species with traits conferring highest sensitivity and lowest adaptive capacity differ from those of highly exposed species, and we identify areas where exposure-based assessments alone may over or under-estimate climate change impacts. We found that 608–851 bird (6–9%), 670–933 amphibian (11–15%), and 47–73 coral species (6–9%) are both highly climate change vulnerable and already threatened with extinction on the IUCN Red List. The remaining highly climate change vulnerable species represent new priorities for conservation. Fewer species are highly climate change vulnerable under lower IPCC SRES emissions scenarios, indicating that reducing greenhouse emissions will reduce climate change driven extinctions. Our study answers the growing call for a more biologically and ecologically inclusive approach to assessing climate change vulnerability. By facilitating independent assessment of the three dimensions of climate change vulnerability, our approach can be used to devise species and area-specific conservation interventions and indices. The priorities we identify will strengthen global strategies to mitigate climate change impacts.

Citation: Foden WB, Butchart SHM, Stuart SN, Vié J-C, Akçakaya HR, et al. (2013) Identifying the World's Most Climate Change Vulnerable Species: A Systematic Trait-Based Assessment of all Birds, Amphibians and Corals. PLoS ONE 8(6): e65427. doi:10.1371/journal.pone.0065427

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Competing Interests: The authors have declared that no competing interests exist.

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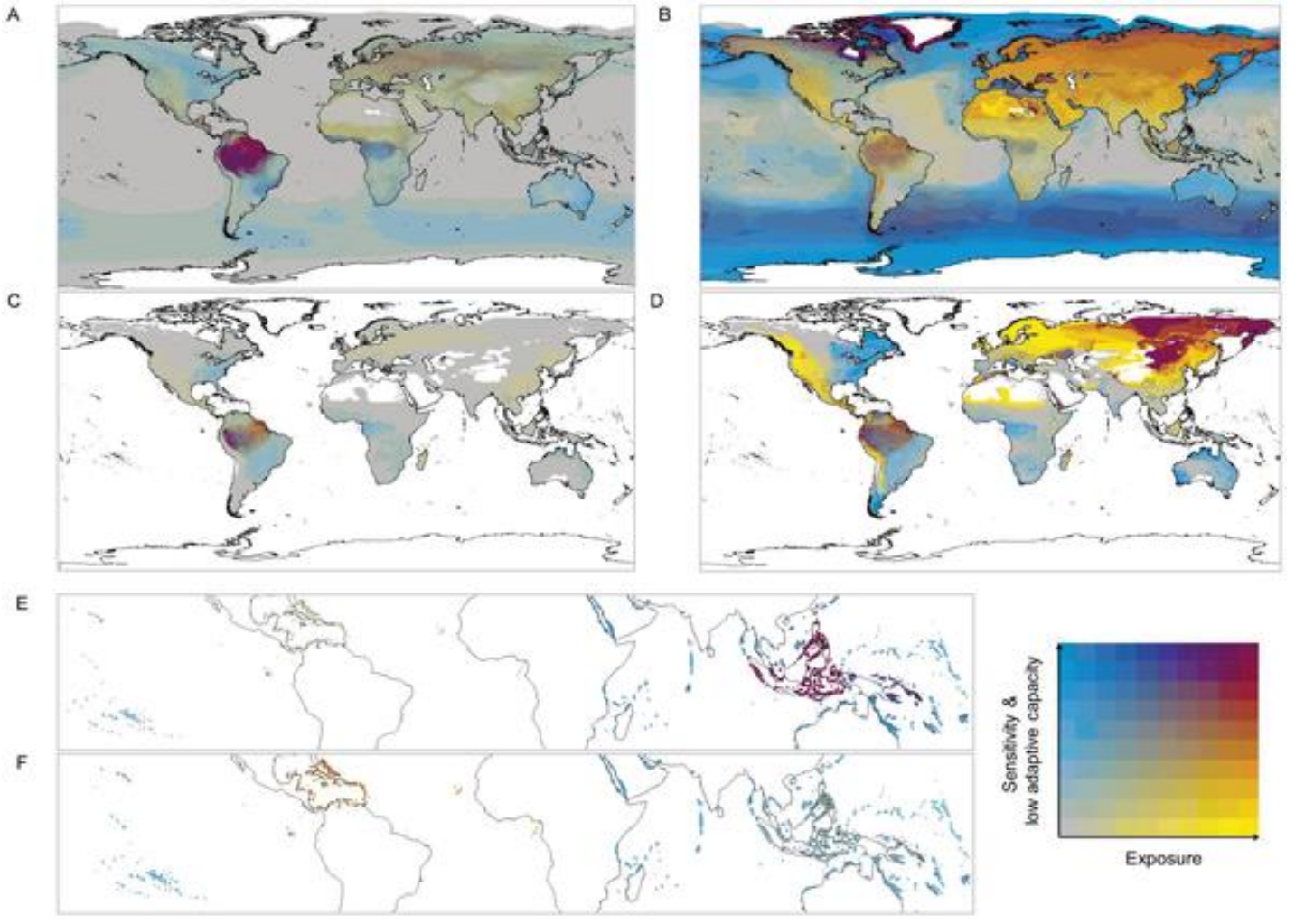
- 16,857 Species
- Global
- Spatial
- **Goal-** Rank Species; Identify Sources of Vulnerability, Geography of Vulnerability

Figure 2. Concentrations of climate change vulnerable species.



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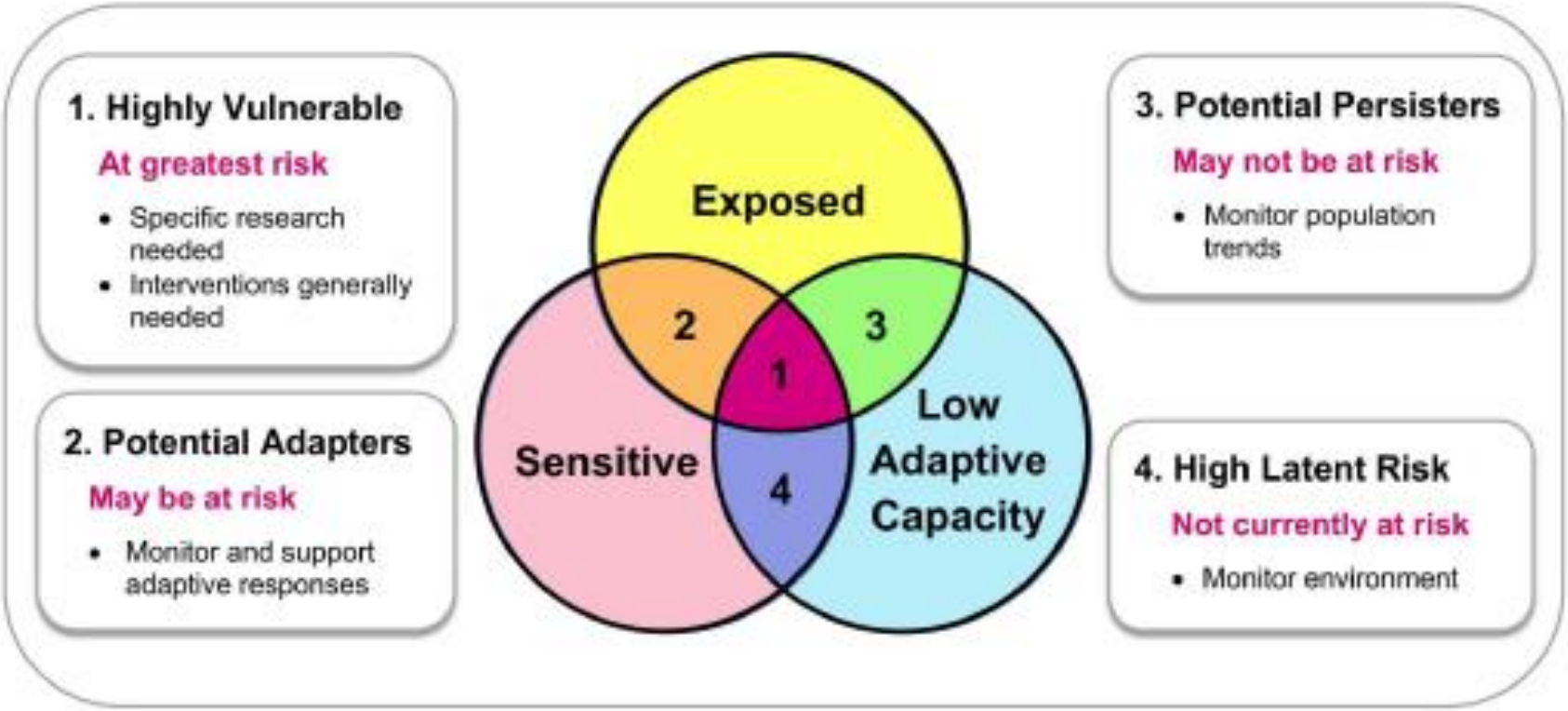

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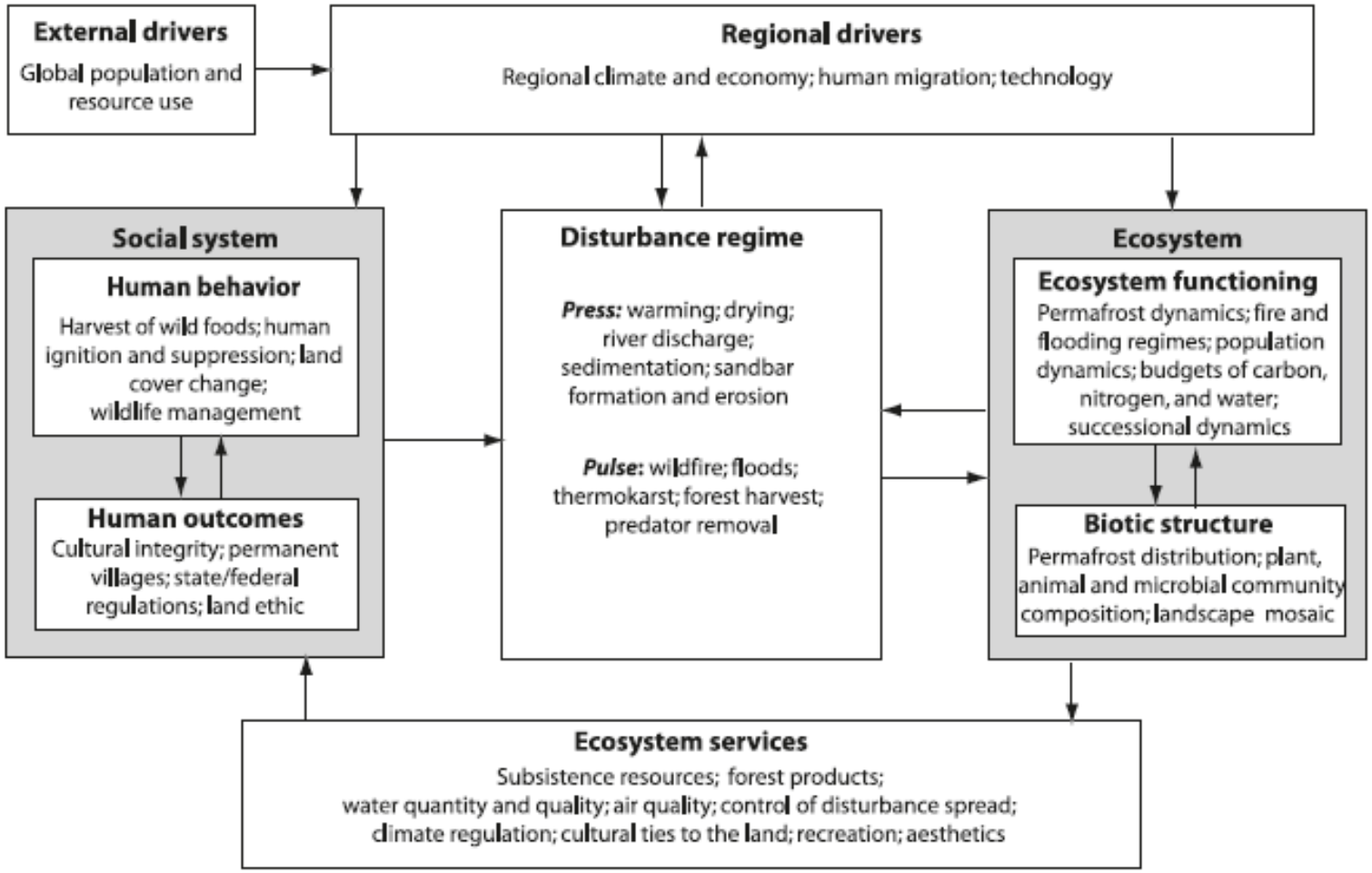
Conceptual Model of Social Ecological System