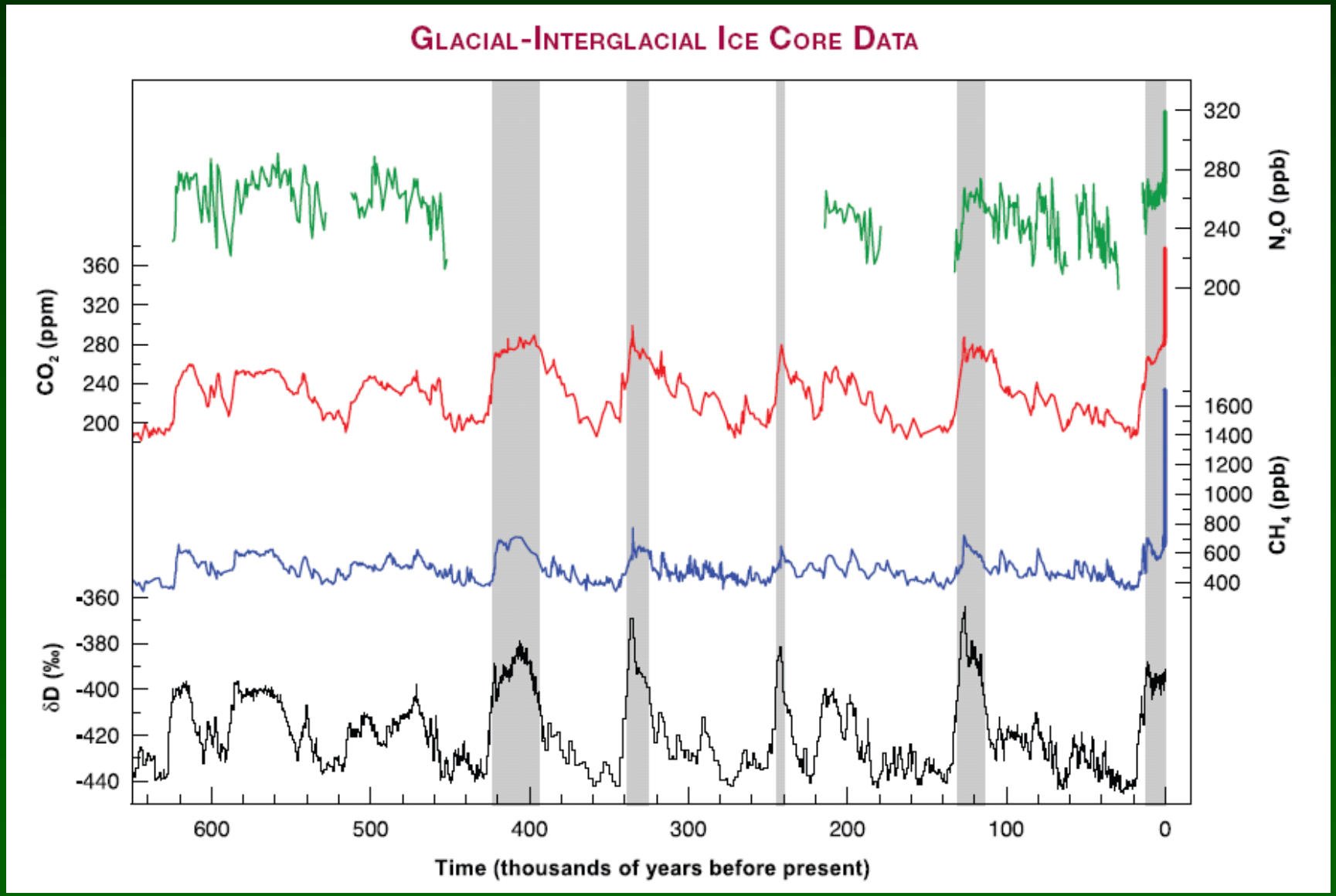
Using SNAP Climate Models to Project Species Shifts, Biome Change, and Landscape Connections

Nancy Fresco
Karen Murphy
Falk Huettmann
John Morton


Glacial-Interglacial Ice Core Data
CO2 (ppm)
360
320
280
240
200
δD (‰)
-360
-380
-400
-420
-440
N2O (ppb)
320
280
240
200
CH4 (ppb)
1600
1400
1200
1000
800
600
400
600
500
400
300
200
100
0
Time (thousands of years before present)

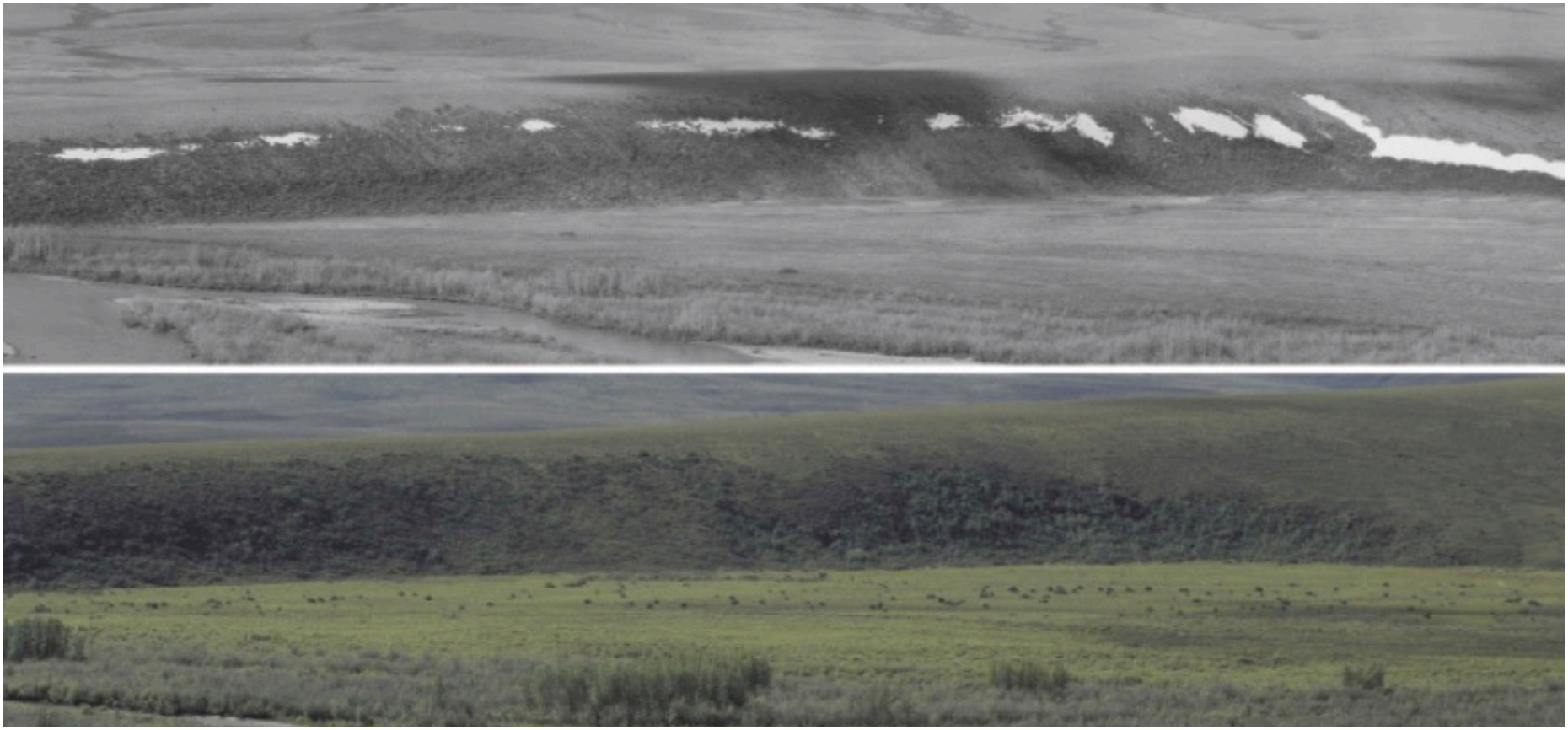
Total Change in Mean Seasonal and Annual Temperature (°F), 1949 - 2008

Region	Location	Winter	Spring	Summer	Autumn	Annual
Arctic	Barrow	6.5	4.4	2.8	3.4	4.3
Interior	Bettles	8.5	4.6	1.8	1.1	3.9
	Big Delta	9.2	3.5	1.2	-0.2	3.4
	Fairbanks	7.7	3.8	2.3	-0.4	3.3
	McGrath	7.4	4.8	2.7	0.6	3.9
West Coast	Kotzebue	6.6	1.8	2.5	1.6	3.1
	Nome	4.4	3.6	2.5	0.6	2.8
	Bethel	6.6	5.0	2.3	0.1	3.6
	King Salmon	8.1	4.7	1.8	0.6	3.8
	Cold Bay	1.5	1.8	1.8	0.9	1.5
	St Paul	1.0	2.4	2.8	1.3	1.9
Southcentral	Anchorage	6.8	3.6	1.6	1.4	3.1
	Talkeetna	8.9	5.4	3.1	2.4	5.0
	Gulkana	8.1	2.4	0.9	0	2.8
	Homer	6.3	4.0	3.4	1.7	3.9
	Kodiak	0.9	2.3	1.2	-0.4	1.0
Southeast	Yakutat	4.9	3.1	1.8	0.3	2.6
	Juneau	6.6	3.1	2.1	1.4	3.3
	Annette	3.9	2.5	1.7	0.2	2.1
	Average	6.0	3.5	2.1	0.9	3.1

Alaska Climate Research Center

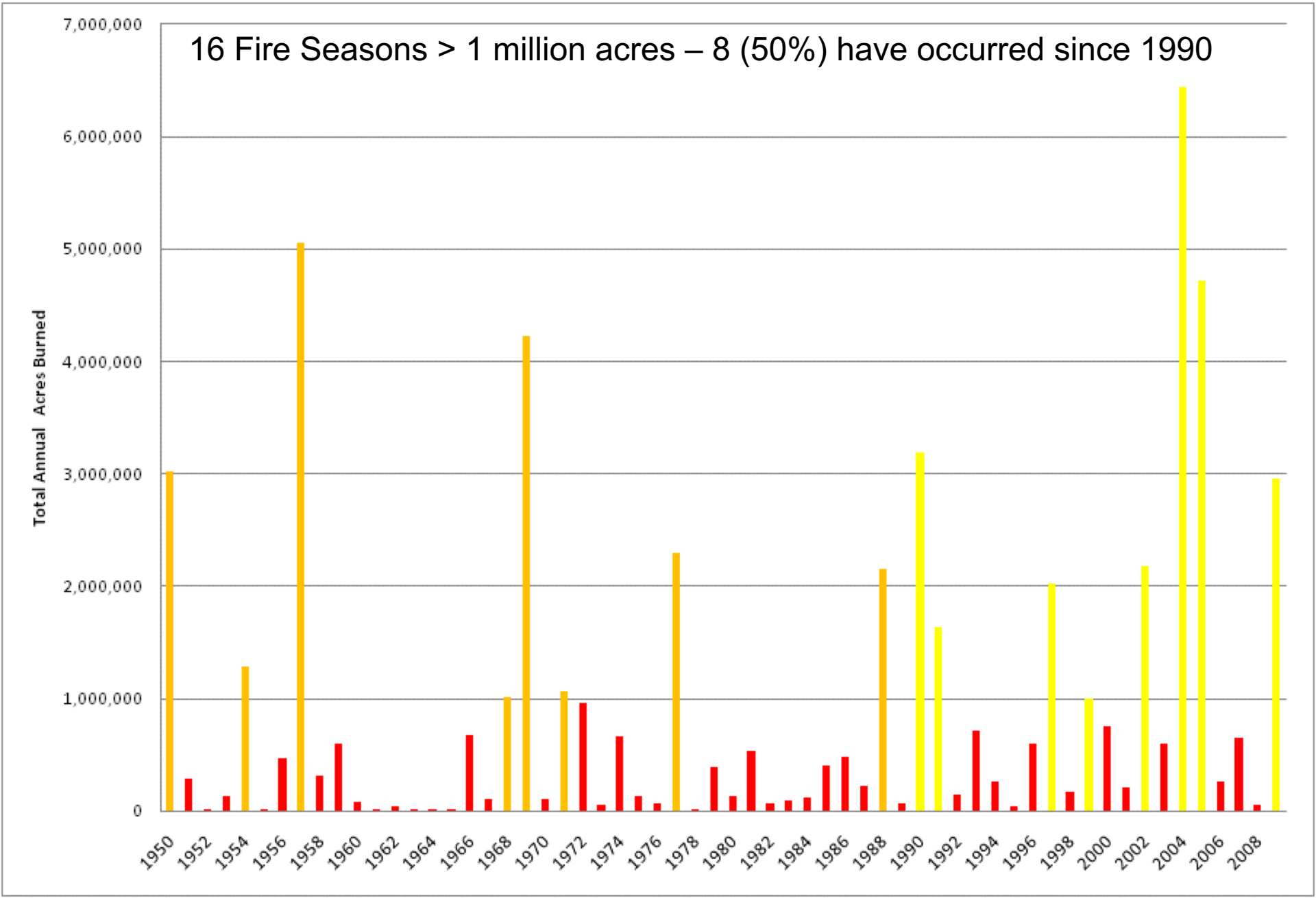
Geophysical Institute, University of Alaska Fairbanks

Shrub Expansion in Northern Alaska



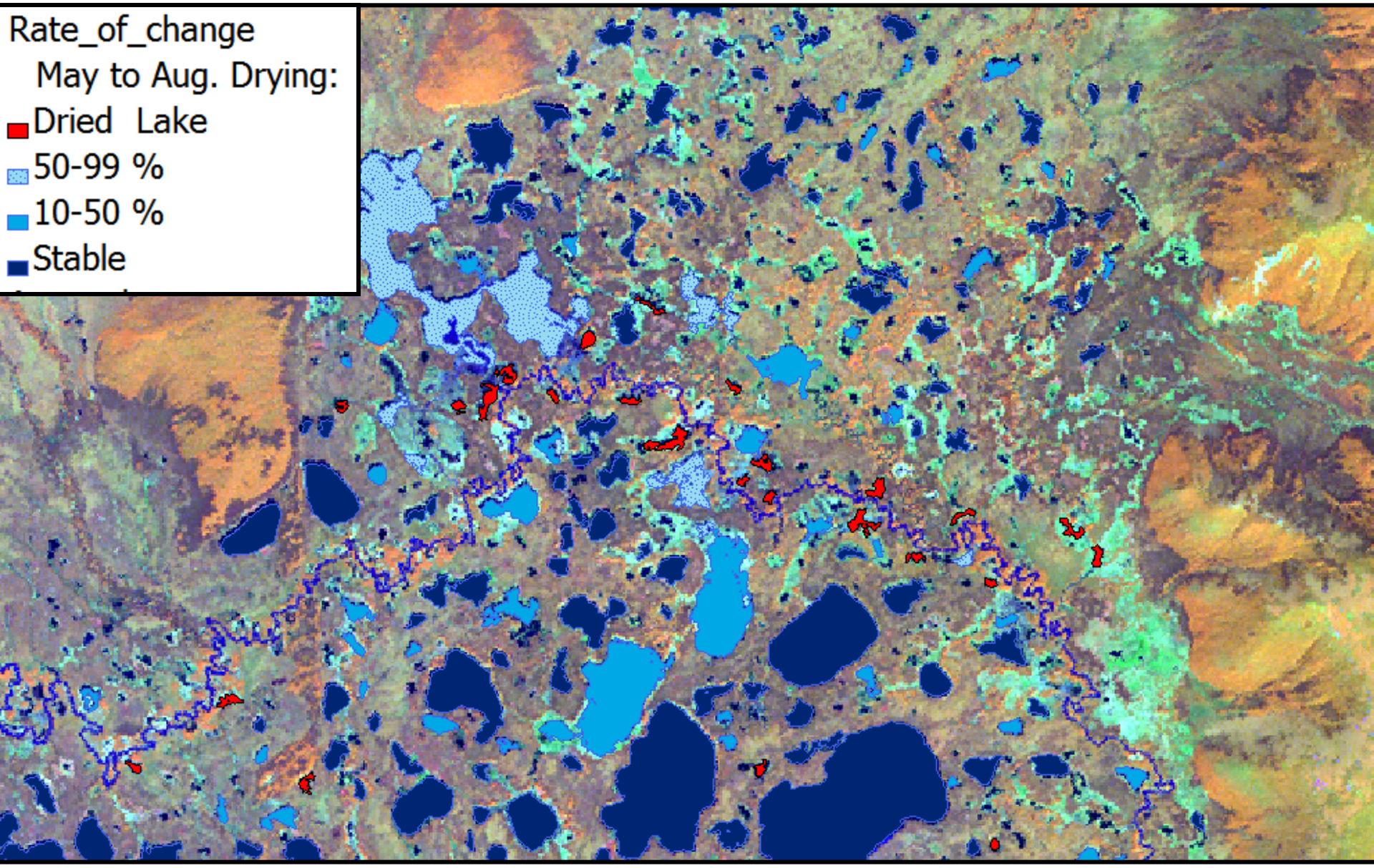
Tape et al. 2006

Total Annual Area Burned in Alaska 1950-2009

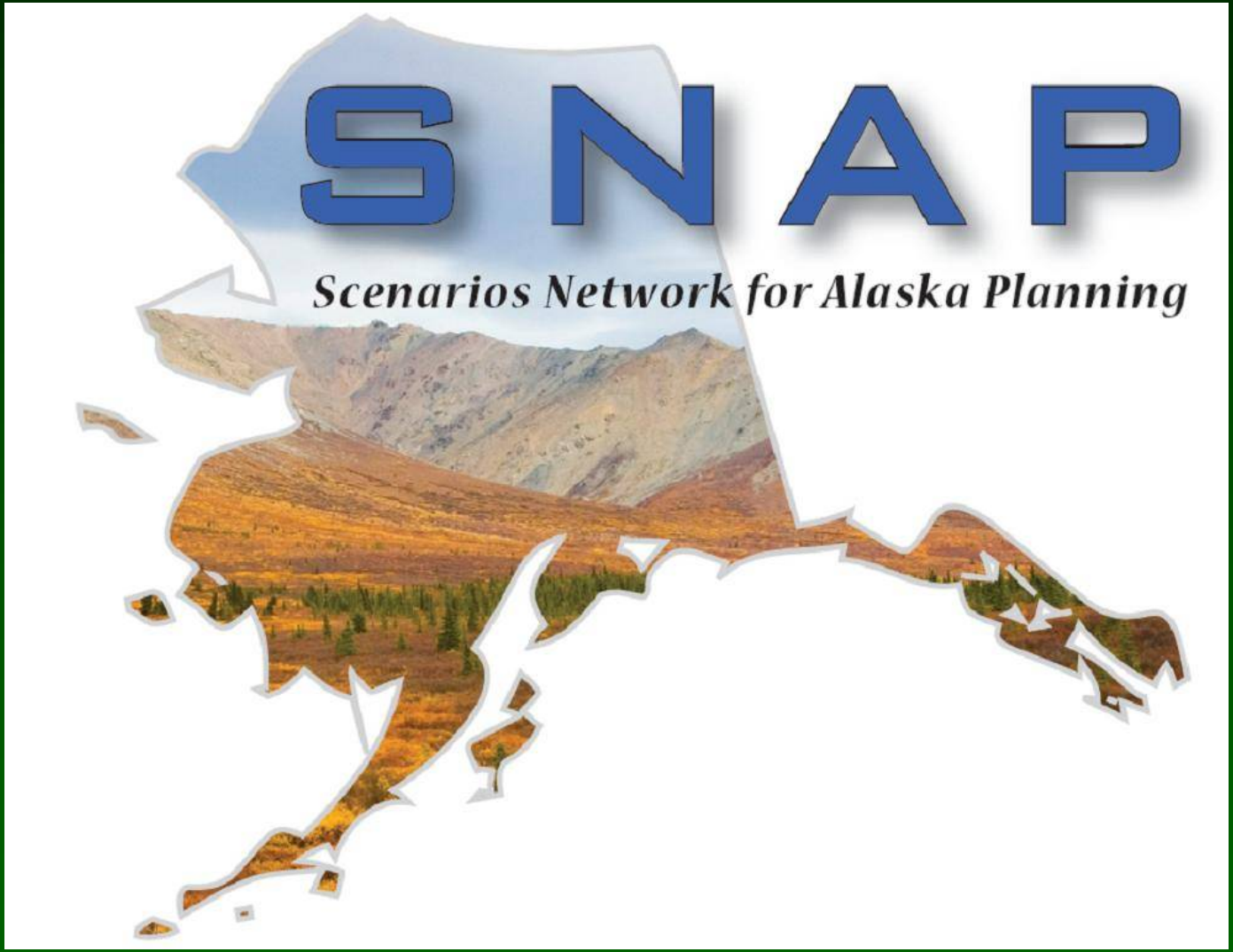



Thermokarst Fens and Forest Conversion
Tanana Flats
1999 Photo by Torre Jorgenson

Denali National Park Seasonal Dynamics of Shallow Lakes



Source: D. Verbyla



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Many Traditions One Alaska

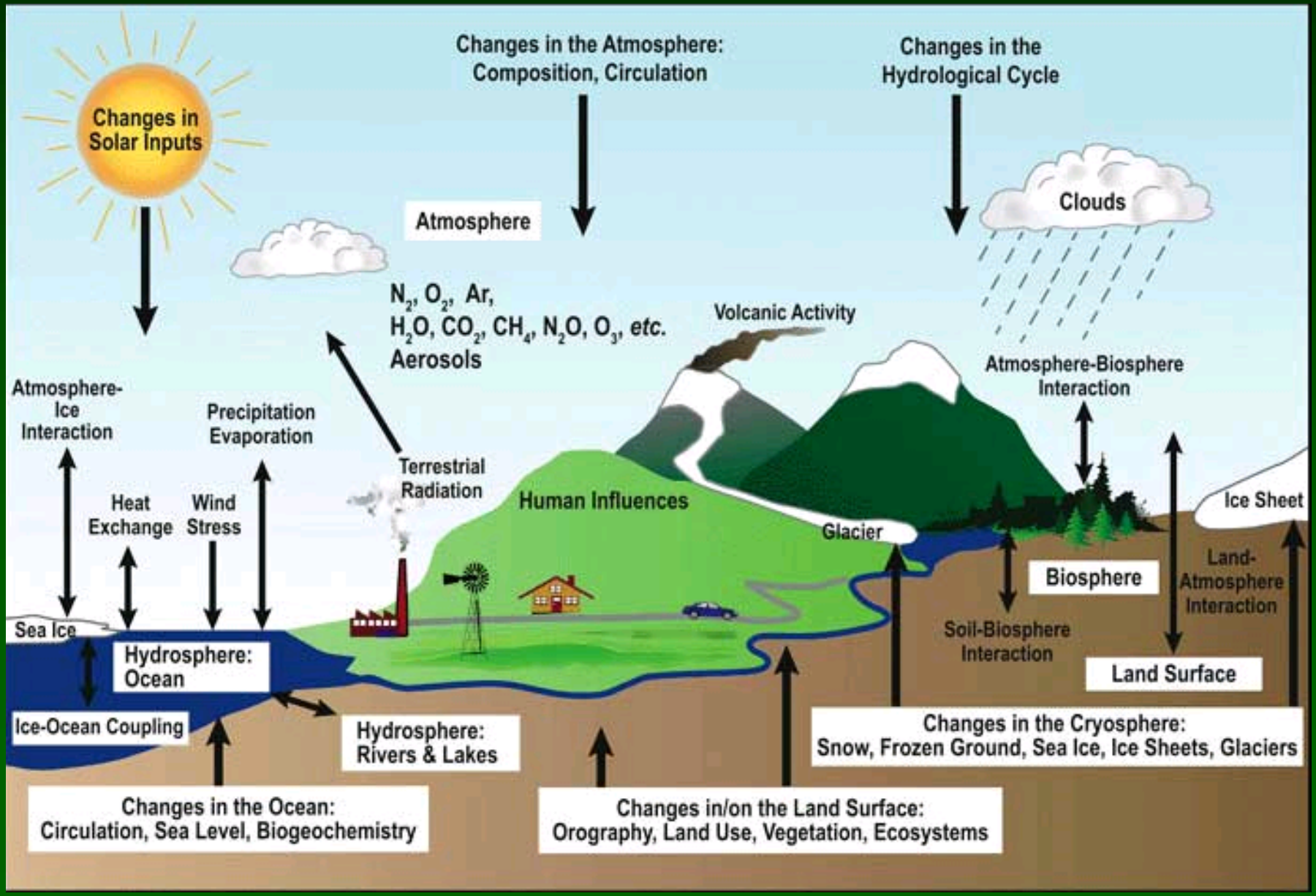
UNIVERSITY OF ALASKA GEOGRAPHY PROGRAM
UAGP

UAF
UNIVERSITY OF ALASKA FAIRBANKS

What is SNAP?

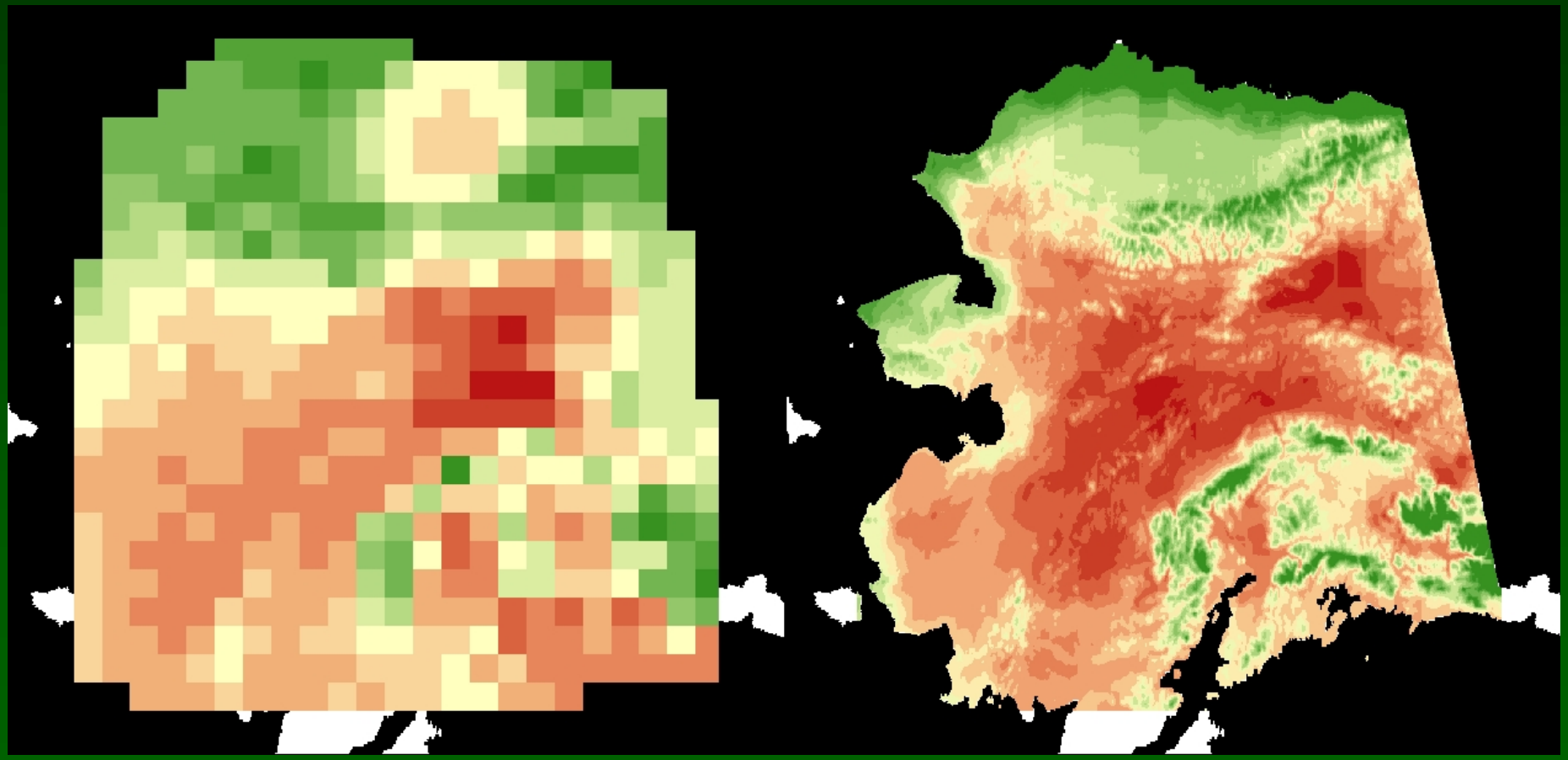
SNAP is a collaborative network of the University of Alaska, state, federal, and local agencies, NGOs, and industry partners.

Its mission is to provide timely access to scenarios of future conditions in Alaska for more effective planning by decision-makers, communities, and industry.


Changes in Solar Inputs
Changes in the Atmosphere: Composition, Circulation
Changes in the Hydrological Cycle
Atmosphere
Clouds
N_2, O_2, Ar,
H_2O, CO_2, CH_4, N_2O, O_3, *etc.*
Aerosols
Volcanic Activity
Atmosphere-Biosphere Interaction
Atmosphere-Ice Interaction
Precipitation Evaporation
Heat Exchange
Wind Stress
Terrestrial Radiation
Human Influences
Glacier
Ice Sheet
Biosphere
Land-Atmosphere Interaction
Soil-Biosphere Interaction
Land Surface
Sea Ice
Hydrosphere: Ocean
Ice-Ocean Coupling
Hydrosphere: Rivers & Lakes
Changes in the Cryosphere: Snow, Frozen Ground, Sea Ice, Ice Sheets, Glaciers
Changes in the Ocean: Circulation, Sea Level, Biogeochemistry
Changes in/on the Land Surface: Orography, Land Use, Vegetation, Ecosystems

Projections based on IPCC models

- Selected the 5 models that performed best for Alaska and the far north
- Three emissions scenarios:
  - A2 (pessimistic)
  - A1B (intermediate)
  - B1 (optimistic)
- Downscaled to 2km



CRU – 0.5 x 0.5 degrees

Downscaled CRU – 2 x 2 km

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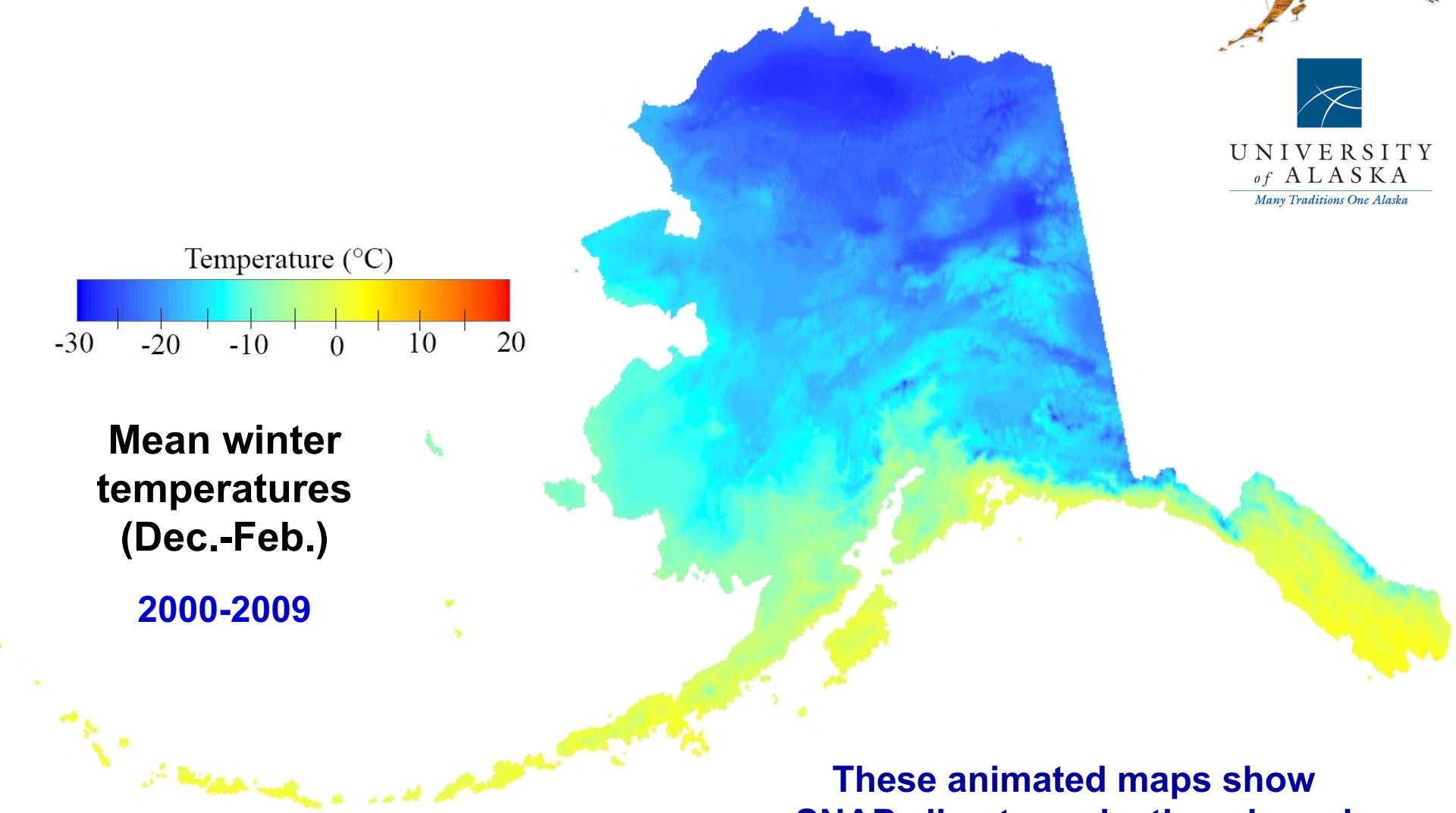

Mean winter temperatures (Dec.-Feb.)

2000-2009

These animated maps show SNAP climate projections based on downscaled global models from the IPCC

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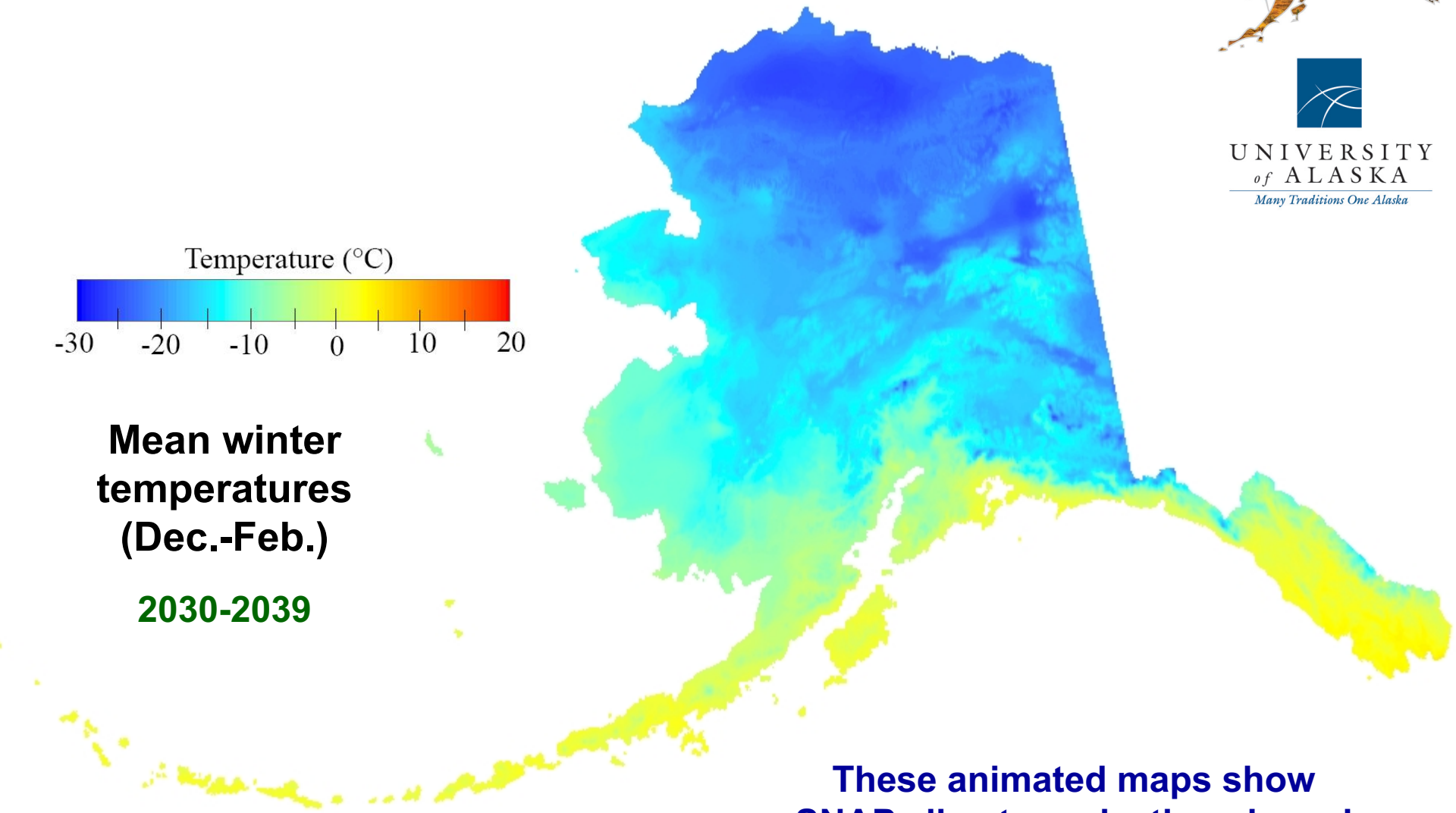

Mean winter temperatures (Dec.-Feb.)

2030-2039

These animated maps show SNAP climate projections based on downscaled global models from the IPCC

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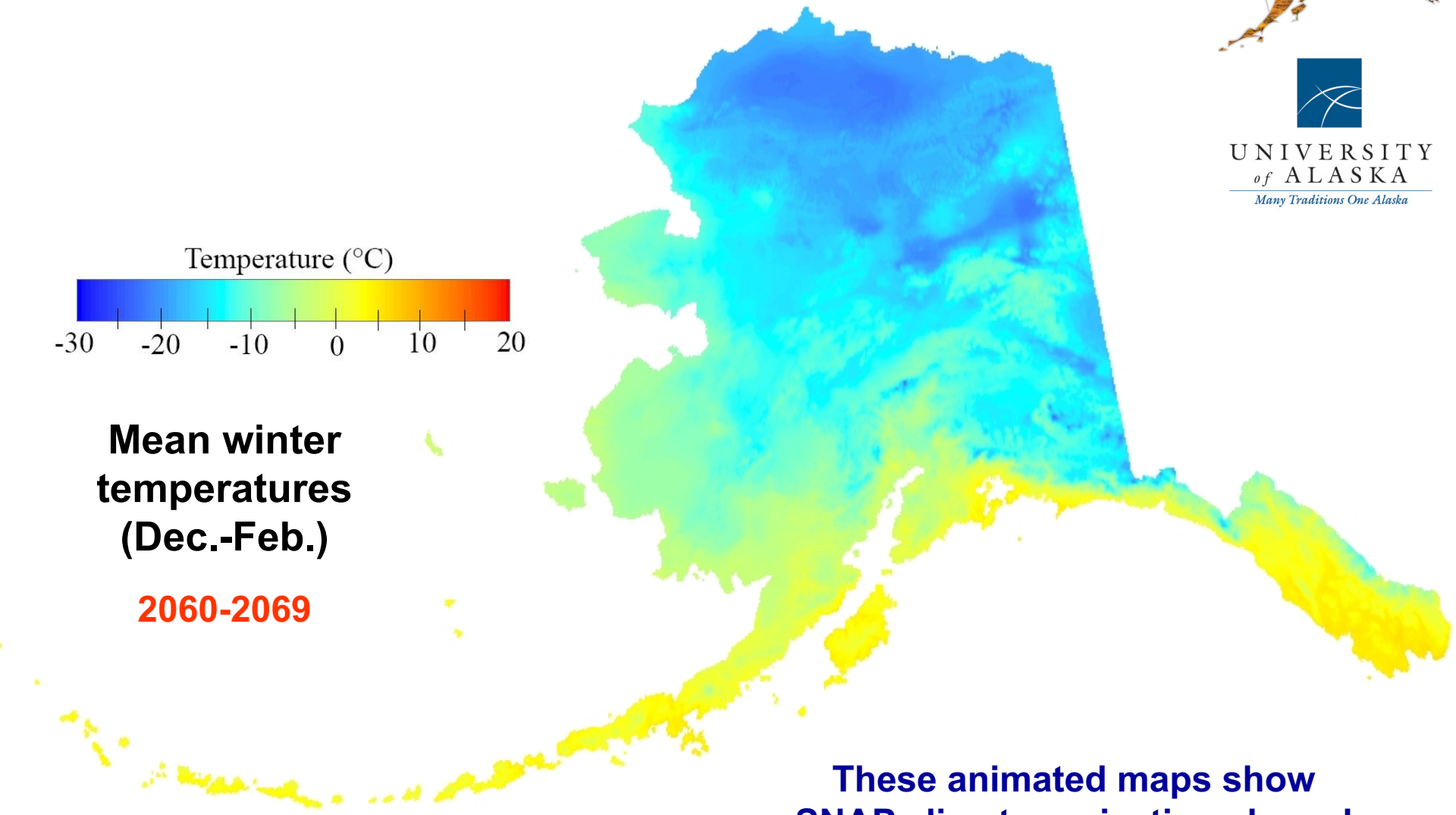

Mean winter temperatures (Dec.-Feb.)

2060-2069

These animated maps show SNAP climate projections based on downscaled global models from the IPCC

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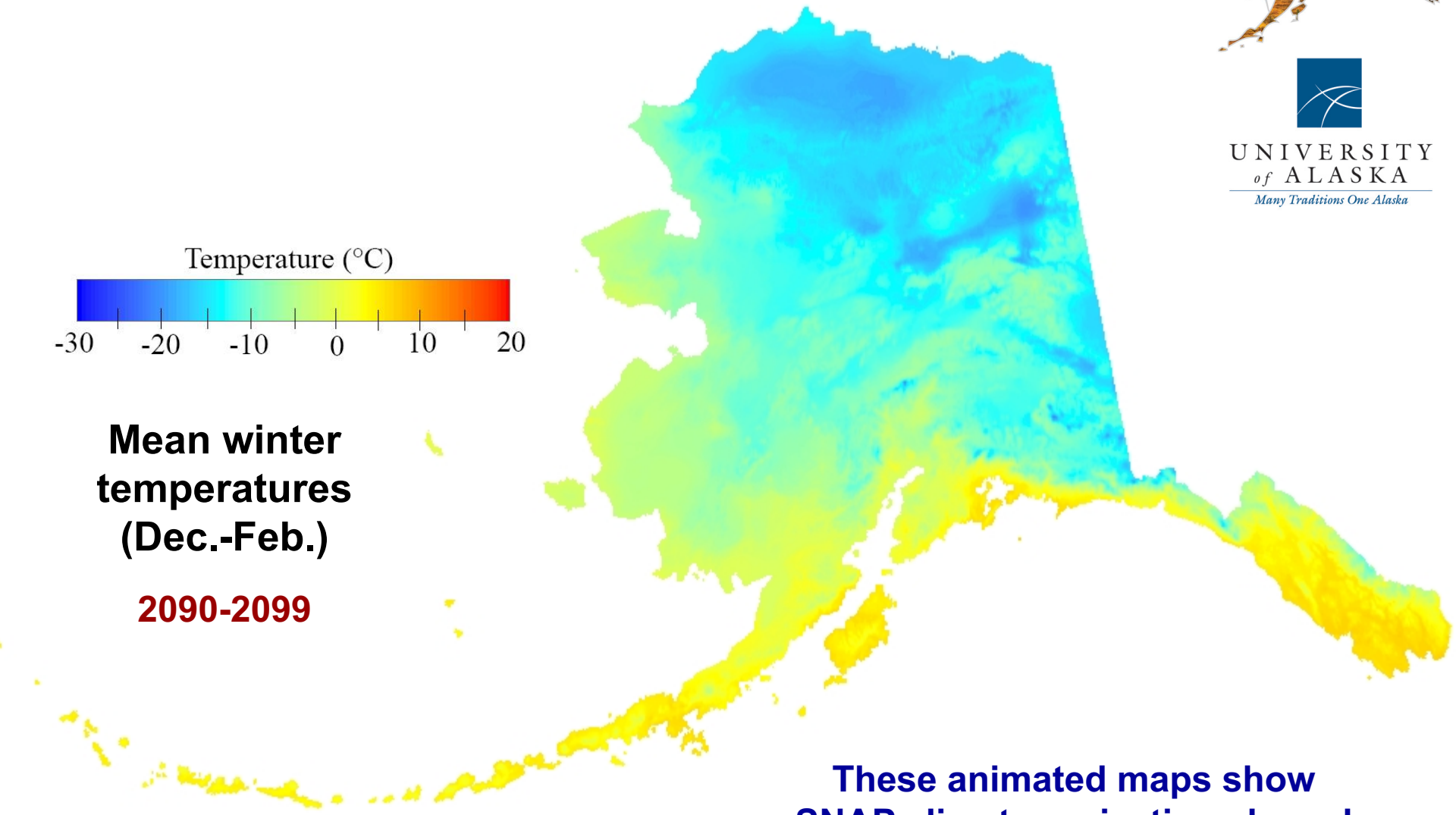
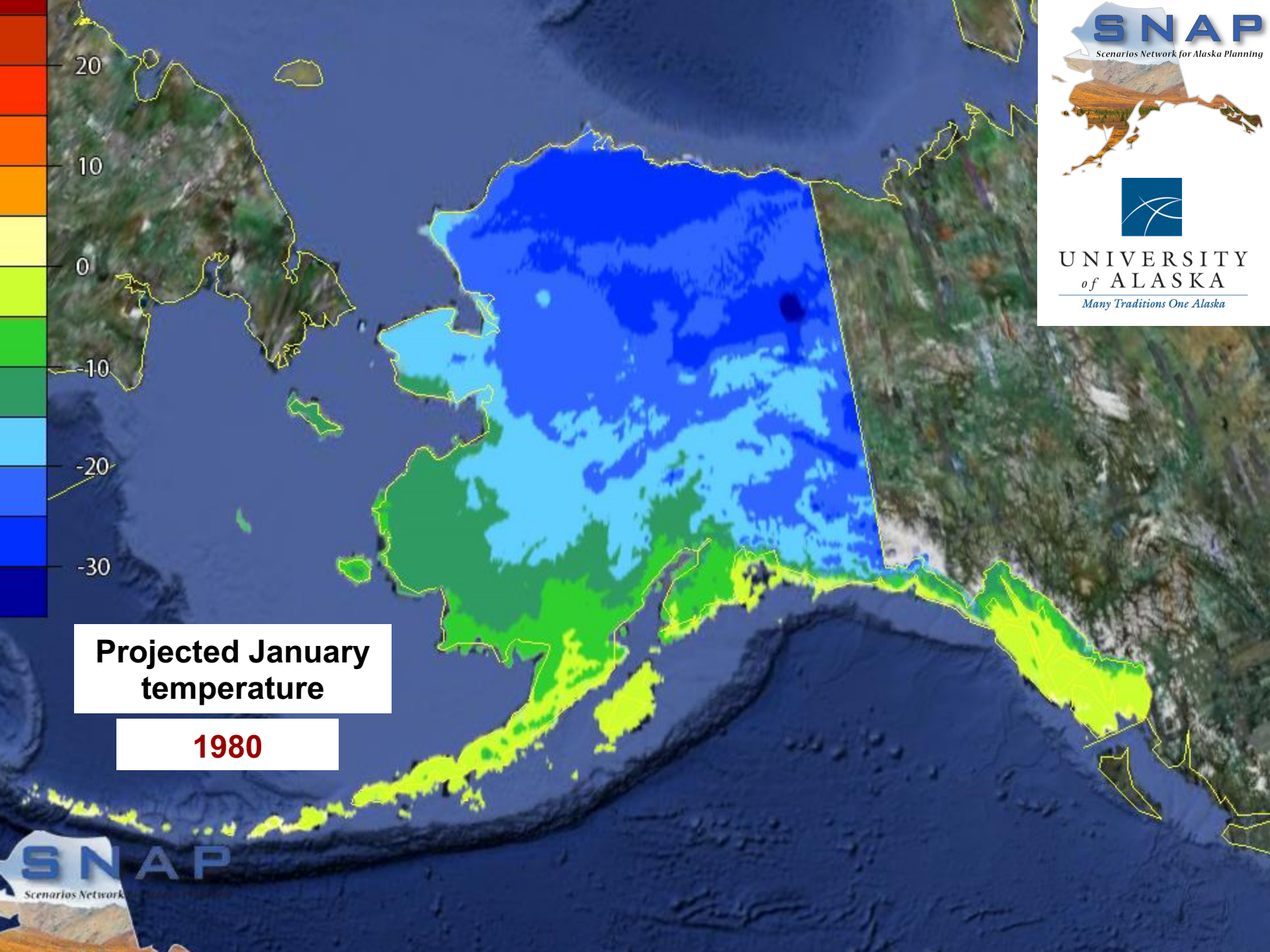


Mean winter temperatures (Dec.-Feb.)

2090-2099

These animated maps show SNAP climate projections based on downscaled global models from the IPCC


20
10
0
-10
-20
-30
Projected January temperature
1980
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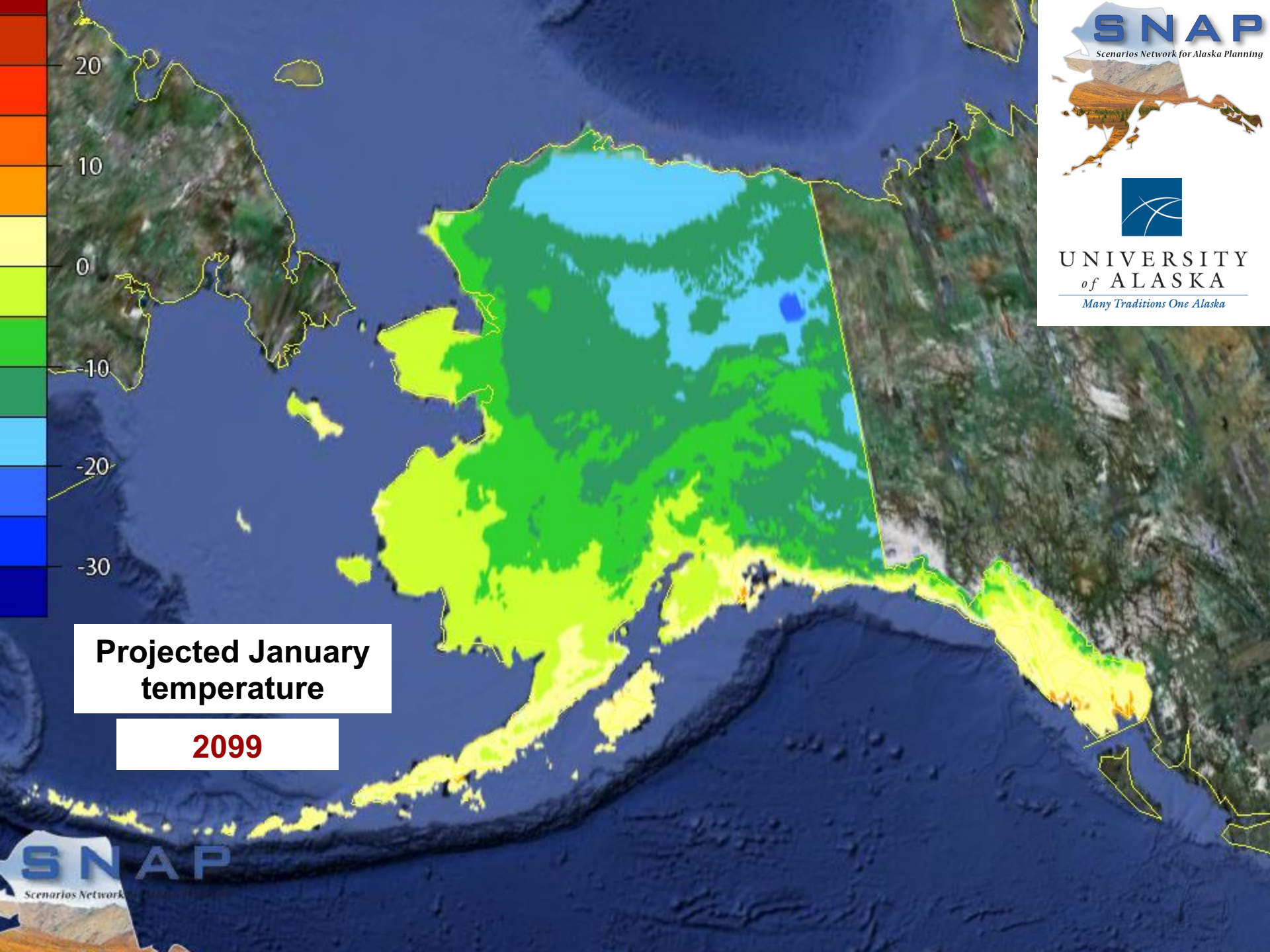
SNAP
Scenarios Network


20
10
0
-10
-20
-30
Projected January temperature
2099
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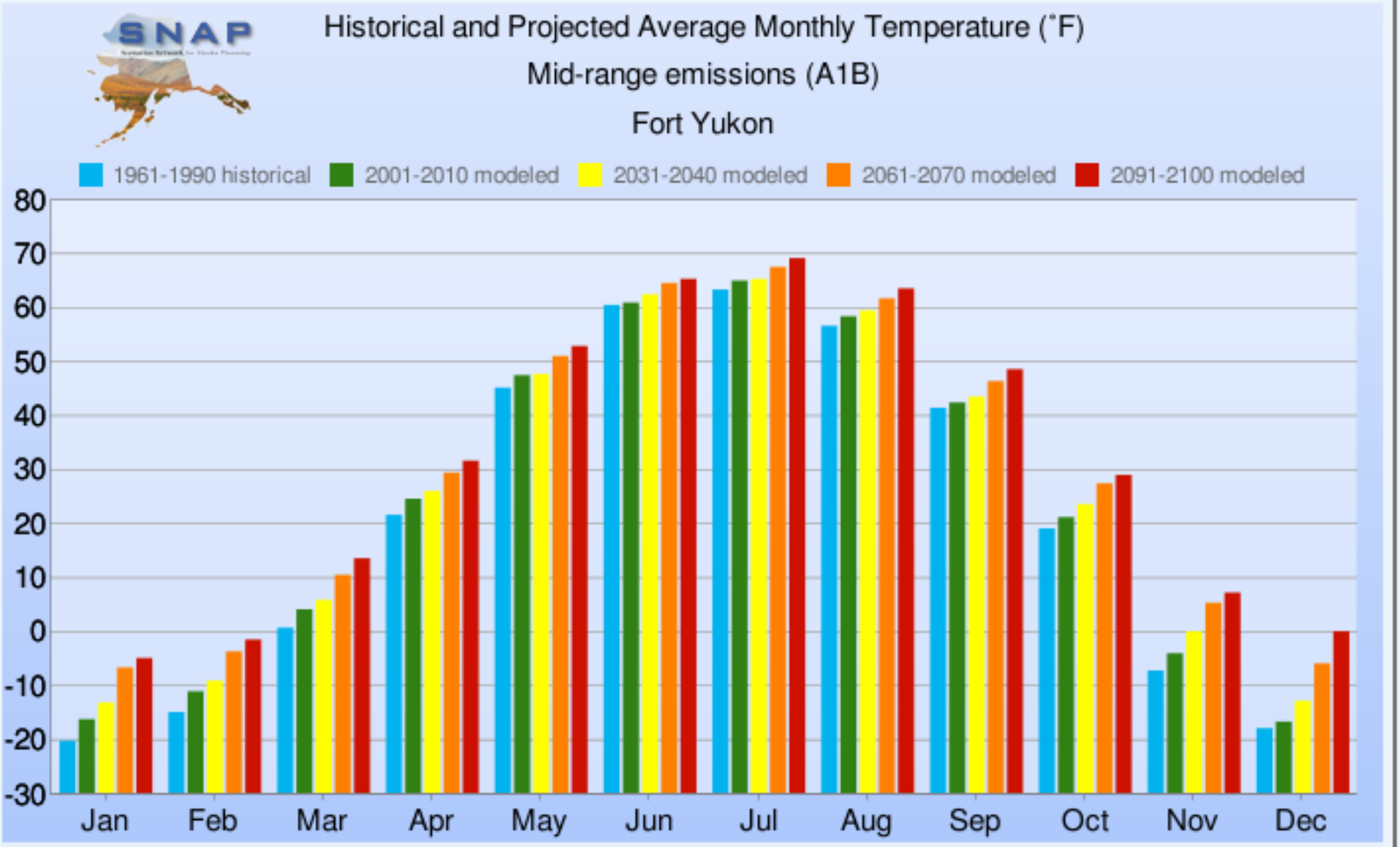
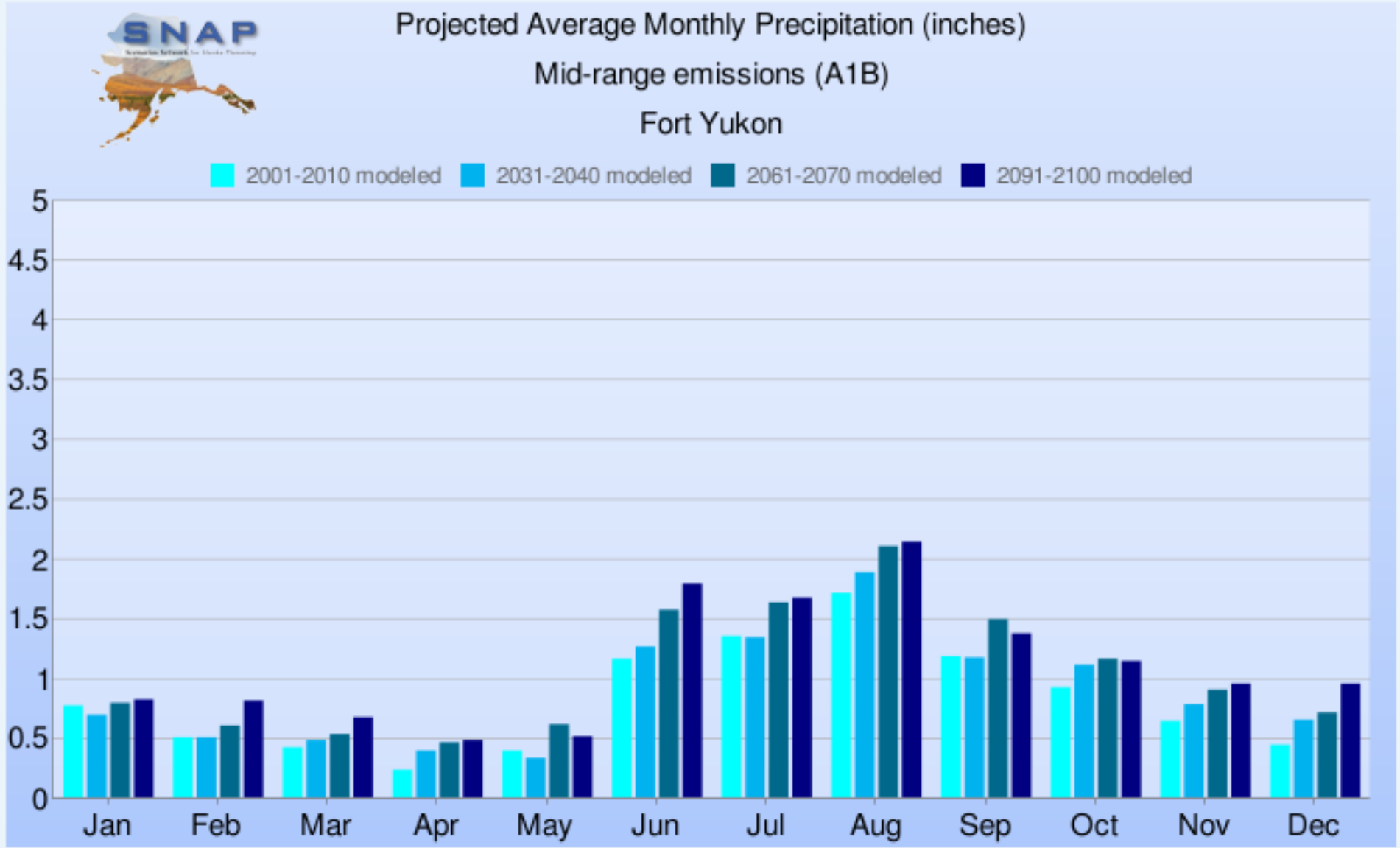
SNAP
Scenarios Network



This graph shows average values from projections from five global climate models used by the Intergovernmental Panel on Climate Change. Due to variability among models and among years in a natural climate system, such graphs are useful for examining trends over time, rather than for precisely predicting monthly or yearly values. For more information on the SNAP program, including derivation, reliability, and variability among these projections, please visit www.snap.uaf.edu.



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Partners: Connecting Landscapes

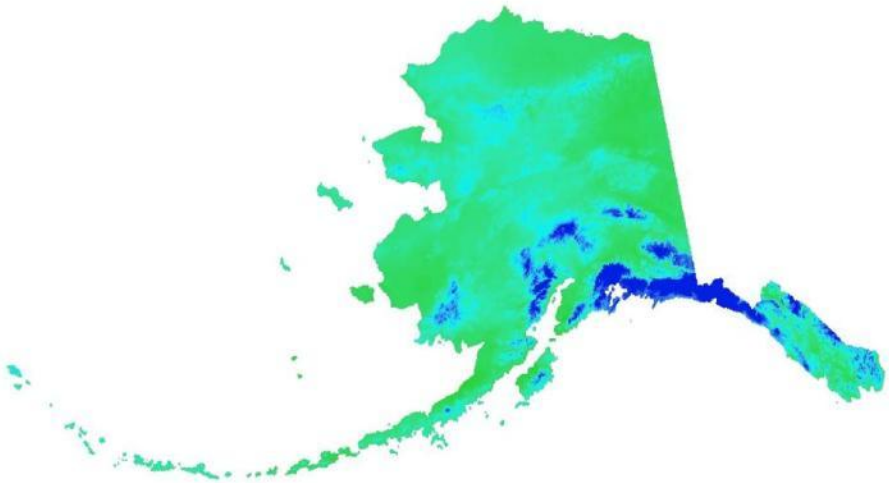
Defenders of Wildlife - The Nature Conservancy - The Wilderness Society - Alaska Natural Heritage Program - Alaska GAP - Alaska Audubon - ADF&G – BLM - NPS - FWS - USGS - USFS

USFWS Region 7, National Wildlife Refuges, Fisheries & Ecological Services, Migratory Birds and State Programs and Subsistence all contributed to funding this project

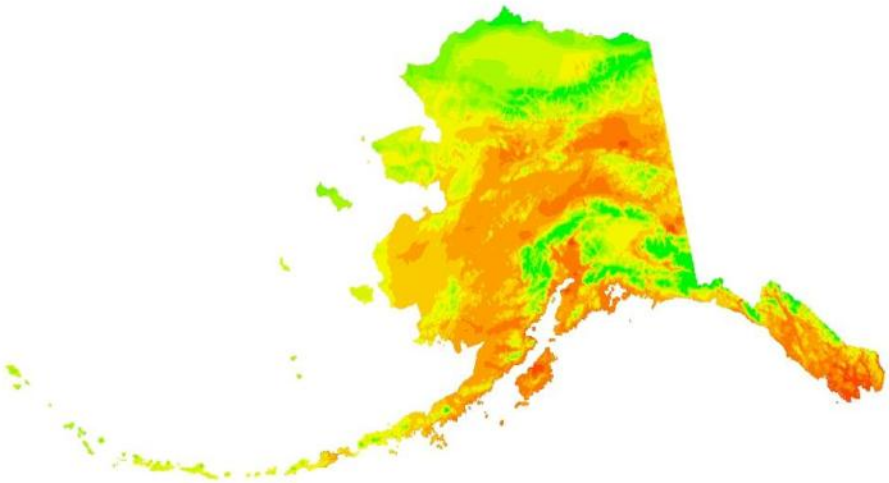
Modeling Subjects

- Biomes
- Vegetation Communities
- Caribou
- Alaska marmot
- Trumpeter swans
- Reed canary grass

Climate change forecasted from SNAP data using RandomForest™



Precipitation



Temperature

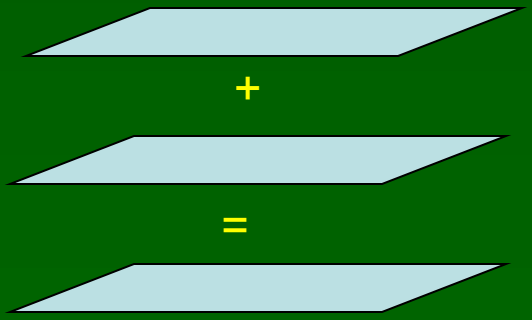
MISSING! Sea level rise & Permafrost change

Mean decadal

Starting:
2000-09

Future:
2030-39
2060-69
2090-99

Classification and regression trees

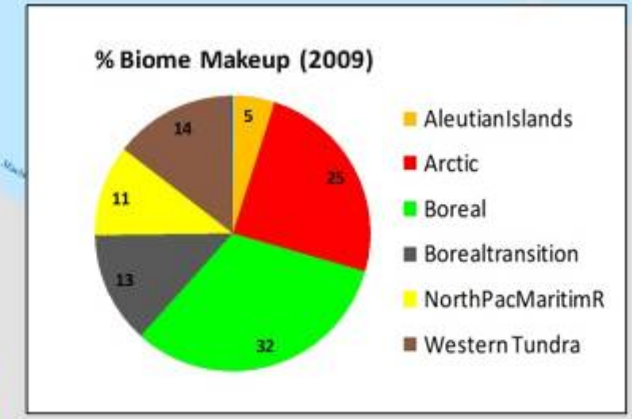


June precipitation
December precipitation
June temperature
December temperature

Multiple interactions

Biome in 2009 Used for Training Data

Alaska Biomes
Derived from Unified Ecoregions
"Nowacki et al 2001"



Arctic

Boreal

Boreal Transition

Western Tundra

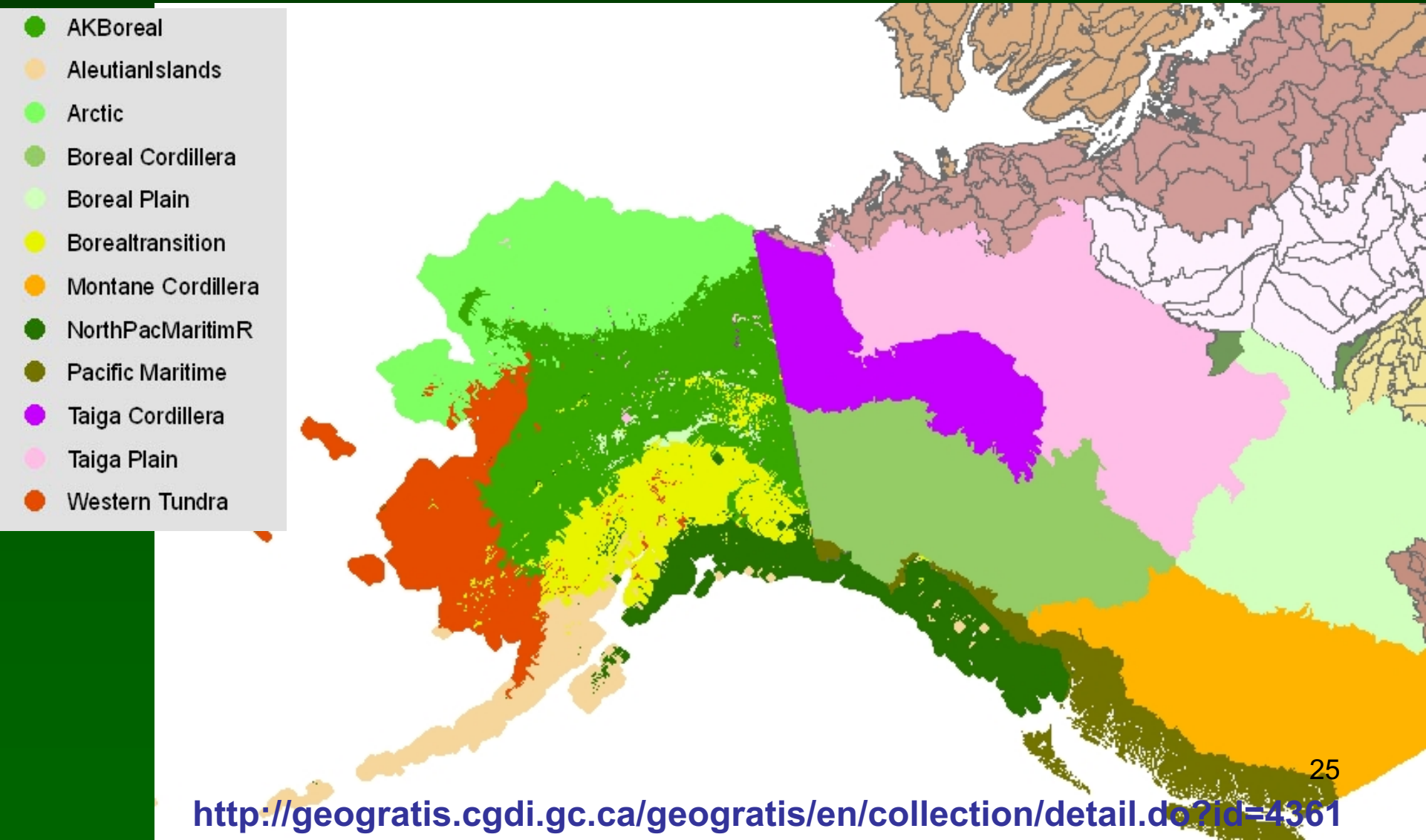
North Pacific Maritime

Aleutians

N

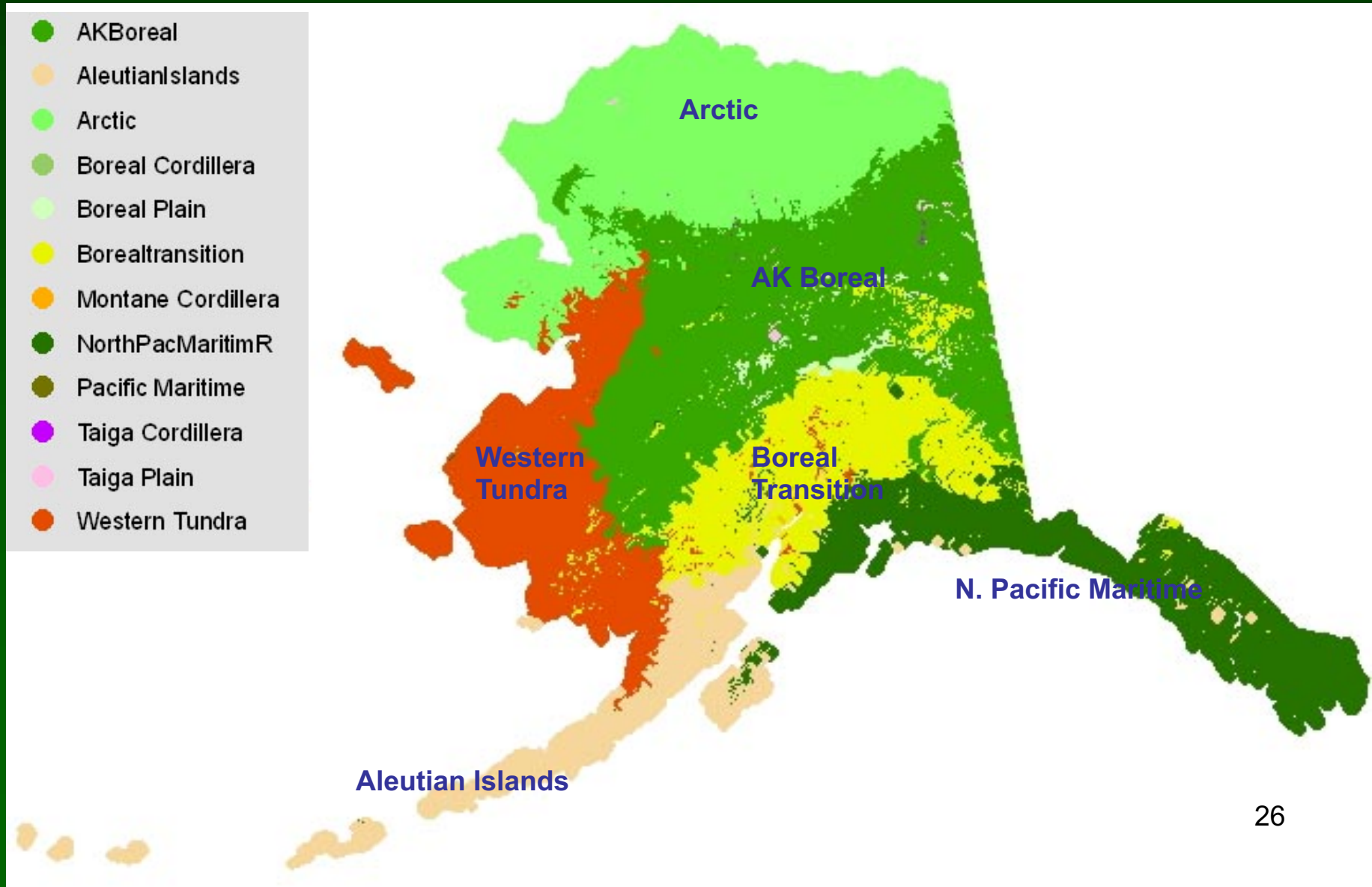
0 250 500 Miles

Western Canadian Ecozones included as training data

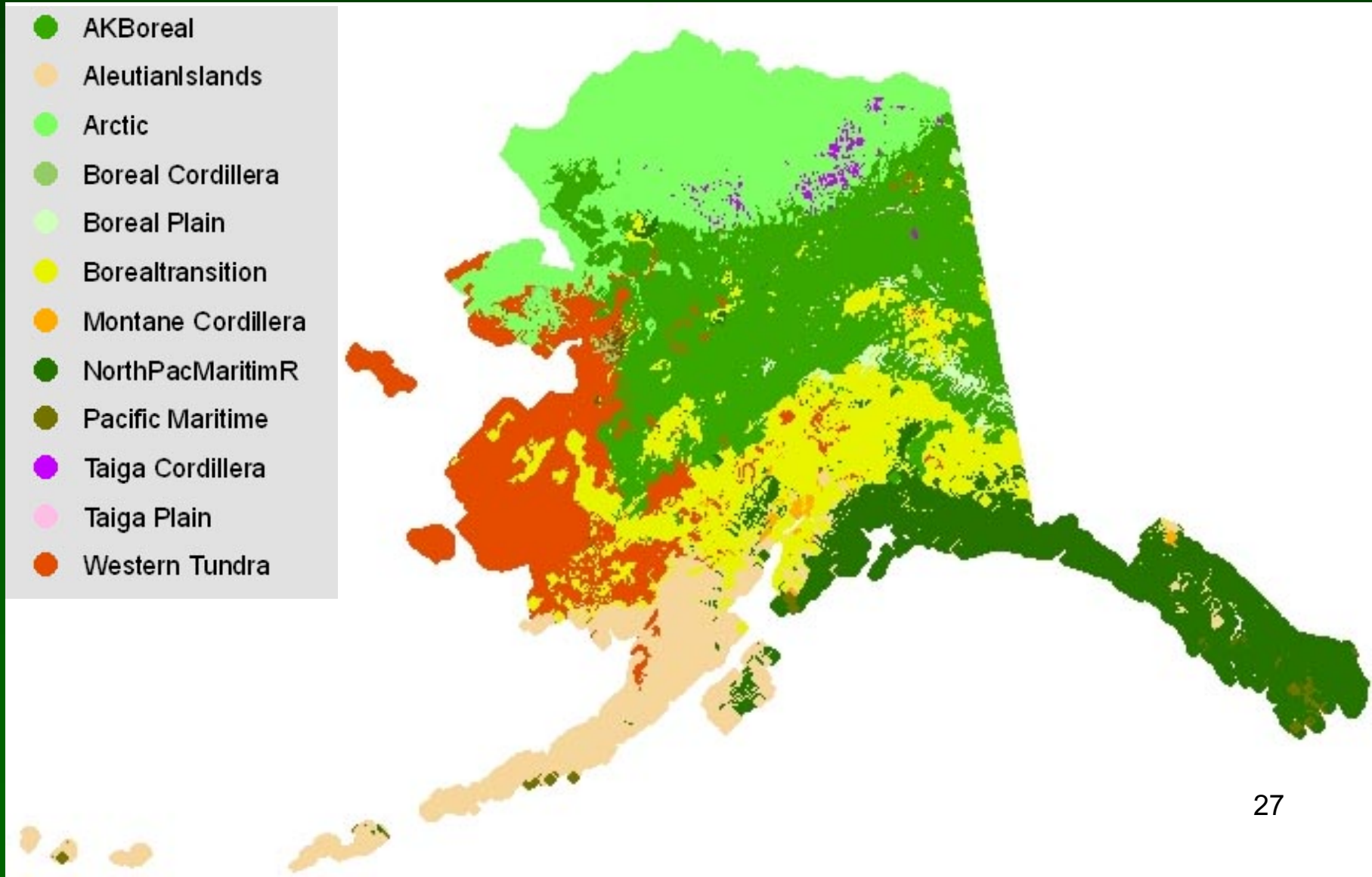


http://geogratis.cgdi.gc.ca/geogratis/en/collection/detail.do?id=4361

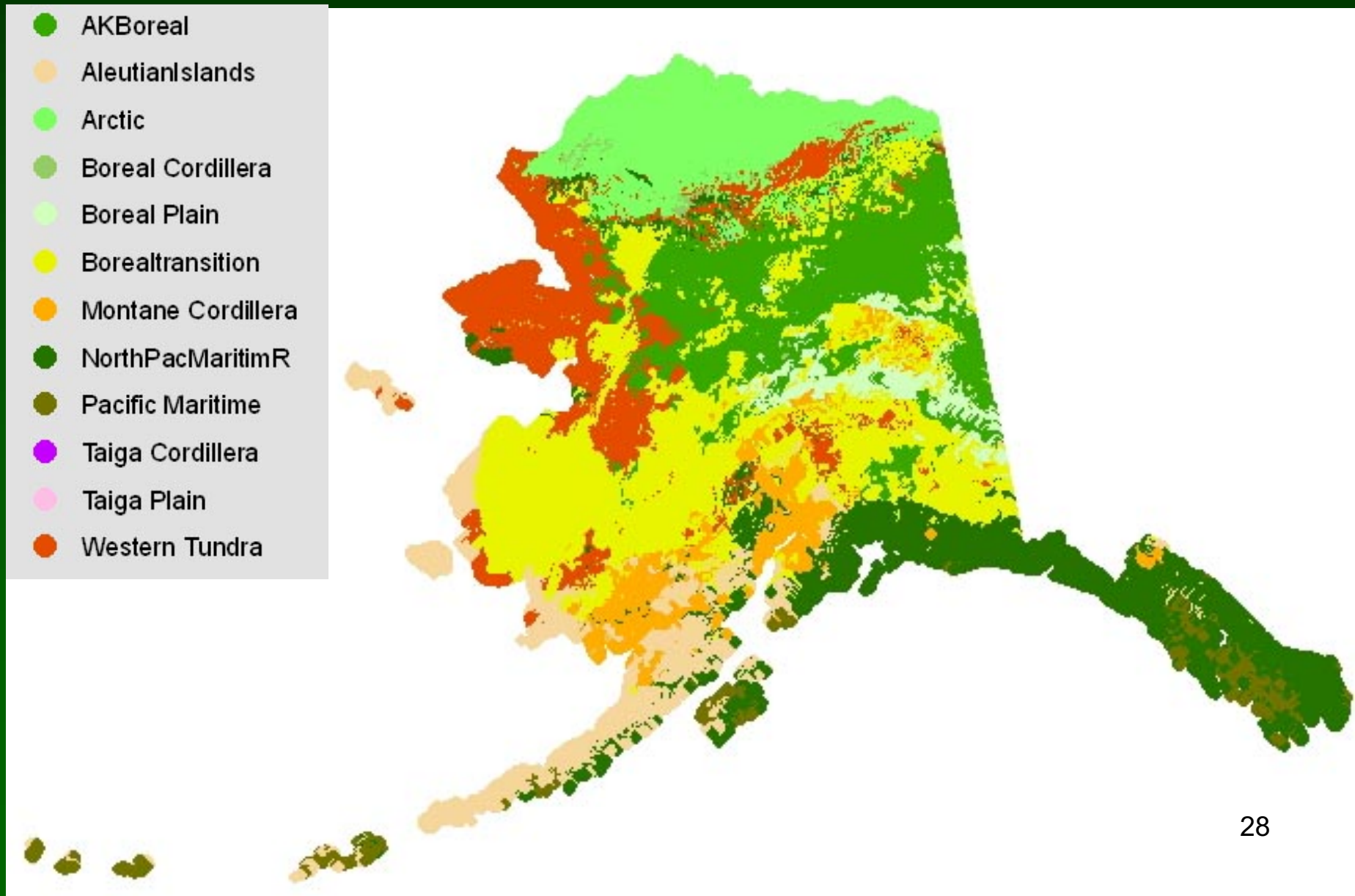
Predicted biome/climate 2000-2009



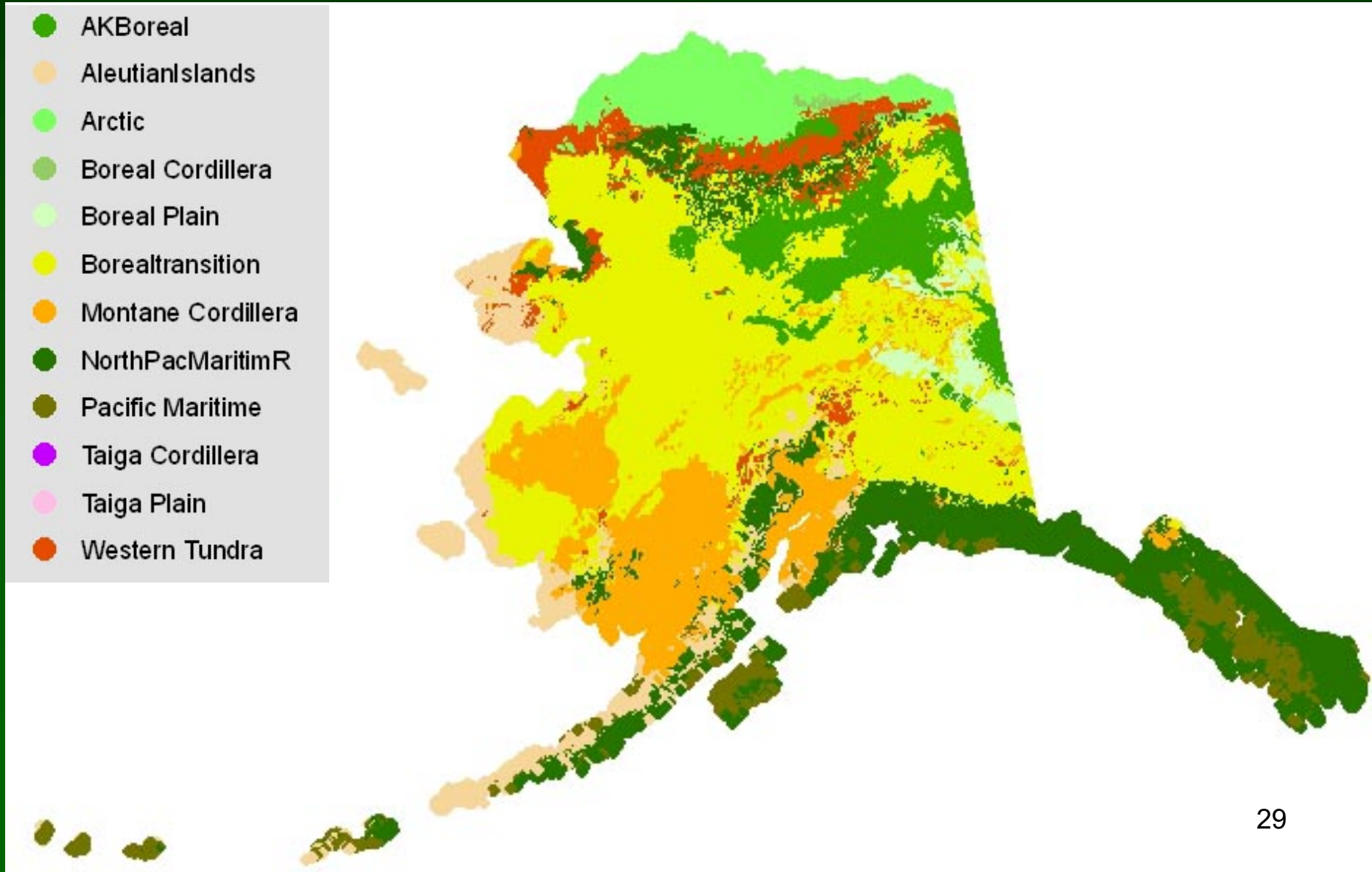
Predicted biome/climate 2030-2039



Predicted biome/climate 2060-2069



Predicted biome/climate 2090-2099



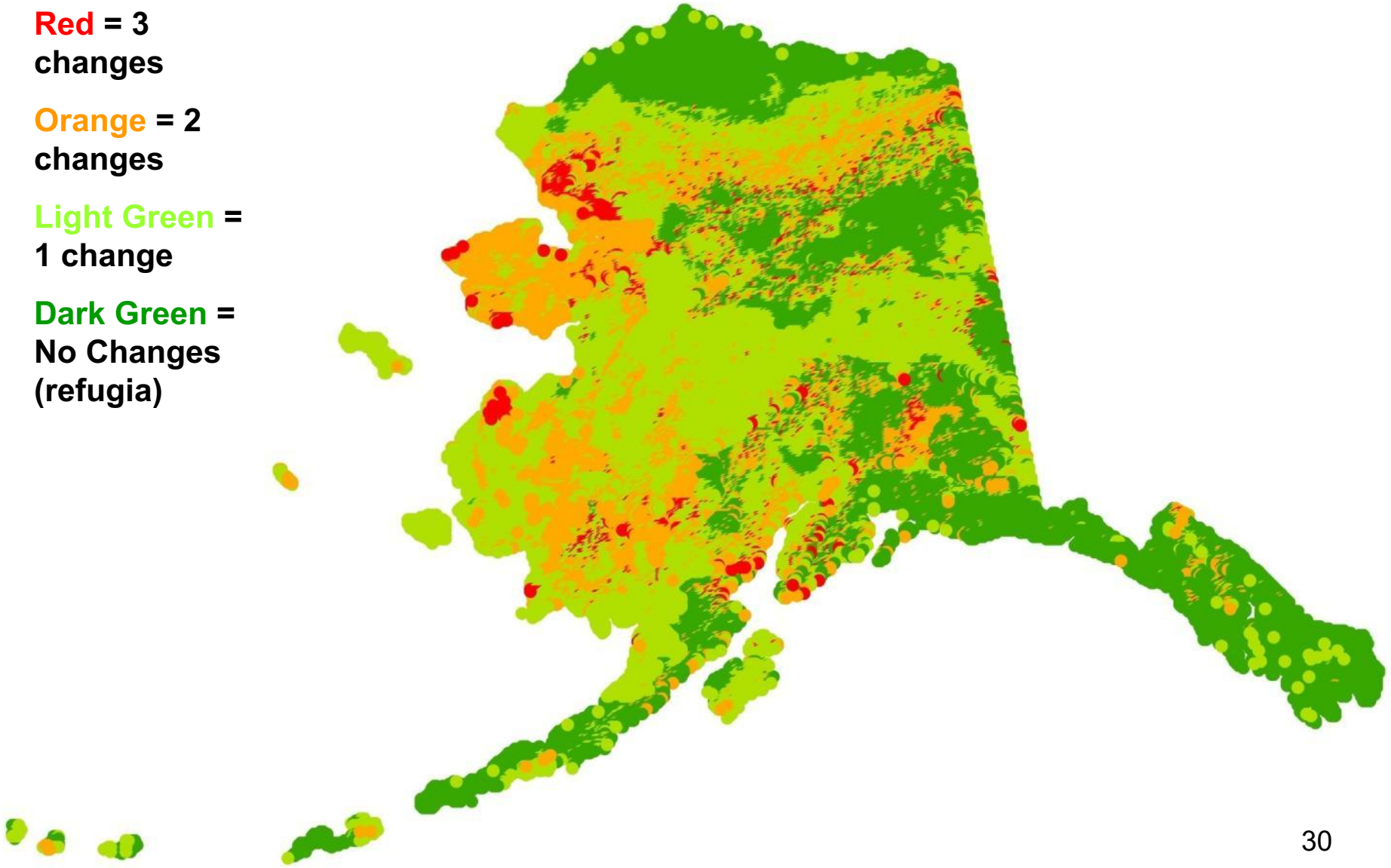
Resiliency

Red = 3 changes

Orange = 2 changes

Light Green = 1 change

Dark Green = No Changes (refugia)



Recommendation: focus on better modeling, delineation, and monitoring of both *refugia and regions of extreme change*…

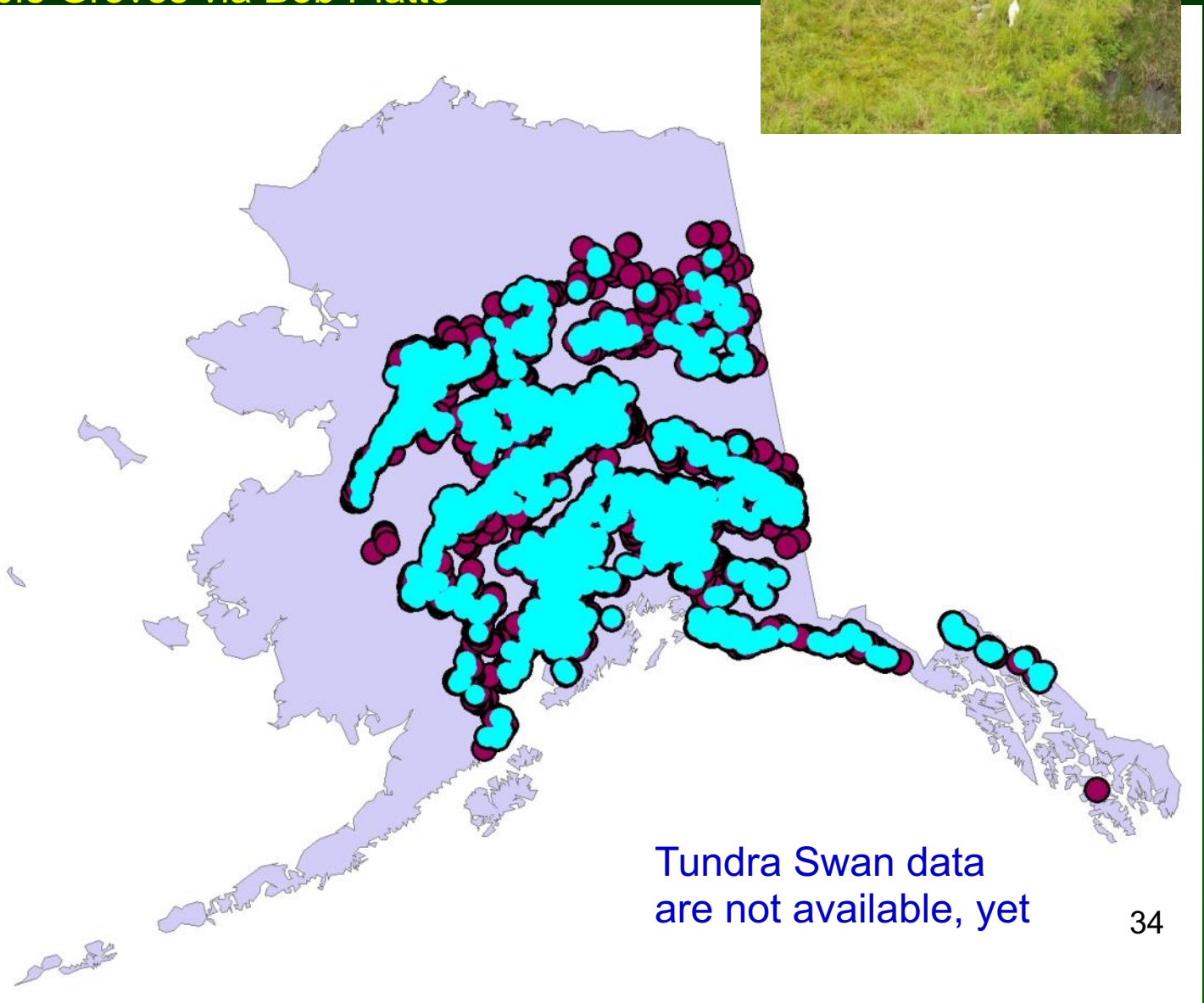
And explore opportunities to develop anticipatory adaptation associated with predicted species responses in parts of Alaska

We can also add species distributions and populations to the analysis

- Each species needs to be modeled for its life history constraints (ability to migrate, temperature tolerance)
- At a minimum, we need good species occurrence data – something that is often lacking
- Use to assess vulnerability and evaluate population objectives

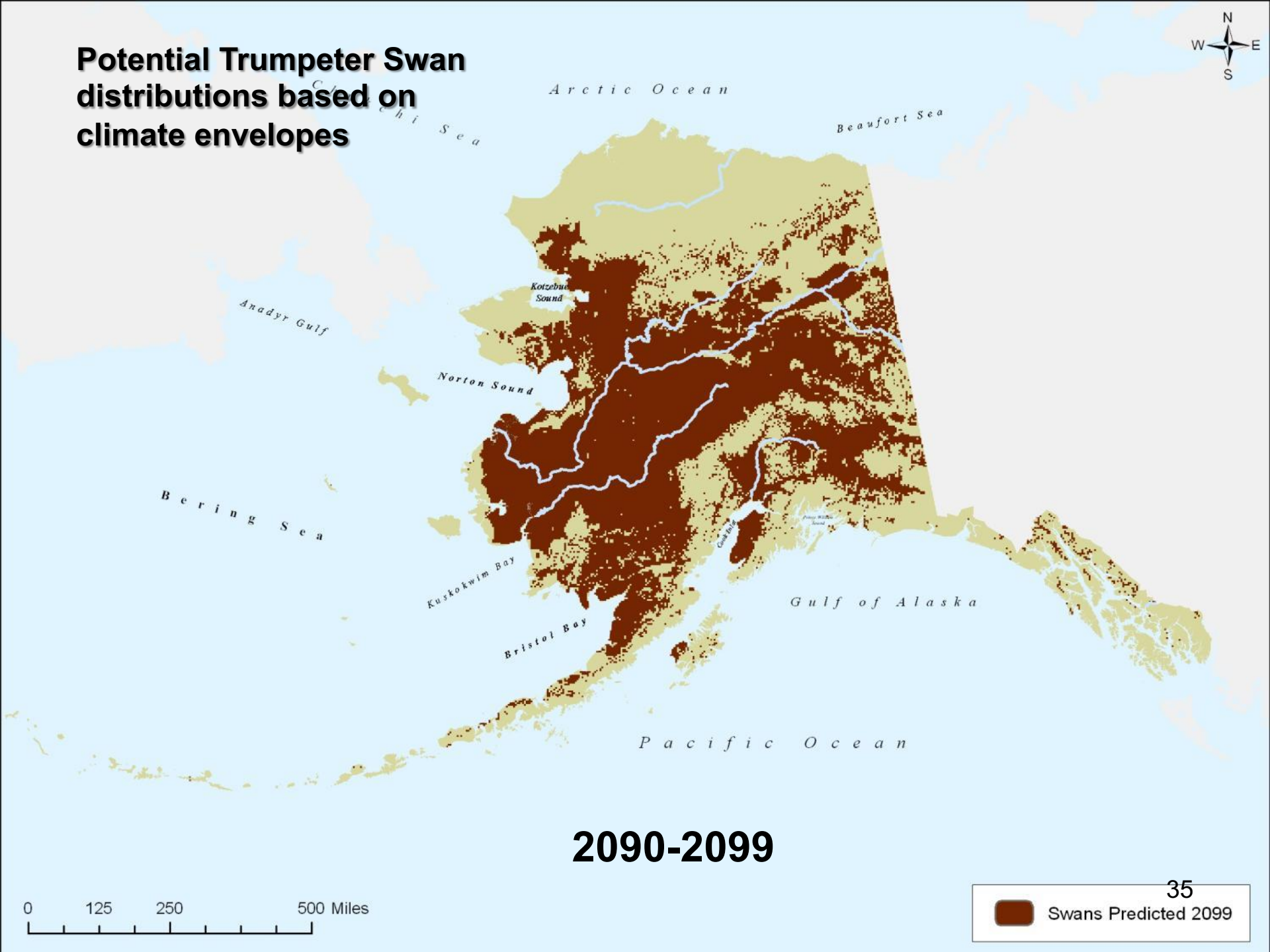
Modeling Trumpeter Swan Occurrence: Future Predictions based on Ice Free Days SNAP data and Connectivity

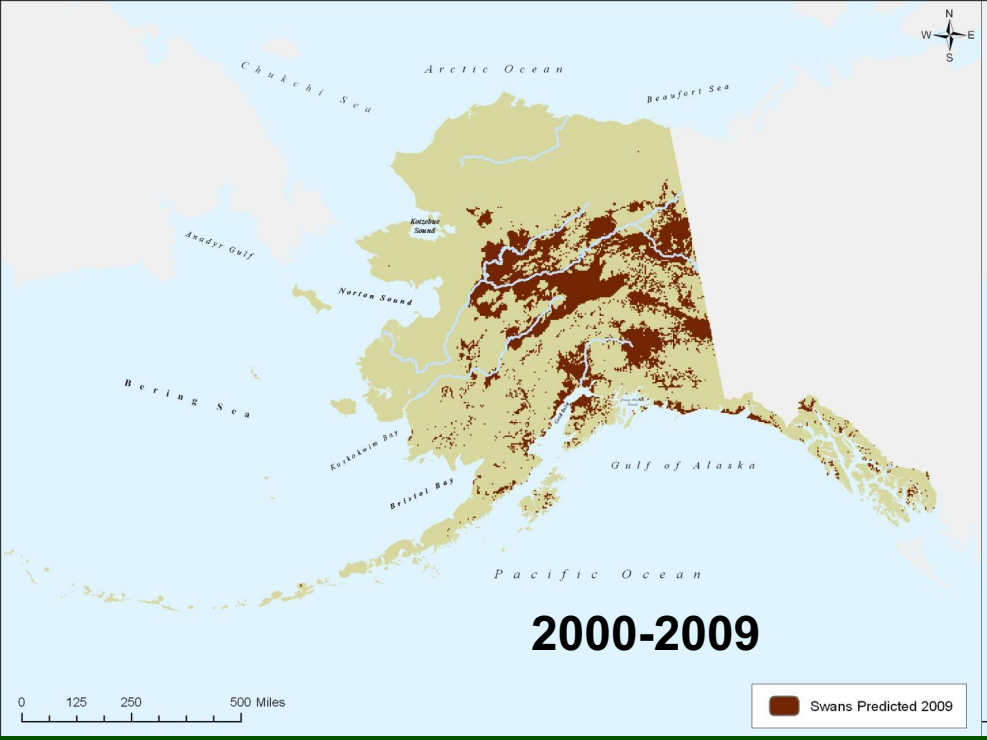
Trumpeter Swan Data
(2005 Trumpeter Swan Survey,
a census flown every 5 years in August)
Provided by Debbie Groves via Bob Platte



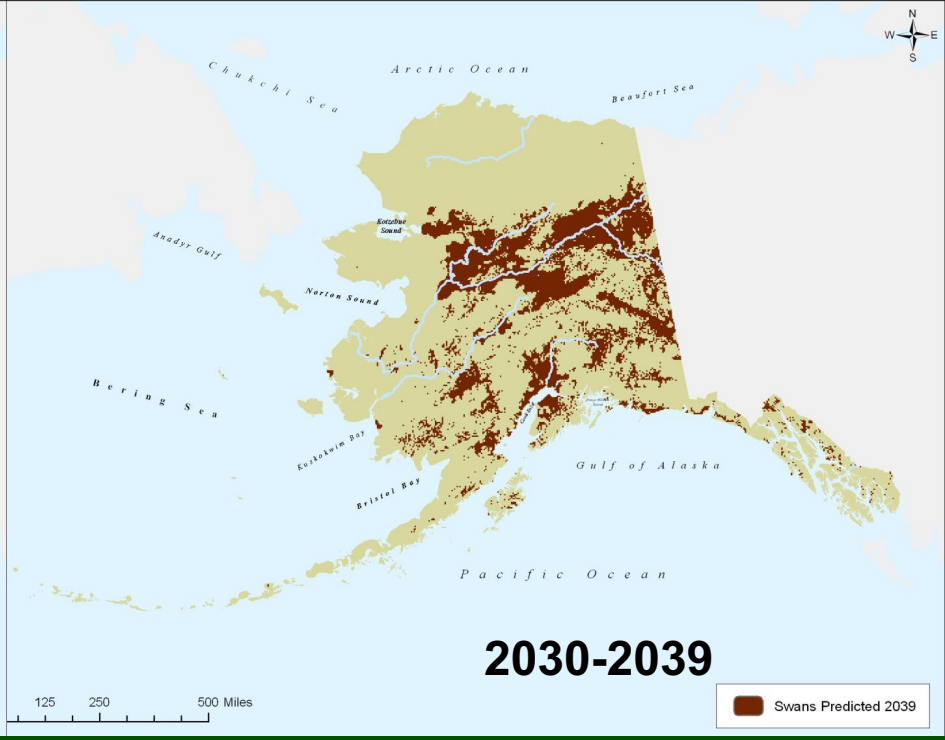
Tundra Swan data
are not available, yet

Potential Trumpeter Swan distributions based on climate envelopes

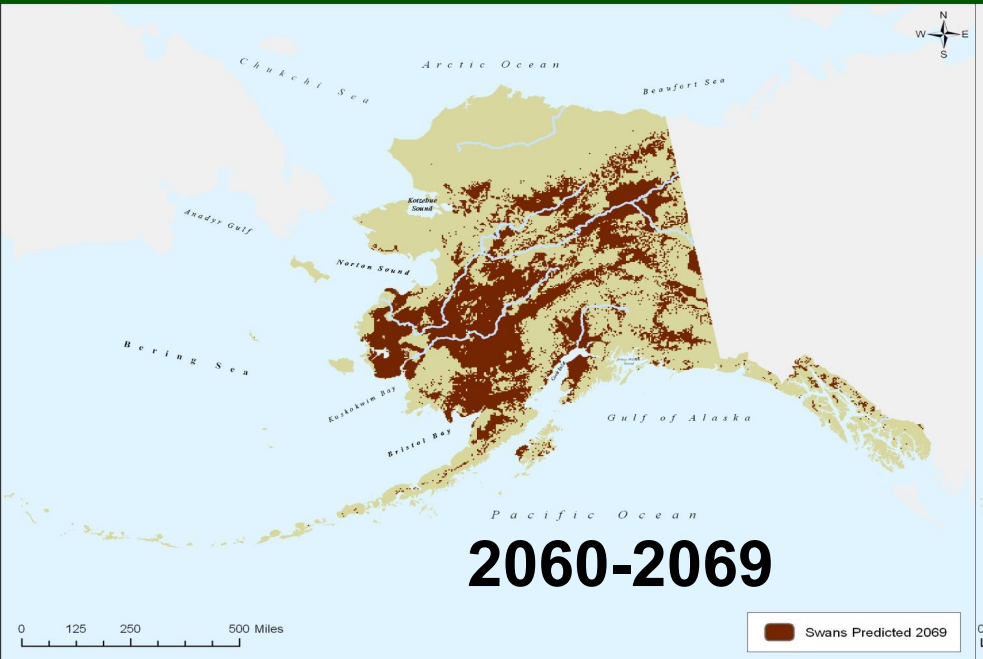




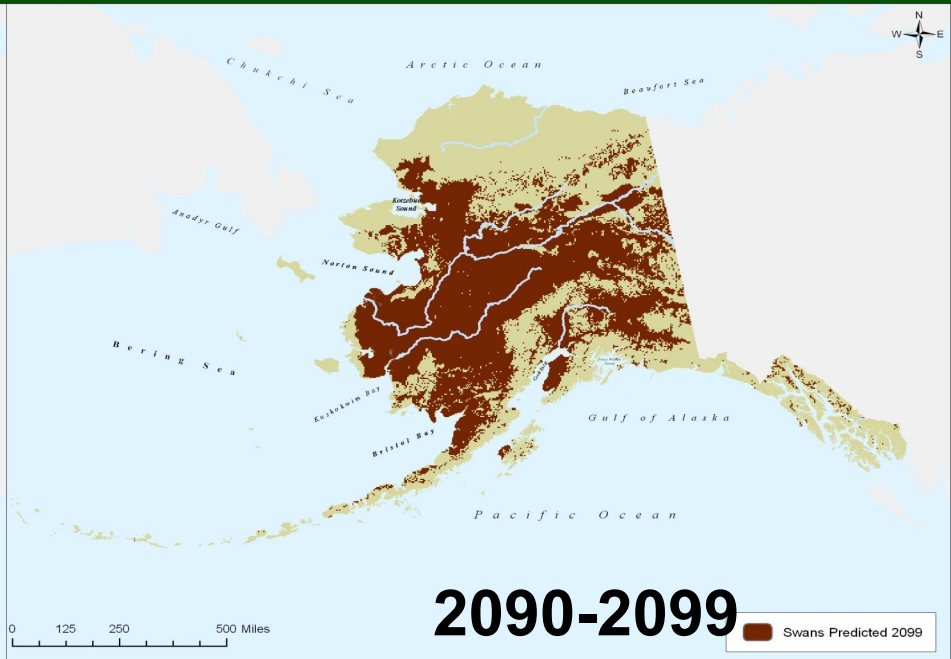
2000-2009



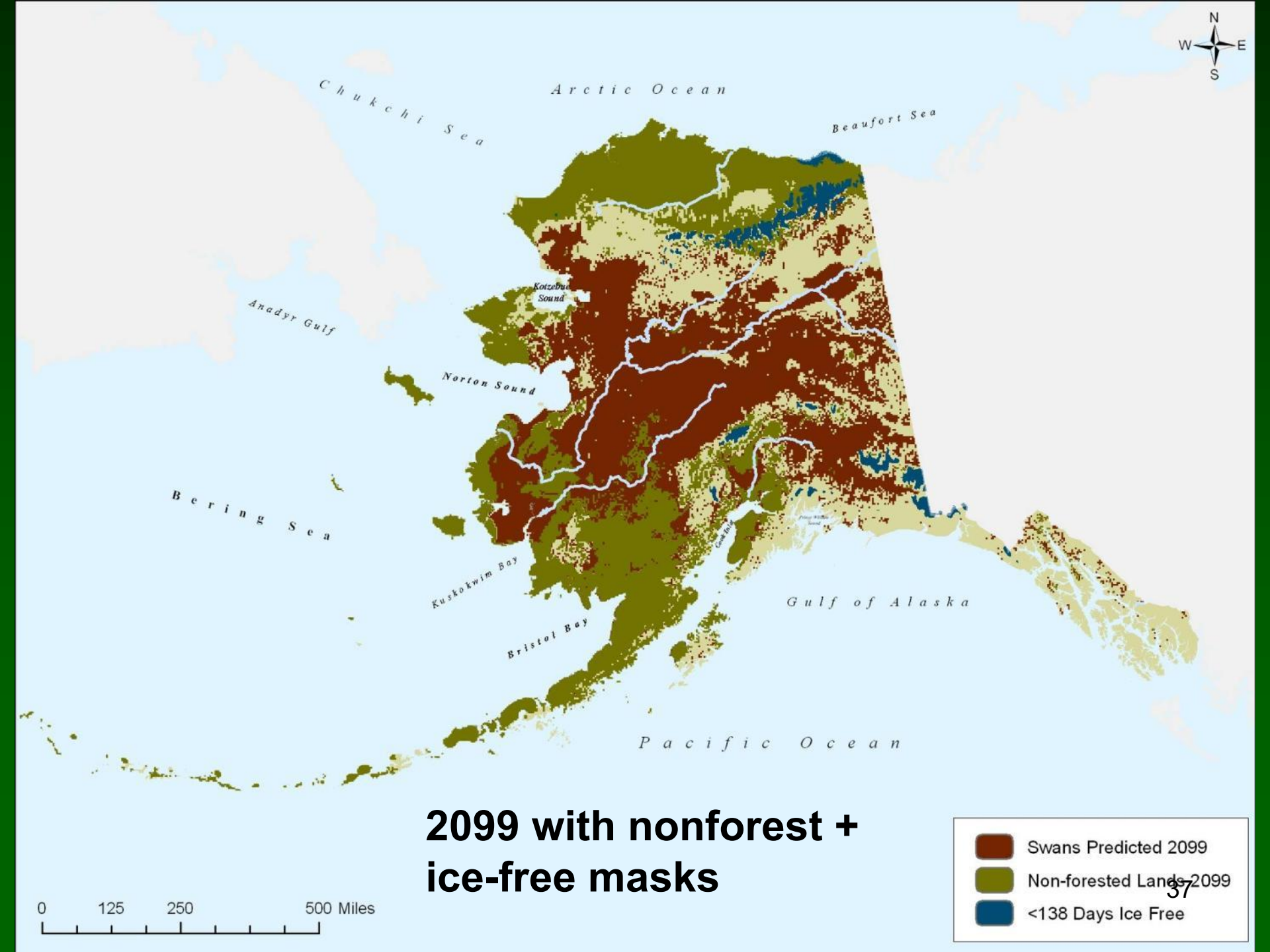
2030-2039



2060-2069



2090-2099



2099 with nonforest + ice-free masks

Modeling Canary Reed Grass: Future Predictions of an Invasive Species (based on Road Proximity and SNAP climatologies and Connectivity)

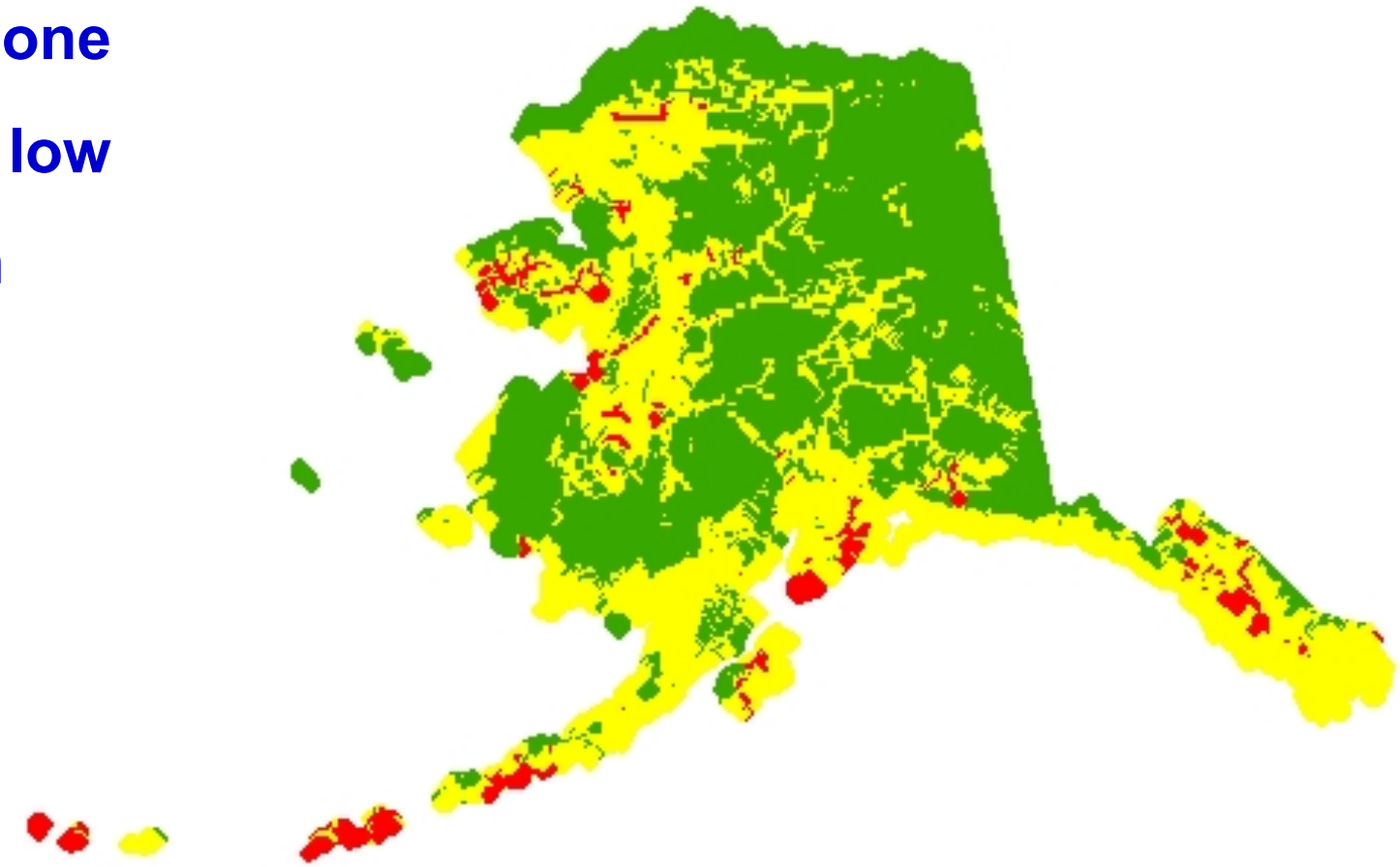
Reed Canary Grass potential distribution

2090-2099

GREEN = none

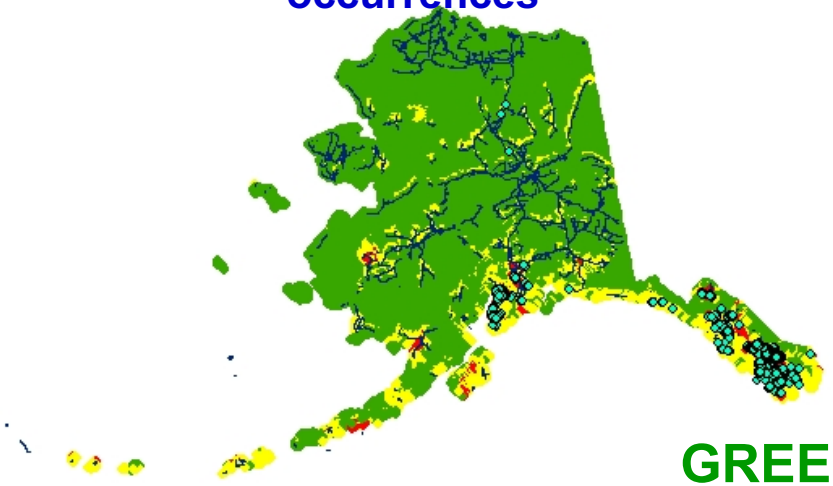
YELLOW = low

RED = high

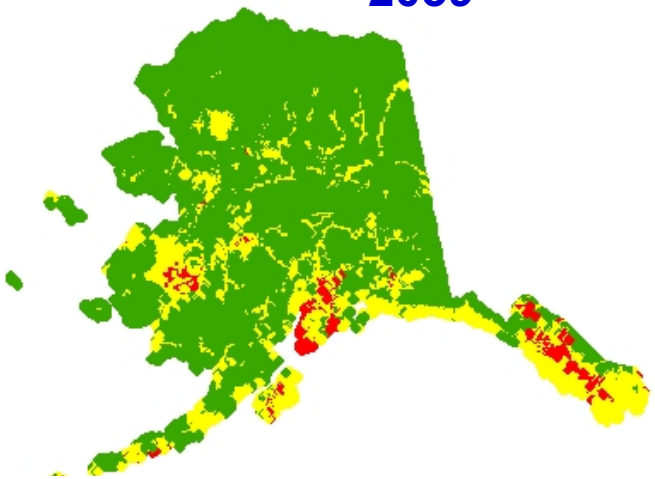


Reed Canary Grass potential distribution

2009 + roads + known occurrences



2039

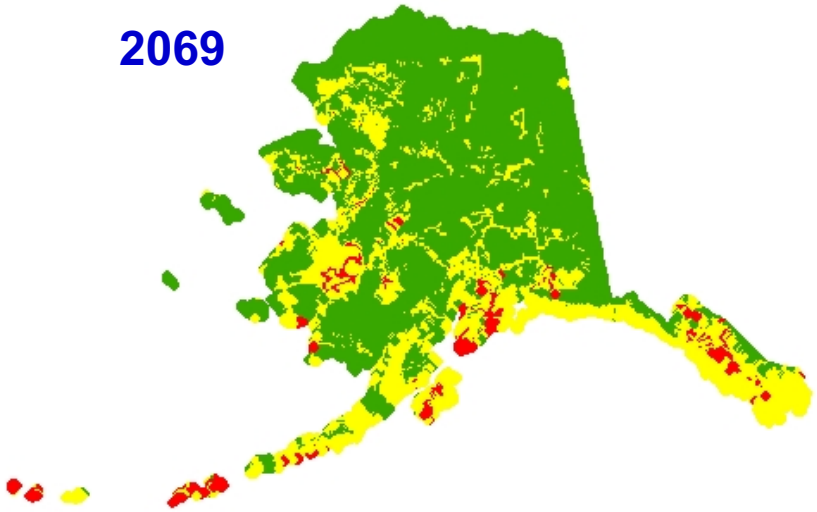


GREEN = none

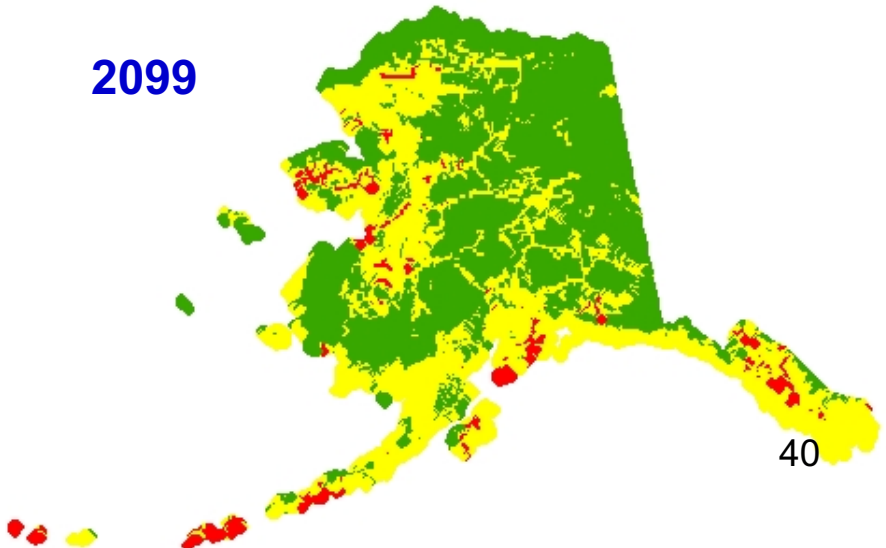
YELLOW = low

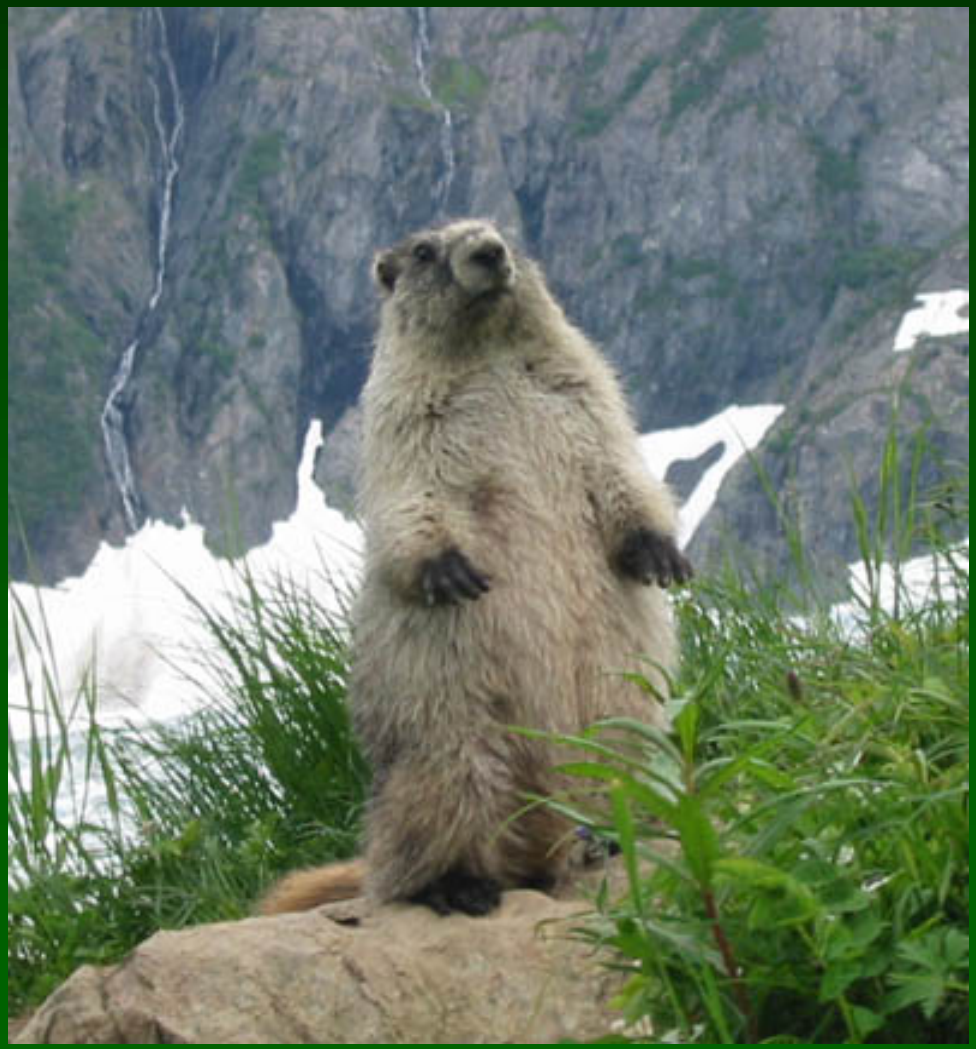
RED = high

2069



2099

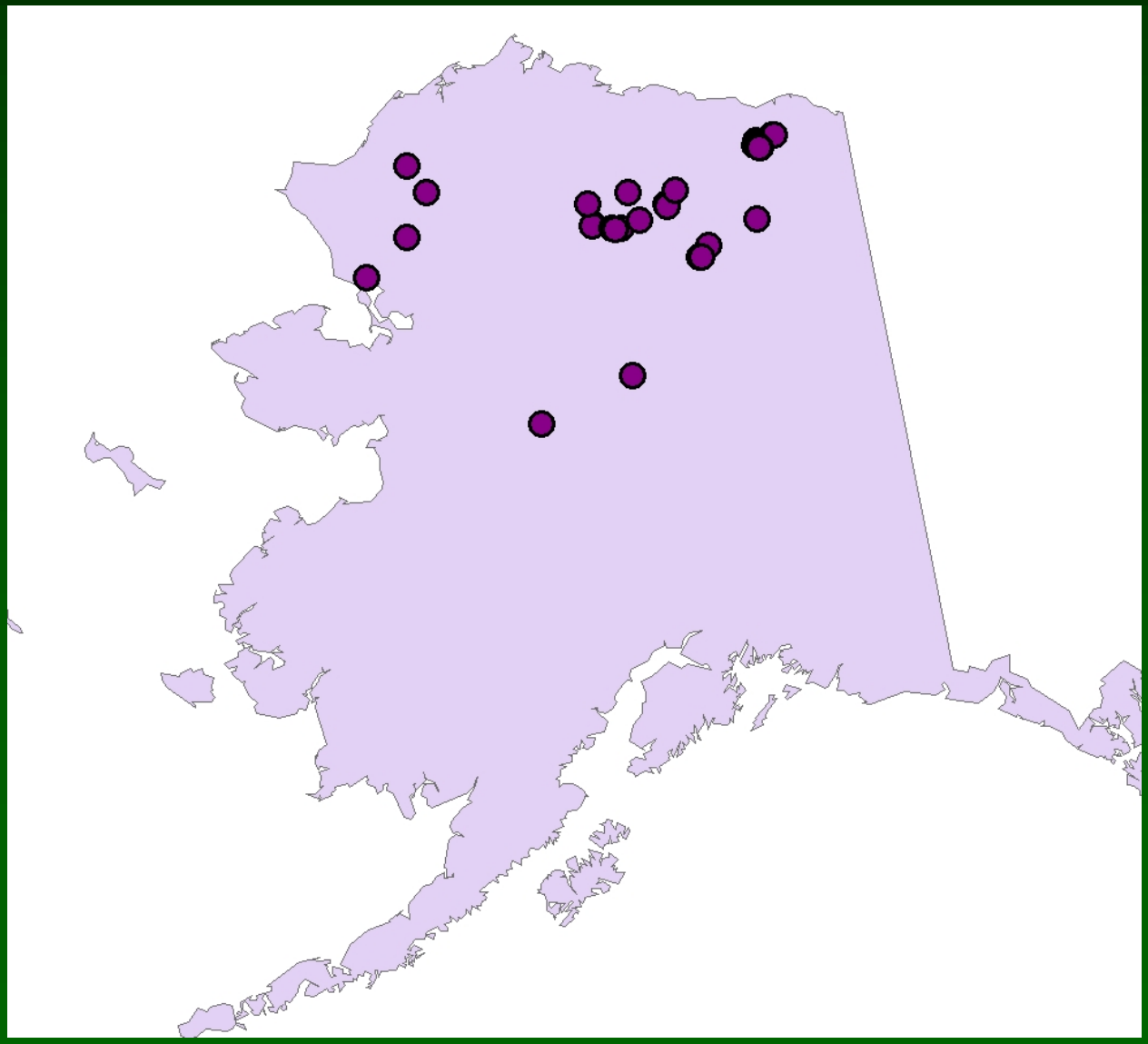




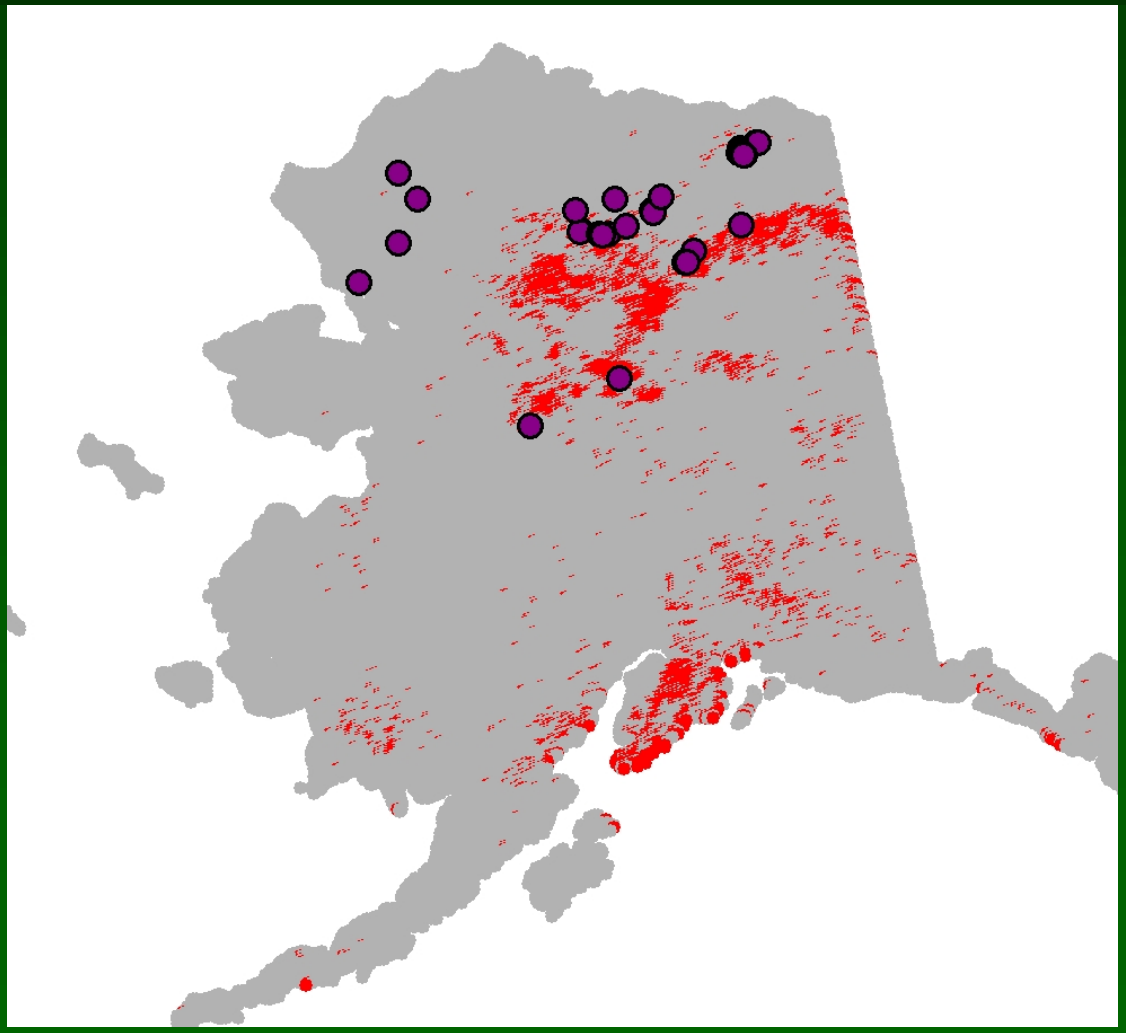
Alaska Marmot

Photo: AKNHP website

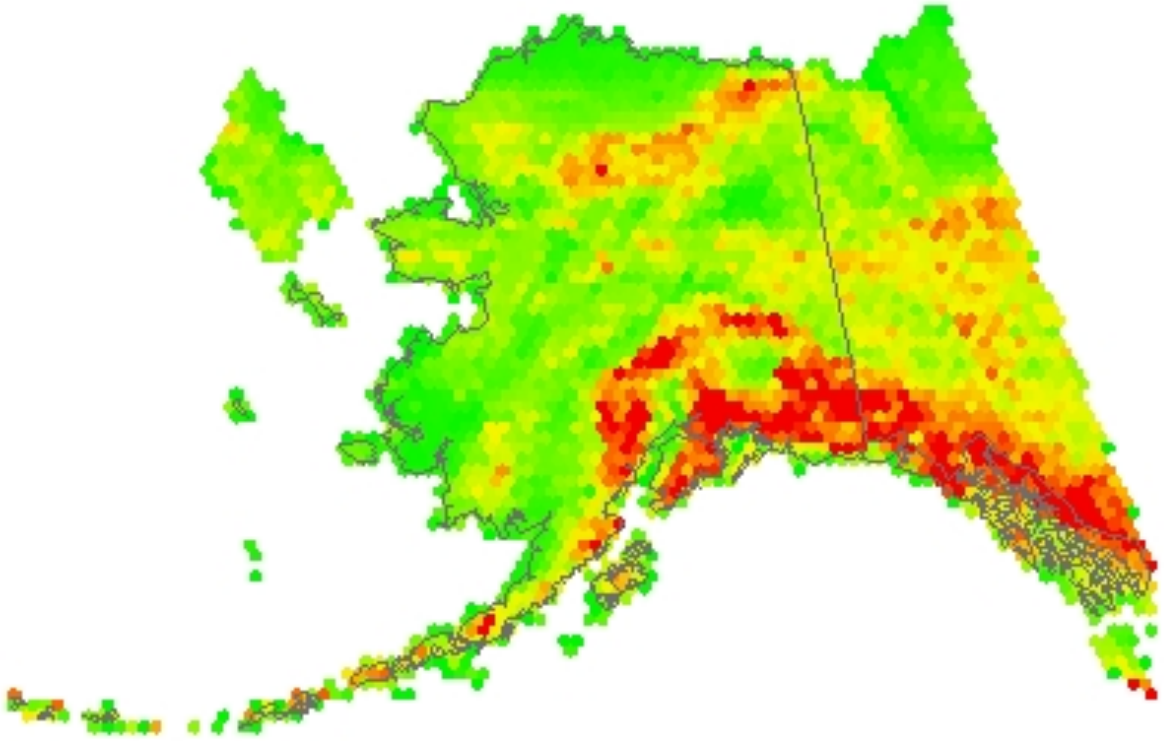
Known occurrences of AK Marmot



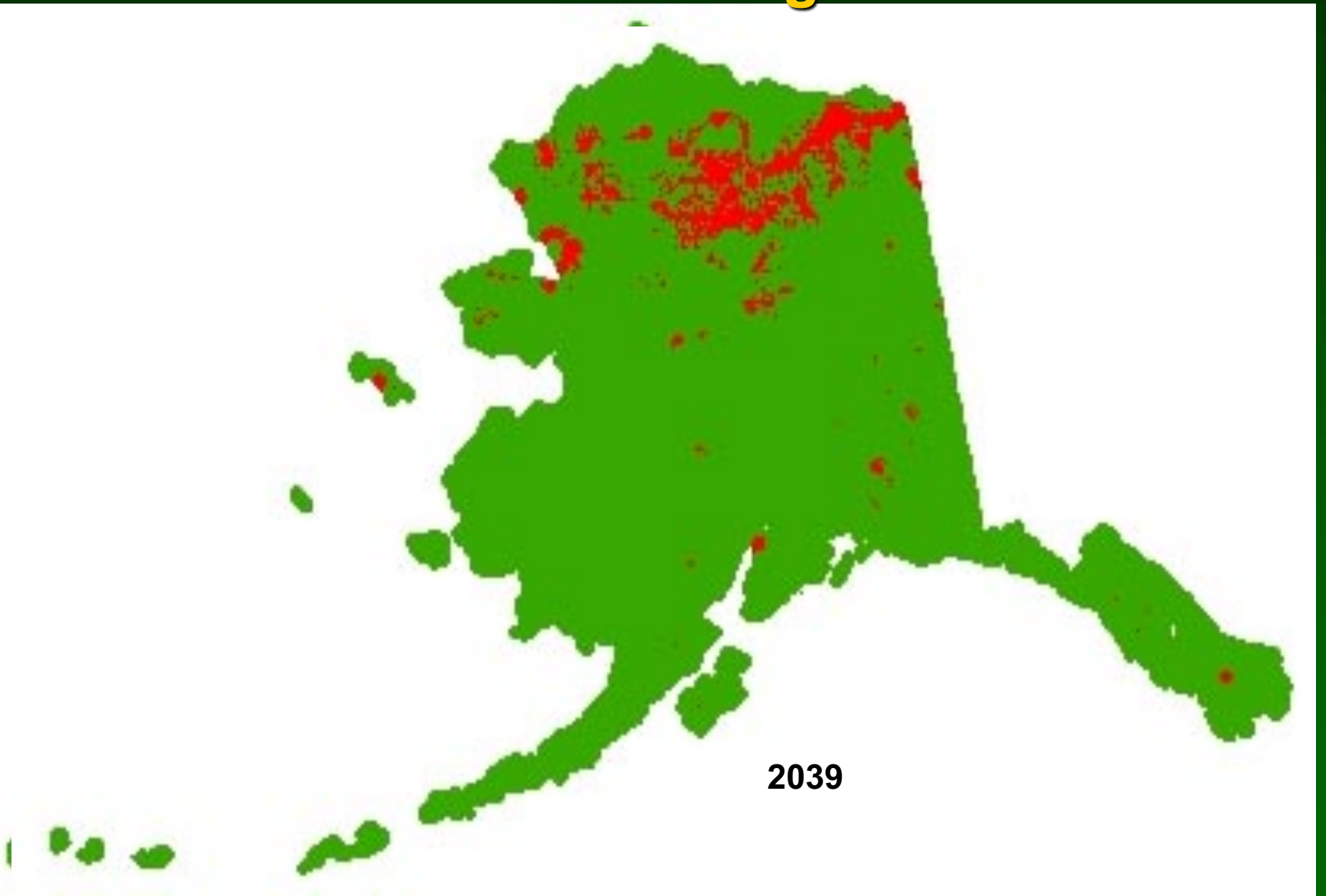
Known occurrences and predicted Alpine



A new layer: DEM roughness

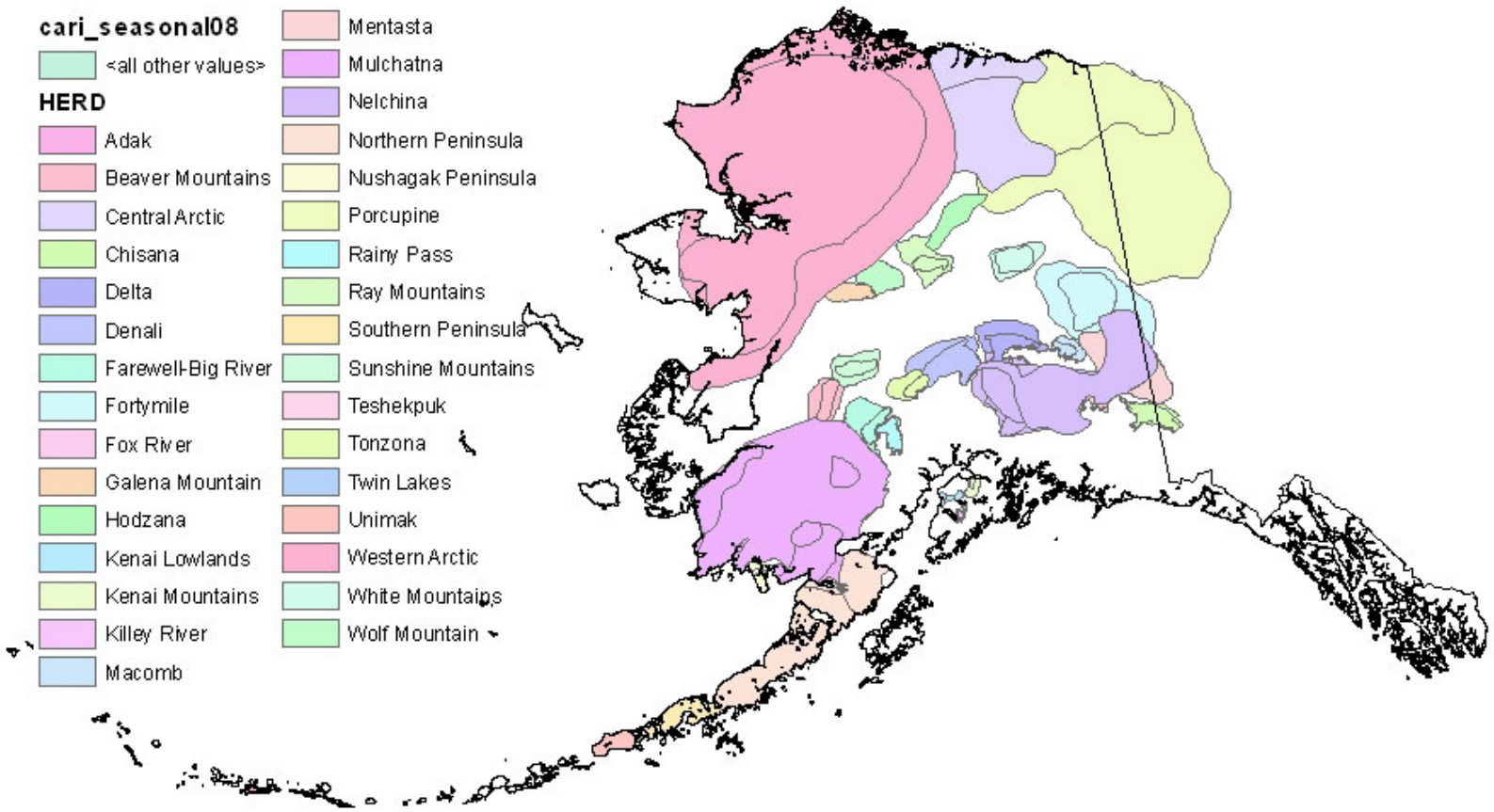


AK Marmot distribution using climate and roughness

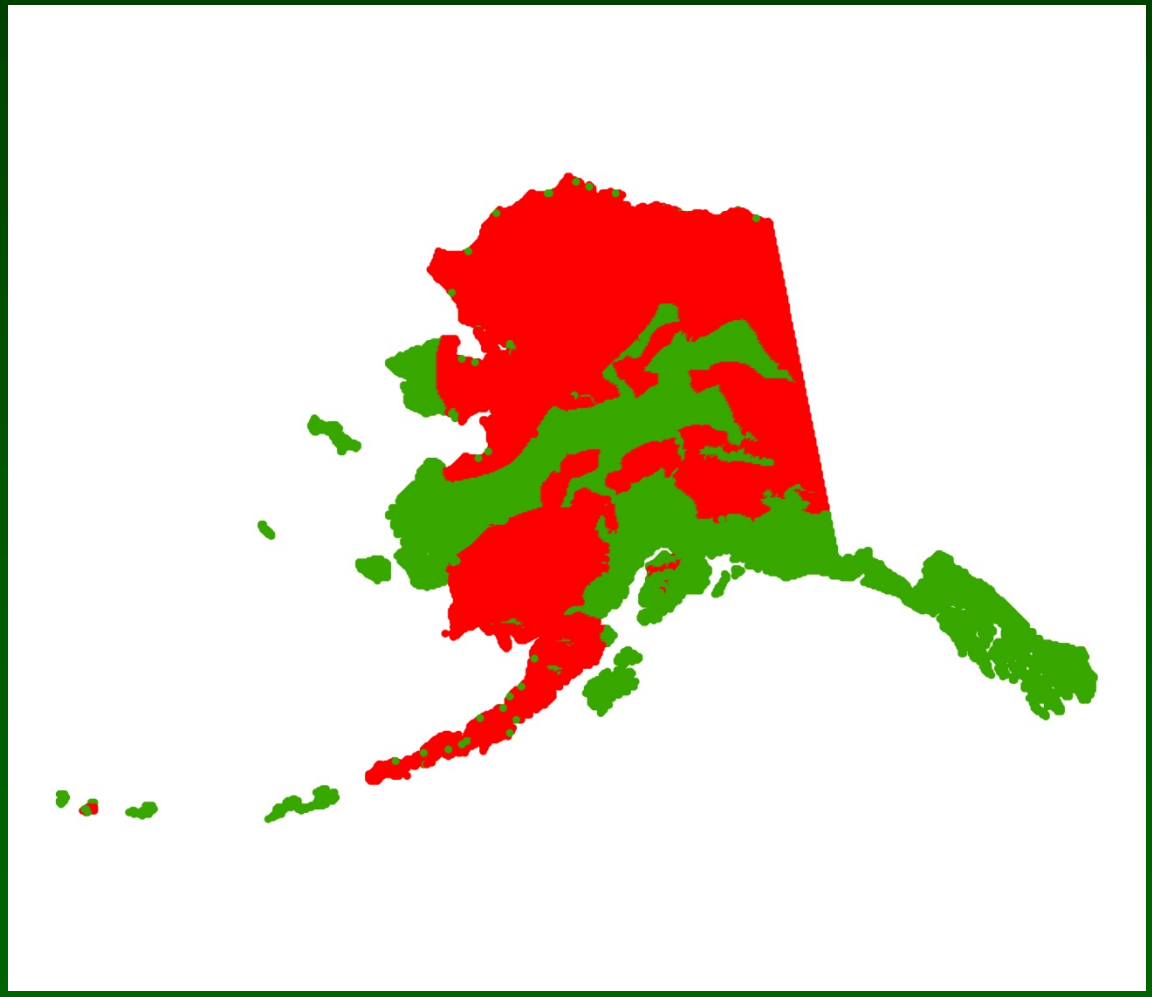


How can we forecast climate and caribou distribution?

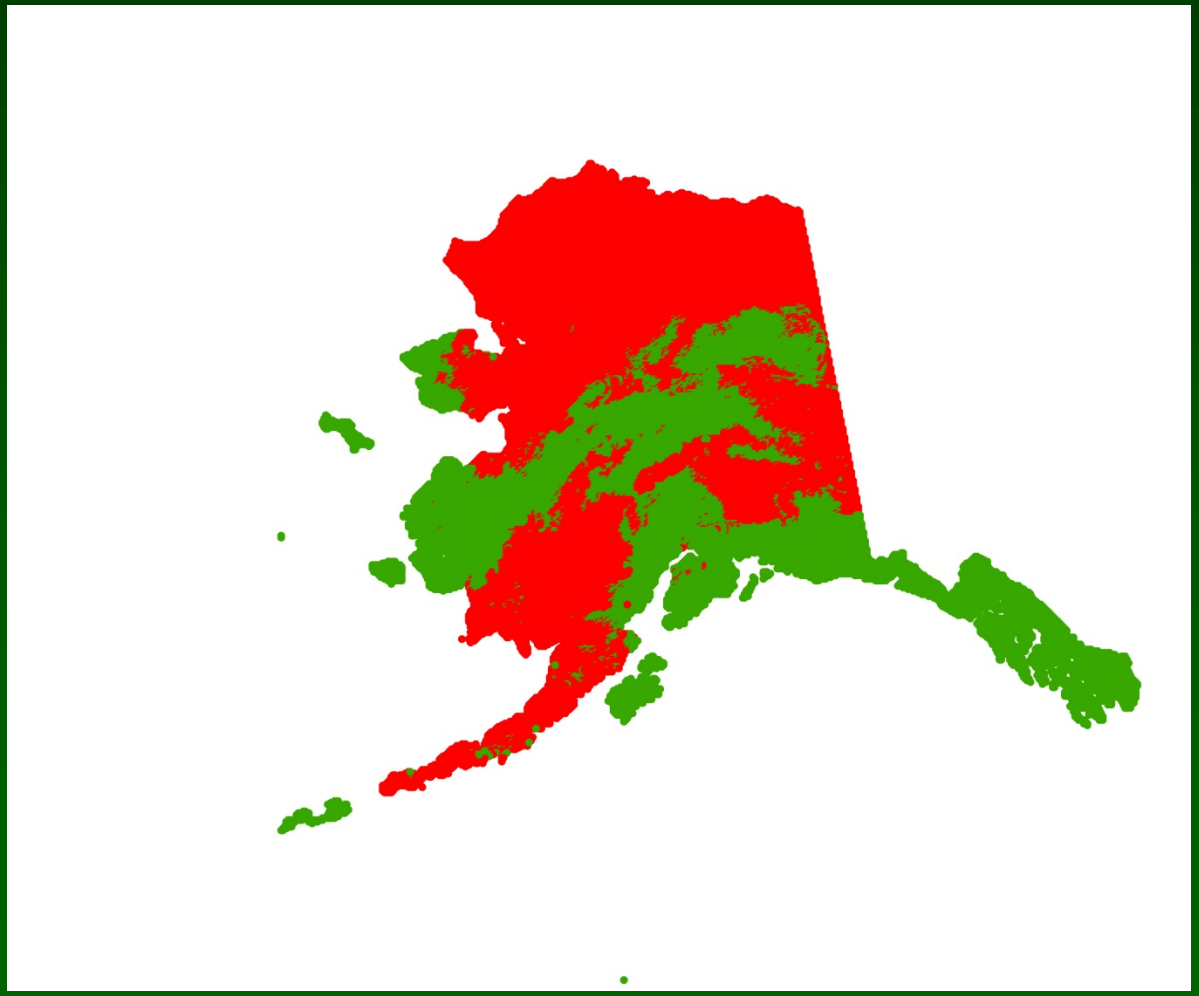
Estimated Caribou Herd distribution (2008)

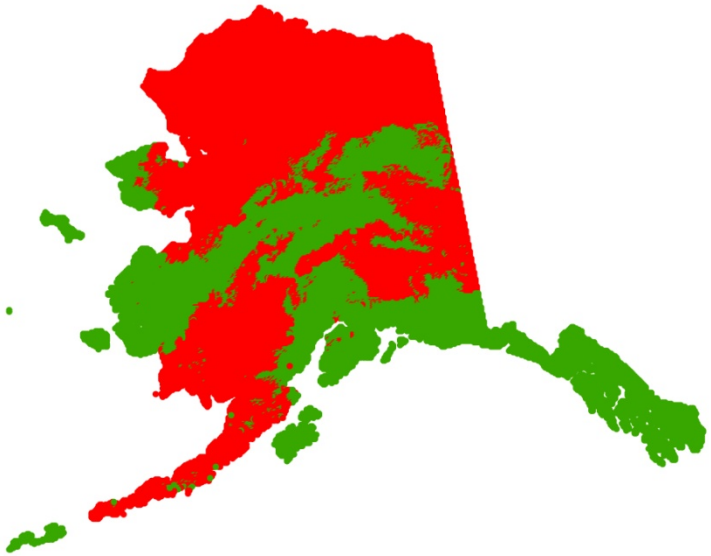


2009 composite distribution

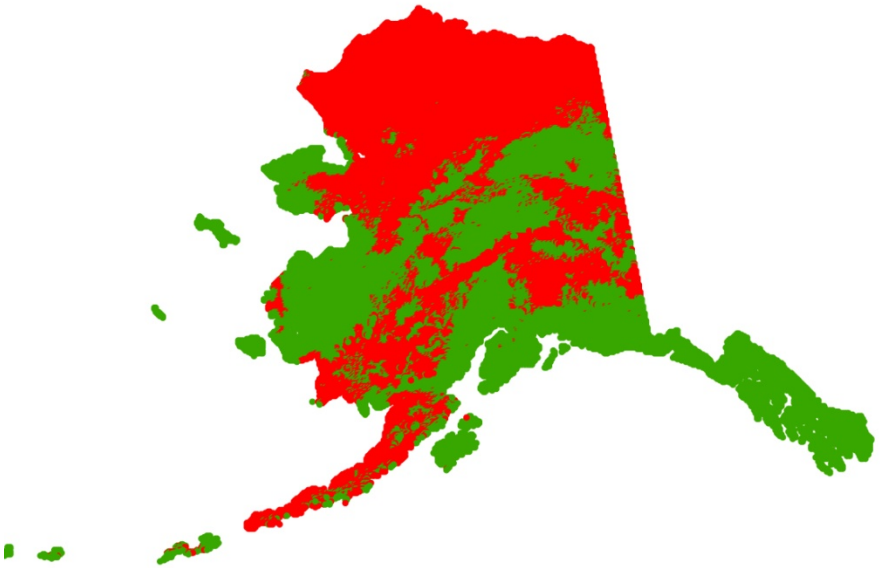


2009 modeled distribution

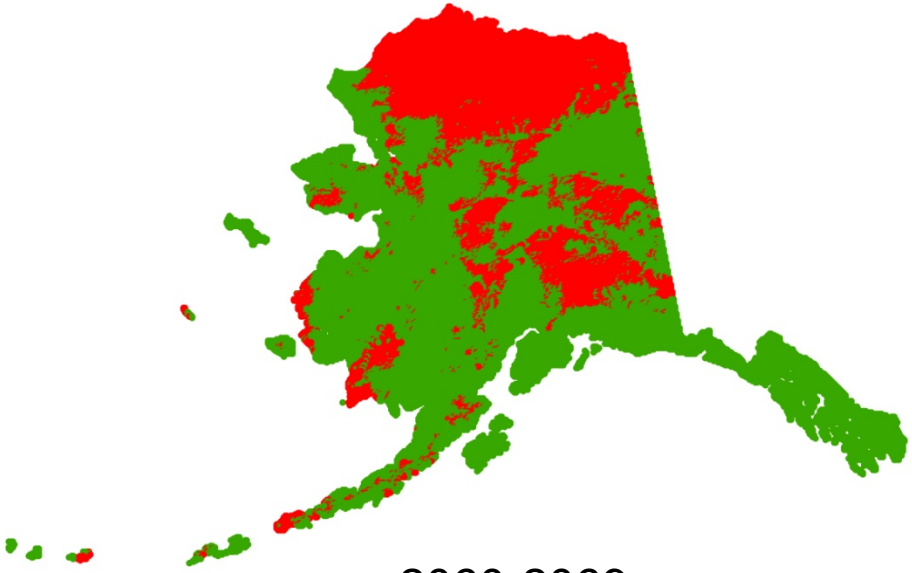




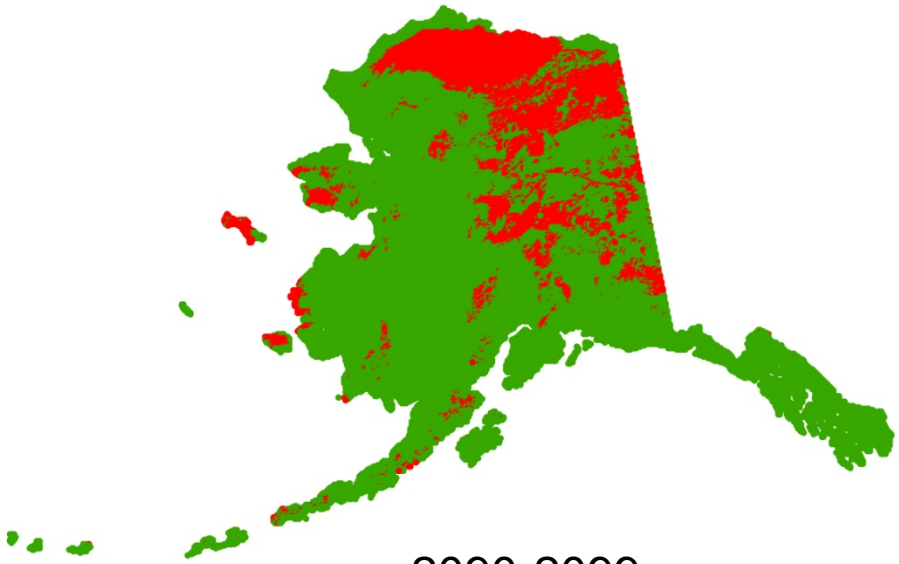
2000-2009



2030-2039

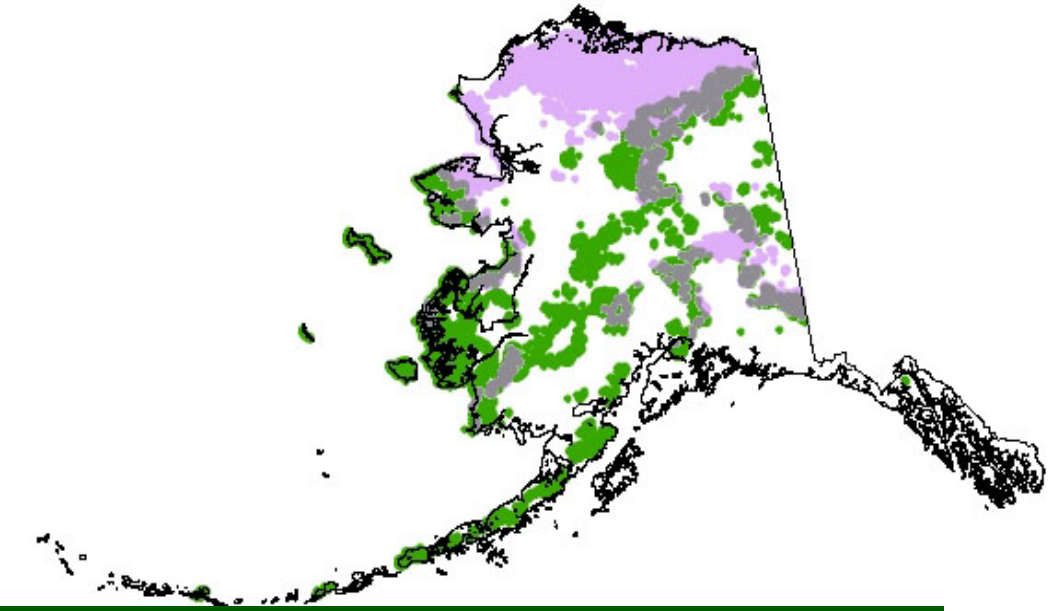


2060-2069

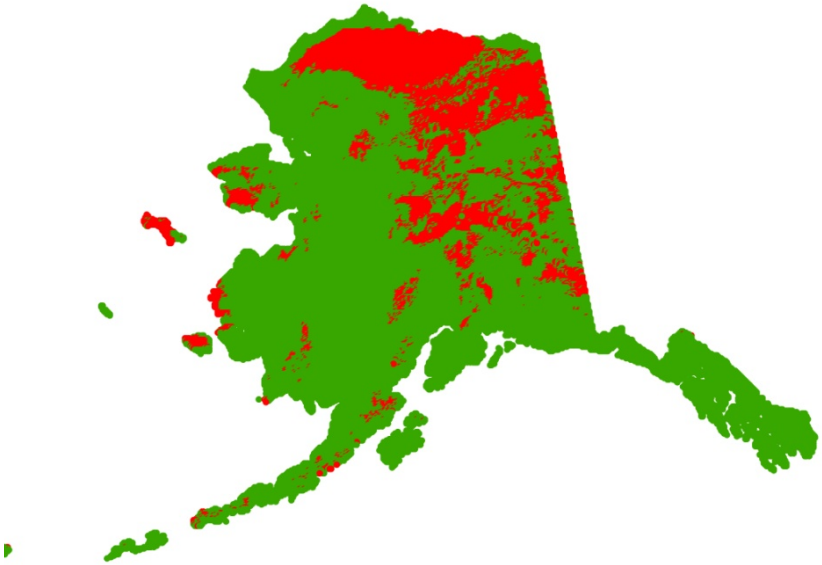


2090-2099

Predicted climate-suitable habitat 2090-2099



Based on subsample of herds with defined Summer and Winter ranges. Winter predictions = purple, Summer prediction = green



Based on the combined herd distributions for all 33 herds. Seasonality not included.

Lessons from species modeling…

- ✓ **Creation of climatic niche is possible to suggest trends but must be done thoughtfully and acknowledge limitation**
- ✓ **Even simple models of distribution shifts require more data than we have readily available**
- ✓ **Classic connectivity models are scale- and species-dependent**
- ✓ **Invasive plant spread likely to accelerate**

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SNAP
Scenarios Network for Alaska Planning

Spotlight

Climate Change Impacts on Water Availability in Alaska

A new report on statewide hydrology is now available, based on a study by The Wilderness Society in conjunction with SNAP. To download the report, look under Reports in the menu on the left... read more »

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Our mission is to provide timely access to management-relevant scenarios of future conditions in Alaska.

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