

# What's an exotic plant in a rapidly changing climate?

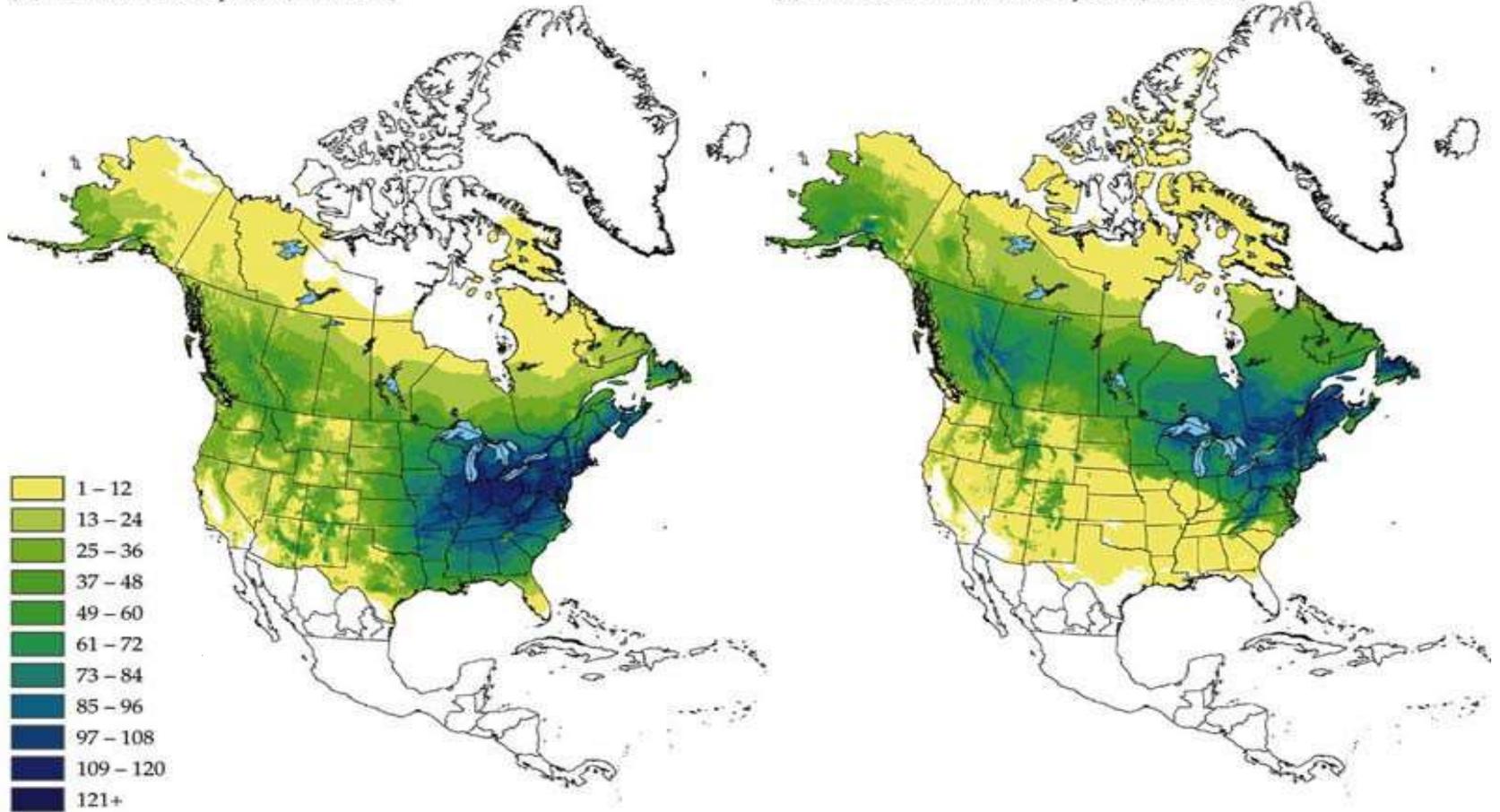


**John Morton**  
**Kenai National Wildlife Refuge**

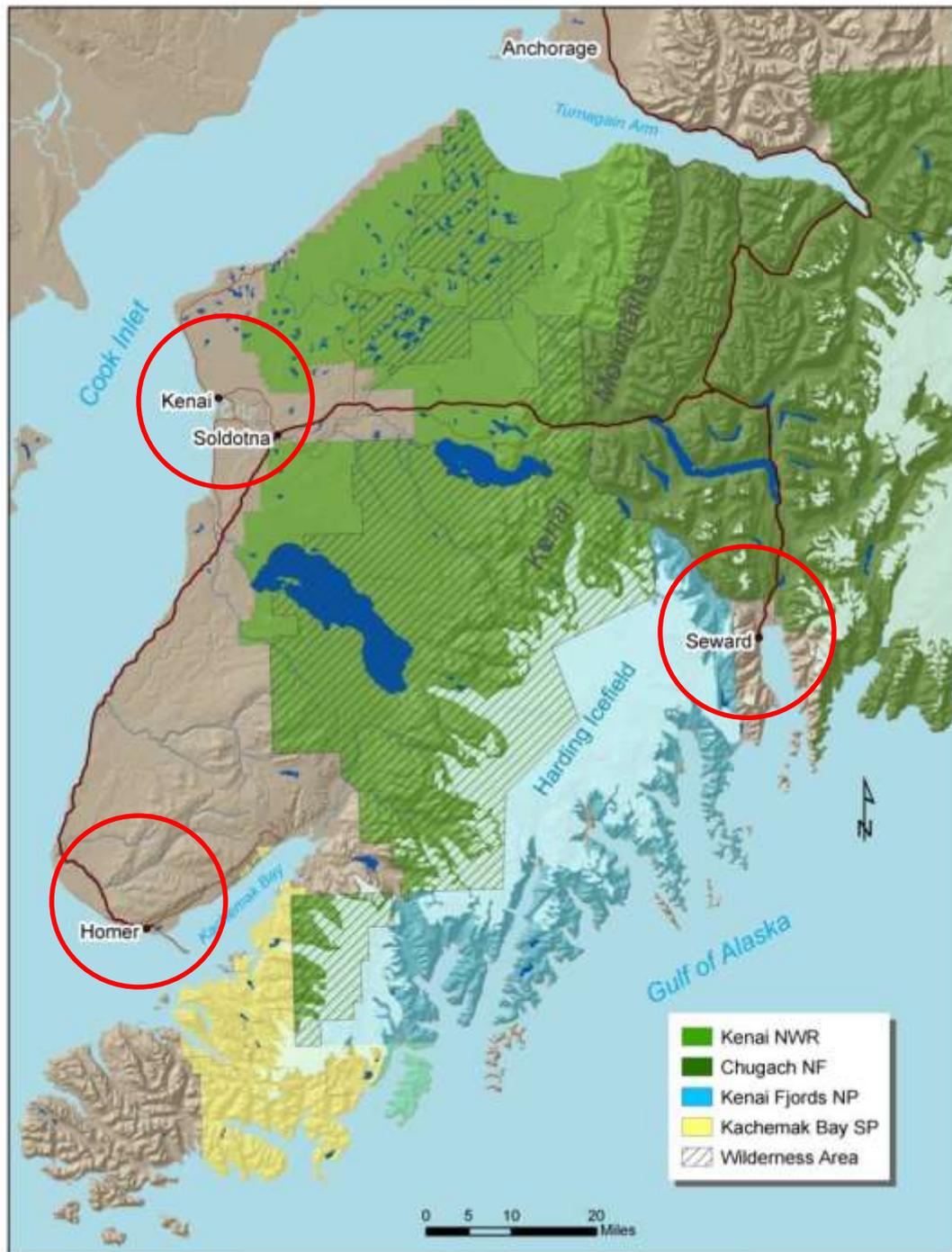
# Northward migrations of tree distributions

(A) Number of tree species (1971–2000)

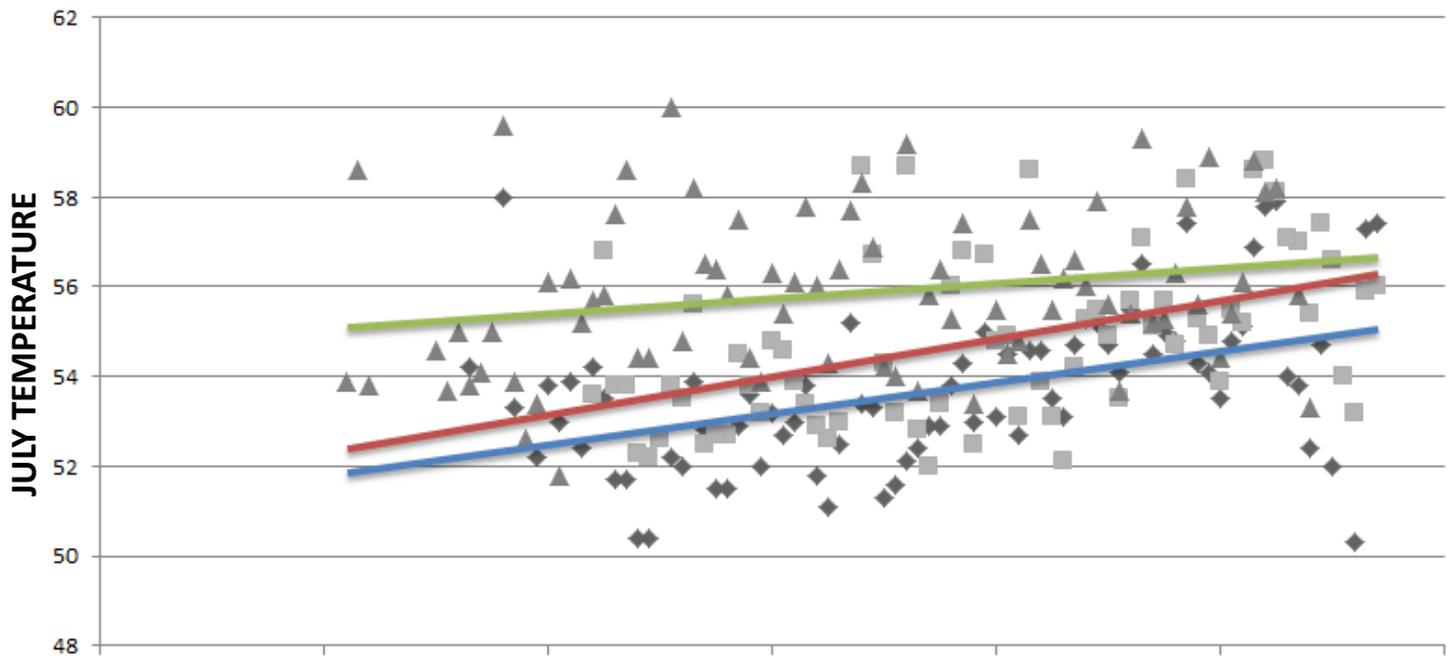
(B) Predicted number of tree species (2071–2100)



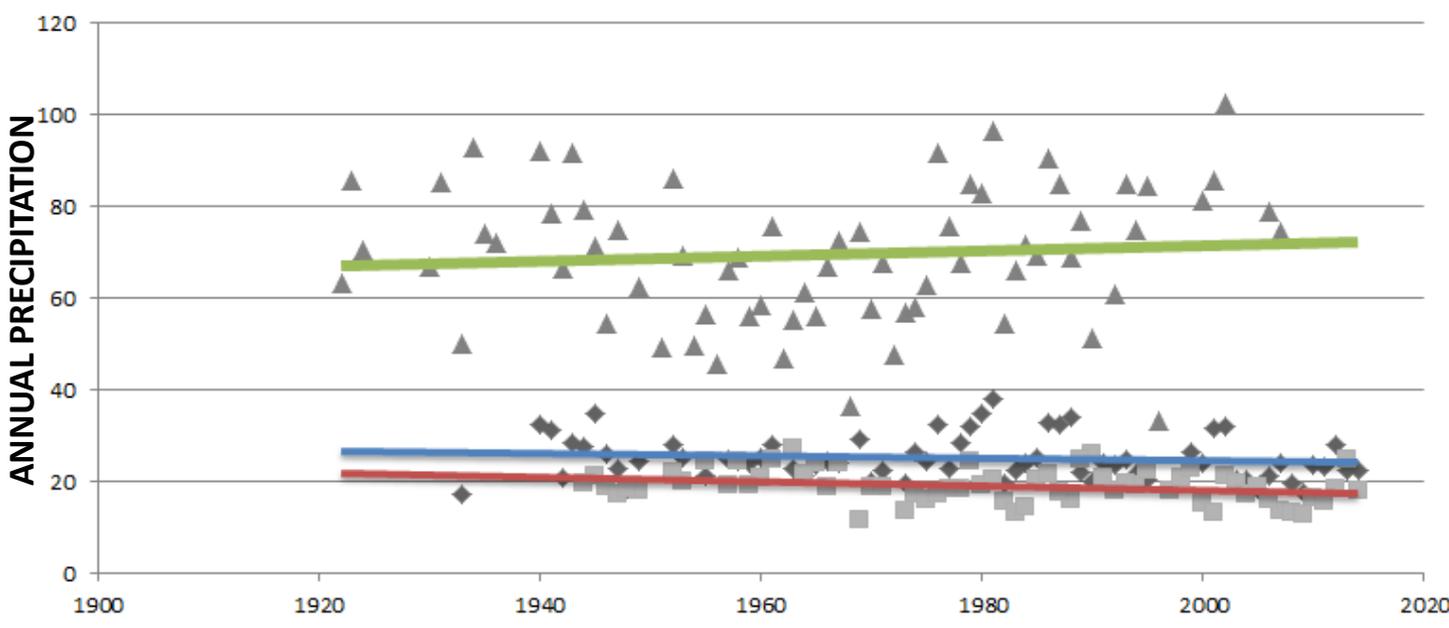
(McKenney et al. 2011)



- ✓ Alaska is warming at 2X Lower 48 rate
- ✓ Climate change effects are not masked by other anthropogenic drivers
- ✓ Kenai Peninsula may be best studied locale in AK outside of high arctic



**SEWARD**  
**KENAI**  
**HOMER**





- Biomes - 2005**
- Aleutian Islands
  - Arctic
  - Boreal
  - Boreal Transition
  - North Pacific Maritime
  - Western Tundra

**Arctic**

**Boreal**

**Boreal Transition**

**Western Tundra**

**North Pacific Maritime**

**Aleutians**

0 125 250 500 Miles





05.15.2007









# 1,865 species recorded on Kenai National Wildlife Refuge

- 34 mammals
  - 154 birds
  - 20 fish
  - 1 amphibian
  - 611 arthropods
  - 7 molluscs
  - 11 other animals
  - 493 vascular plants
  - 180 bryophytes
  - 29 fungi
  - 325 lichens
- \*1,771 native, 89 non-native, 5 include both native and non-native subspecies

# Kenai is ground zero for climate change

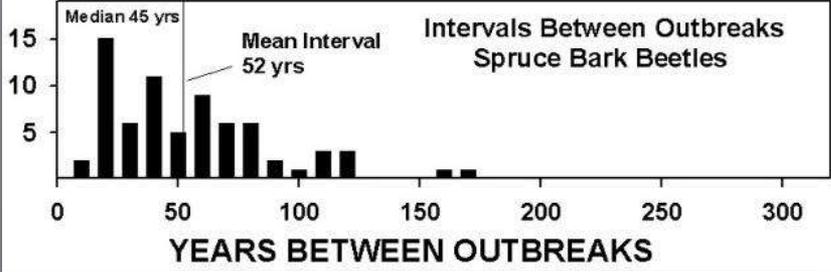
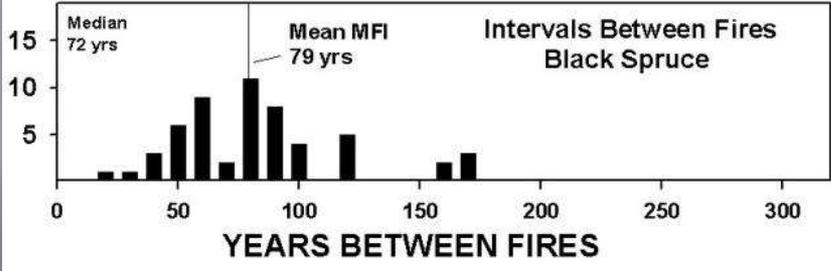
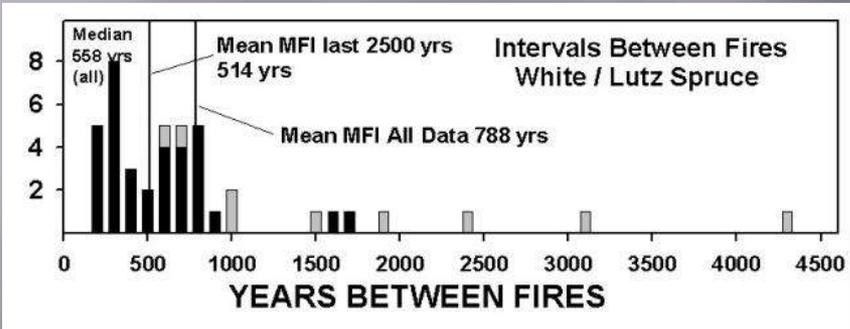
- ✓ Kenai winters have warmed more than summers
- ✓ Kenai nights have warmed more than days
- ✓ Homer has jumped 2 USDA plant zones
- ✓ Biggest future uncertainty on Kenai is form and variation of increasing precipitation
  - ✓ Extreme events likely
  - ✓ Snow may increase at higher elevations but decrease along coast

# Kenai's landscape has changed dramatically in last 50 years in response to warming and drying

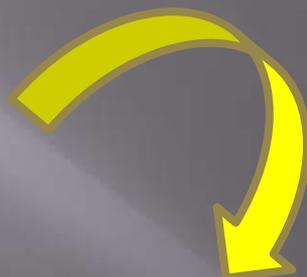
- available water (60% loss since 1968)
- wetlands (6 – 11% per decade)
- glaciers (11% surface area, 21 m elevation)
- + treeline (10 m per decade,  $2.8 \text{ m}\cdot\text{y}^{-1}$ )
- + SB beetle outbreaks (triggered by 2 consecutive warm summers)



# Official fire season is now April 1 instead of May 1



# Woody shrub encroachment into 8000 year old Sphagnum peatlands



# Conversion of white/Lutz spruce forests to Calamagrostis savannah



See Boucher and Mead 2006

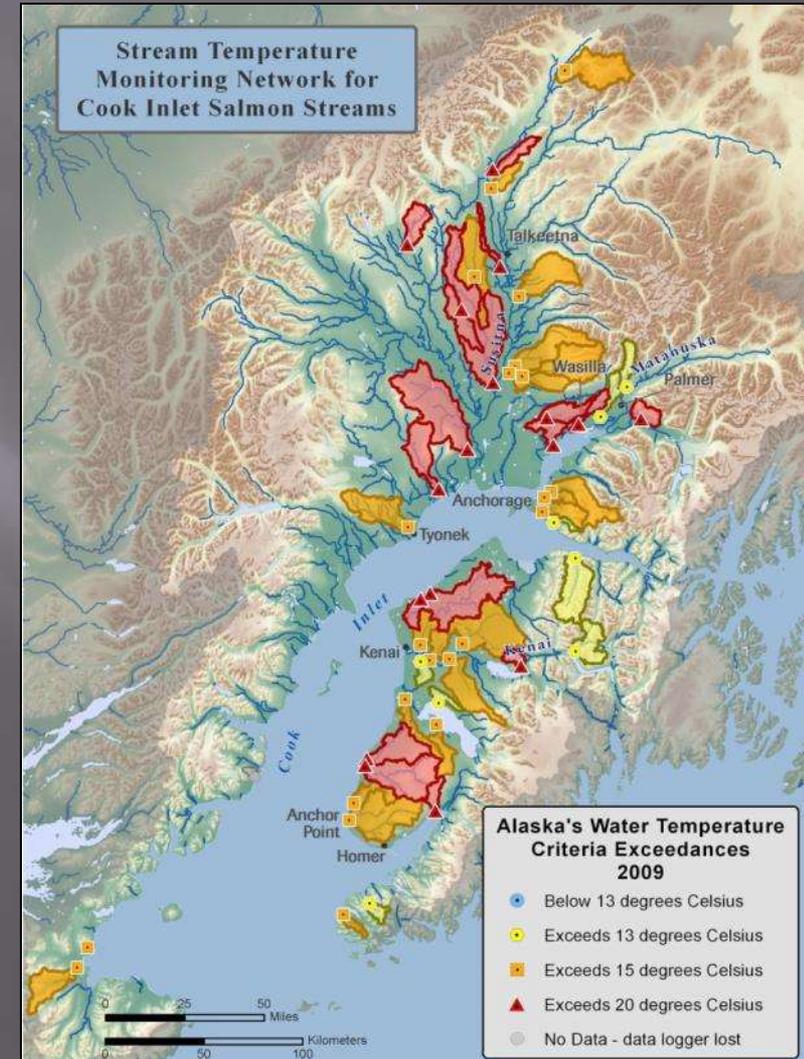
# Salmon in 47 of 48 non-glacial streams experience thermal stress in July



47 > 13°C  
39 > 15°C  
17 > 20°C

These maximum temperatures shall not be exceeded:

- egg & fry incubation = 13°C
- spawning areas = 13°C
- migration routes = 15°C
- rearing areas = 15°C
- and may not exceed 20°C at any time



# Changing migration window in last decade



eBird data

- ✓ Earlier arrival records for 33 species
- ✓ Later departure records for 38 species
- ✓ 27 new species since 2007

Eurasian-collared dove\*  
Redwing\*  
Jack snipe\*  
Skylark\*  
Long-billed murrelet\*  
Black-tailed godwit\*  
Northern mockingbird  
Spotted towhee  
Turkey vulture  
Western kingbird  
Western meadowlark  
Willow flycatcher  
Northern wheatear  
Western tanager  
Yellow-bellied sapsucker  
Warbling vireo  
Swamp sparrow  
Tennessee warbler  
Cape May warbler  
Nashville warbler  
Wilson's phalarope  
Great egret  
Willet  
Red-footed booby  
Black guillemot  
Heerman's gull  
Lesser black-backed gull

# Early January 2016



## In the news

### Winter warmer-land: U.S. breaks record for hottest winter

WASHINGTON (AP) — Federal meteorologists say the winter that has just ended was the hottest in U.S. records, thanks to the combination of El Nino and man-made global warming.

The average temperature for the Lower 48 from December through February — known as meteorological winter — was 36.8 degrees, 4.6 degrees above normal. It breaks the record set in 1999-2000.

Last month was the seventh warmest February. National Oceanic and Atmospheric Administration climate scientist Jake Crouch said a super-hot December pushed the winter to record territory. The fall of 2015 also was a U.S. record.

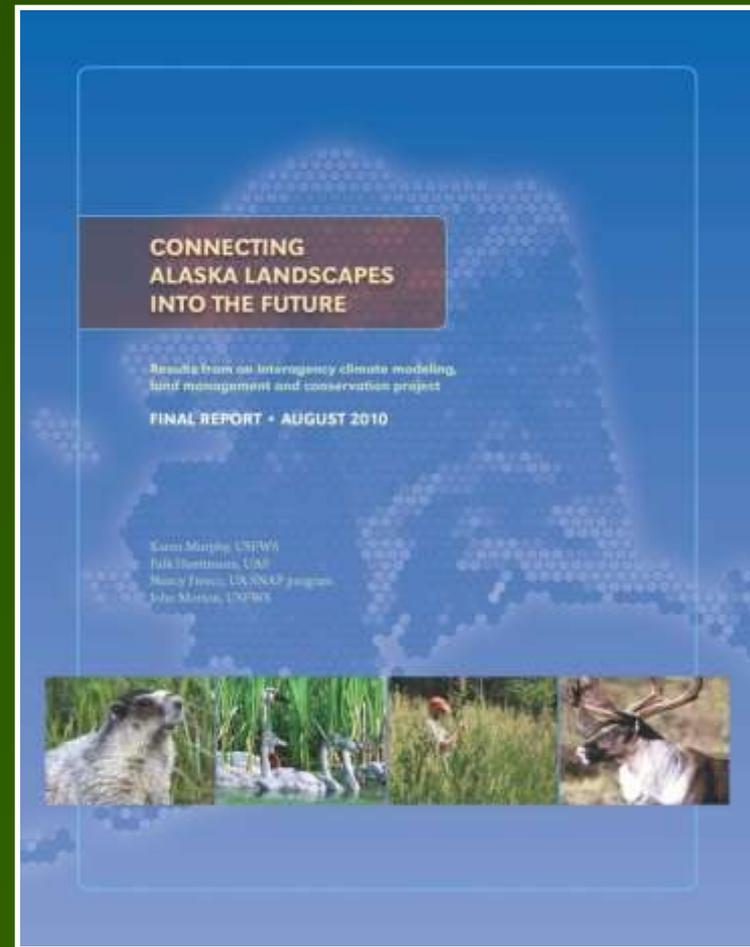
All six New England states had their warmest winters. Every state in the Lower 48 had winters at least 1.7 degrees warmer than normal. Alaska was 10.6 degrees warmer than normal.

Records go back to 1895.

**Take this with a grain of salt....**



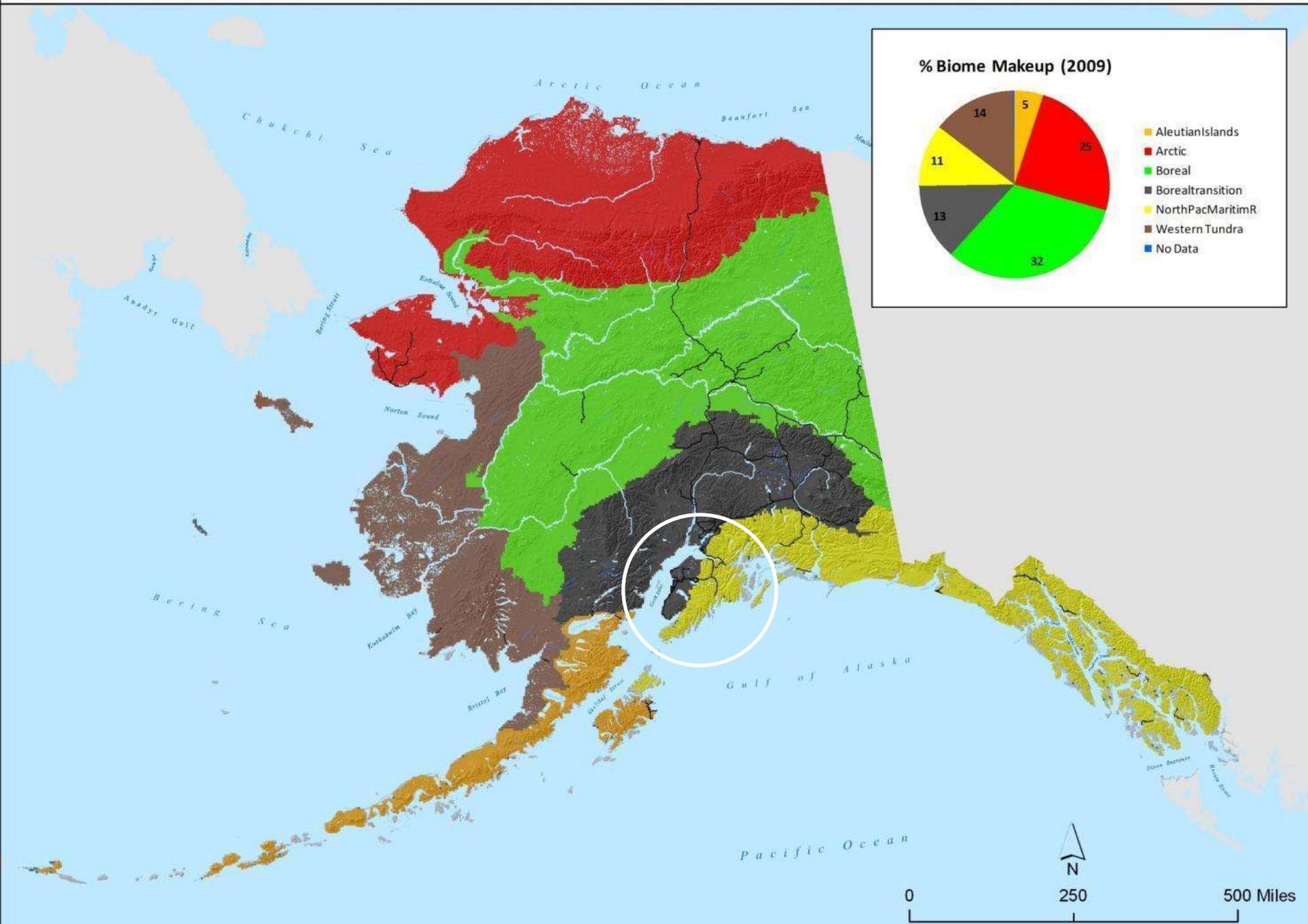
# Interagency effort to pioneer the assessment of climate change impacts on biome and species distributions using climate envelope models



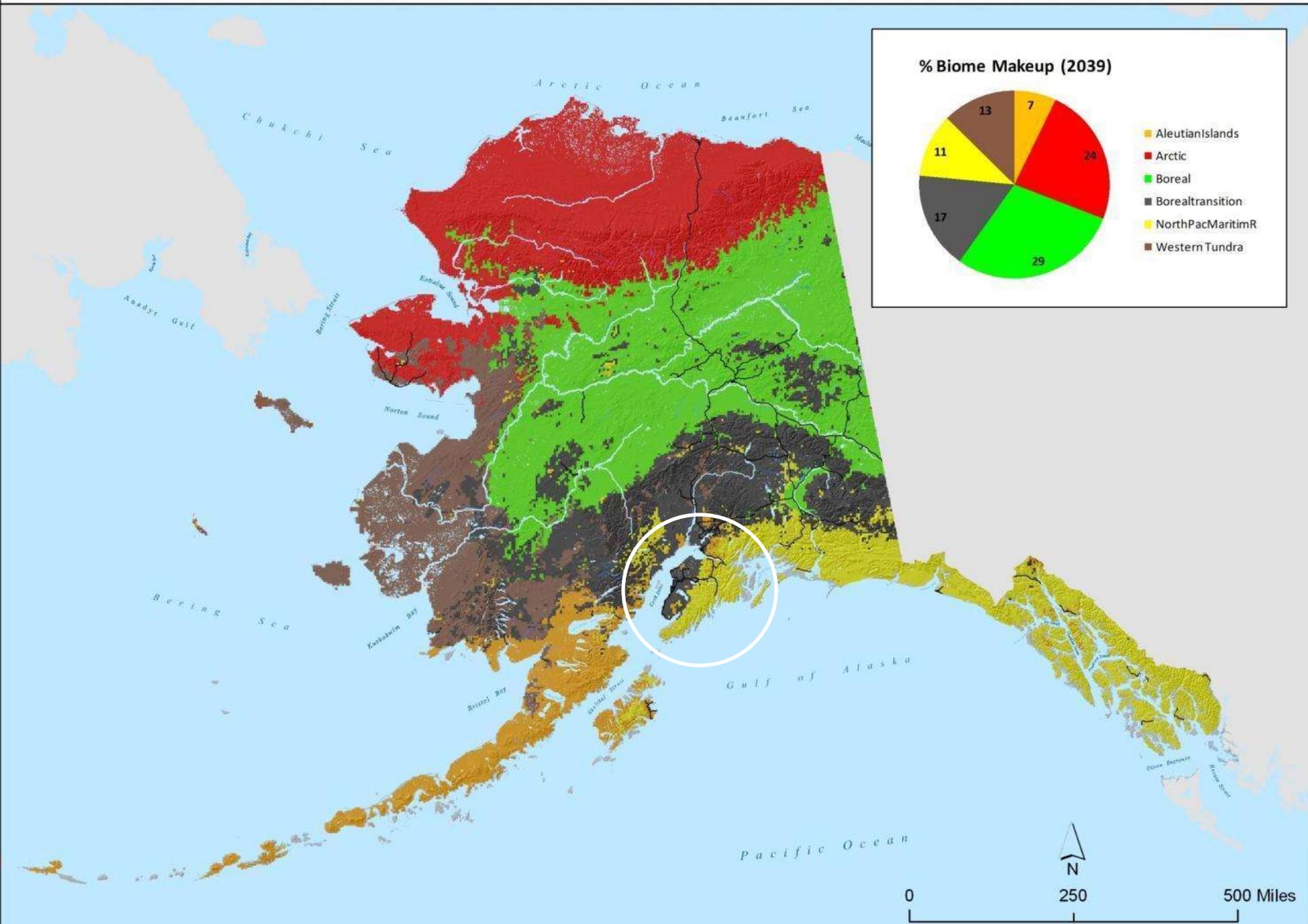
# Why are potential and realized niches different?

- ✓ Climate (photoperiod, temperature, precipitation)
- ✓ Species-specific generational times
- ✓ Competitive interactions with other plants
- ✓ Competitive interactions with herbivores
- ✓ Soil (soil type/litter, mycorrhizal fungi, soil temperature, permafrost)
- ✓ Host-parasitoid relationships
- ✓ Dispersal mechanisms (wind, cones, insects, birds)
- ✓ Barriers (mountains, glaciers, oceans)

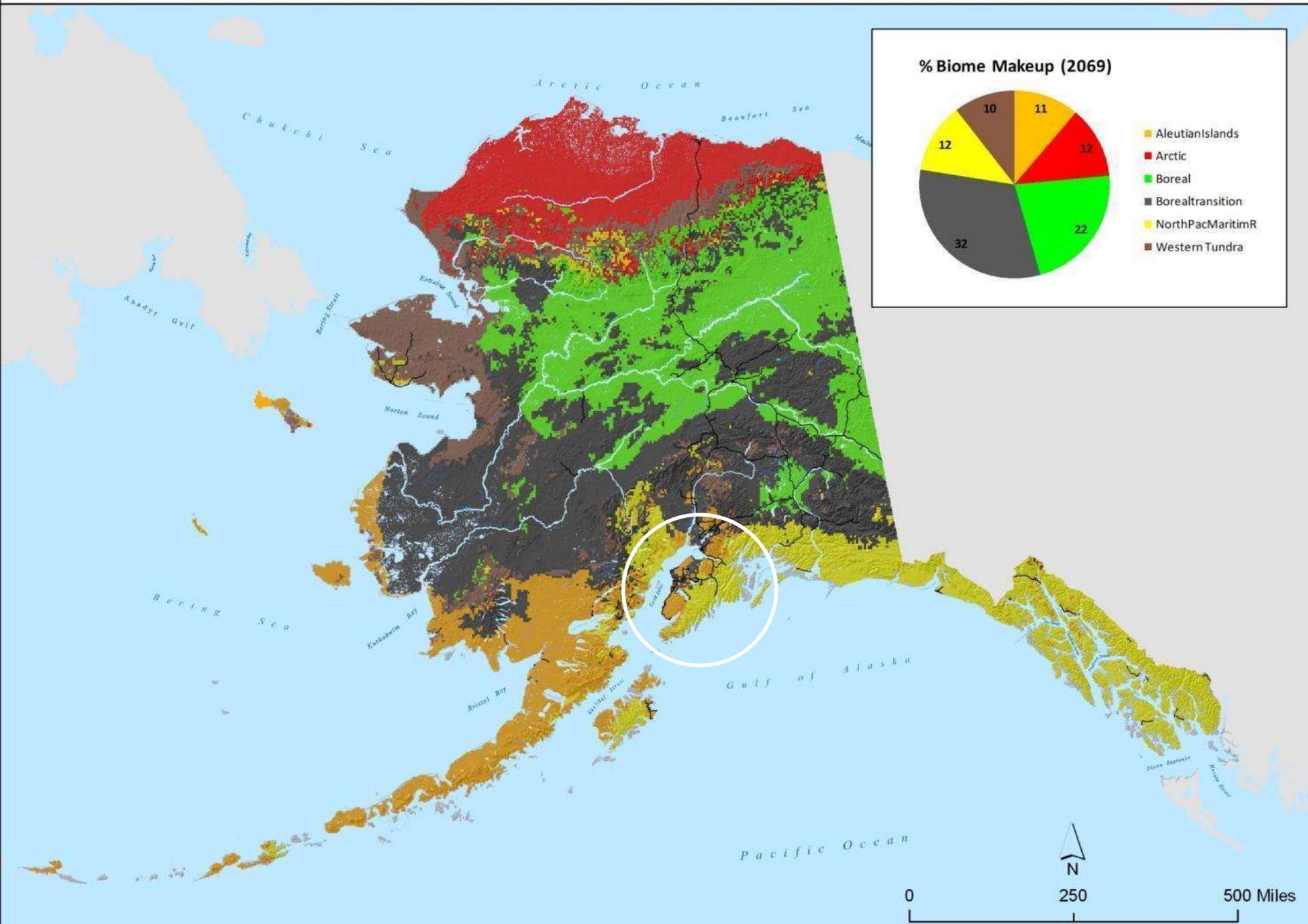
# Biome in 2009



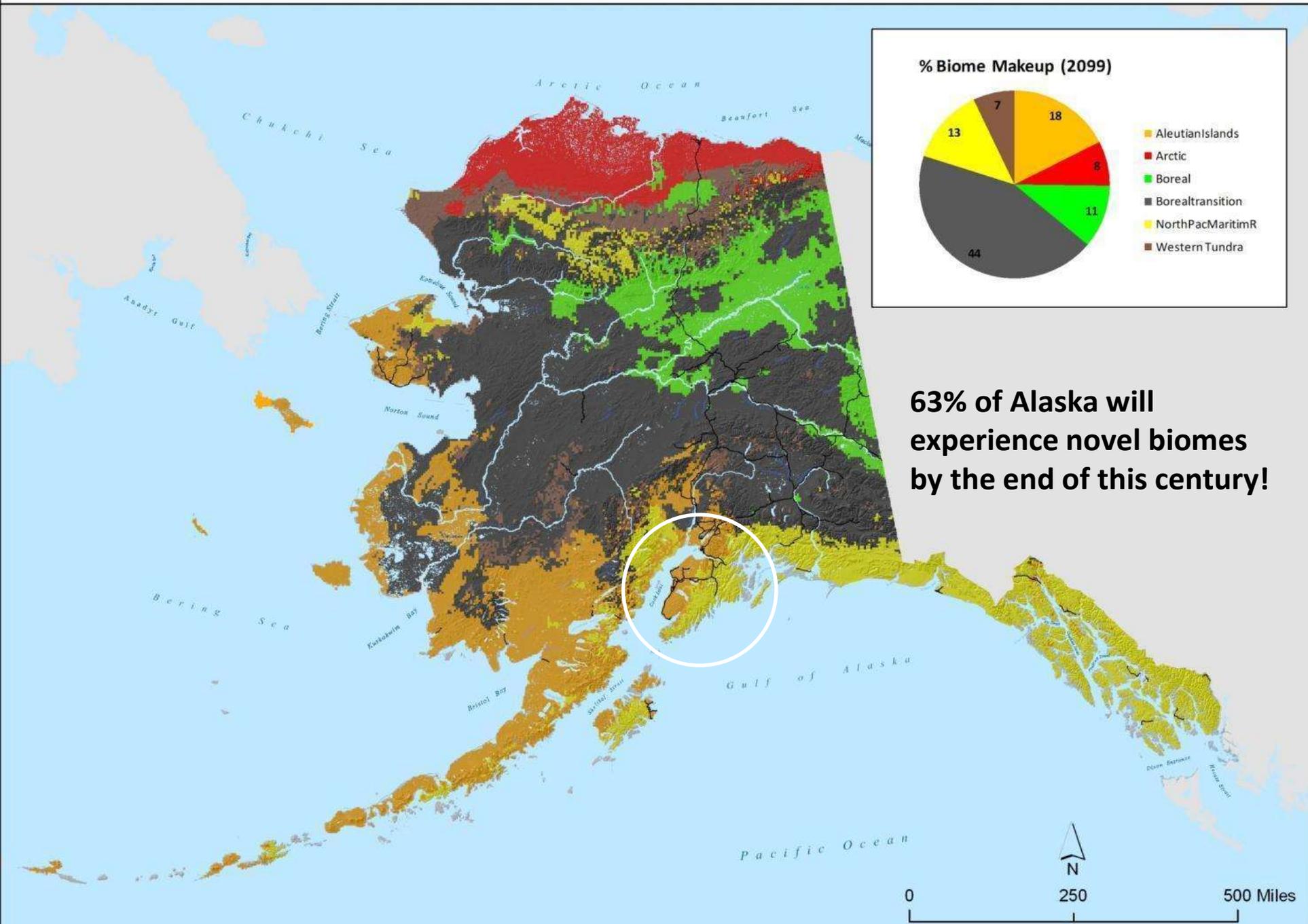
# Biome in 2039



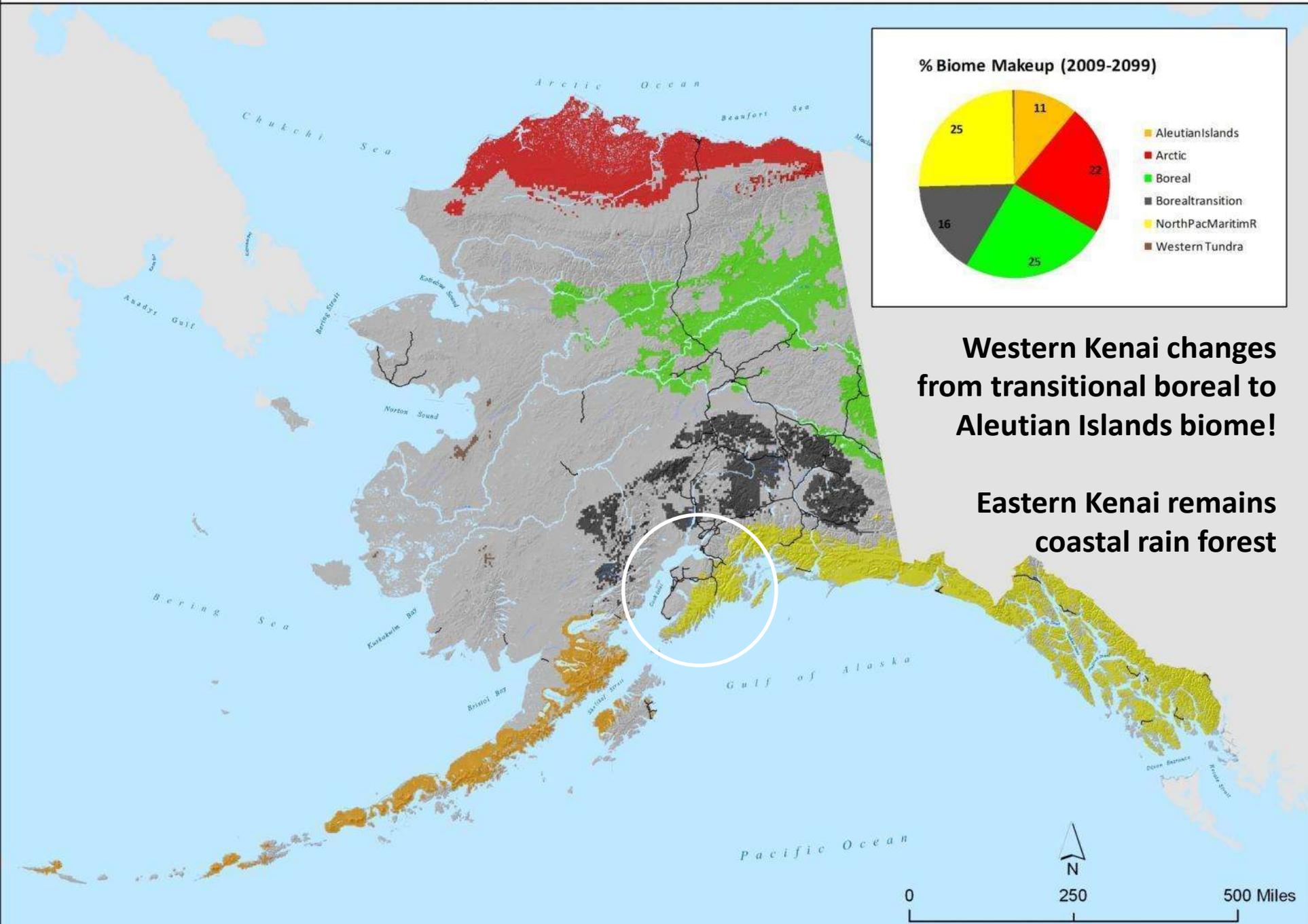
# Biome in 2069



# Biome in 2099



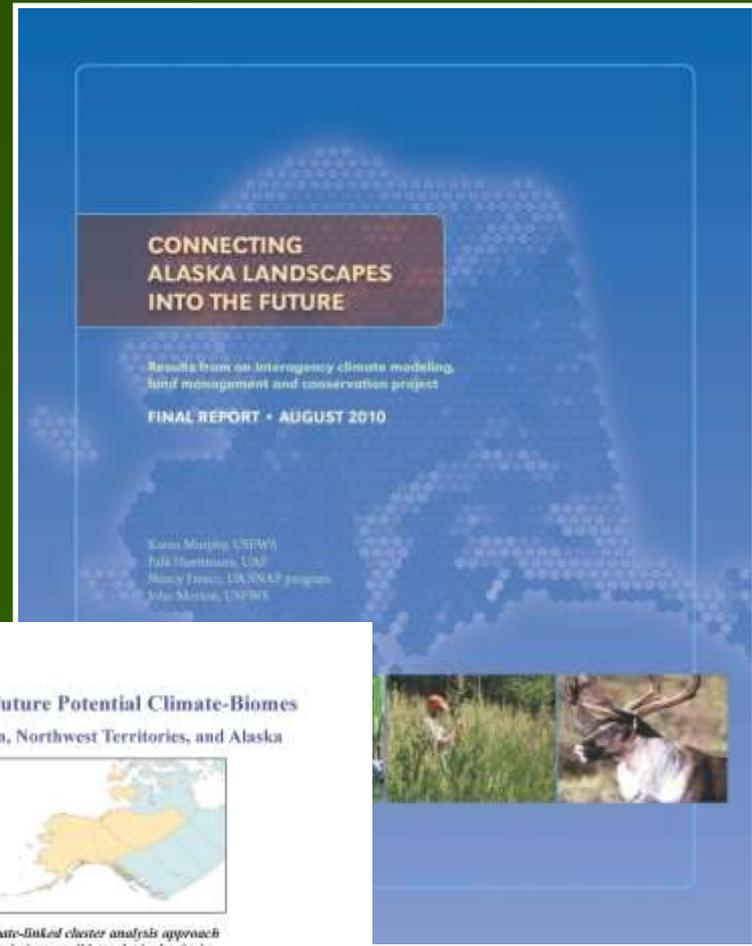
# No Change in Biome from 2009 to 2099



**Take this with a grain of salt....**



# Interagency effort to pioneer the spatial modeling of climate change impacts on biome and species distributions



## Predicting Future Potential Climate-Biomes for the Yukon, Northwest Territories, and Alaska



*A climate-linked cluster analysis approach to analyzing possible ecological refugia and areas of greatest change*

Prepared by the Scenario Network for Arctic Planning and the ESWHALE lab, University of Alaska Fairbanks

on behalf of

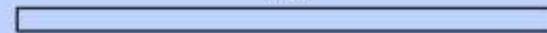
The Nature Conservancy's Canada Program  
Arctic Landscape Conservation Cooperative  
The US Fish and Wildlife Service  
Ducks Unlimited Canada  
Government Canada  
Government Northwest Territories

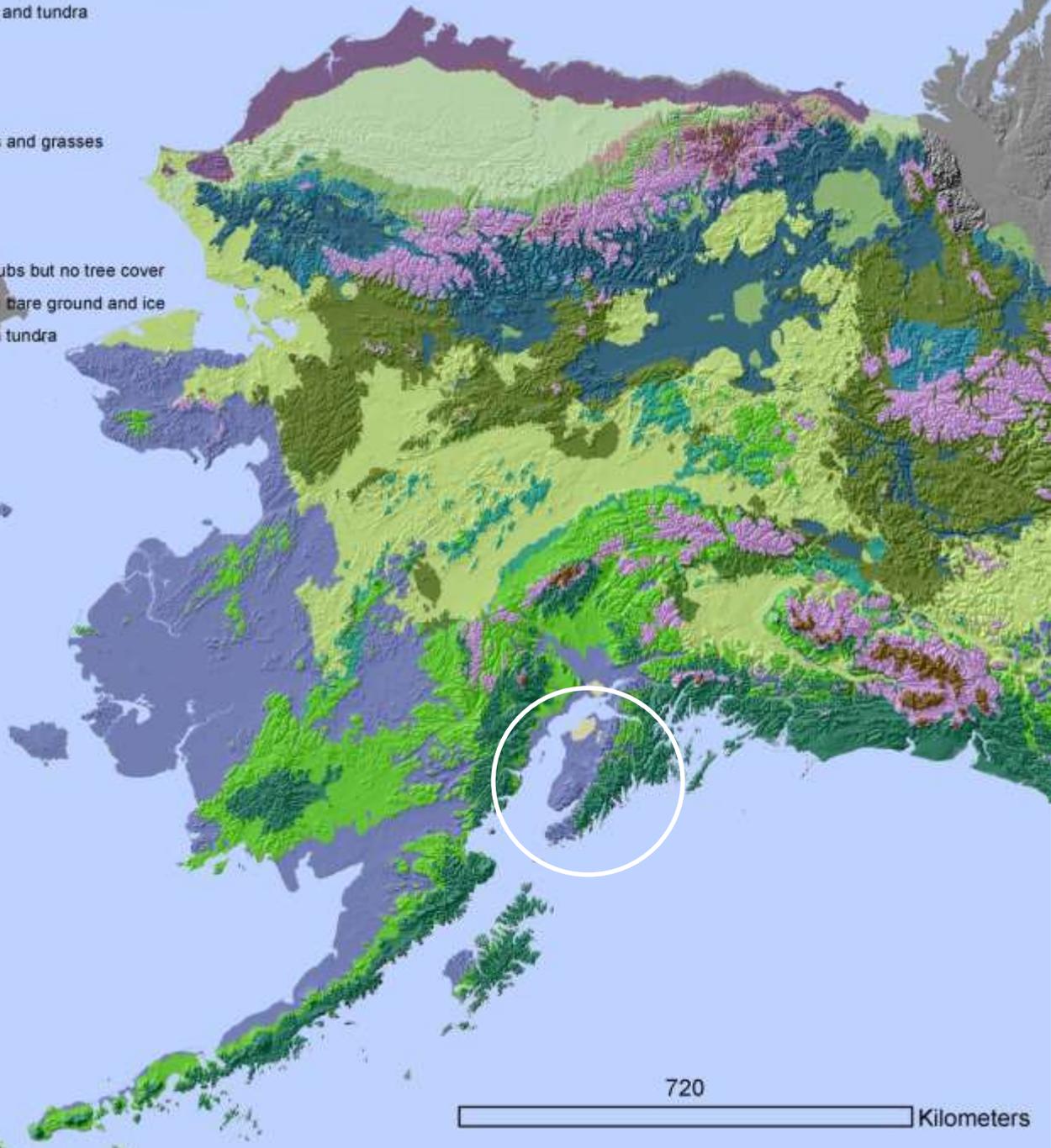


2012

- 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 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

 **2009**

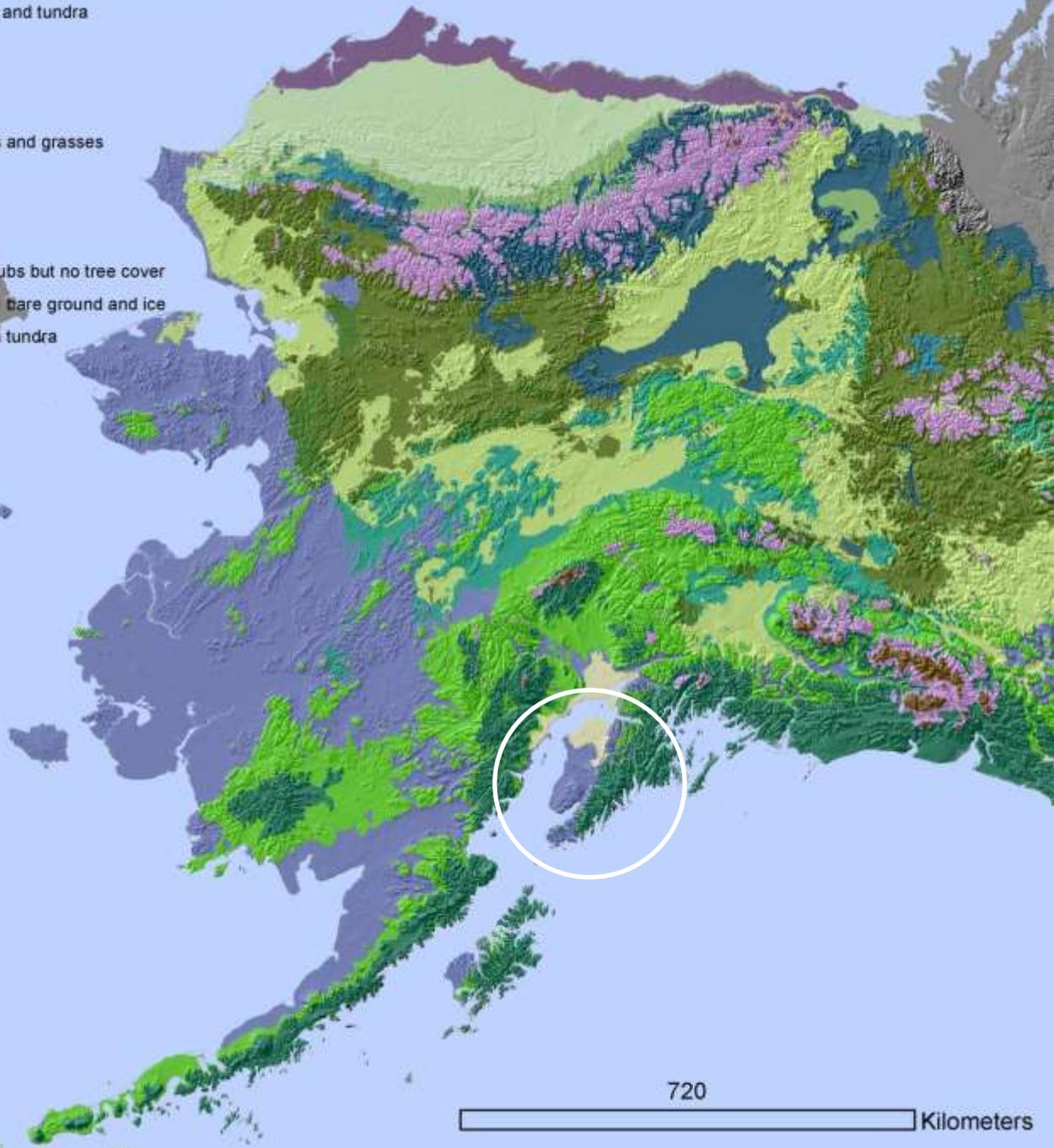
720  
 Kilometers



- 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 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

**2039**

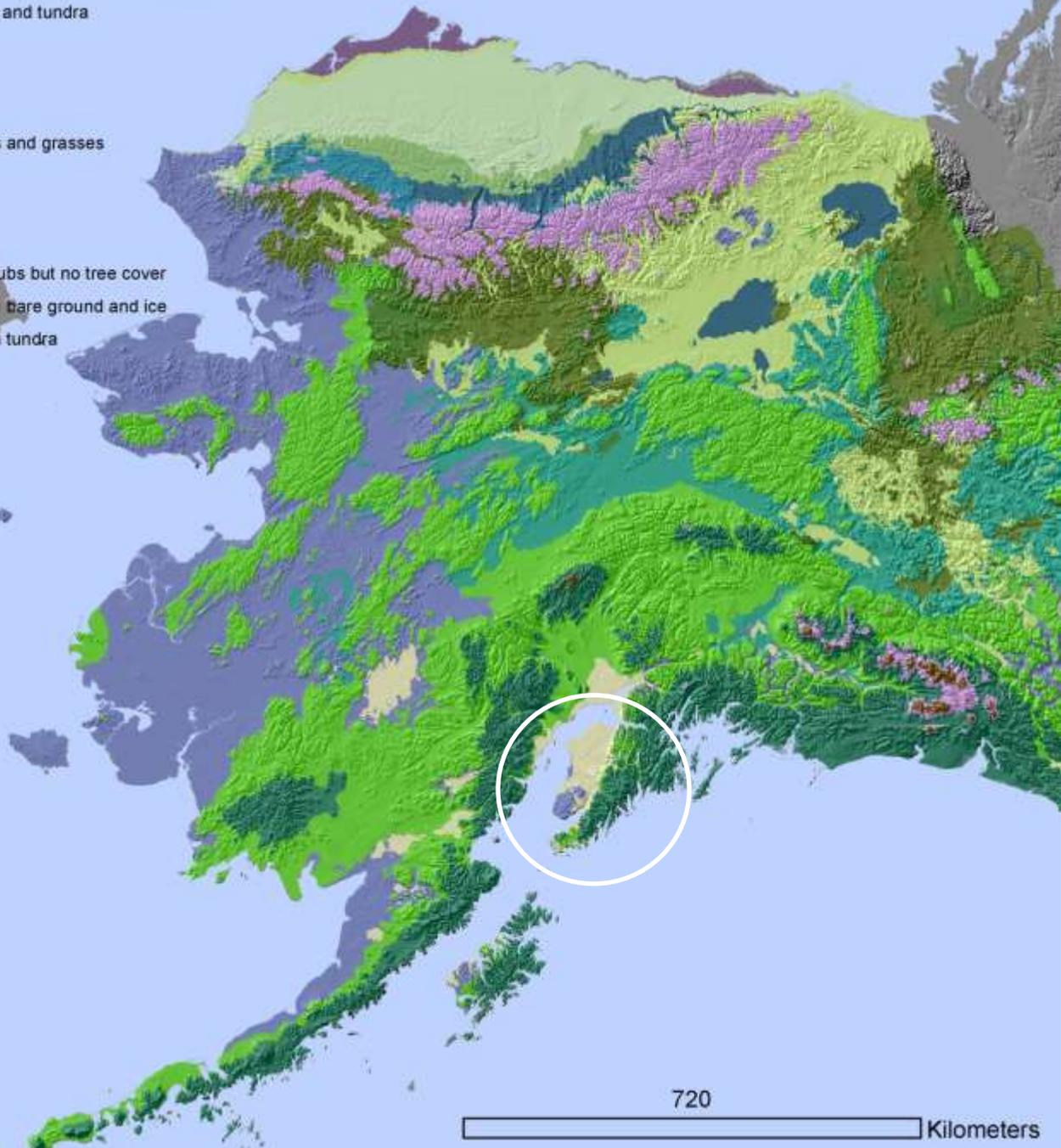
720 Kilometers



- 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 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

**2069**

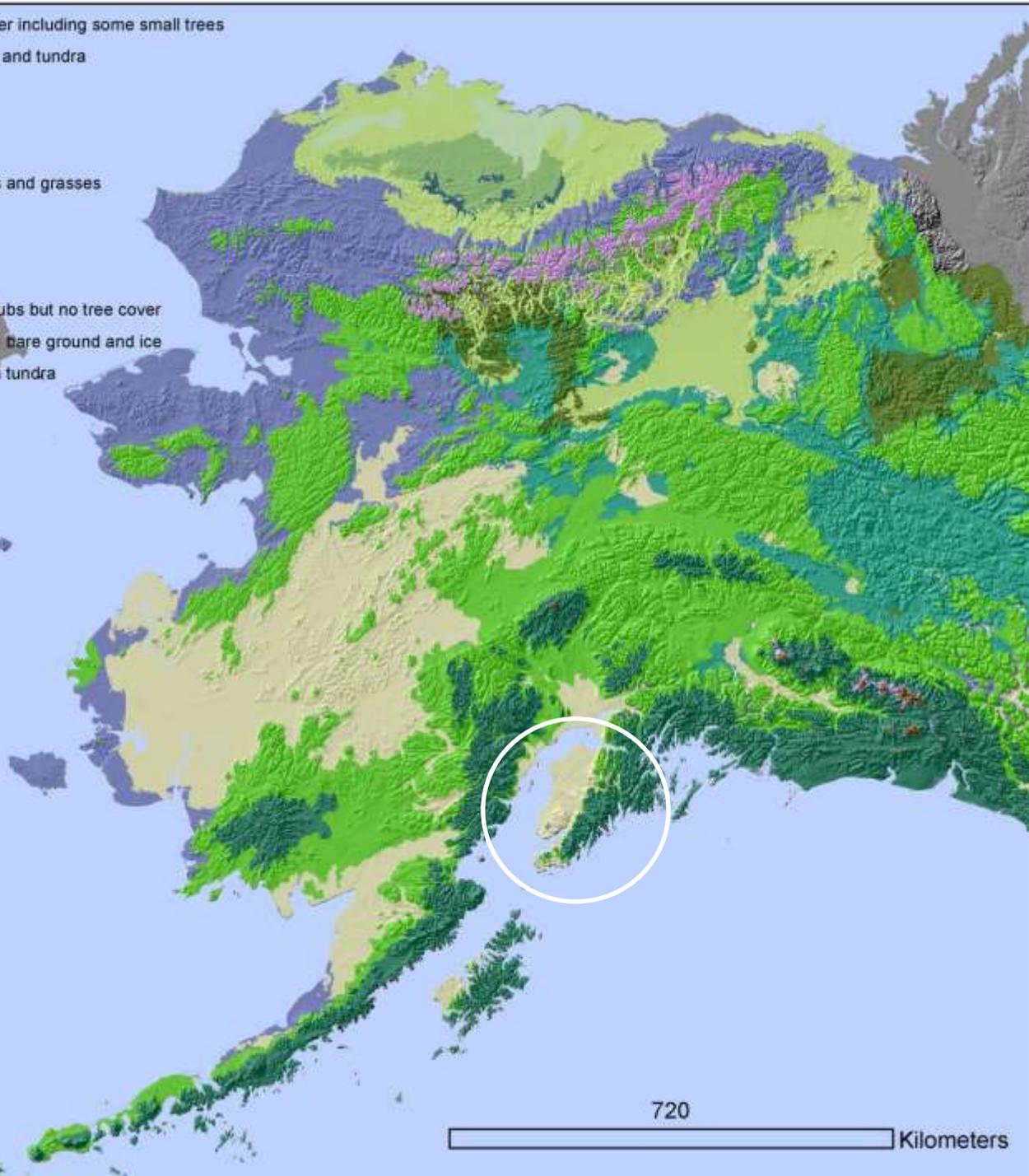
720 Kilometers



- 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 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

**2099**

720 Kilometers





**By 2100...**

- ✓ Only 25% of Alaska remains as biome refugia
- ✓ Western Kenai goes from boreal forest to grasslands
- ✓ Eastern Kenai stays coastal rainforest

**2099**



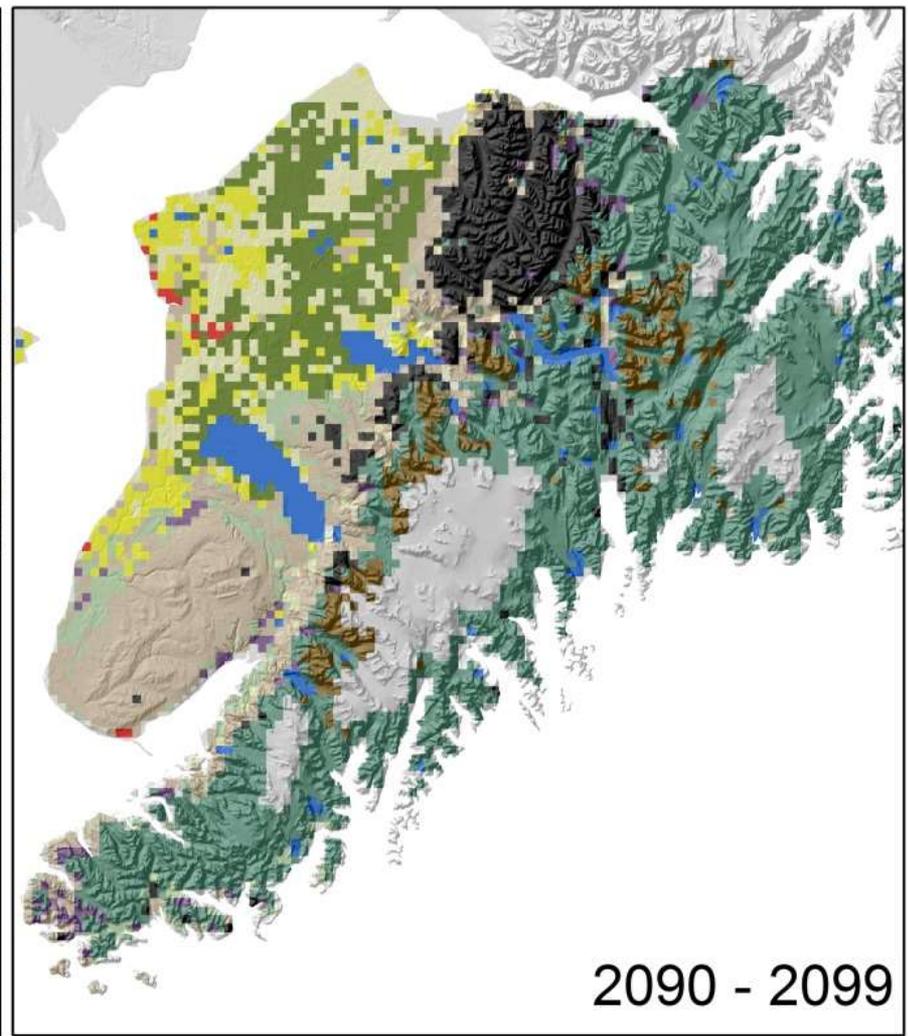
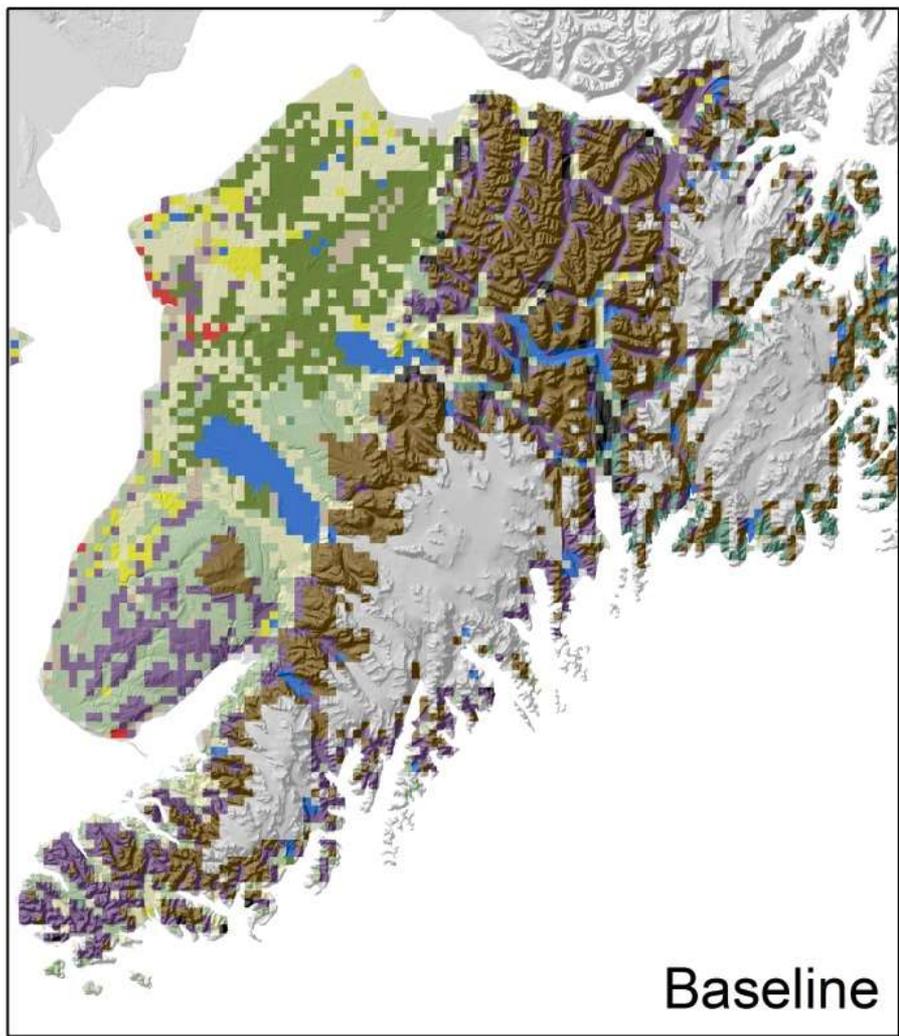
**Take this with a grain of salt....**



# Forecasting the Kenai Peninsula's landscape through 2100

- ✓ Climate envelope modeling using Random Forests™
- ✓ a1b scenario decadal averages for temperature, precipitation (SNAP)
- ✓ landcover type with the greatest % cover in 2km pixels
- ✓ if previous landcover type for each timestep (2039, 2069, 2099)  $P > 0.5$  then stay; if  $P < 0.5$  then landcover type with highest probability





# 37% of Kenai Peninsula landcover types are forecasted to change by 2099!

- ✓ Eastern side shows **afforestation** of alpine (hemlock) and coast (Sitka spruce)
- ✓ Western side shows **deforestation** (white and black spruce), expanding grasslands

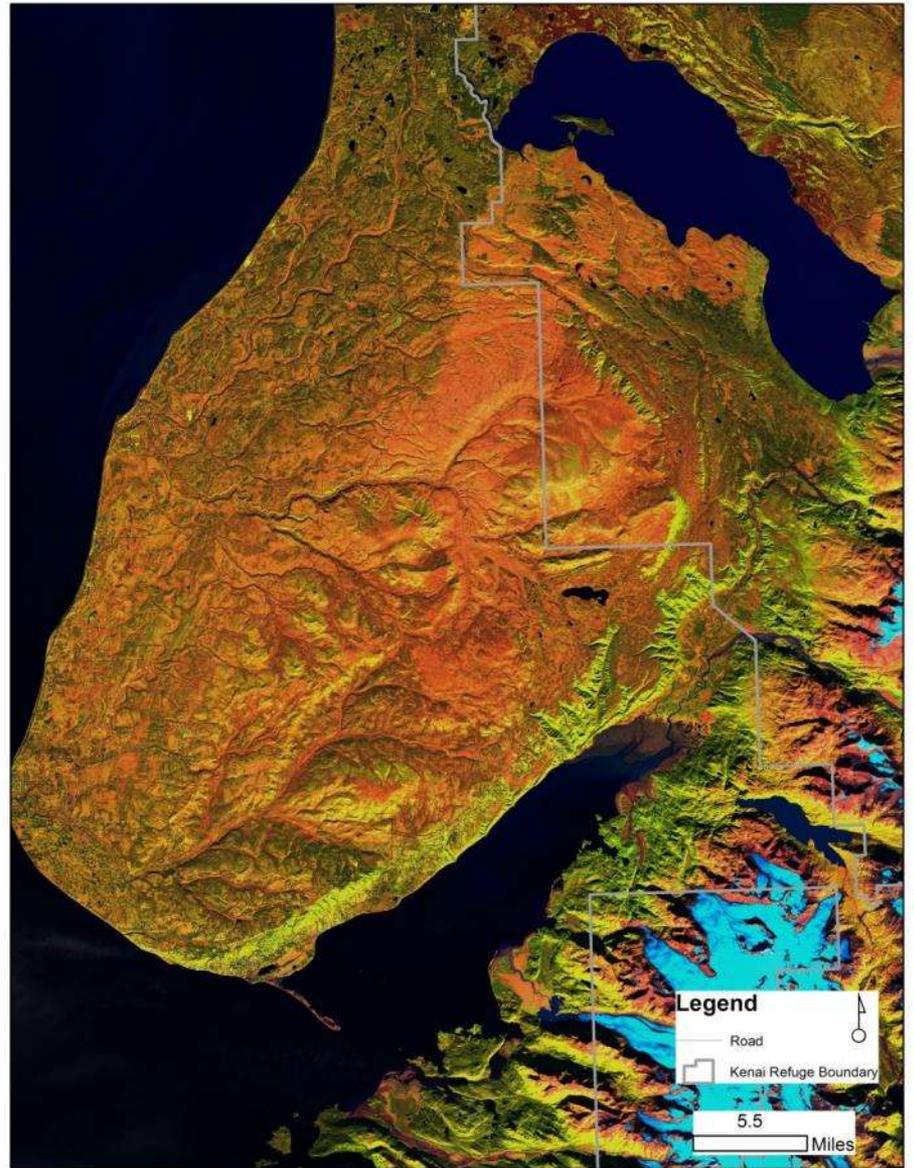


**Take this with a grain of salt....**





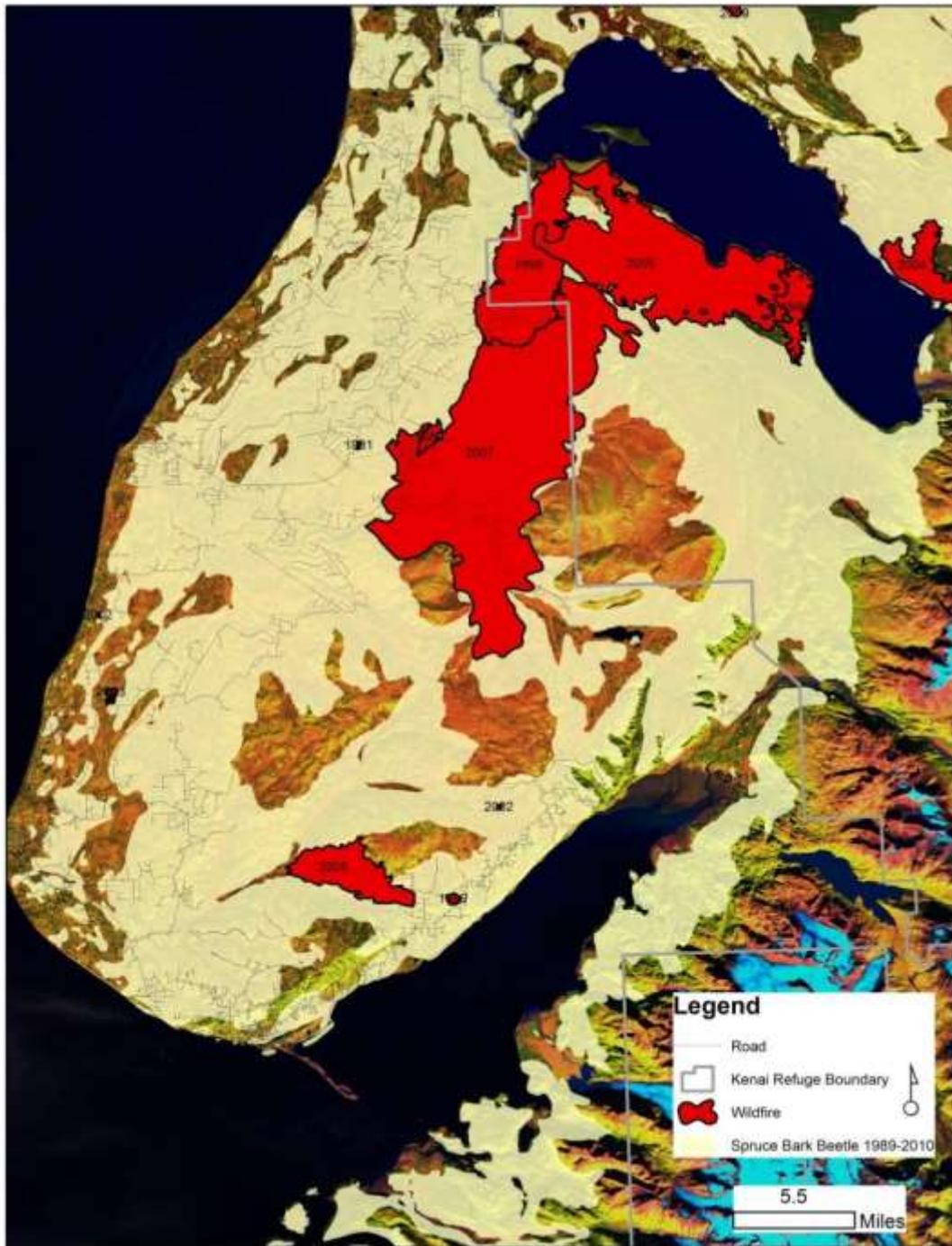
**SEPT 1985**



**SEPT 2014**



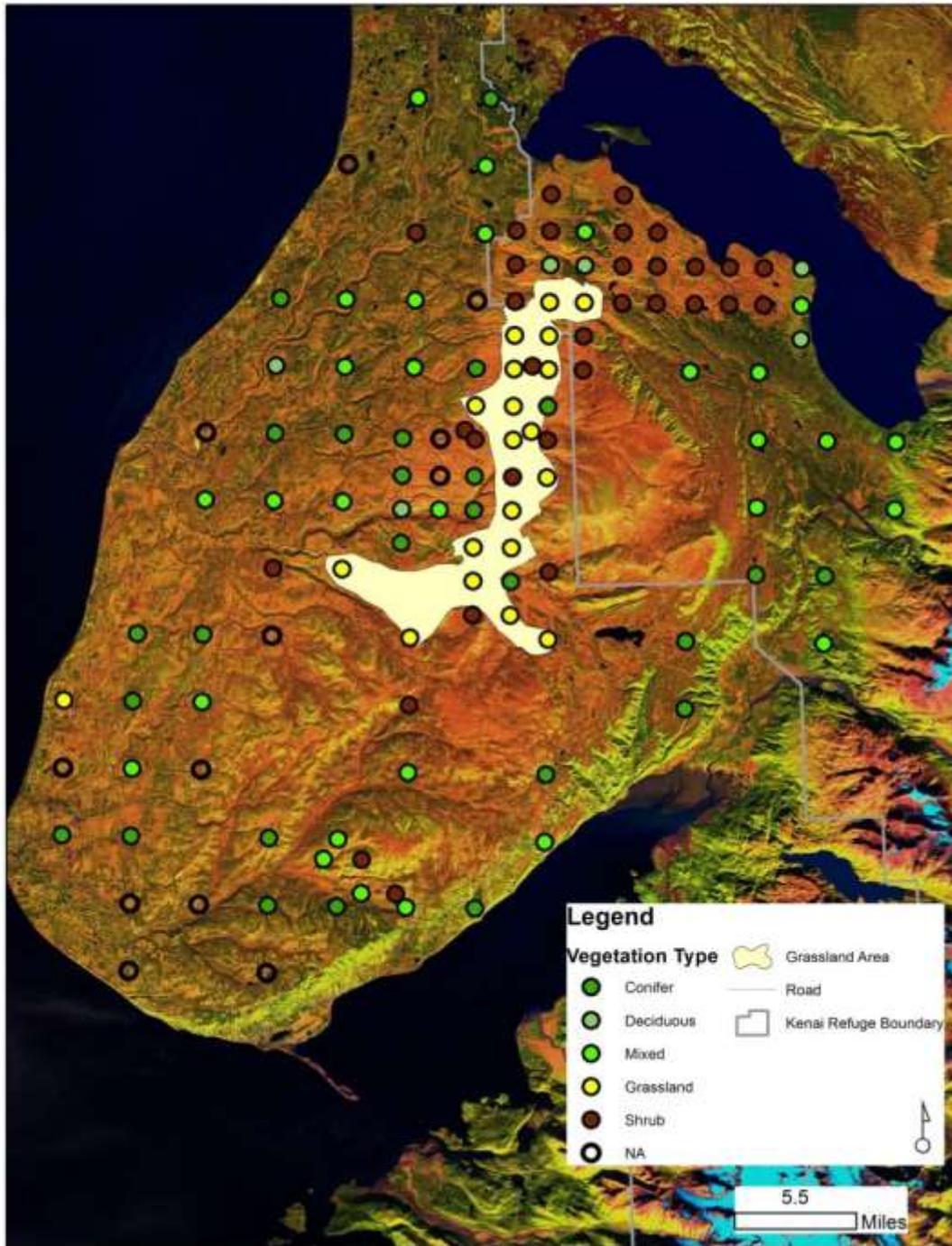
## Spruce Bark Beetle Mortality (1989-2010)



## Wildfires (1994–2007)

- 1994 Windy Point
- 1996 Crooked Creek
- 2005 Glacier Creek
- 2005 Fox Creek
- 2005 Tracy Avenue
- 2007 Caribou Hills

## 40,000-acre contiguous grassland polygon in 2015



### 2002 imagery

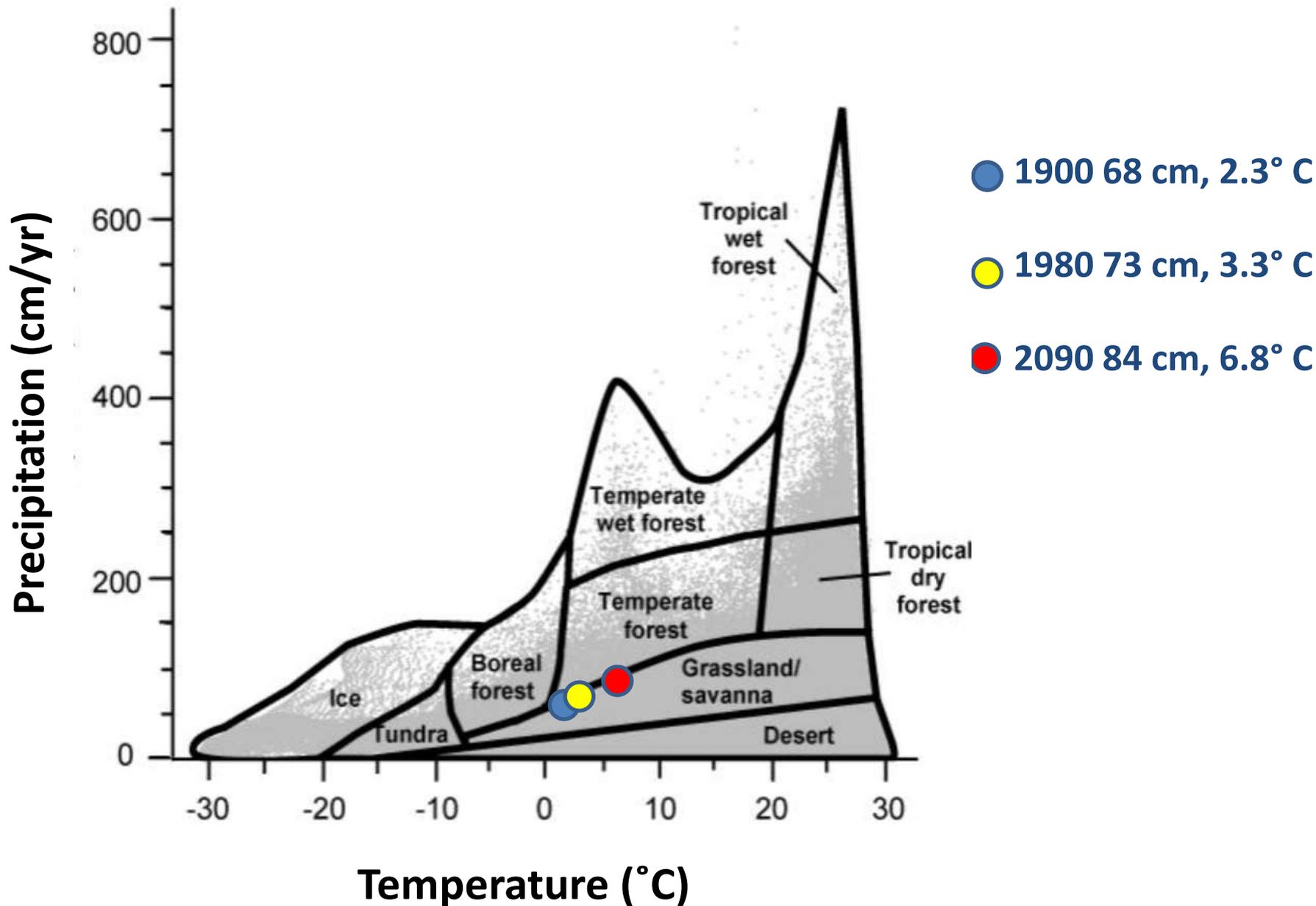
- Forest 55%
- Other 40%
- Herbaceous 5%



2015/07/19







Staudinger et al. 2012. Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment.

# Surface soil temperatures?



**White birch**

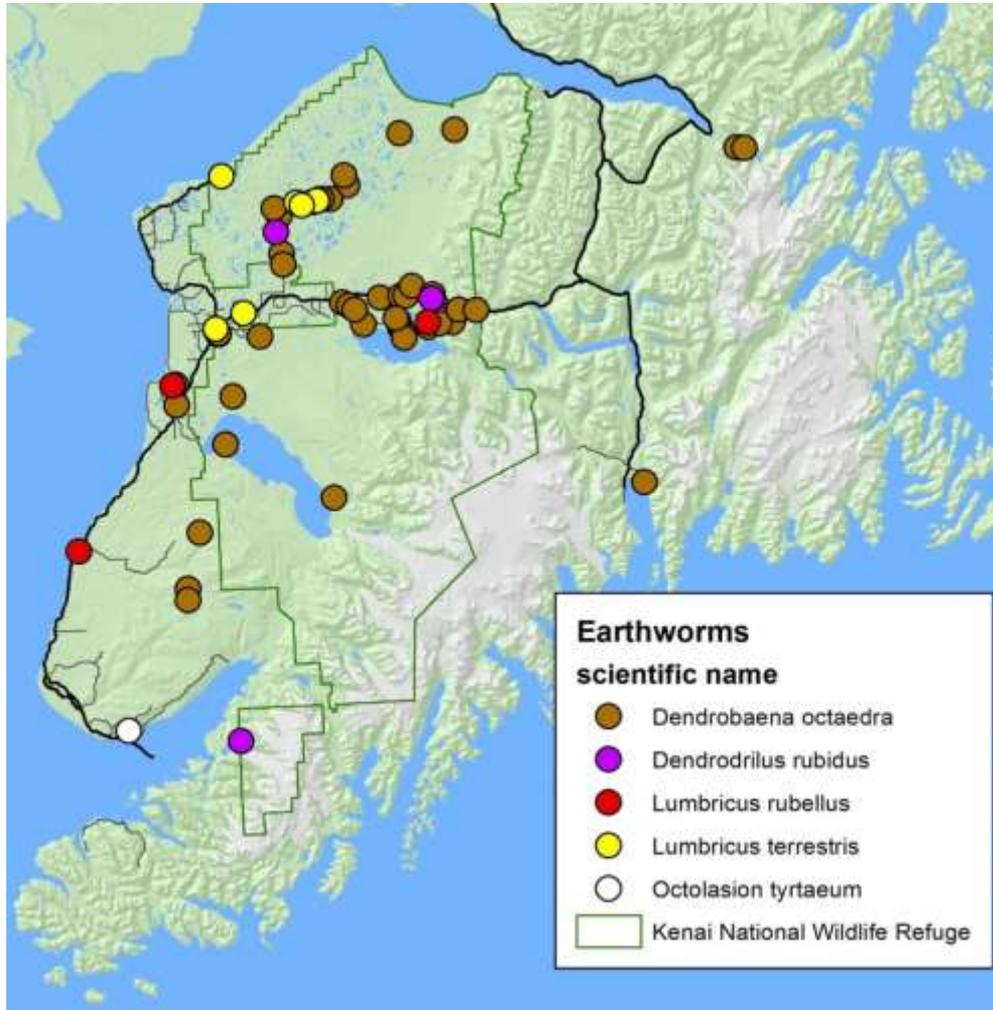
**9° to 11° C (48°- 52° F)**



**Balsam poplar**

**8° to 14° C (46°- 57° F)**

# Exotic earthworms?



# Invasive plants?





> 138 exotic species of flora (108) and fauna (30) occur on the Kenai Peninsula and are poised to fill novel assemblages

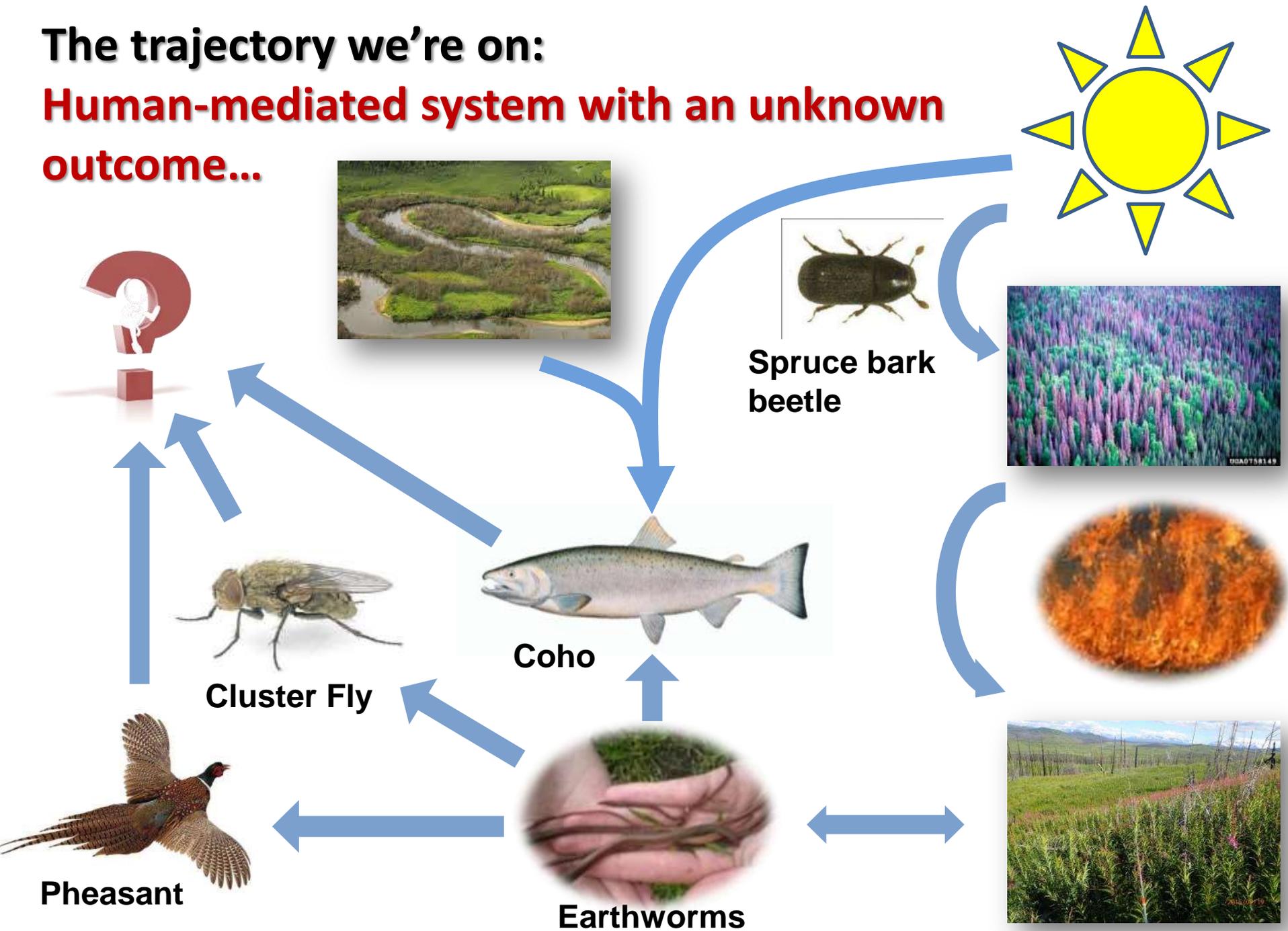


**Take this with a grain of salt....**



The trajectory we're on:

**Human-mediated system with an unknown outcome...**



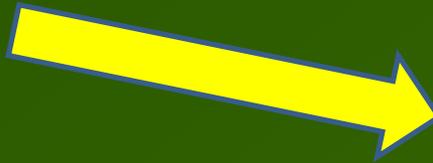
# Do what you want with the salt, but the Kenai is changing...

- ✓ Kenai Peninsula is already responding to a changing climate and forecasted to continue doing so
- ✓ Novel assemblages ≠ simple re-shuffling of native flora and fauna
- ✓ Many extant native species are on a trajectory for extirpation
- ✓ Many exotic species already introduced and more enroute
- ✓ Should we influence these outcomes?

**Same climate forecast  
but potentially  
different outcomes....**



**Boreal Transitional**



**We are already  
making choices!**

# What's an exotic plant in a rapidly changing climate?





# Hardwoods

- Ash (green)
- Birch (Rocky Mountain white, weeping)
- Elm (Siberian)
- Linden (big leaf, little leaf)
- Maple (Amur, Norway, red, silver, Tatarian)
- Mountain ash (European/*S. aucuparia*)
- Oak (Burr, Red)
- Russian olive
- Poplar (Norway)
- Willows (11 species)

- ✓ Aspen (quaking)
- ✓ Birch (Kenai, white)
- ✓ Cottonwood (balsam, black)
- ✓ Mountain ash (*S. scopulina*)
- ✓ Willows (Scouler, Pacific)



# Softwoods

- Cedar (Western red, white)
  - Dawn redwood (*Metasequoia*)
  - Fir (balsam, Douglas, grand, Korean, Sakhalin, Shasta red, silver, subalpine, white)
  - Hemlock (Eastern)
  - Juniper
  - Larch (Alaska, Dahurian, Siberian, Western)
  - Pine (Austrian, bristlecone, Eastern white, lodgepole, limber, Manchurian, Mugo, Ponderosa, Scotch, Siberian, Western white)
  - Spruce (Black Hills, blue, dwarf Alberta, Englemann, Norway)
- ✓ Hemlock (mountain, Western)
  - ✓ Spruce (black, Lutz, Sitka, white)



# Fruit trees

- Apples (several varieties)
- Apricot (Manchurian)
- Cherry (several varieties)
- Chokecherry
- Crab apple
- Mayday
- Pear (Ussurian)
- Serviceberry (Saskatoon berry)

✓ *Amelanchier alnifolia*, *A. florida*





**Questions????**