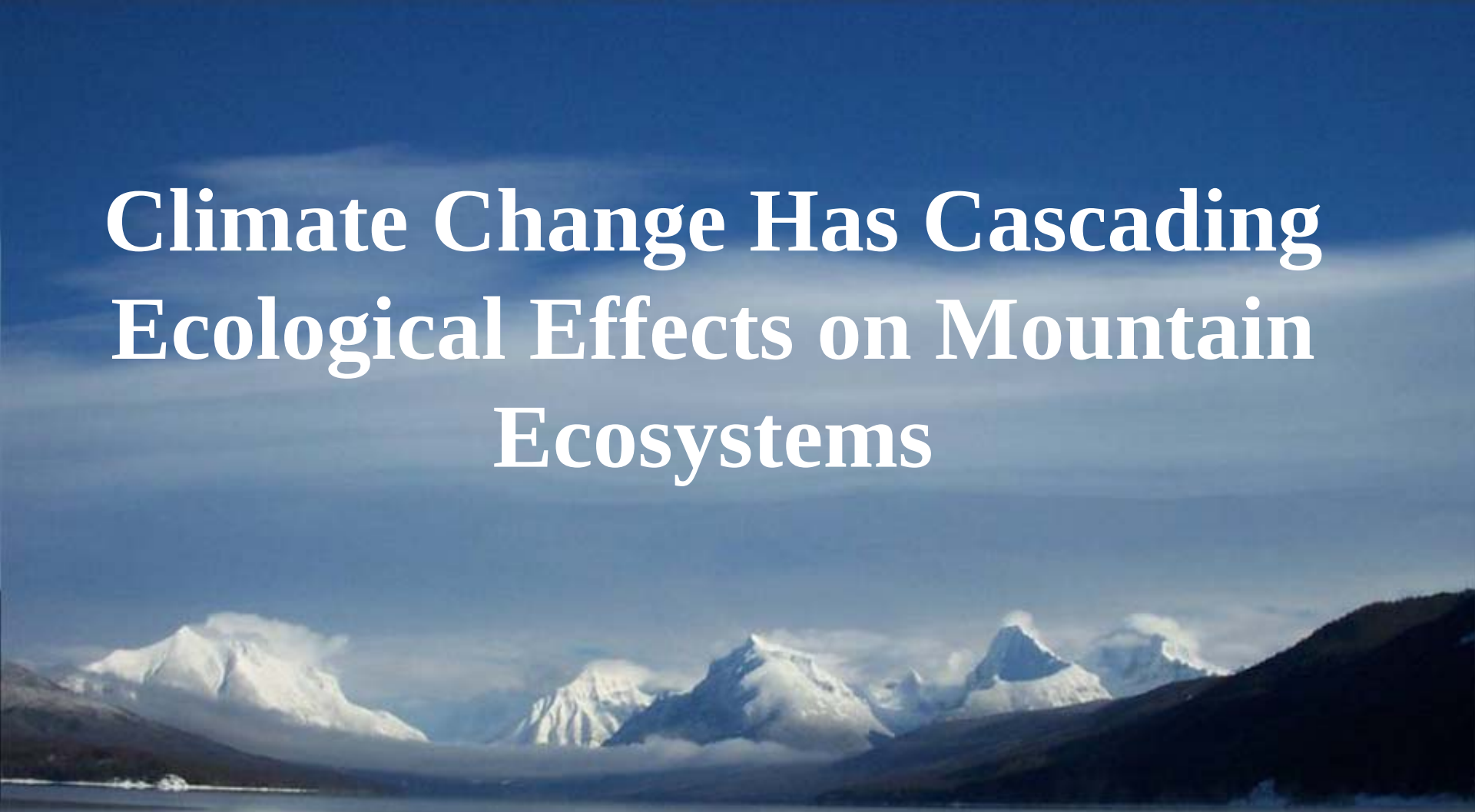
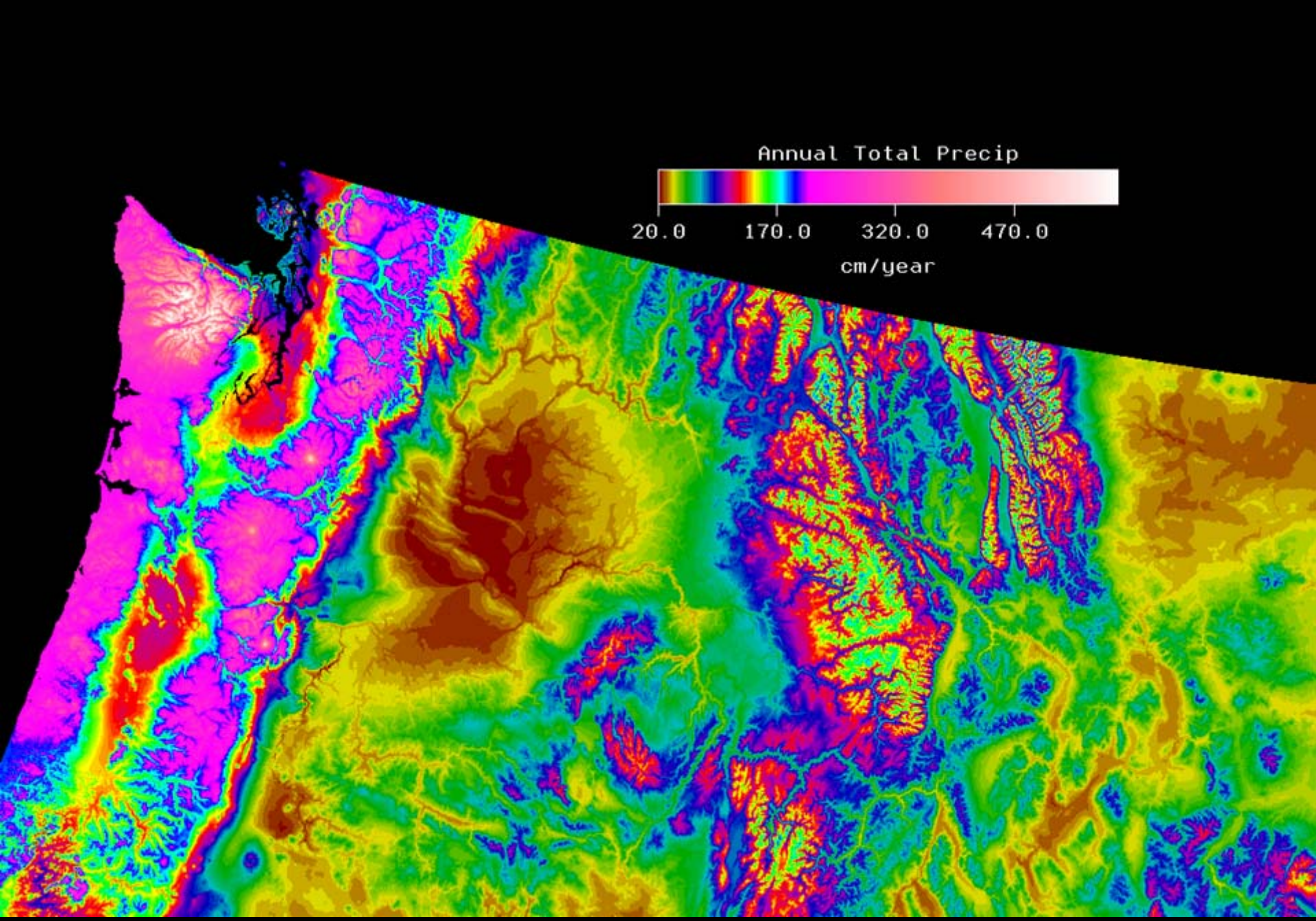
Climate Change Has Cascading Ecological Effects on Mountain Ecosystems



Daniel B. Fagre
Northern Rocky Mountain
Science Center

USGS
science for a changing world


Annual Total Precip
20.0
170.0
320.0
470.0
cm/year

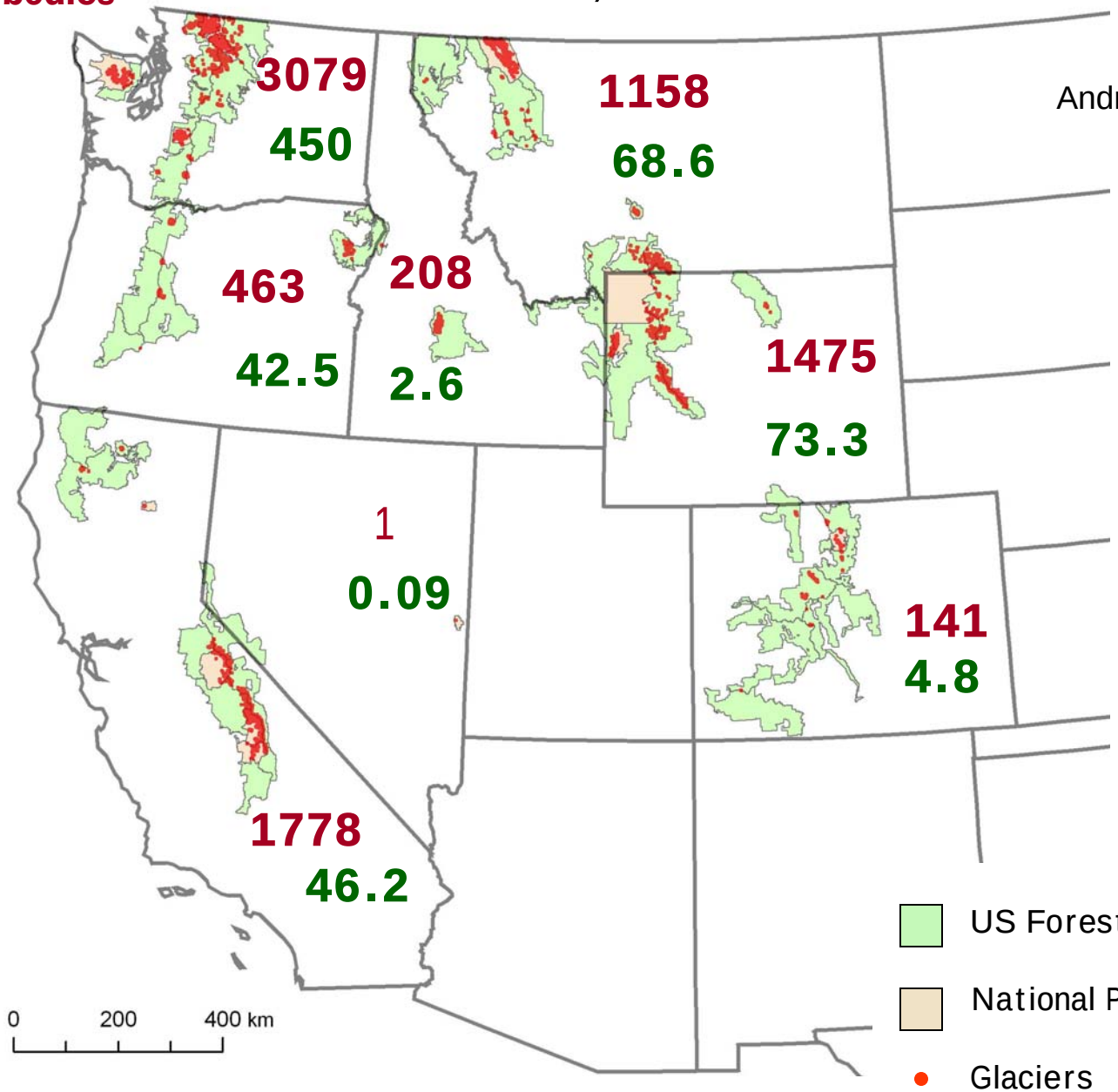
Glaciers in the American West

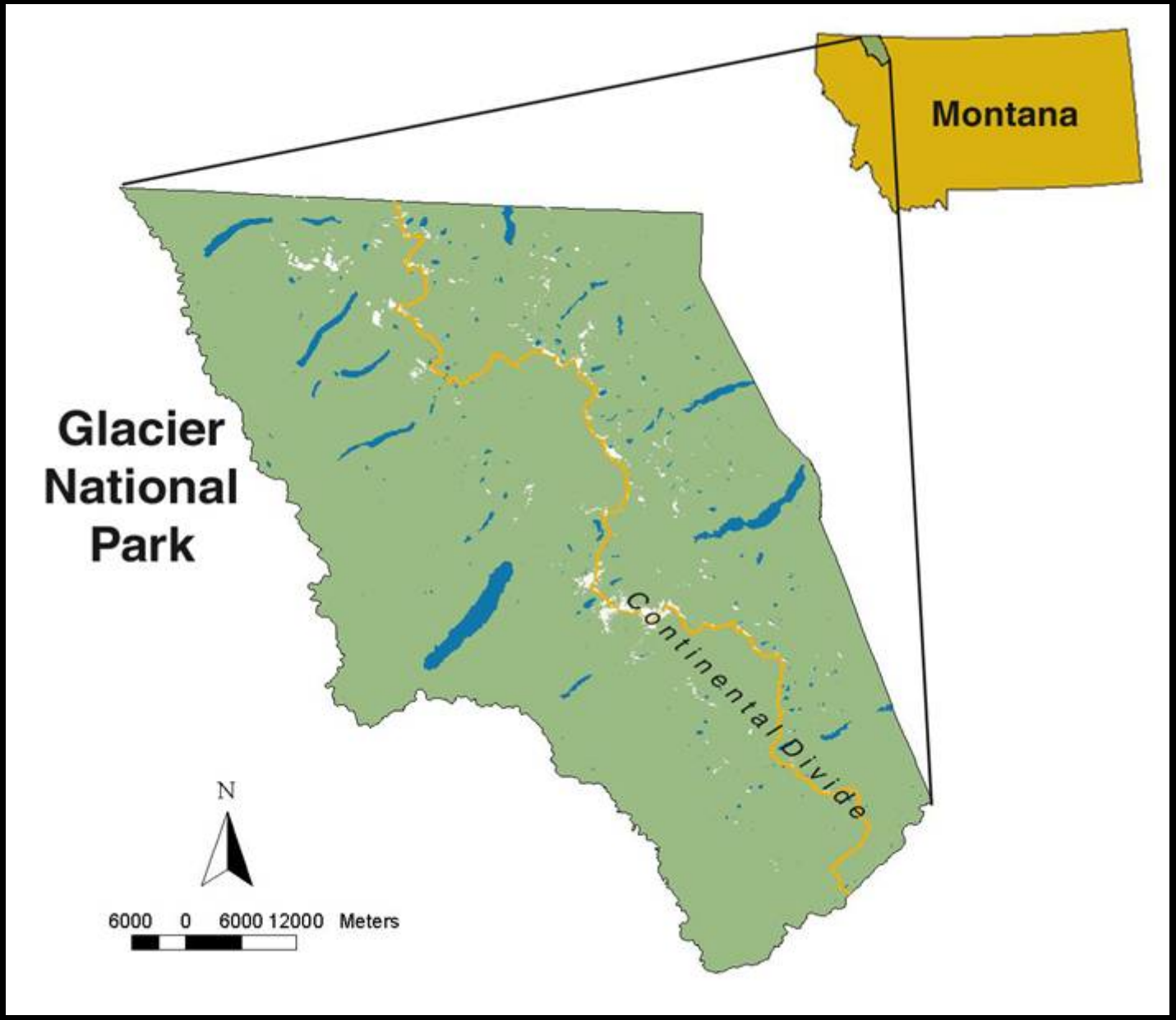
1 : 24,000

8303 permanent snow and ice bodies

688 km²

Andrew G. Fountain

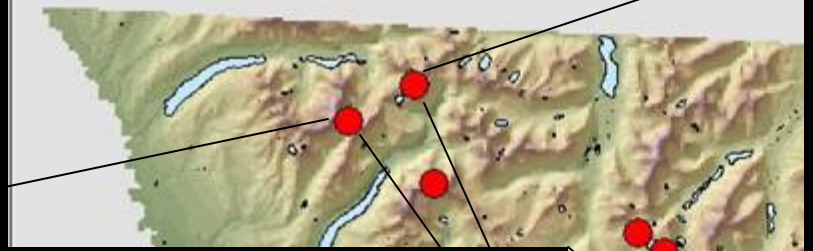



Montana
Glacier
National
Park
Continental Divide
N
6000 0 6000 12000 Meters

Grinnell Lake and Grinnell Glacier, 1910

Photo by Kiser, courtesy GNP Archives

USGS Repeat Photography Points in Glacier National Park



Sperry Glacier
Glacier National Park

Morton Elrod photo *1907*
Courtesy Glacier NP Archives

W. C. Alde
Courtesy of

Grinnell Glacier 1910 - 1998

1910 Photo by Kiser, GNP Archives

1998 Photo by McKeon, USGS

L. McKeon
Courtesy of

Lisa McKeon photo, USGS *2001*

Shepard Glacier

W. C. Alden/ USGS photo. **1913**

B. Reardon/ USGS photo. **2005**

Grinnell Glacier from Mt. Gould

1938
Hileman photo/ GNP Archives

1981
Key/ USGS photo

1998
Fagre/ USGS photo

2005
Reardon/ USGS photo

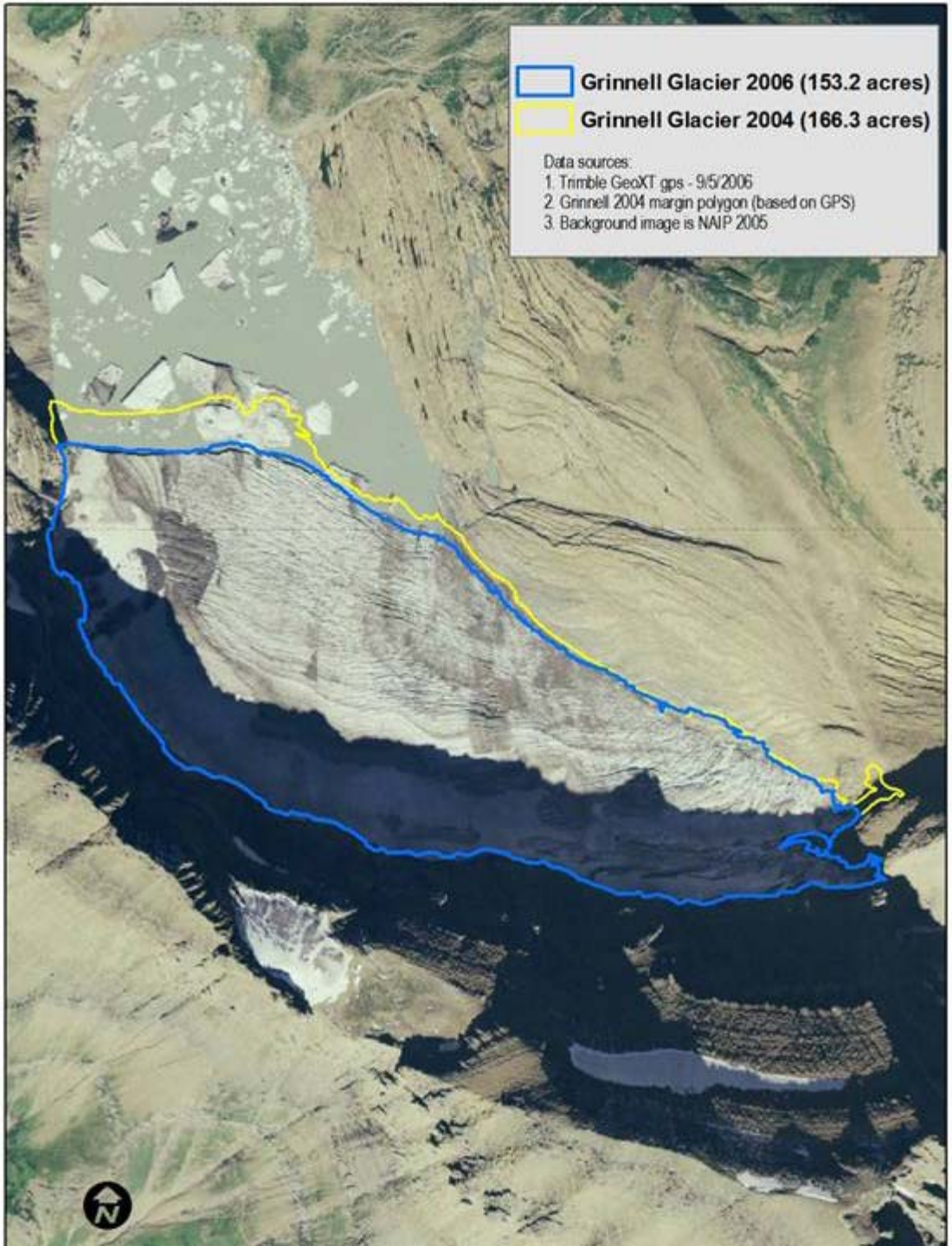
Grinnell Glacier

1940

2006


1911
US Geological Survey


2006
www.glacierparkphotos.com


Grinnell Glacier 2006 (153.2 acres)
Grinnell Glacier 2004 (166.3 acres)
Data sources:
1. Trimble GeoXT gps - 9/5/2006
2. Grinnell 2004 margin polygon (based on GPS)
3. Background image is NAIP 2005
N

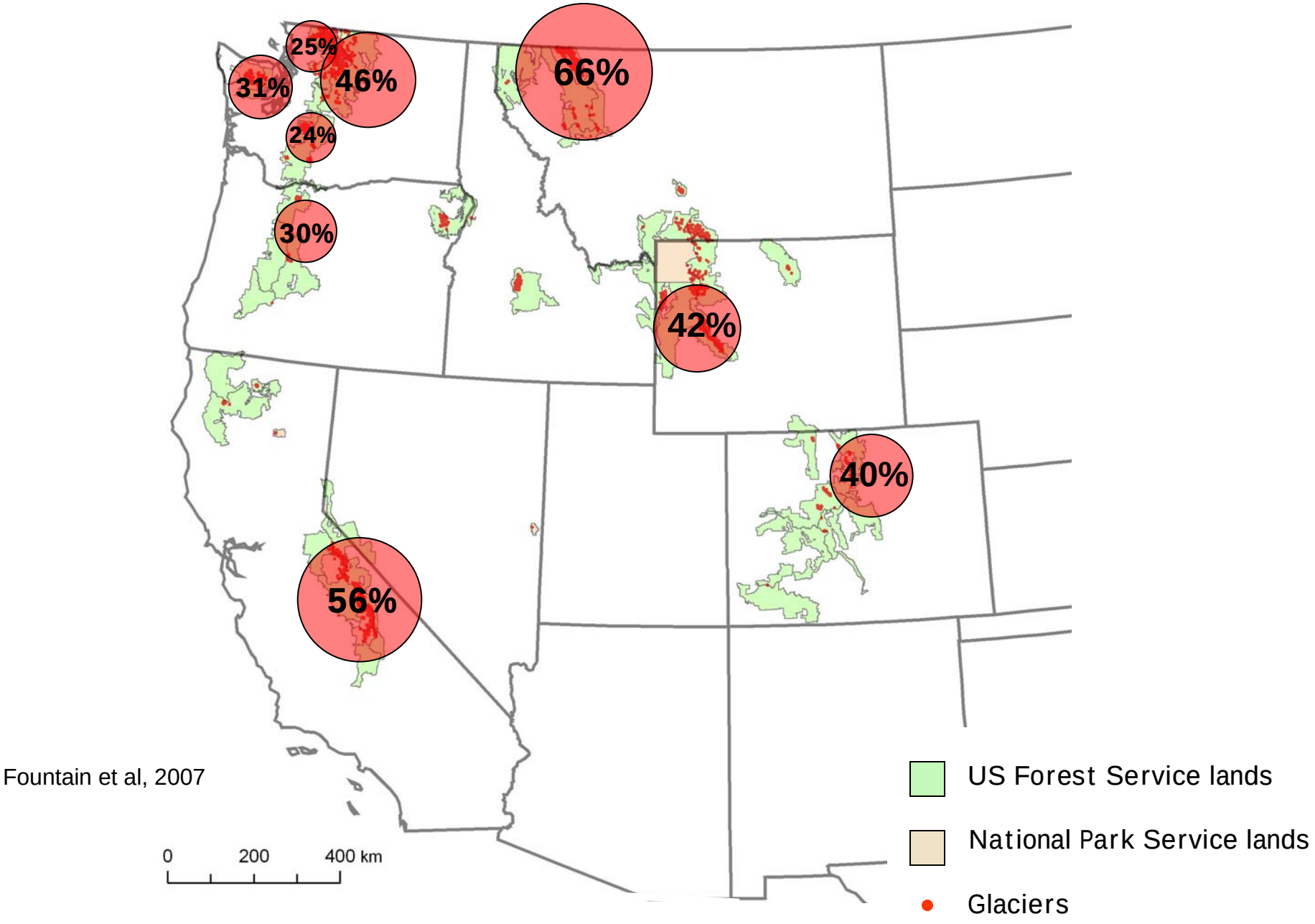
Boulder Glacier

Glacier National Park, MT

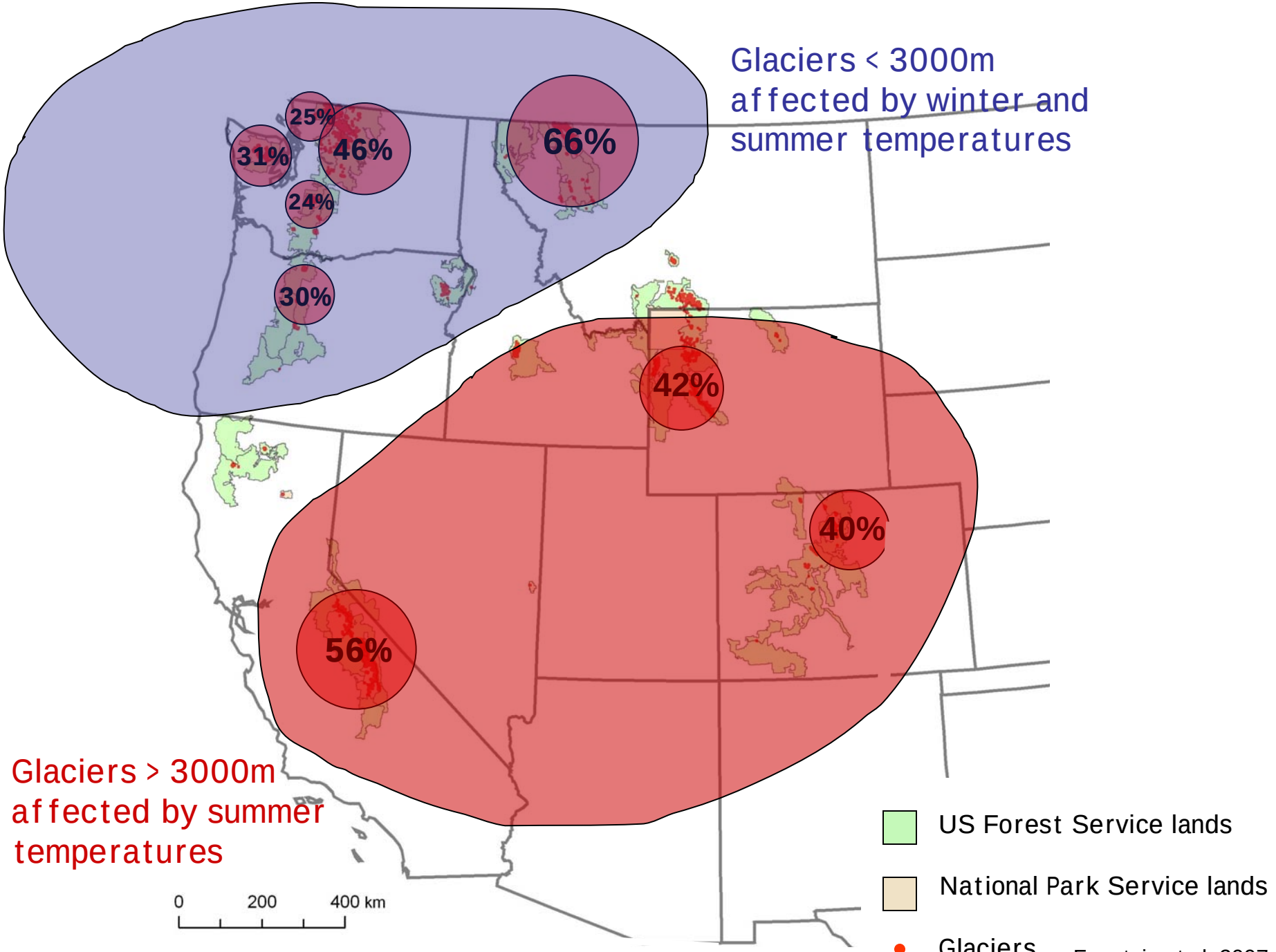
Morton Elrod photo
Courtesy of GNP Archives

Fagre/Pederson photo
USGS

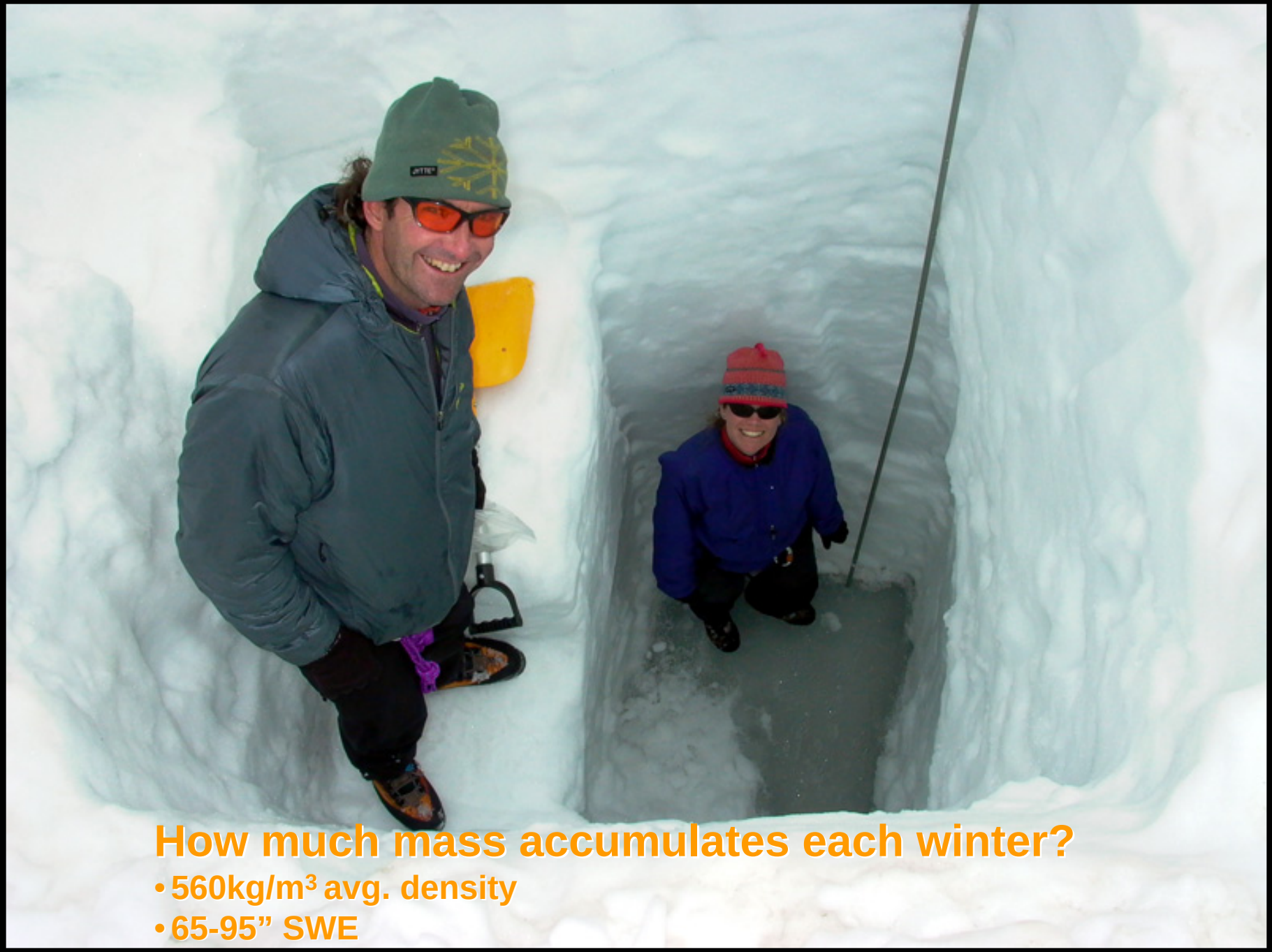
Fraction of Glacier Area Lost since 1900



Fountain et al, 2007


Glaciers < 3000m
affected by winter and
summer temperatures
25%
31%
46%
66%
24%
30%
42%
40%
56%
Glaciers > 3000m
affected by summer
temperatures
0
200
400 km
US Forest Service lands
National Park Service lands
Glaciers
Fountain et al, 2007

Sperry Glacier. June 24, 2005. Photos by *Blasé Reardon and Dan Fagre.*



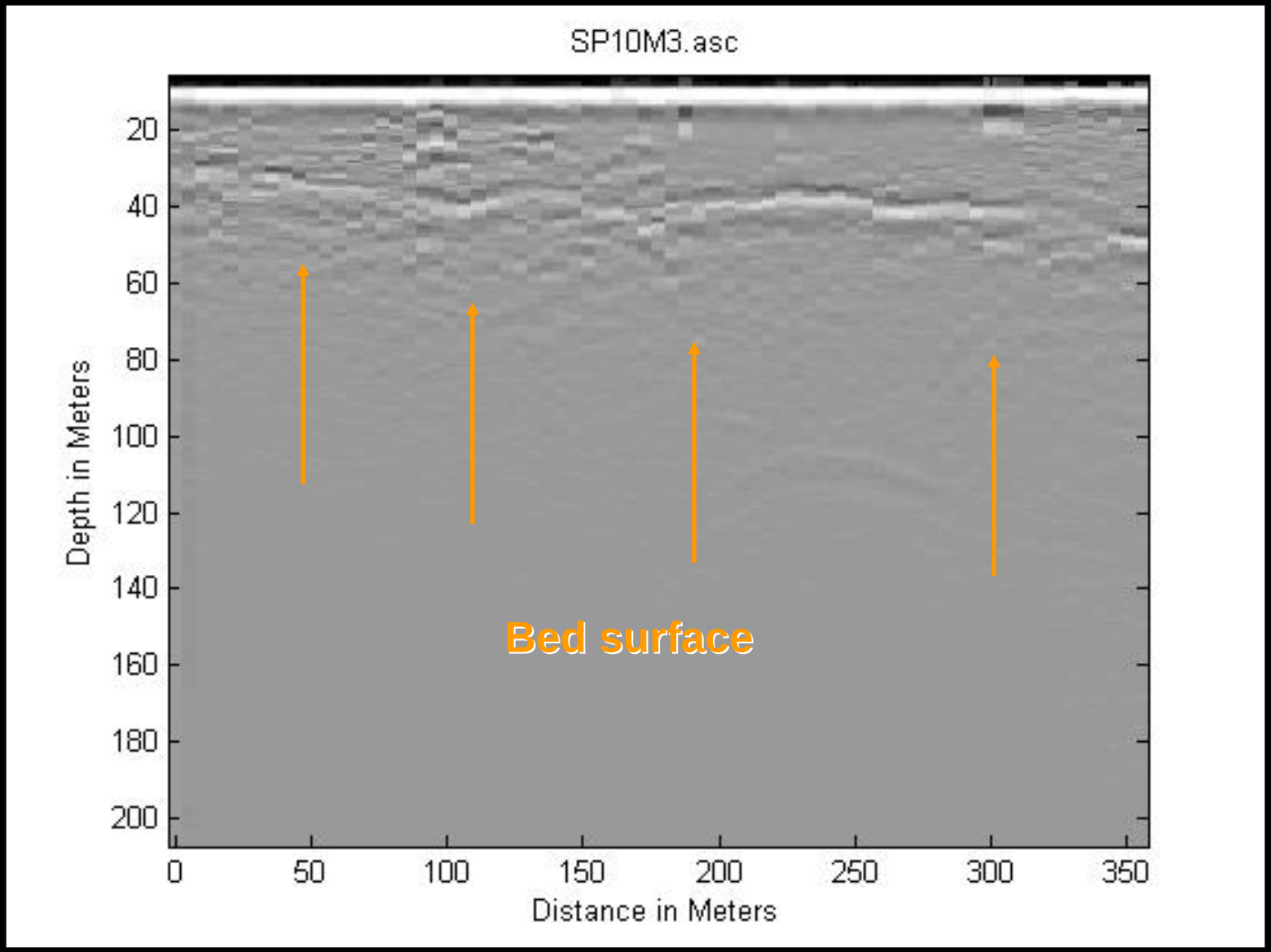
How much mass accumulates each winter?

- 560kg/m^3 avg. density
- 65-95” SWE

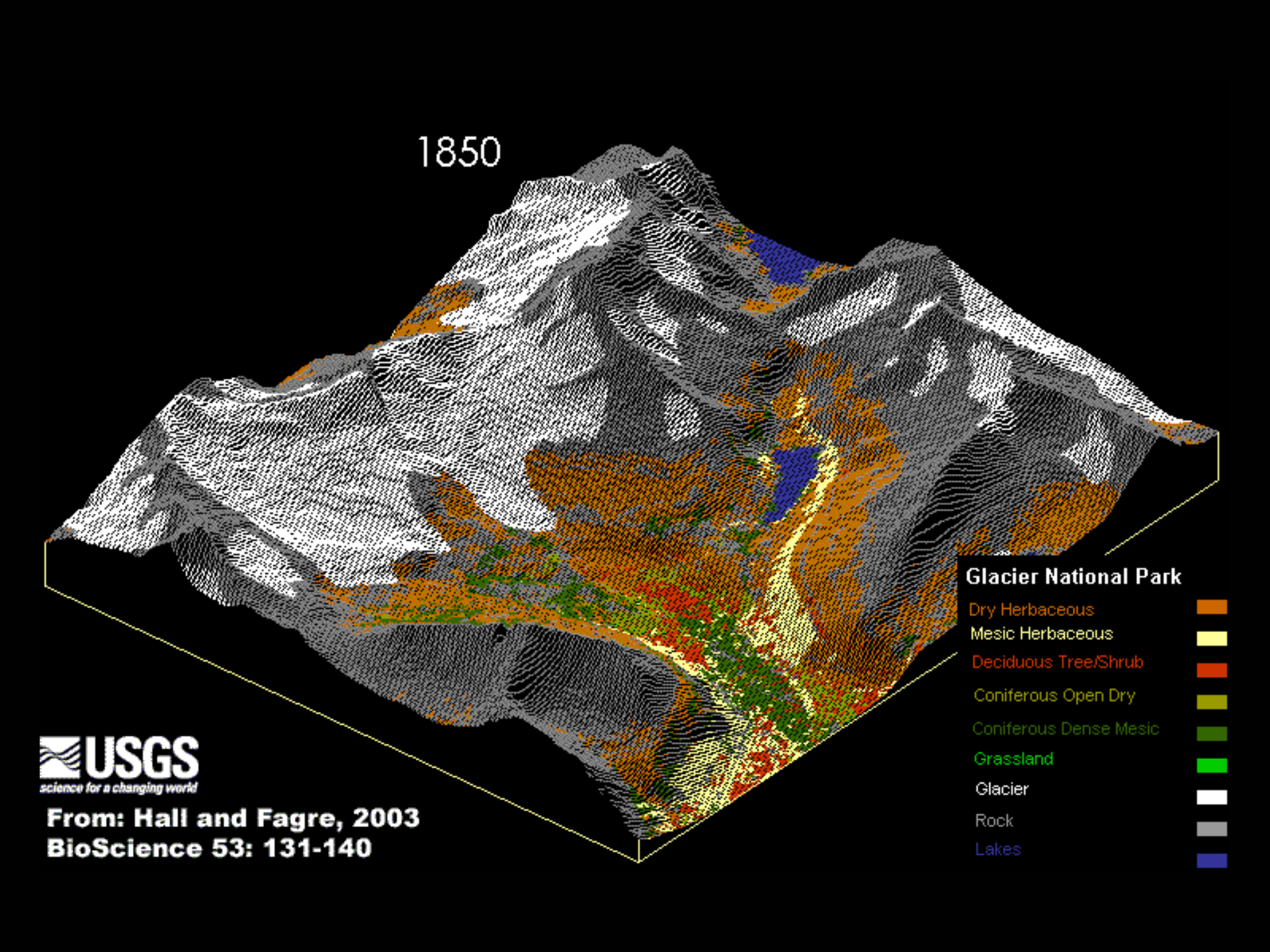
Sperry Glacier. June 25, 2005. *Dan Fagre photo.*

1.7m ice loss each summer

Sperry Glacier, Aug. 8, 2005. *John Newton photo*



Sperry Glacier, Sept. 2005. Longitudinal Transect


1850
Glacier National Park
Dry Herbaceous
Mesic Herbaceous
Deciduous Tree/Shrub
Coniferous Open Dry
Coniferous Dense Mesic
Grassland
Glacier
Rock
Lakes
USGS
science for a changing world
From: Hall and Fagre, 2003
BioScience 53: 131-140

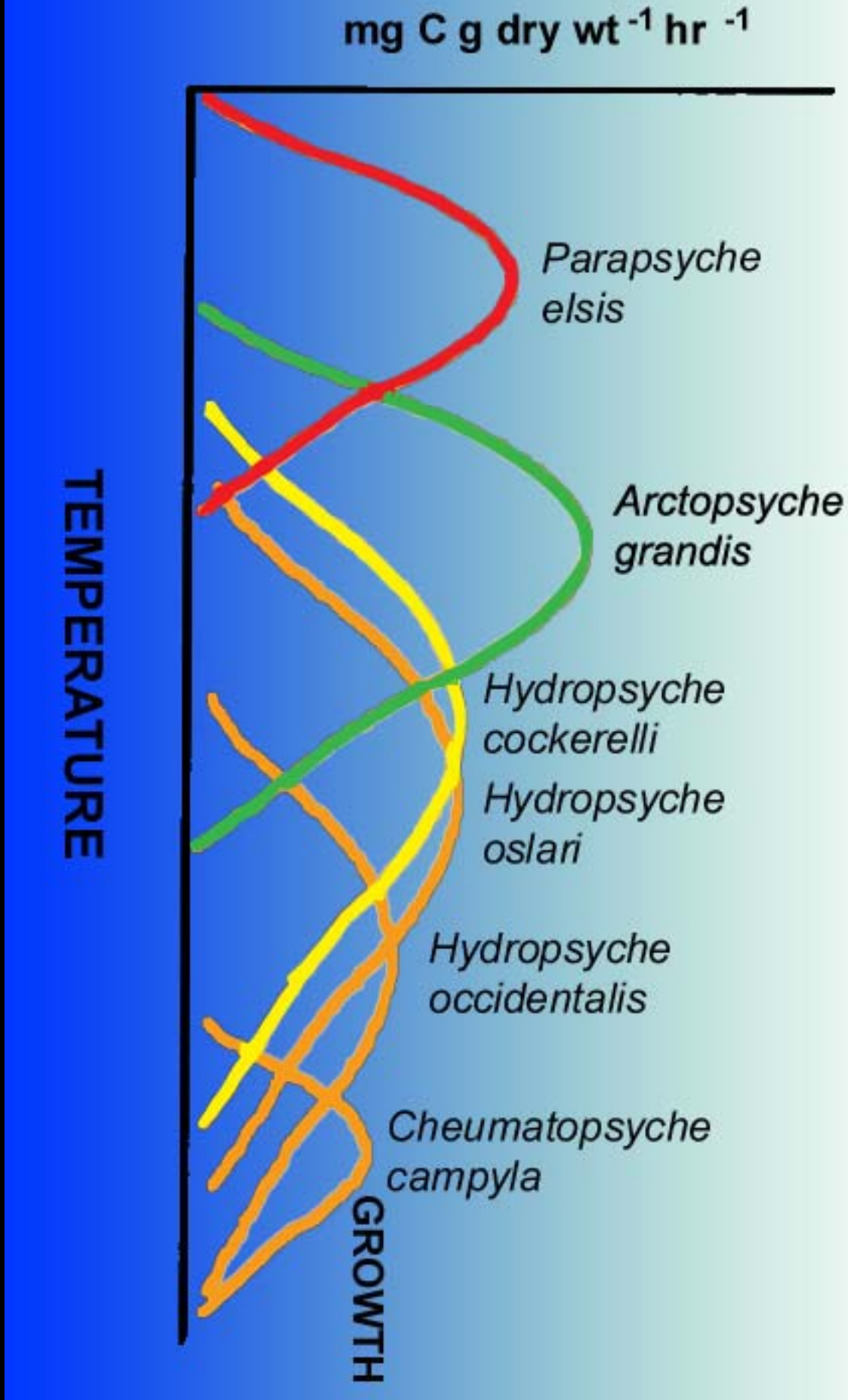
ACTUAL AREA for Jackson/Blackfoot Glaciers

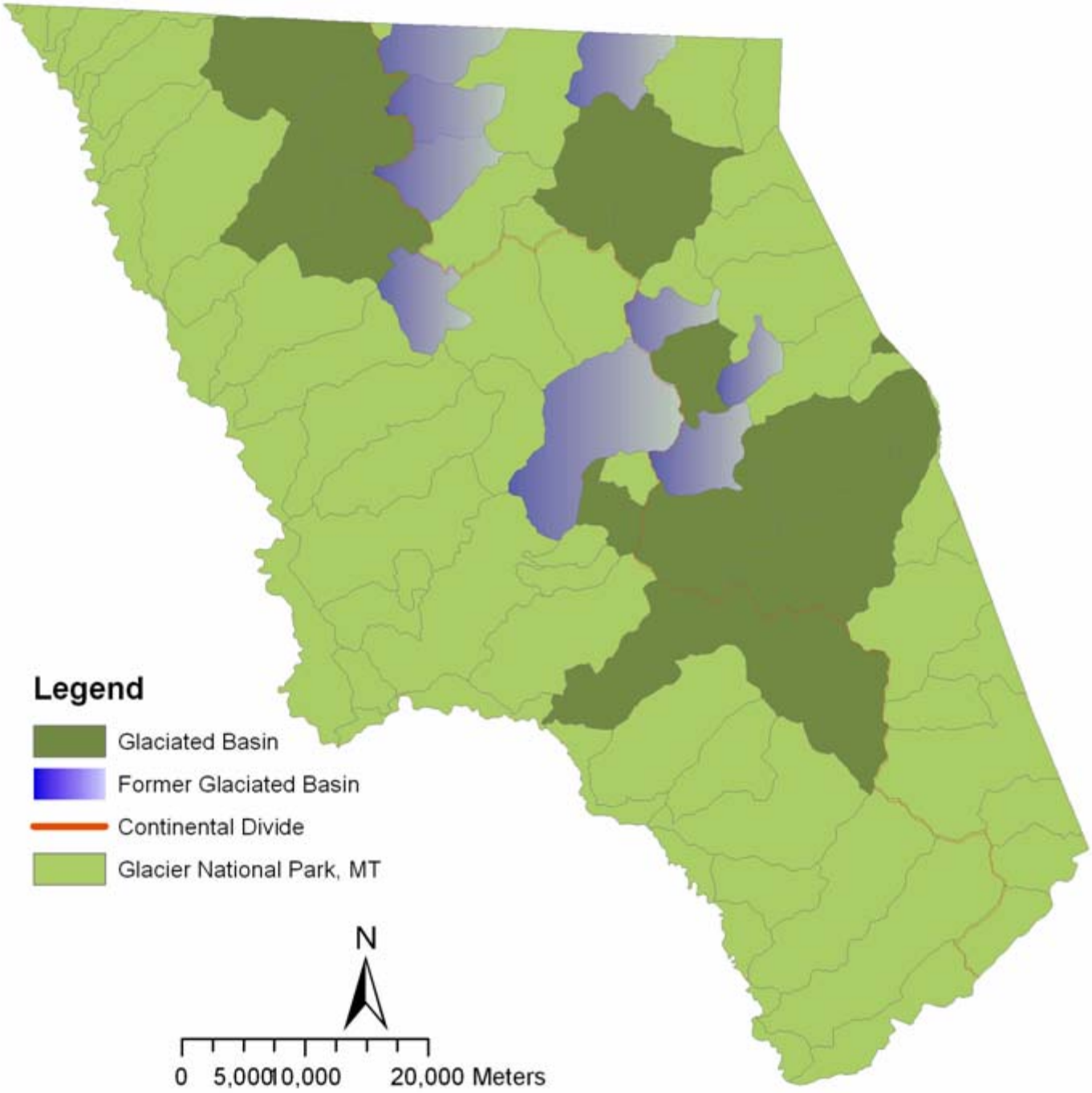
1998 - 2.94 square kilometers

PREDICTED AREA for Jackson/Blackfoot Glaciers

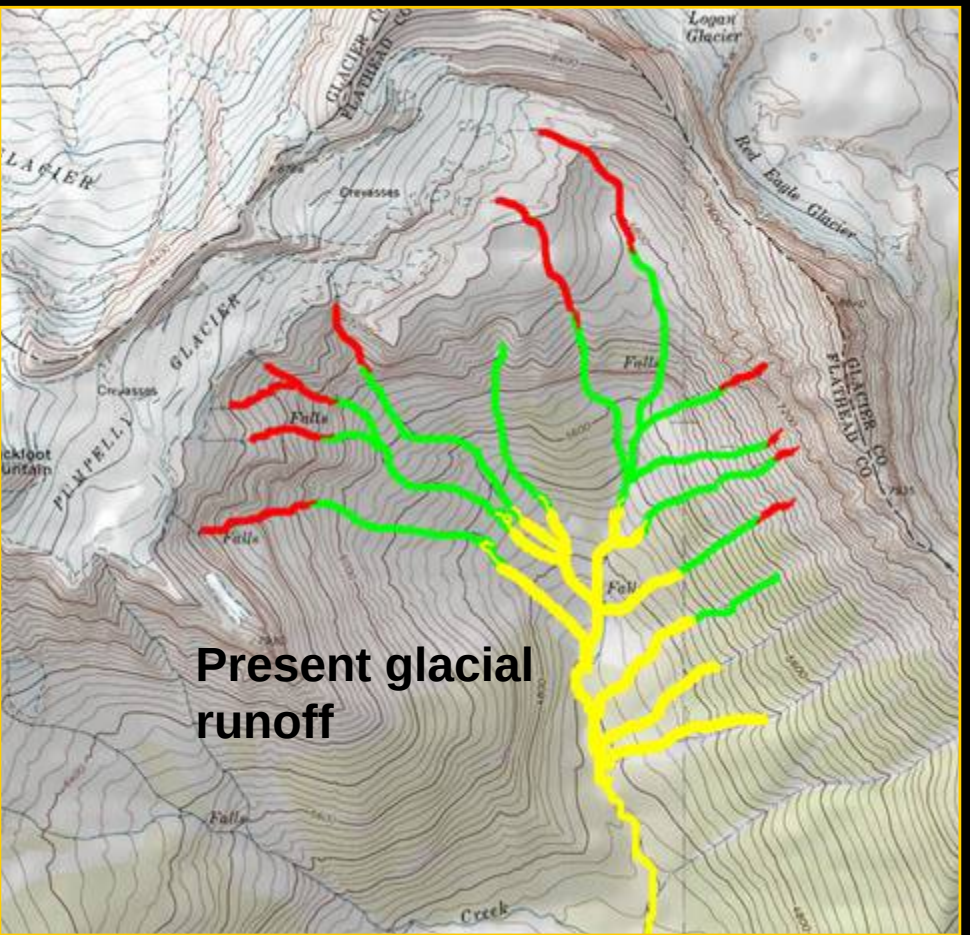
2000 - 3.89 square kilometers
2010 - 2.44 square kilometers

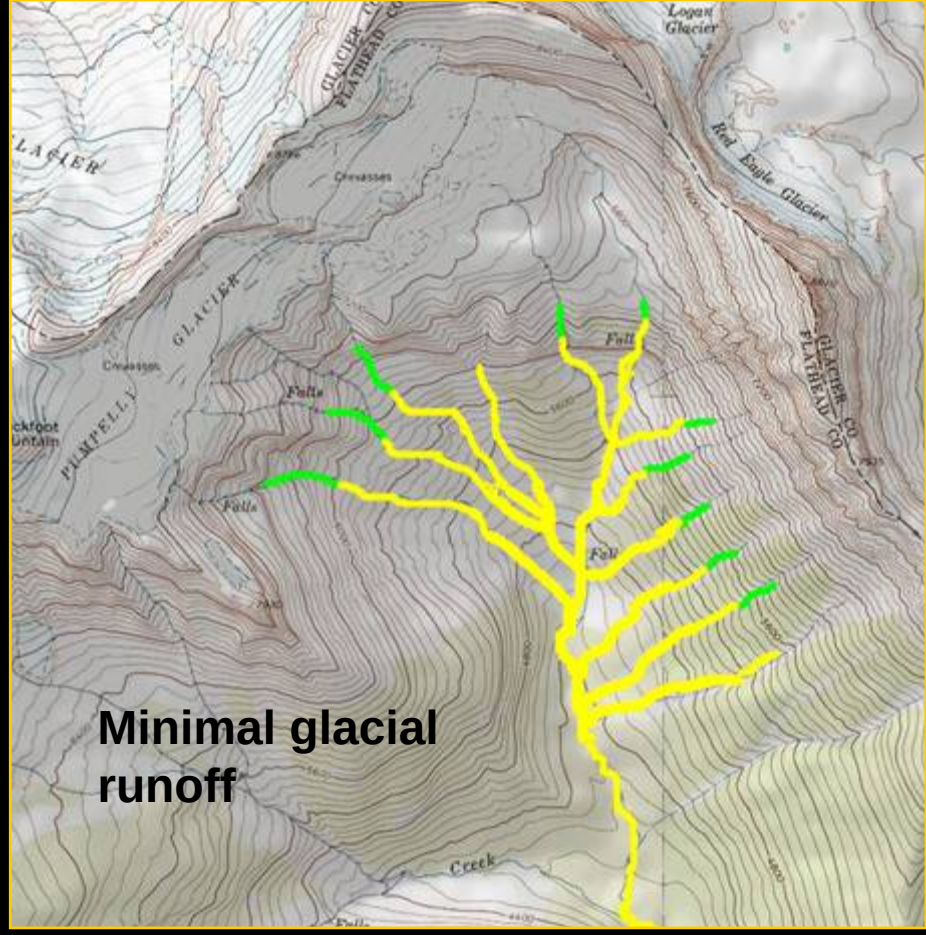
We are approximately 10 years ahead of the predicted rate of melting for these glaciers


mg C g dry wt -1 hr -1
TEMPERATURE
GROWTH
Parapsyche elsis
Arctopsyche grandis
Hydropsyche cockerelli
Hydropsyche oslari
Hydropsyche occidentalis
Cheumatopsyche campyla


Legend
Glaciated Basin
Former Glaciated Basin
Continental Divide
Glacier National Park, MT
N
0 5,000 10,000 20,000 Meters

Aquatic invertebrate species distribution in response to stream temperature





Parapsyche elsis

Arctopsyche grandis

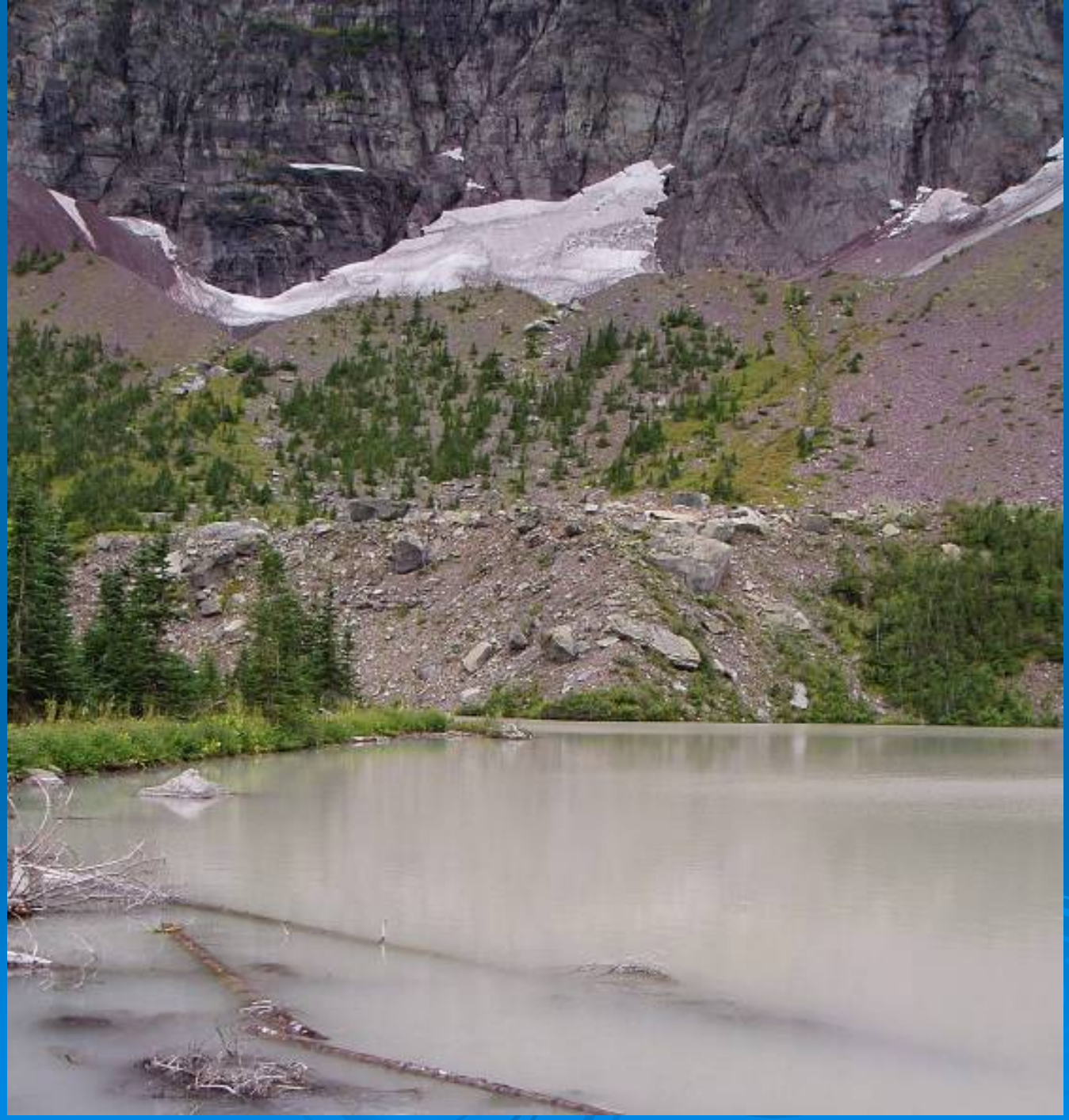
Hydropsyche cockerelli

Threats

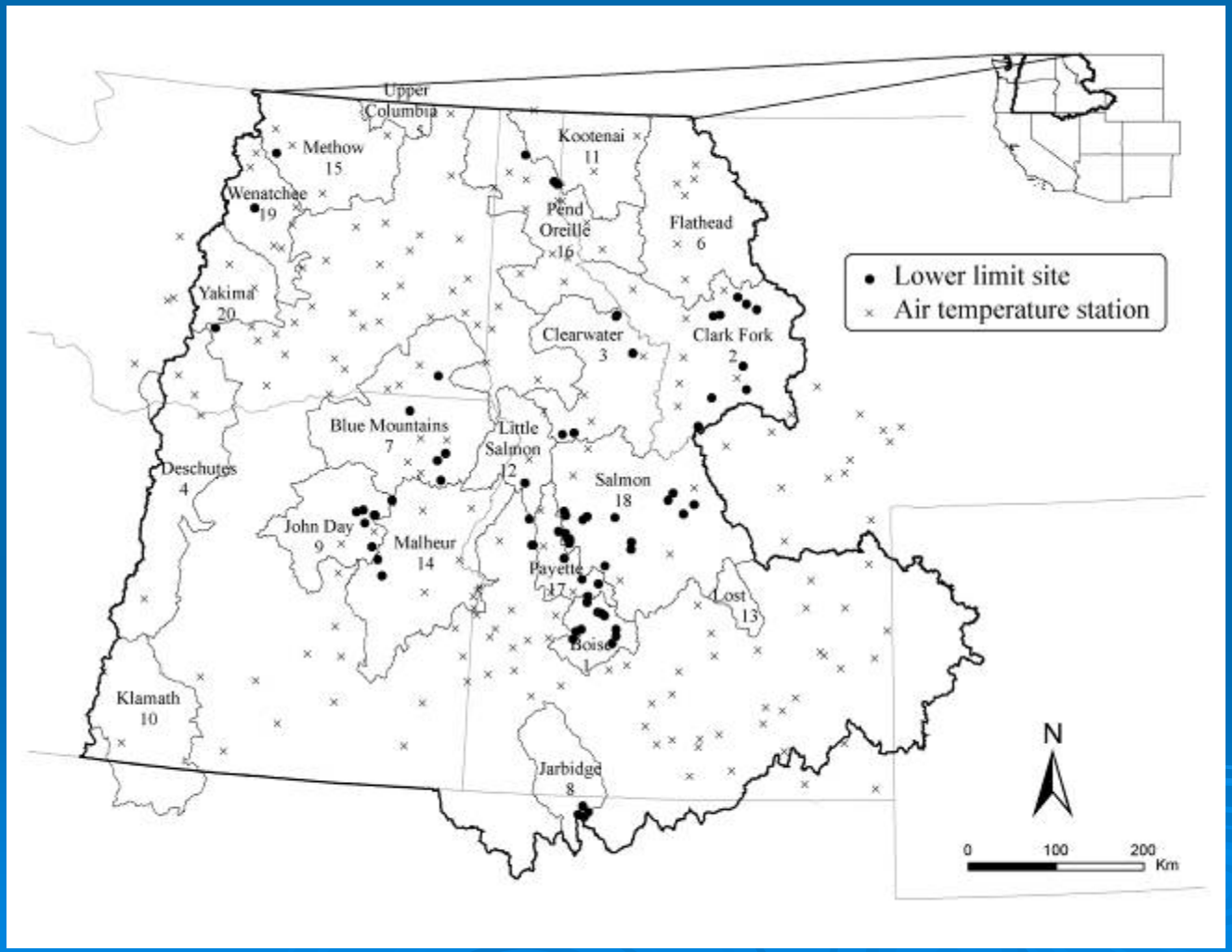
Invasion of the Nonnatives

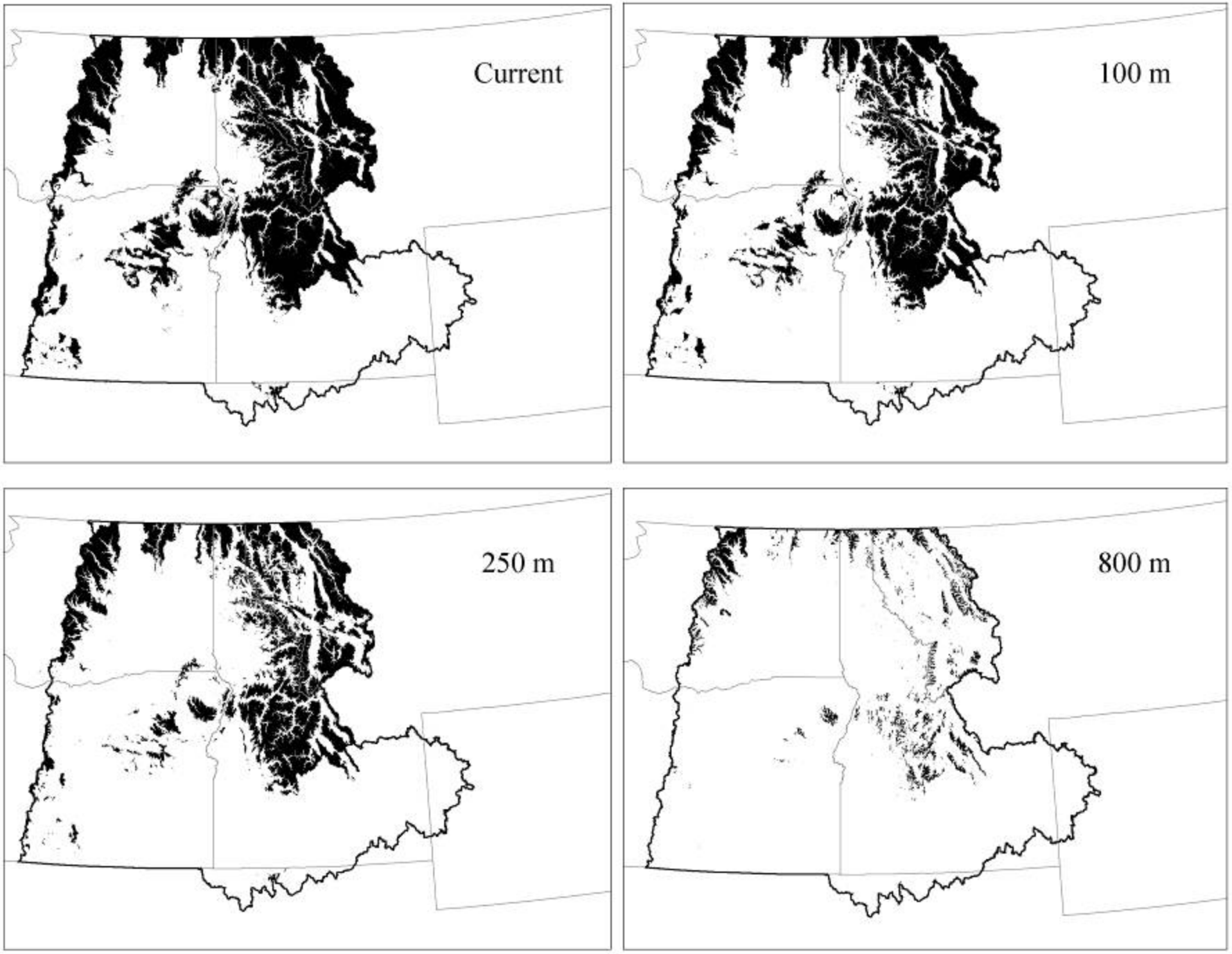
Bull trout
(native)

Lake trout
(introduced)



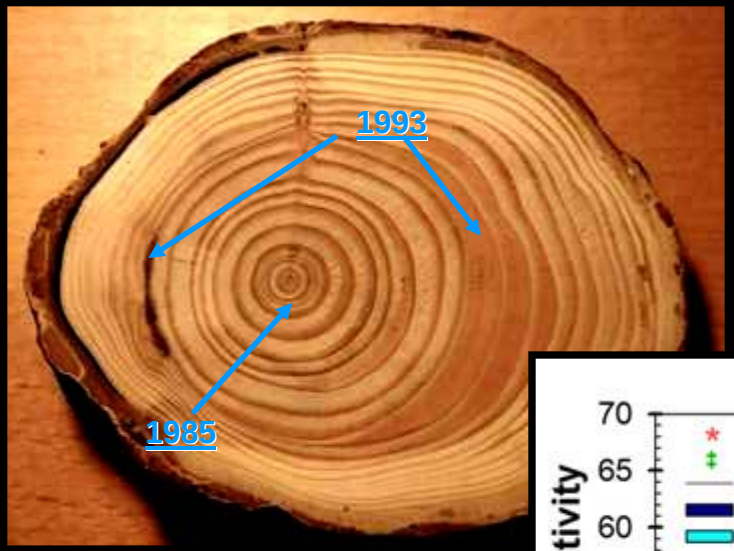
Climate Change



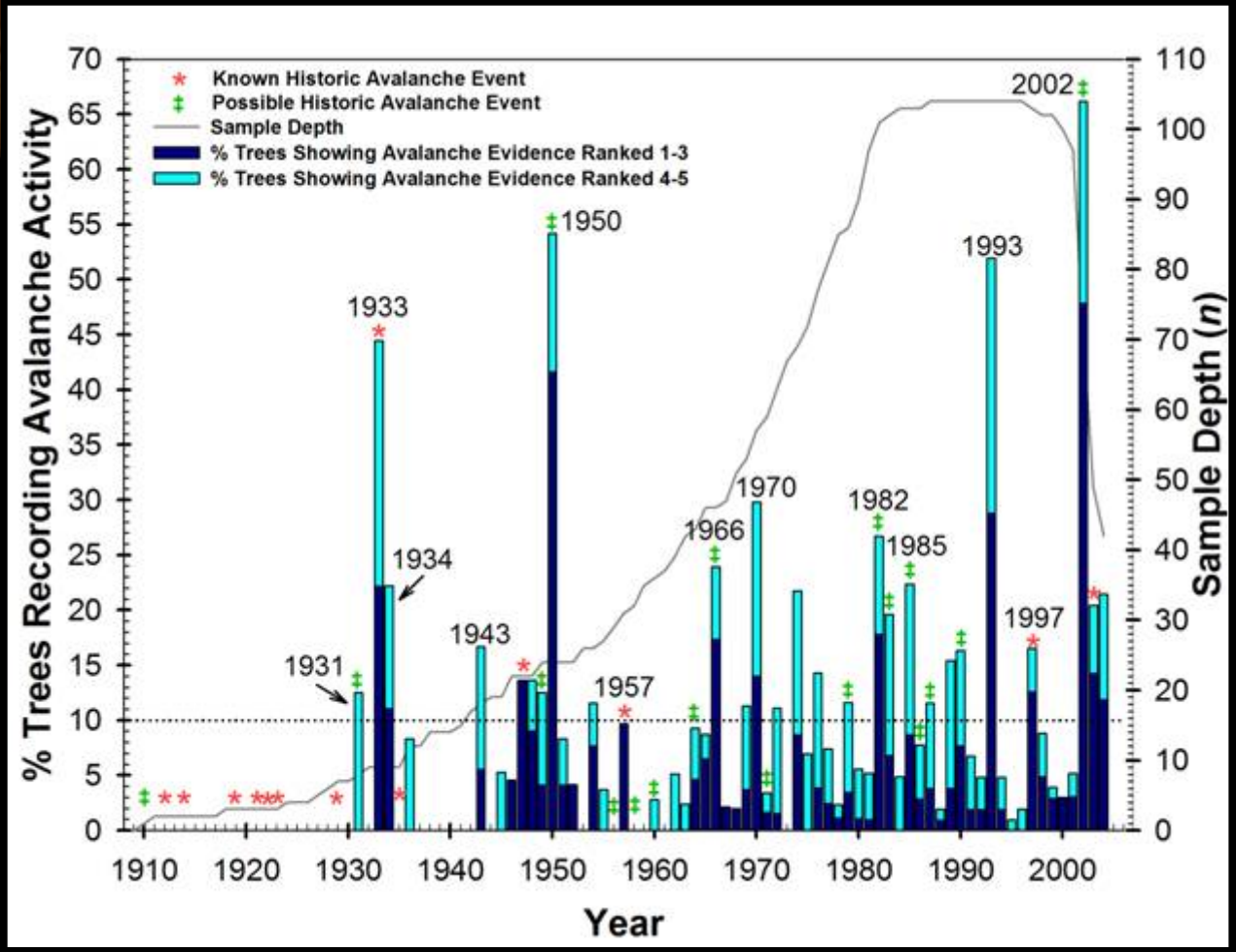

Current
100 m
250 m
800 m

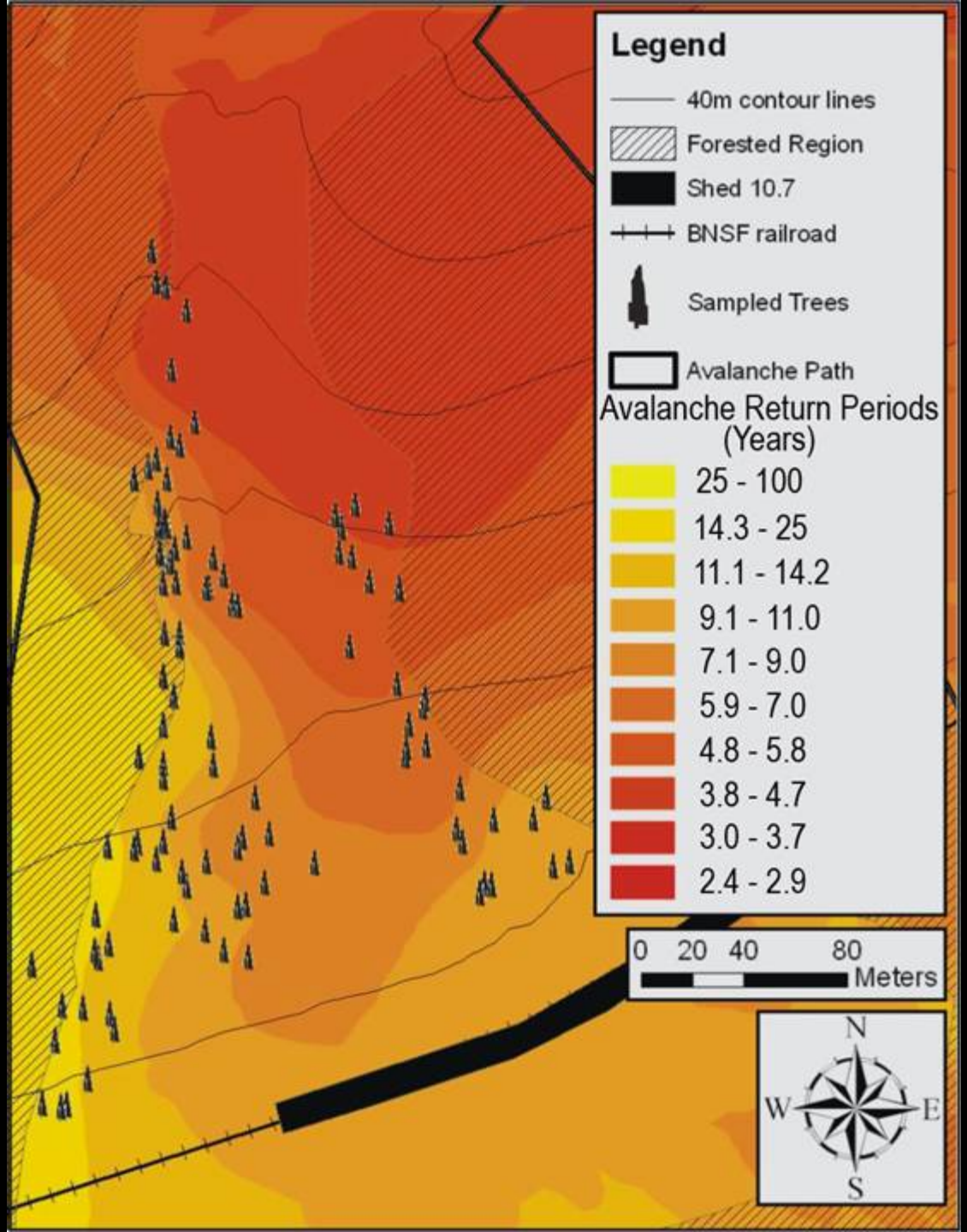
1163 Path, Jan. 28, 2004. *Photo courtesy BNSF R*

Midvale Creek, July 2003



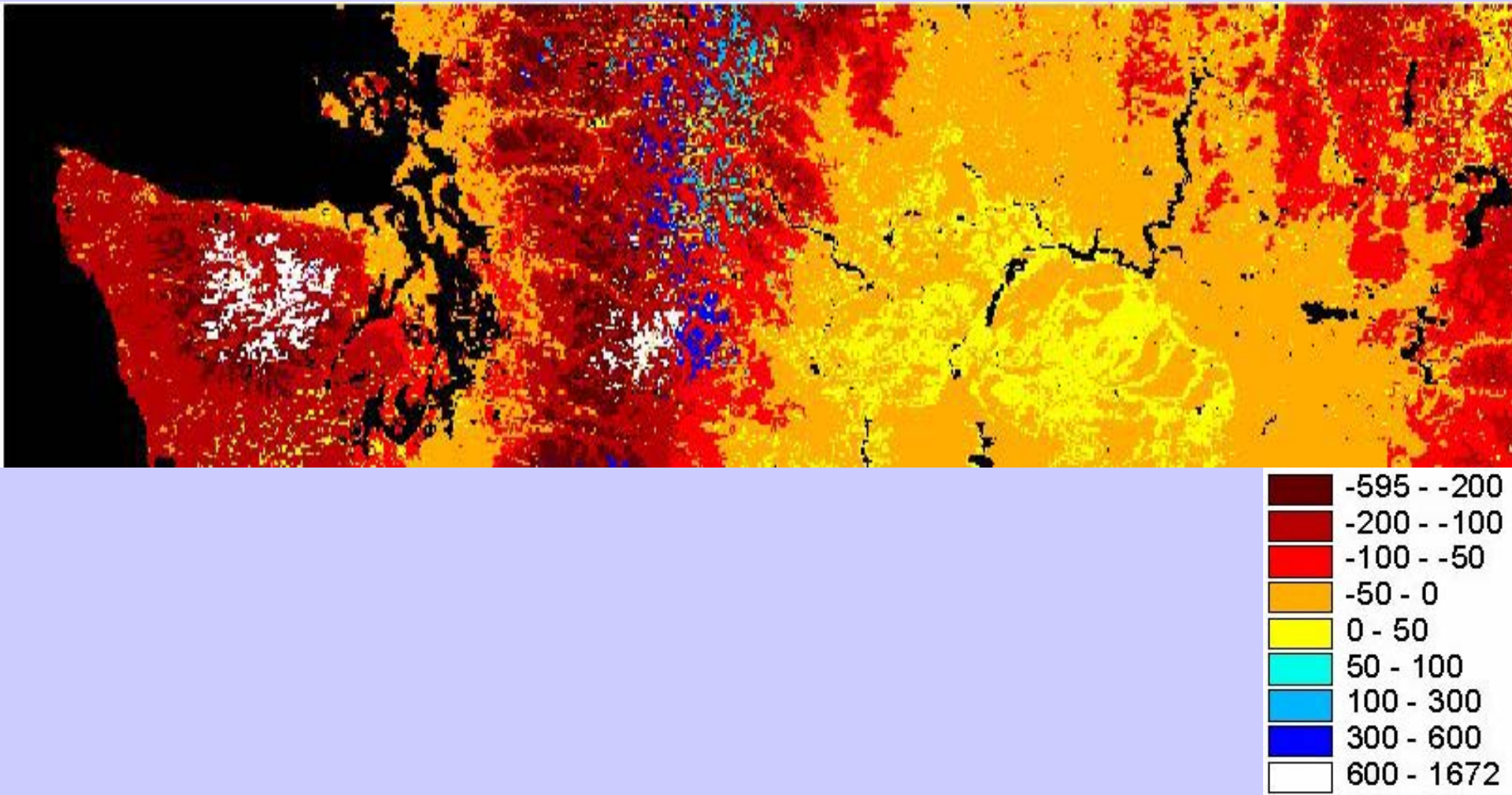
What is the frequency of natural avalanches?




Legend
40m contour lines
Forested Region
Shed 10.7
BNSF railroad
Sampled Trees
Avalanche Path
Avalanche Return Periods (Years)
25 - 100
14.3 - 25
11.1 - 14.2
9.1 - 11.0
7.1 - 9.0
5.9 - 7.0
4.8 - 5.8
3.8 - 4.7
3.0 - 3.7
2.4 - 2.9
0 20 40 80
Meters
N
W
E
S

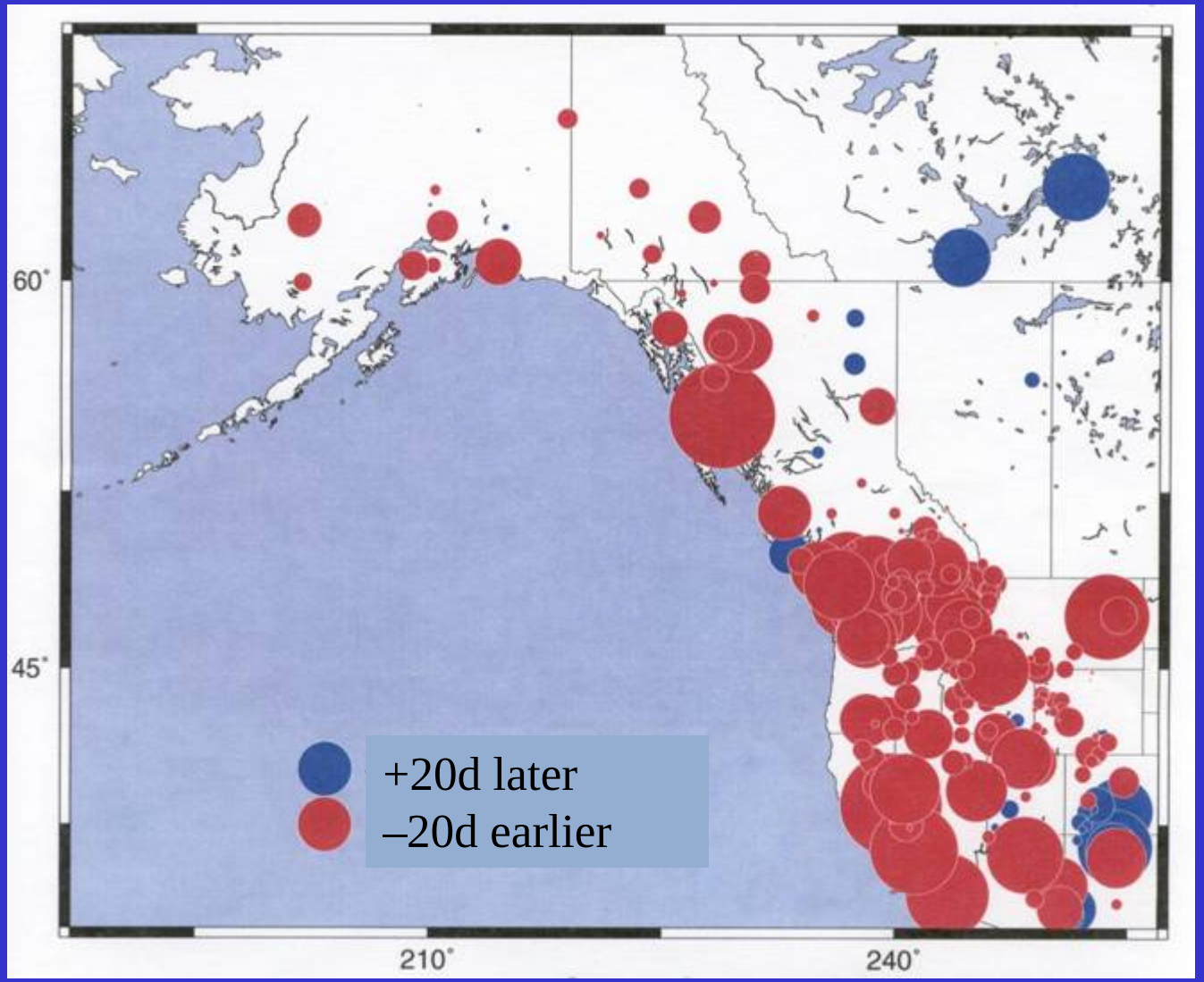
Change Detection Map

Outflow (A2 minus Control simulation)




Midslope = zone of greatest change

Trends in Timing of Spring Snowmelt



Courtesy of Mike Dettinger, Iris Stewart, Dan Cayan

Understand and predict responses of Western mountain ecosystems to climatic variability and change – emphasizing their sensitivities, thresholds, resistance, and resilience.

SCIENCE ACCOMPLISHMENTS

Regional and continental scale assessments

New understanding through syntheses of existing data and knowledge

Getting diverse disciplines and groups working together, opening up information exchanges

New capabilities with modeling

Relevance to managers (fire, drought, threatened species, forestry)

Bring a focus to mountains

CIRMOUNT

Consortium for Integrated Climate Research in Western Mountains

Anticipating Challenges to Western Mountain Ecosystems and Resources

http://www.fs.fed.us/psw/cirmount/

Mapping New Terrain: Climate Change and the America's West

Mountain Views Newsletter

MTNCLIM 2008