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ALPACKA RAFT
HYPERLITE MOUNTAIN GEAR

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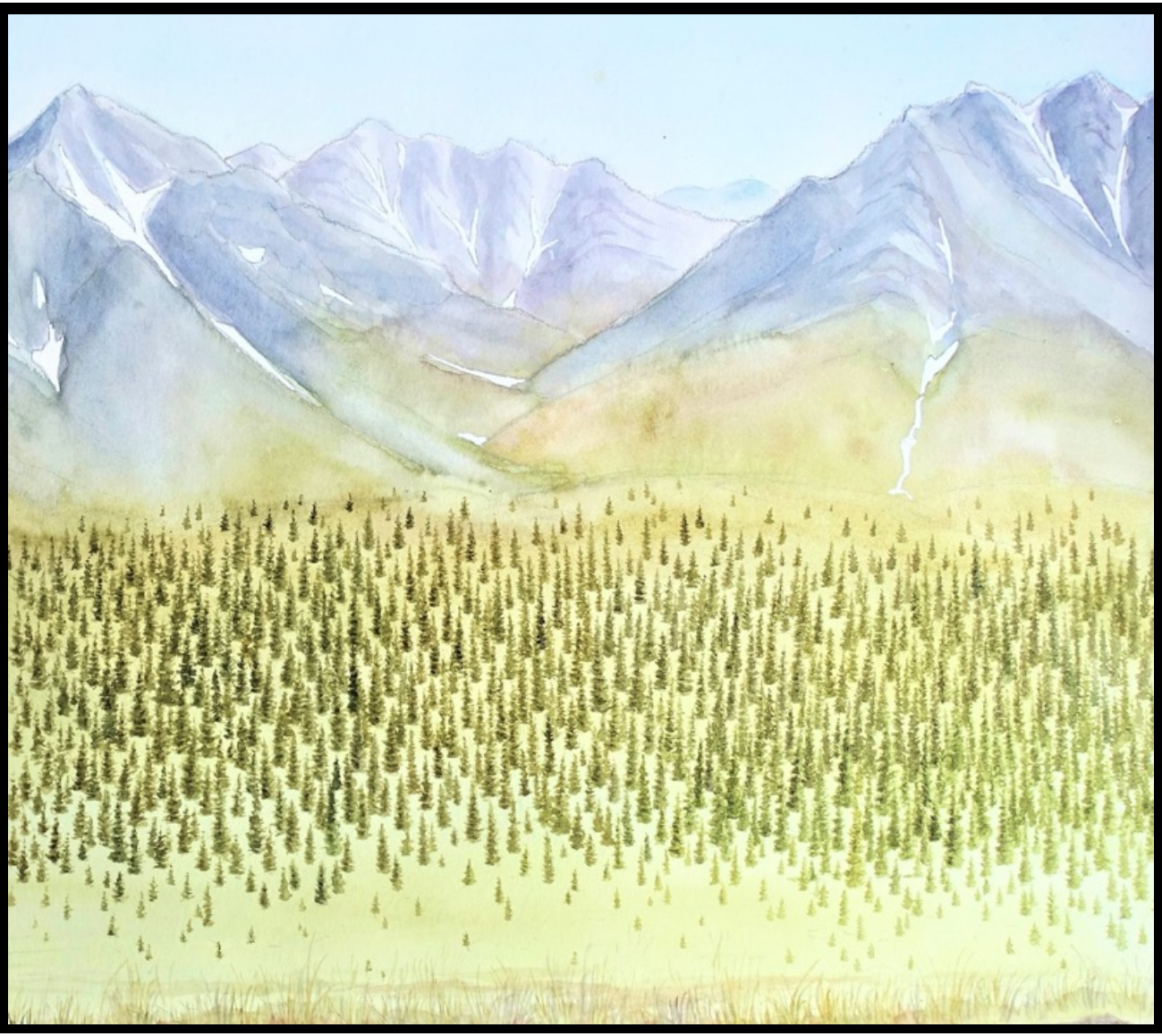
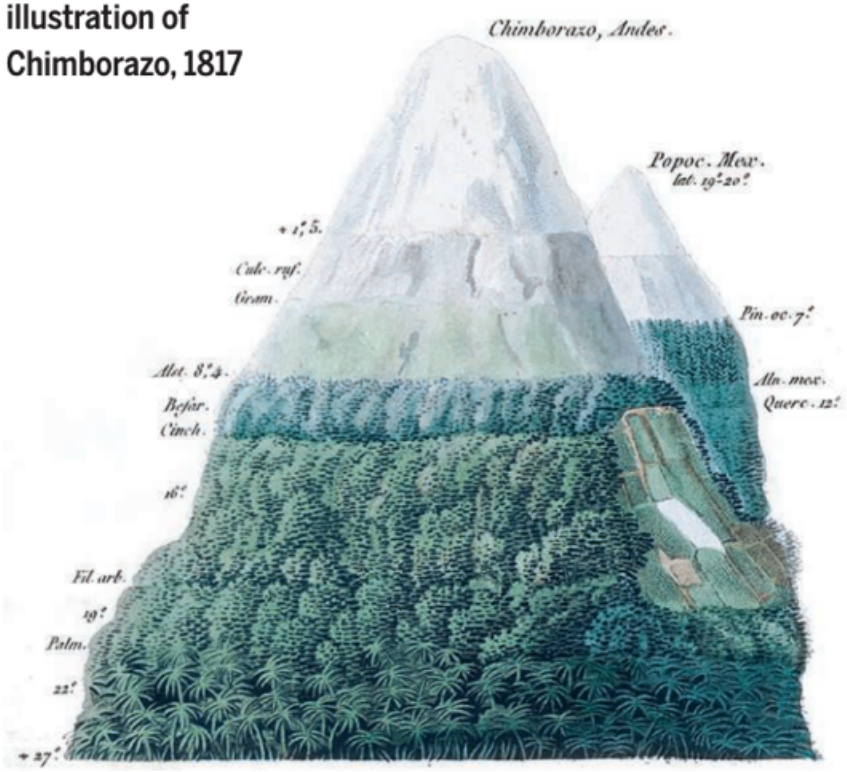
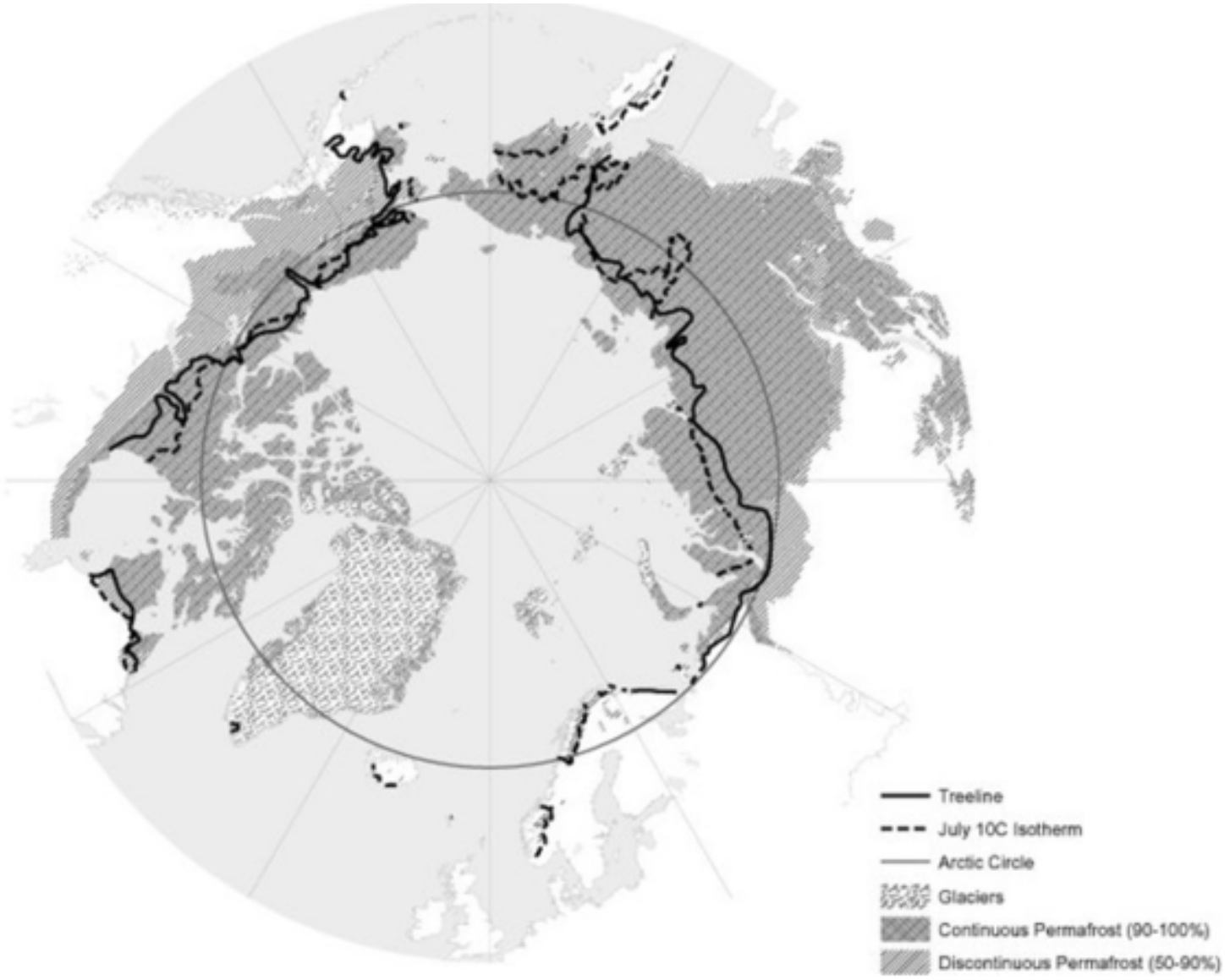
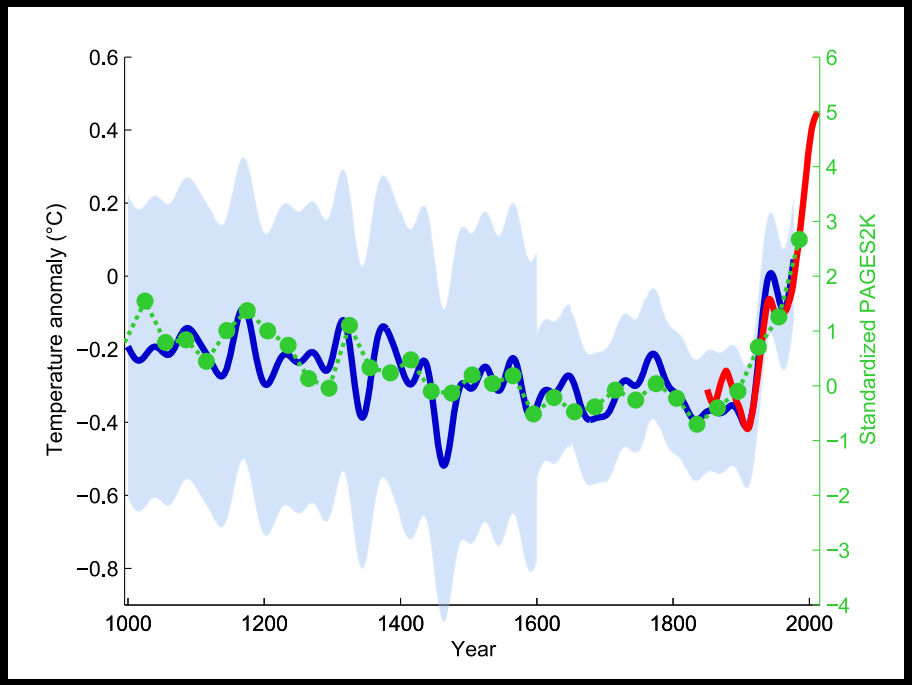


Humboldt's illustration of Chimborazo, 1817




Treeline
July 10C Isotherm
Arctic Circle
Glaciers
Continuous Permafrost (90-100%)
Discontinuous Permafrost (50-90%)



If it warms up 0.5C/100 years

and mountain air cools at rate of 5C/1000m uphill
and Arctic air cools at 5C/1000km north

Up

1m/year

Isotherm speeds

North

1km/year

Like the snowline
or 10C July isotherm

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Check for updates

PRIMARY RESEARCH ARTICLE

Global Change Biology WILEY

Is subarctic forest advance able to keep pace with climate change?

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 536 -37

THE NOATAK-KOBUK REGION ALASKA

BY

PHILIP S. SMITH

OHIO STATE UNIVERSITY
WASHINGTON
GOVERNMENT PRINTING OFFICE
1913

"The northern limit of trees is so sharply defined as to make a decidedly abrupt break which seems to have been controlled by some other factors than temperature and elevation."

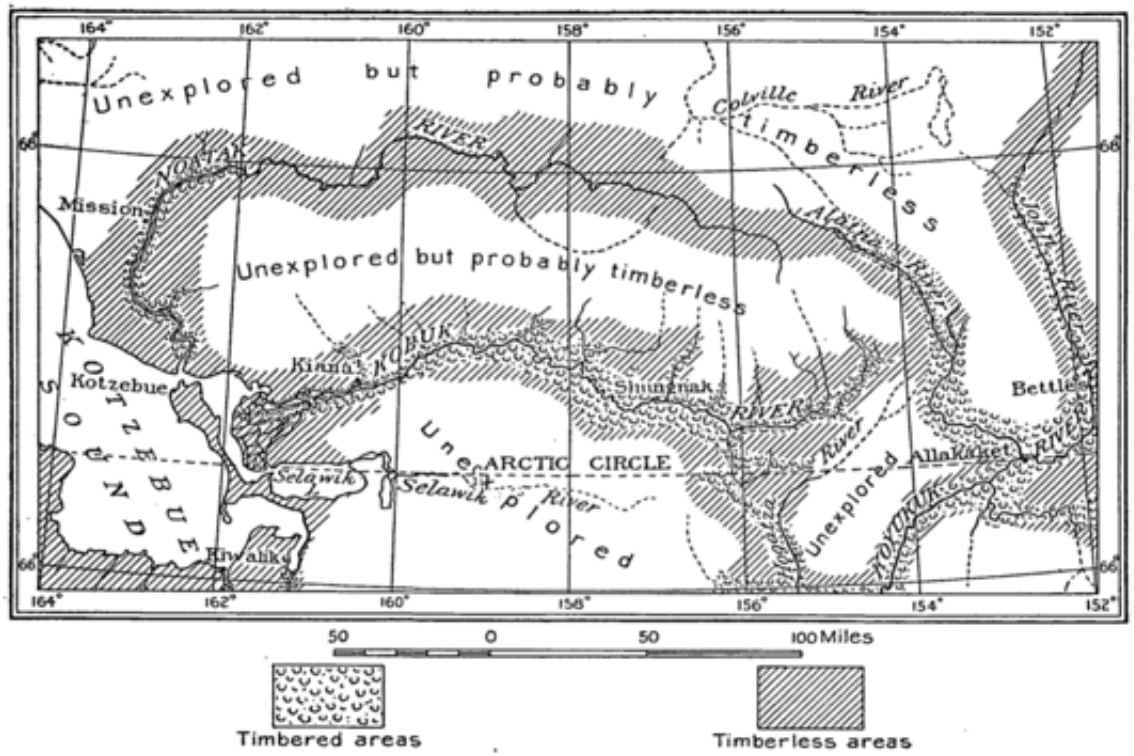


FIGURE 1.—Map showing distribution of timber in Noatak-Kobuk region.


1911
2008

Brooks Range treeline advancing
1 km per 150 years

"... the experiment to test
my theory that lack of time,
not unfavorable climatic conditions,
had prevented the progress of the
northern timberline."

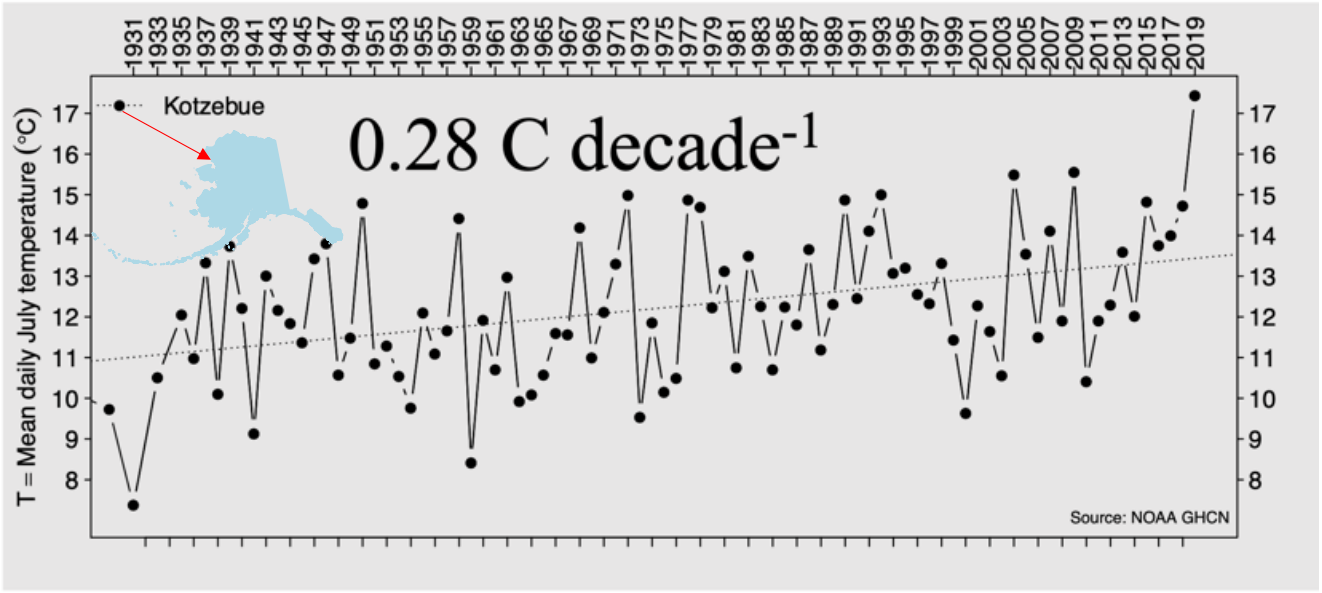
Bob Marshall
Arctic Wilderness

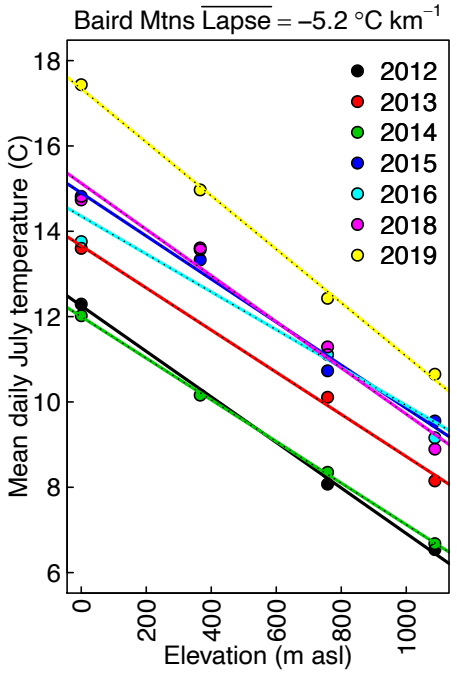
To test his hypothesis, Marshall sowed white spruce seeds north of the tree line in three separate watersheds

2001: 37 years old
30 cm tall vs 9 m tall in Fairbanks

Bob Marshall's plot in Barrenland Creek, Brooks Range, Alaska, with members of the expedition. Left to right: Joerg Sommer, Martin Wilmking, and Jens Ibendorf. No seeds sprouted and survived from Marshall's planting in 1939, but two seedlings planted by Sam Wright in 1968 are alive and show recent growth on their tips.

5 AK seedlings of 100 4-year olds survived 20 years (1968-1989)





If it warms up 0.25C/10 years

and mountain air cools at rate of 5C/1000m uphill
and Arctic air cools at 5C/1000km north

Average treeline speeds

2m/year
(0.8m/year)
5m/year

Norway mtn birch

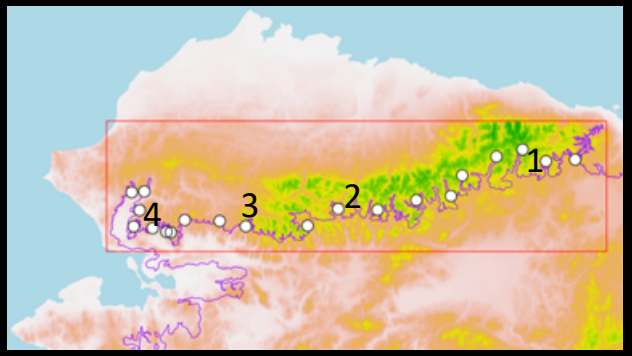
Isotherm speeds

0.3km/year
(0.08km/year)
5km/year

Where is treeline moving fastest in Alaska's Arctic?
And what factors control its speed?

4

1

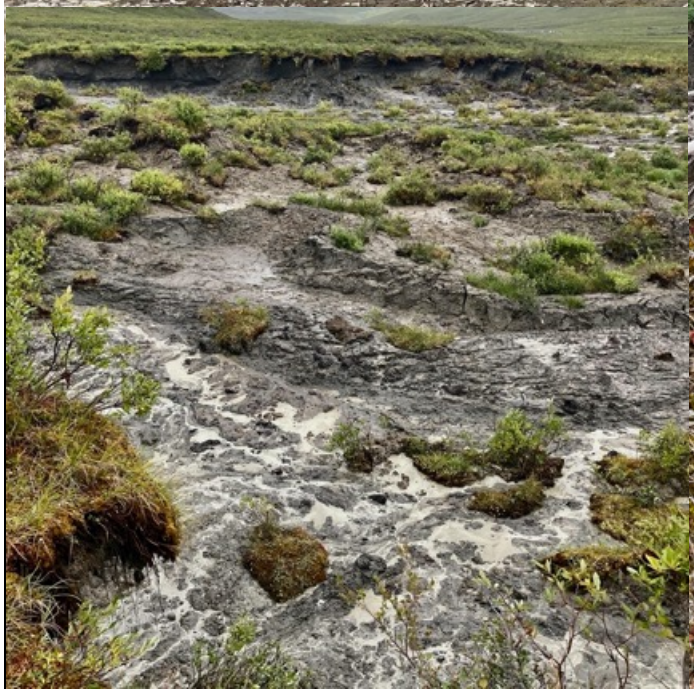


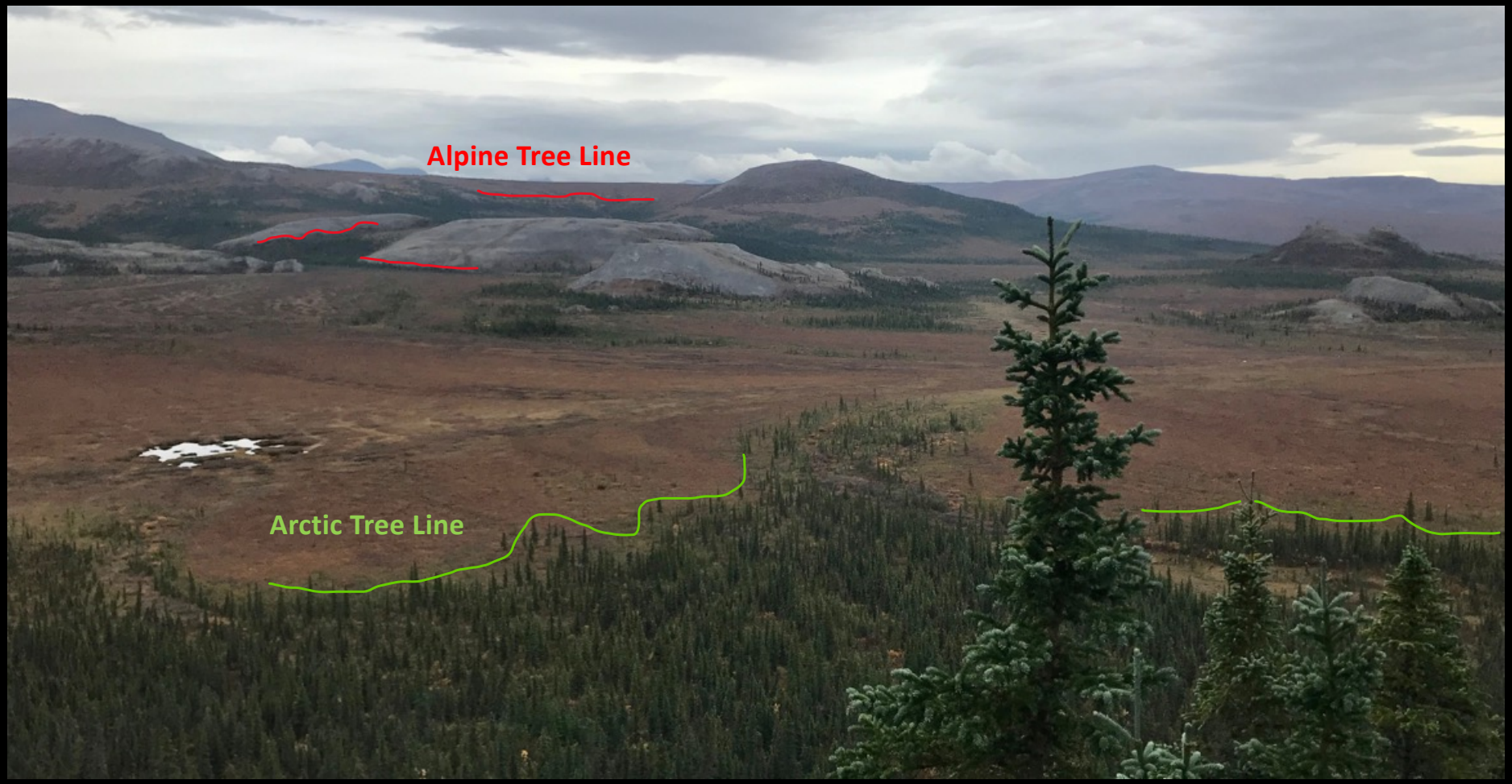
3

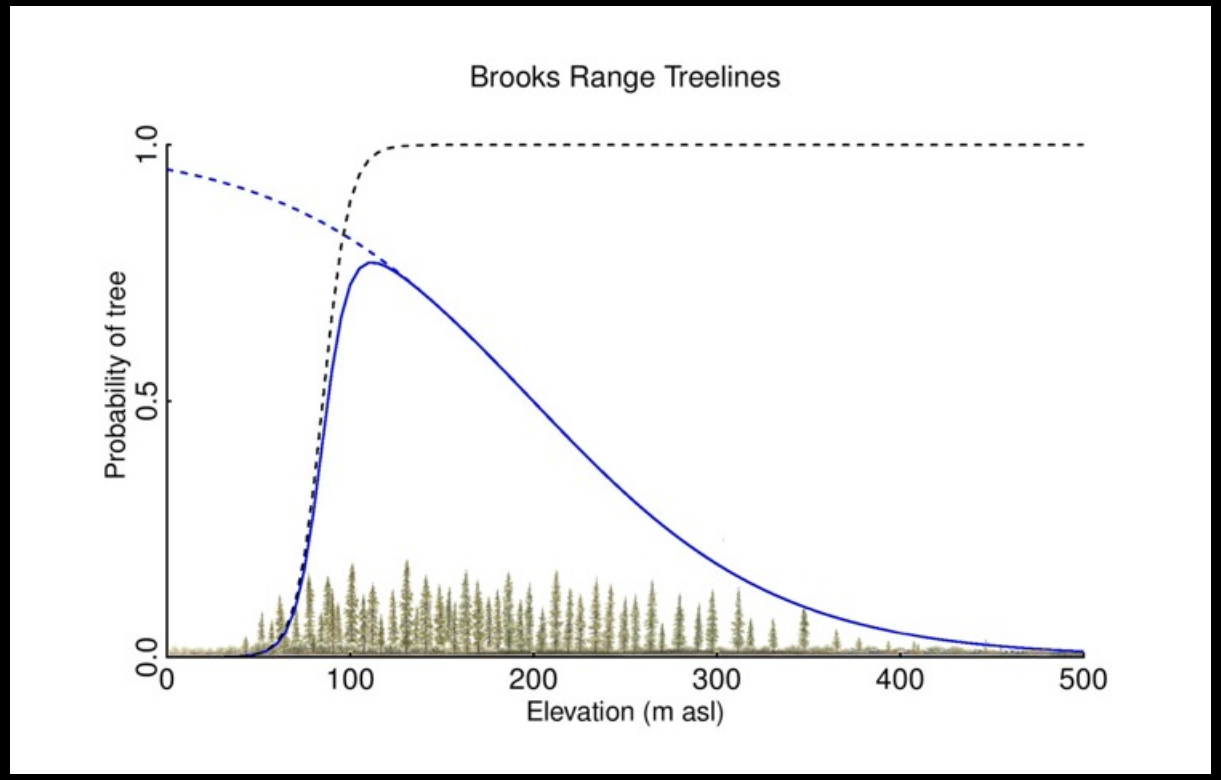
2

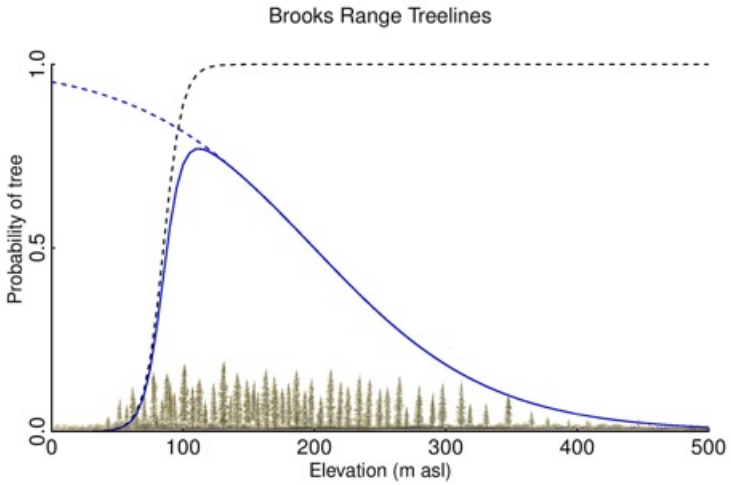

Kokatat




Alpine Tree Line
Arctic Tree Line


Brooks Range Treelines
Probability of tree
0.0
0.5
1.0
0
100
200
300
400
500
Elevation (m asl)


Brooks Range Treelines
Probability of tree
0.0
0.5
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200
300
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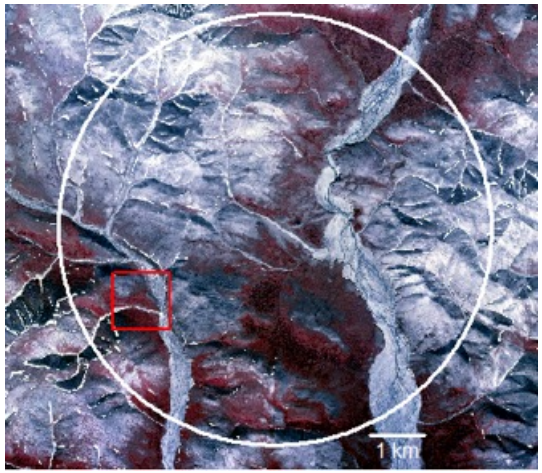
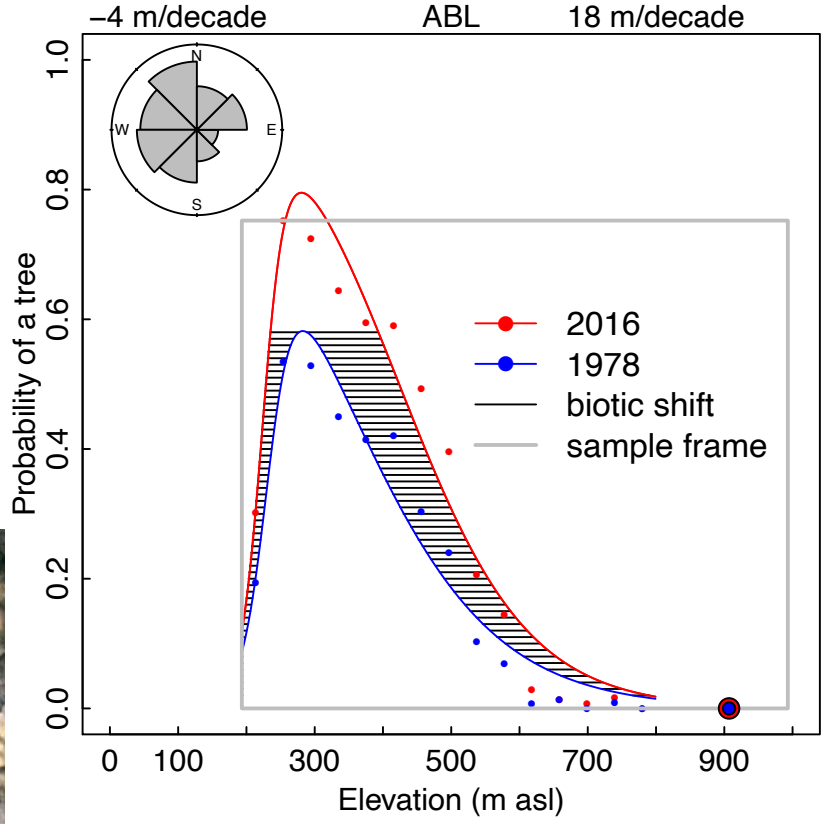
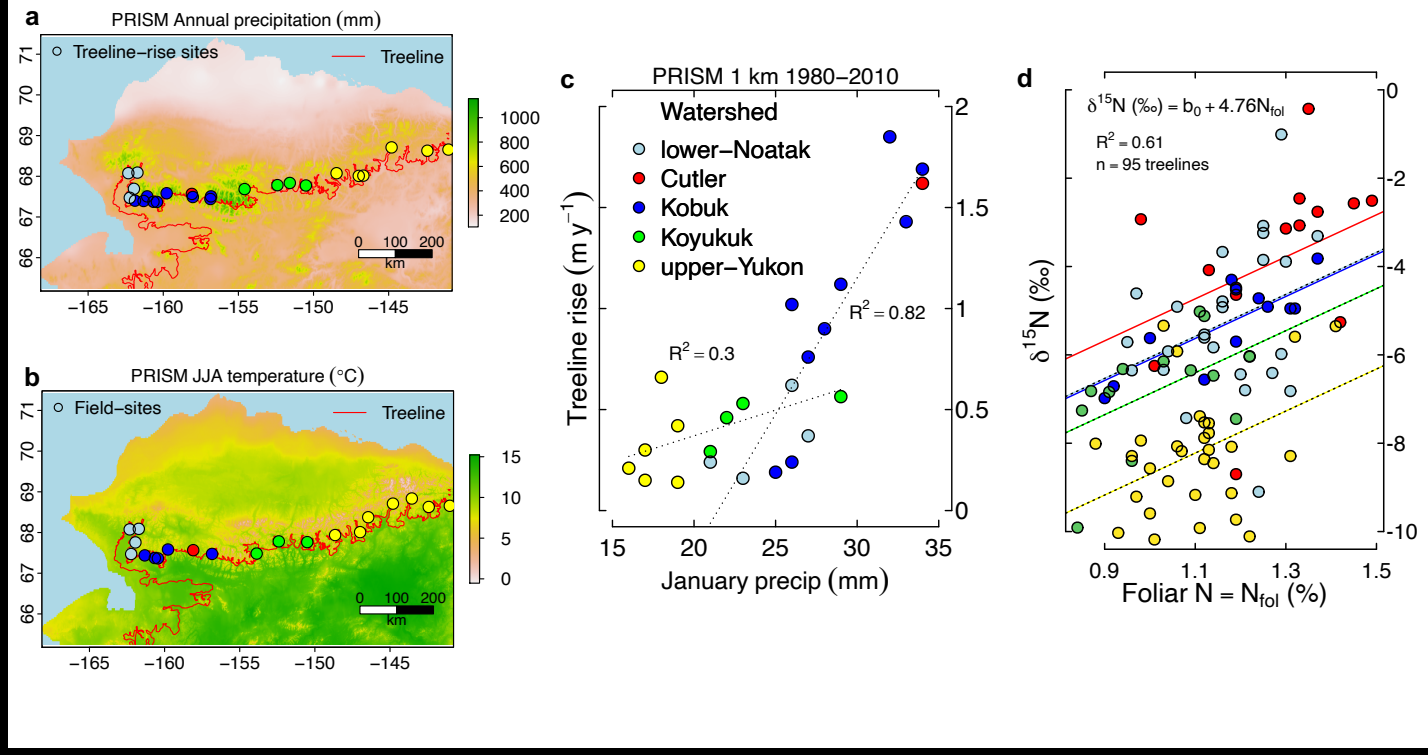
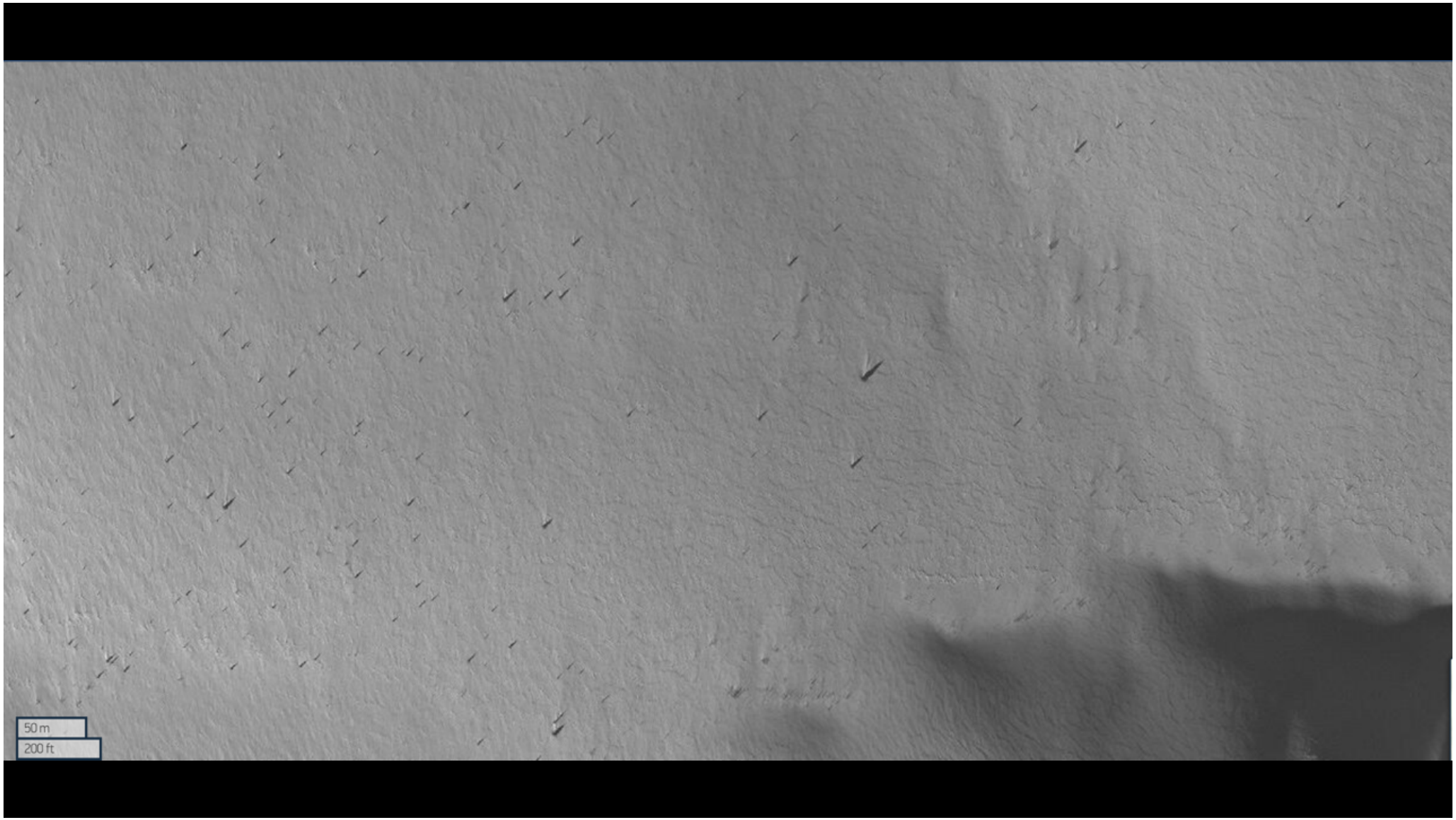
Elevation (m asl)

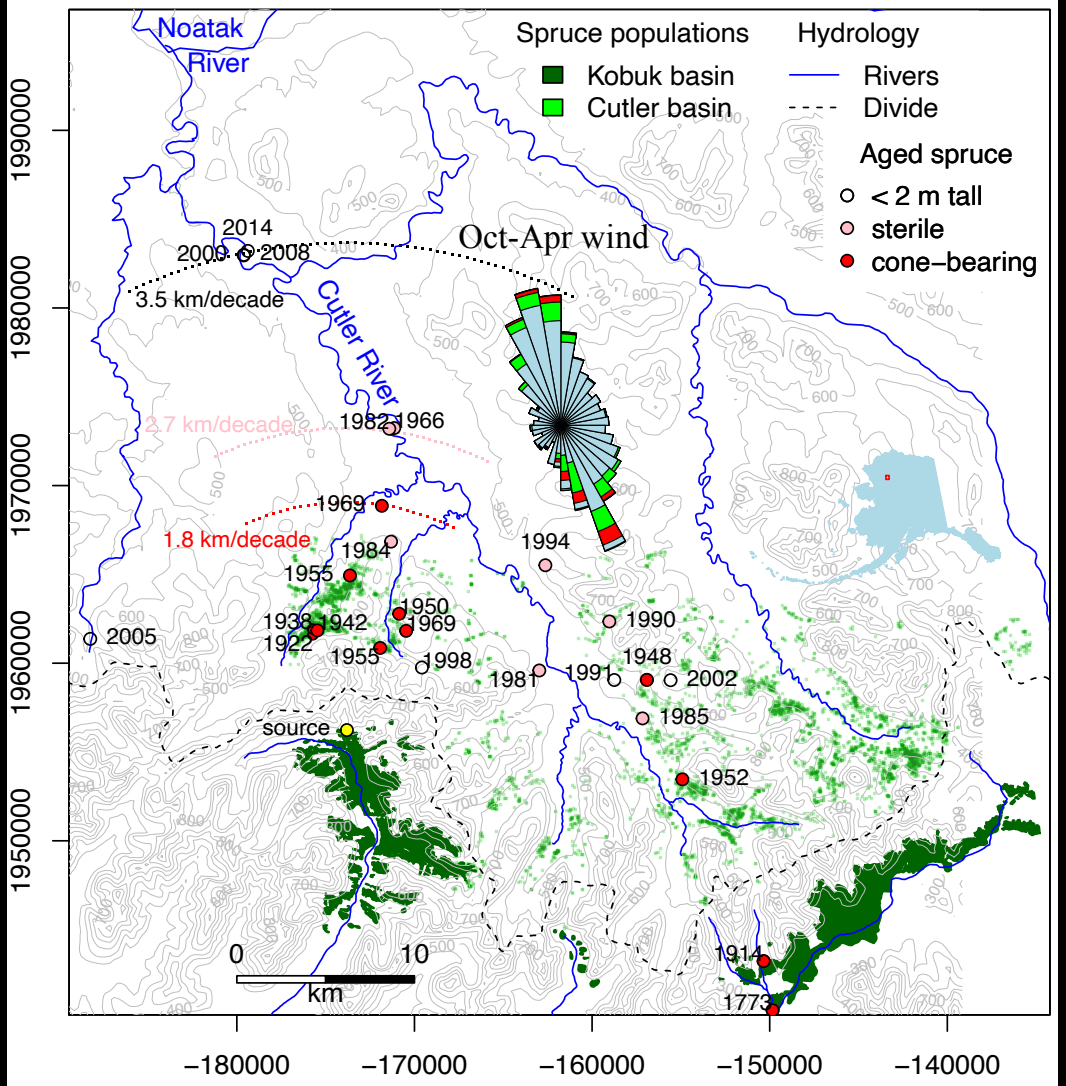

1 km


–4 m/decade
ABL
18 m/decade
N
W
E
S
Probability of a tree
0.0
0.2
0.4
0.6
0.8
1.0
2016
1978
biotic shift
sample frame
0
100
300
500
700
900
Elevation (m asl)

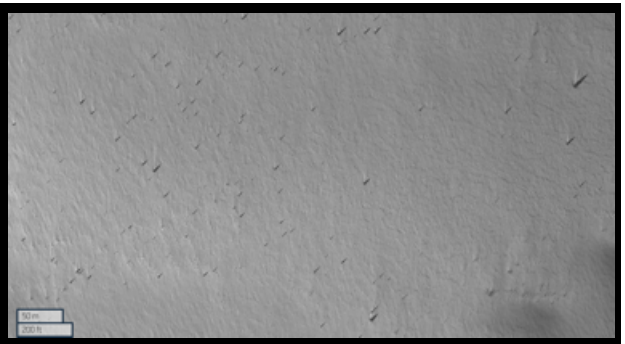

a
PRISM Annual precipitation (mm)
Treeline–rise sites
Treeline
1000
800
600
400
200
0 100 200
km
71
70
69
68
67
66
−165
−160
−155
−150
−145
b
PRISM JJA temperature (°C)
Field–sites
Treeline
15
10
5
0
0 100 200
km
c
PRISM 1 km 1980–2010
Watershed
lower–Noatak
Cutler
Kobuk
Koyukuk
upper–Yukon
$R^2 = 0.3$
$R^2 = 0.82$
Treeline rise (m y^{-1})
January precip (mm)
d
$\delta^{15}N$ (‰) = $b_0 + 4.76N_{fol}$
$R^2 = 0.61$
n = 95 treelines
$\delta^{15}N$ (‰)
Foliar N = N_{fol} (%)


50 m
200 ft


50 m
200 ft

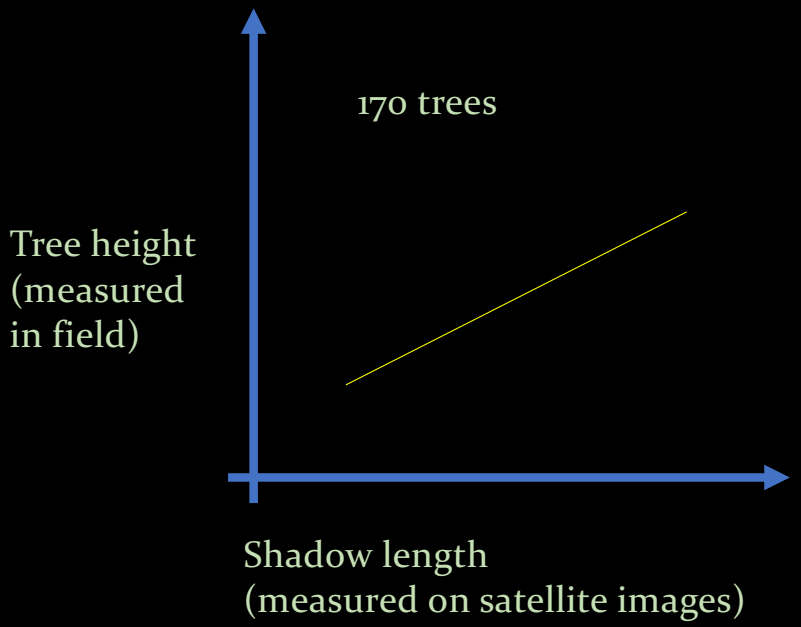

Noatak River
Spruce populations
Kobuk basin
Cutler basin
Hydrology
Rivers
Divide
Aged spruce
< 2 m tall
sterile
cone–bearing
Oct-Apr wind
2014
2009
2008
3.5 km/decade
Cutler River
2.7 km/decade
1.8 km/decade
1982
1966
1969
1984
1955
1950
1938
1942
1969
1922
1955
1998
2005
1994
1990
1948
1991
2002
1981
1985
source
1952
1914
1773
0
10
km
1990000
1980000
1970000
1960000
1950000
−180000
−170000
−160000
−150000
−140000

Height = 0.3 x Shadow length + snow depth

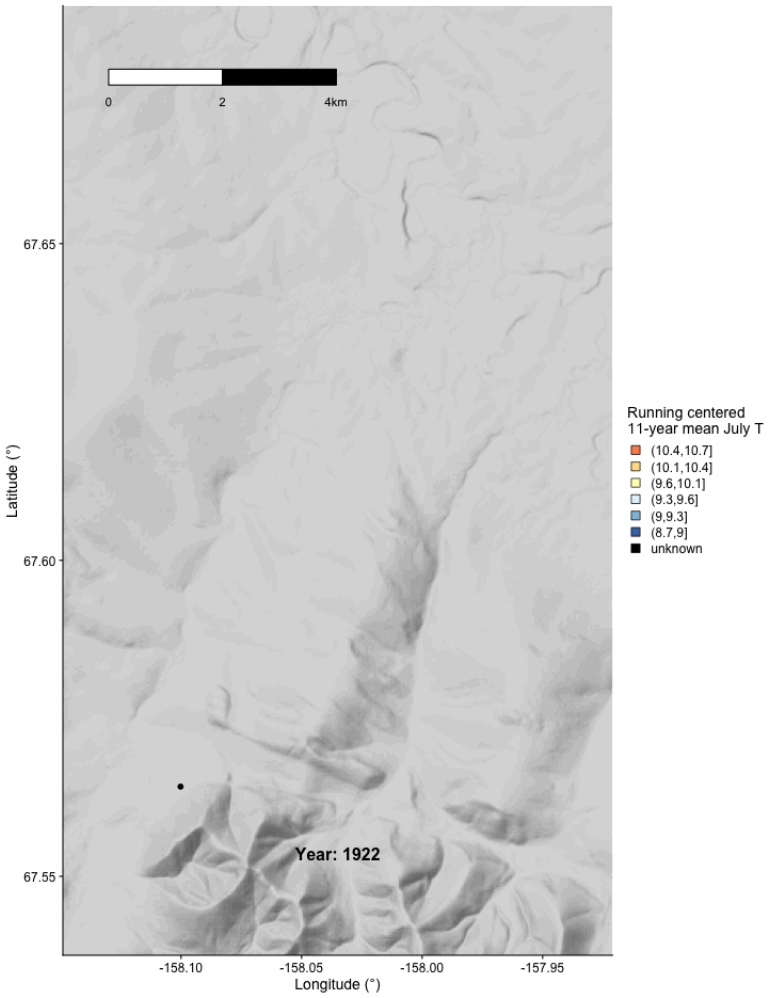


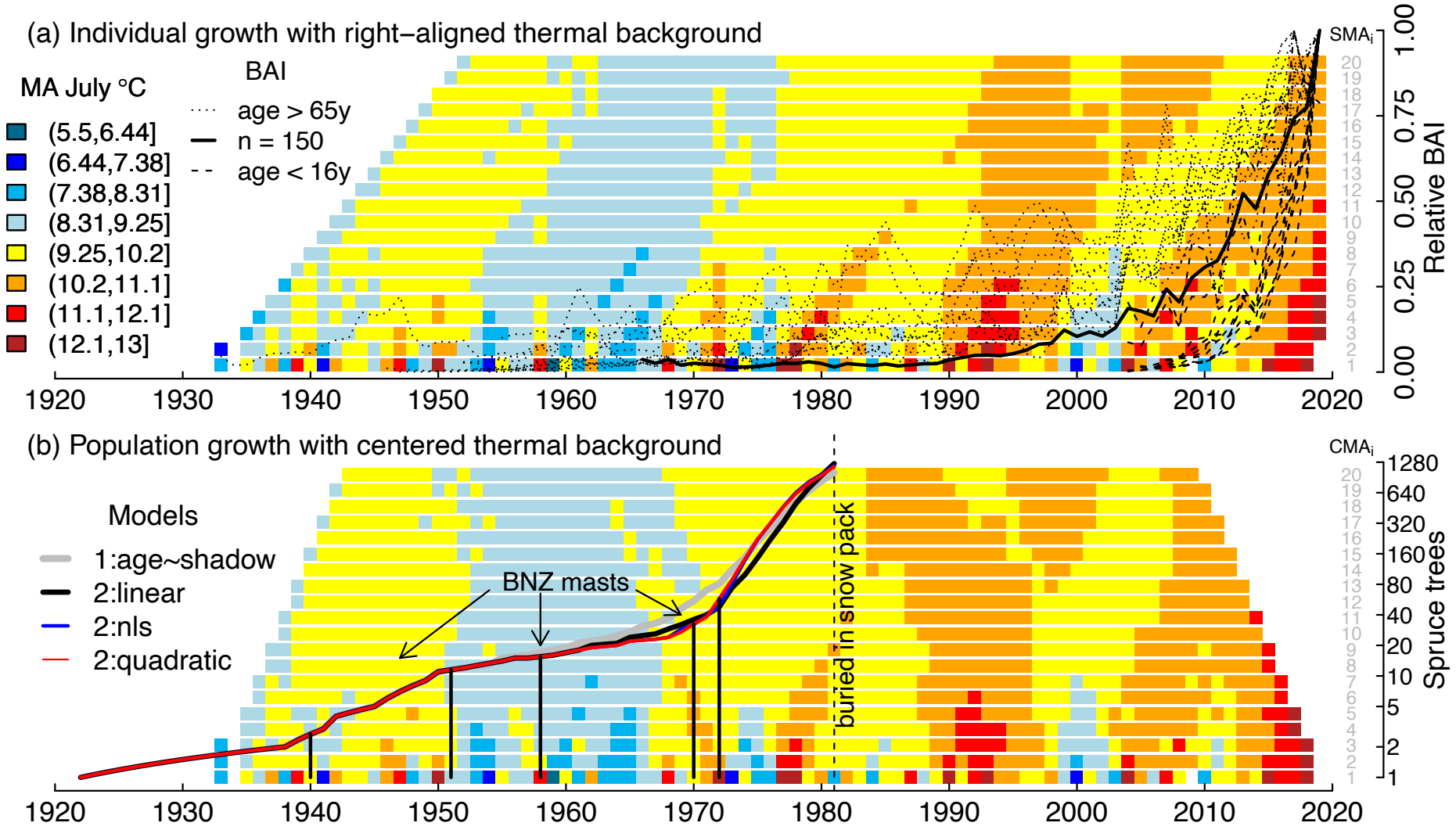
120 trees

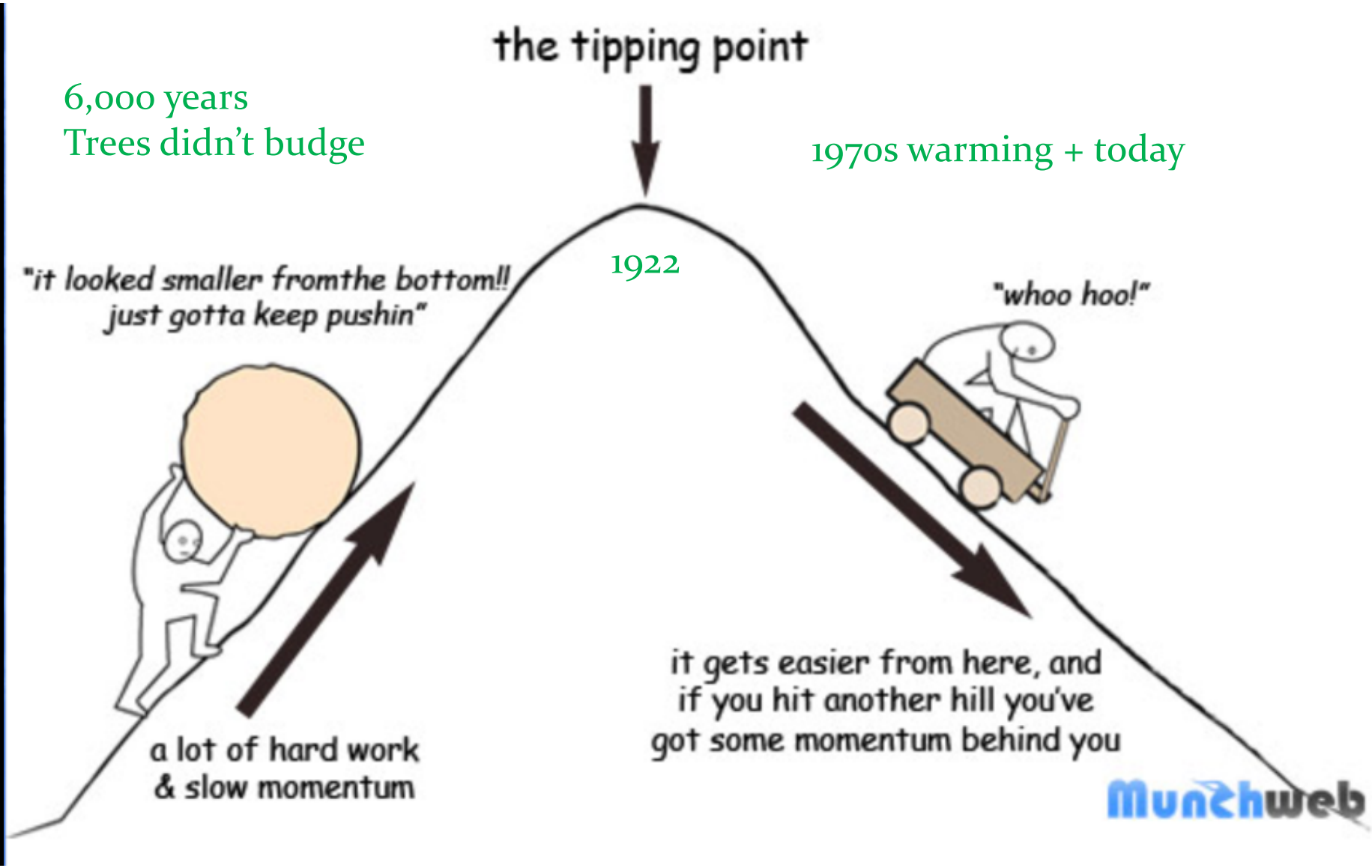
Age = 12.5 x Height



2,000 shadows give 2,000 ages
Oldest 1922
after 1981 too short to see


0
2
4km
67.65
67.60
67.55
Latitude (°)
-158.10
-158.05
-158.00
-157.95
Longitude (°)
Year: 1922
Running centered
11-year mean July T
(10.4,10.7]
(10.1,10.4]
(9.6,10.1]
(9.3,9.6]
(9,9.3]
(8.7,9]
unknown


(a) Individual growth with right−aligned thermal background
MA July °C
(5.5,6.44]
(6.44,7.38]
(7.38,8.31]
(8.31,9.25]
(9.25,10.2]
(10.2,11.1]
(11.1,12.1]
(12.1,13]
BAI
age > 65y
n = 150
age < 16y
SMA$_i$
Relative BAI
0.00
0.25
0.50
0.75
1.00
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
(b) Population growth with centered thermal background
Models
1:age~shadow
2:linear
2:nls
2:quadratic
BNZ masts
buried in snow pack
CMA$_i$
Spruce trees
1280
640
320
160
80
40
20
10
5
2
1


the tipping point
6,000 years
Trees didn't budge
1970s warming + today
1922
"it looked smaller fromthe bottom!! just gotta keep pushin"
"whoo hoo!"
a lot of hard work & slow momentum
it gets easier from here, and if you hit another hill you've got some momentum behind you
Munchweb


Short spruce trees (less than six feet tall) with cones:
GPS location
smart phone photo showing height
smart phone photo of cones
roman@alaskapacific.edu