What role does changing climate play in reforestation decisions?

Marcus Warwell, PhD
Geneticist USDA, Forest Service Rocky Mountain Research Station
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Overview: Reforestation management recommendations under changing climate

- **Consider** conservation of genetic diversity in anticipation of climate change impacts
- **Consider** matching species and seed source with the expectation of changing climate.

Sup

Overview: Available Tools

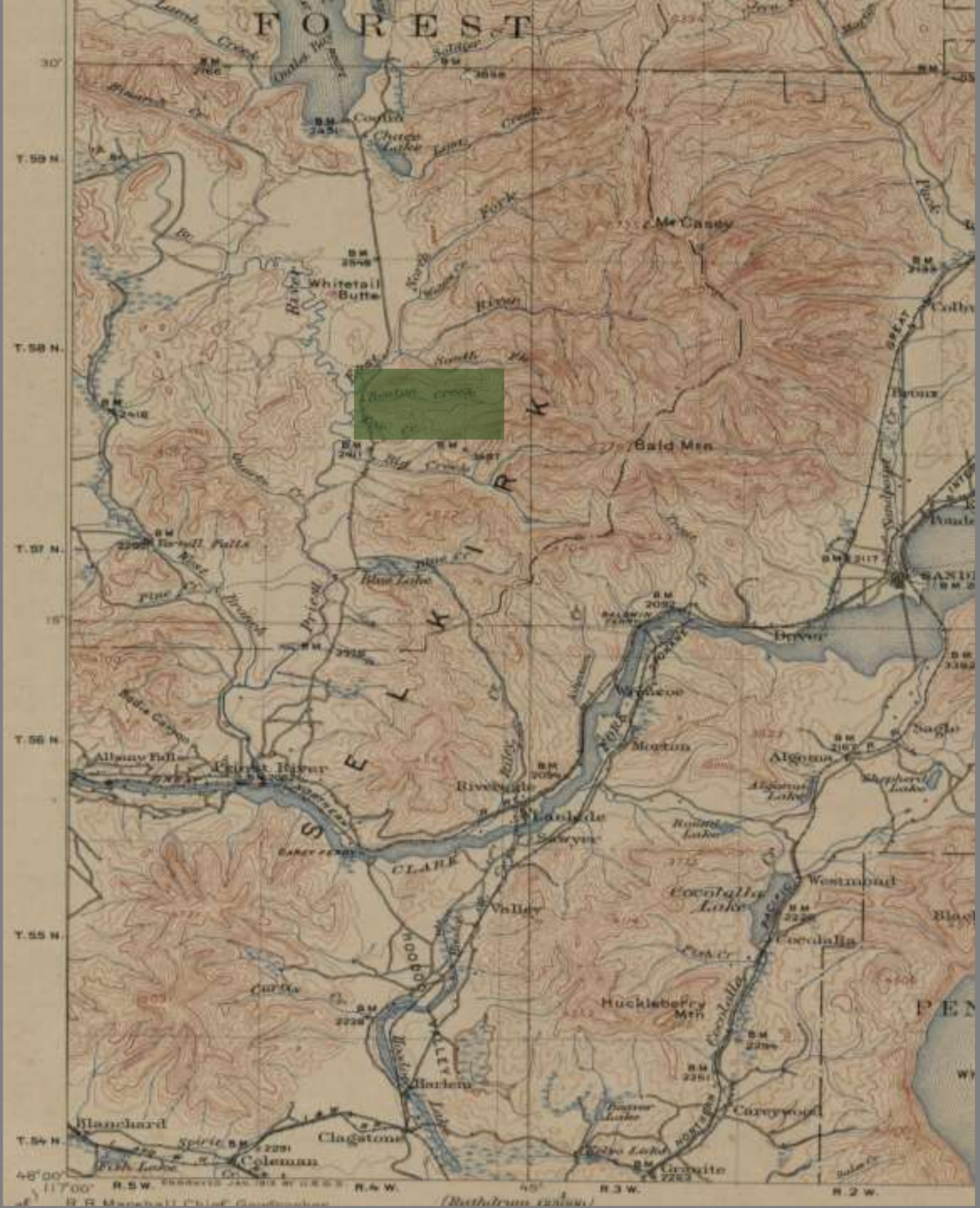
Websites:

- Climate Estimates, Climate Change and Plant Climate Relationships – VT
- Climate-Forest Vegetation Simulator
- Seed Selection Tool

Overview

Focus on a few key ecological genetic concepts:

- 1911 Ponderosa Pine Pioneer Plantation
- Historic and Local Climate Context



Priest River Experimental Station, Est. 1911

Purpose: Research to inform management decisions.

From:http://www.lib.utexas.edu/maps/topo/idaho/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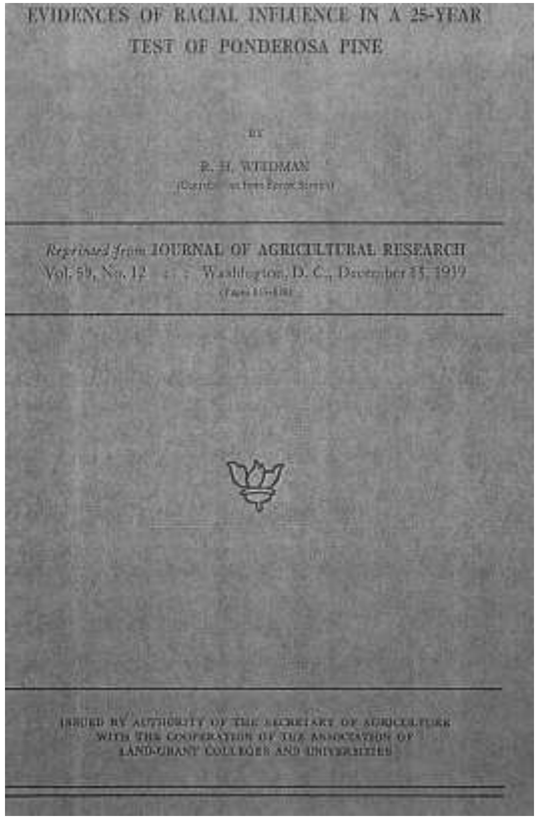


EVIDENCES OF RACIAL INFLUENCE IN A 25-YEAR TEST OF PONDEROSA PINE

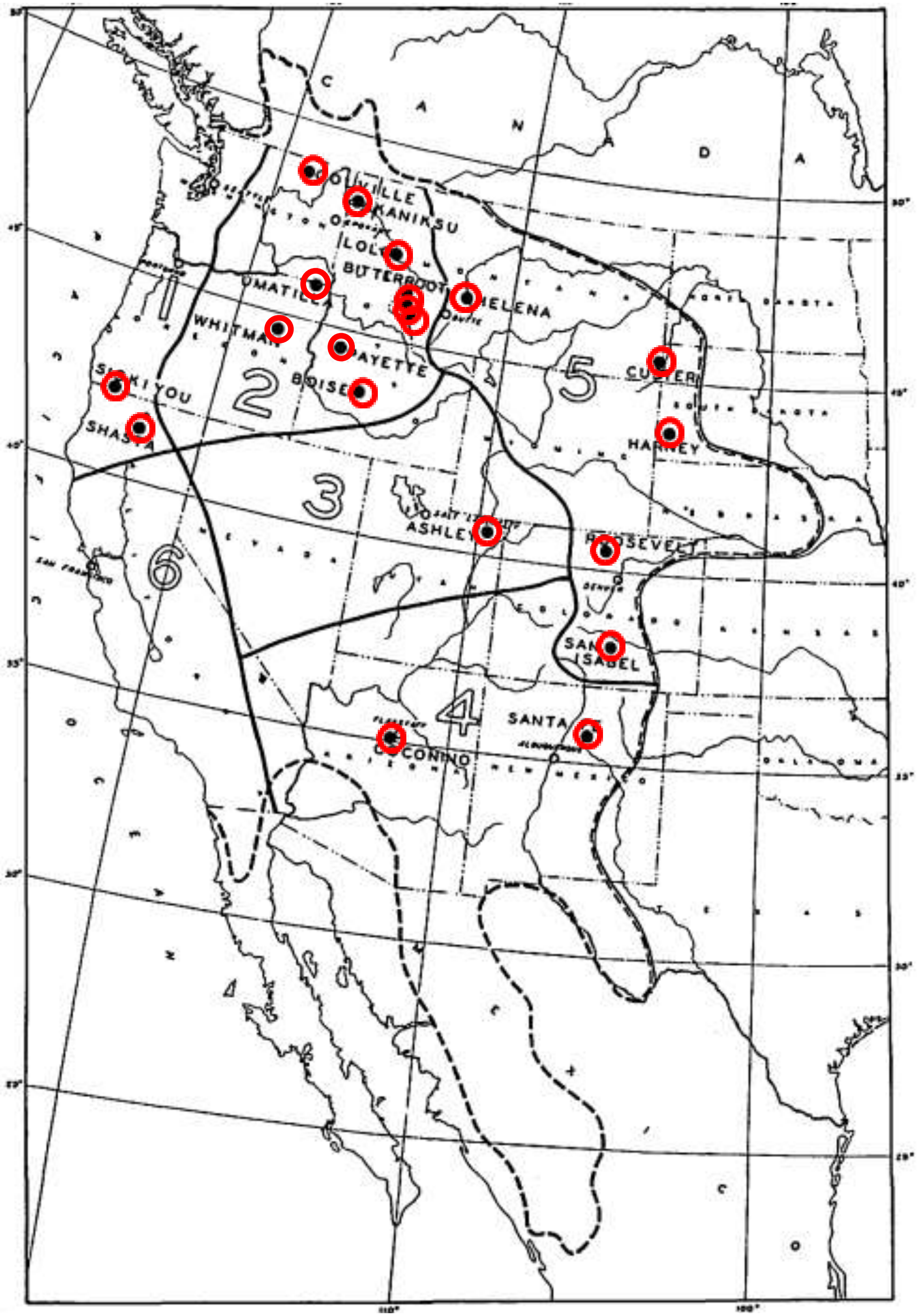
BY

R. H. WEIDMAN

Reprinted from JOURNAL OF AGRICULTURAL RESEARCH
Vol. 59, No. 12 . . . Washington, D. C., December 15, 1939

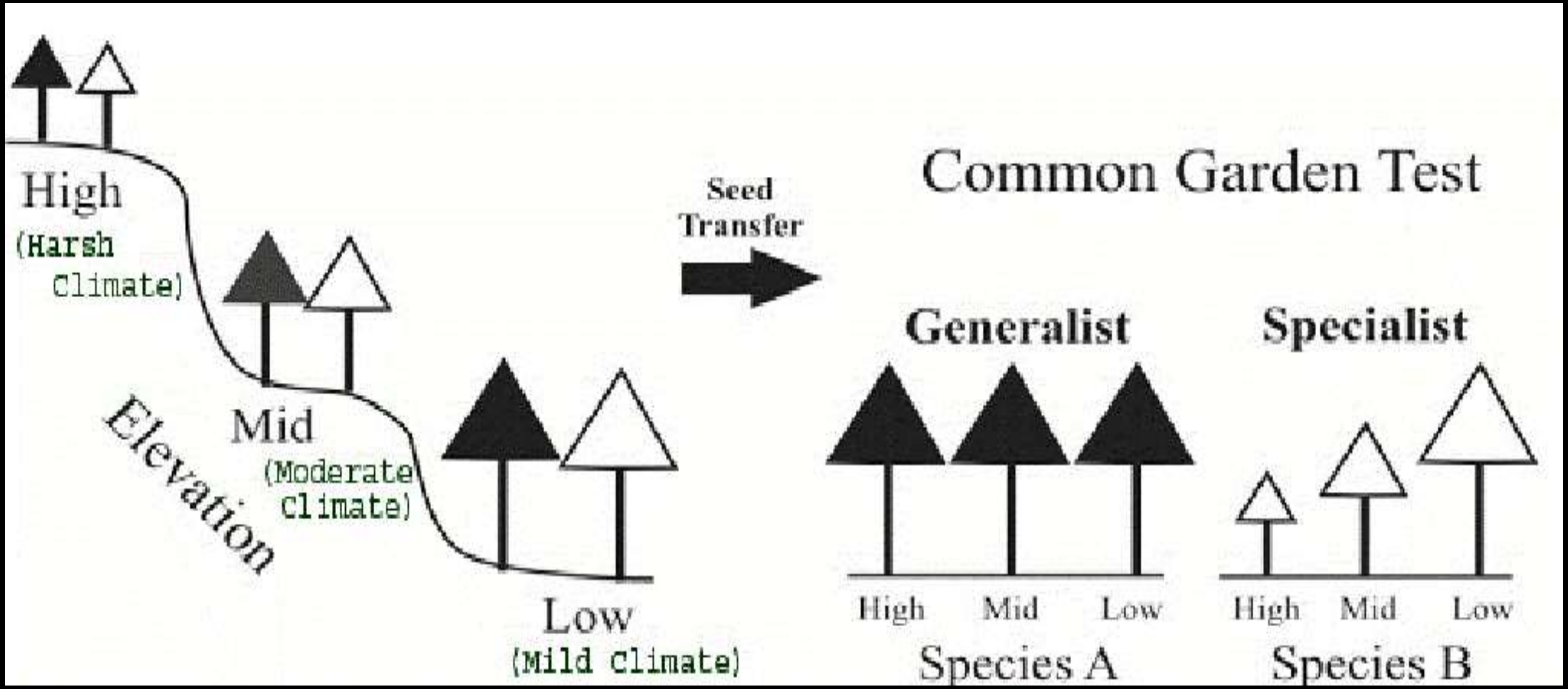
ISSUED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE WITH THE COOPERATION OF THE ASSOCIATION OF LAND-GRANT COLLEGES AND UNIVERSITIES

Squillace and Silen, 1962

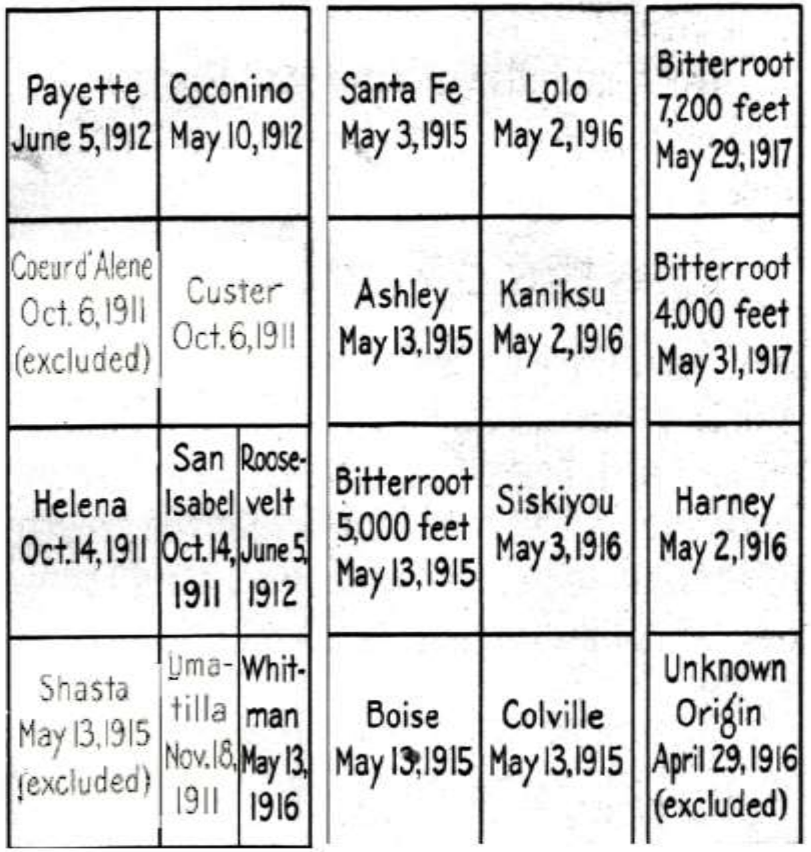


Concepts

P = G x E　　　　P = G x E



- Common garden experiments are used to assess adaptive genetic structure and evolutionary response



'IGURE 3.—Arrangement of progeny plots, and dates of first planting. The large plots are 50 by 50 feet and the small ones 25 by 50 feet.

Walter Kempf: PI

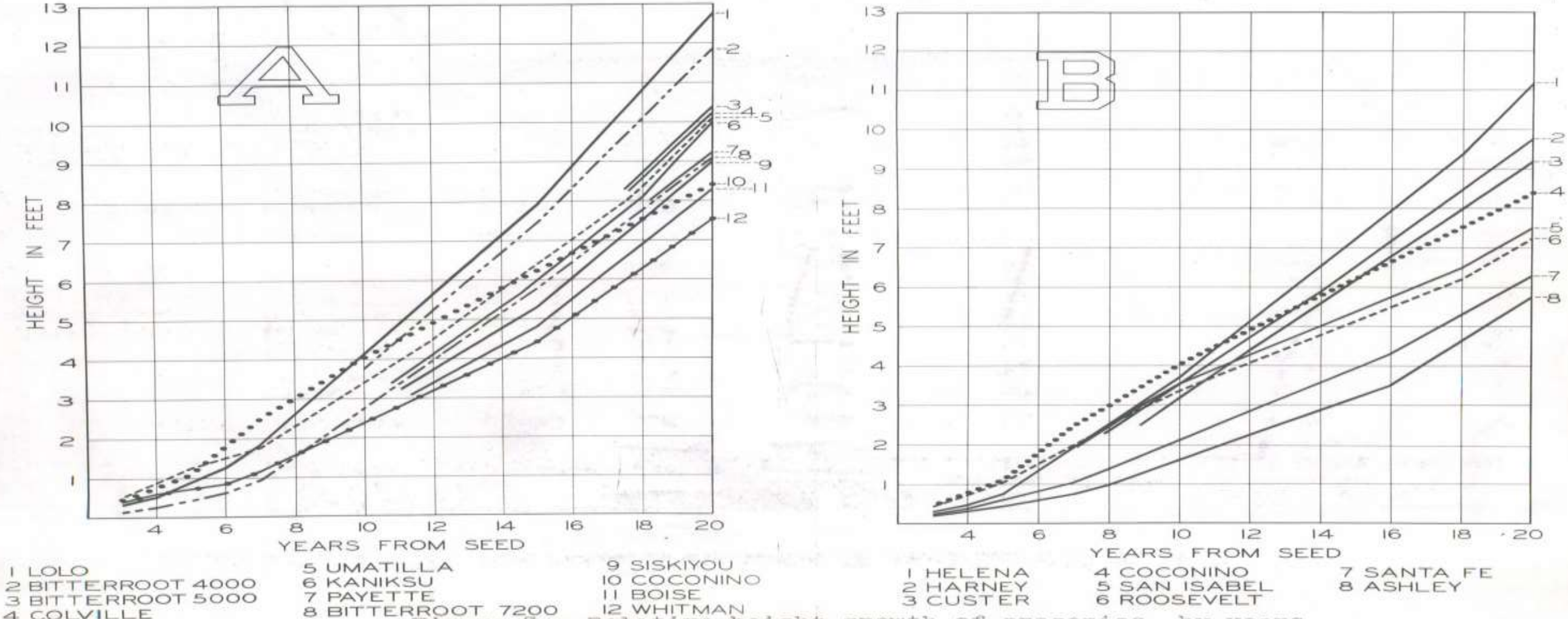


Figure 3.--Relative height growth of progenies, by years.

Age 12, 20, 50 and 80 years

- Survival
- Height
- Volume

Squillace and Silen, 1962

No. 270752 Source of seed experiment on Priest River Experimental Forest. Ponderosa Pine stand grown from Helena seed. July-August, 1932.

No. 270756 Source of seed experiment on Priest River Experimental Forest. Ponderosa Pine stand grown from Pecos seed. July-August, 1932.





United States
Department of
Agriculture

Forest Service

**Intermountain
Forest and Range
Experiment Station
Ogden, UT 84401**

General Technical
Report INT-159

December 1983

Climate of Priest River Experimental Forest, Northern Idaho

Arnold I. Finklin

United States
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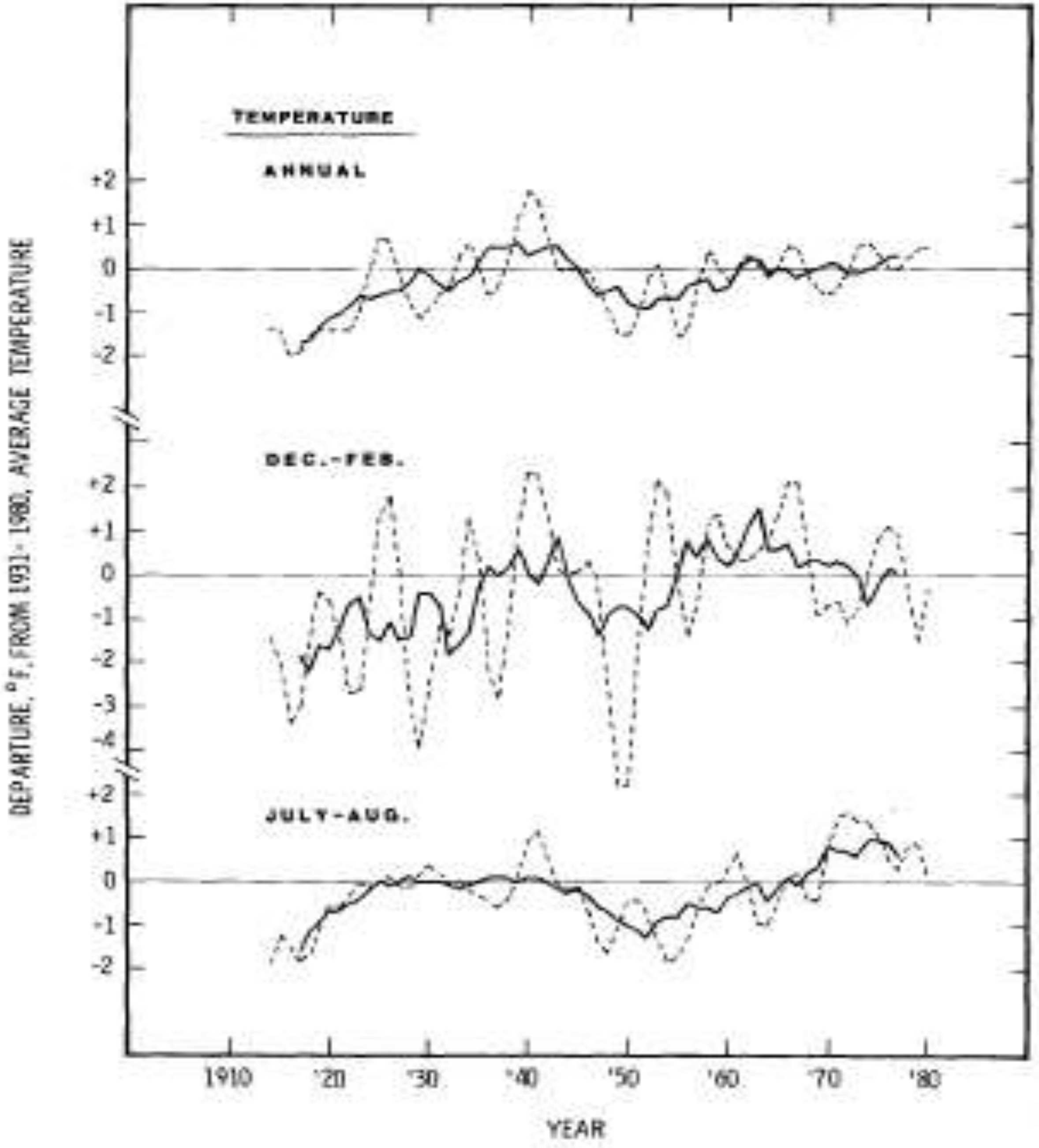
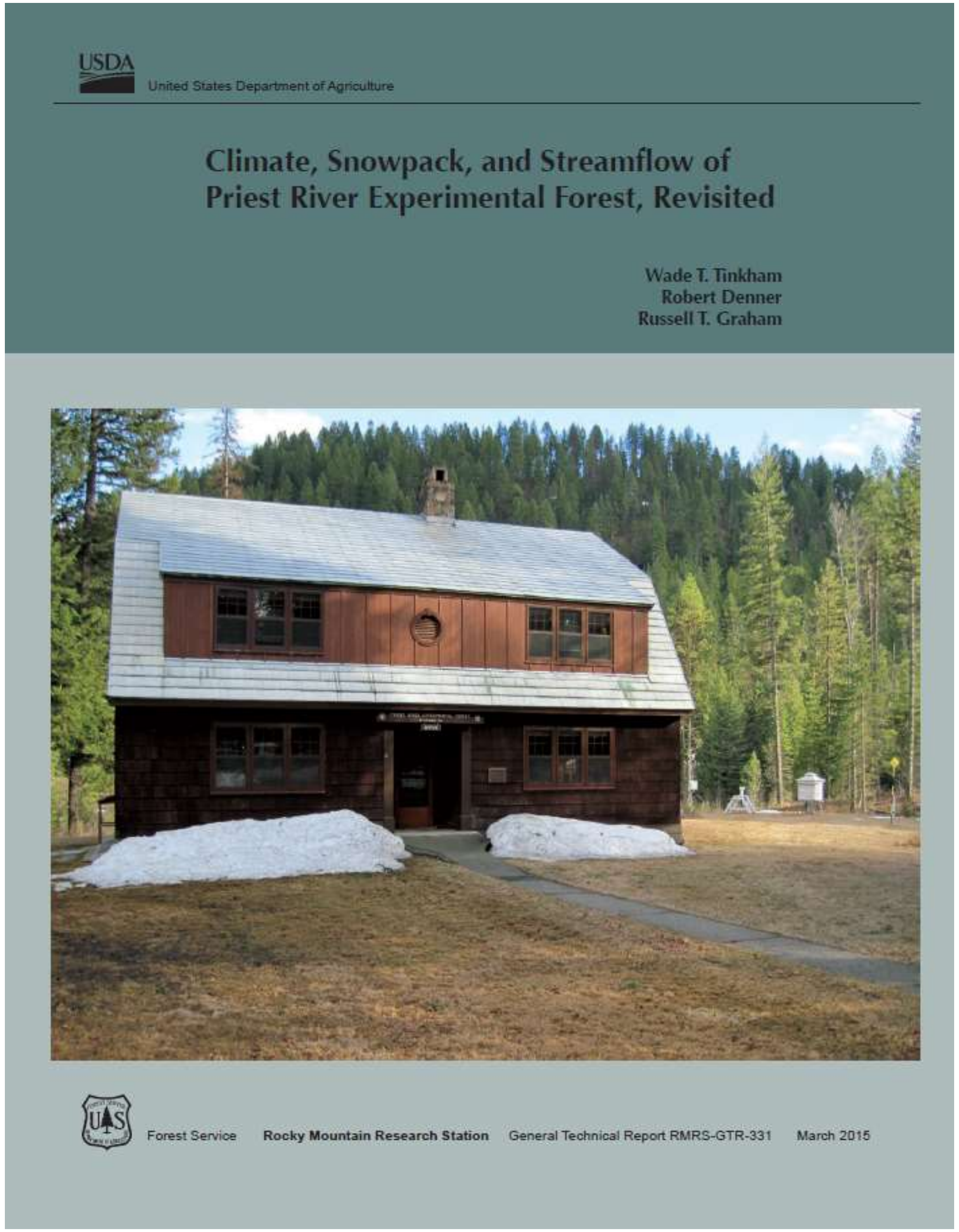
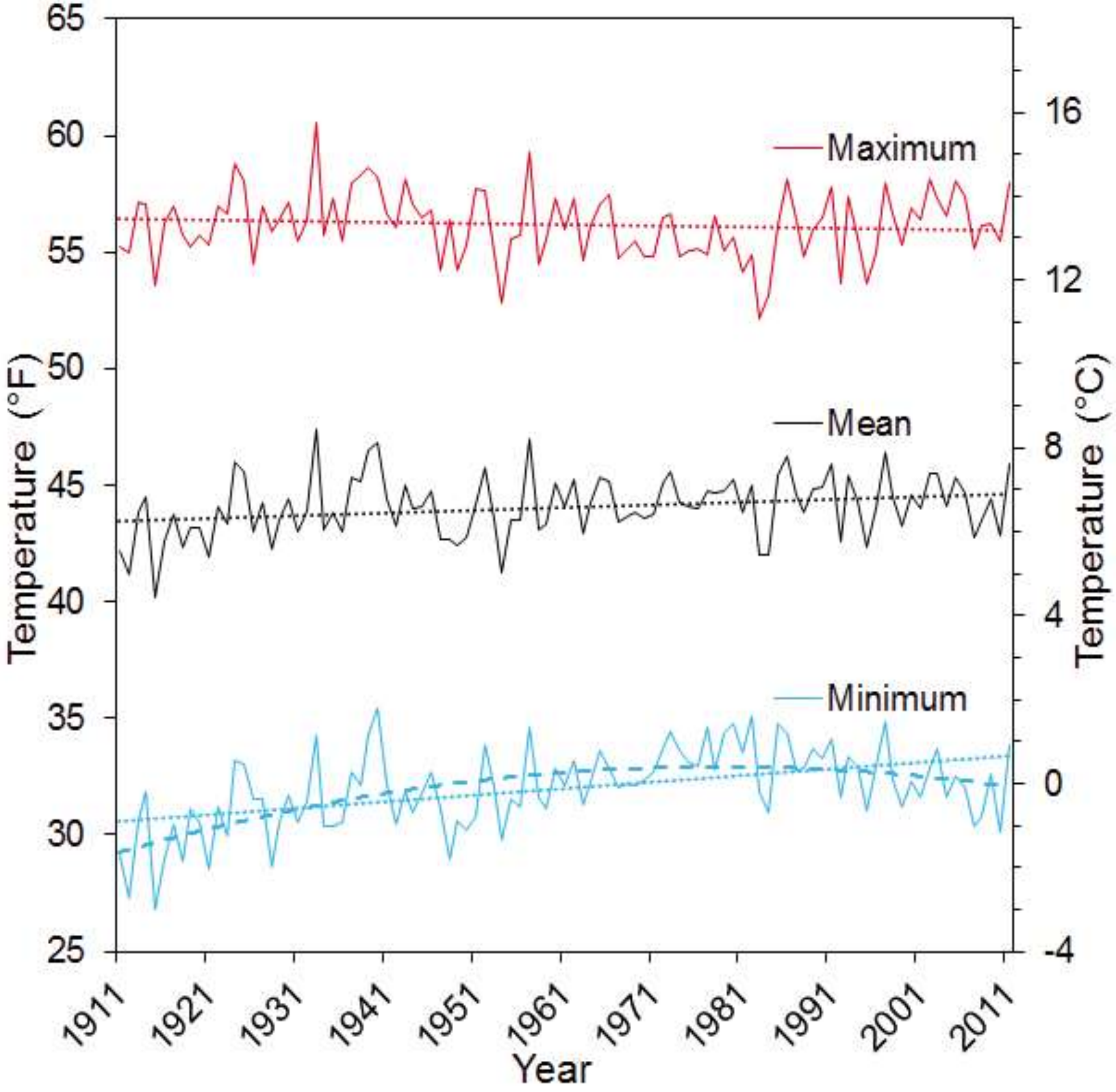
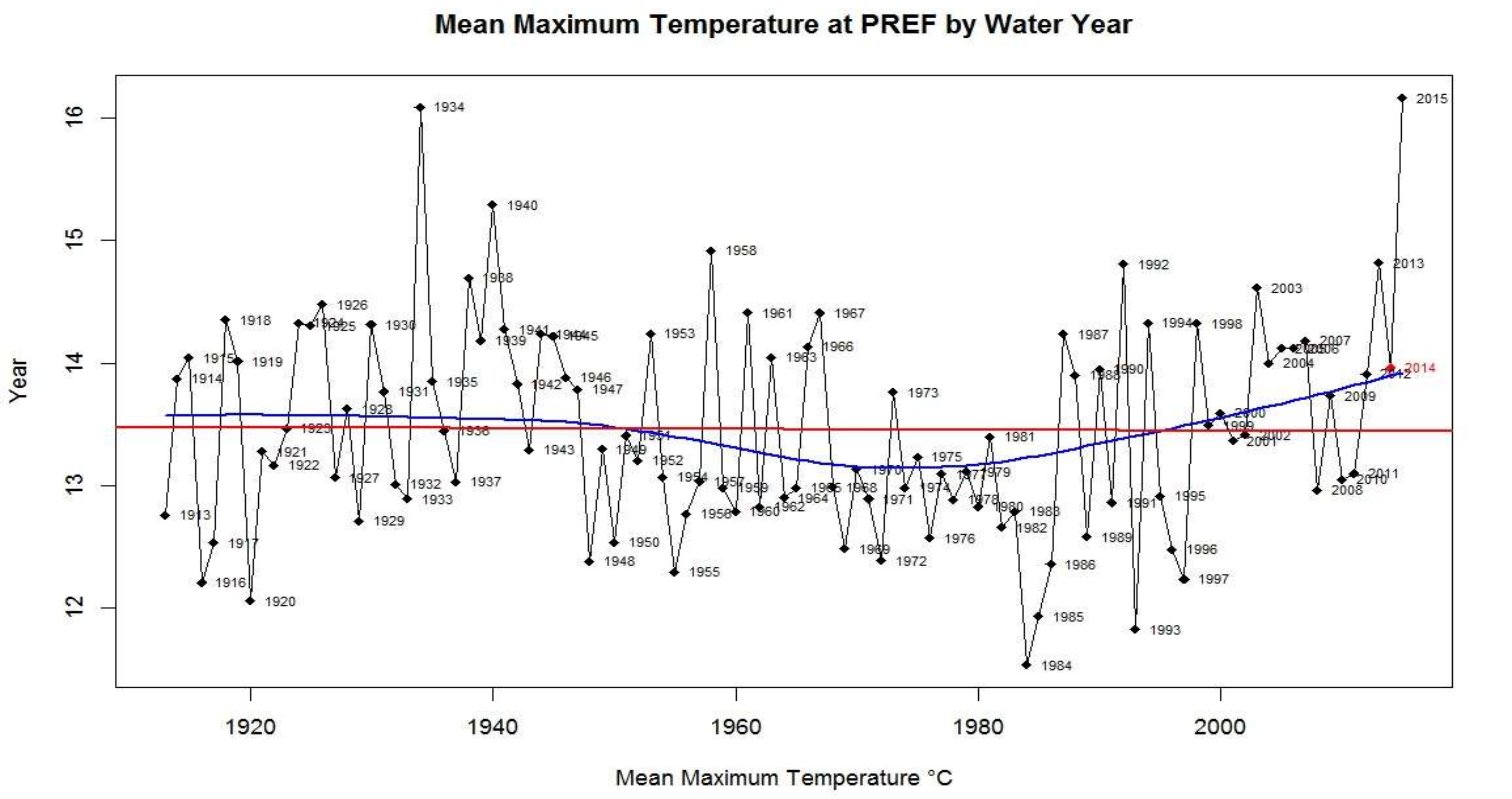
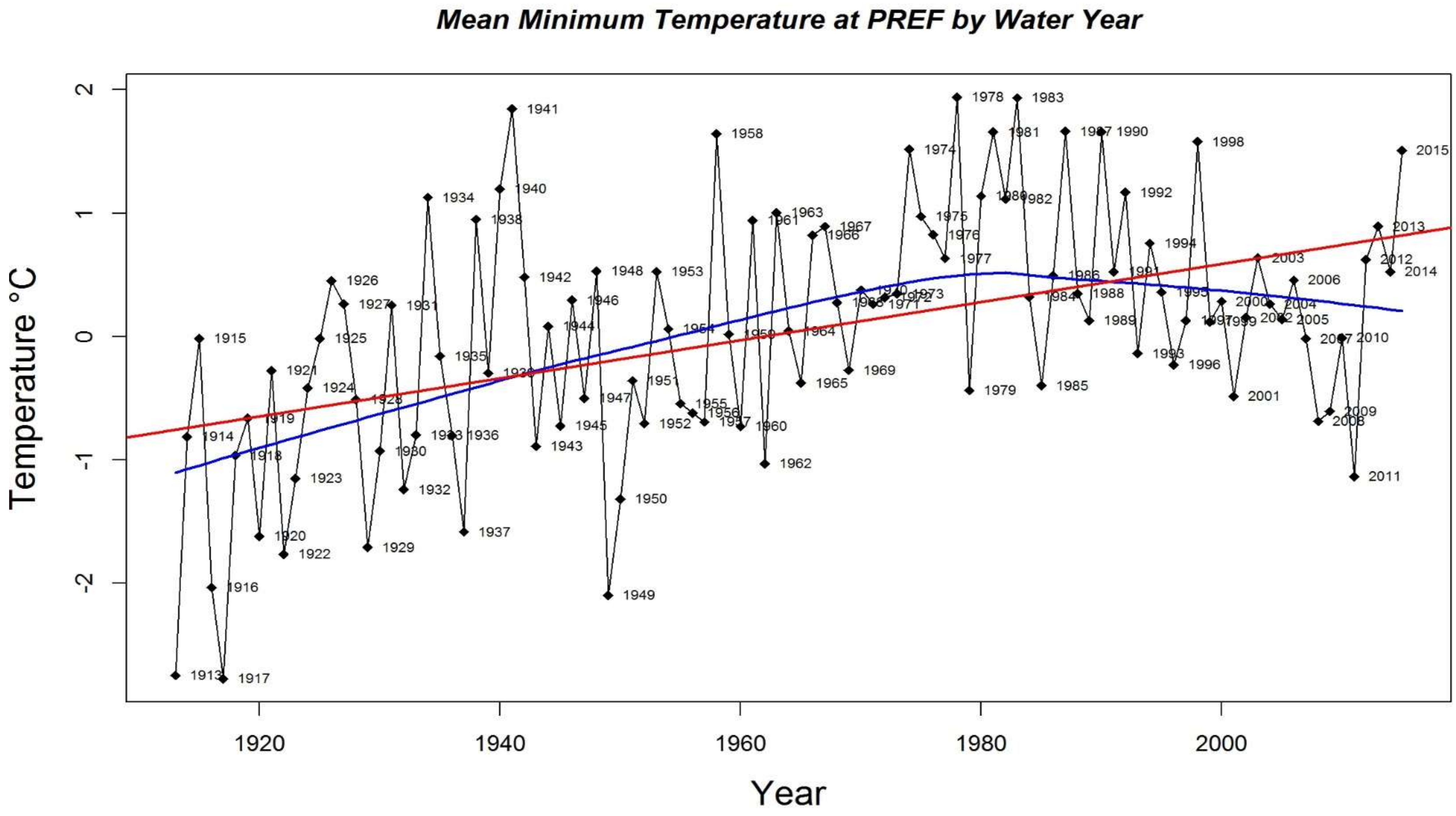


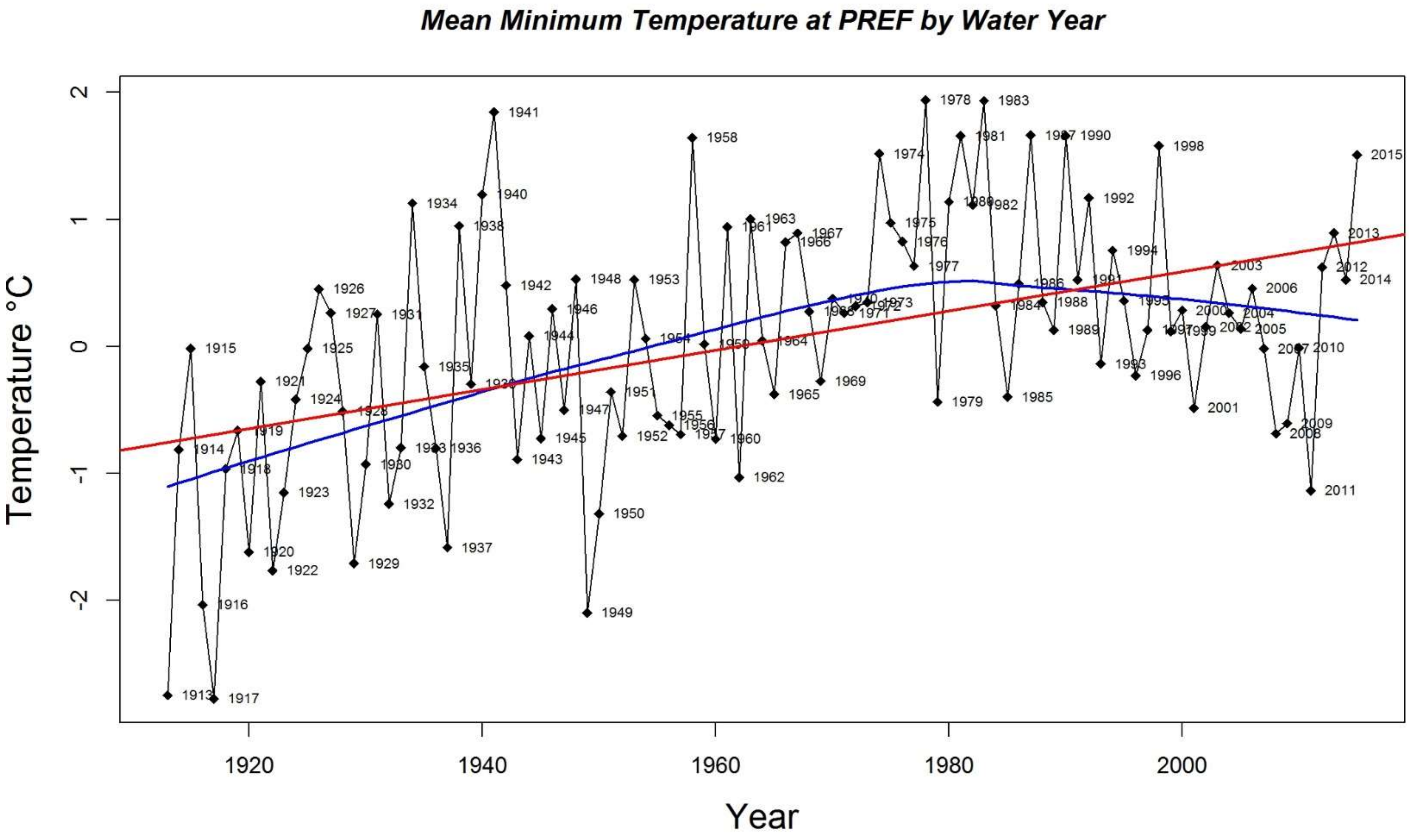

USDA
United States Department of Agriculture
Climate, Snowpack, and Streamflow of
Priest River Experimental Forest, Revisited
Wade T. Tinkham
Robert Denner
Russell T. Graham
Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-331
March 2015


Maximum
Mean
Minimum
Temperature (°F)
Temperature (°C)
Year
65
60
55
50
45
40
35
30
25
16
12
8
4
0
-4
1911
1921
1931
1941
1951
1961
1971
1981
1991
2001
2011



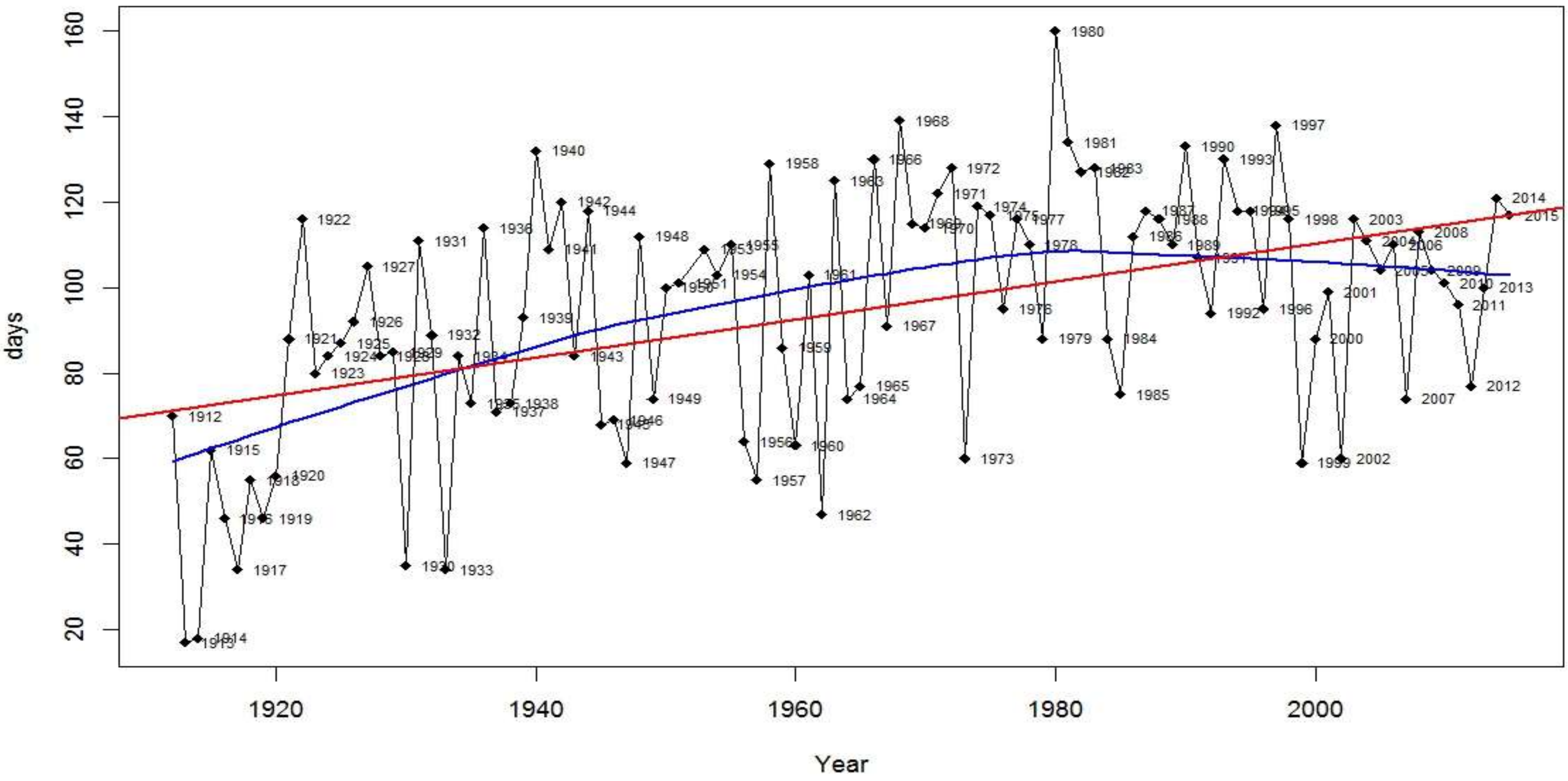
Mean Maximum Temperature at PREF by Water Year
Year
12
13
14
15
16
1920
1940
1960
1980
2000
Mean Maximum Temperature °C

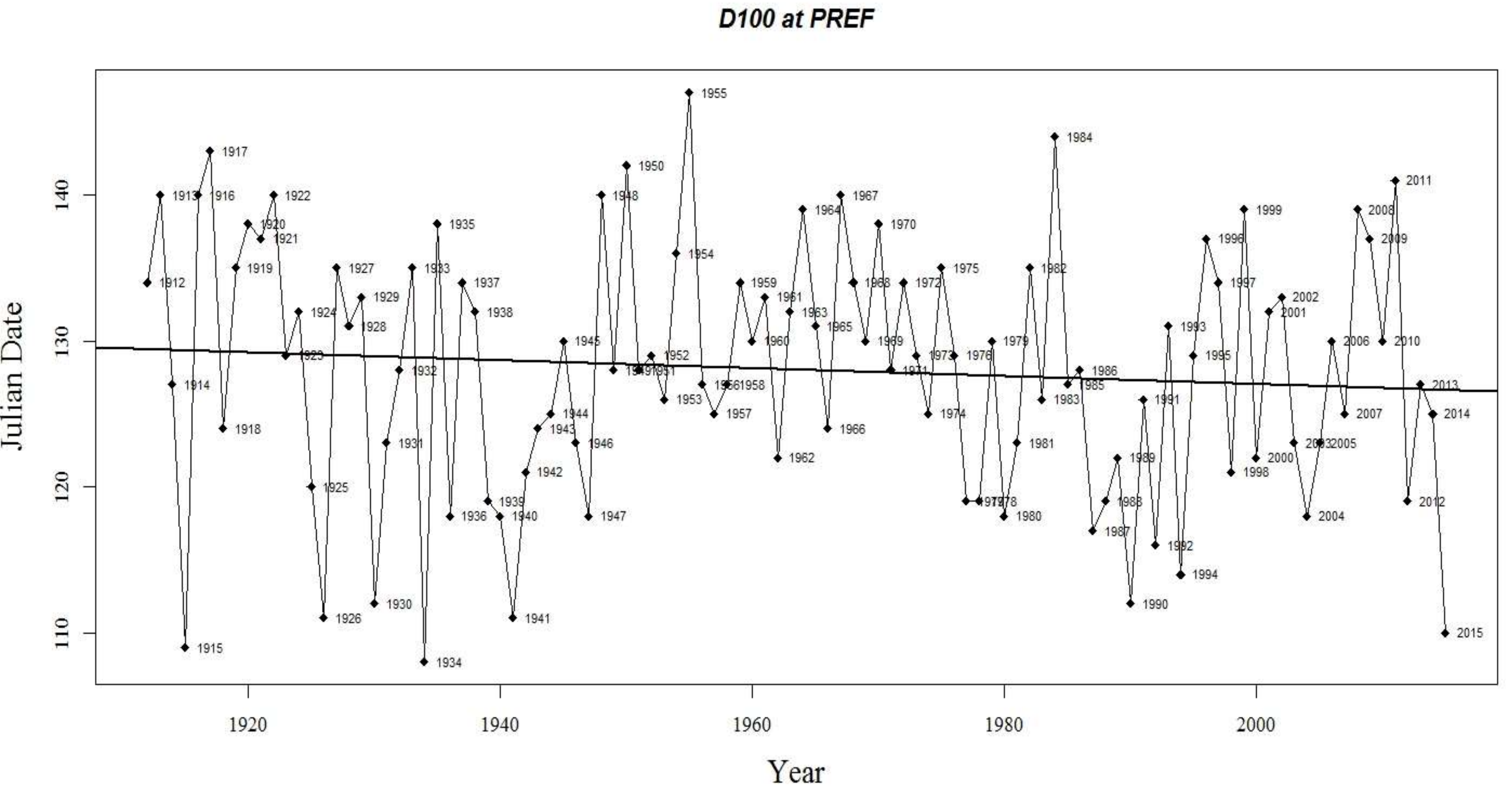

Mean Minimum Temperature at PREF by Water Year
Temperature °C
Year
2
1
0
-1
-2
1920
1940
1960
1980
2000

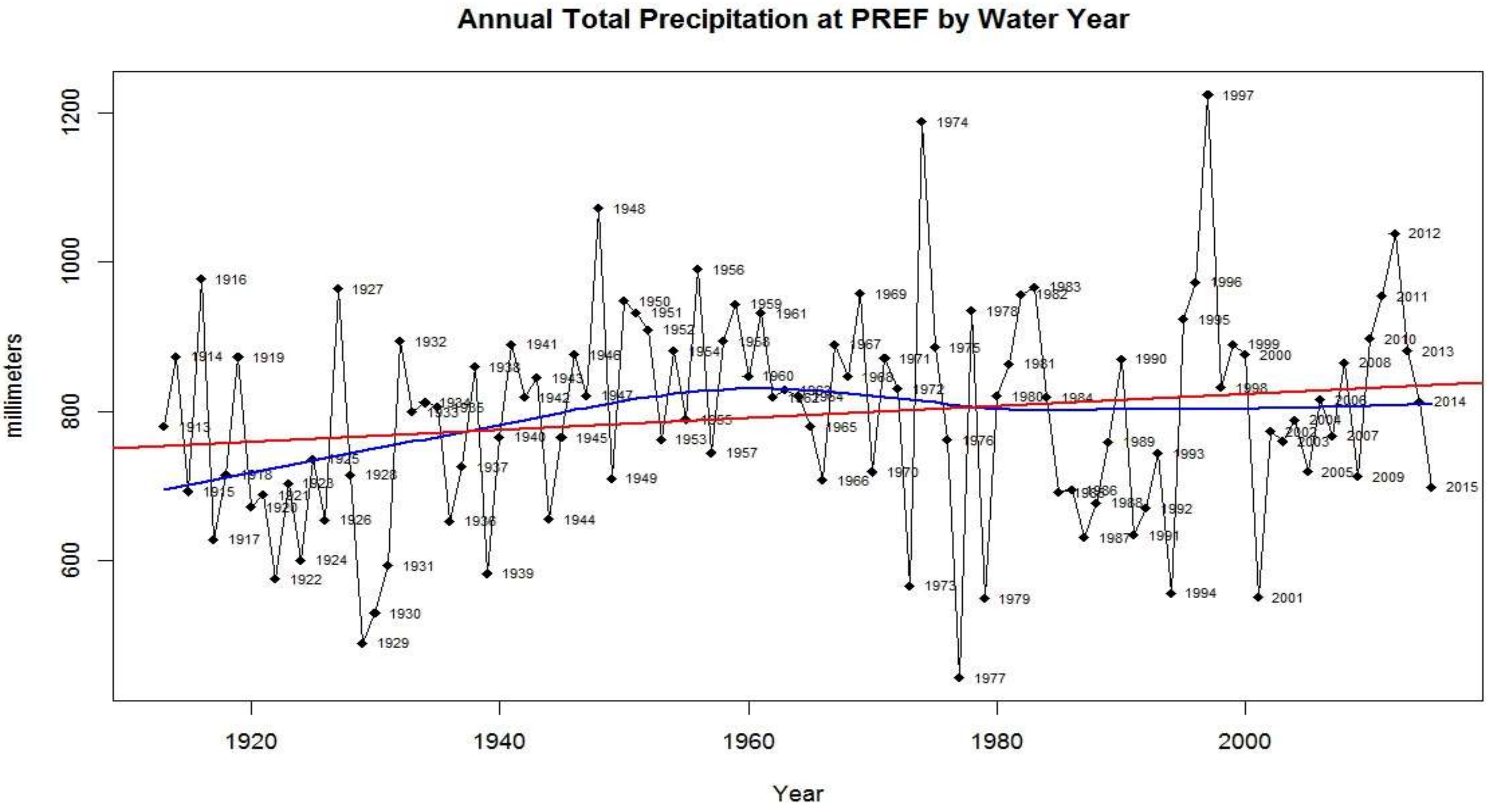
Mean Minimum Temperature at PREF by Water Year
Temperature °C
Year

Frost Free Period at PREF





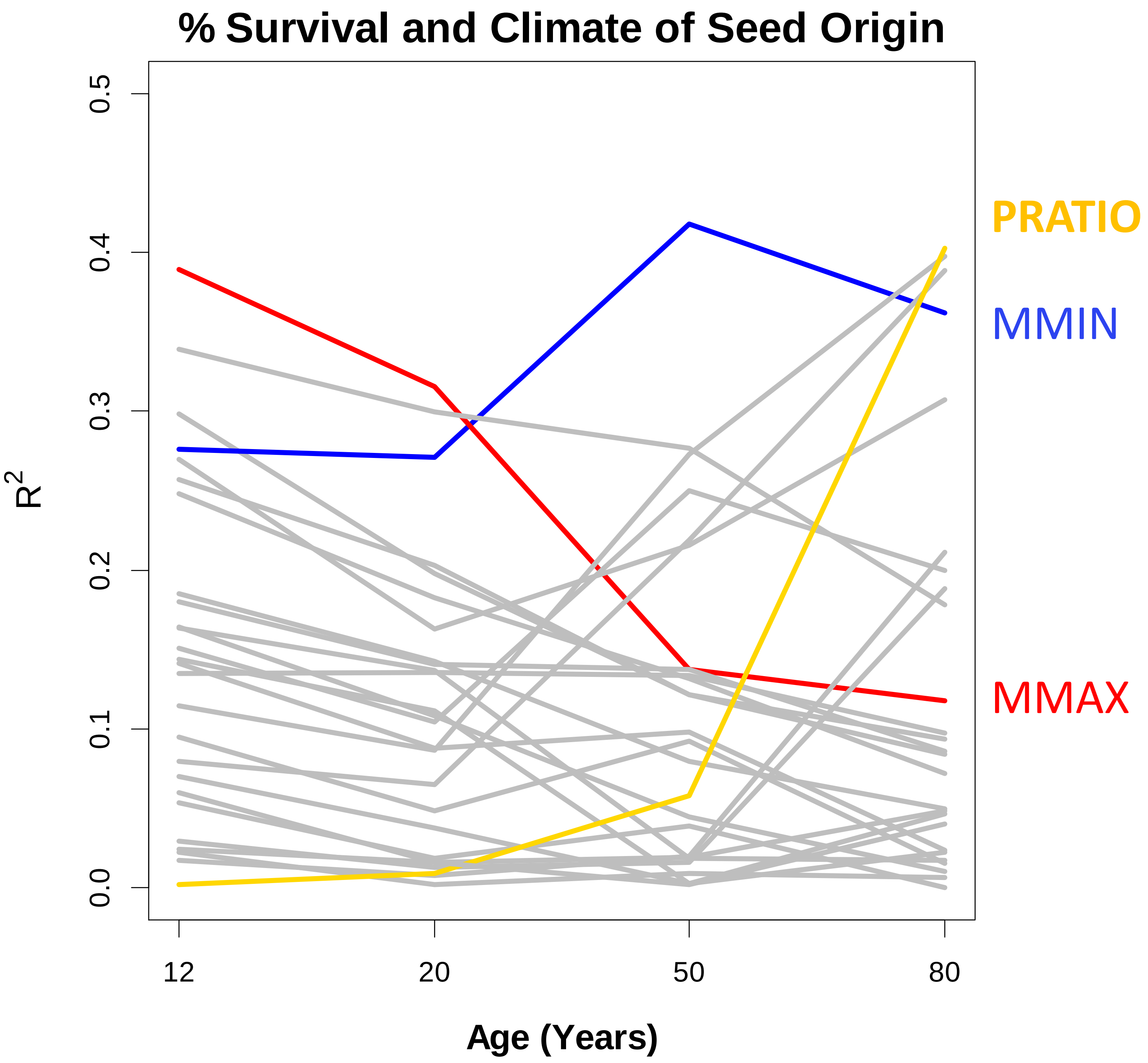
D100 at PREF
Julian Date
Year
110
120
130
140
1920
1940
1960
1980
2000



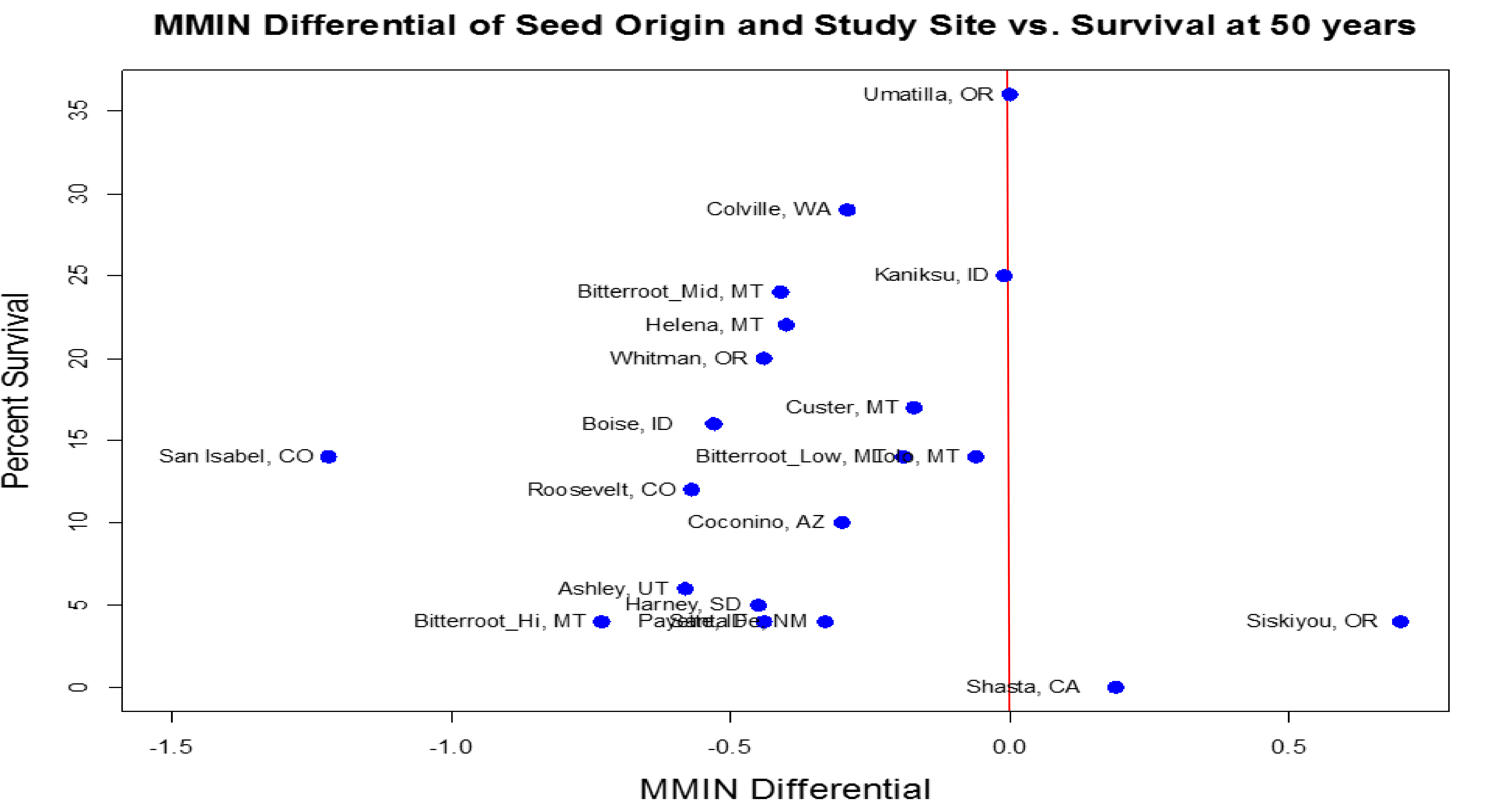
Annual Total Precipitation at PREF by Water Year
millimeters
Year

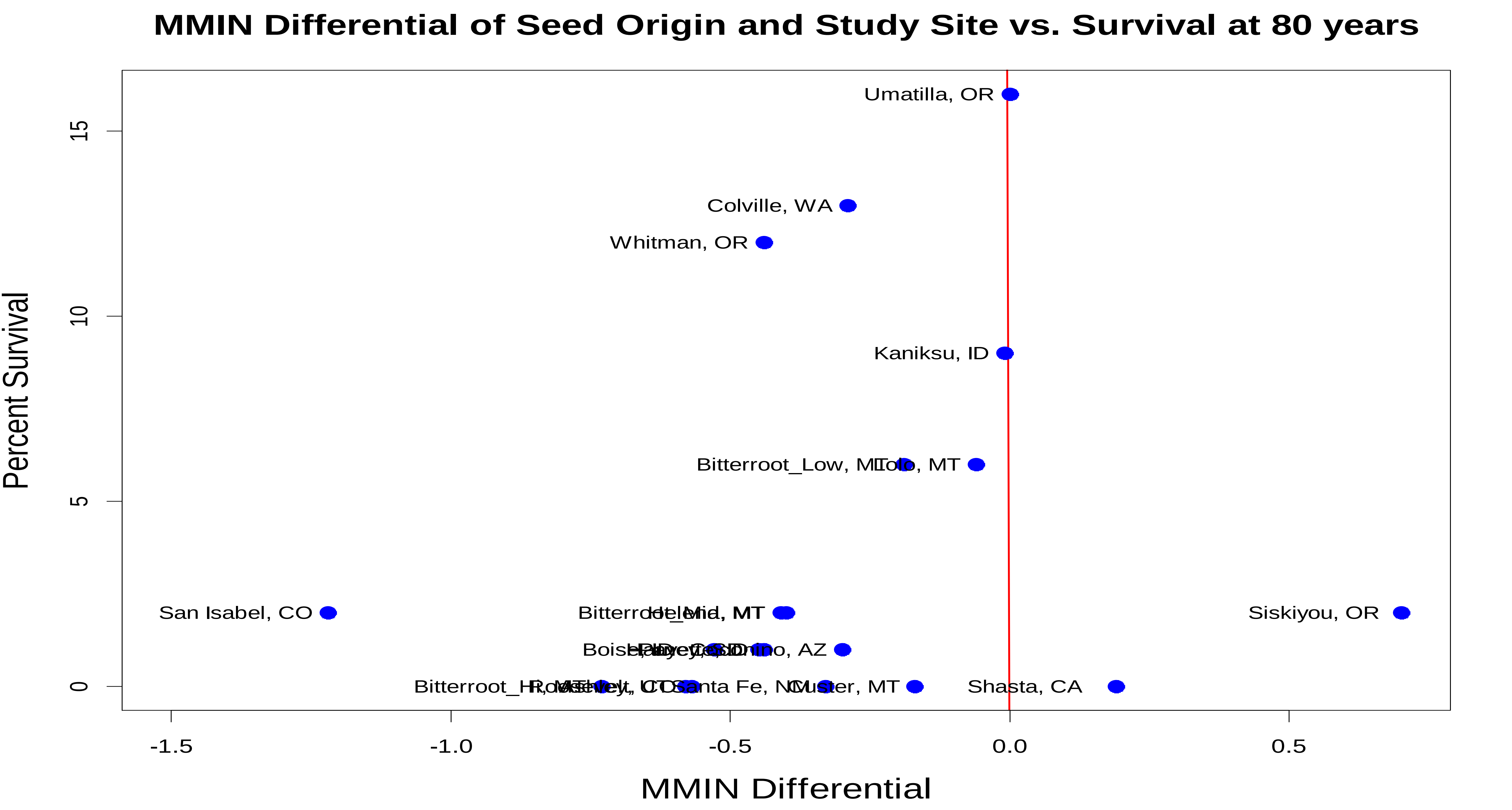
Annual Temperature	
Mean annual temperature	MAT
Temperature: Warmth	
Mean annual maximum temperature	MMAX
Mean temperature in the warmest month	MTWM
Degree-days > 5°C (based on mean monthly temperature)	DD5
Degree-days > 5°C accumulating within the frost-free period	GSDD5
Temperature: Coldness	
Mean annual minnumum temperature	MMIN
Mean temperature in the coldest month	MTCM
Degree-days < 0°C (based on mean monthly temperature)	DD0
Degree-days < 0°C (based on mean minimum monthly temperature)	MMINDD0
Seasonal Temperature: Balance and Timing	
Temperature differential between mean warmest and coldest months	TDIFF
Julian date the sum of degree-days > 5°C reaches 100	D100
Julian date of the last freezing date of spring	SDAY
Julian date of the first freezing date of autumn	FDAY
Length of the frost-free period (days)	FFP
Timing of Annual Precipitation	
Mean annual precipitation	MAP
Growing season precipitation, April to September	GSP
Spring precipitation: (April+May)	SPRP
Summer precipitation: (July+August)	SMRP
Winter precipitation: (November+December+January +Febuary)	WINP
Precipitation: Sesonal Balance	
Ratio of growing season precipitatioin to total precipitation, gsp/map	PRATIO
Interaction of Temperature and Precipitation	
Annual dryness index, dd5/map	ADI
Summer dryness index, gsdd5/gsp	SDI
Adi*mmindd0	ADIMMINDD0
Summer dryness index, gsdd5/gsp	SDIMMINDD0

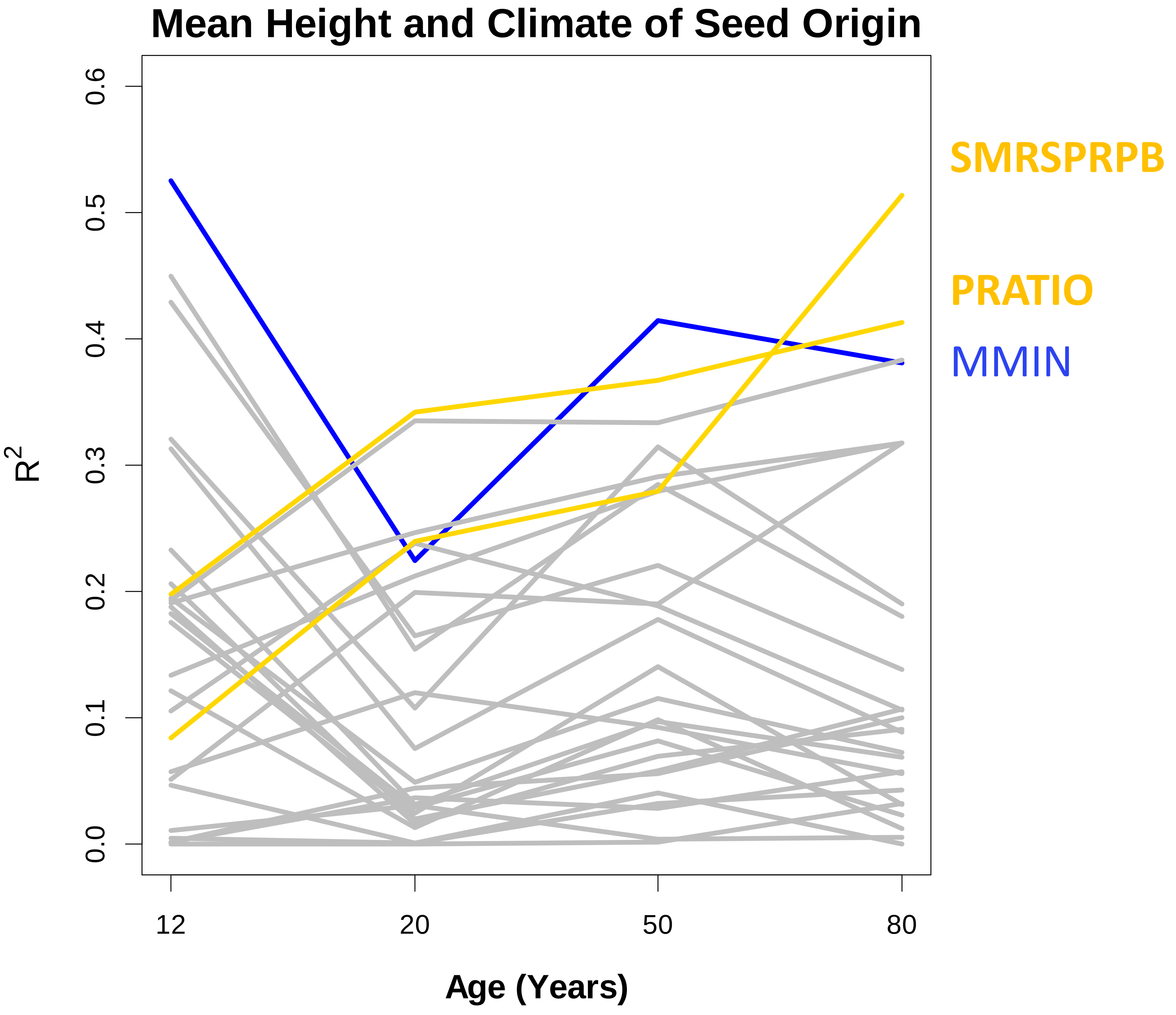
- 26 Derived climate variables



Preliminary Analysis

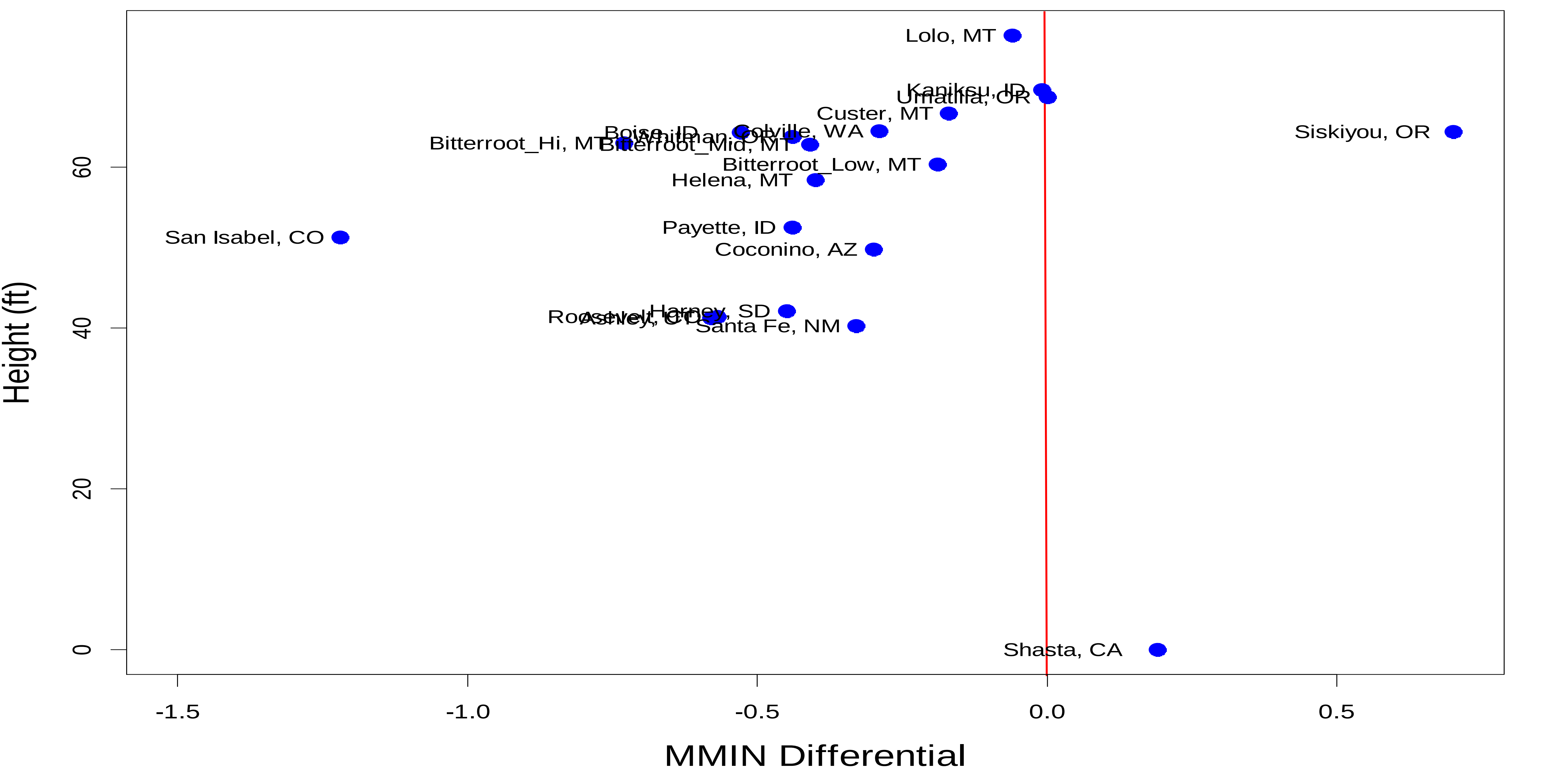

MMIN Differential of Seed Origin and Study Site vs. Survival at 50 years
Percent Survival
MMIN Differential
0
5
10
15
20
25
30
35
-1.5
-1.0
-0.5
0.0
0.5
Umatilla, OR
Colville, WA
Kaniksu, ID
Bitterroot_Mid, MT
Helena, MT
Whitman, OR
Custer, MT
Boise, ID
San Isabel, CO
Roosevelt, CO
Coconino, AZ
Ashley, UT
Harney, SD
Bitterroot_Hi, MT
Siskiyou, OR
Shasta, CA


MMIN Differential of Seed Origin and Study Site vs. Survival at 80 years
Percent Survival
MMIN Differential
0
5
10
15
-1.5
-1.0
-0.5
0.0
0.5
Umatilla, OR
Colville, WA
Whitman, OR
Kaniksu, ID
Lolo, MT
San Isabel, CO
Siskiyou, OR
Custer, MT
Shasta, CA

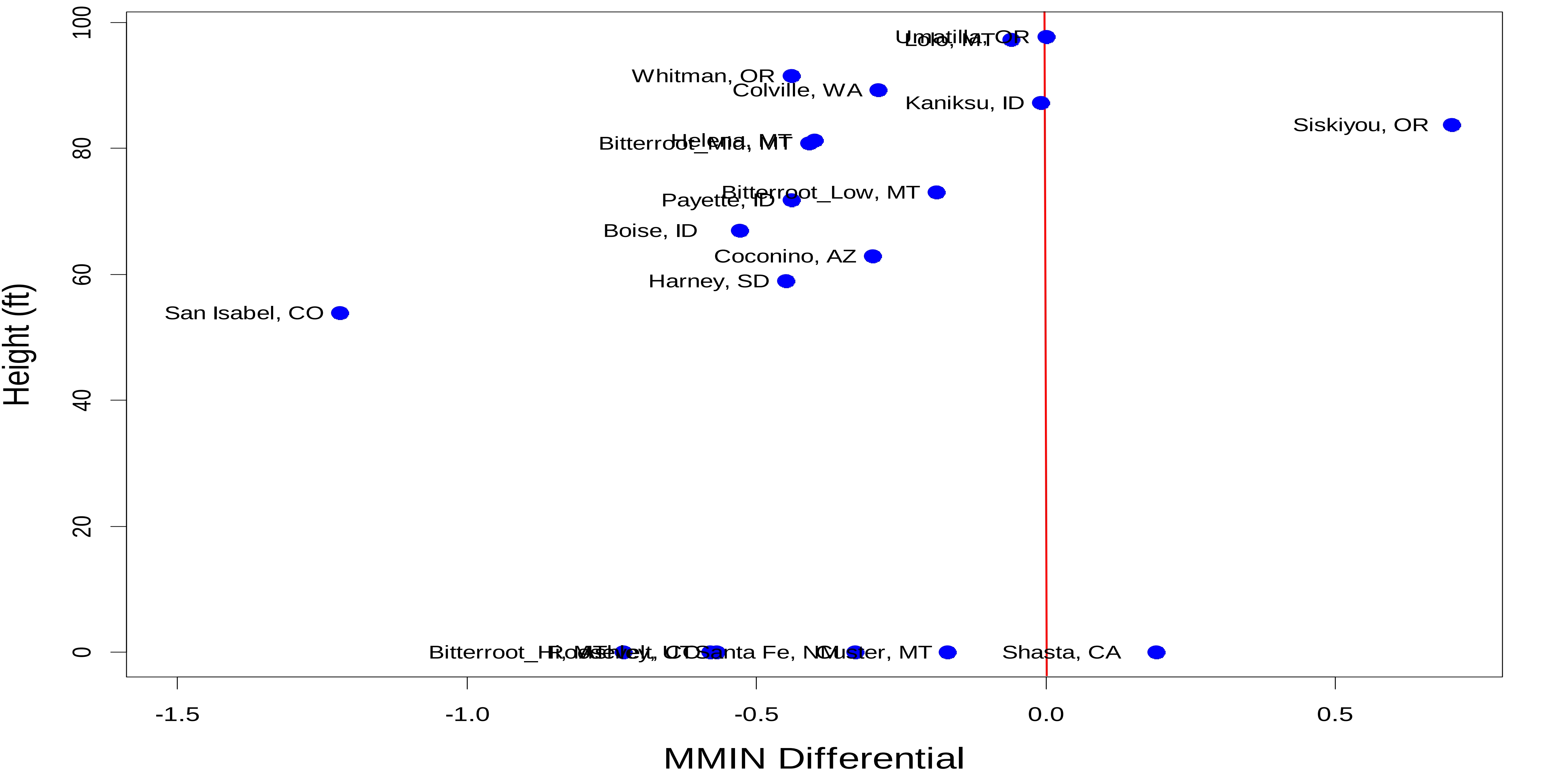


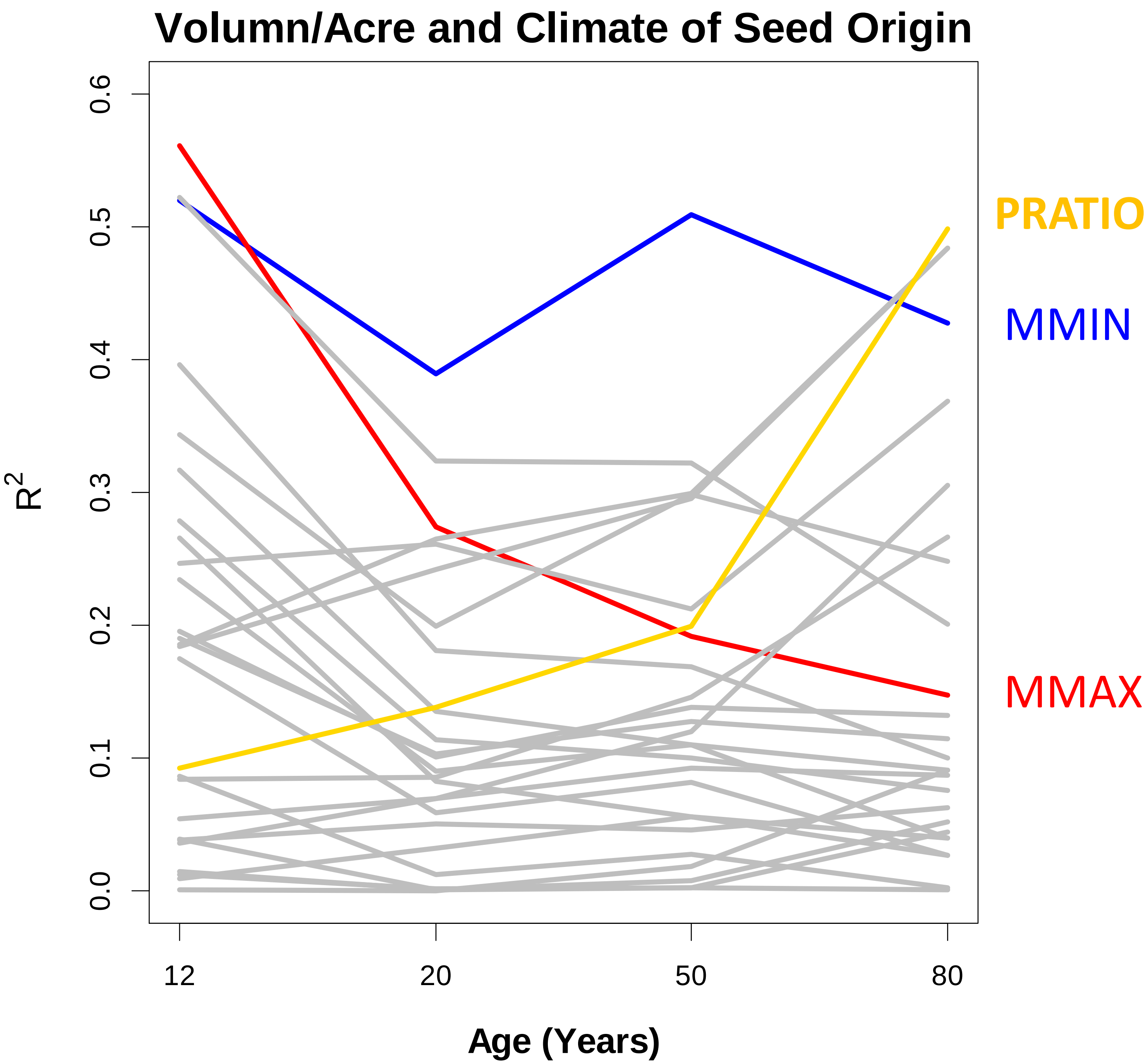
Mean Height and Climate of Seed Origin
SMRSPRPB
PRATIO
MMIN
R^2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
12
20
50
80
Age (Years)

MMIN Differential of Seed Origin and Study Site vs. Height at 50 years

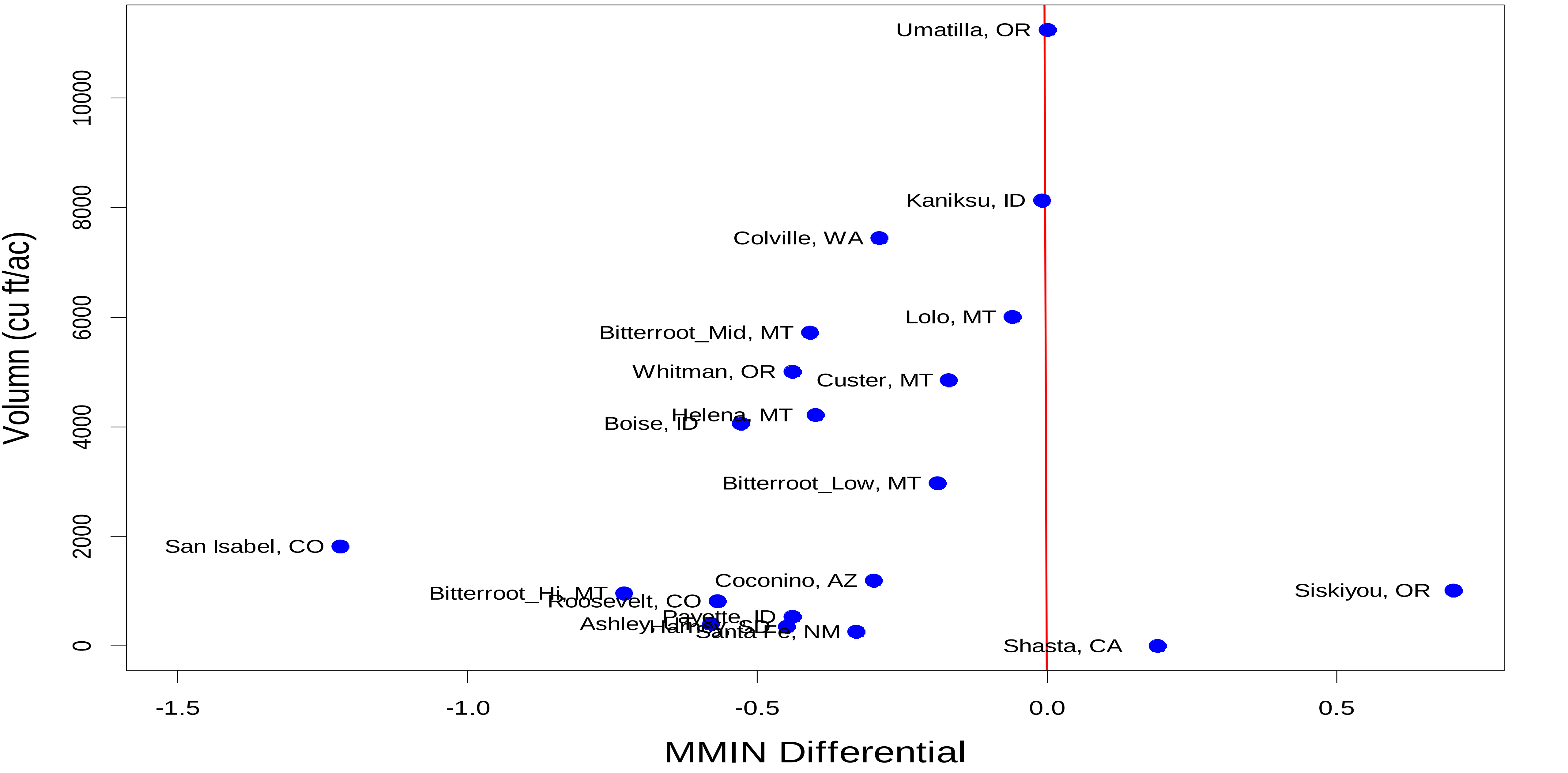


MMIN Differential of Seed Origin and Study Site vs. Height at 80 years

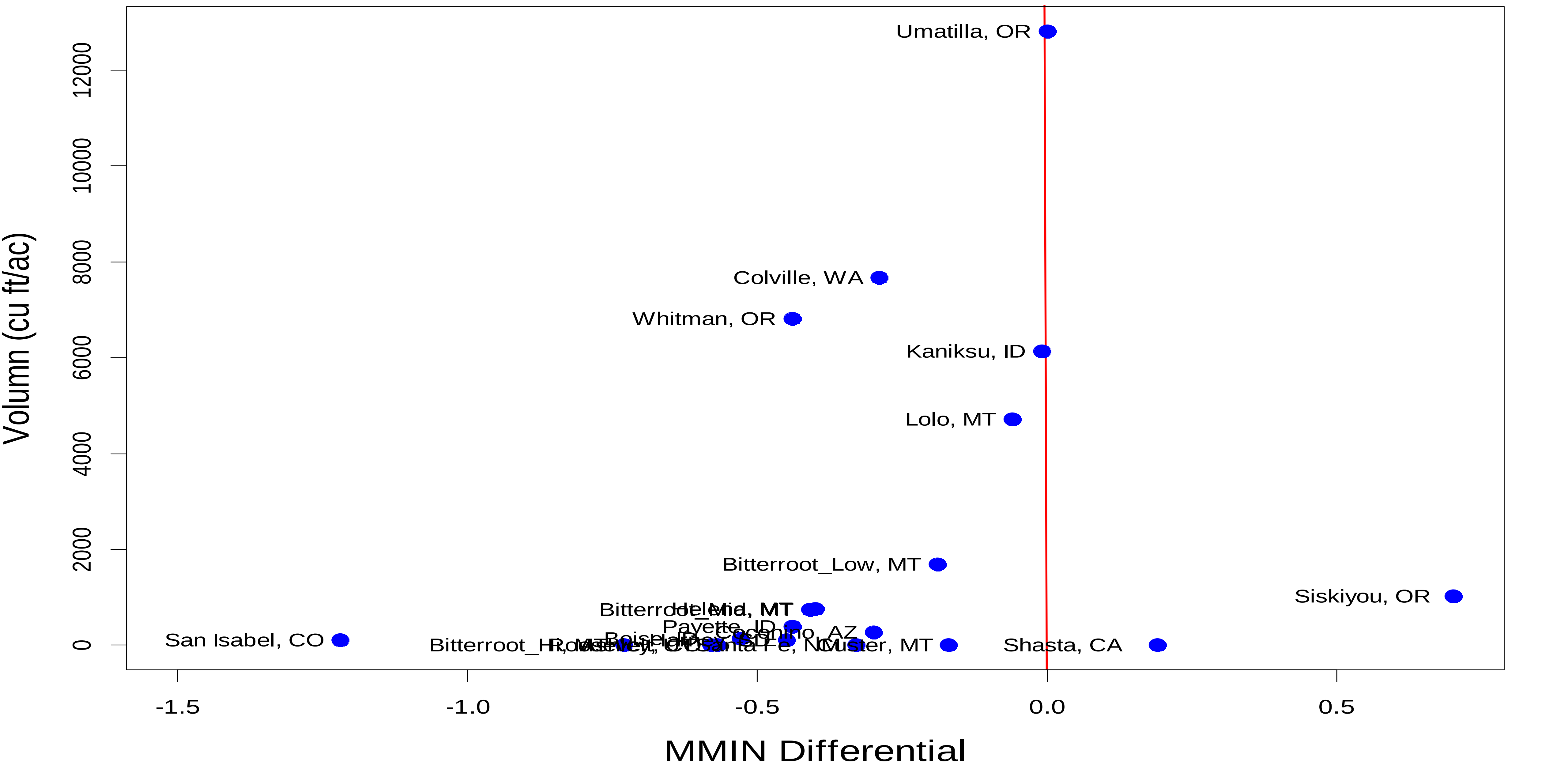



Volumn/Acre and Climate of Seed Origin
0.0
0.1
0.2
0.3
0.4
0.5
0.6
R2
12
20
50
80
Age (Years)
PRATIO
MMIN
MMAX

MMIN Differential of Seed Origin and Study Site vs. Volumn at 50 years



MMIN Differential of Seed Origin and Study Site vs. Volumn at 80 years



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journal homepage: www.elsevier.com/locate/foreco

ELSEVIER

Comparative genetic responses to climate in the varieties of *Pinus ponderosa* and *Pseudotsuga menziesii*: Clines in growth potential

CrossMark

Gerald E. Rehfeldt [a,*], Laura P. Leites [b], J. Bradley St Clair [c], Barry C. Jaquish [d], Cuauhtémoc Sáenz-Romero [e], Javier López-Upton [f], Dennis G. Joyce [g]

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[f] Colegio de Postgraduados, Km 35.5 Carretera México-Texcoco, Montecillo, México C.P. 56230, Mexico
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ABSTRACT

Height growth data were assembled from 10 *Pinus ponderosa* and 17 *Pseudotsuga menziesii* provenance tests. Data from the disparate studies were scaled according to climate similarities of the provenances to provide single datasets for 781 *P. ponderosa* and 1193 *P. menziesii* populations. Mixed effects models were used for two sub-specific varieties of each species to describe clines in growth potential associated with provenance climate while accounting for study effects not eliminated by scaling. Variables related to winter temperatures controlled genetic variation within the varieties of both species. Clines were converted to climatypes by classifying genetic variation, using variation within provenances in relation to the slope of the cline to determine climatype breadth. Climatypes were broader in varieties of *P. ponderosa* than in *P. menziesii* and were broader for varieties inhabiting coastal regions of both species than for varieties from interior regions. Projected impacts of climate change on adaptedness used output from an ensemble of 17 general circulation models. Impacts were dependent on cline steepness and climatype breadth but implied that maintaining adaptedness of populations to future climates will require a redistribution of genotypes across forested landscapes.

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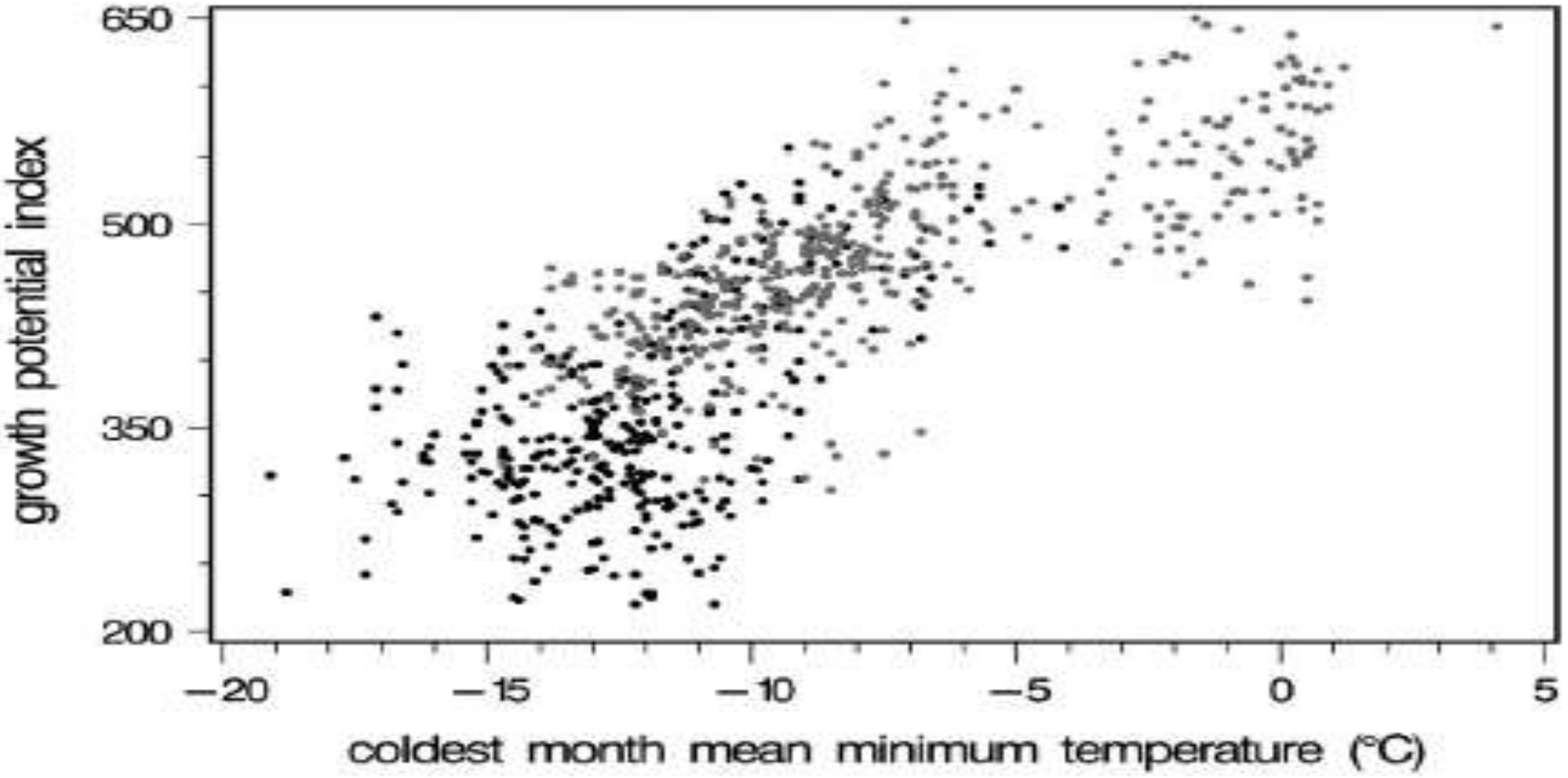
1. Introduction

From the earliest (e.g., Kempff, 1928; Munger and Morris, 1936) to more recent (Burdon and Low, 1991, St Clair et al., 2005), provenance tests have demonstrated extensive genetic differentiation among populations of *Pinus ponderosa* and *Pseudotsuga menziesii* ... et al., 1967). Subsequent tests, addressing regional genetic effects within varieties, repeatedly illustrated genetic differences among populations for traits controlling growth, phenology, cold hardiness (e.g., Callaham and Liddicoet, 1961; Wells, 1964; Campbell, 1979) and tolerances to pests (e. g., Burdon and Low, 1991; Stephan, 1980; McDermott and Robinson, 1989). In this paper

- MMINNDDO
- 10 Studies
  - Age 3 -22 years old
  - 38 – 138 population



Rehfeldt et al. 2014

Key Points

- Climate maladaptation is expressed as decreased health and productivity.

- Cold hardiness should be considered when moving populations from warmer to colder contemporary climates.

- Species that are more finely attuned to climate variation (specialist) are at greater risk of maladaptation under changing climate

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Rehfeldt, Leites, Joyce, Weiskittle - Unpublished

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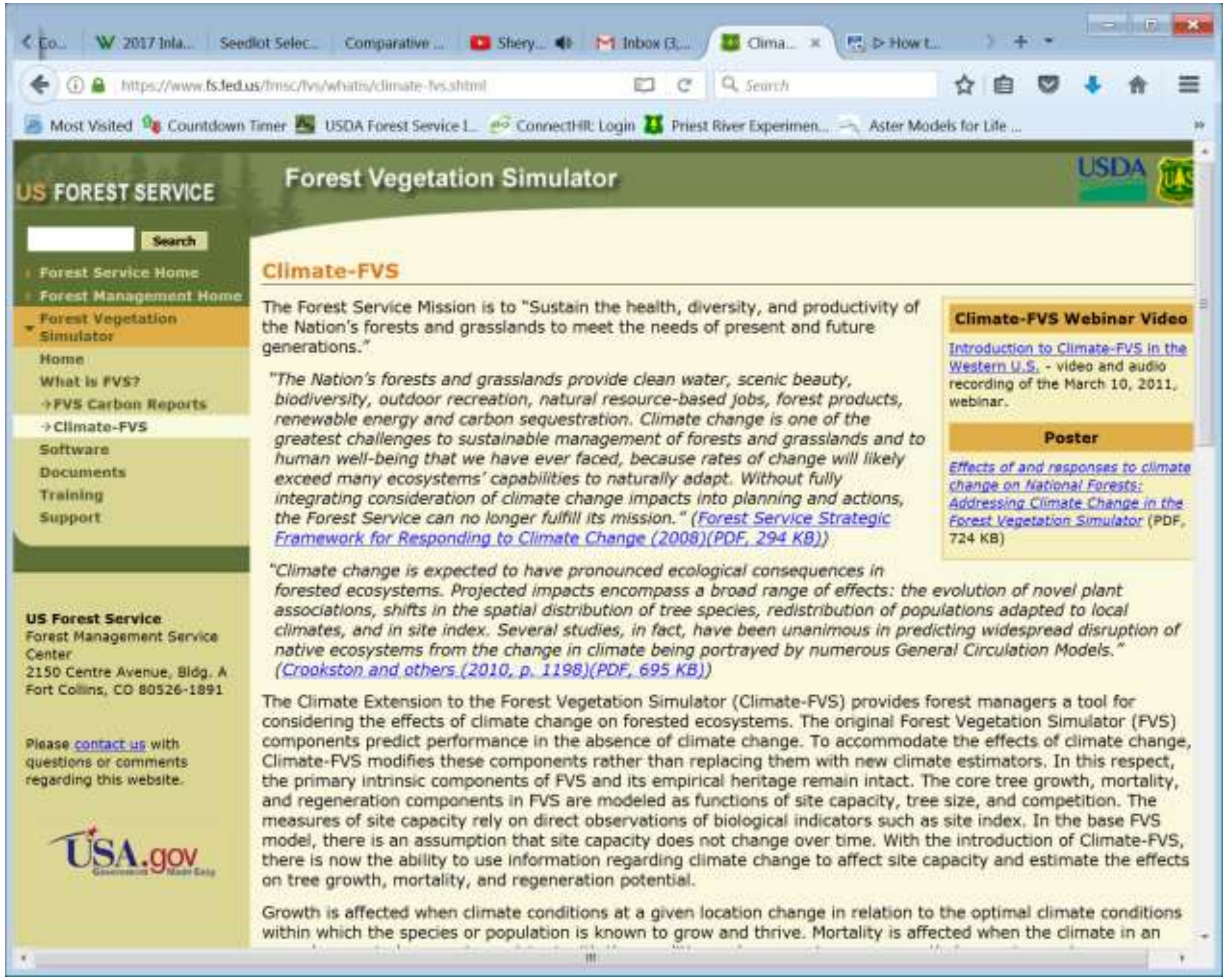
Reforestation Management Recommendations Under Changing Climate

- **Consider** conservation of genetic diversity in anticipation of impacts of changing climate
- **Consider** matching species and seed sources with expected future climates.

http://charcoal.cnre.vt.edu/climate/

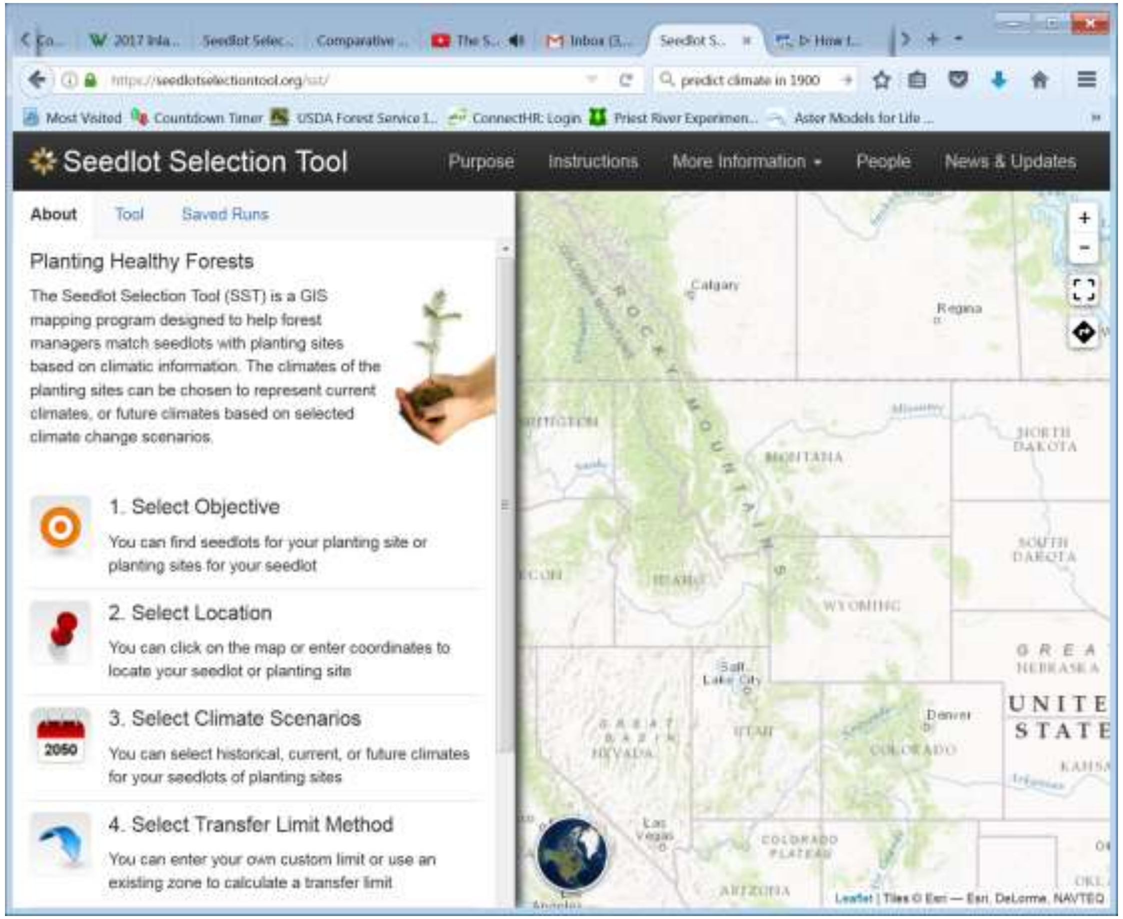
- Nicholas Crookston, USDA Forest Service Ret.

Climate FVS



- Nicholas Crookston, USDA Forest Service Ret.

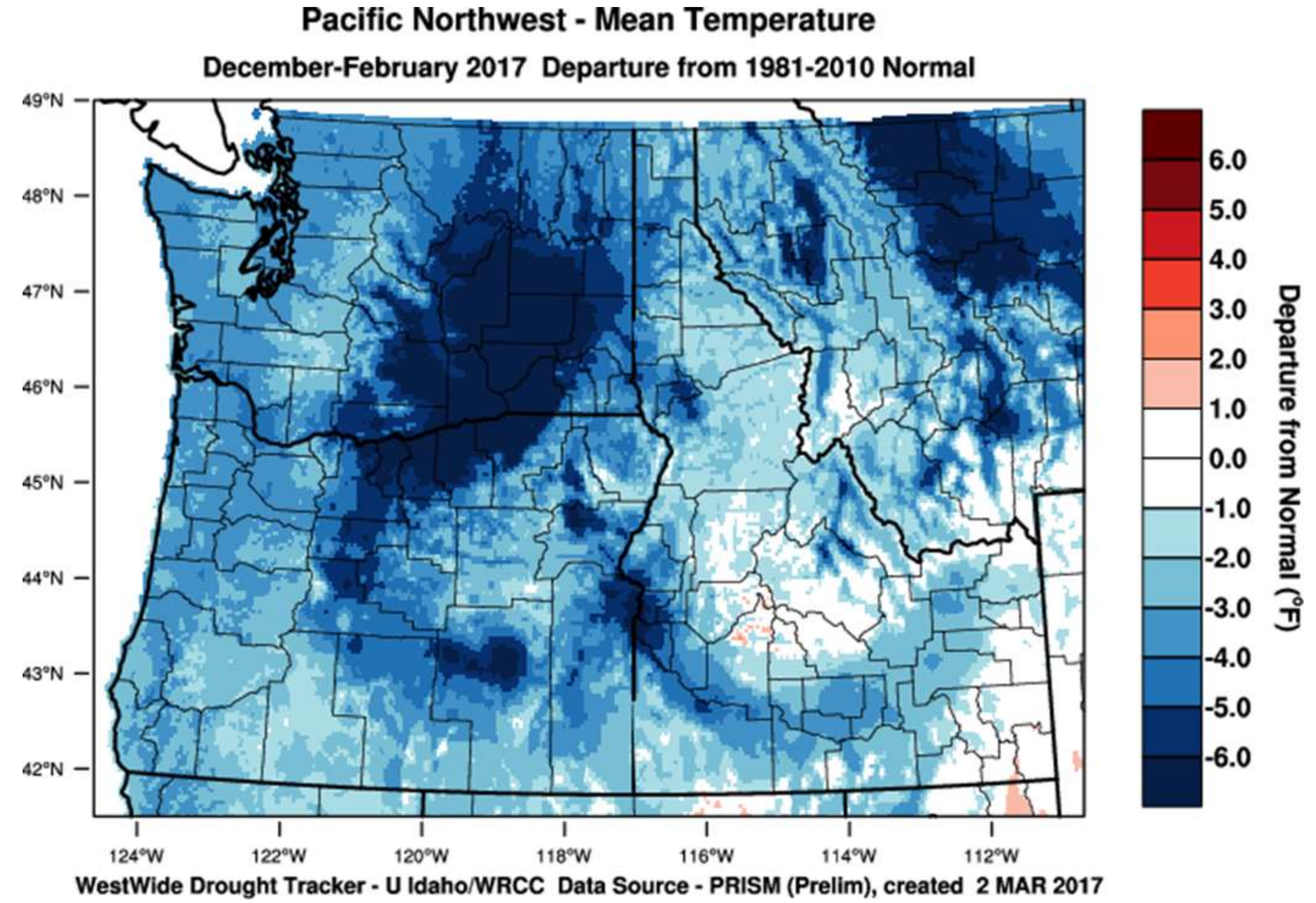
https://seedlotselectiontool.org



- Glenn Howe, Oregon State University
- Brad St.Clair, USDA Forest Service
- Dominique Bachelet, Conservation Biology Institute

http://www.torreyaguardians.org/assisted-migration.html

- Connie Barlow



See: https://climateinw.wordpress.com/2017/03/06/winter-wont-end/