A web-based tool for assessing post-fire reforestation potential across the western U.S.

Zack Holden – USFS Region 1
Allen Warren – U. Montana
Ellen Jungck – USFS Region 1
Marco Maneta – U.Montana
Solomon Dobrowski – U.Montana
Kim Taylor-Davis – U.Montana
Vince Archer – USFS Region 1
Shelagh Fox – USFS Region 1

NASA applied science funding (2018-2021)

Integrating Earth observations, ecohydrologic, and plant hydraulic models for forecasting recruitment failure in semi-arid forests: Decision support for adaptive forest management.

Team:

PI: Solomon Dobrowski, Associate Professor of Landscape Ecology, Department of Forest Management, The University of Montana

Co-I: Marco Maneta, Associate Professor of Ecohydrology, Department of Geosciences, The University of Montana

Co-I: Zachary Holden, Scientist, USDA Forest Service Region 1

Collaborator: Shelagh Fox, Regional Silviculturalist, USDA Forest Service Region 1

Collaborator: Vince Archer, Regional Soil Scientist, USDA Forest Service Region 1

Tools are needed for identifying/prioritizing planting opportunities

- **Region 1 ArcGIS reforestation tool:**

-Restricted to Region 1

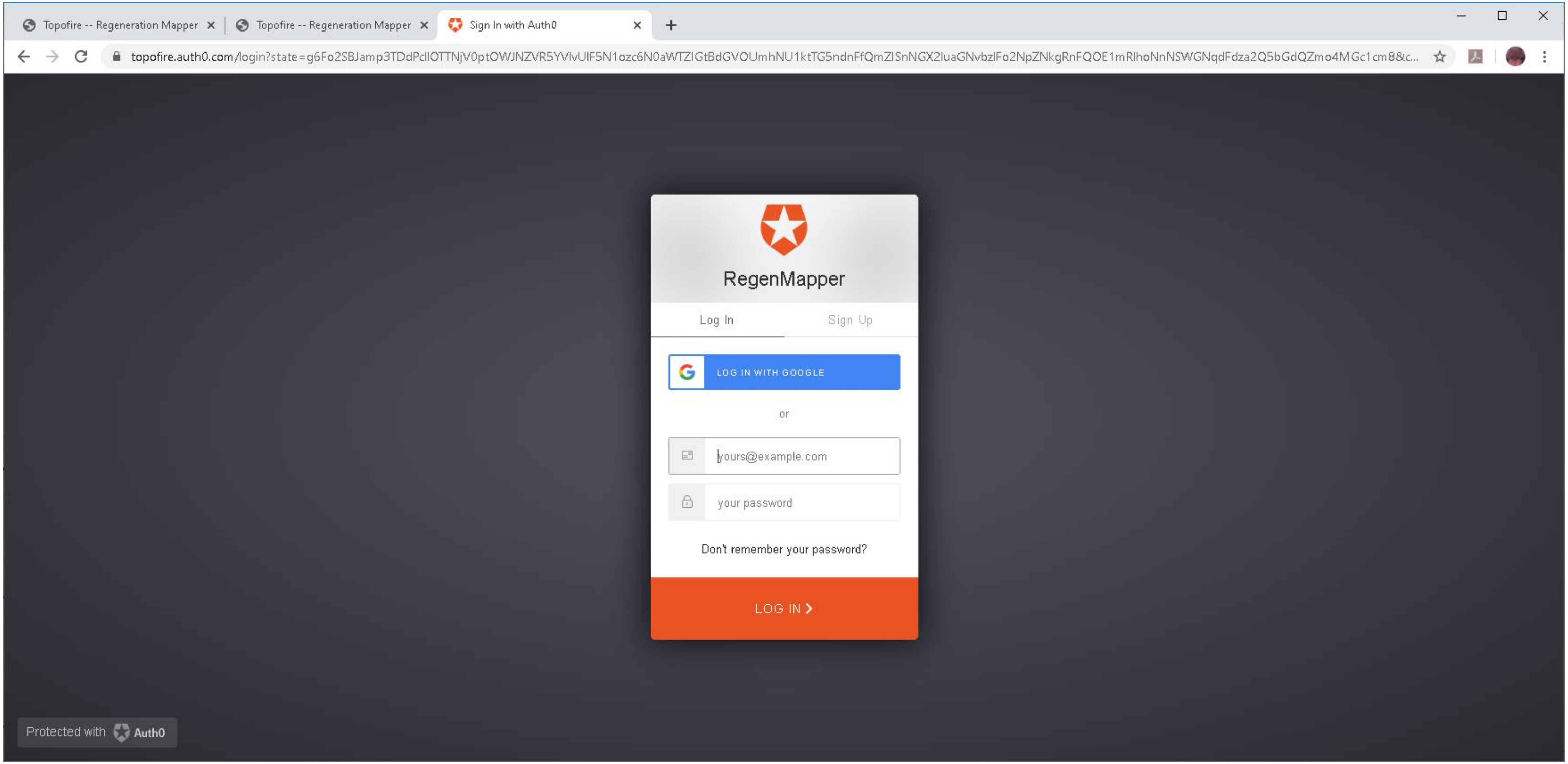
-Uses region-specific datasets

-Requires GIS specialist to run

-Not suitable for non-FS partner lands

-No quantitative estimate of regeneration potential

https://orthanc.dbs.umt.edu/regenmapper



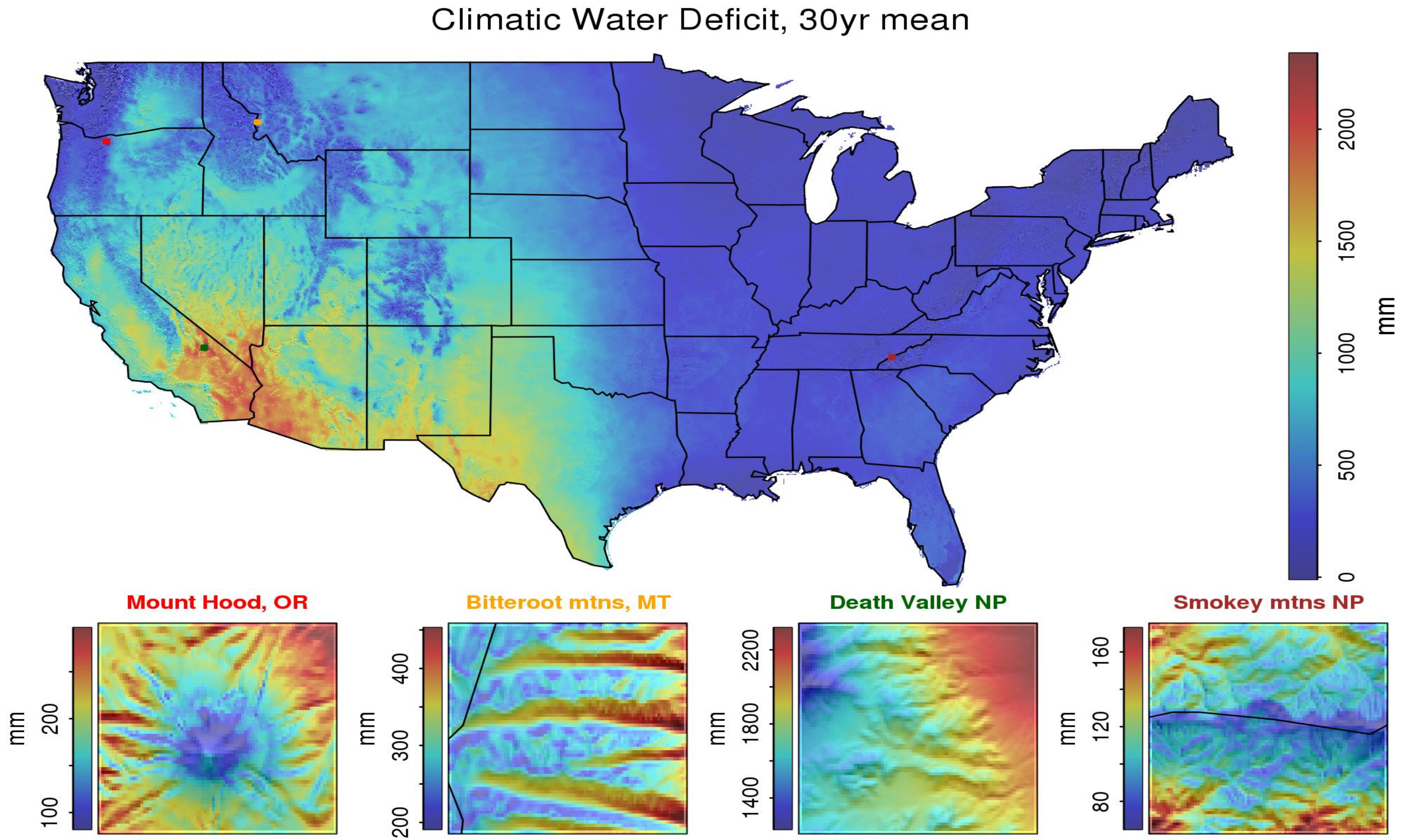
Wildfires and climate change push low-elevation forests across a critical climate threshold for tree regeneration

Kimberley T. Davis[a,1], Solomon Z. Dobrowski[b], Philip E. Higuera[a], Zachary A. Holden[c], Thomas T. Veblen[d], Monica T. Rother[d,e], Sean A. Parks[f], Anna Sala[g], and Marco P. Maneta[h]

[a]Department of Ecosystem and Conservation Sciences, University of Montana, Missoula, MT 59812; [b]Department of Forest Management, University of Montana, Missoula, MT 59812; [c]US Forest Service Region 1, Missoula, MT 59807; [d]Department of Geography, University of Colorado, Boulder, CO 80309; [e]Department of Environmental Sciences, University of North Carolina, Wilmington, NC 28403; [f]Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, US Forest Service, Missoula, MT 59801; [g]Division of Biological Sciences, University of Montana, Missoula, MT 59812; and [h]Department of Geosciences, University of Montana, Missoula, MT 59812

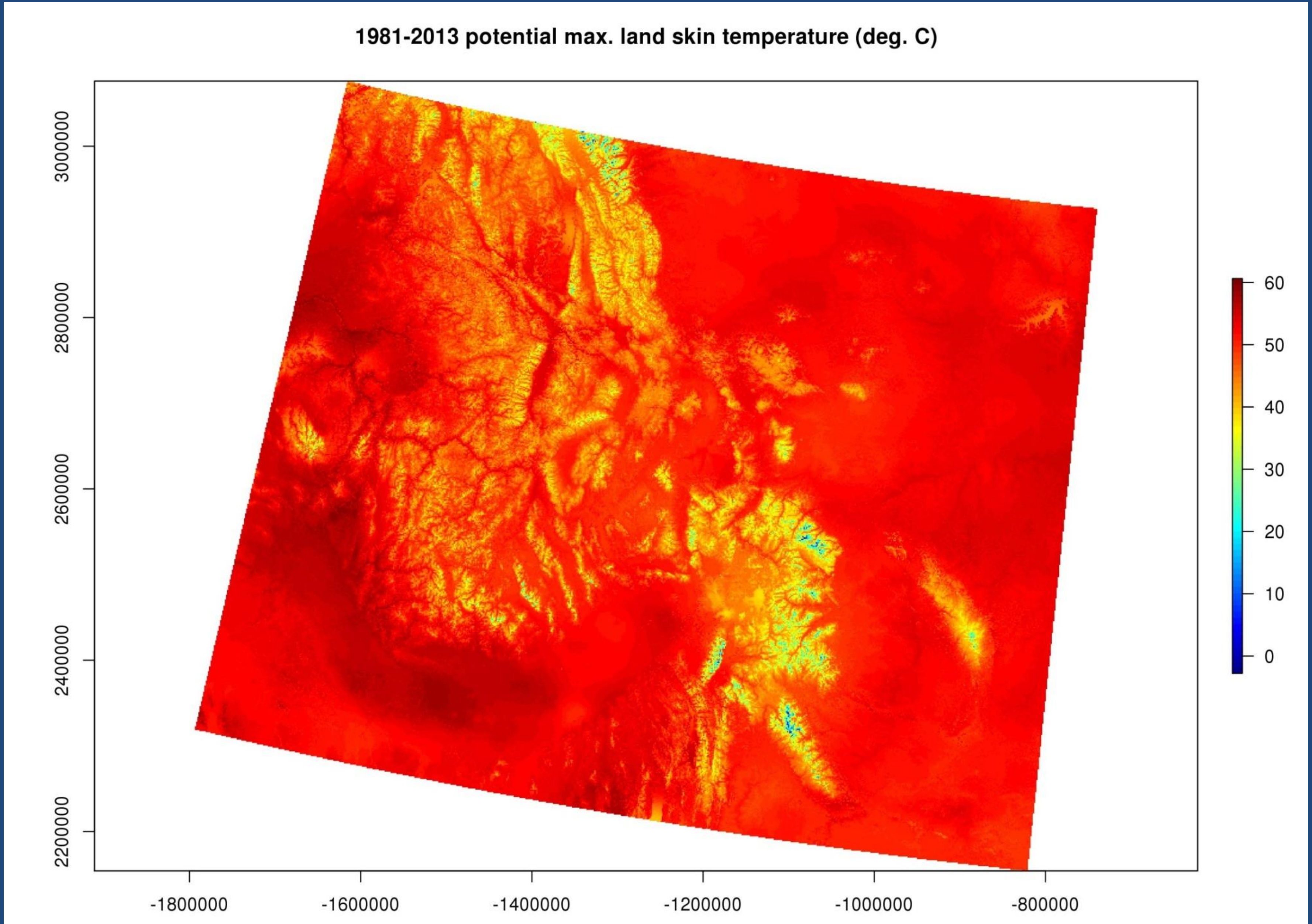
32 historical wildfires
89 Sites
1833 plots

Regen Prob=*f*(*TimeSinceFire + GrowDegDays + Deficit*Species + SkinTemperature*DistanceToSeed | randomEffect=Site)*



Holden et al. (2019). TOPOFIRE: A topgraphically resolved drought and wildfire danger monitoring system.

Potential land skin temperature climatology

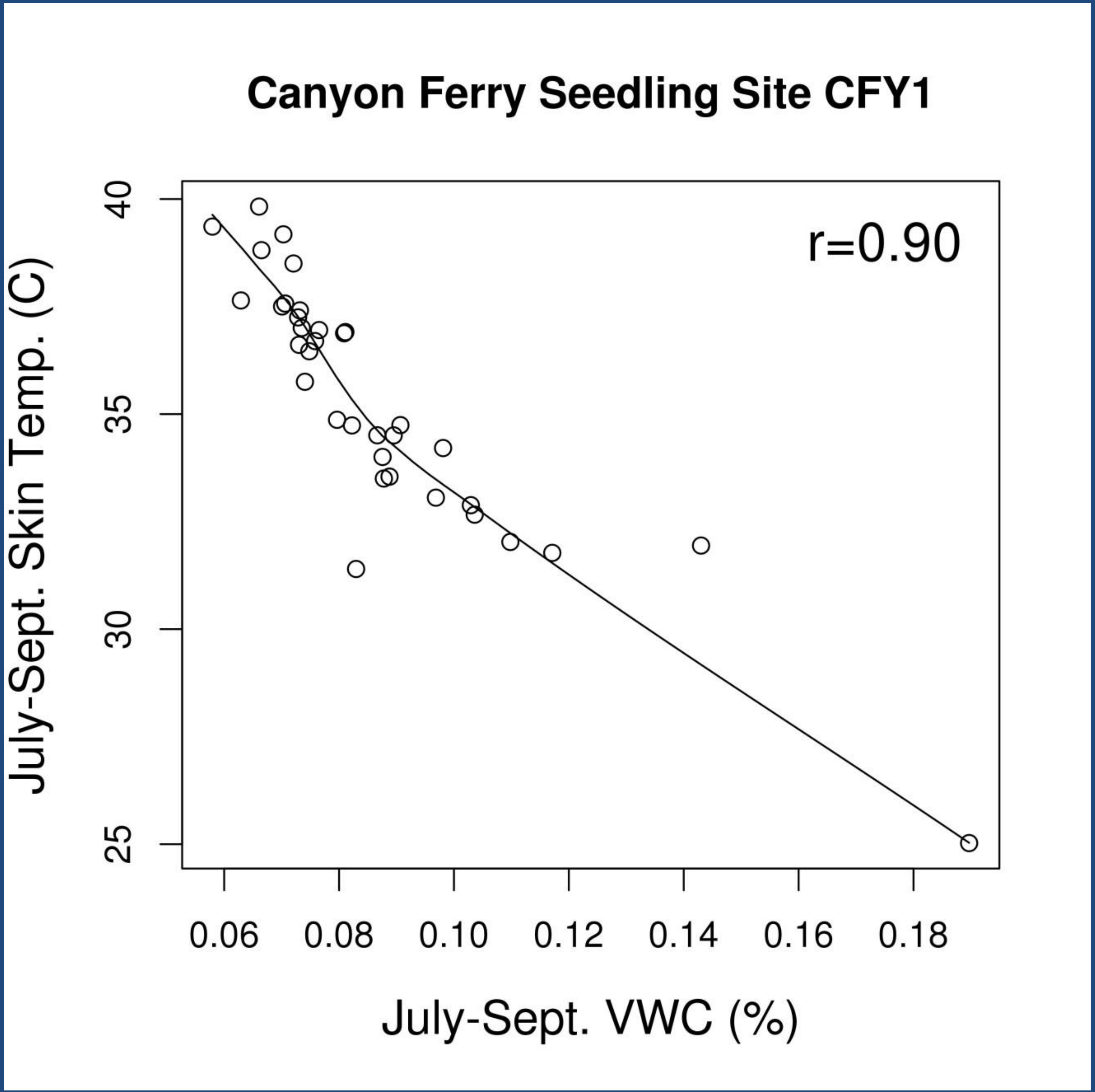


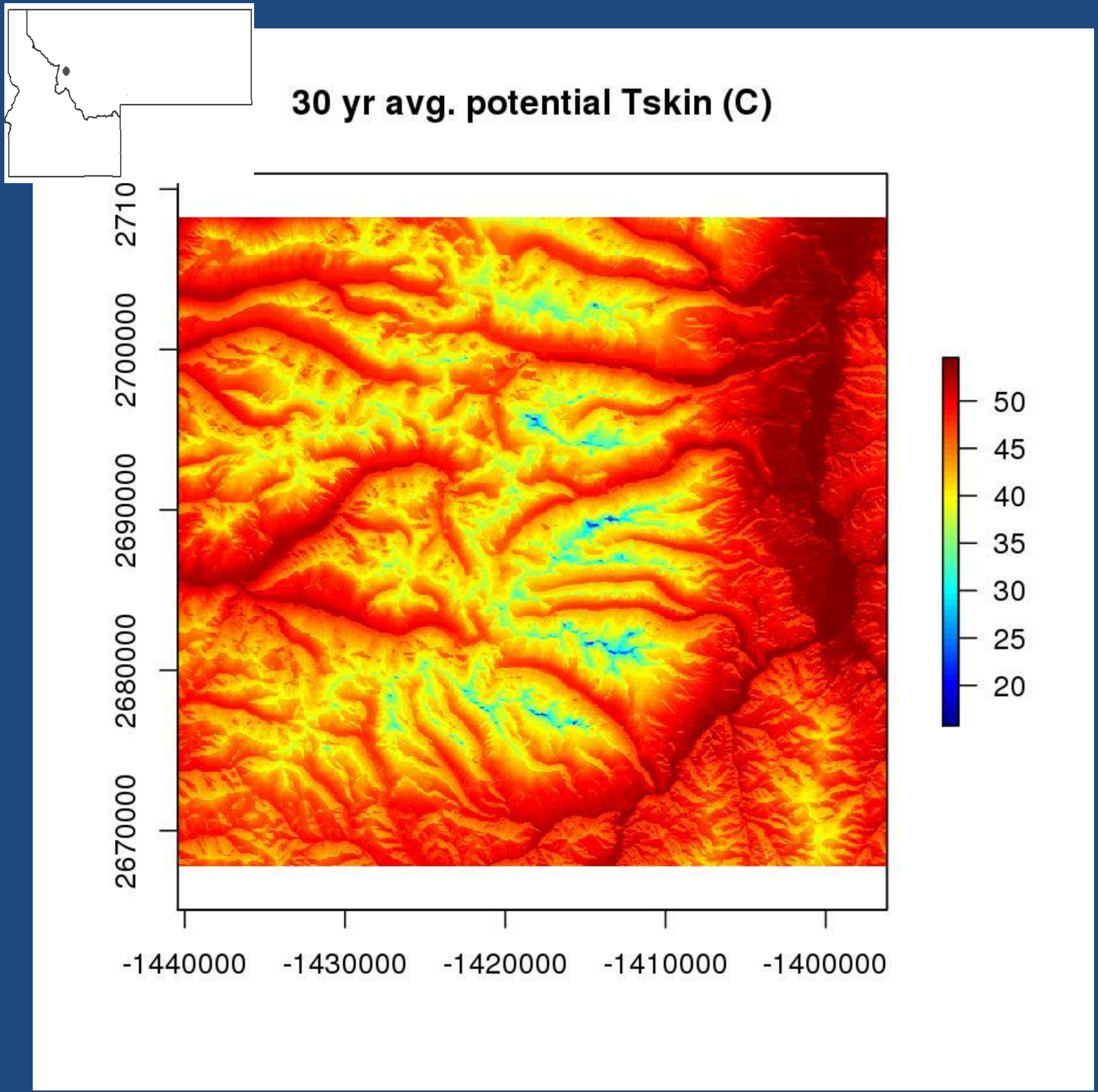
Plant lethal temperatures

- Very brief exposure to temperatures of 55 °C can kill conifer seedlings

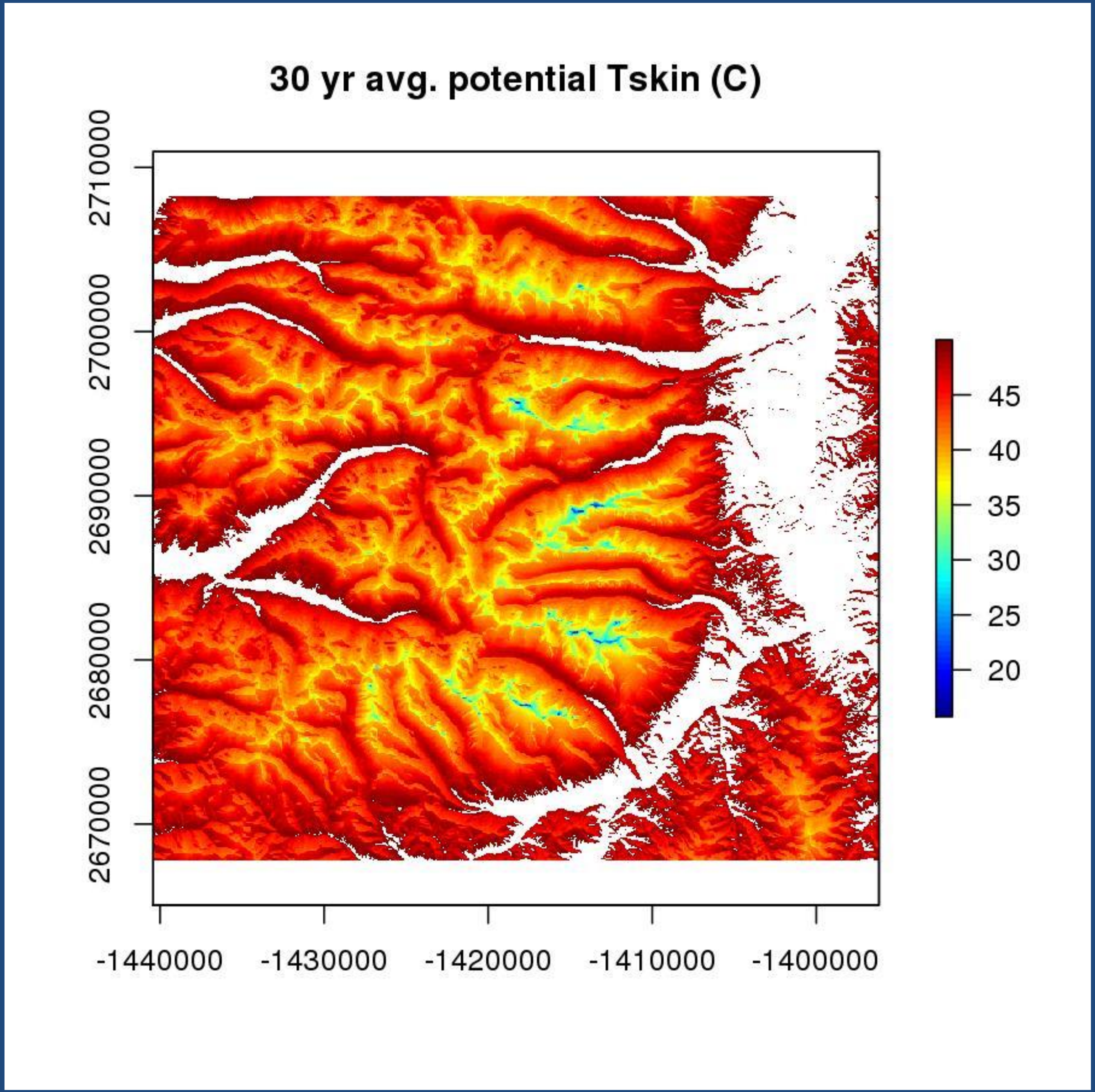
- Cambial damage and girdling;
- lose ability to move water from soil to atmosphere

Daubenmire 1943; Seidel 1987; Kolb and Robberecht 1996


Canyon Ferry Seedling Site CFY1
r=0.90
July-Sept. Skin Temp. (C)
40
35
30
25
0.06
0.08
0.10
0.12
0.14
0.16
0.18
July-Sept. VWC (%)



30 yr avg. potential Tskin (C)
2710
2700000
2690000
2680000
2670000
-1440000
-1430000
-1420000
-1410000
-1400000
50
45
40
35
30
25
20



30 yr avg. potential Tskin (C)
2710000
2700000
2690000
2680000
2670000
-1440000
-1430000
-1420000
-1410000
-1400000
45
40
35
30
25
20

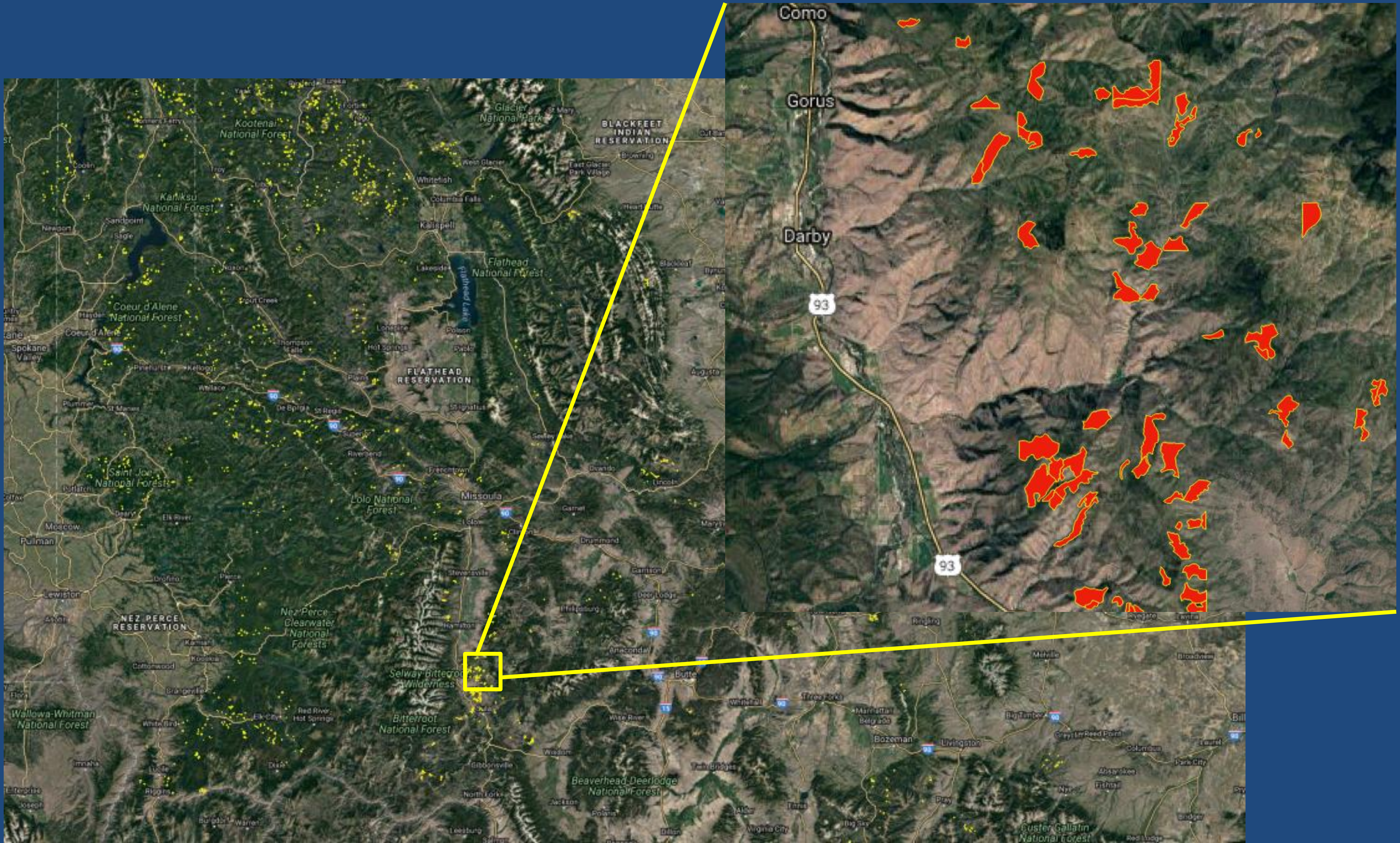
93
Lolo
93
Bitterroot River
Bitterroot River


Bitterroot River
Bitterroot River

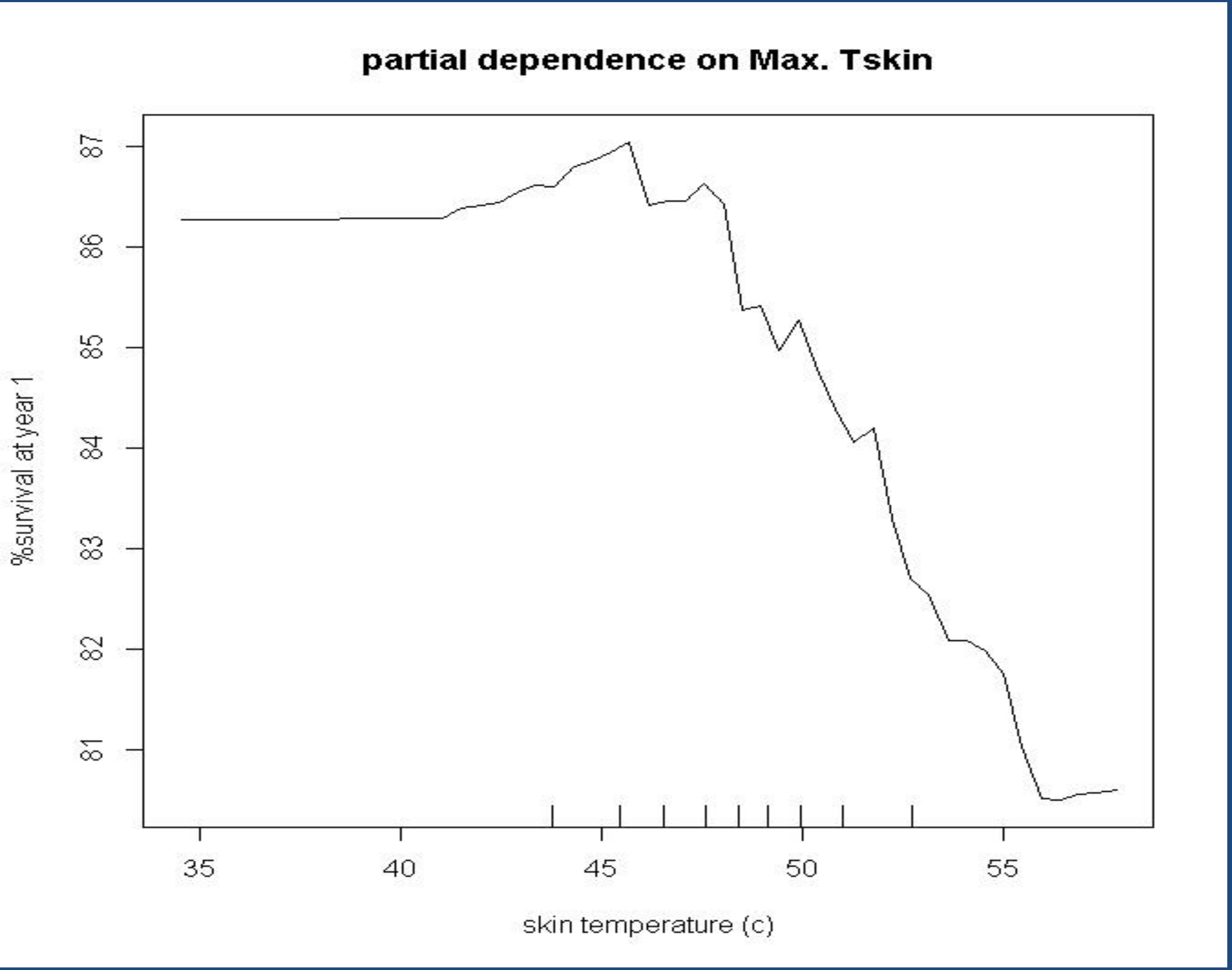
Region 1 Stakerow data (2001-2015)

survival of outplanted seedlings tracked at >2500 sites

% survival monitored 1 and 3 years post-planting

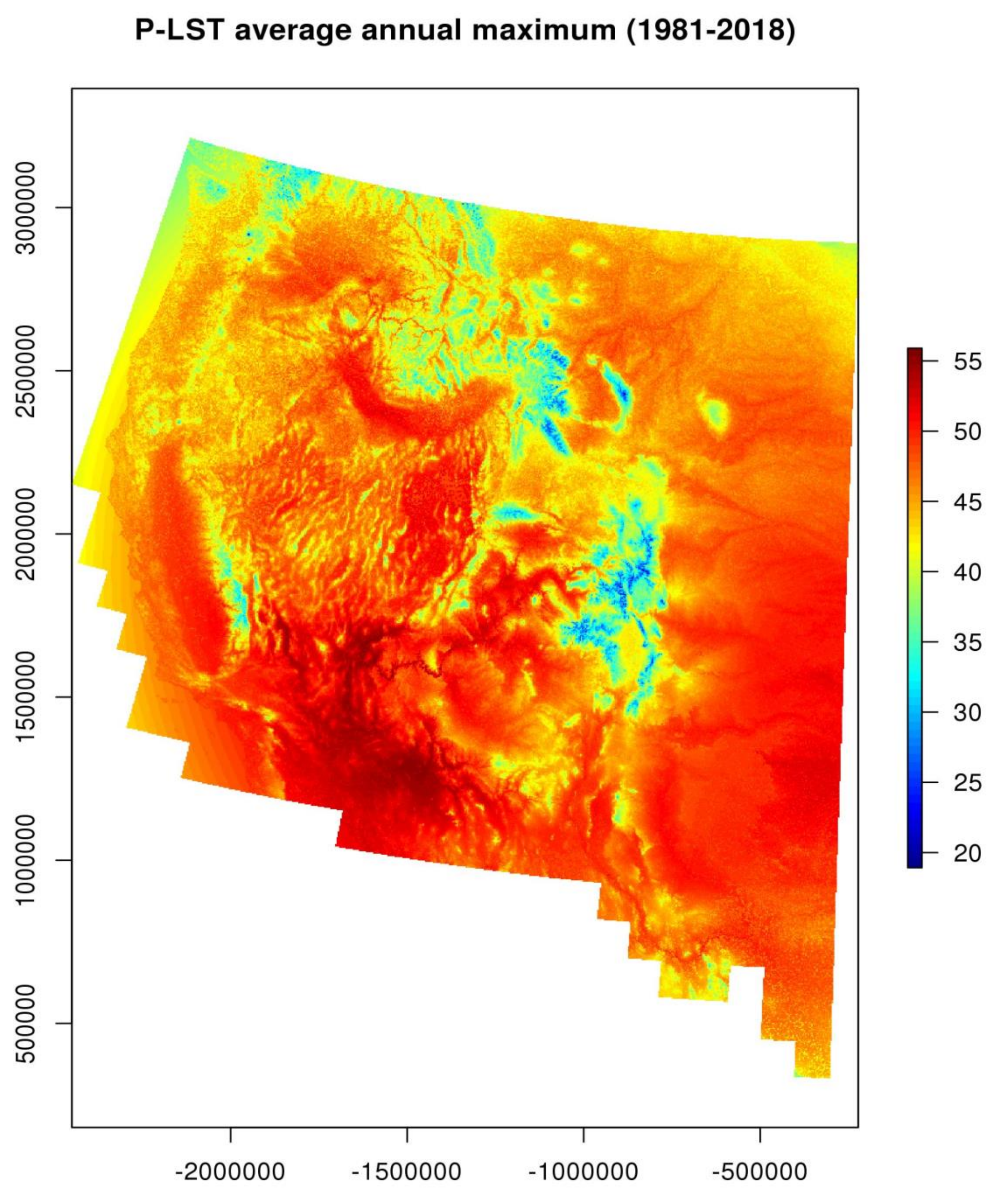


Strong increase in mortality as we approach lethal temperatures



Preliminary West-wide P-LST mapping completed (30m resolution)

Future (2050) simulations for 3 GCMs in progress

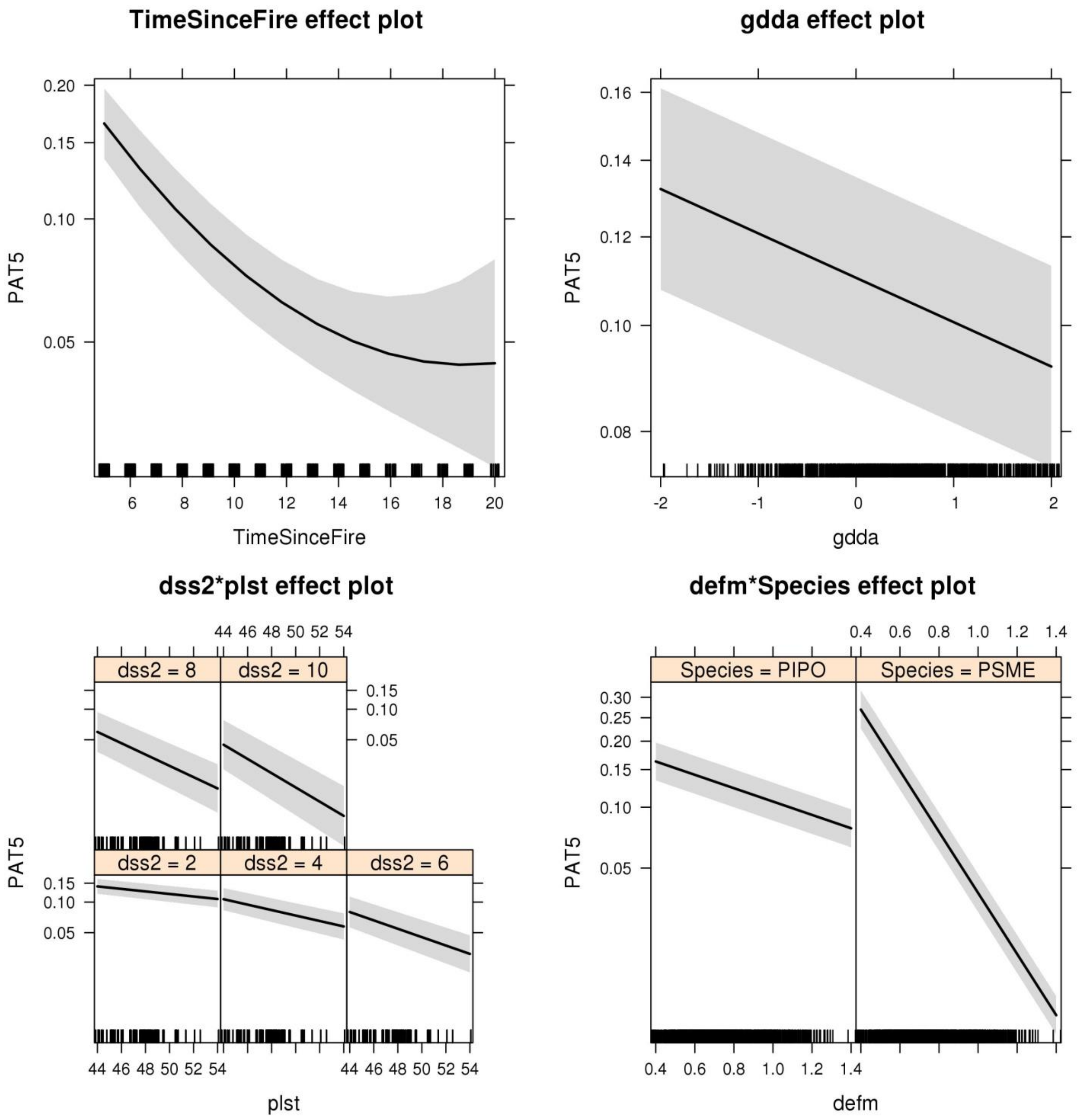


Model partial effects

-Hold each variable at it's mean value
-examine response of a single variable

Decreasing prob. of natural regeneration where:

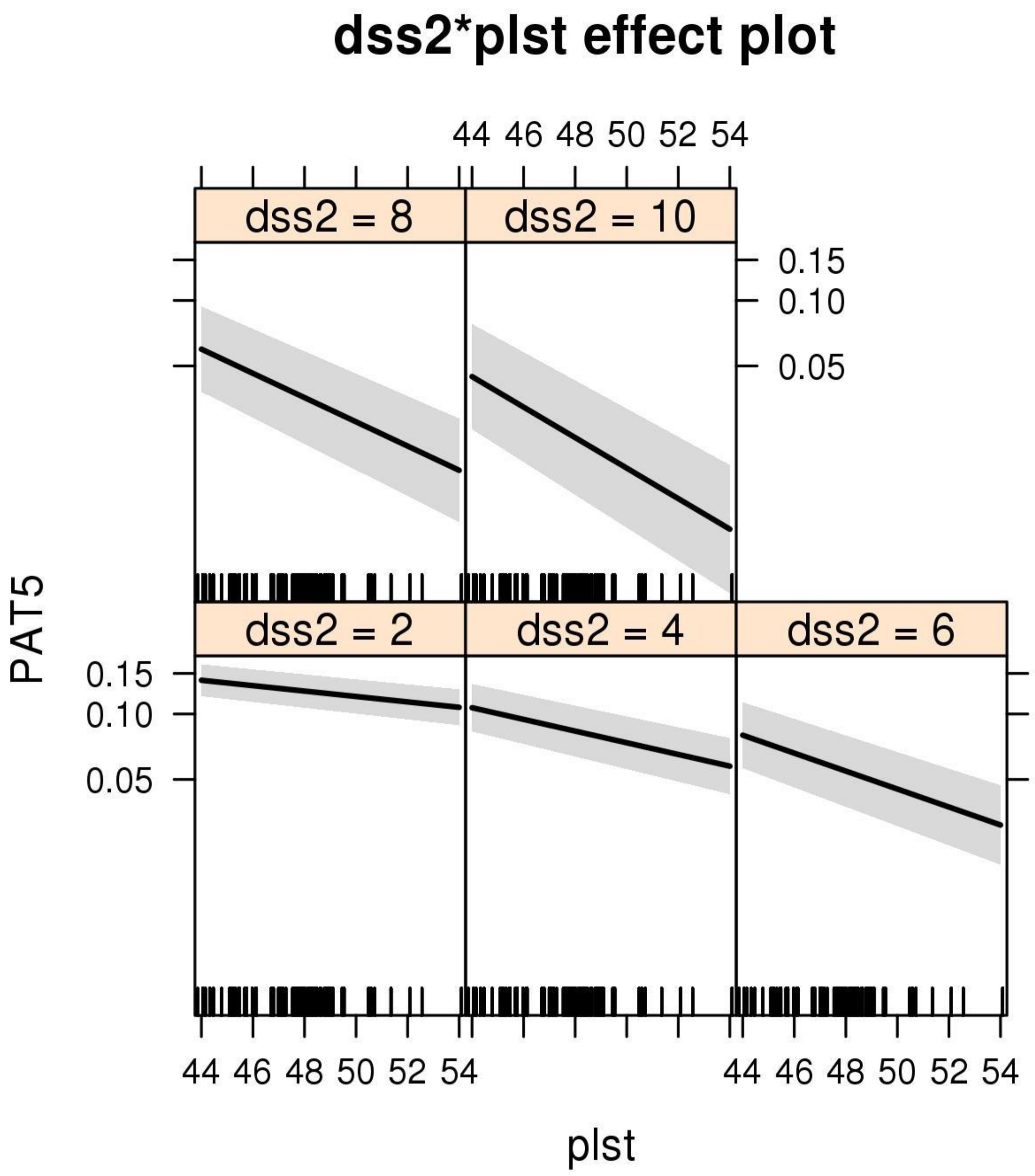
-longer time after the fire
-Higher growing degree days (warm years)
-Higher climatic water deficit (drought stress)
-Longer distance to live adult trees (seed source)



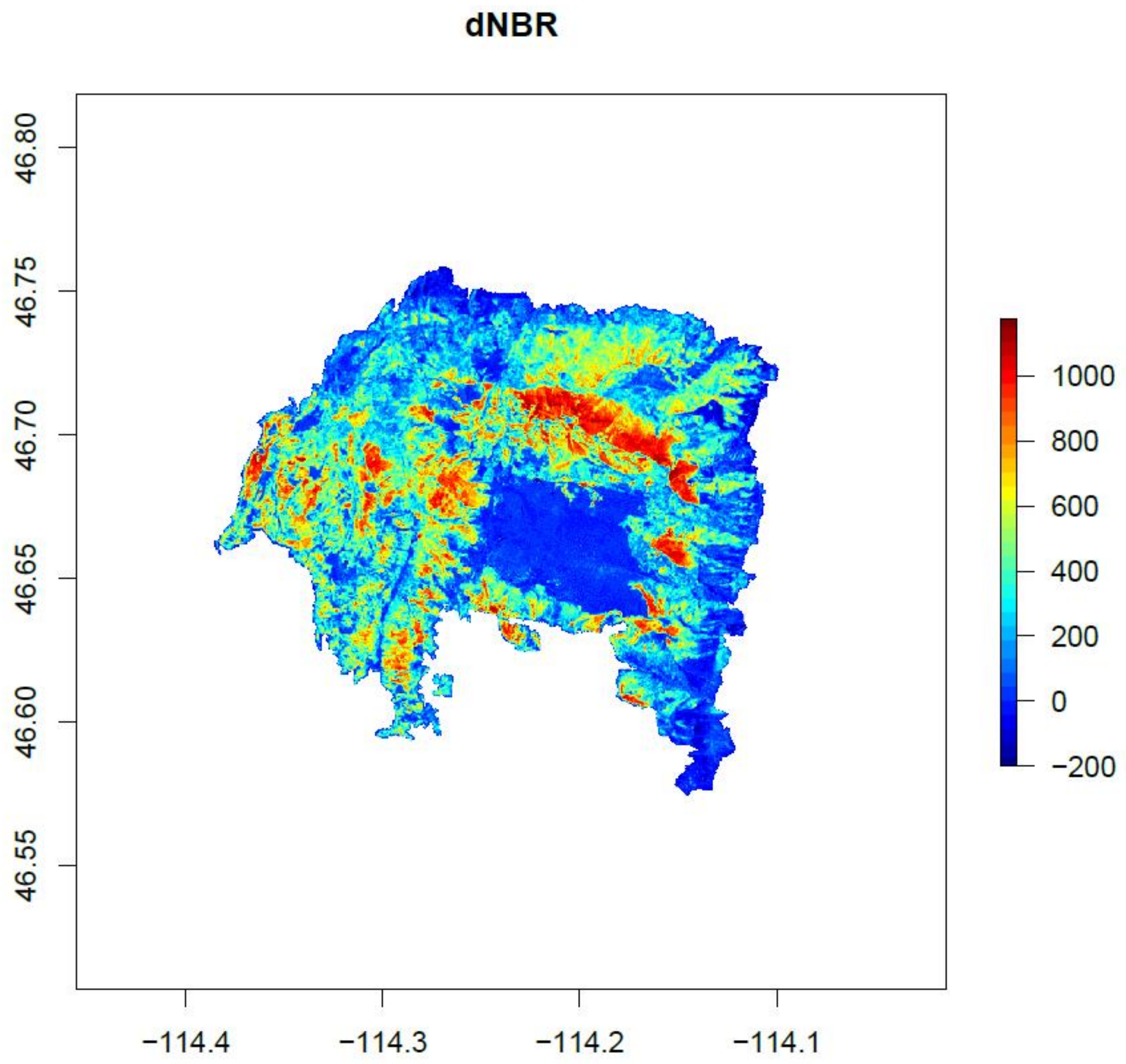
Interaction between distance to live trees and land surface temperature

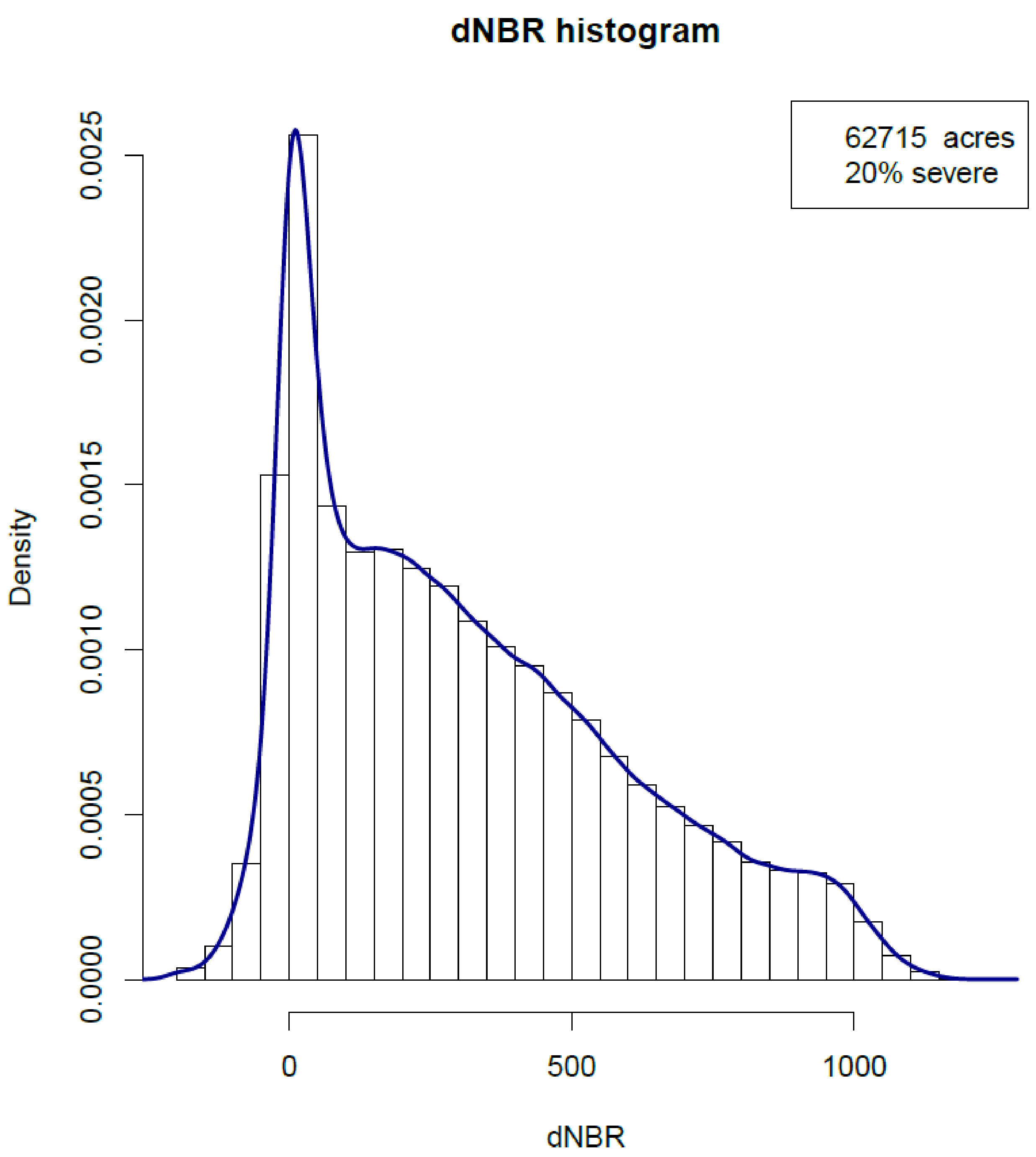
- Sites near the forest edge are buffered from effects of surface heating

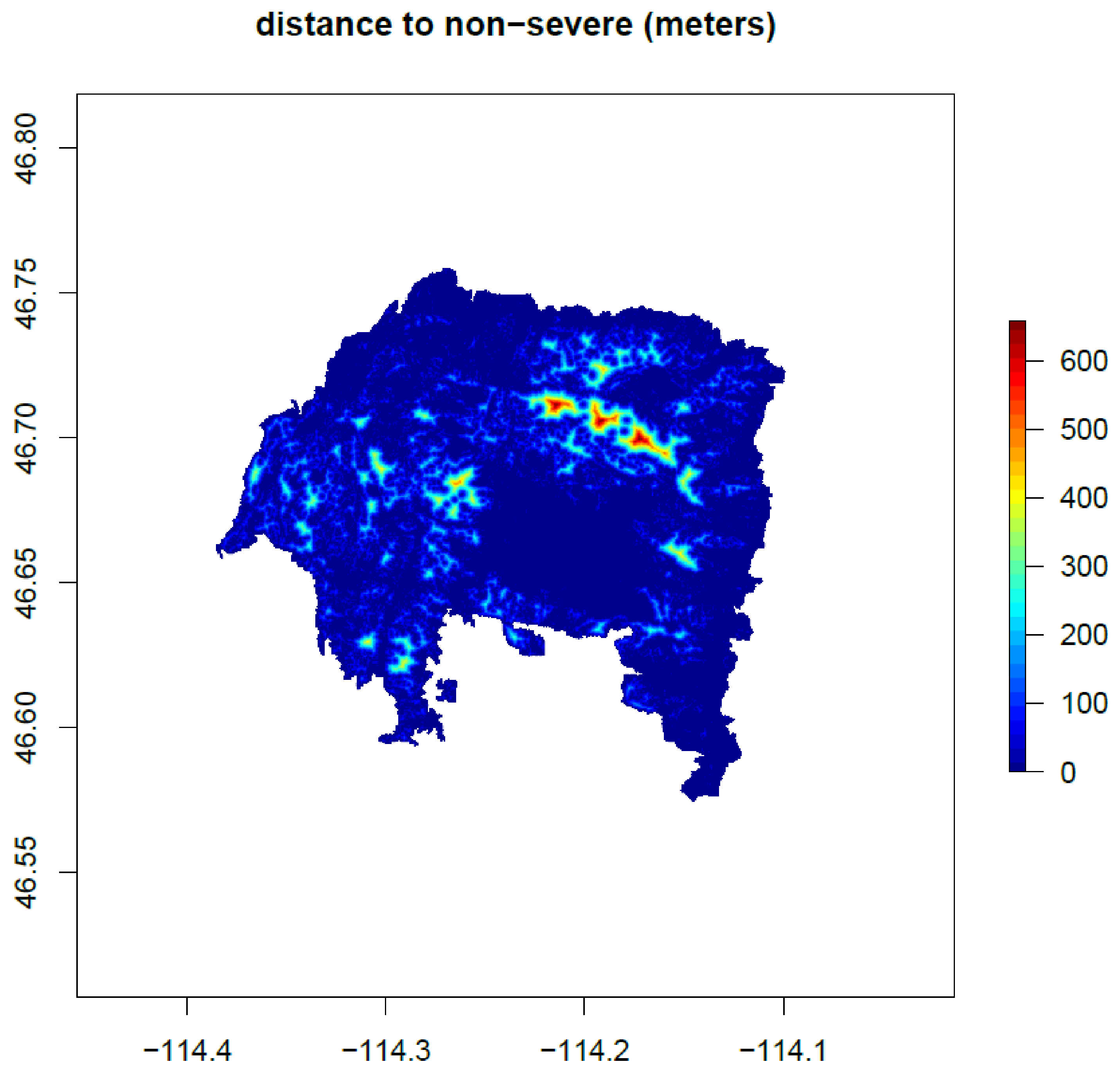
- **Microclimate/Nurse tree effect**



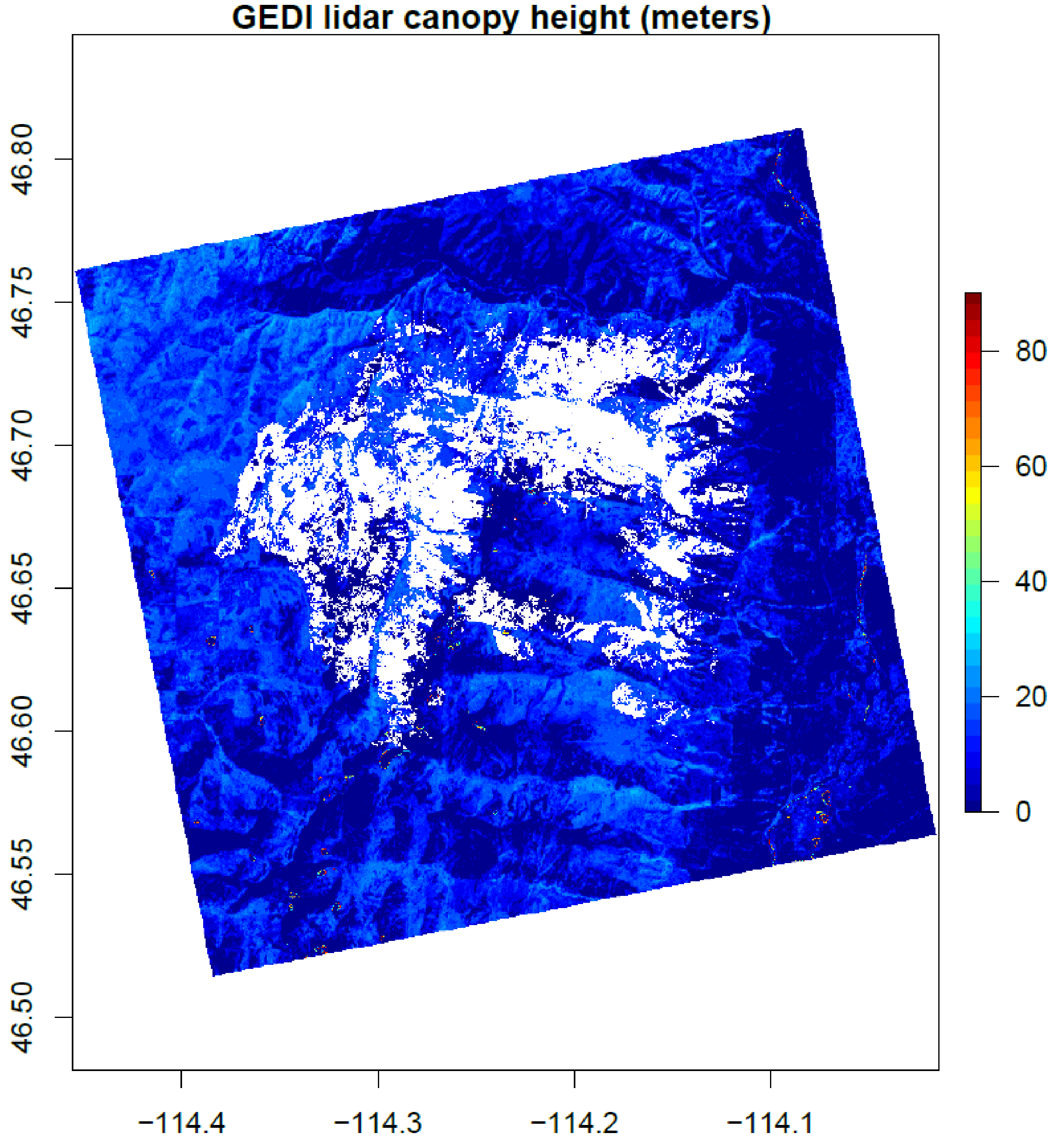
Regenmapper outputs


dNBR
46.80
46.75
46.70
46.65
46.60
46.55
−114.4
−114.3
−114.2
−114.1
1000
800
600
400
200
0
−200


dNBR histogram
62715 acres
20% severe
Density
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025
0
500
1000
dNBR

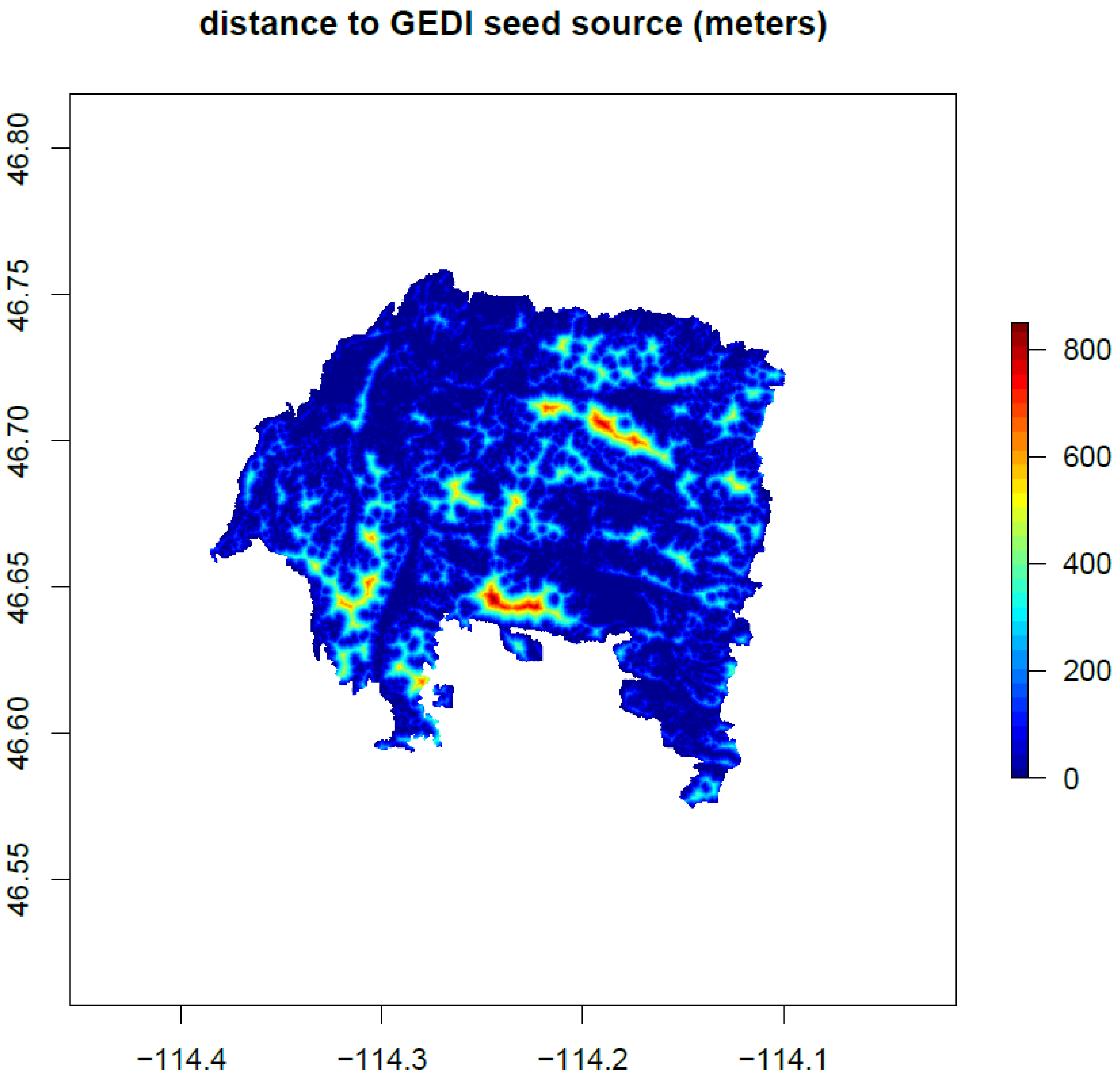

distance to non−severe (meters)
46.80
46.75
46.70
46.65
46.60
46.55
−114.4
−114.3
−114.2
−114.1
600
500
400
300
200
100
0

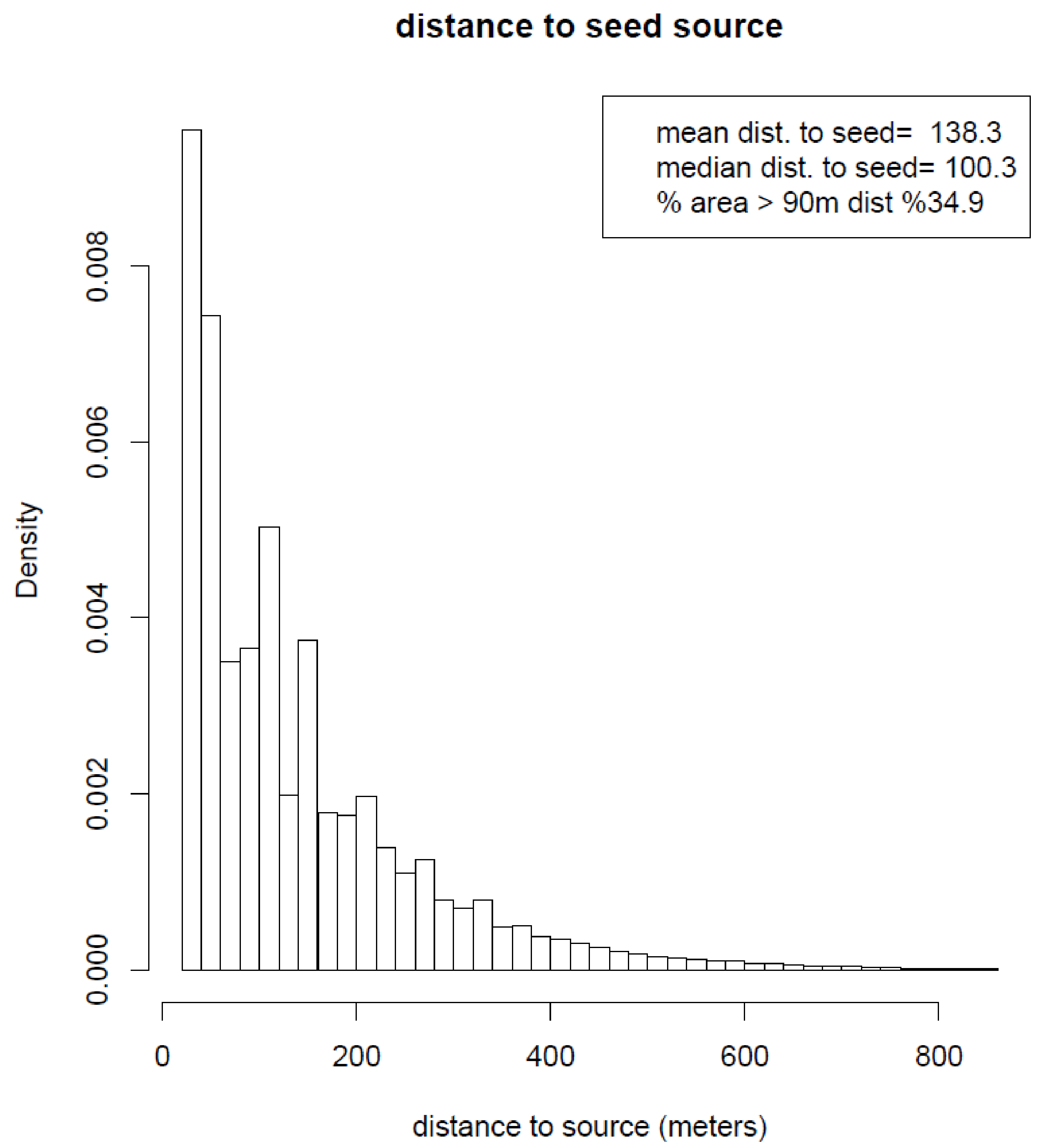
- Global 25 meter resolution canopy height model from spaceborn LiDAR
- 2019-2020 collection
- User defined threshold for determining height of adult seed-bearing trees

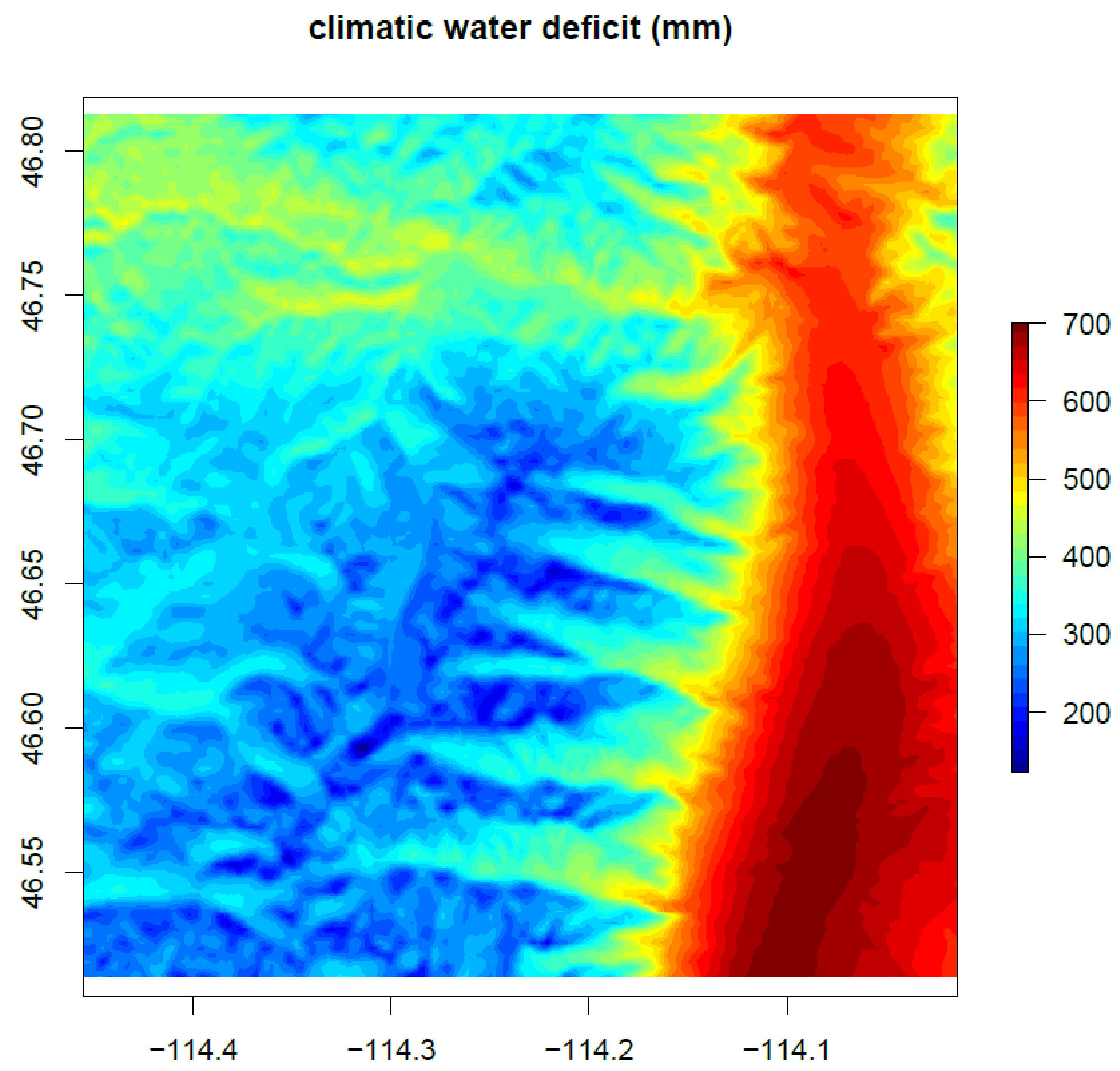


- Distance to potential seed source is the primary control on natural regeneration of disturbed forest patches

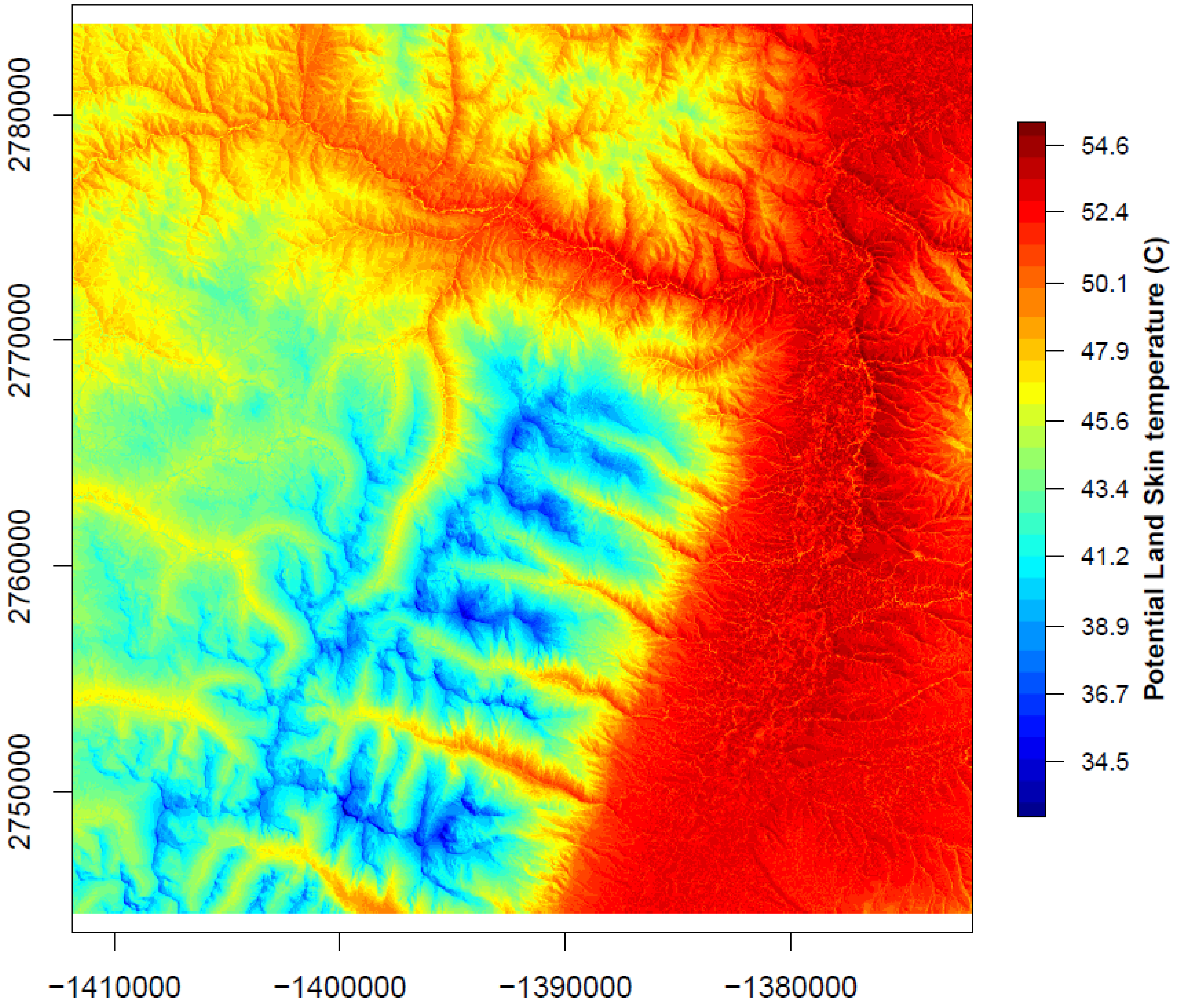
- (exceptions for serotinous lodgpole pine, aspen, others?)

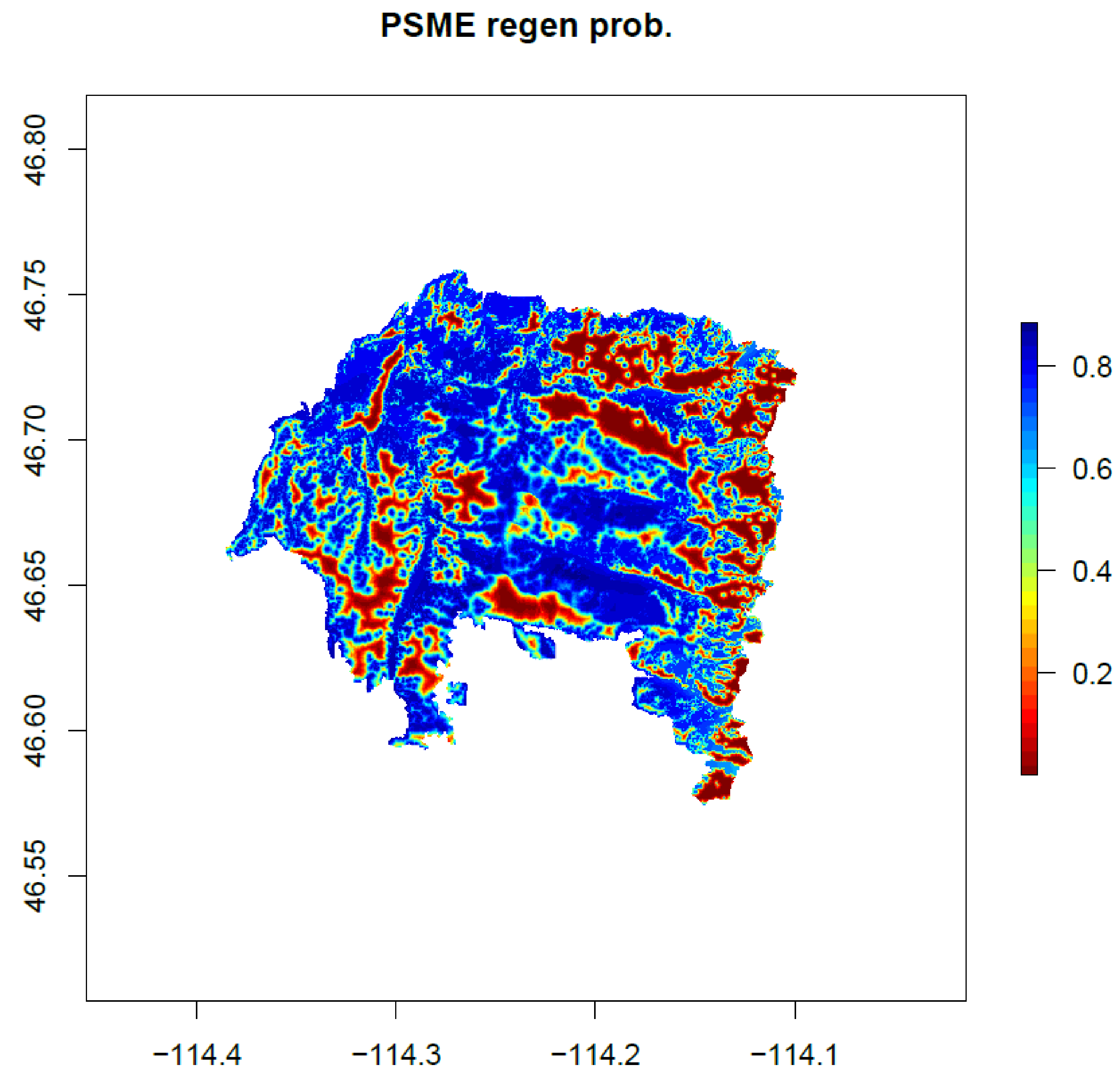


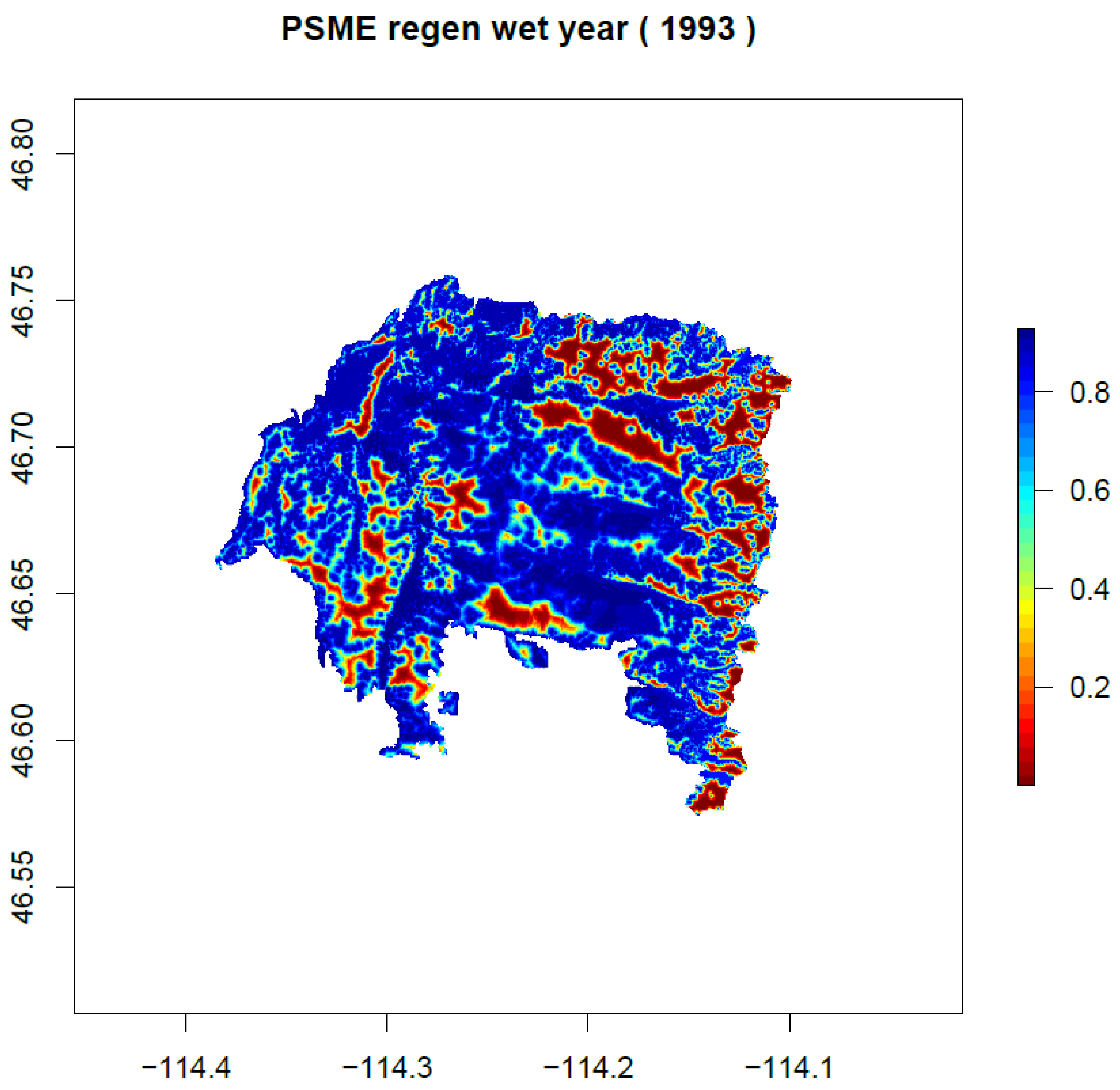

distance to seed source
mean dist. to seed= 138.3
median dist. to seed= 100.3
% area > 90m dist %34.9
Density
0.000
0.002
0.004
0.006
0.008
0
200
400
600
800
distance to source (meters)


climatic water deficit (mm)
46.80
46.75
46.70
46.65
46.60
46.55
−114.4
−114.3
−114.2
−114.1
700
600
500
400
300
200

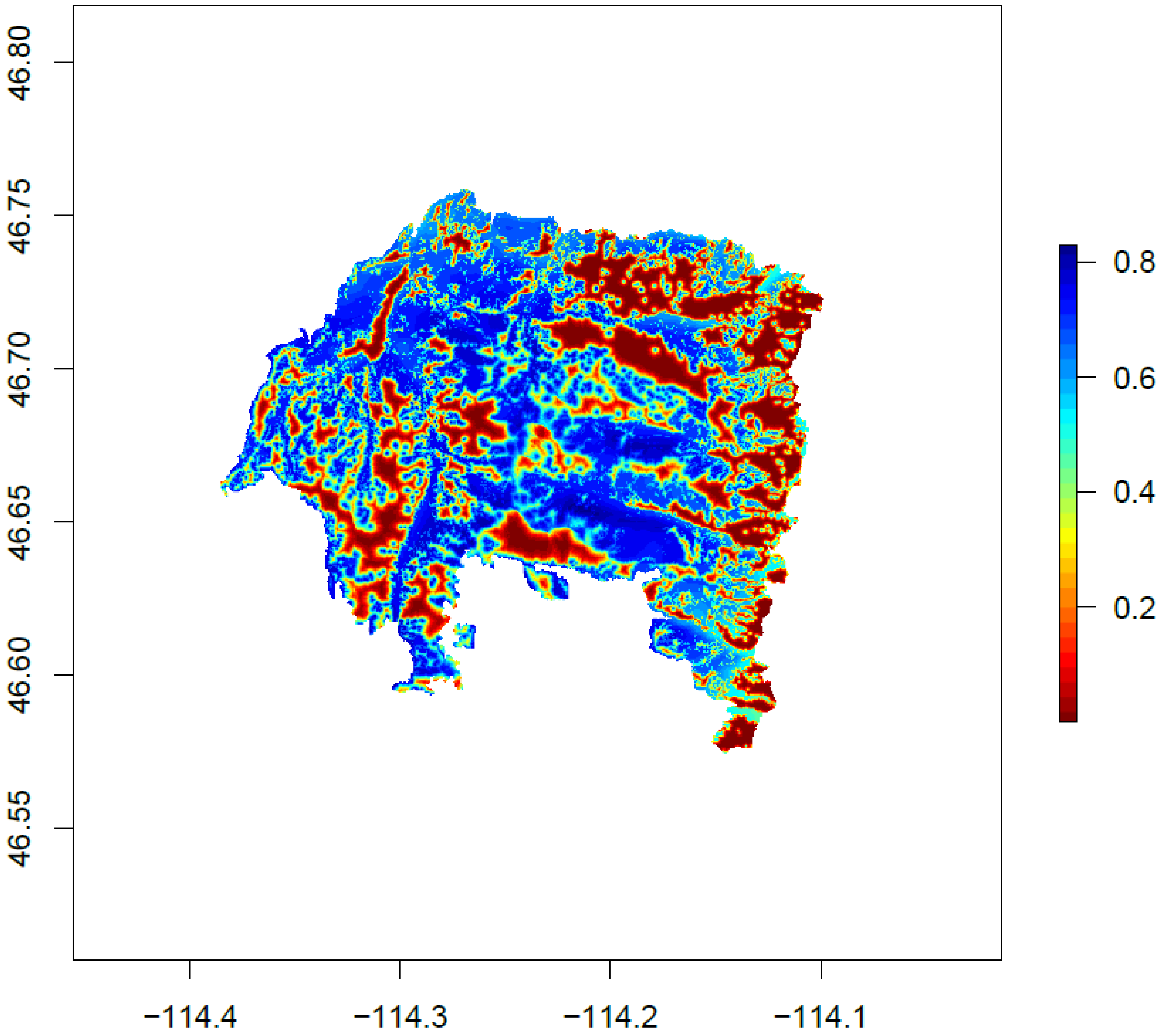
30 year avg. max. skin temperature

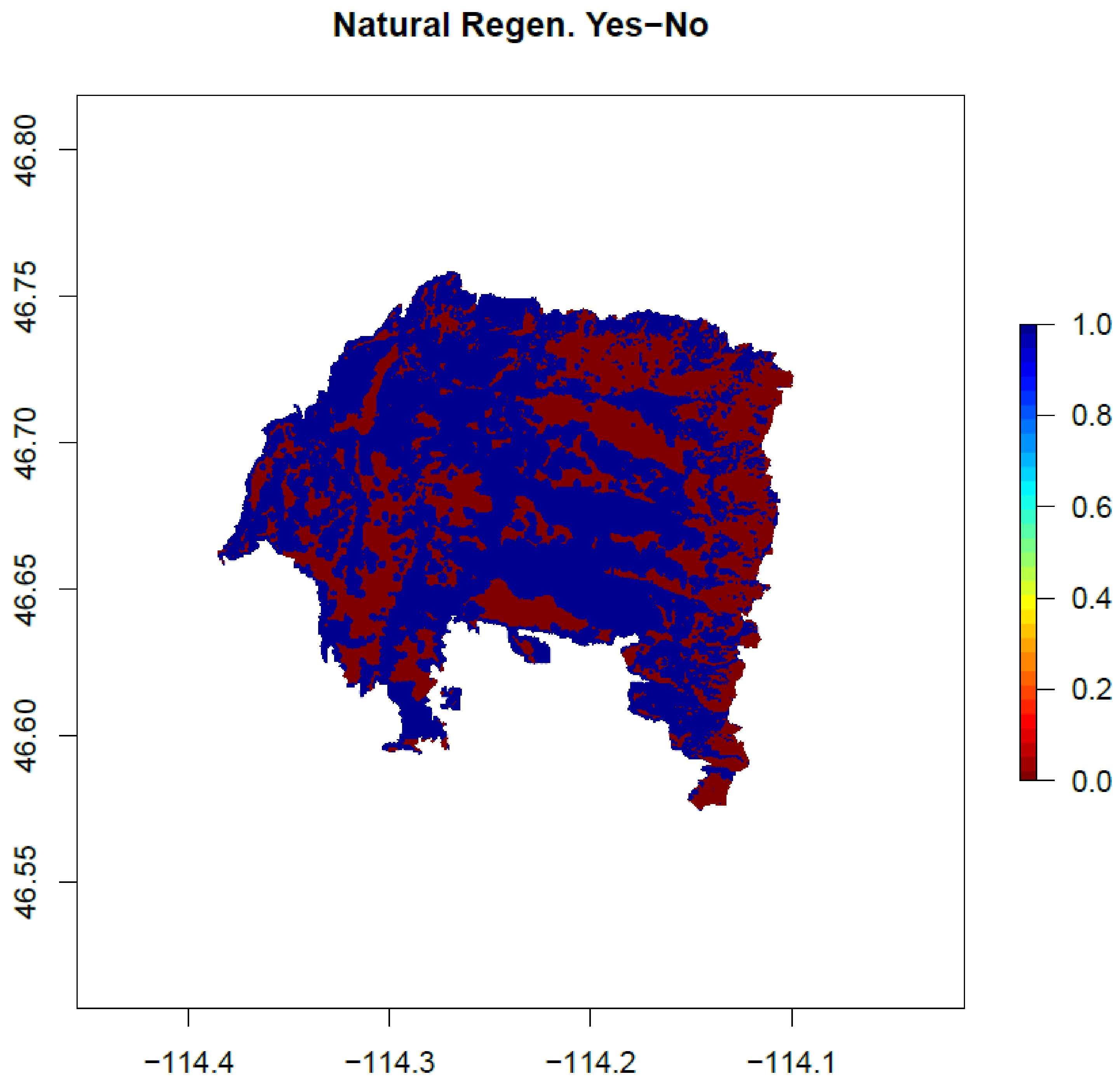



PSME regen prob.
46.80
46.75
46.70
46.65
46.60
46.55
−114.4
−114.3
−114.2
−114.1
0.8
0.6
0.4
0.2


PSME regen wet year (1993)
46.80
46.75
46.70
46.65
46.60
46.55
−114.4
−114.3
−114.2
−114.1
0.8
0.6
0.4
0.2

PSME regen dry year (2007)




Natural Regen. Yes−No
46.80
46.75
46.70
46.65
46.60
46.55
−114.4
−114.3
−114.2
−114.1
1.0
0.8
0.6
0.4
0.2
0.0

With limited resources how should we prioritize selection of sites for planting?

- All else being equal, Select sites that are:

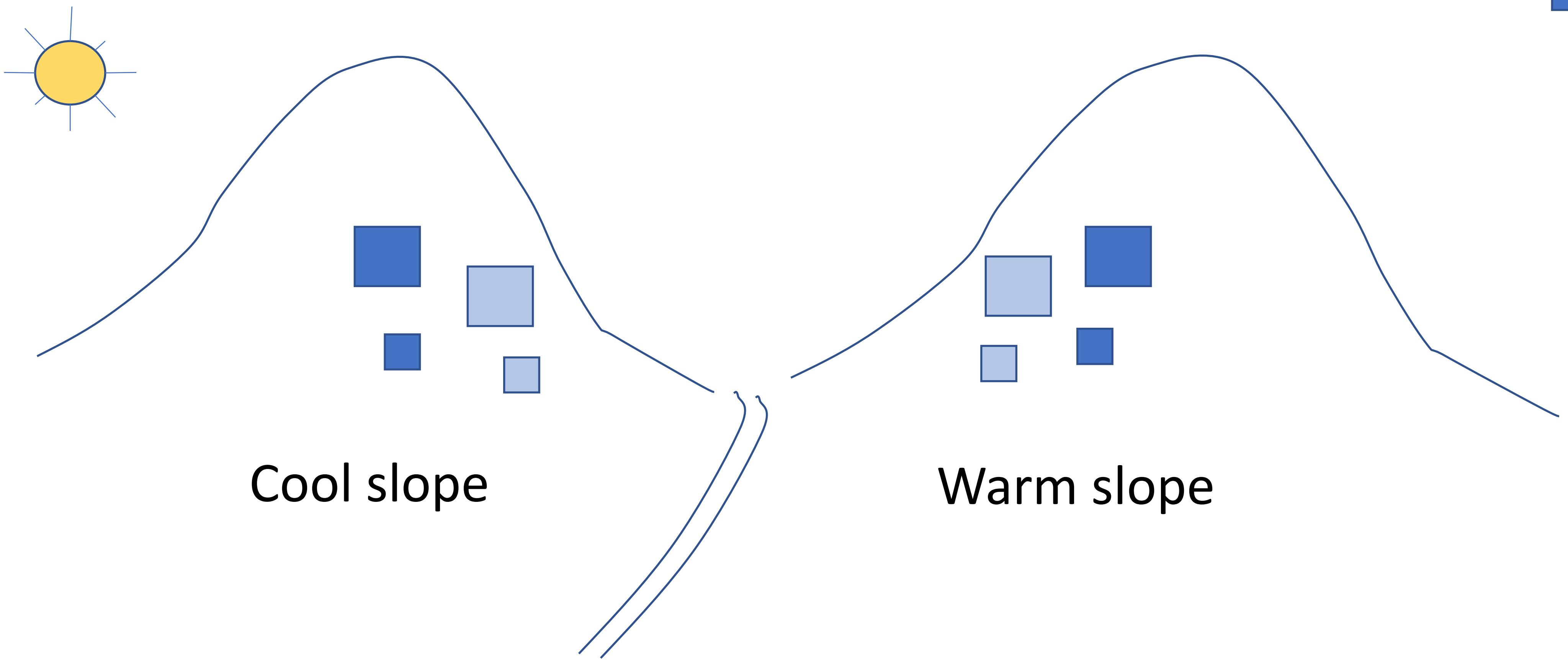
1. Unlikely to recover naturally and need assisted planting
2. Closer to roads, easy to access, less expensive
3. Have higher chance of survival if we invest in planting there

= large patch
No nearby seeds

= small patch
Close to seed source

= close to road
Low cost

= far from road
Higher cost



Reforestation Cost-Benefit Index

Step 1: Cost Index = (1/Cost* w) * Psurvival*(1- PNatRegen)

*w = user defined cost/per acre weight

Step 2: Apply spatial clustering to cost index to identity discrete patches

Calculate Local Moran's I; Cluster using K-means

CSIRO PUBLISHING

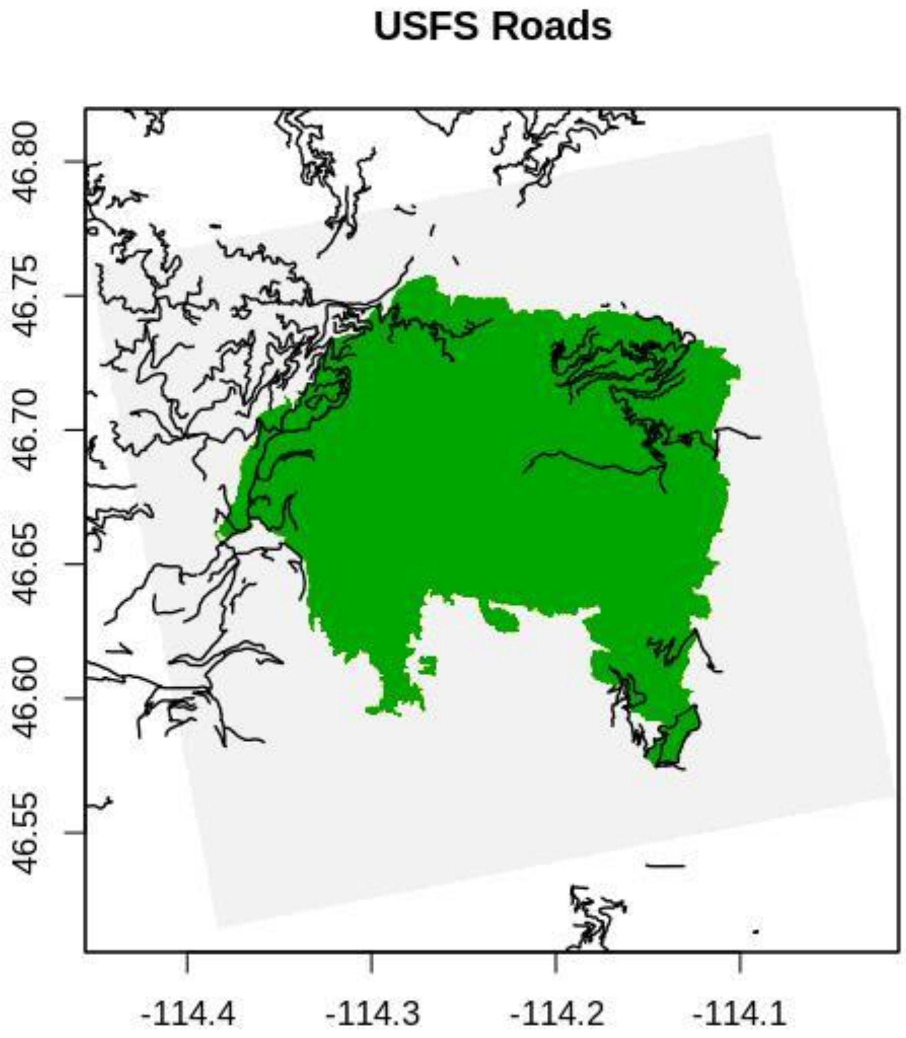
www.publish.csiro.au/journals/ijwf — *International Journal of Wildland Fire* **2010**, *19*, 853–860

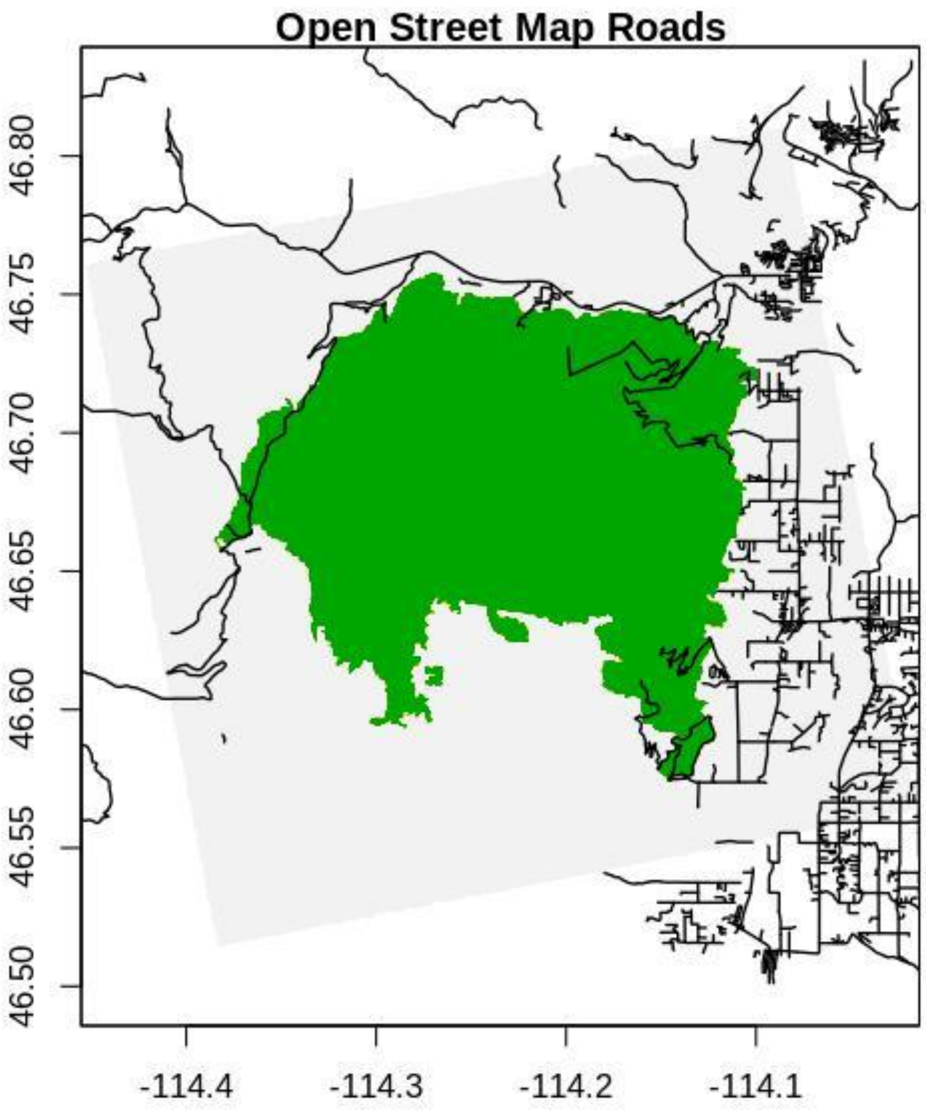
Using fuzzy C-means and local autocorrelation to cluster satellite-inferred burn severity classes

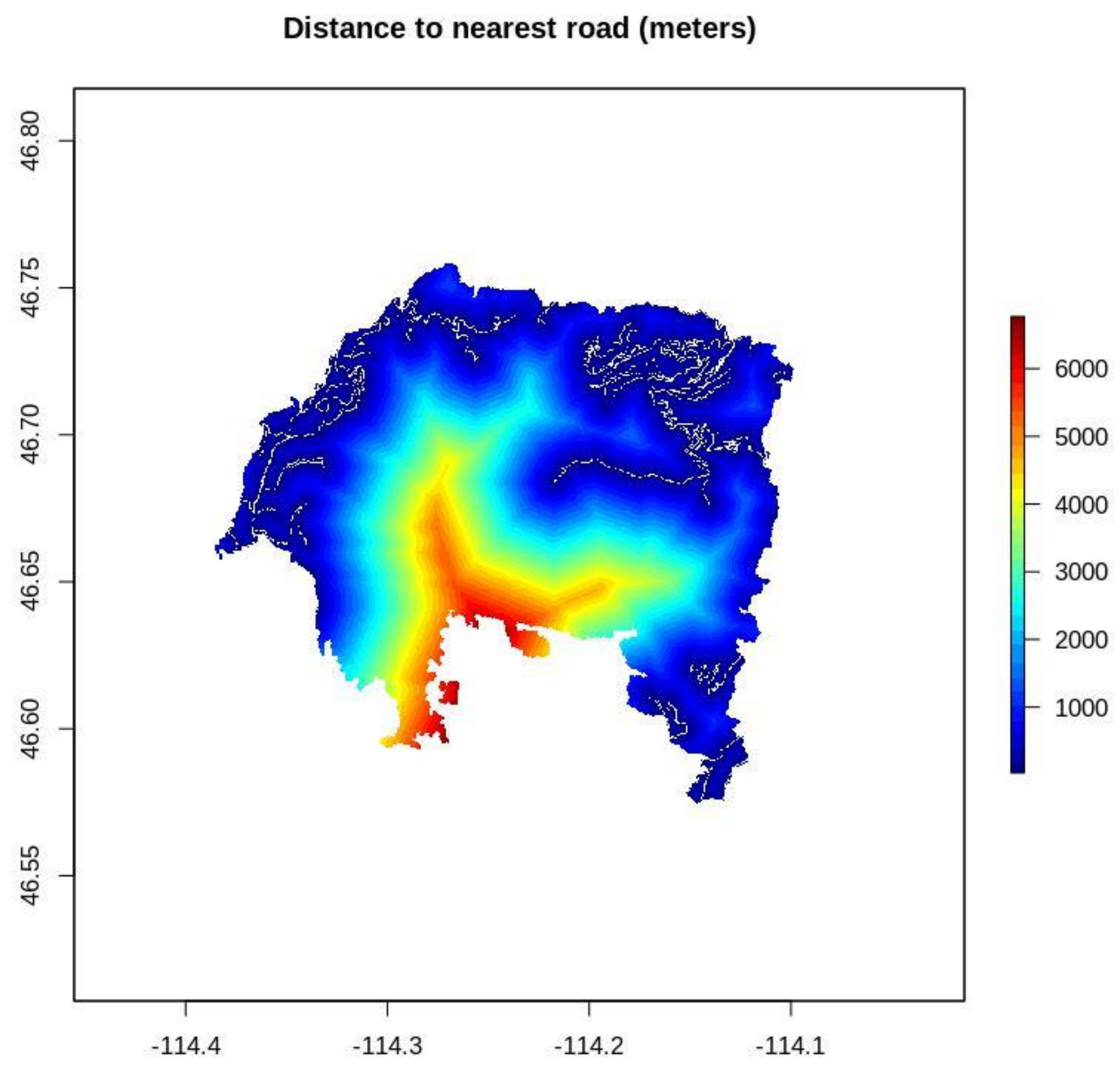
Zachary A. Holden[A,C] *and Jeffrey S. Evans*[B]

Concept and algorithm proposed by Marco Maneta, Geosciences Dept. U. Montana

postGIS database with national road features

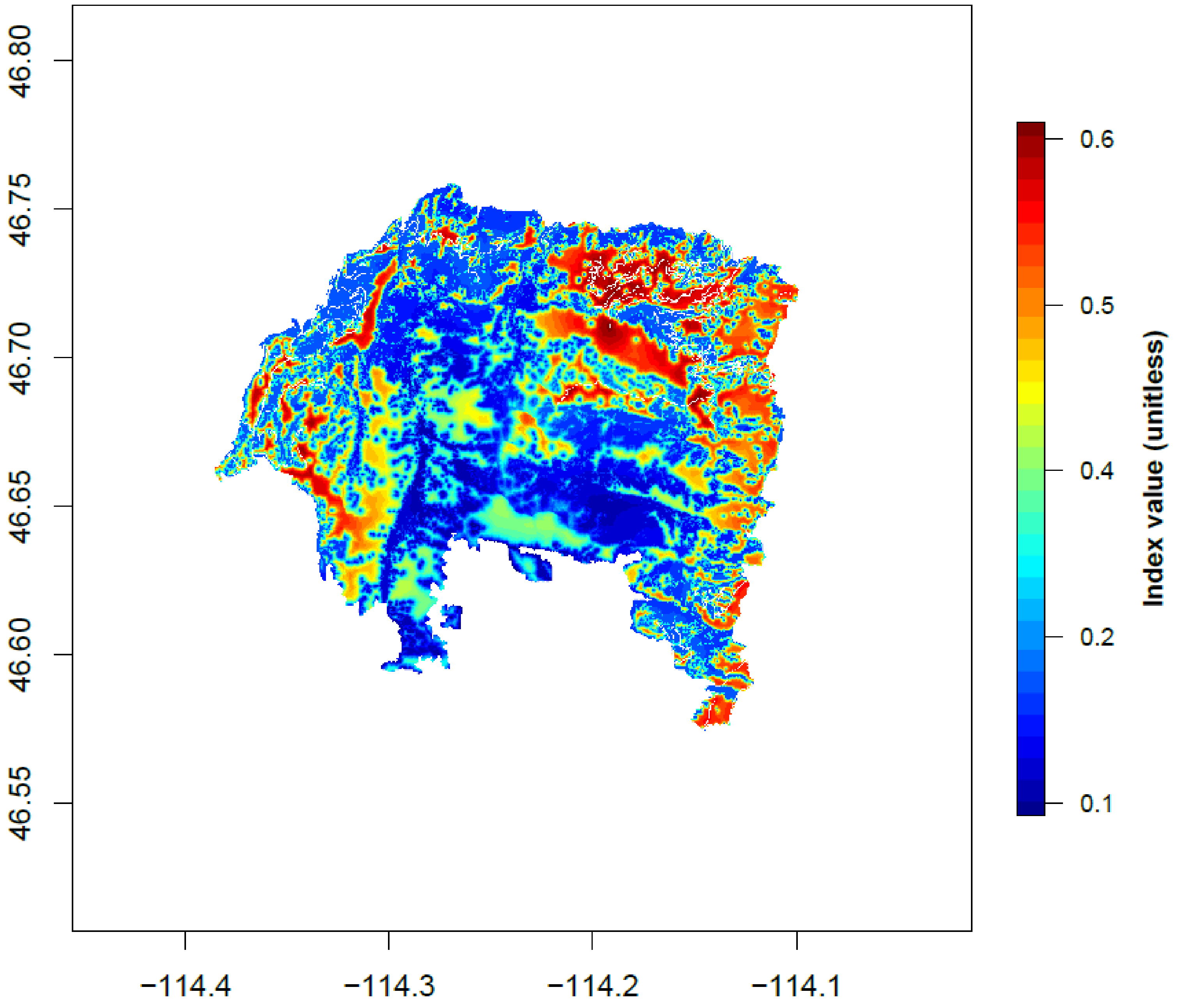


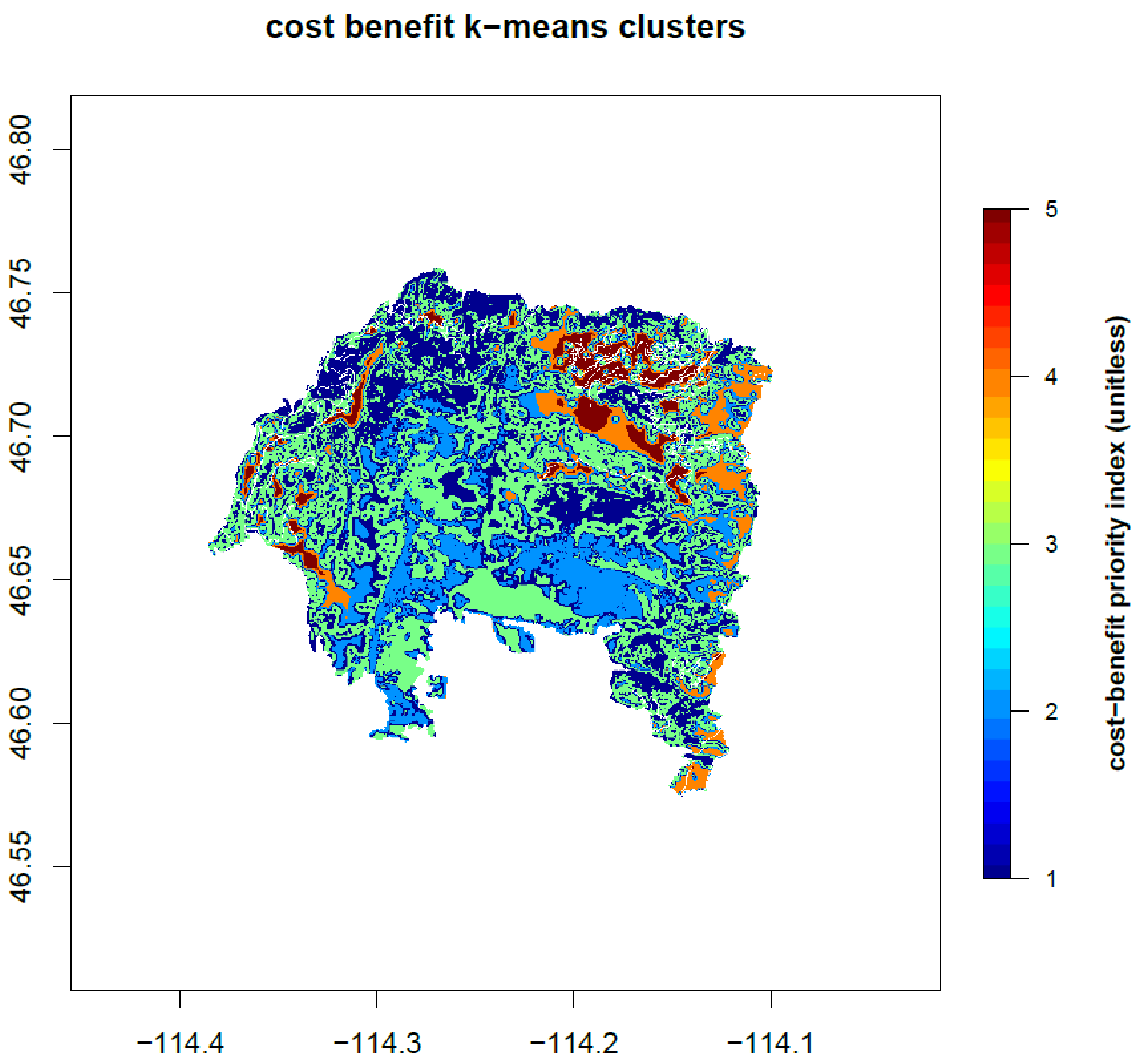




Distance to nearest road (meters)
46.80
46.75
46.70
46.65
46.60
46.55
-114.4
-114.3
-114.2
-114.1
6000
5000
4000
3000
2000
1000

cost−benefit index

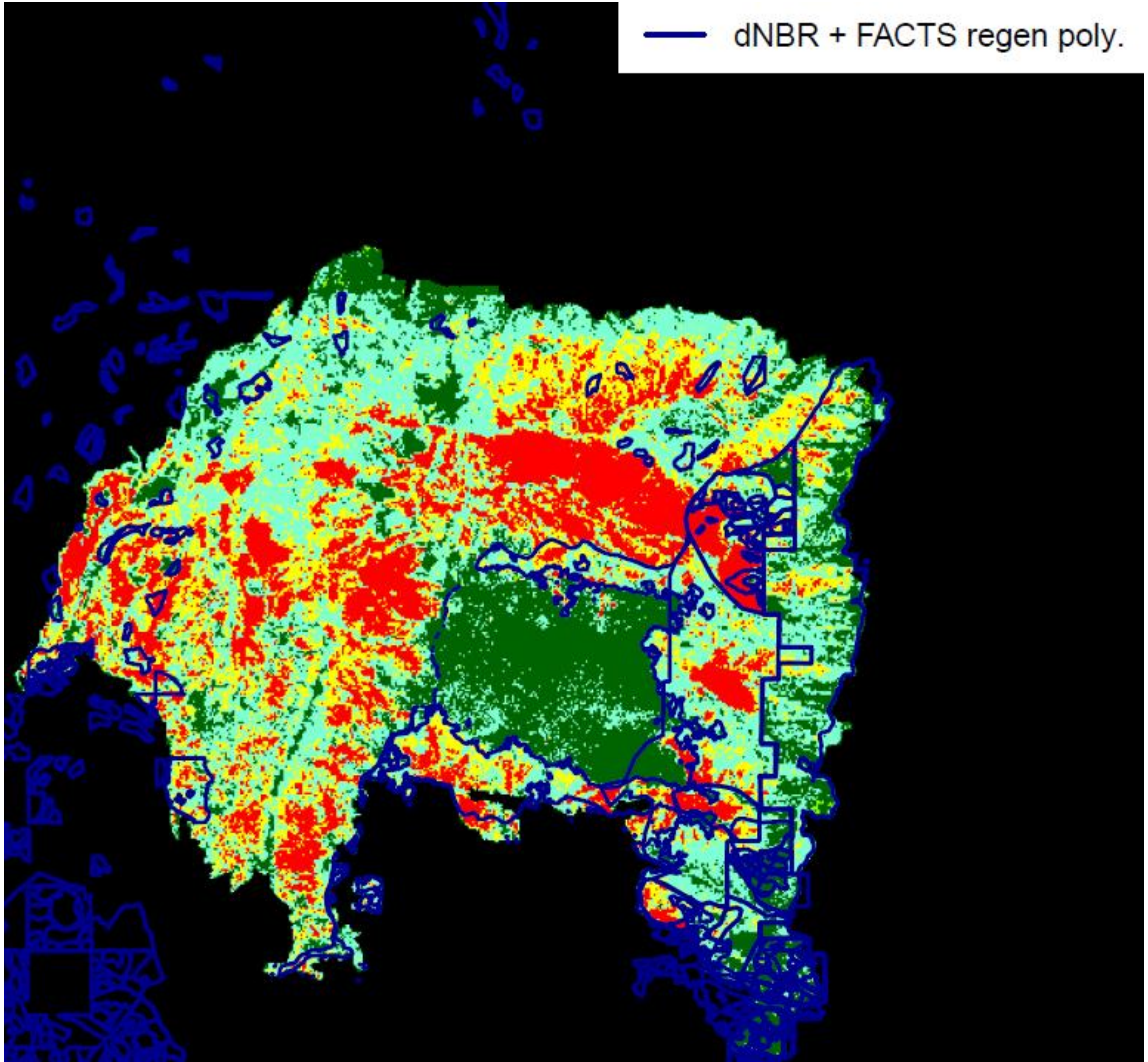



cost benefit k−means clusters
46.80
46.75
46.70
46.65
46.60
46.55
−114.4
−114.3
−114.2
−114.1
5
4
3
2
1
cost−benefit priority index (unitless)

FACTS database

- USFS lands only
- Forest Activity Tracking System
- Mandated by congress
- Tabular and spatial tracking of all activities on USFS lands

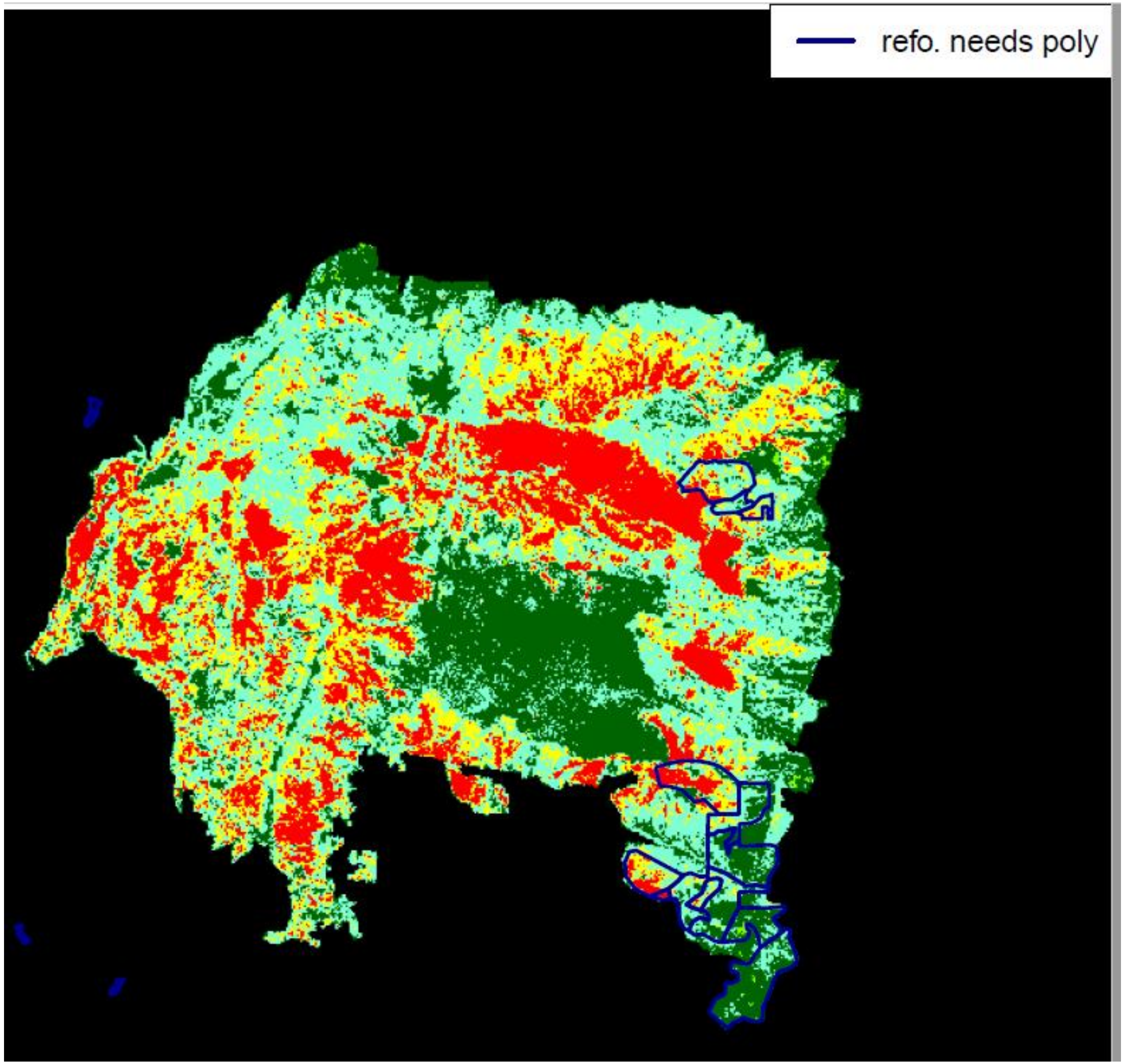
- Return codes relevant to reforestation (Ellen Jungck)



National Reforestation Needs

- Some past activities by law require planting under NFMA
- Query and return all Refo. Needs polygons in burned area

- National reforestation needs layer made publicly available about 2 days ago, will be operational/up to date soon.

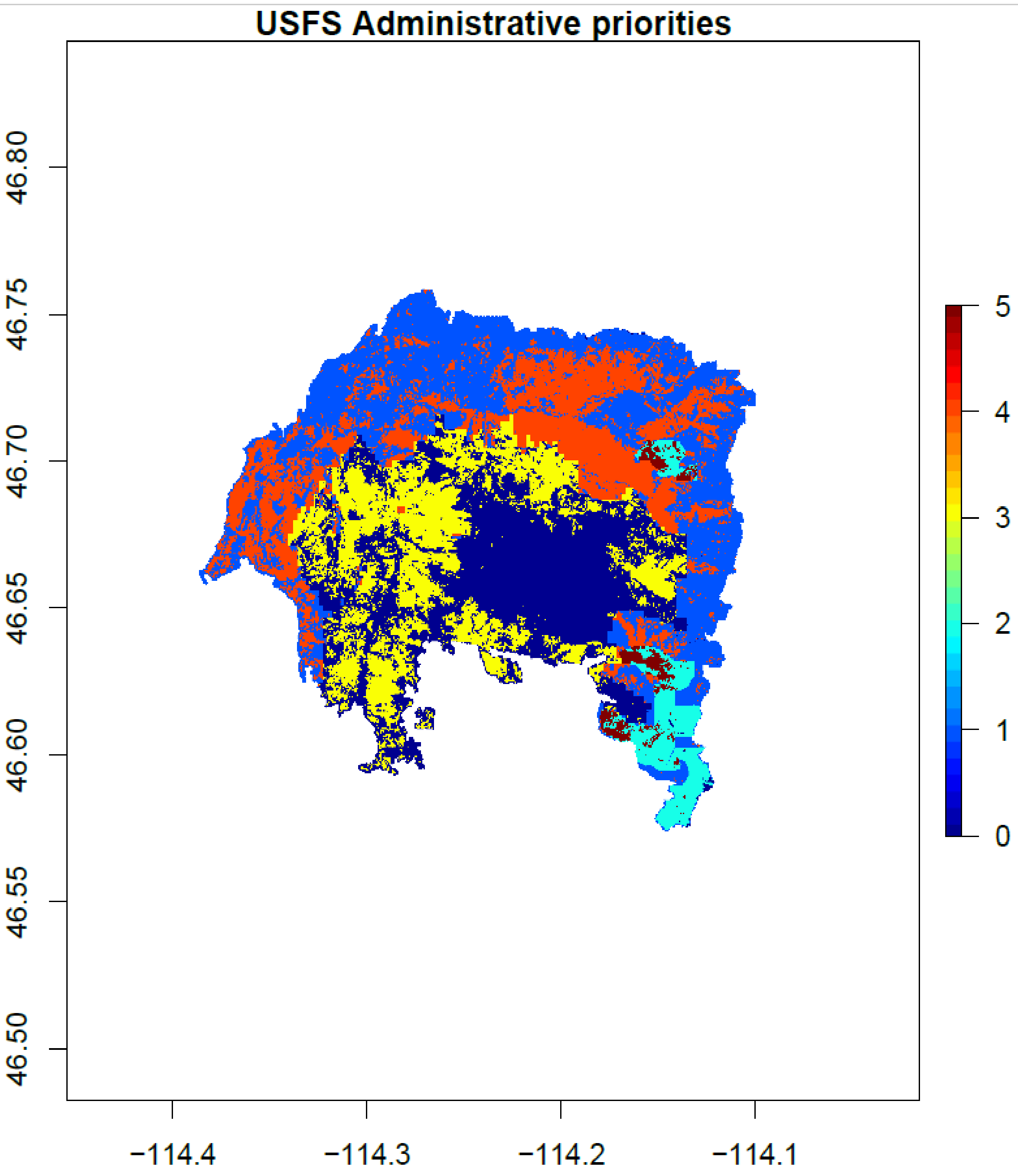


USFS reforestation decision matrix (Ellen Jungck)
- some past activities require reforestation by law

These situations will trump other factors (climate, regen. Potential, cost).

- Severe fire + refo + timberbase = 5 (high priority)
- Severe fire + refo + timberbase = 4 (moderate)
- Unique cases (not in timber base municipal water) = 3
- Low severity + refo_needs = 2
- Low severity + no refo_needs = 1

- 30 meter raster of this prioritization provided for every fire “USFS_admin_priorities.tif”



Planned additions in 2021

- Future Land surface temperature
- Future climatic water balance deficit
- Species-specific distance to seed calculations

- Detailed plant hydraulics model that predicts seedling mortality

New Phytologist

Research

Coupled ecohydrology and plant hydraulics modeling predicts ponderosa pine seedling mortality and lower treeline in the US Northern Rocky Mountains

Caelan Simeone[1,6], Marco P. Maneta[1], Zachary A. Holden[2,3], Gerard Sapes[4], Anna Sala[4] and Solomon Z. Dobrowski[5]

[1]Department of Geosciences, University of Montana, Missoula, MT 59812, USA; [2]US Forest Service, Region 1, Missoula, MT 59807, USA; [3]Department of Geography, University of Montana, Missoula, MT 59812, USA; [4]Division of Biological Sciences, Ecology, and Evolution, University of Montana, Missoula, MT 59812, USA; [5]Department of Forest Management, University of Montana, Missoula, MT 59812, USA; [6]Present address: US Geological Survey, New England Water Science Center, Augusta, ME 04330, USA