The Normal Fire Environment

Modeling Large Wildfire Suitability using Past, Present, and Future Climate Normals

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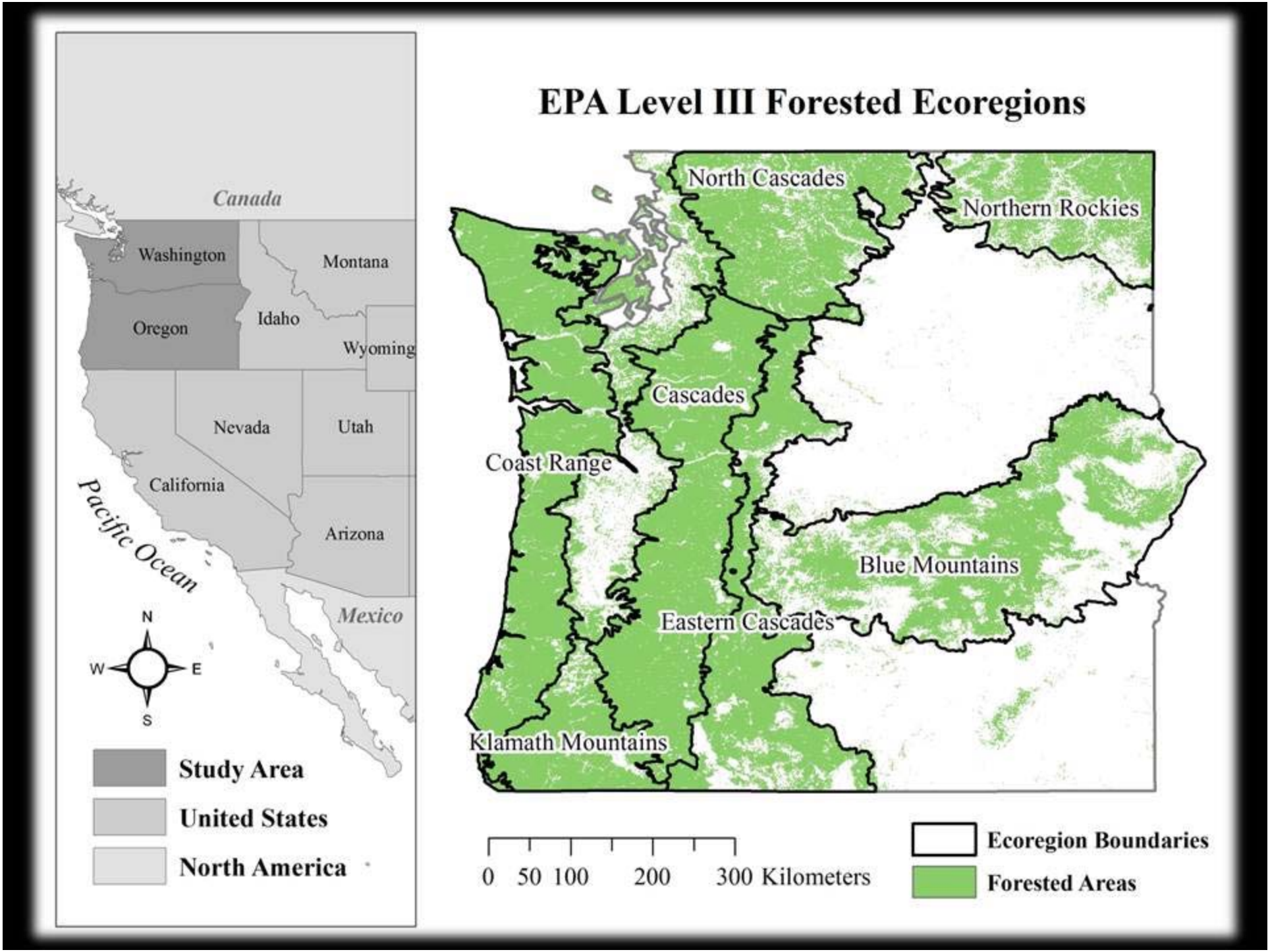
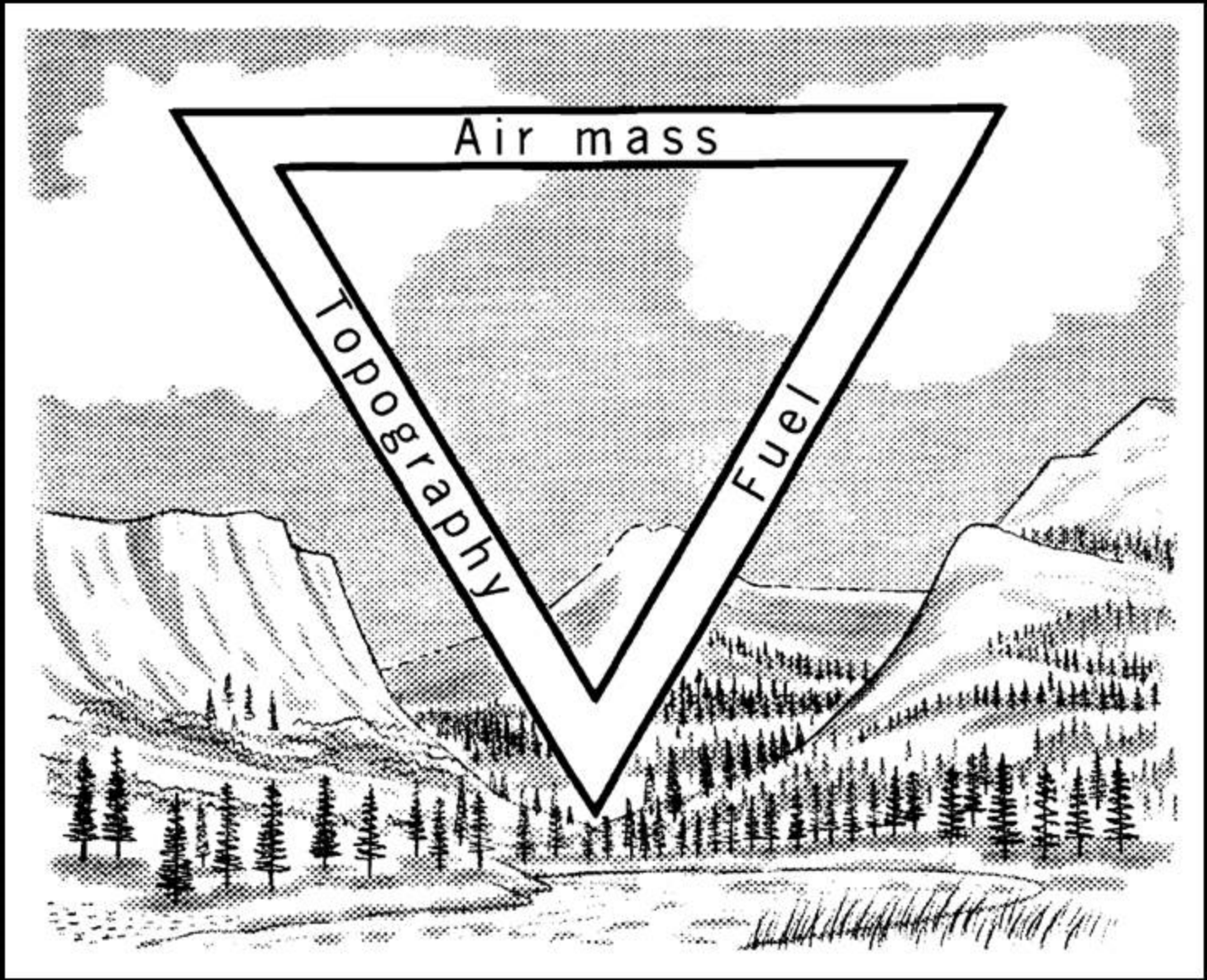
Andrew Yost (ODF)


EPA Level III Forested Ecoregions
Canada
Washington
Montana
Oregon
Idaho
Wyoming
Nevada
Utah
California
Arizona
Pacific Ocean
Mexico
N
W
E
S
Study Area
United States
North America
North Cascades
Northern Rockies
Cascades
Coast Range
Blue Mountains
Eastern Cascades
Klamath Mountains
0 50 100 200 300 Kilometers
Ecoregion Boundaries
Forested Areas

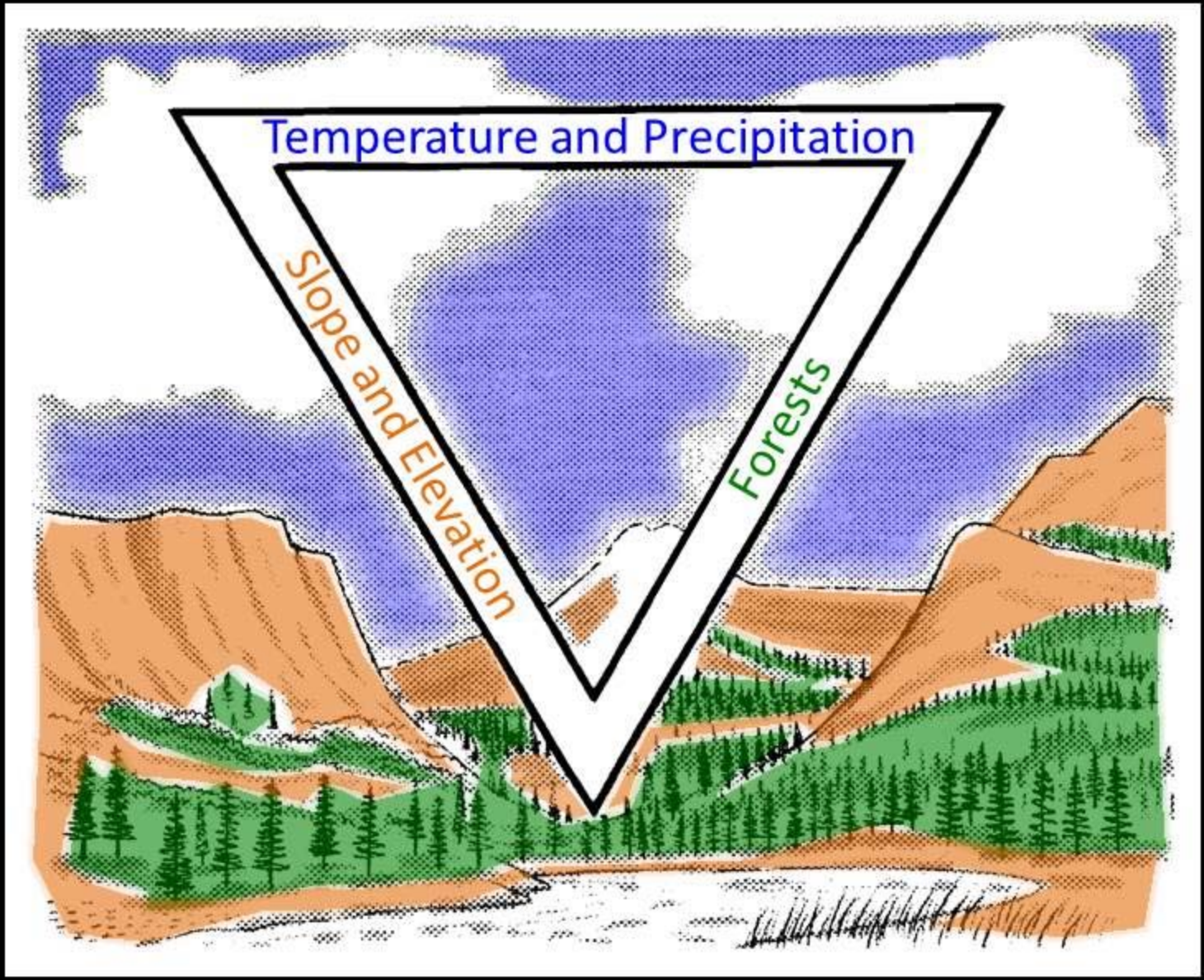
The Fire Environment

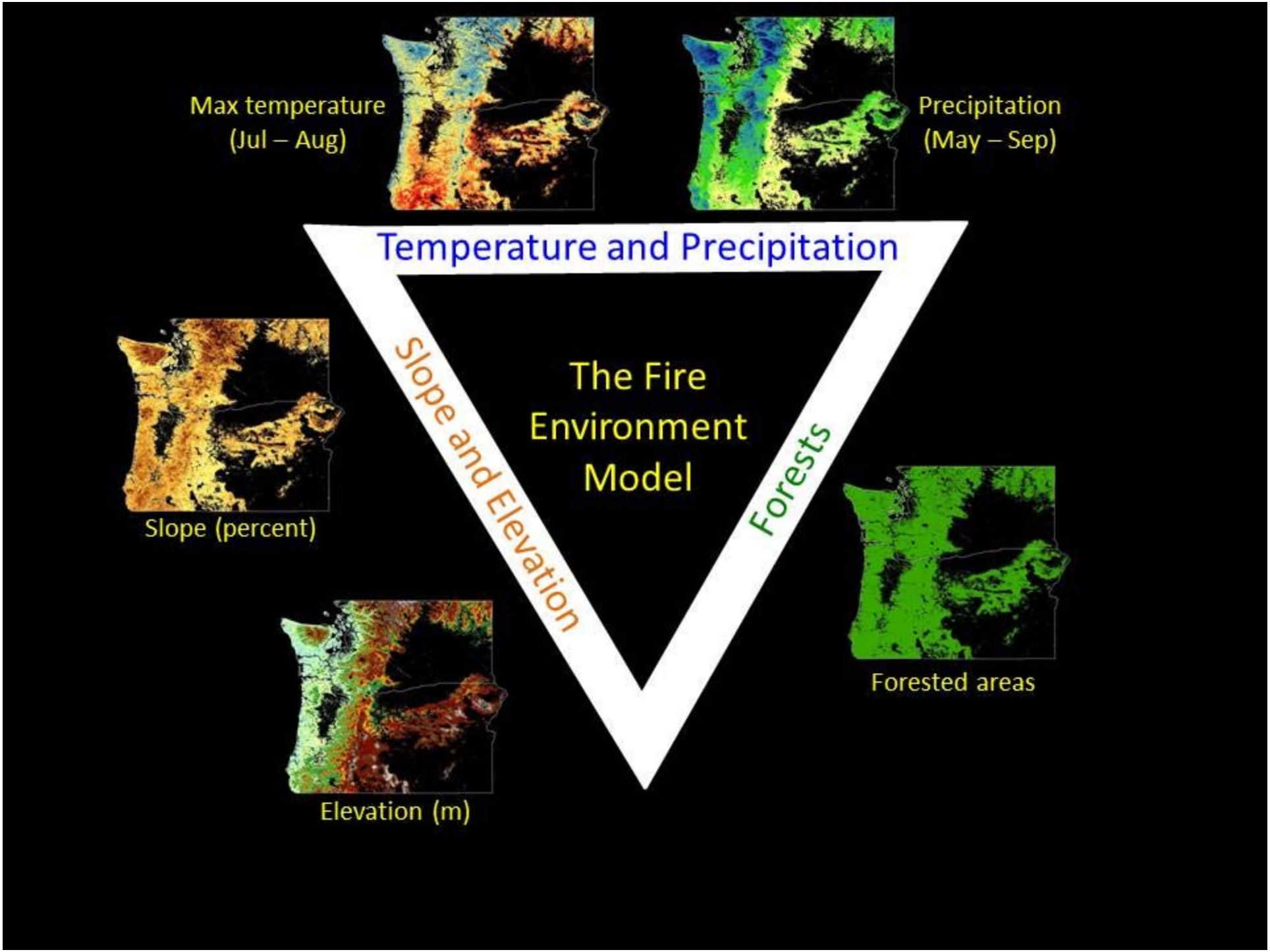
Countryman 1972 – The Fire Environment Concept



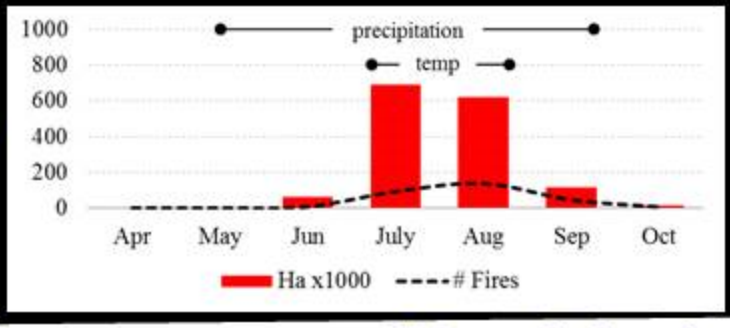
The Fire Environment

Large (≥100 ac) Wildfire Suitability Baseline Model (1971-2000)




Max temperature
(Jul – Aug)
Precipitation
(May – Sep)
Temperature and Precipitation
Slope and Elevation
Forests
The Fire
Environment
Model
Slope (percent)
Forested areas
Elevation (m)

Max temperature
(Jul – Aug)



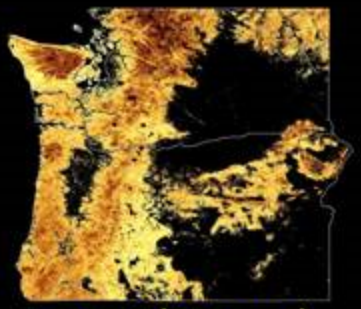
Precipitation
(May – Sep)

Temperature and Precipitation

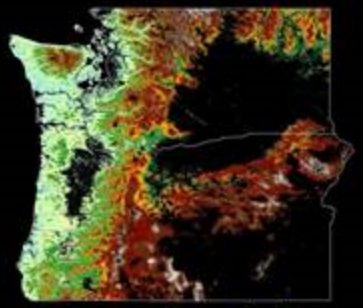
Slope and Elevation

Forests

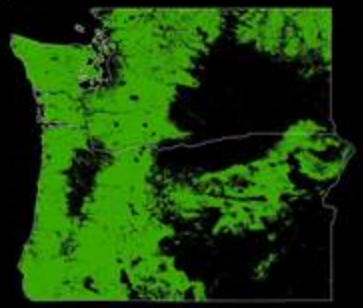
The Fire Environment Model



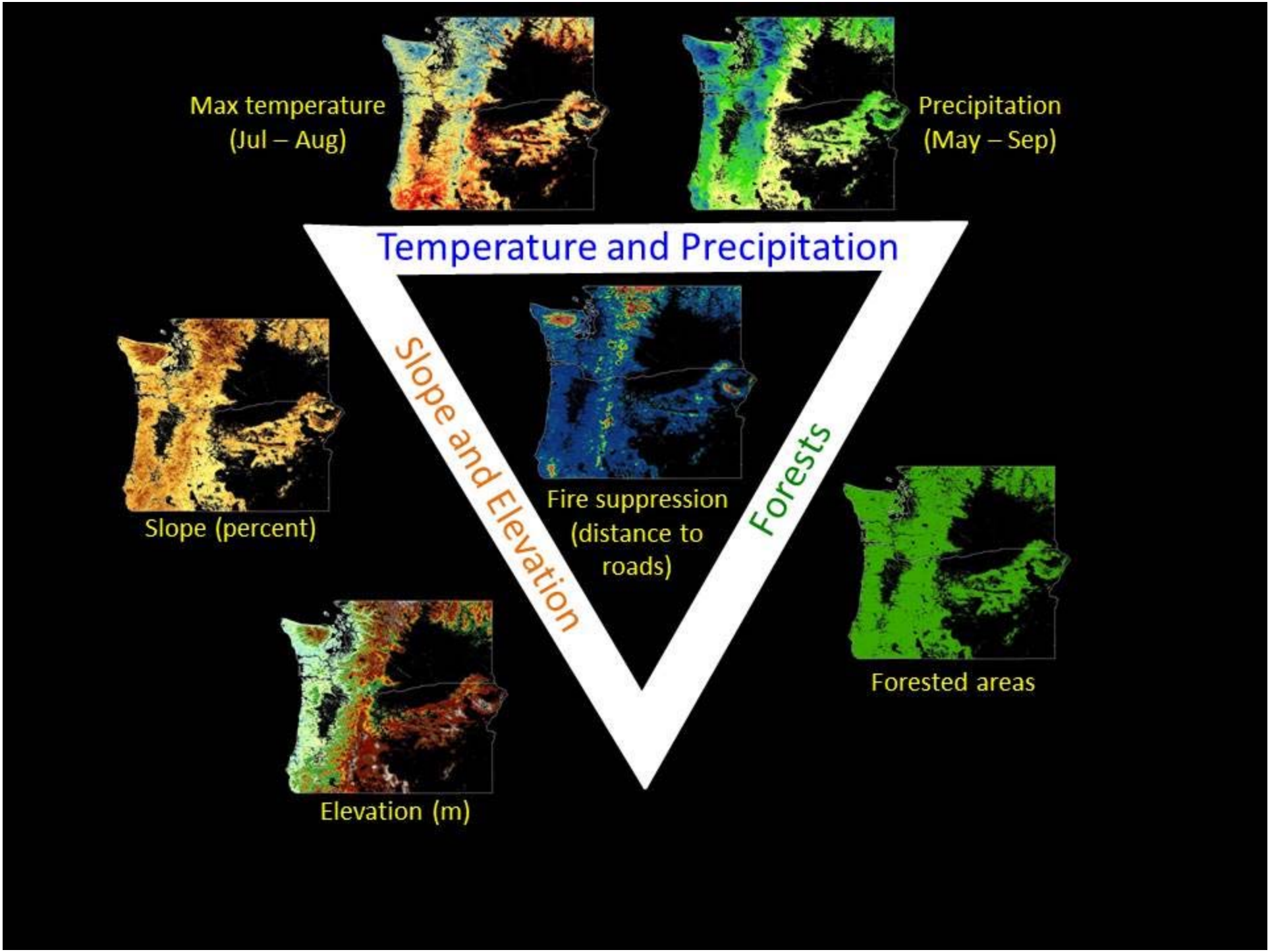
Slope (percent)

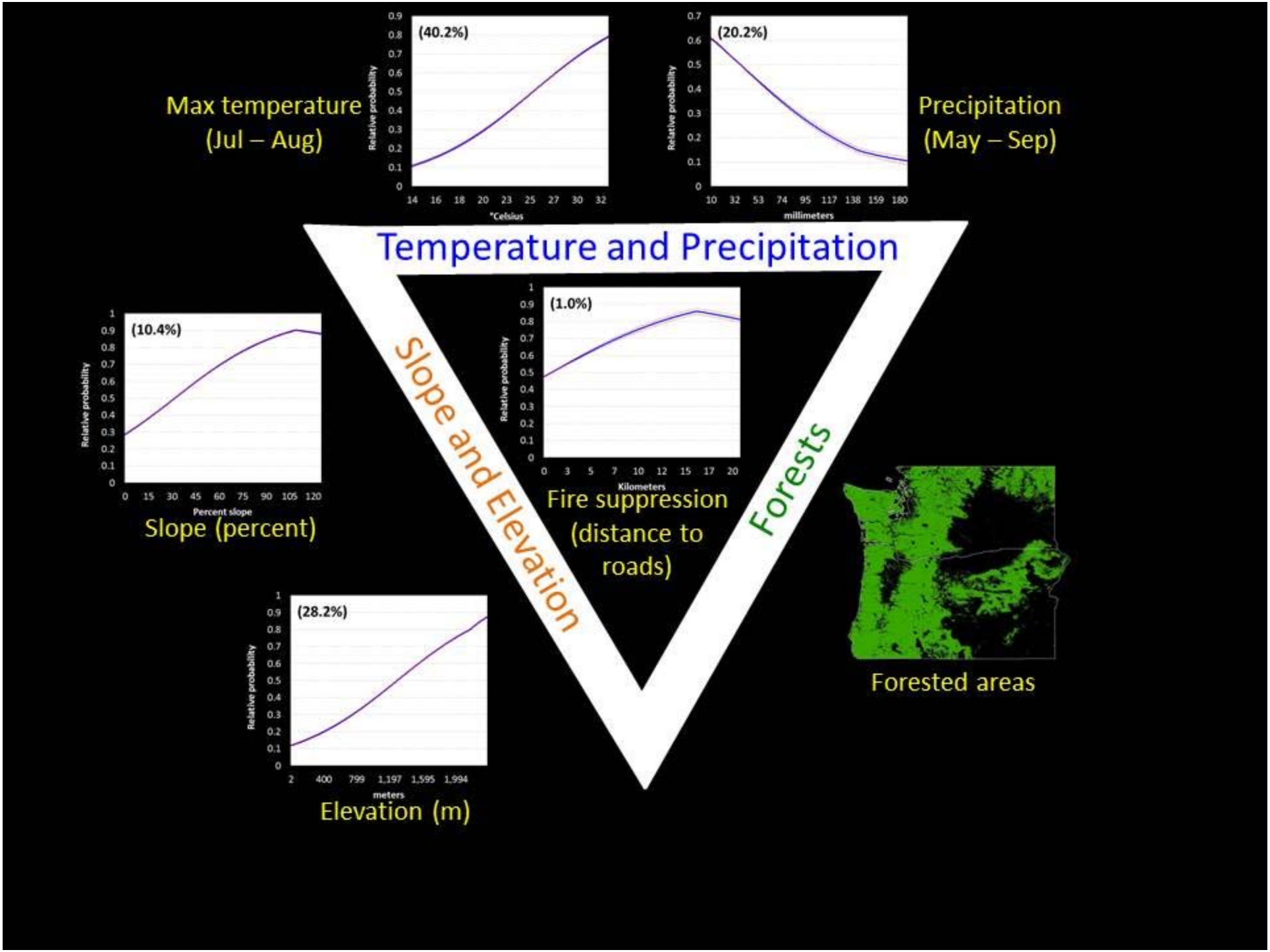


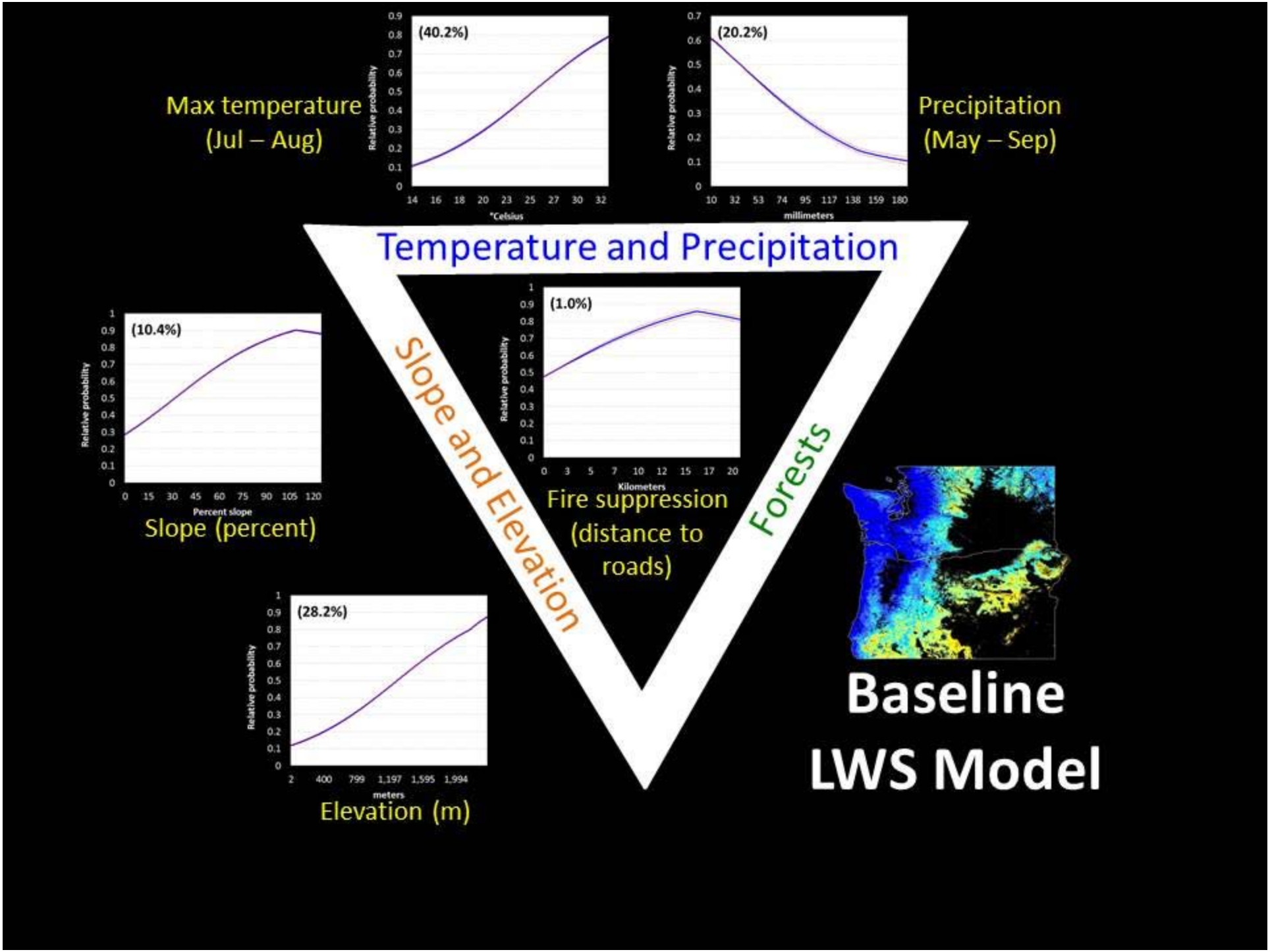
Elevation (m)

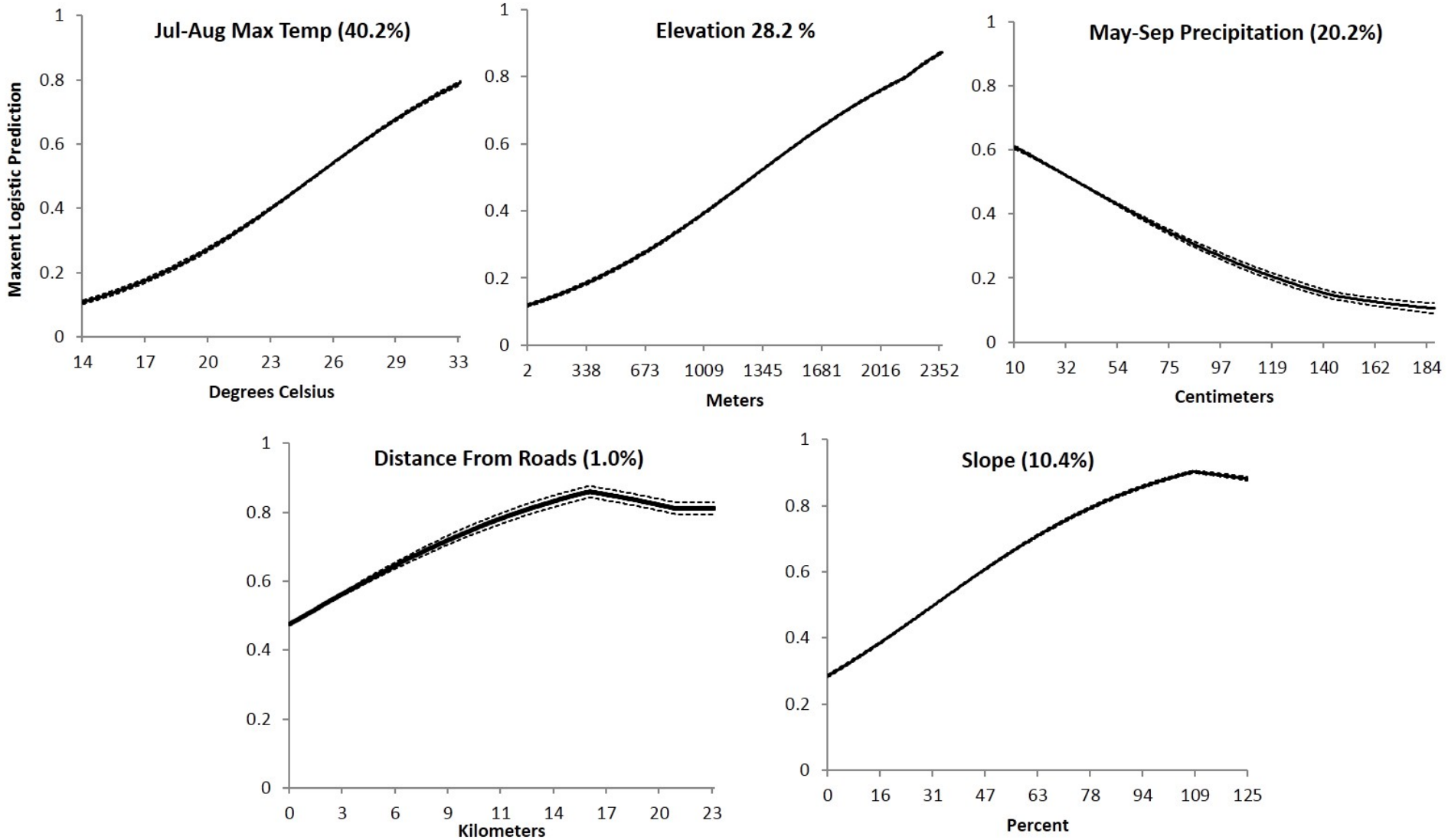


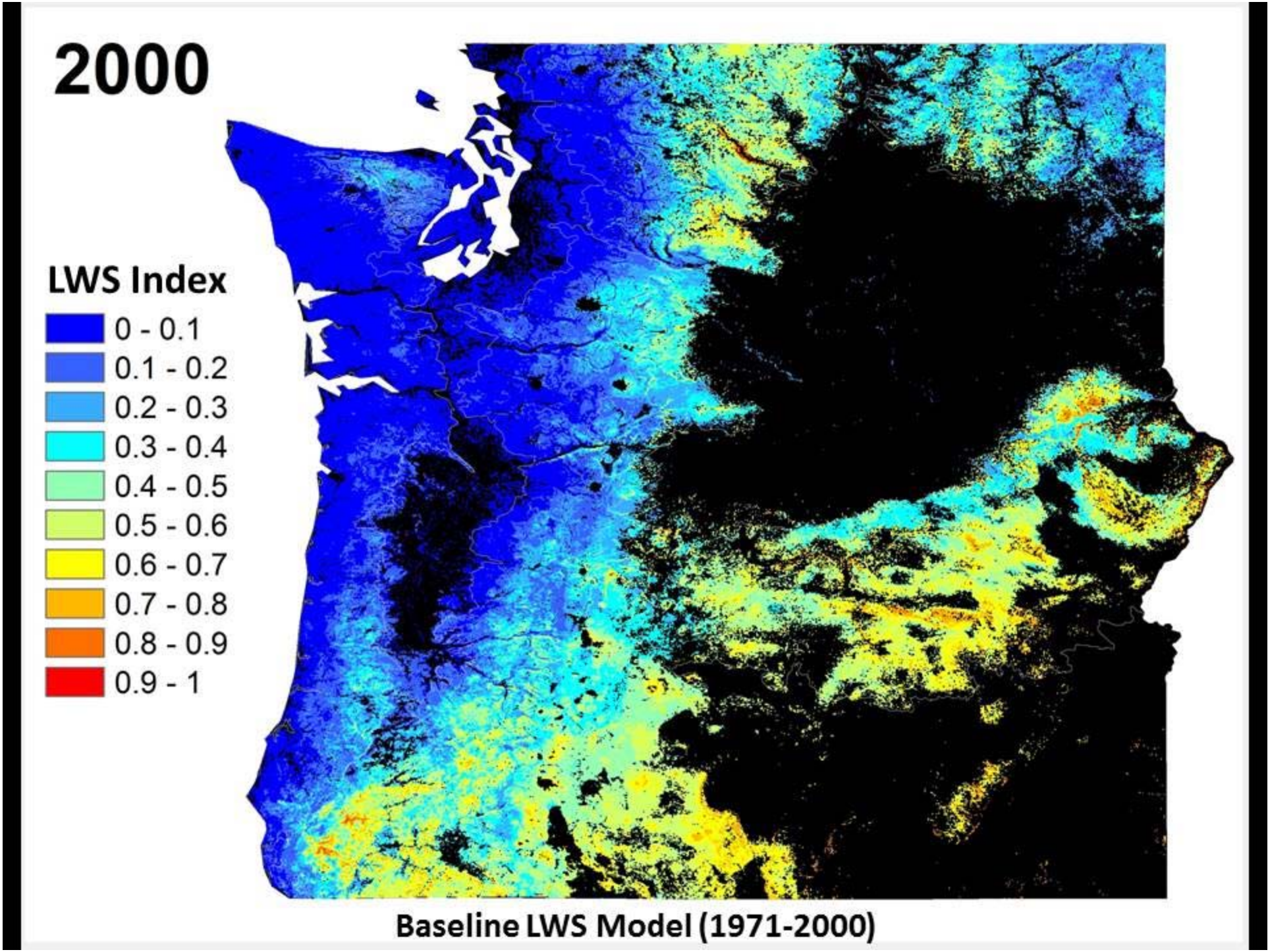
Forested areas

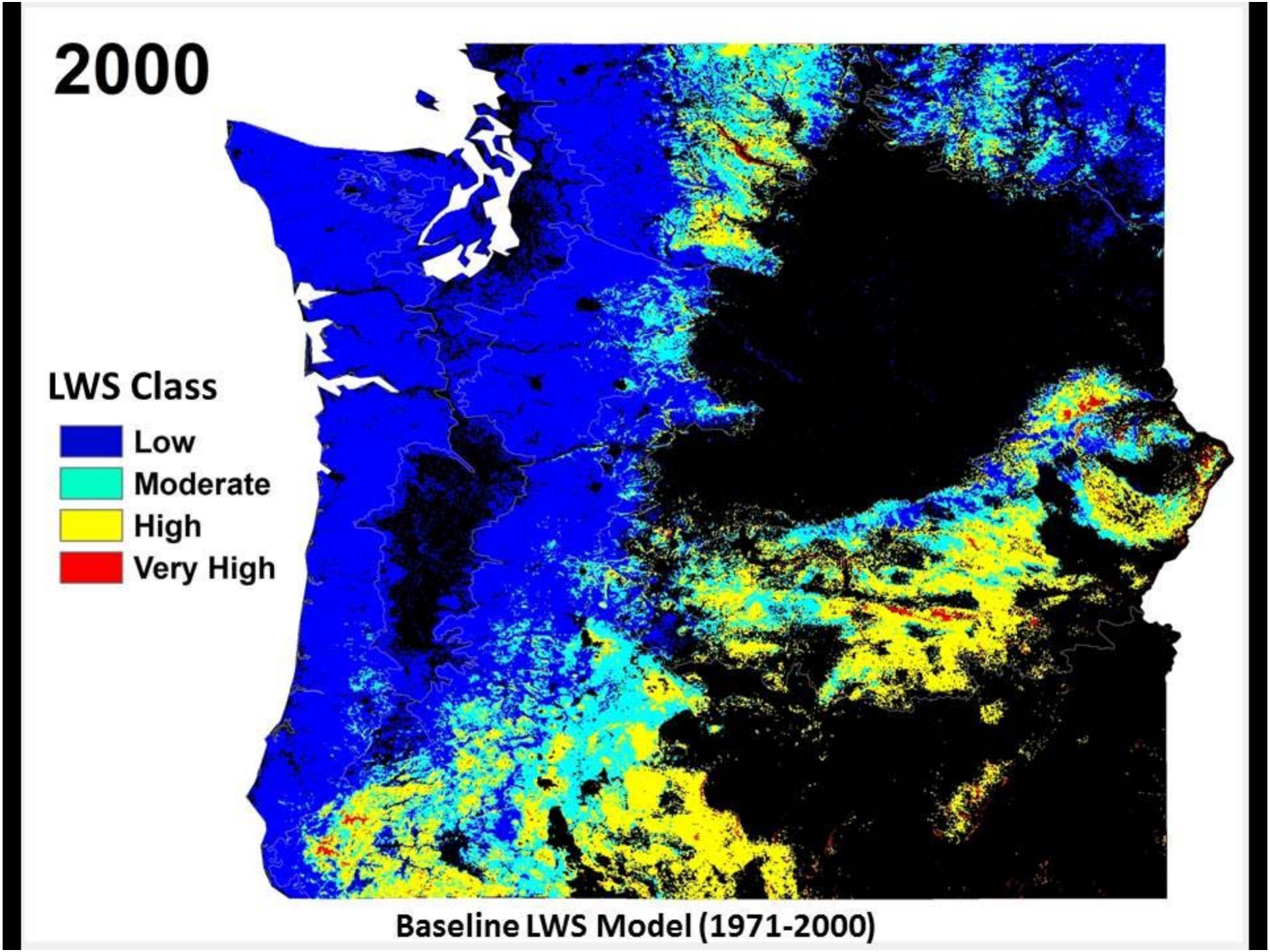

Max temperature
(Jul – Aug)
Precipitation
(May – Sep)
Temperature and Precipitation
Slope and Elevation
Forests
Slope (percent)
Fire suppression
(distance to
roads)
Forested areas
Elevation (m)


Max temperature
(Jul – Aug)
(40.2%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
14 16 18 20 23 25 27 30 32
°Celsius
(20.2%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
10 32 53 74 95 117 138 159 180
millimeters
Precipitation
(May – Sep)
Temperature and Precipitation
Slope and Elevation
Forests
(10.4%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 15 30 45 60 75 90 105 120
Percent slope
Slope (percent)
(1.0%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 3 5 7 10 12 15 17 20
Kilometers
Fire suppression
(distance to
roads)
Forested areas
(28.2%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
2 400 799 1,197 1,595 1,994
meters
Elevation (m)


Max temperature
(Jul – Aug)
(40.2%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
14 16 18 20 23 25 27 30 32
°Celsius
(20.2%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
10 32 53 74 95 117 138 159 180
millimeters
Precipitation
(May – Sep)
Temperature and Precipitation
Slope and Elevation
Forests
(10.4%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 15 30 45 60 75 90 105 120
Percent slope
Slope (percent)
(1.0%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 3 5 7 10 12 15 17 20
Kilometers
Fire suppression
(distance to
roads)
(28.2%)
Relative probability
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
2 400 799 1,197 1,595 1,994
meters
Elevation (m)
Baseline
LWS Model

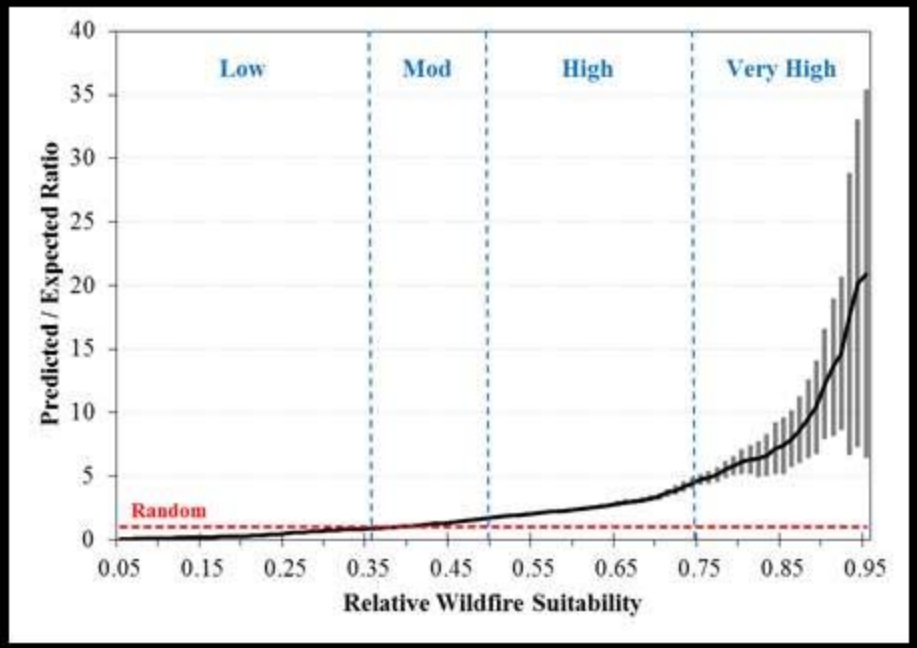

Jul-Aug Max Temp (40.2%)
Maxent Logistic Prediction
Degrees Celsius
Elevation 28.2 %
Meters
May-Sep Precipitation (20.2%)
Centimeters
Distance From Roads (1.0%)
Kilometers
Slope (10.4%)
Percent


2000
LWS Index
0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
Baseline LWS Model (1971-2000)

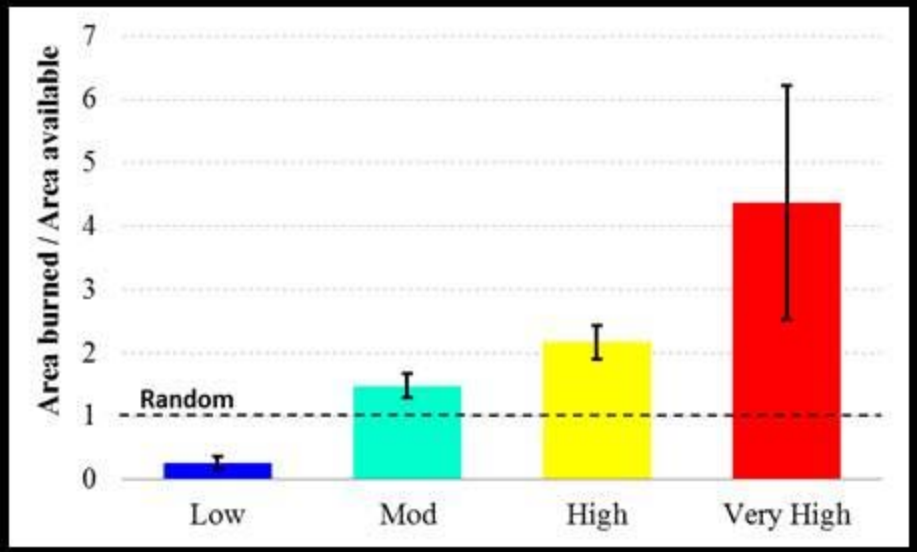

2000
LWS Class
Low
Moderate
High
Very High
Baseline LWS Model (1971-2000)

Model Classification and Evaluation

Bootstrap Test
Random 50% of large wildfire locations (1971-2000) for 50 replicates



Independent Test
All large wildfire locations (2001-2013)



Examples of this Type of Modeling

Davis et al. 2011 – PNW-GTR-850

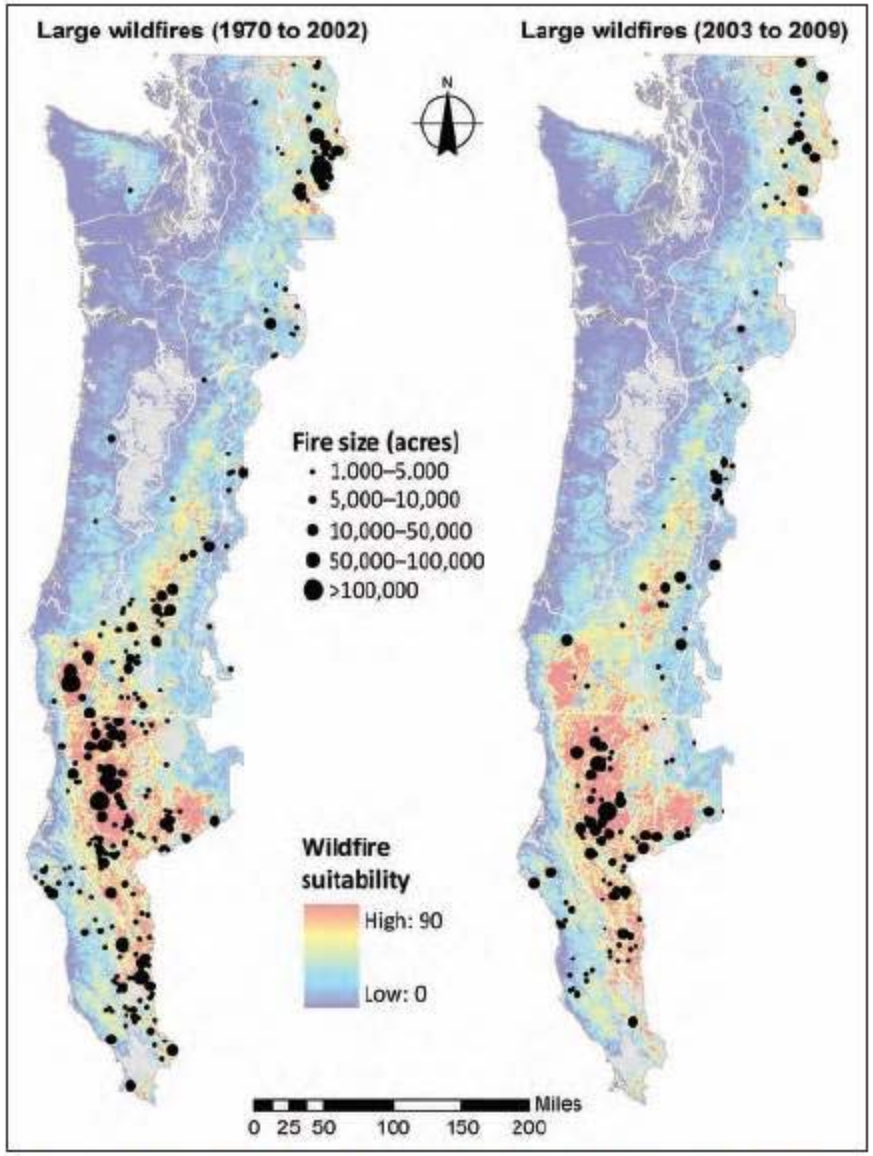


Figure 4-7—The full gradient version of the wildfire suitability model showing locations of large wildfires used to train the model (left) and locations of large wildfires that occurred after 2002 (right) that served as our independent testing data.

Examples of this Type of Modeling

Parisien et al. 2009 - Ecological Monographs

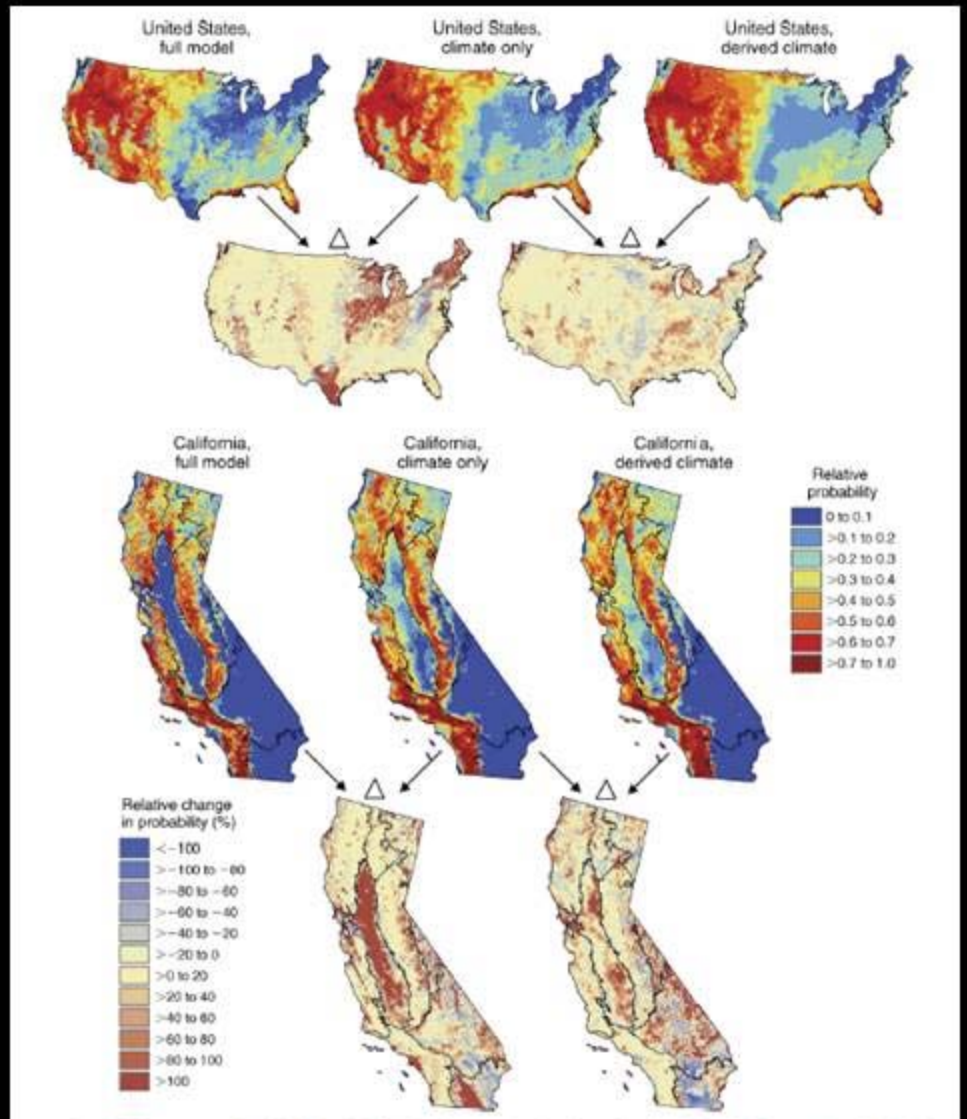
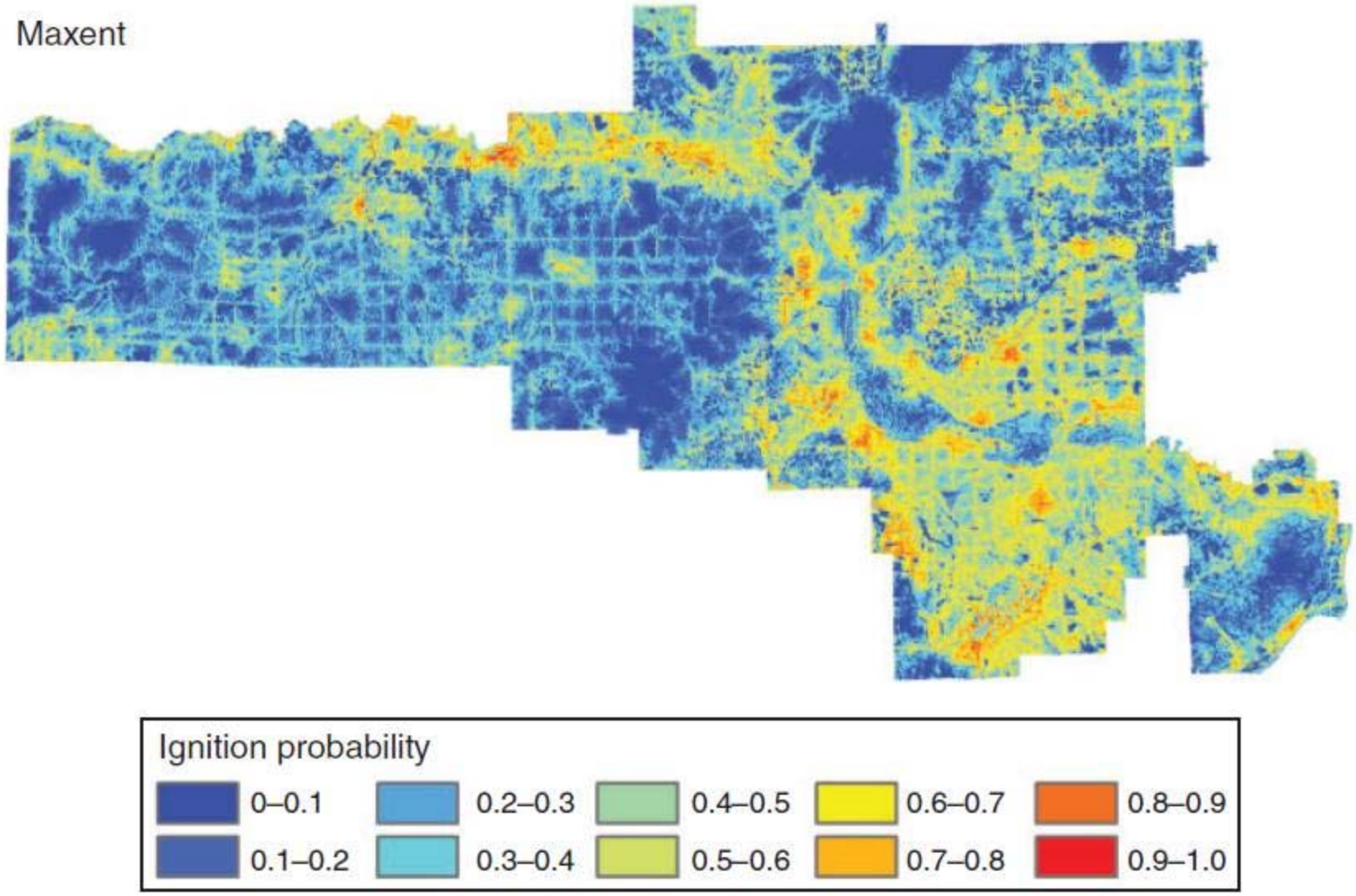


FIG. 4. Maxent outputs for the U.S. and California study areas, based on inputs from the full model, climate-only, and derived-climate scenarios (see *Methods*) and the relative difference (indicated by "delta" [Δ] symbols) between output predictions as expressed in relative change in probability (for "climate only" minus "full," and "derived climate" minus "climate only").

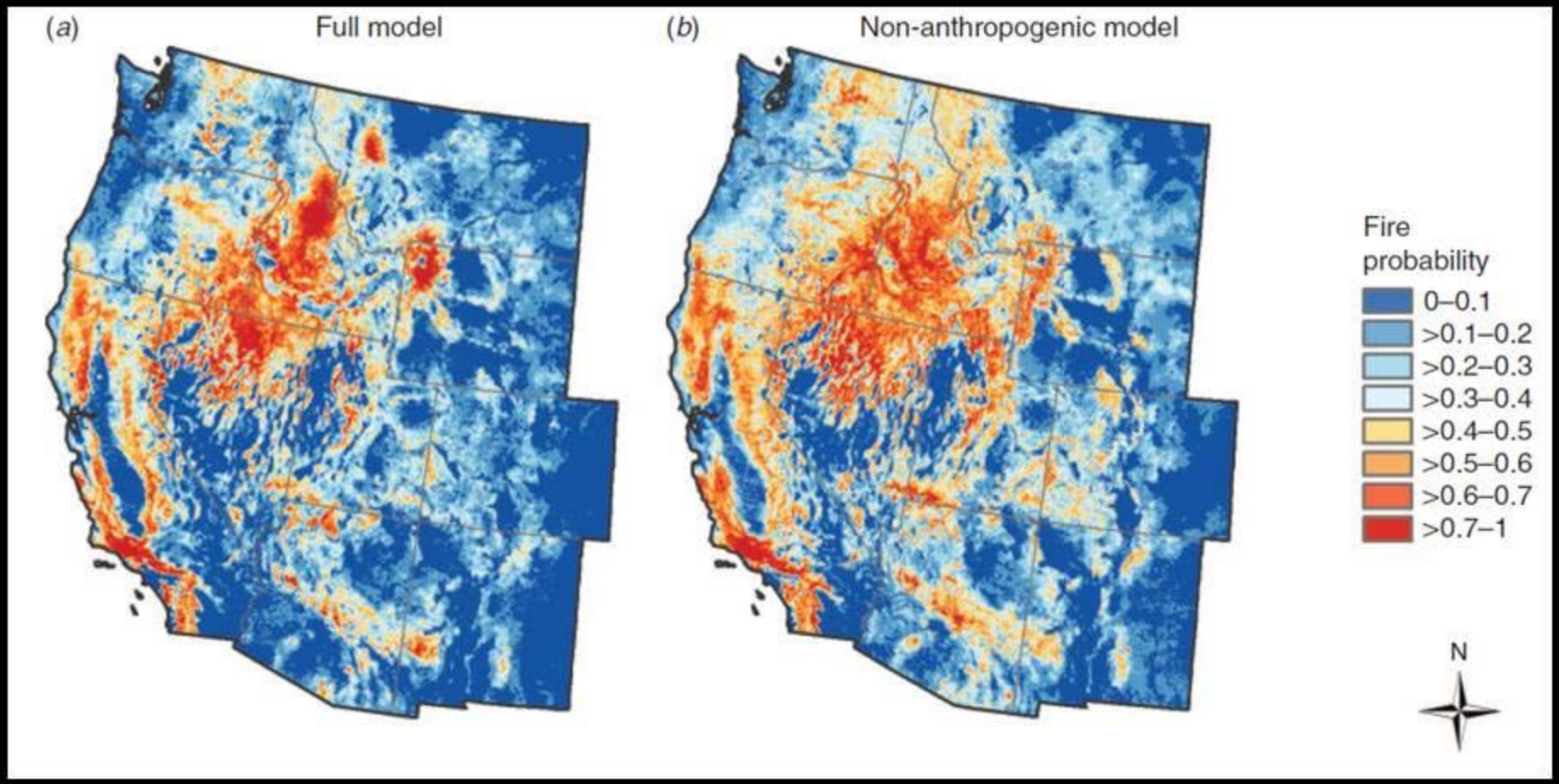
Examples of this Type of Modeling

Bar Massada et al. 2011 – International Journal of Wildland Fire



Examples of this Type of Modeling

Parisien et al. 2012 – International Journal of Wildland Fire



Examples of this Type of Modeling

Syphard et al. 2013 – PLOS one

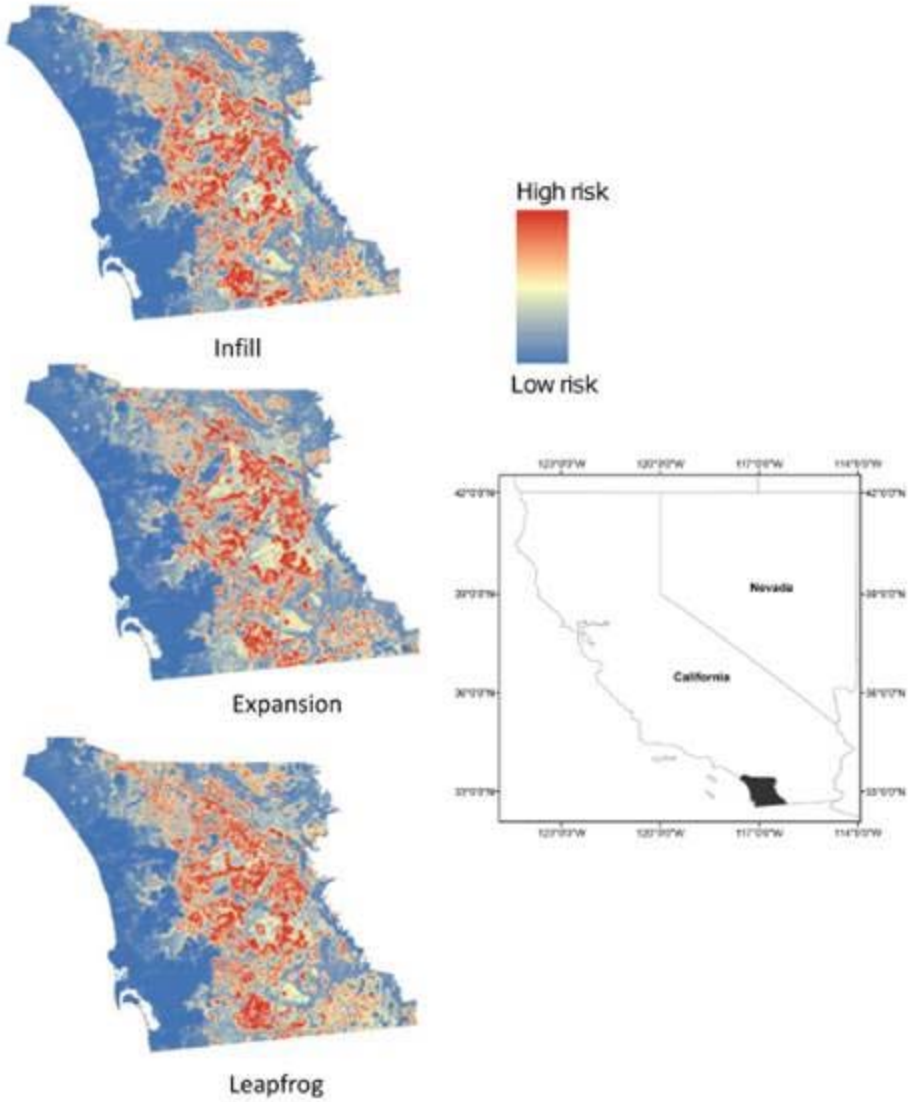
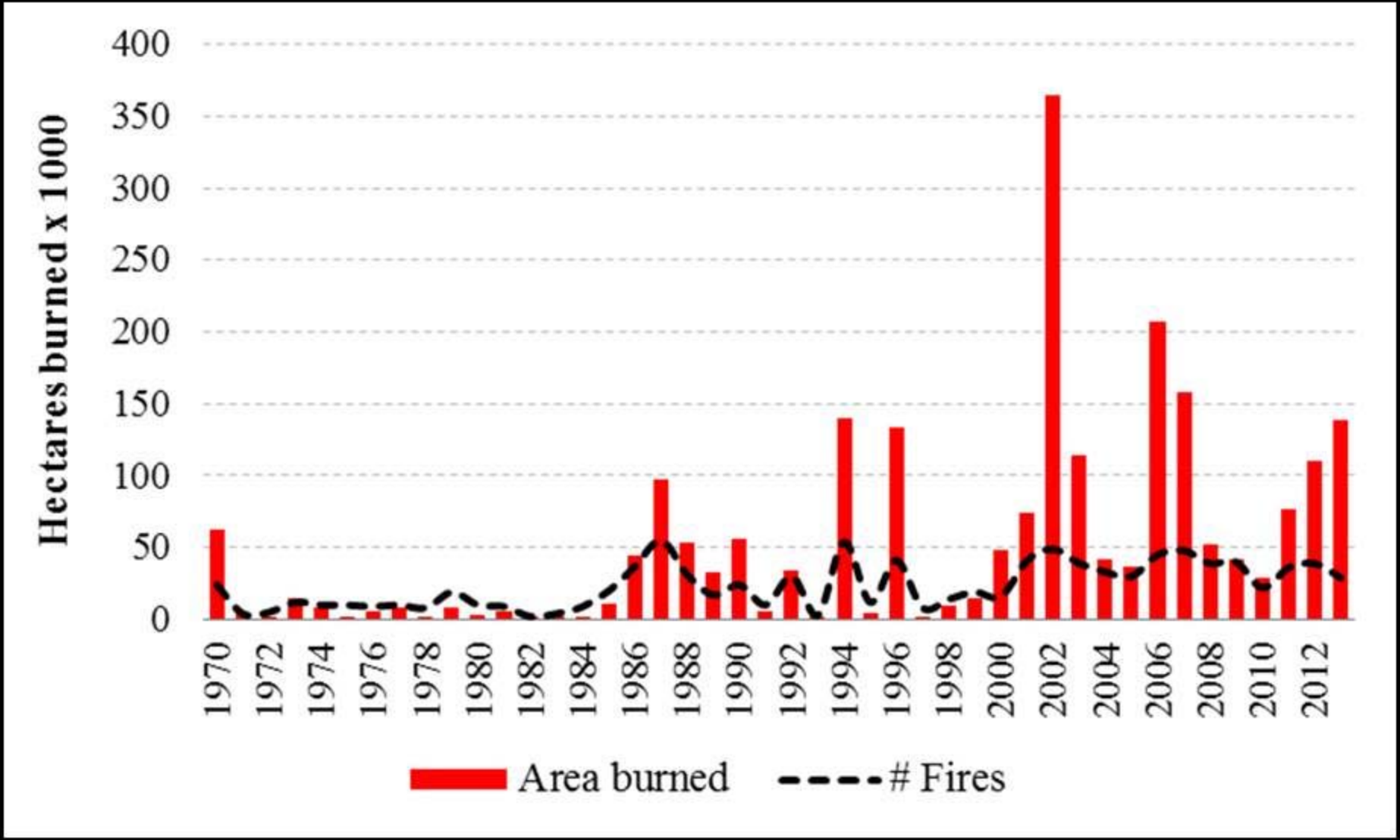


Figure 4. Maps of the study area showing projected wildfire risk at year 2030 for simulations of residential development under policies emphasizing infill, expansion, or leapfrog growth.
doi:10.1371/journal.pone.0071708.g004

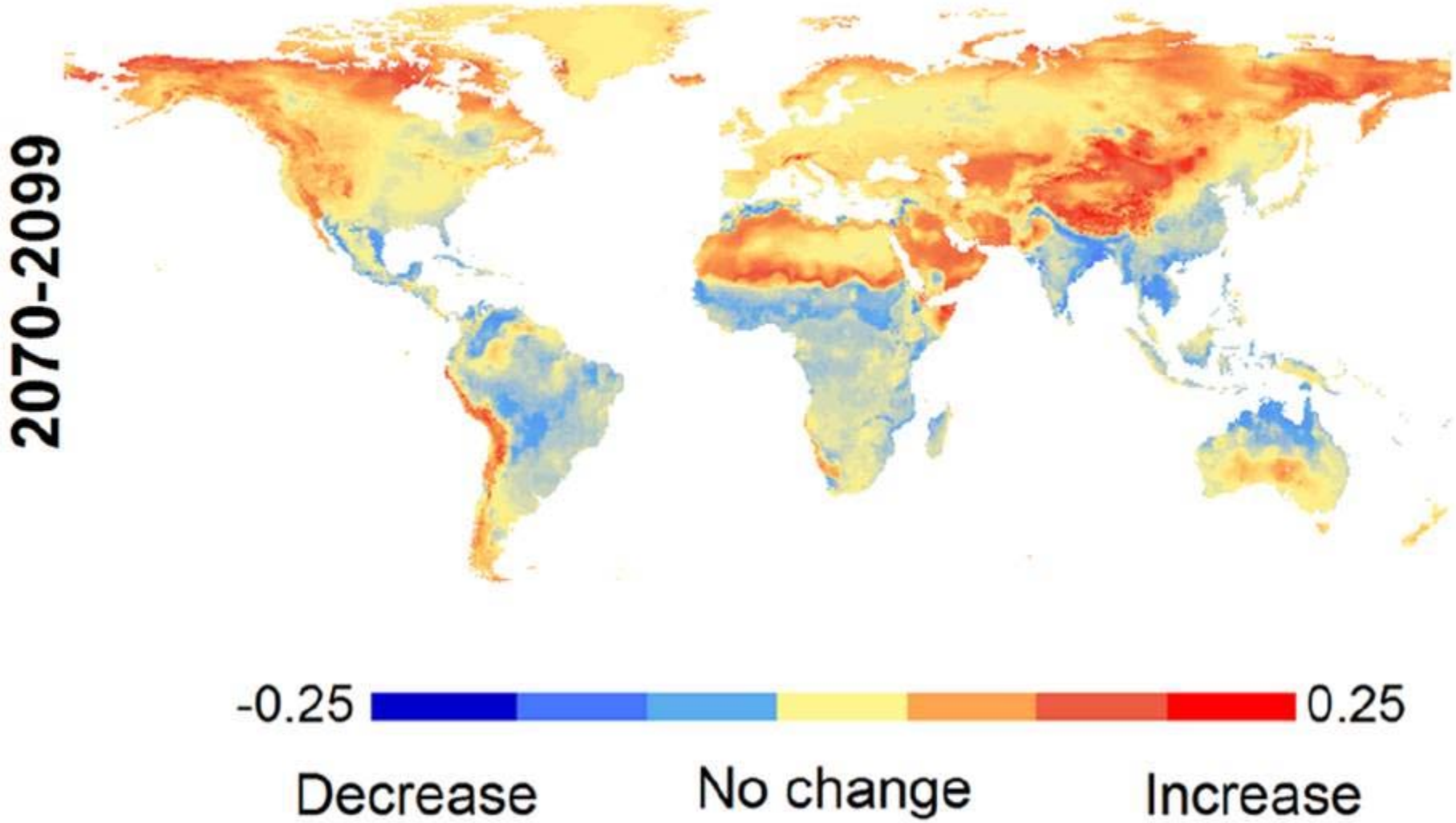
Climate Change and Large Wildfires

Trend in numbers of large widlfires and total area burned (1970-2013)



Climate Change and Wildfire Example

Mortiz et al. 2012 - Ecosphere



Climate Change and LWS Modeling

Representative Concentration Pathways

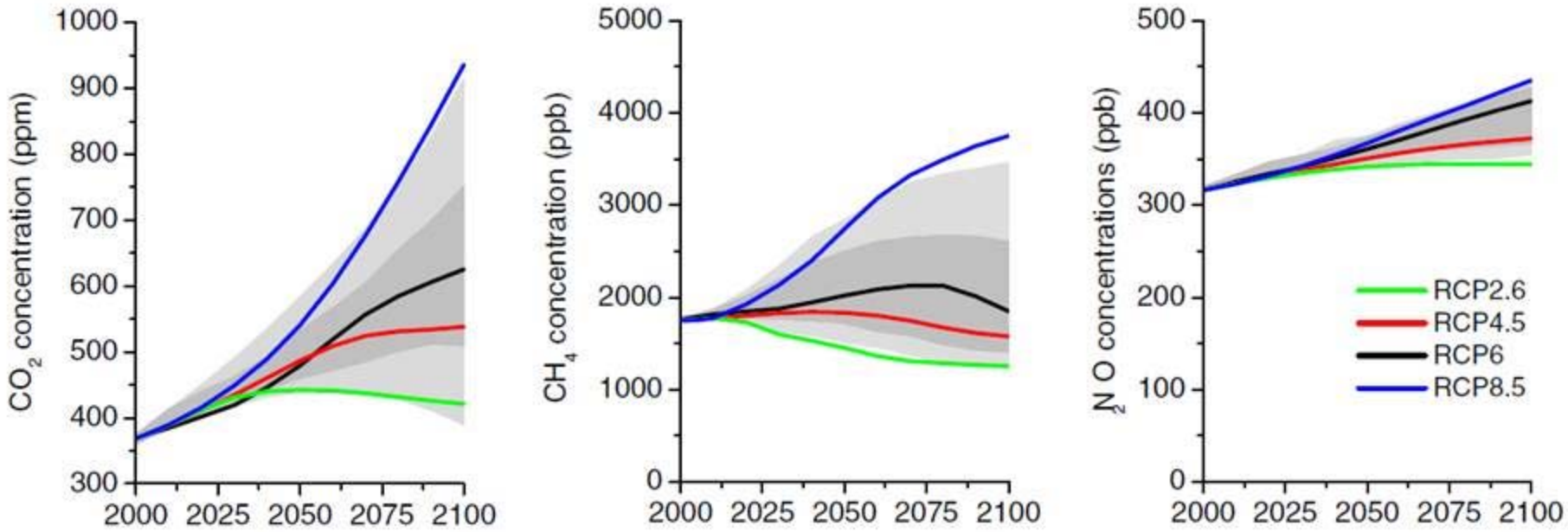


Fig. 9 Trends in concentrations of greenhouse gases. Grey area indicates the 98th and 90th percentiles (light/dark grey) of the recent EMF-22 study (Clarke et al. 2010)

	ipsl-cm5a-lr	access1-0	gfdl-esm2m	canesm2	cesm1-bgc	miroc5	miroc-esm-chem	hadgem2-cc	inmcm4	ipsl-cm5b-lr	cesm1-cam5	ipsl-cm5a-mr	bcc-csm1-1-m	ccsm4	csiro-mk3-6-0	giss-e2-r	gfdl-esm2g	hadgem2-ao	fio-esm	mri-cgcm3	bnu-esm	giss-e2-h-cc	mpi-esm-lr	bcc-csm1-1	gfdl-cm3	fgoals-g2	giss-e2-r-cc	cnrm-cm5	noresm1-m	hadgem2-es	cmcc-cm	miroc-esm	mpi-esm-mr	Counts
RCP26	✔		✔	✔		✔	✔				✔	✔		✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔			✔	✔		✔	✔	23
RCP45	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	33
RCP60	✔		✔			✔	✔				✔	✔		✔	✔	✔	✔	✔	✔					✔	✔				✔	✔		✔		17
RCP85	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	31
Historical	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	33

Applying Maxent Fire model to GCM data

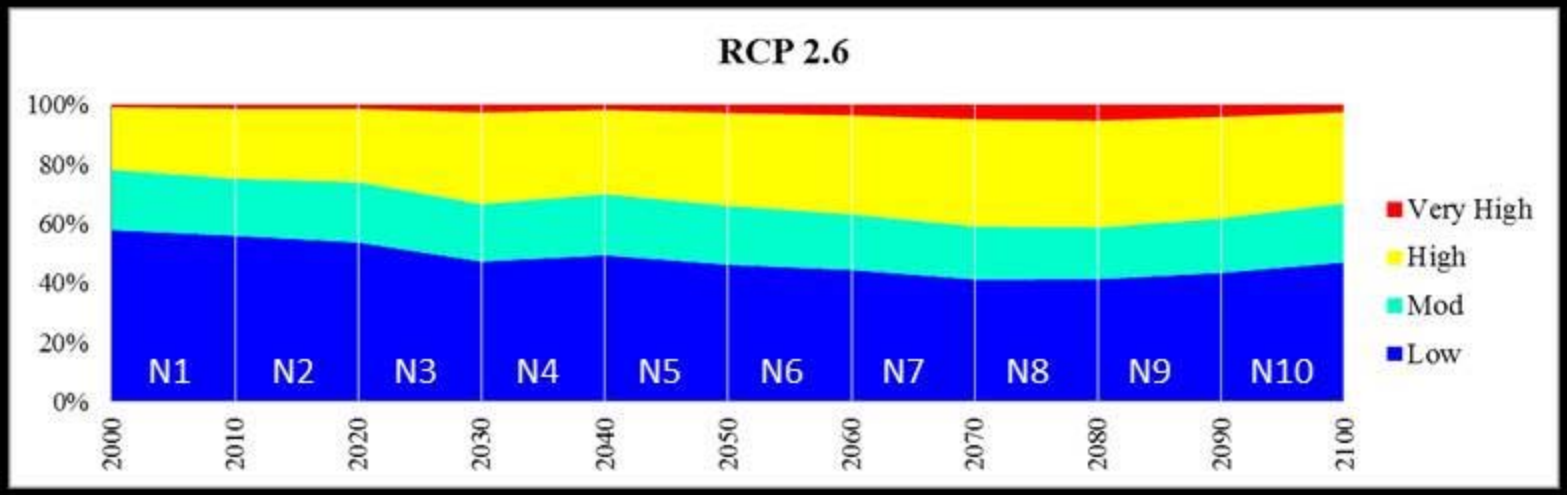
- 33 models
- 4 RCP scenarios

- 30 years moving window from 2010
- Every 10 years
- July+August / by month groups
- Spatial trend analysis

Climate Change and LWS Modeling

Representative Concentration Pathways

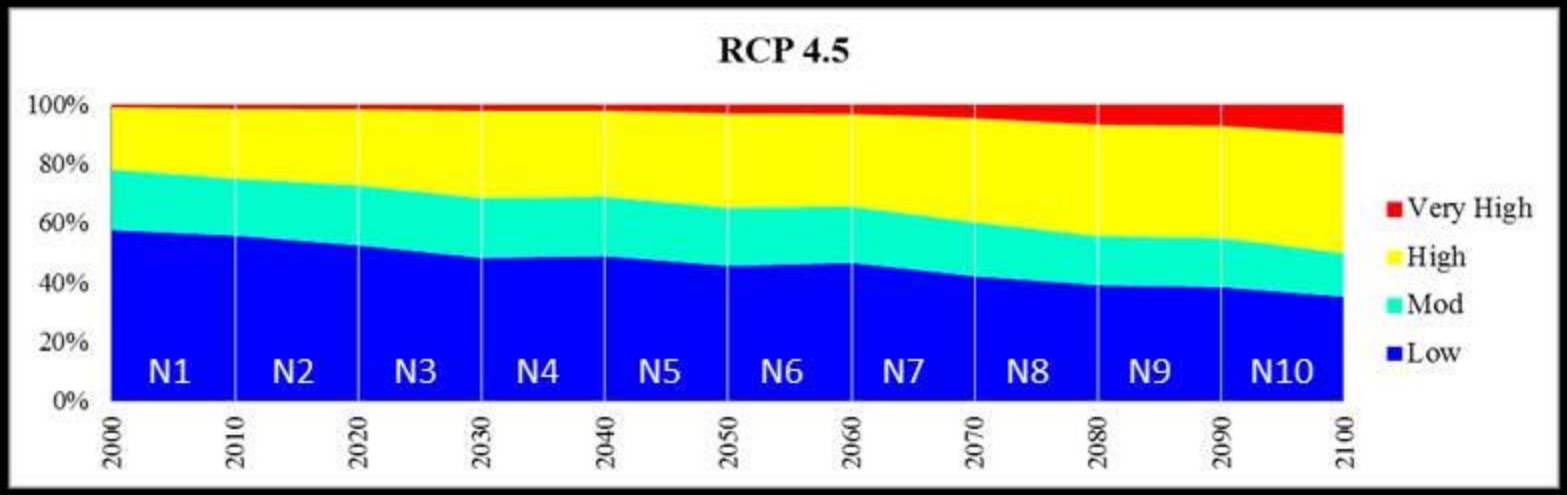
Forest LWS Class Distribution Trend – RCP 2.6



Climate Change and LWS Modeling

Representative Concentration Pathways

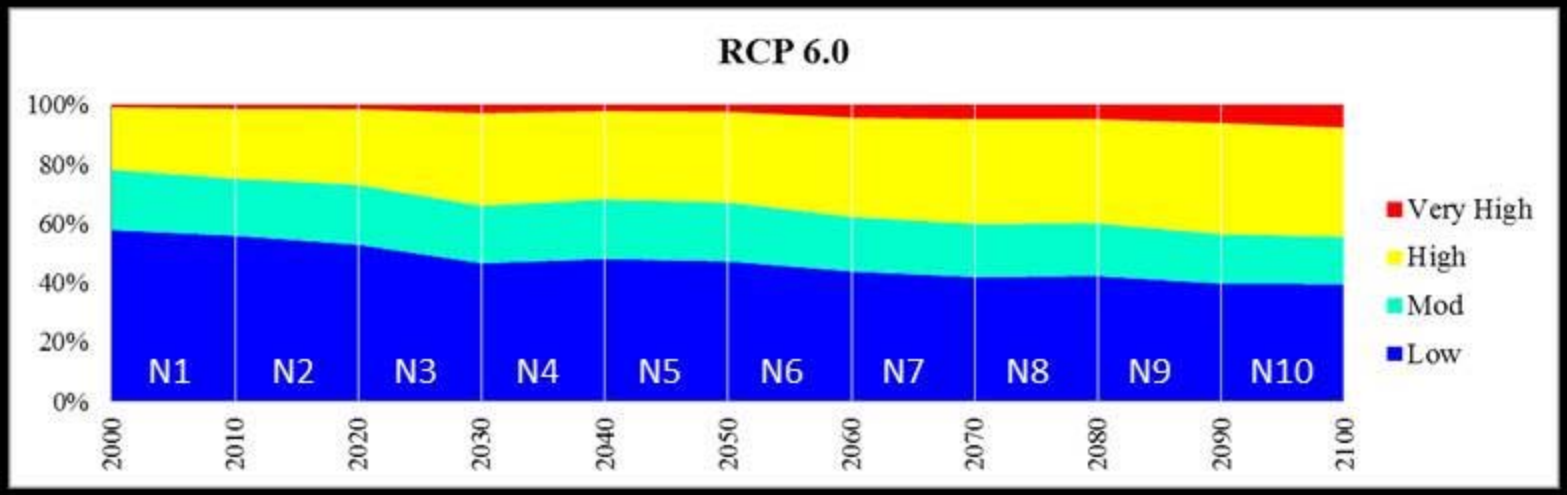
Forest LWS Class Distribution Trend – RCP 4.5



Climate Change and LWS Modeling

Representative Concentration Pathways

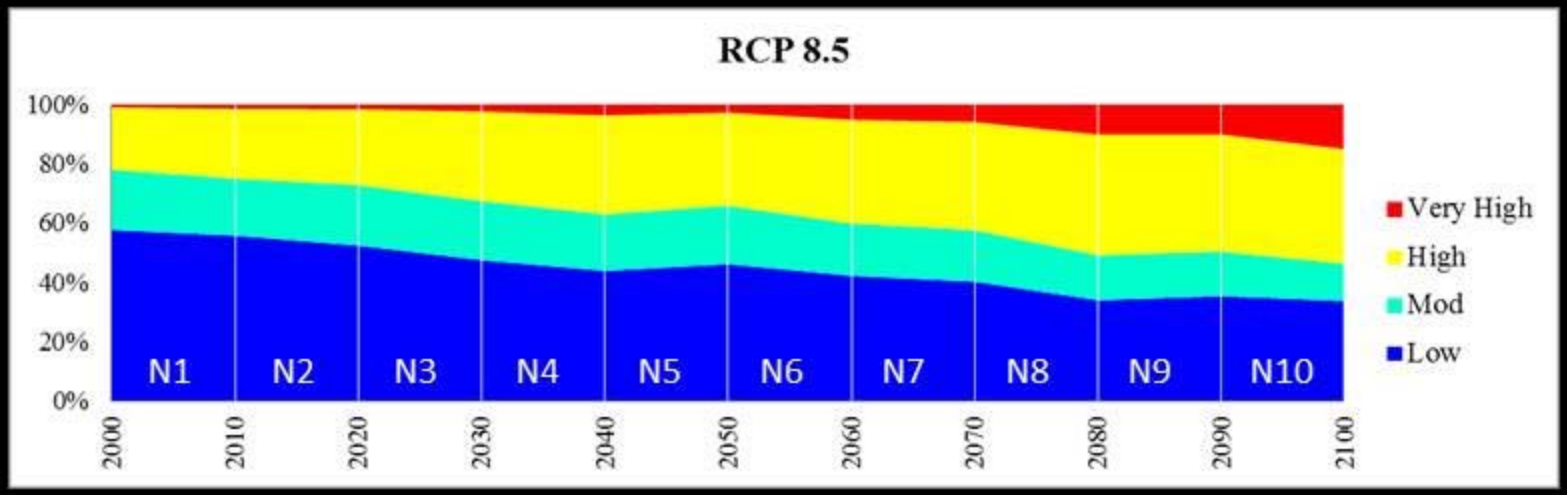
Forest LWS Class Distribution Trend – RCP 6.0



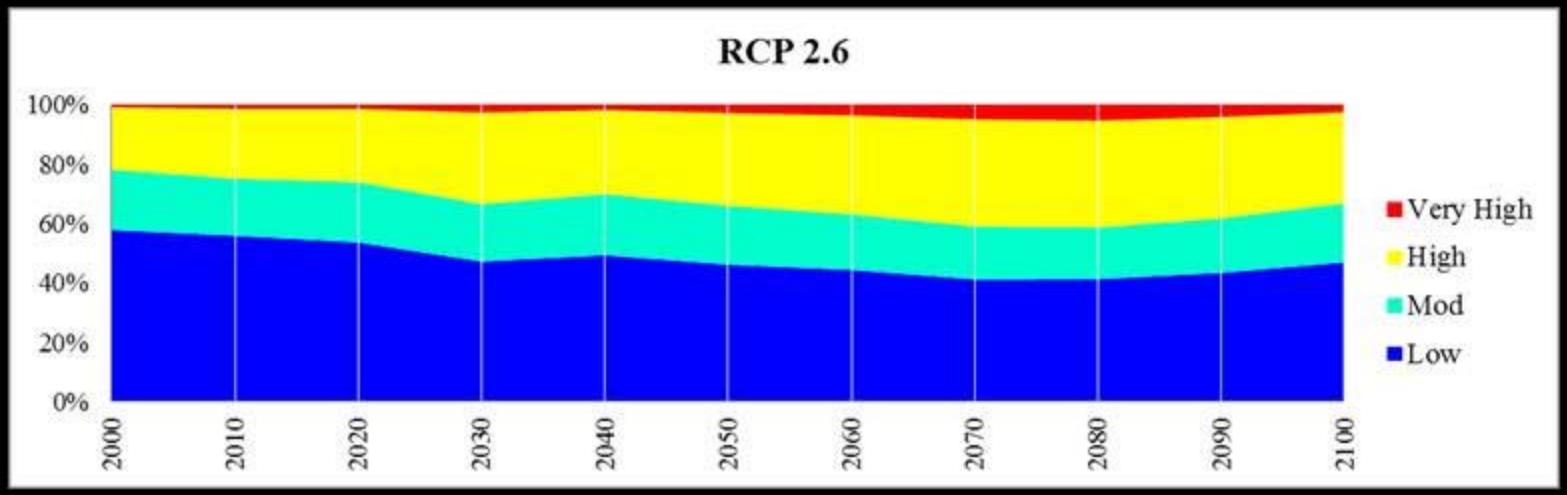
Climate Change and LWS Modeling

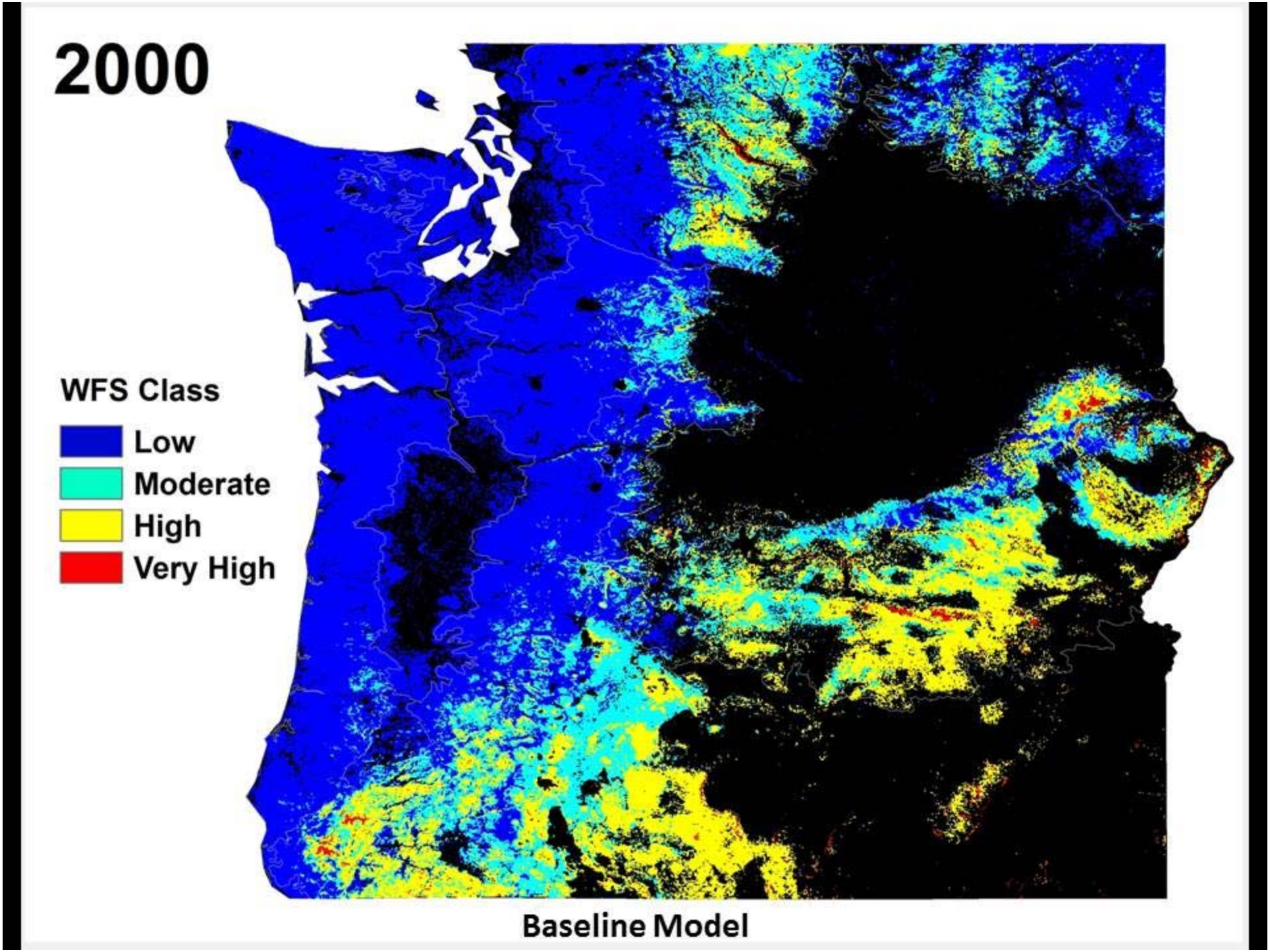
Representative Concentration Pathways

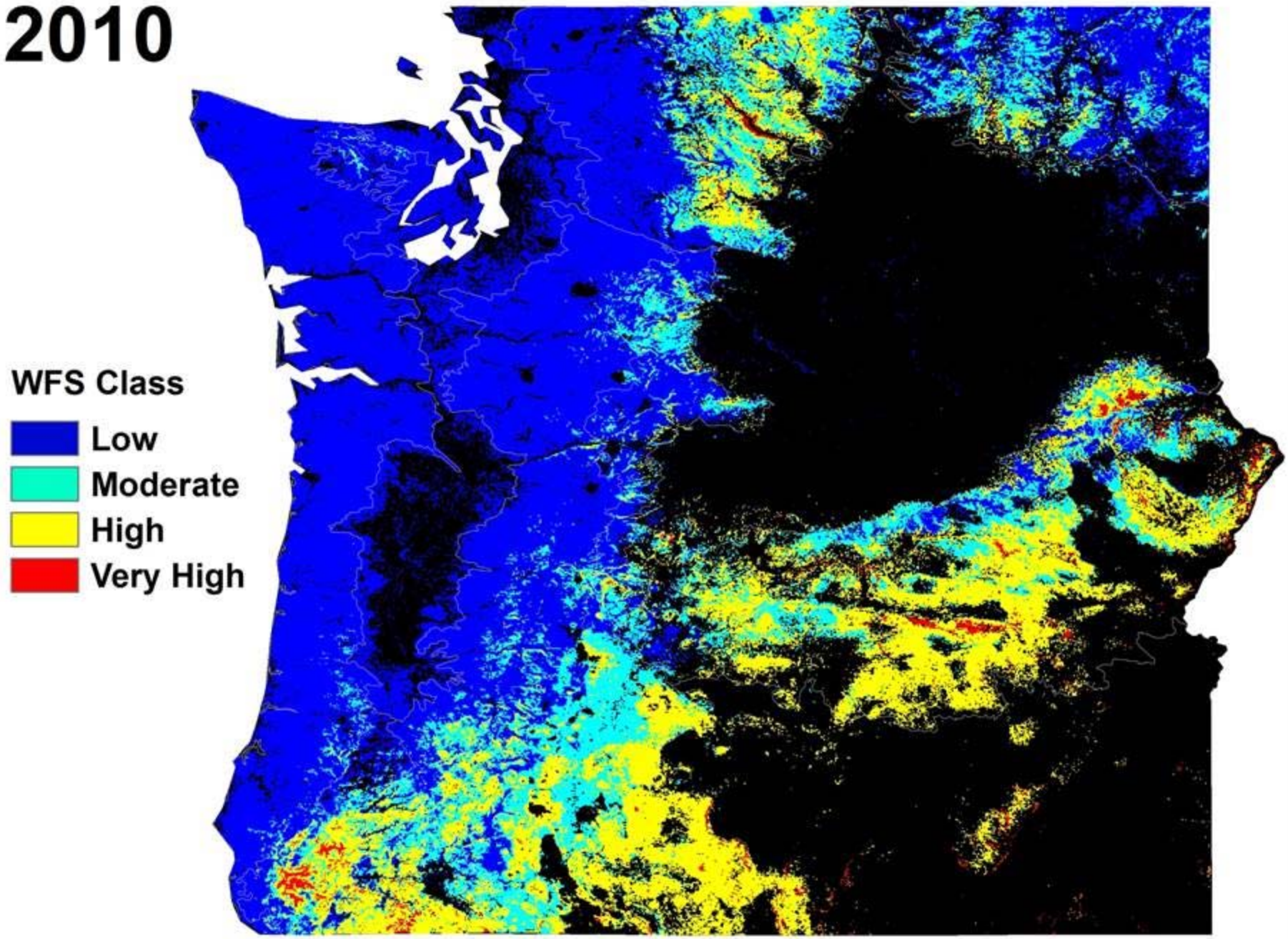
Forest LWS Class Distribution Trend – RCP 8.5



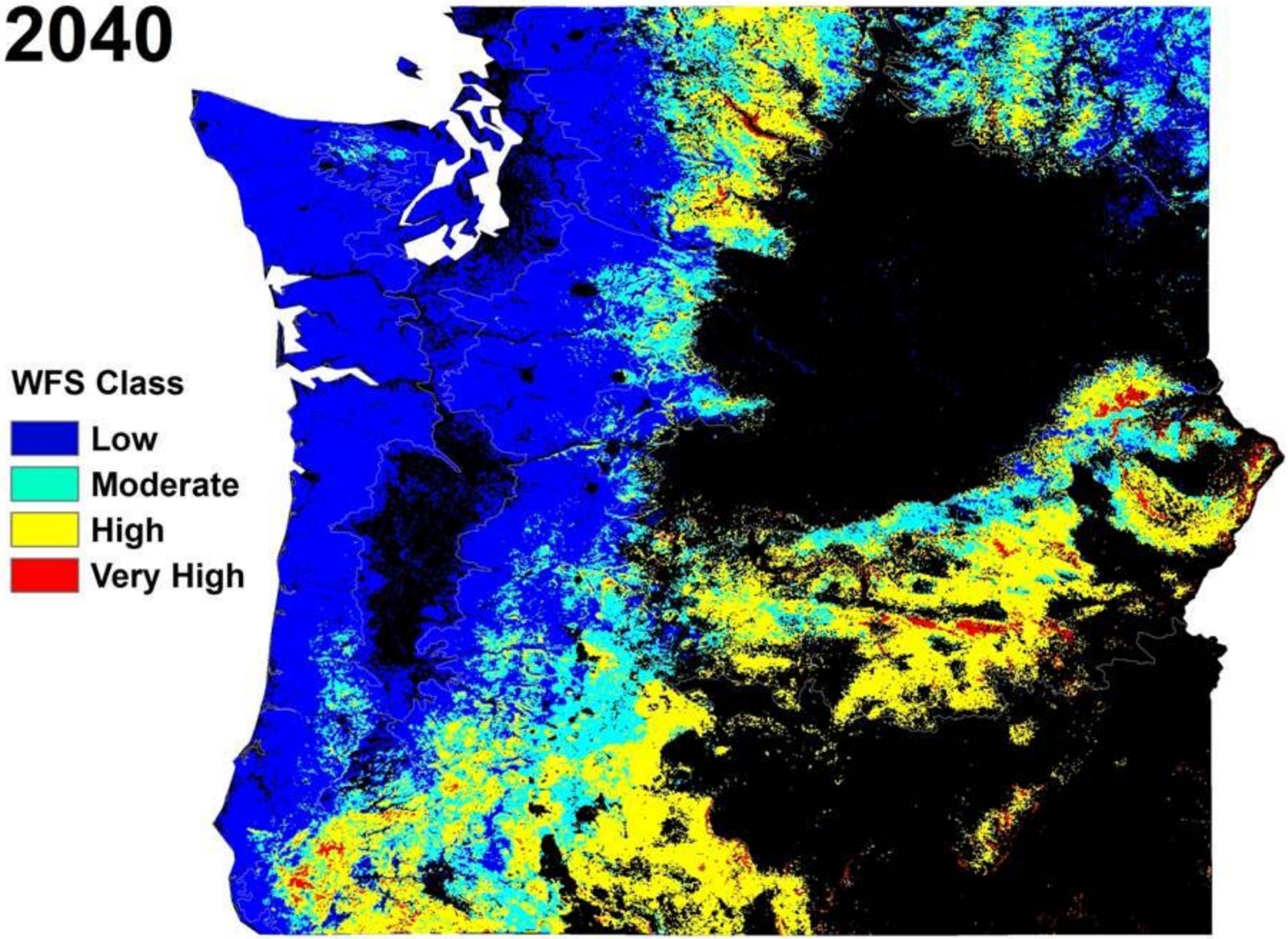
RCP 2.6
Map Visualization



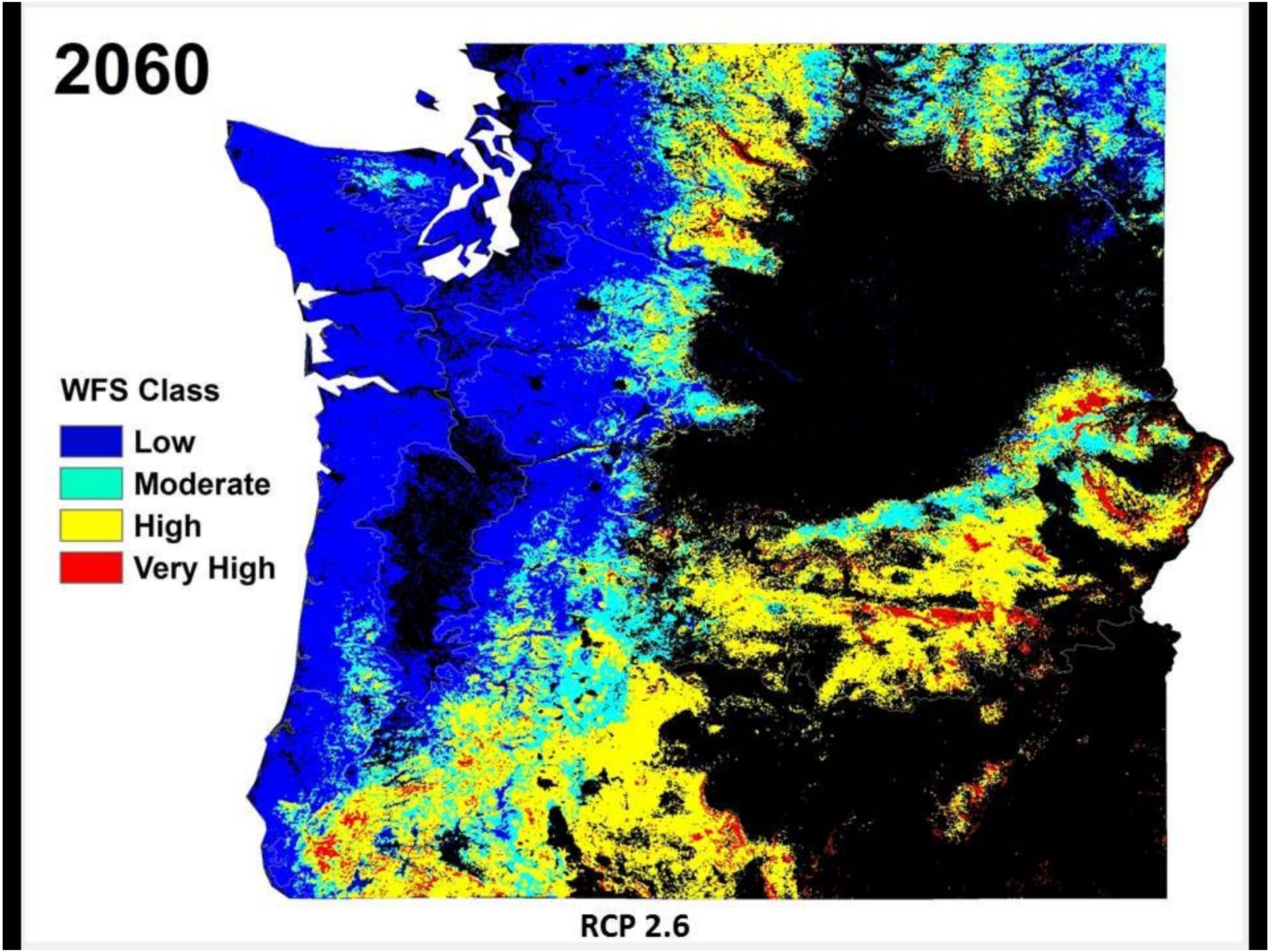

2000
WFS Class
Low
Moderate
High
Very High
Baseline Model

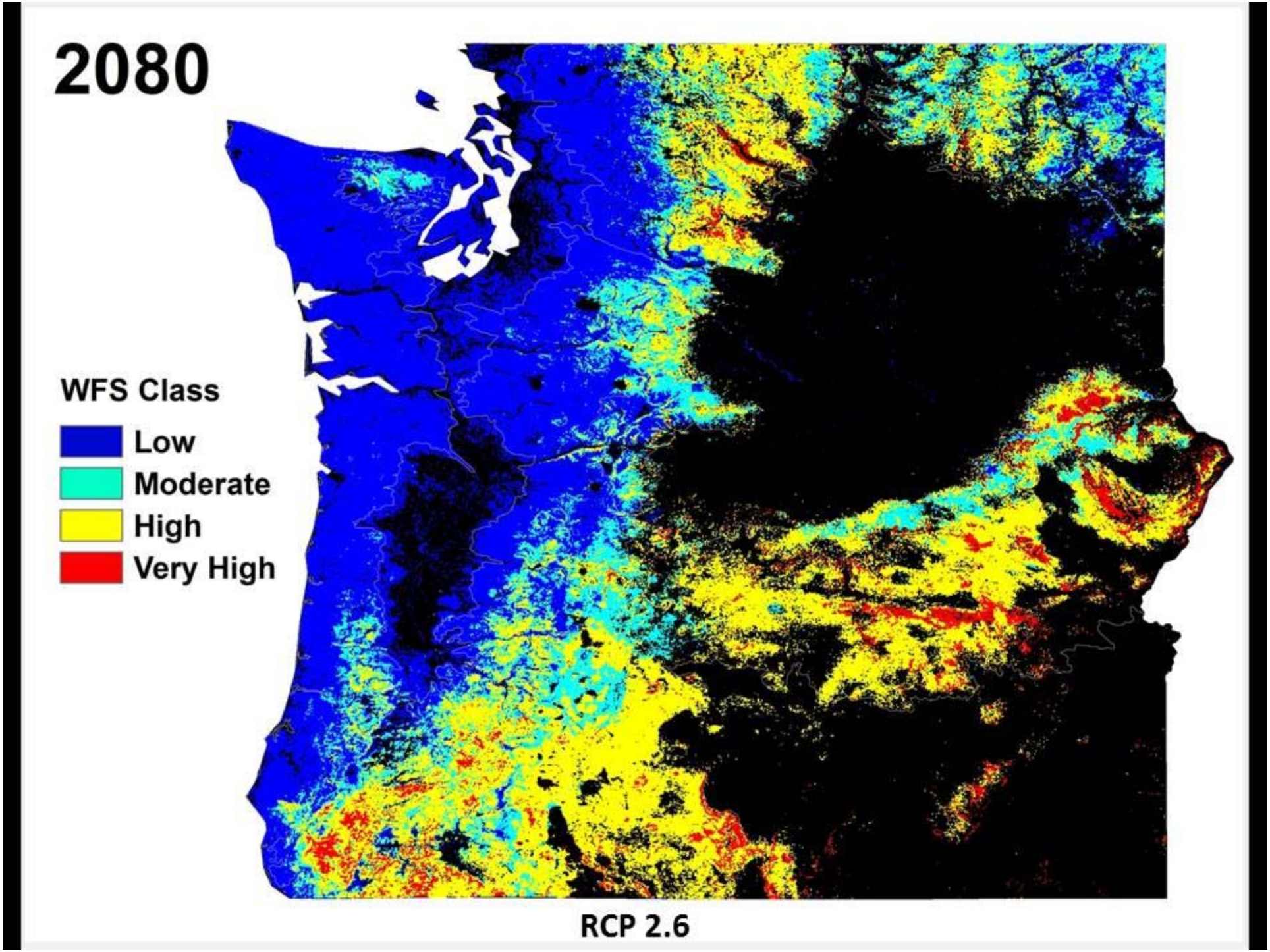


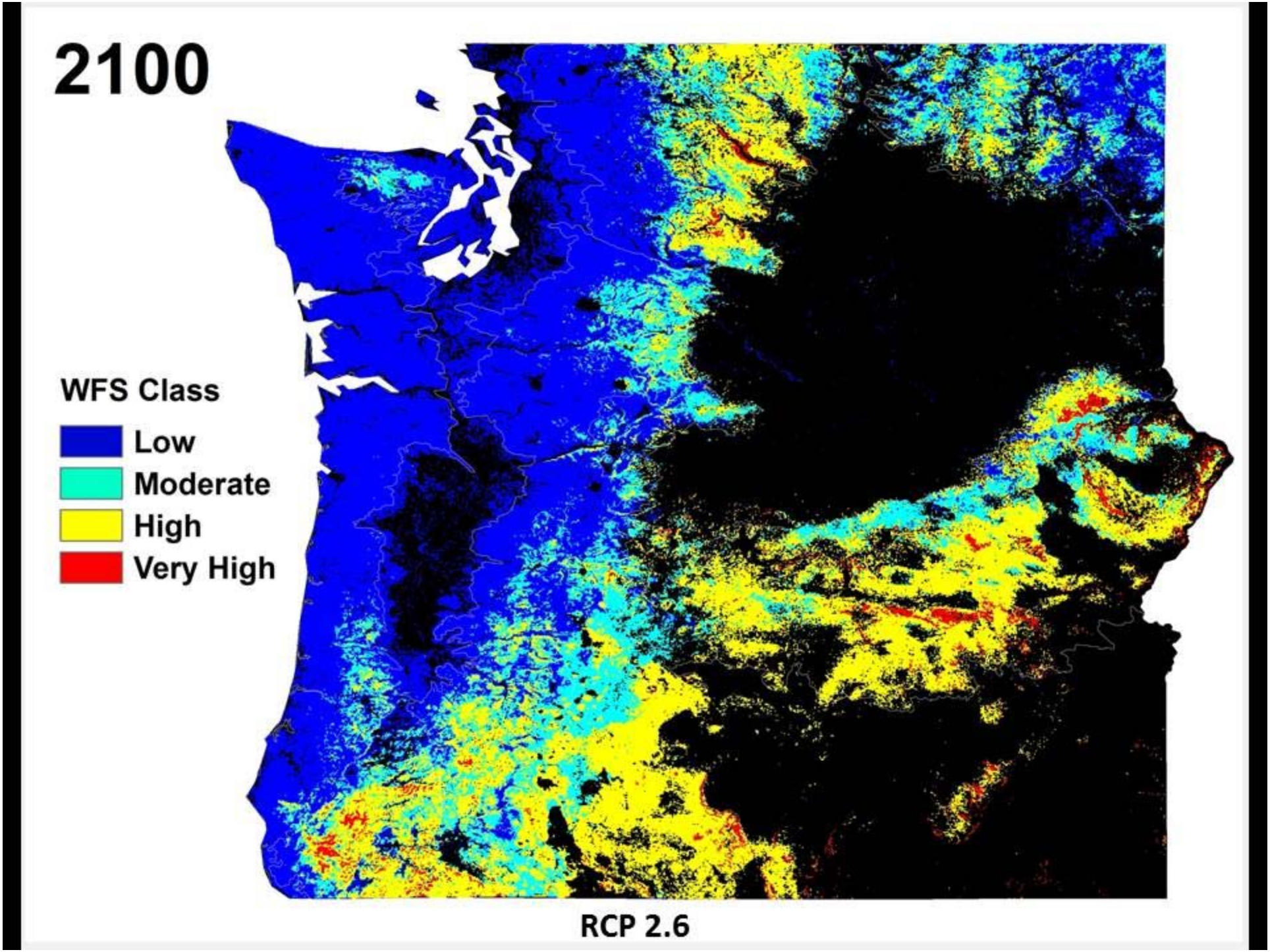
Current Climate



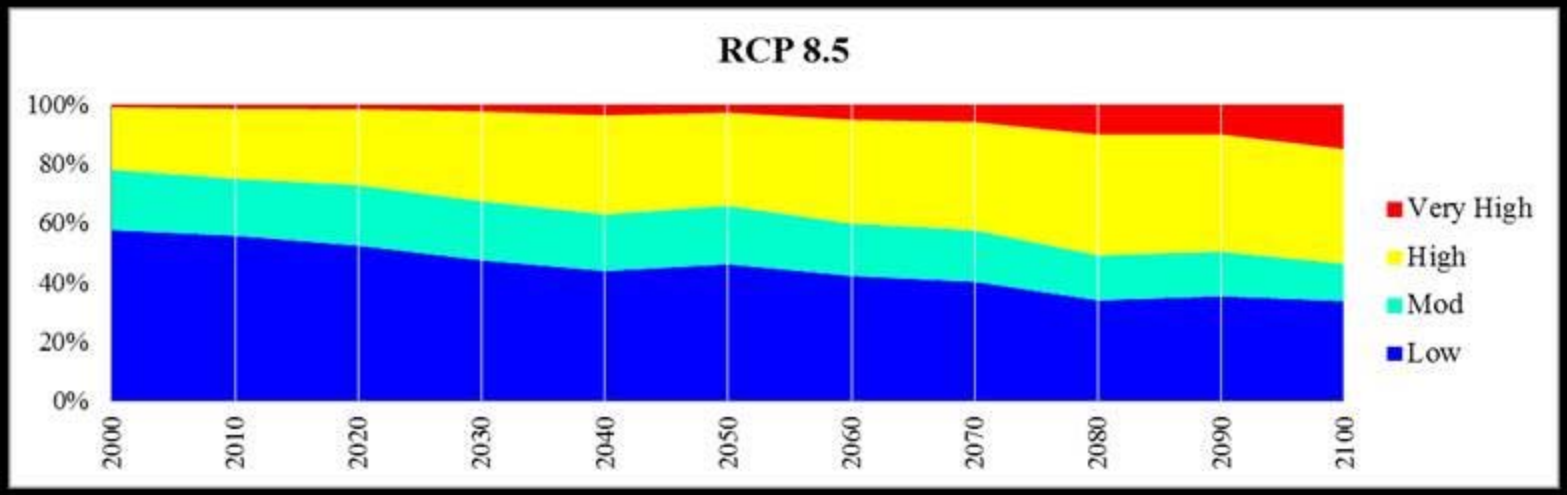
RCP 2.6

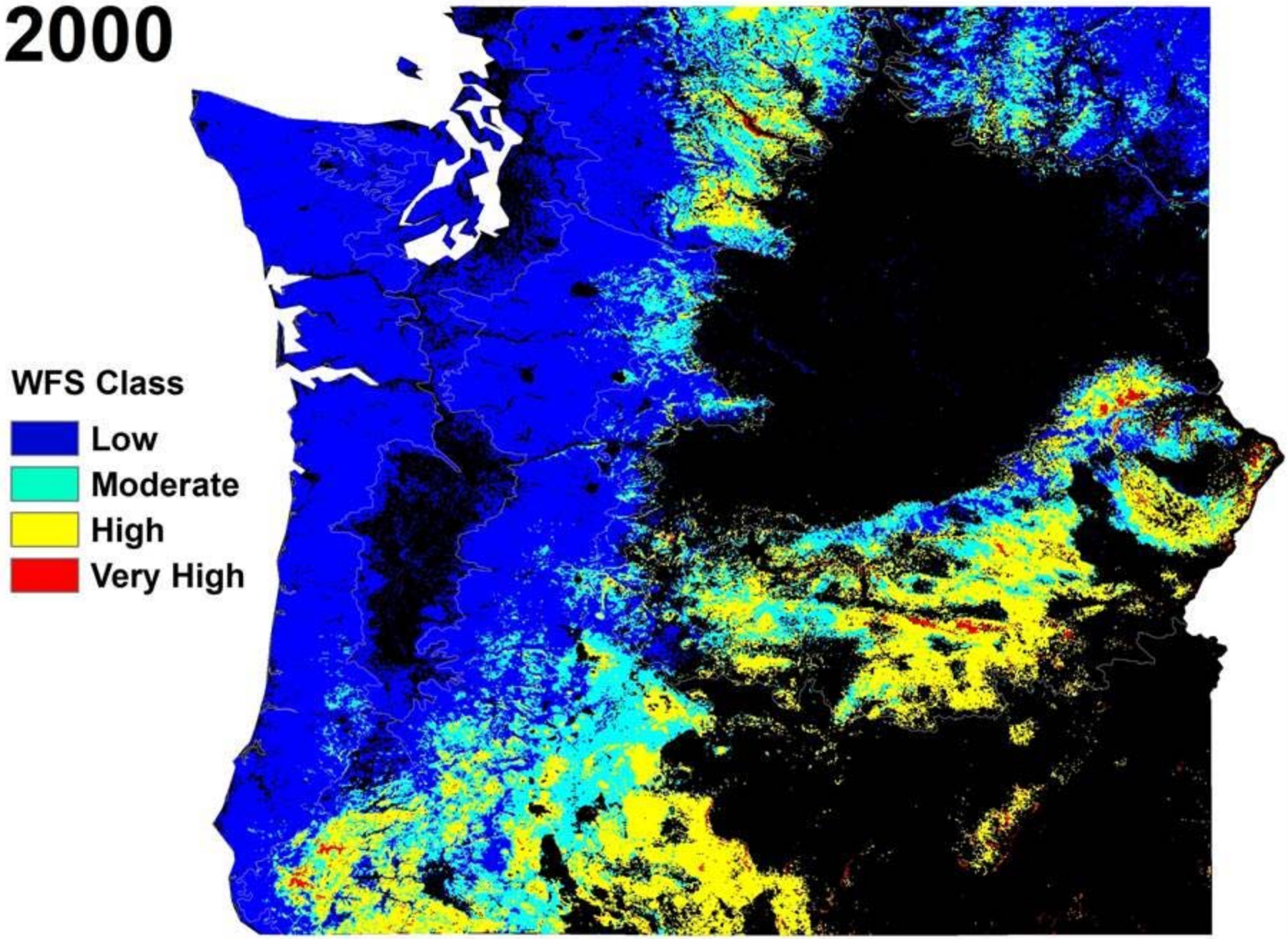

2060
WFS Class
Low
Moderate
High
Very High
RCP 2.6


2080
WFS Class
Low
Moderate
High
Very High
RCP 2.6

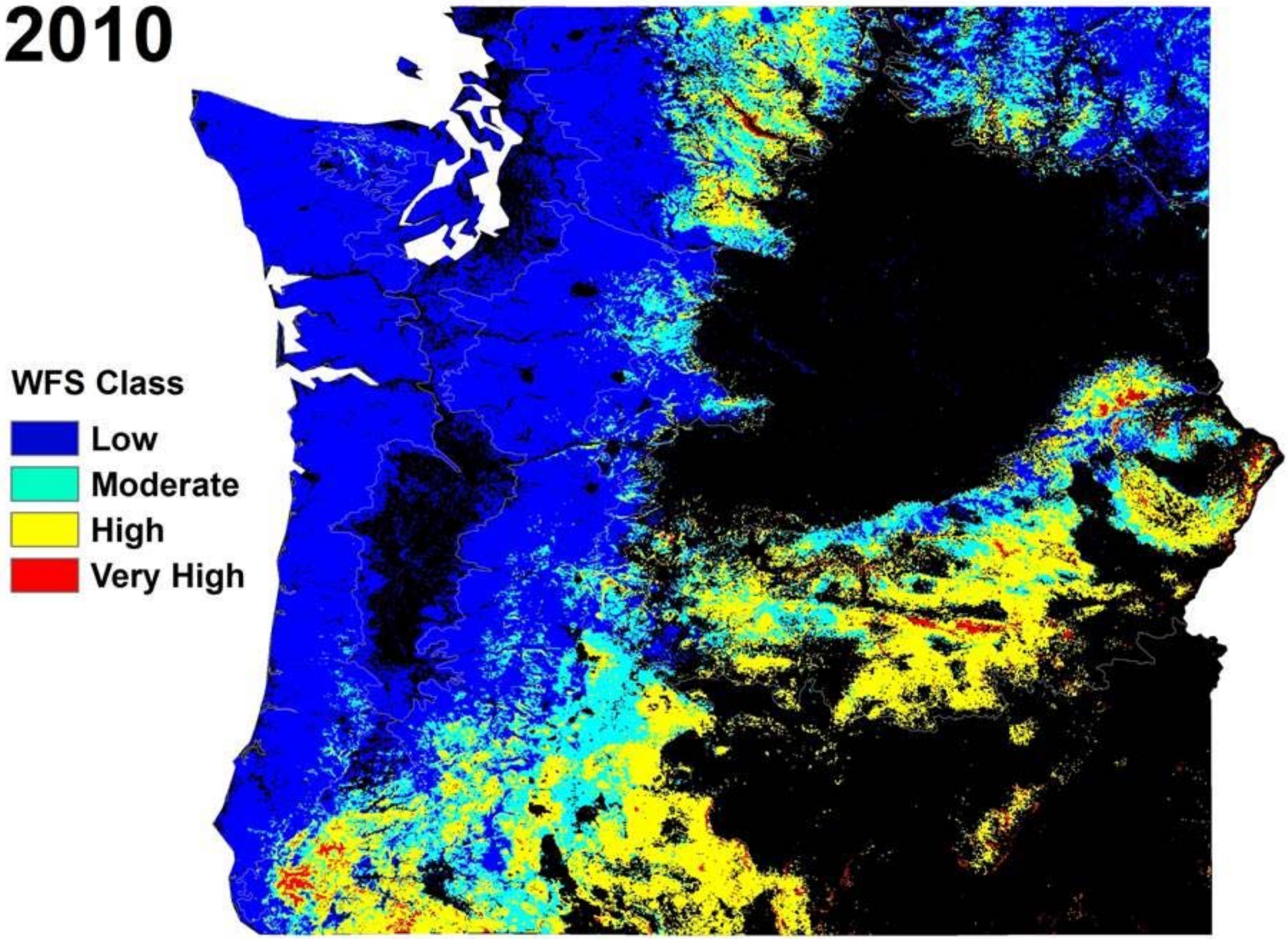

2100
WFS Class
Low
Moderate
High
Very High
RCP 2.6

RCP 8.5
Map Visualization

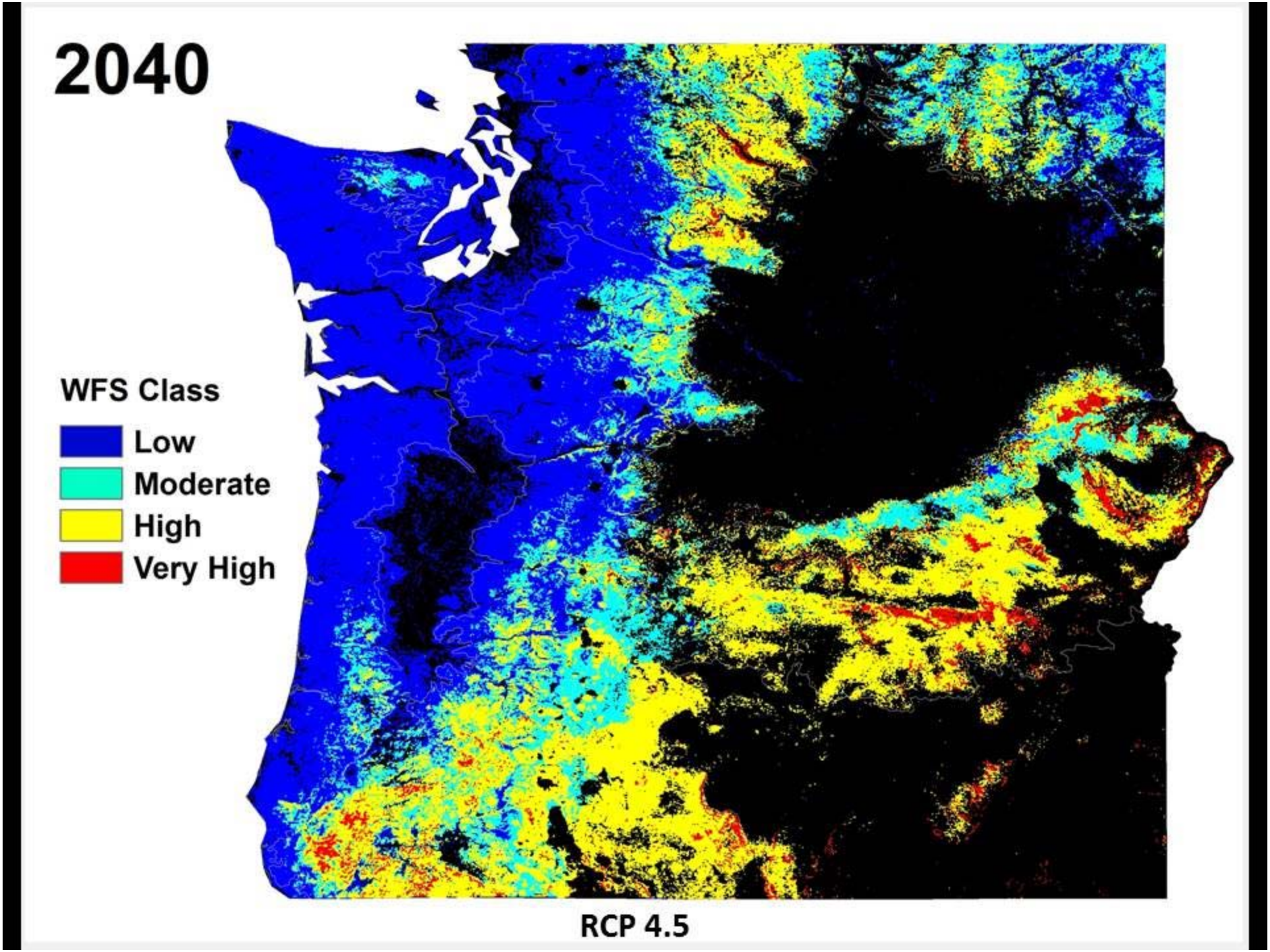


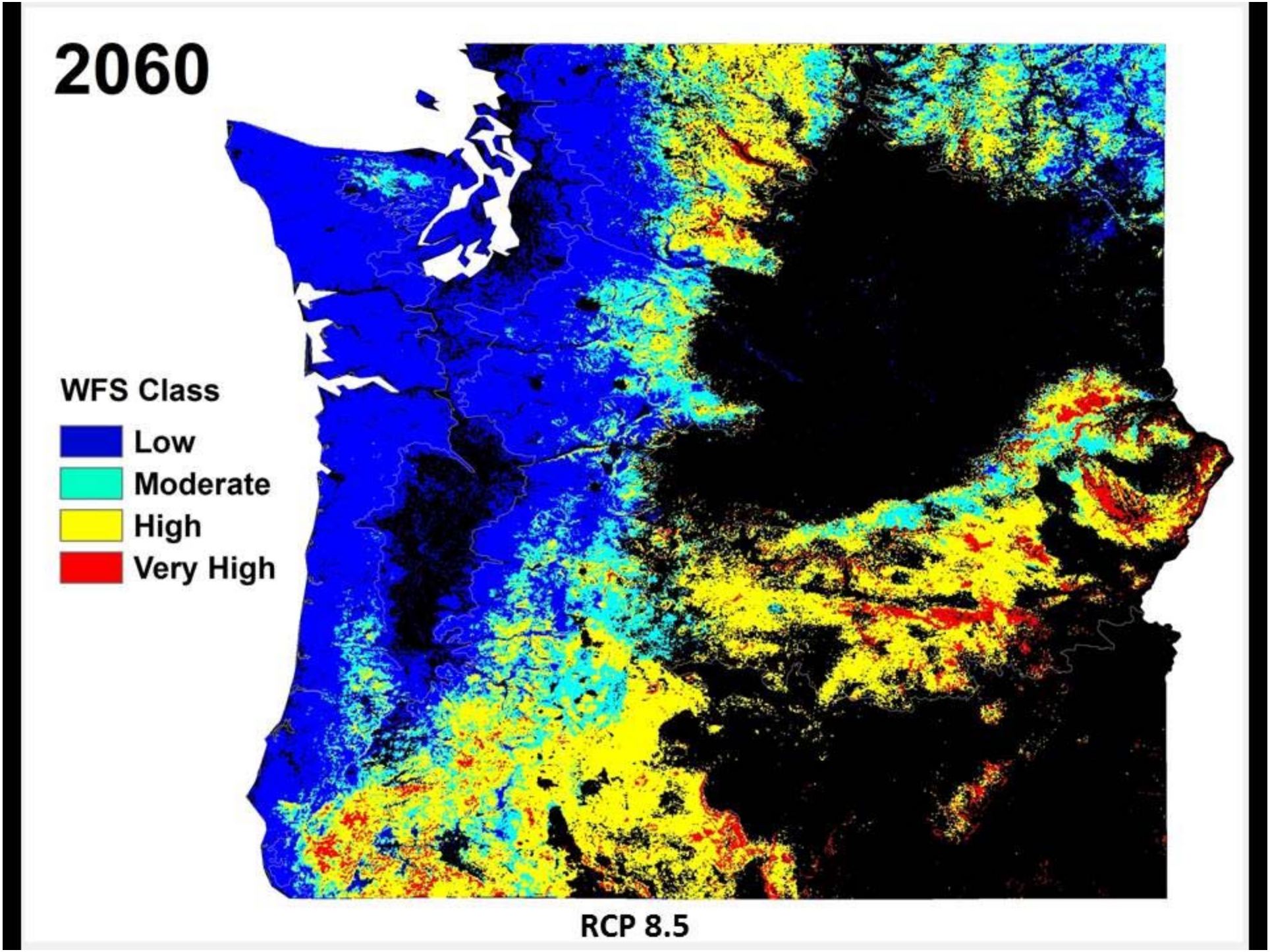


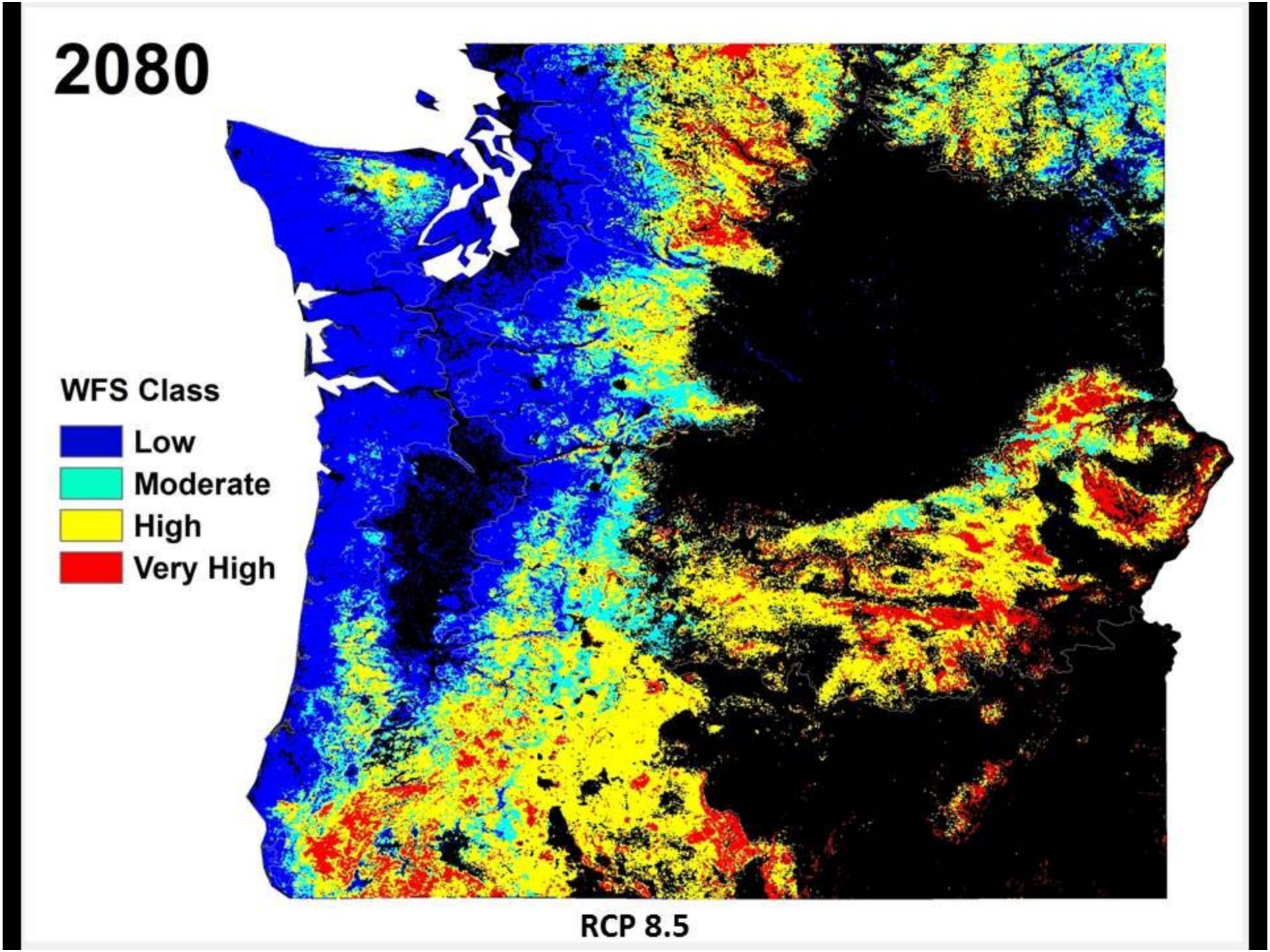
Baseline Model

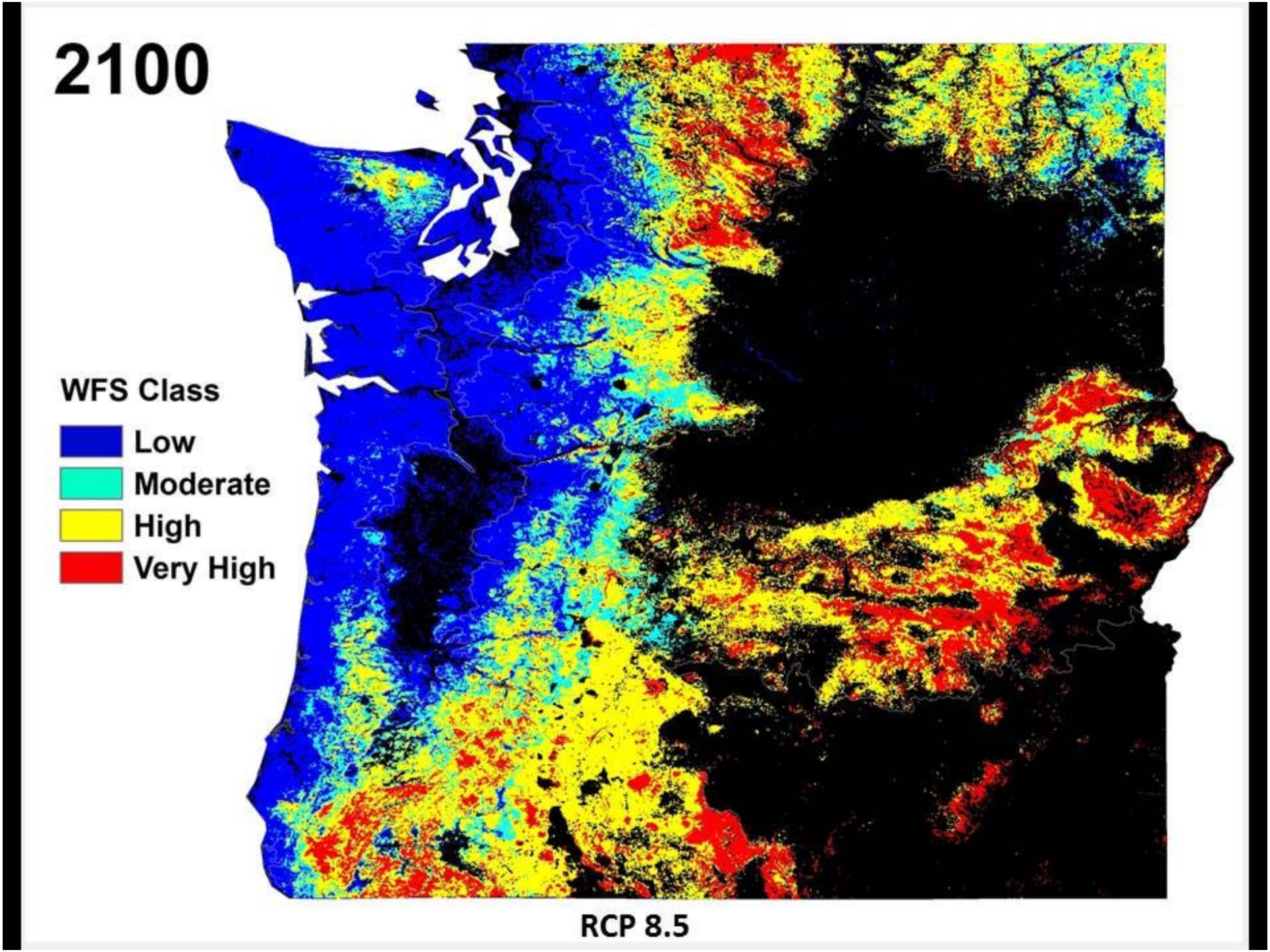


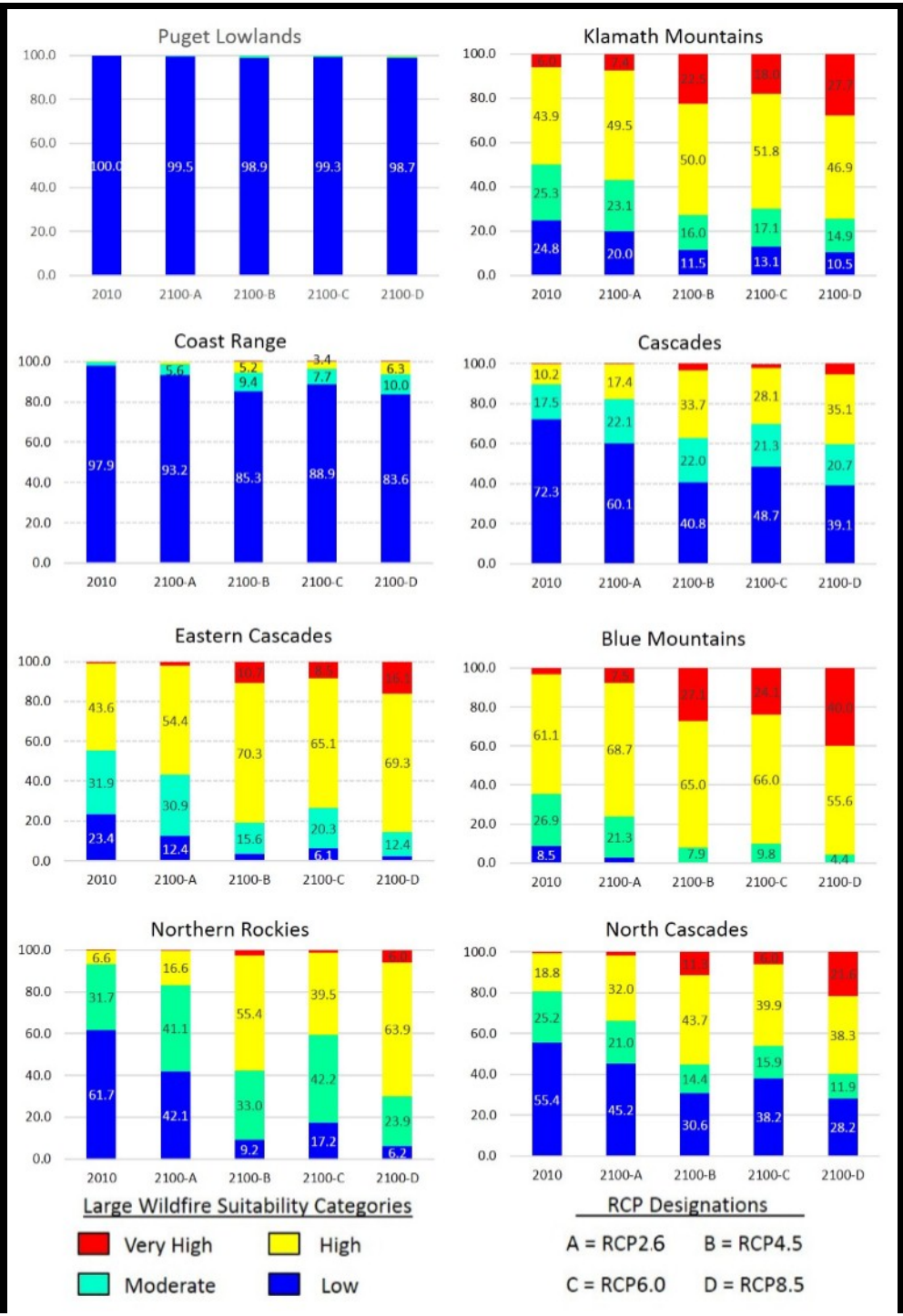
Current Climate

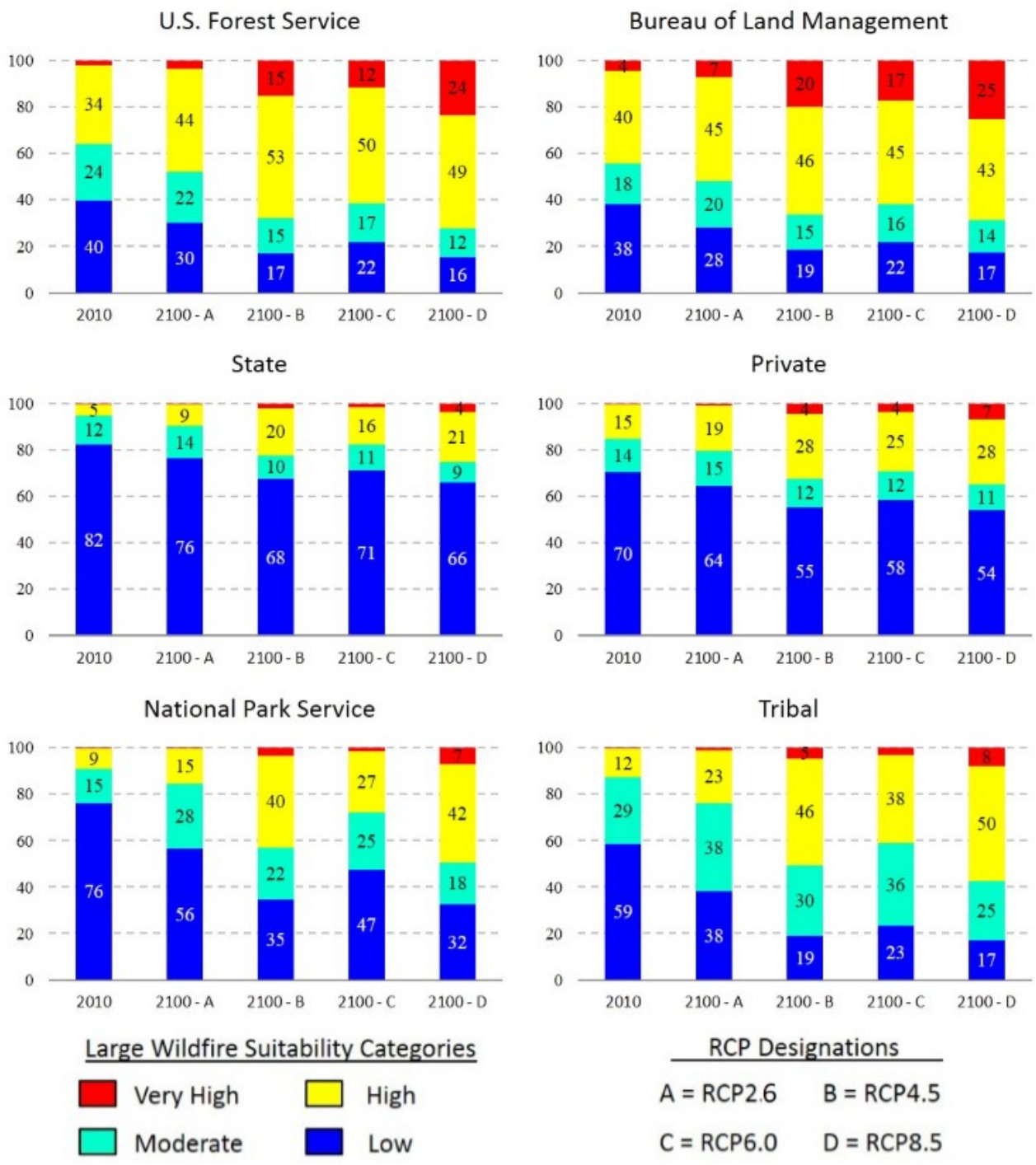

2040
WFS Class
Low
Moderate
High
Very High
RCP 4.5


2060
WFS Class
Low
Moderate
High
Very High
RCP 8.5


2080
WFS Class
Low
Moderate
High
Very High
RCP 8.5


2100
WFS Class
Low
Moderate
High
Very High
RCP 8.5


Puget Lowlands
100.0
99.5
98.9
99.3
98.7
Klamath Mountains
43.9
25.3
24.8
49.5
23.1
20.0
50.0
16.0
11.5
51.8
17.1
13.1
46.9
14.9
10.5
Coast Range
97.9
5.6
93.2
5.2
9.4
85.3
3.4
7.7
88.9
6.3
10.0
83.6
Cascades
10.2
17.5
72.3
17.4
22.1
60.1
33.7
22.0
40.8
28.1
21.3
48.7
35.1
20.7
39.1
Eastern Cascades
43.6
31.9
23.4
54.4
30.9
12.4
70.3
15.6
65.1
20.3
6.1
69.3
12.4
Blue Mountains
61.1
26.9
8.5
68.7
21.3
65.0
7.9
66.0
9.8
55.6
4.4
Northern Rockies
6.6
31.7
61.7
16.6
41.1
42.1
55.4
33.0
9.2
39.5
42.2
17.2
63.9
23.9
6.2
North Cascades
18.8
25.2
55.4
32.0
21.0
45.2
43.7
14.4
30.6
39.9
15.9
38.2
38.3
11.9
28.2
2010
2100-A
2100-B
2100-C
2100-D
Large Wildfire Suitability Categories
Very High
High
Moderate
Low
RCP Designations
A = RCP2.6
B = RCP4.5
C = RCP6.0
D = RCP8.5


U.S. Forest Service
2010: 40, 24, 34
2100 - A: 30, 22, 44
2100 - B: 17, 15, 53, 15
2100 - C: 22, 17, 50, 12
2100 - D: 16, 12, 49, 24
Bureau of Land Management
2010: 38, 18, 40, 4
2100 - A: 28, 20, 45, 7
2100 - B: 19, 15, 46, 20
2100 - C: 22, 16, 45, 17
2100 - D: 17, 14, 43, 25
State
2010: 82, 12, 5
2100 - A: 76, 14, 9
2100 - B: 68, 10, 20
2100 - C: 71, 11, 16
2100 - D: 66, 9, 21, 4
Private
2010: 70, 14, 15
2100 - A: 64, 15, 19
2100 - B: 55, 12, 28, 4
2100 - C: 58, 12, 25, 4
2100 - D: 54, 11, 28, 7
National Park Service
2010: 76, 15, 9
2100 - A: 56, 28, 15
2100 - B: 35, 22, 40
2100 - C: 47, 25, 27
2100 - D: 32, 18, 42, 7
Tribal
2010: 59, 29, 12
2100 - A: 38, 38, 23
2100 - B: 19, 30, 46, 5
2100 - C: 23, 36, 38
2100 - D: 17, 25, 50, 8
0
20
40
60
80
100
2010
2100 - A
2100 - B
2100 - C
2100 - D
Large Wildfire Suitability Categories
Very High
High
Moderate
Low
RCP Designations
A = RCP2.6
B = RCP4.5
C = RCP6.0
D = RCP8.5