Climatic domain maps for Sudden Oak Death: current climate (1971-2000), and future climate scenarios (Hadleyb2 and CGCM2b), 2011-2040 and 2041-2070

(Using known confirmed North American sites, California and Oregon only)

PLUS

An extreme minimum temperature model that may indicate North American distribution limits on SOD

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SOD Bioclimatic analysis

To support the Canadian Food Inspection Agency's risk assessment a bioclimatic analysis of SOD was undertaken by the Canadian Forest Service using BIOCLIM/BIOMAP procedures (now called ANUCLIM, Nix, 1986, http://cres.anu.edu.au/outputs/software.html). This is an update from the previous CFIA PRA for SOD. It is generally accepted that climate constrains the distribution of many organisms but it is difficult to quantify the exact nature of such constraints, especially for new exotic species.

Bioclim is one of relatively few options for developing potential distribution models from presence-only observation data (see Elith and Burgman, in press). Bioclim requires geo-referenced occurrence data and uses these locations to generate a climatic envelop of the species. This envelop is then mapped. The result can be interpreted as a map of the climatic domain of the species. Thus the resulting map shows where the climate closely matches where the species is known to occur. This is one approach to help define possible distributions for risk assessments and guide field surveys. Bioclim has been successfully used for ecological applications in Australia and in Canada e.g. Lindenmayer et al, 1996; McKenney et al. 1998, 2003; see also www.planthardiness.gc.ca).

However, it is important to be clear about the interpretation of the map, especially regarding exotic species. Firstly, the climatic range map does not mean that the species actually occurs in all these locations. There are many other influences on a species being present at a location or not. For example in the case of a damaging insect or disease, a host is necessary. In some, but not all, cases the climatic range of hosts and insects/diseases completely overlap. A second important point is that some species thrive in areas outside their original/natural climatic range but this is not known in the early days of a species' establishment in a new region/continent.

The climatic profile of established SOD sites is shown in Table 2). In this case 511 geo-referenced locations were available primarily in California (http://kellylab.berkeley.edu/SODmonitoring/) and Oregon. This profile was mapped at approximately a 8-10km resolution across all of North America although higher resolutions are possible. The results are shown in the following maps.

For Canada two important questions include: 1) will the organism survive in Canadian climatic conditions; 2) what might happen with a rapidly changing climate.

As noted the first question is perhaps problematic in the absence of experimental or extensive field data. The organism has been identified at nurseries in a number of locations in the United States but apparently has not overwintered or become established in those areas (see attached figures, Fowler pers., comm.). If this changes these maps can be quickly updated. In Canada the presence of snow may insulate the organism in areas that would be otherwise too cold. However this is unknown at this time.

To at least partially address the second question, several climate change scenarios were compared to the current climatic profile. Some results are shown in several figures and suggest, at least at this scale and for these scenarios, that the geographic spread of the current climatic profile may not increase. Note however, the same caveat about not having full knowledge about the current climatic niche still applies. Details on how the climate change scenarios were developed can be found in McKenney et al., 2005. Canadian and British climate change scenario models were used. Only the two models resulting in the largest predicted potential climatic domains are shown.

Future efforts may include other risk modelling approaches (sensu Kelly et al., 2004).

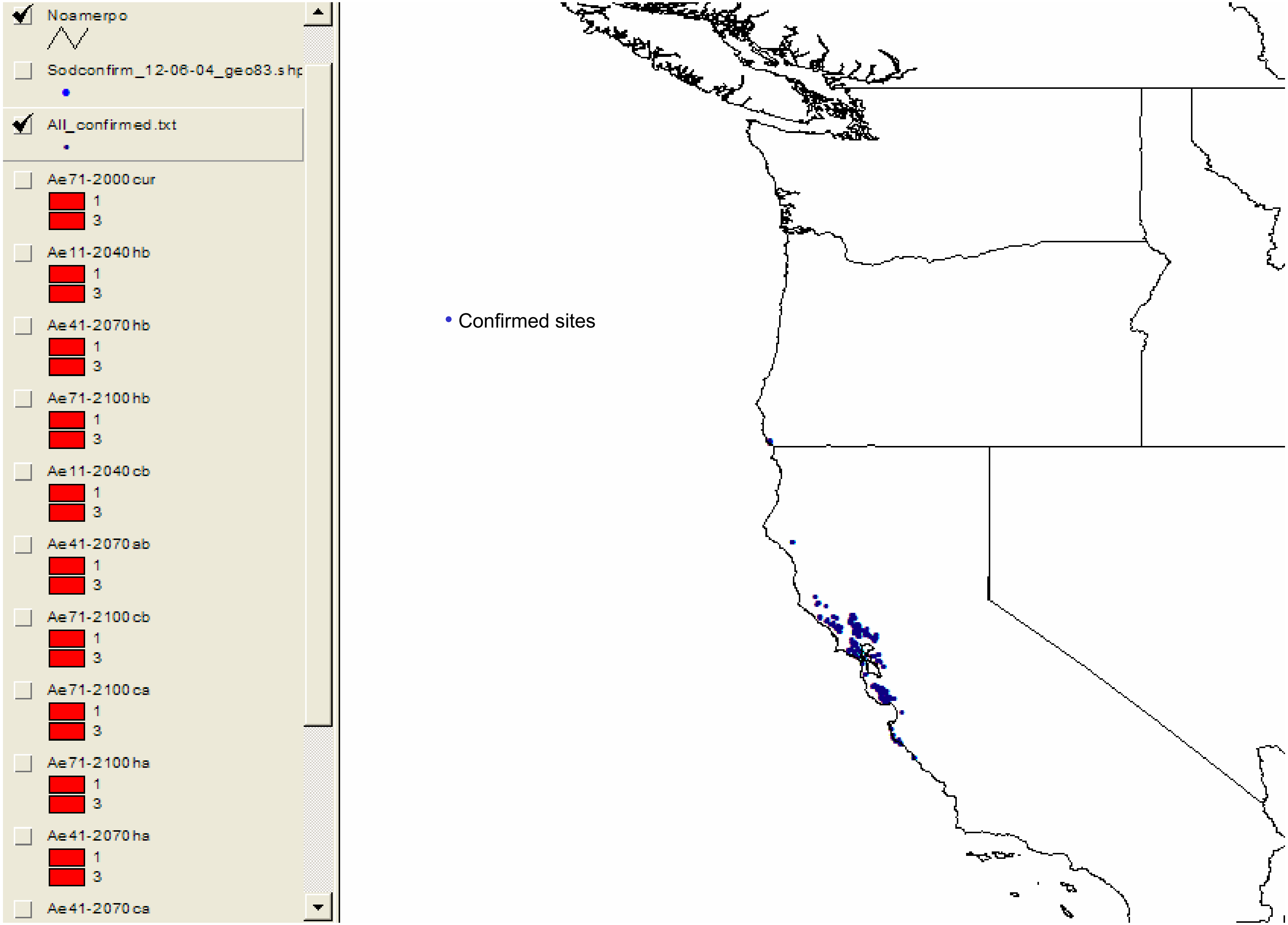
Thanks to Maggi Kelli (University of California) for occurrence data and Glenn Fowler (USFS) for nursery locations.

Table 1. Bioclim variables used in SOD models

Annual Mean Temperature
Mean Diurnal Range (Mean(period max-min))
Isothermality
Temperature Seasonality (C of V)
Max Temperature of Warmest Period
Min Temperature of Coldest Period
Temperature Annual Range (5-6)
Mean Temperature of Warmest Quarter
Mean Temperature of Coldest Quarter
Precipitation of Warmest Quarter
Precipitation of Coldest Quarter

Table 2. Bioclimatic Profile for SOD based on current established occurences

Paremeter	MEAN	SD	2.50%	5%	10%	25%	50%	75%	90%	95%	97.50%	MAX	MIN
1. Annual Mean Temperature	13.80	0.83	11.10	12.50	12.90	13.40	13.90	14.20	14.80	15.10	15.30	15.70	10.70
2. Mean Diurnal Range(Mean(period max-min))	12.70	1.34	9.70	10.10	10.70	11.70	12.80	13.80	14.30	14.70	15.20	15.50	8.70
3. Isothermality 2/7	0.54	0.05	0.49	0.49	0.49	0.51	0.53	0.56	0.62	0.63	0.63	0.63	0.47
4. Temperature Seasonality (C of V)	1.33	0.30	0.76	0.78	0.82	1.13	1.37	1.57	1.68	1.74	1.80	1.85	0.74
5. Max Temperature of Warmest Period	26.90	2.63	22.50	22.90	23.20	24.90	27.00	28.70	30.60	31.20	31.70	32.60	21.70
6. Min Temperature of Coldest Period	3.30	0.96	1.60	1.90	2.20	2.60	3.00	4.00	4.80	5.00	5.20	6.10	1.10
7. Temperature Annual Range (5-6)	23.60	3.28	18.90	19.10	19.30	21.10	23.70	26.70	28.30	29.00	29.70	30.50	16.00
8. Mean Temperature of Wettest Quarter	9.60	1.05	7.10	7.80	8.30	8.80	9.60	10.30	11.00	11.10	11.20	11.20	6.70
9. Mean Temperature of Driest Quarter	18.50	1.63	15.70	16.00	16.20	17.30	18.80	19.70	20.60	21.30	21.60	21.90	15.30
10. Mean Temperature of Warmest Quarter	18.70	1.53	16.00	16.20	16.40	17.60	18.90	19.80	20.60	21.30	21.60	21.90	15.40
11. Mean Temperature of Coldest Quarter	9.20	1.02	6.90	7.60	8.00	8.50	9.10	10.00	10.70	10.80	10.90	11.00	6.60
12. Annual Precipitation	988.00	284.65	550.00	632.00	716.00	840.00	935.00	1069.00	1264.00	1542.00	2014.00	2145.00	467.00
13. Precipitation of Wettest Period	49.00	10.27	30.00	31.00	35.00	43.00	49.00	55.00	60.00	68.00	82.00	83.00	23.00
15. Precipitation Seasonality(C of V)	94.00	4.21	76.00	85.00	91.00	92.00	94.00	96.00	97.00	98.00	98.00	98.00	74.00
16. Precipitation of Wettest Quarter	559.00	130.14	343.00	369.00	411.00	504.00	547.00	609.00	702.00	838.00	967.00	1026.00	275.00
17. Precipitation of Driest Quarter	3.00	12.96	0.00	0.00	1.00	2.00	4.00	6.00	7.00	25.00	70.00	73.00	0.00
18. Precipitation of Warmest Quarter	17.00	12.63	6.00	6.00	7.00	9.00	13.00	19.00	26.00	30.00	74.00	80.00	5.00
19. Precipitation of Coldest Quarter	539.00	132.53	326.00	348.00	391.00	483.00	531.00	593.00	681.00	824.00	958.00	1016.00	251.00



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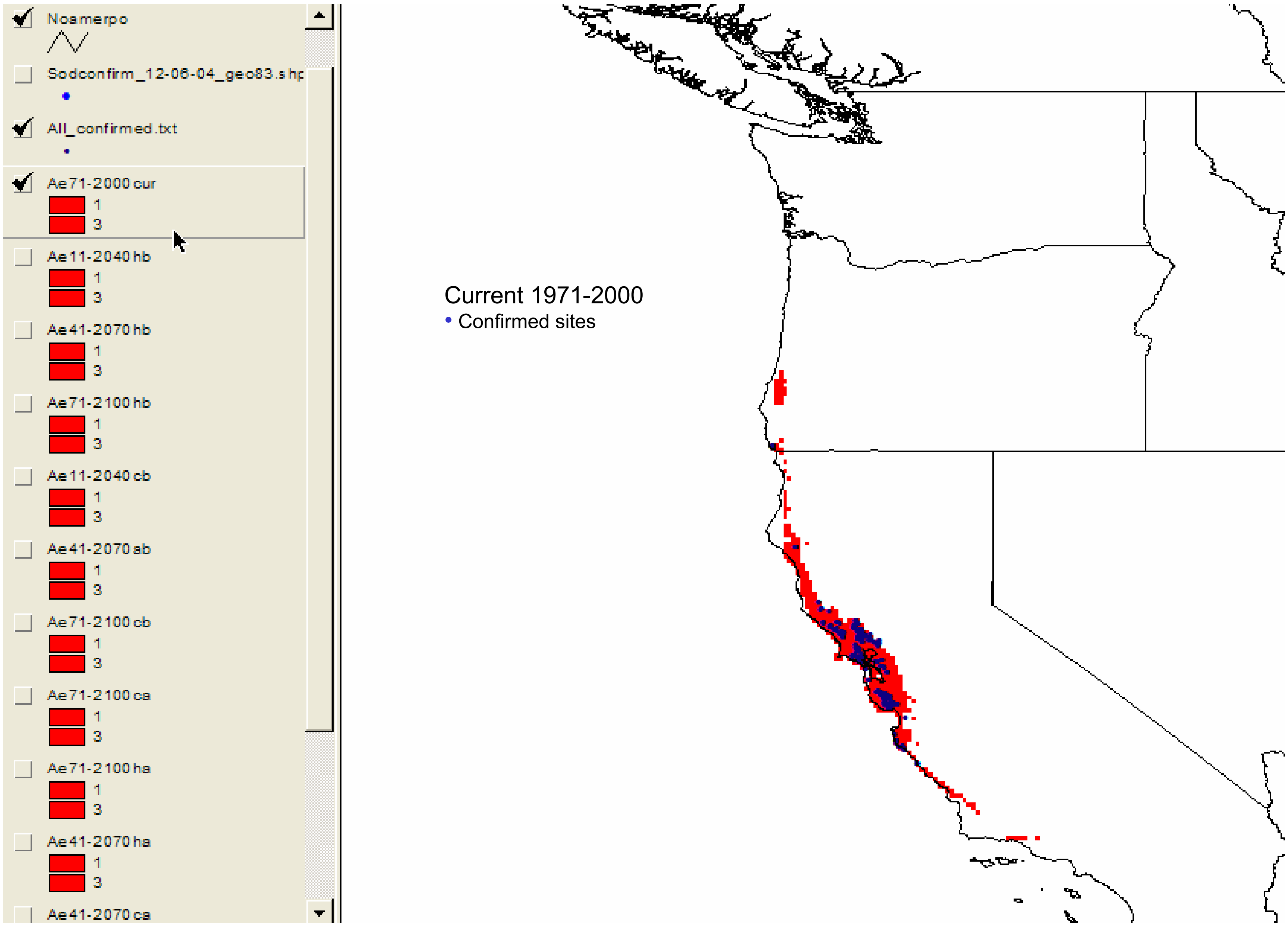
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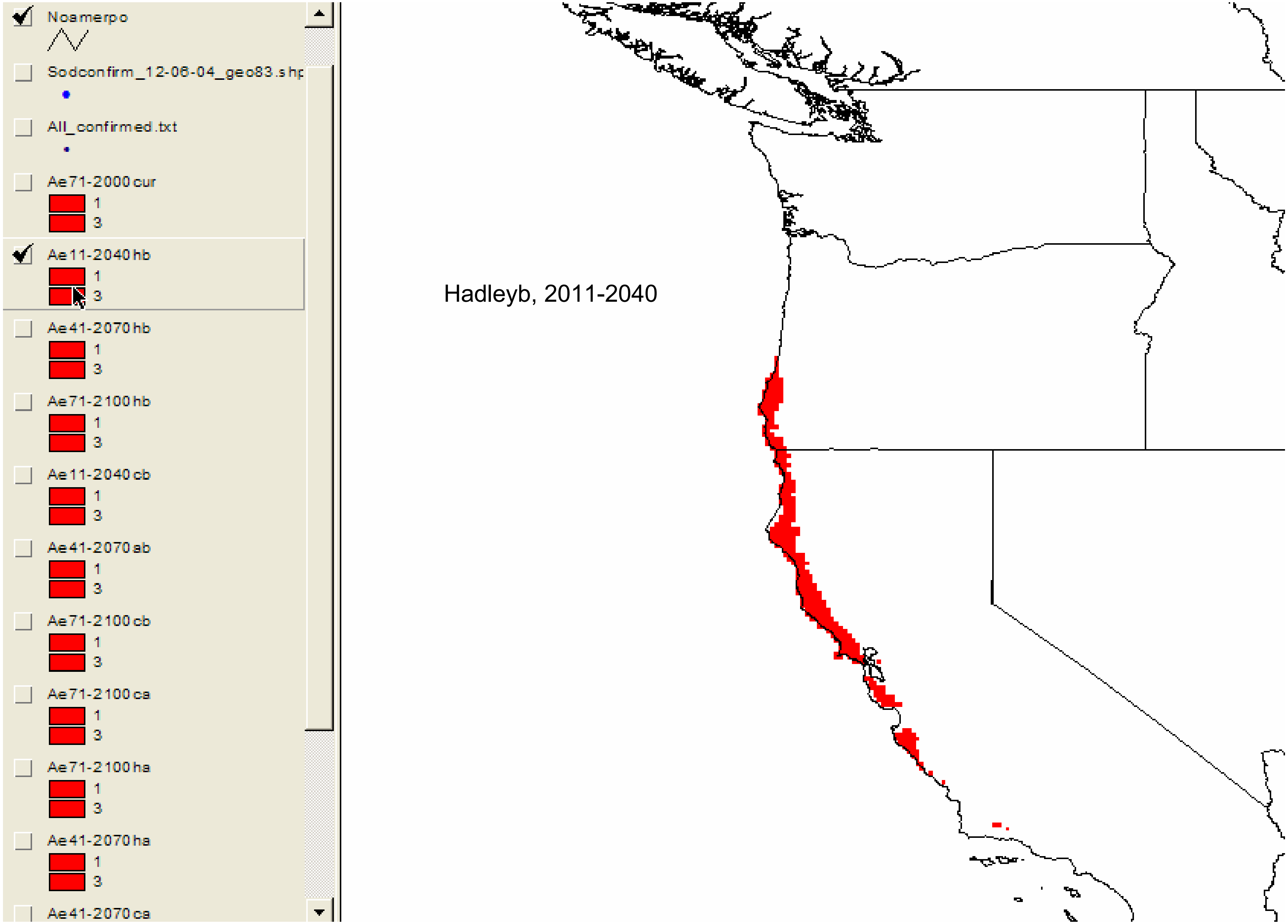

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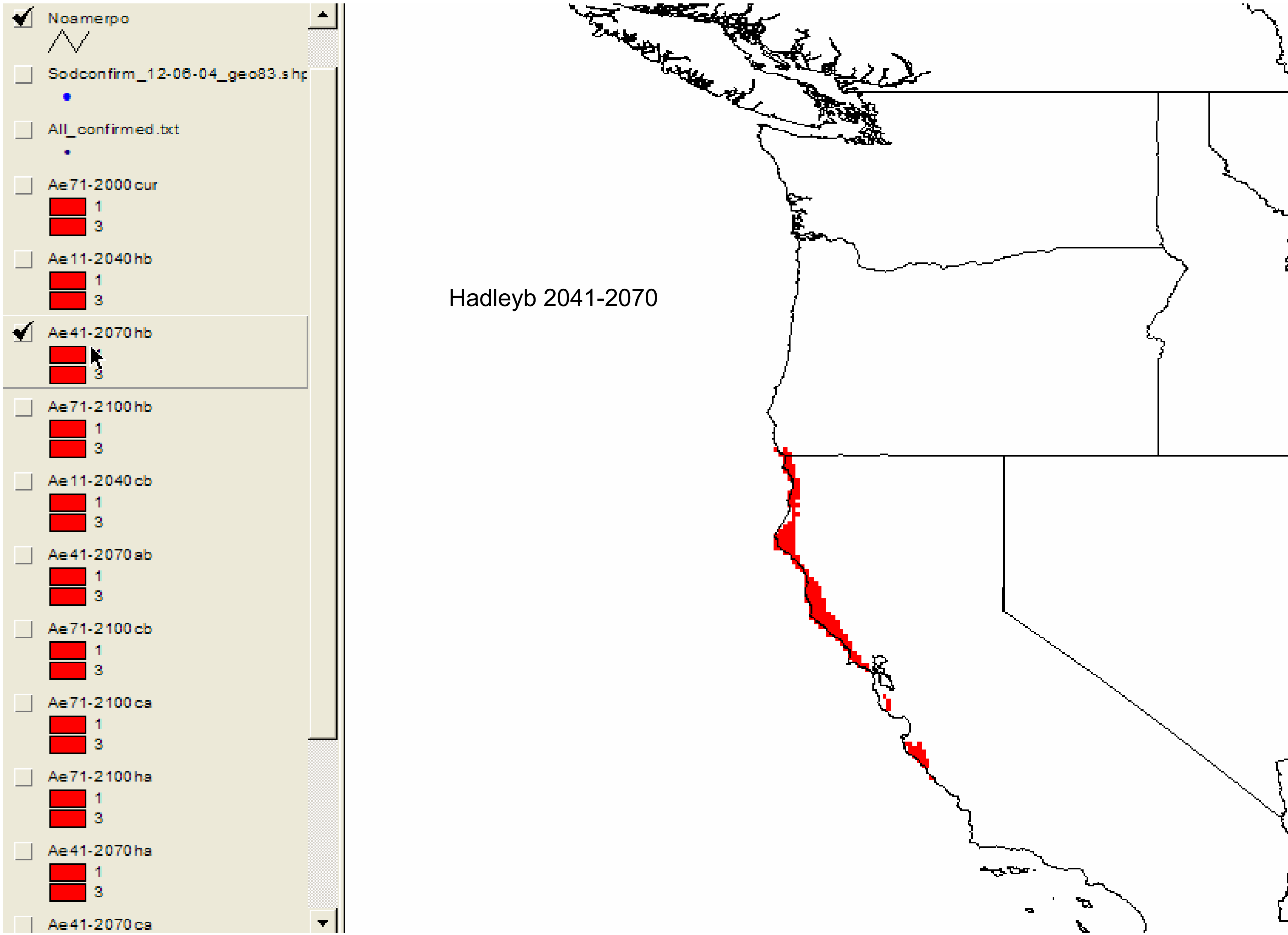
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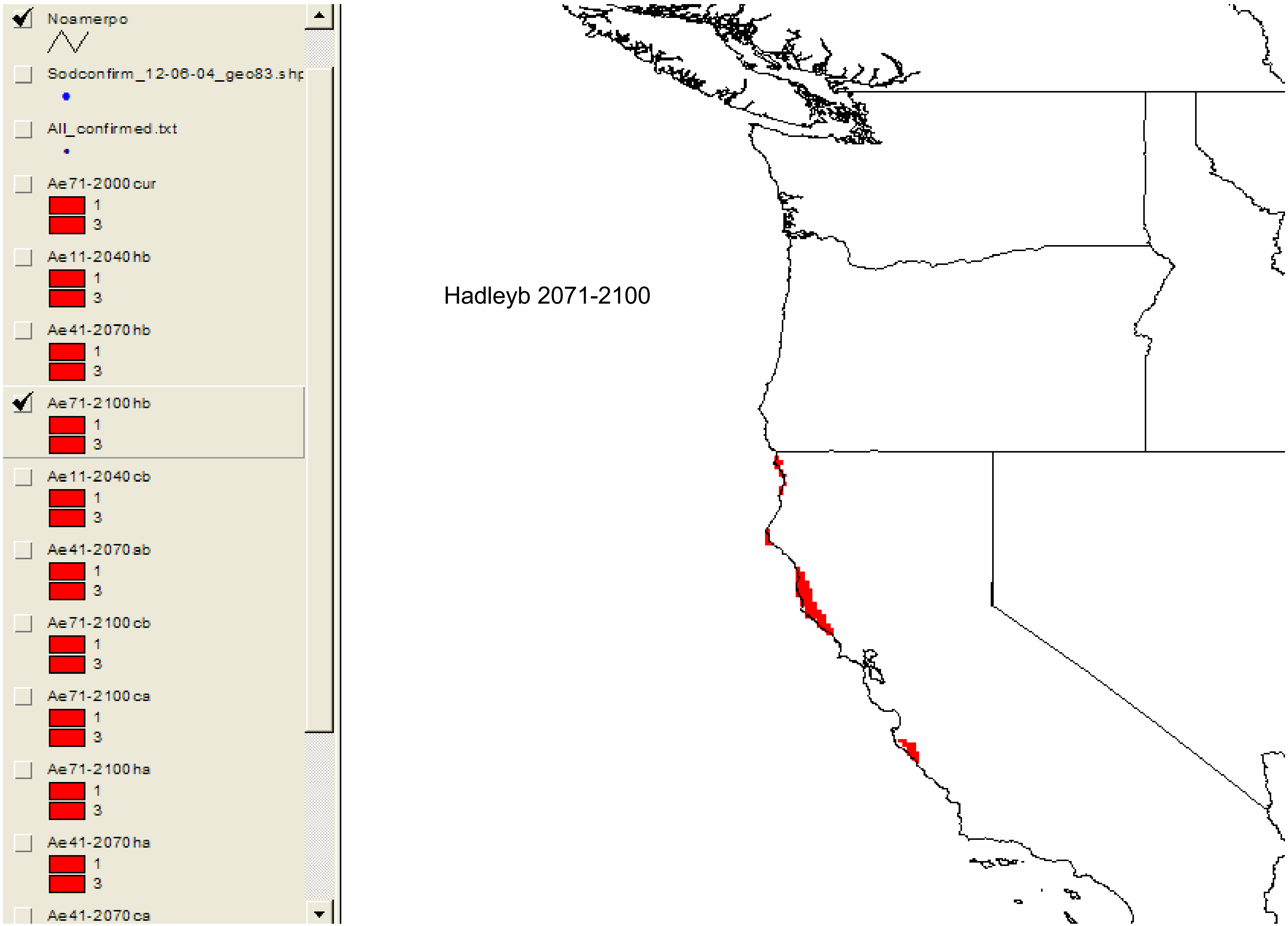

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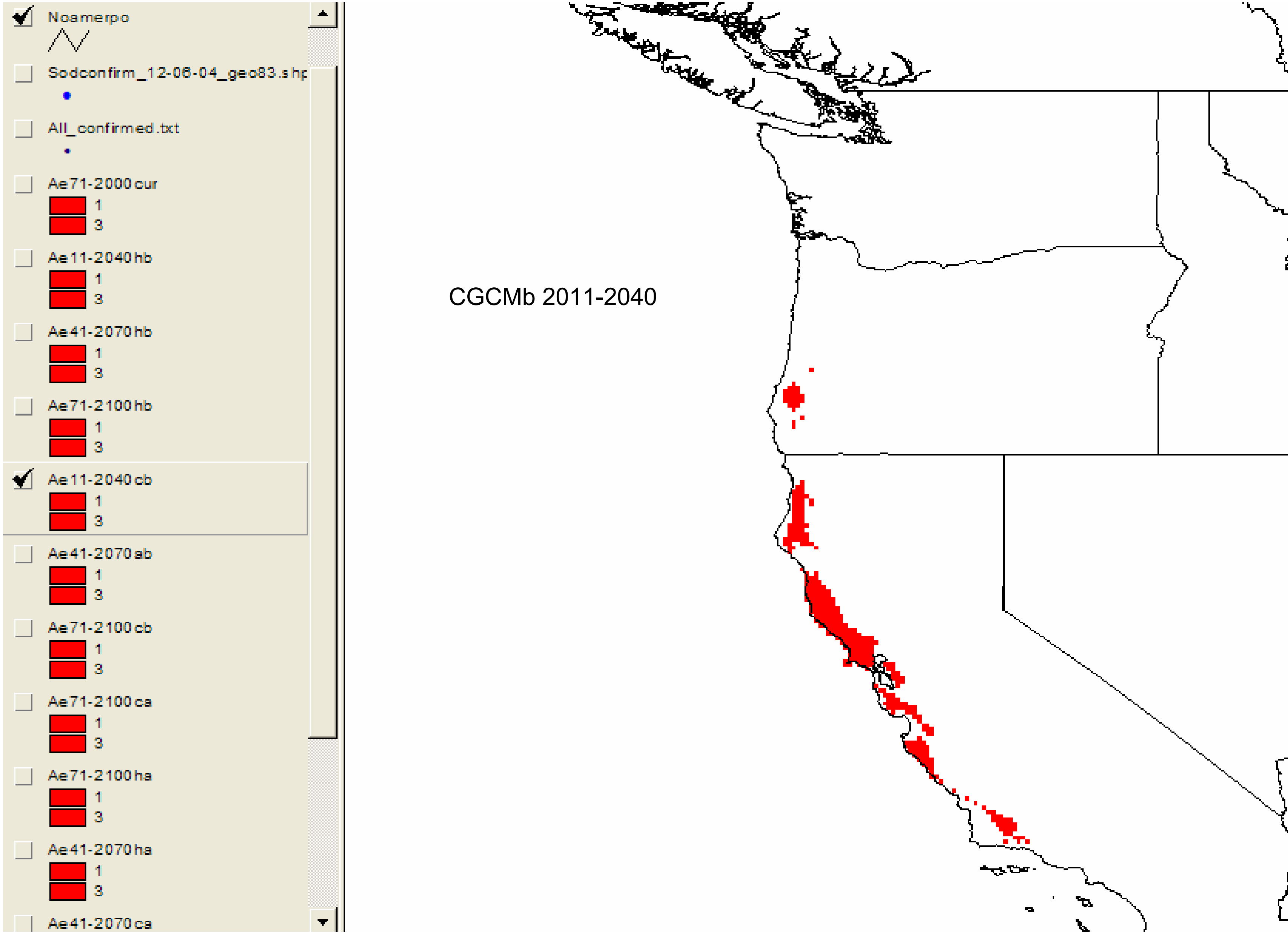
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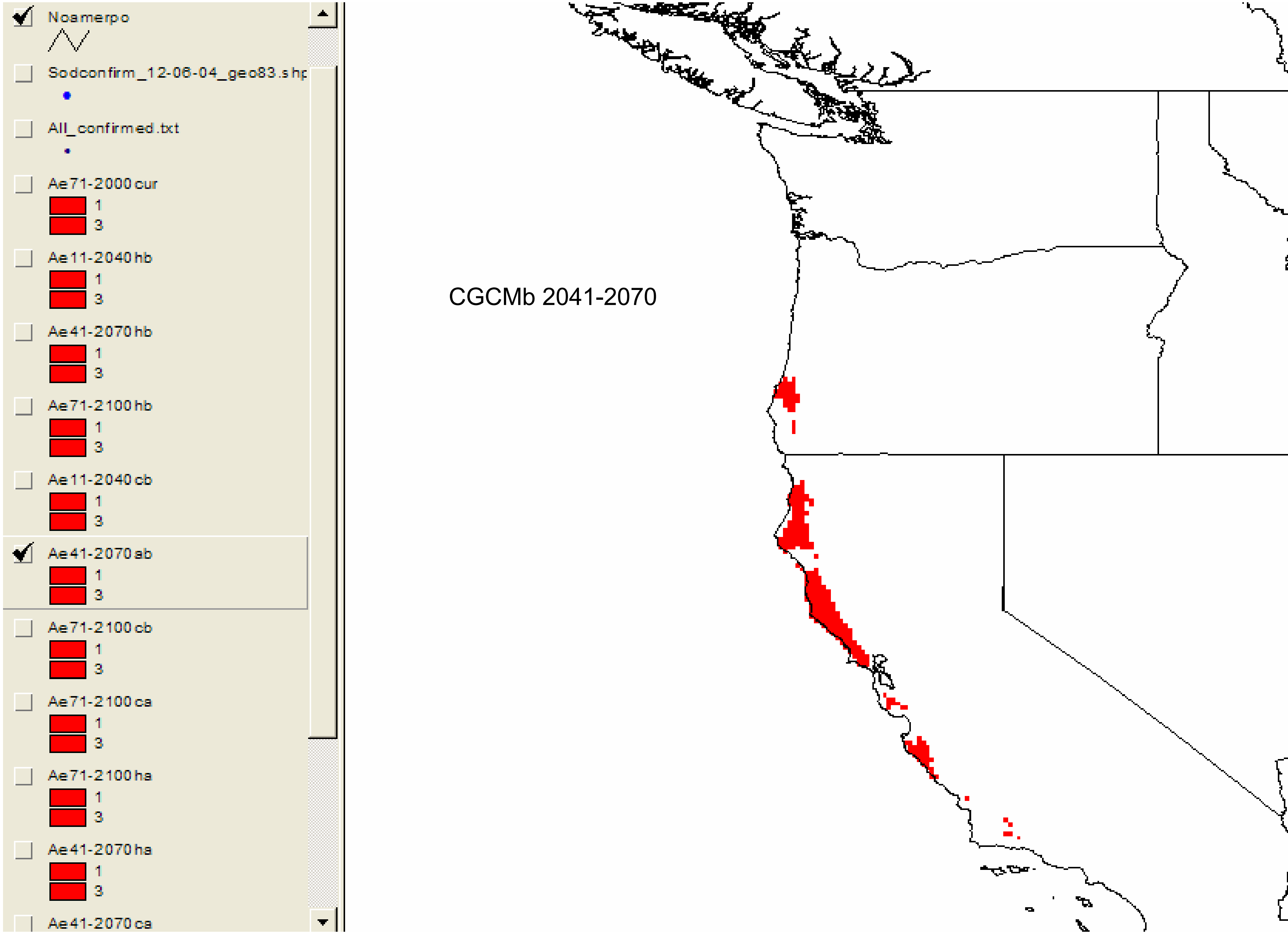
CGCMb 2011-2040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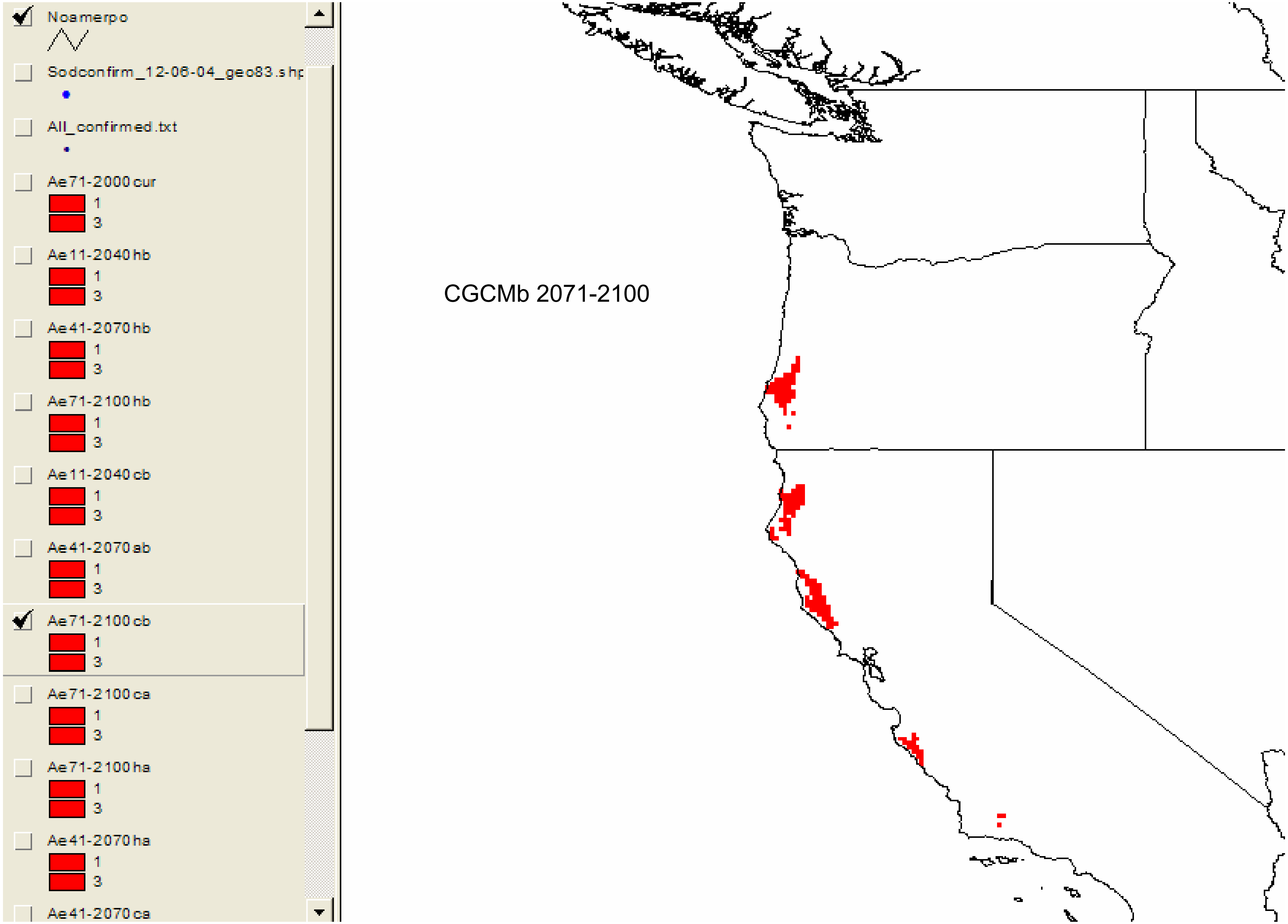
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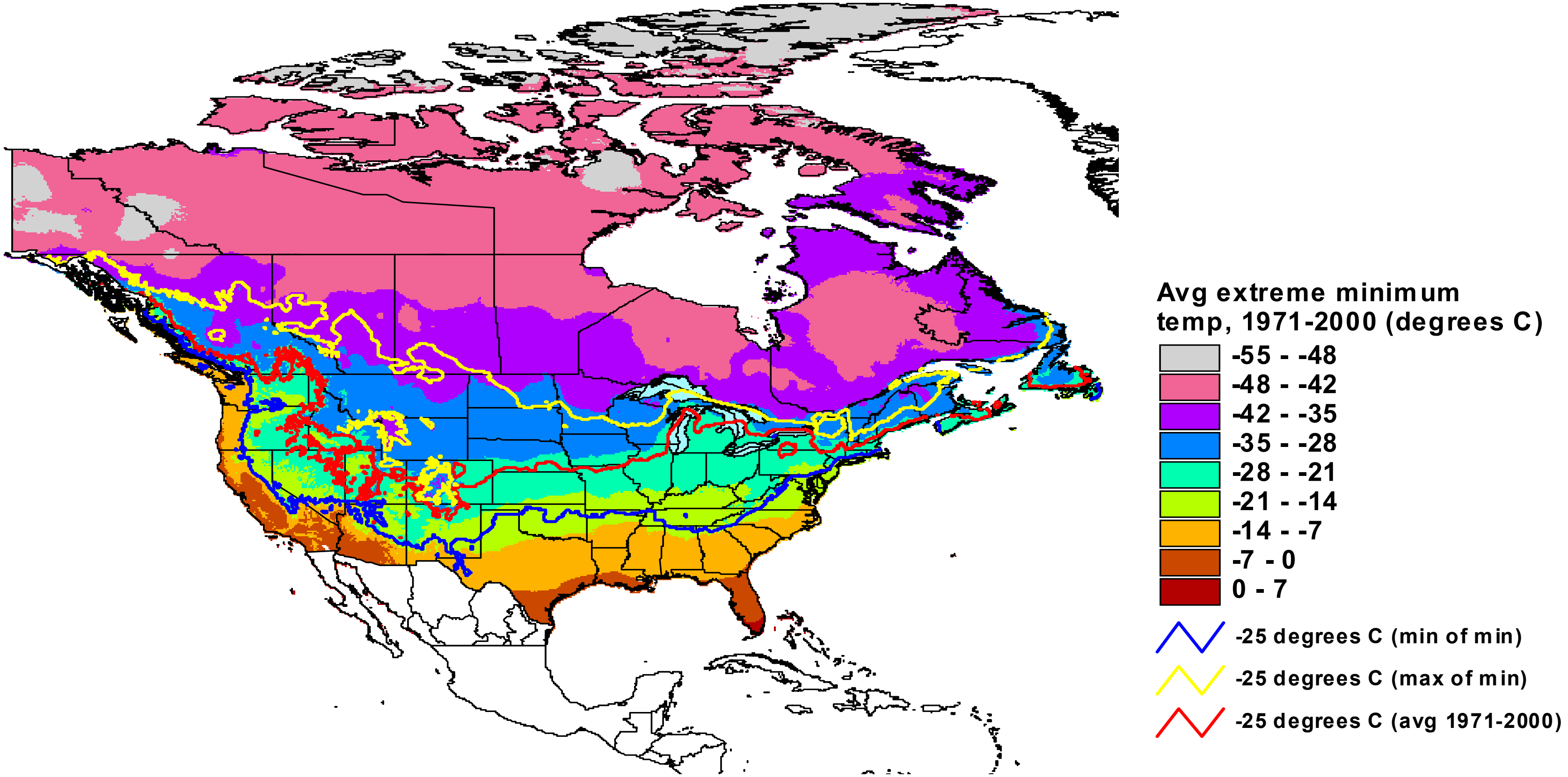
CGCMb 2071-2100

Another potential climate-related risk model for *P. ramorum*

- The following map is based on some new continent-wide extreme minimum temperature models (300 arcsecond resolution ~8-10km) http://www.glfc.cfs.nrcan.gc.ca/landscape/ph_usda_e.html
- Isotherms show coldest winter "day" – average over 1971/2000 period (red line)
- The "coldest" value at each grid cell for any single year from 1961 to 2000 ("min of the min" - blue line) (i.e. it has reached at least –25 everywhere north of the line at some point since 1961)
- also the "warmest" value at each grid cell for every year from 1961 to 2000 ("max of the min" - yellow line) (i.e. it always reaches at least –25 north of this line)
- A DEFRA (United Kingdom) report indicates all *P. ramorum* spores are killed after a 4 hour exposure to –25 degrees celcius (1 hour exposure killed most spores)
- An obvious problem with this type of model is not accounting for the insulating influences of snow and soil

Extreme Minimum Temperature Models for North America



References:

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Link - from APHIS

http://www.ncpmc.org/sod/

List of research questions - from APHIS

http://www.aphis.usda.gov/ppq/ispm/pramorum/sciencepanel.html

http://www.aphis.usda.gov/ppq/ispm/pramorum/