National and regional BMSB models and factors affecting presence/absence and population abundance

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Washington State University

Funding

USDA United States Department of Agriculture National Institute of Food and Agriculture
Specialty Crop Research Initiative

Collaborating Institutions

NC STATE UNIVERSITY
PennState
OSU Oregon State
UNIVERSITY OF MARYLAND
UNIVERSITY OF GEORGIA
WASHINGTON STATE UNIVERSITY
Northeastern IPM Center
Cornell University
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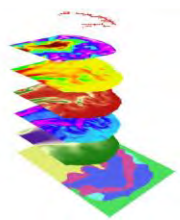
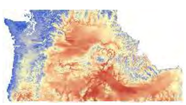
This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Specialty Crop Research Initiative under award number 2016-51181-25409.

Questions/Main aims

-  Can we effectively predict the risk of invasion (establishment) and abundance (impact) of BMSB using ecological modelling?

-     What are the most important environmental factors driving BMSB occurrence and abundance?

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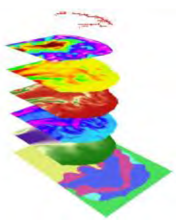
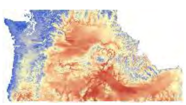
-  Can we effectively predict the risk of invasion (establishment) and abundance (impact) of BMSB using ecological modelling?

-    What are the most important environmental factors driving BMSB occurrence and abundance?

Team

- 40+ scientists from 25 research groups across 17 states

- The most responsive team we've ever worked with! Thank you all

Strengths

- Our nation-wide BMSB monitoring scheme represent a very rare and ideal dataset to tackle these questions

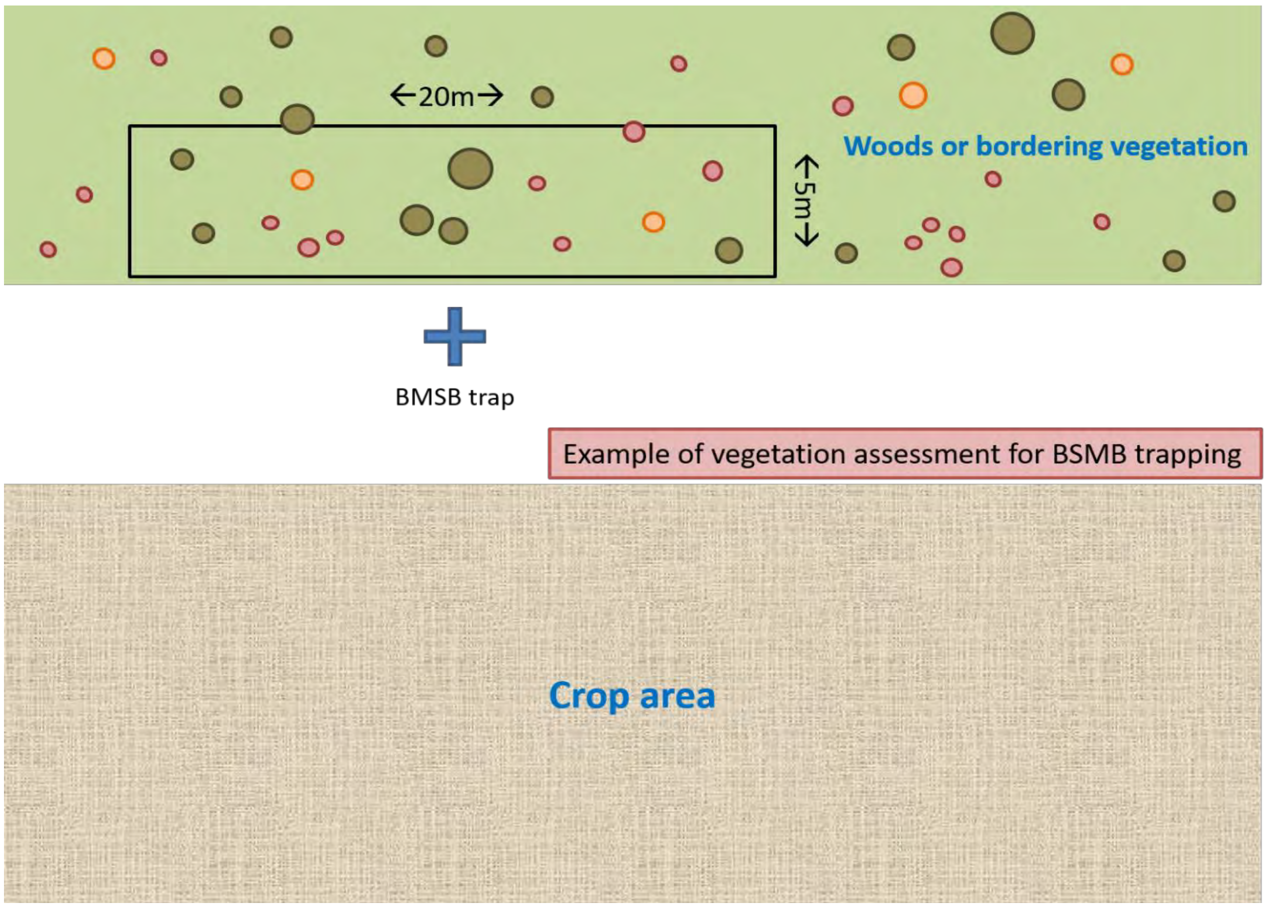
- Novel study: SDMs are rarely applied to non-natural systems or agricultural insect pests

Sampling protocol

BMSB sampling:

- Unique trapping location
- 3 traps per site (<50m apart)
- Interface of natural habitats and host crops
- Sampled from early spring into the fall

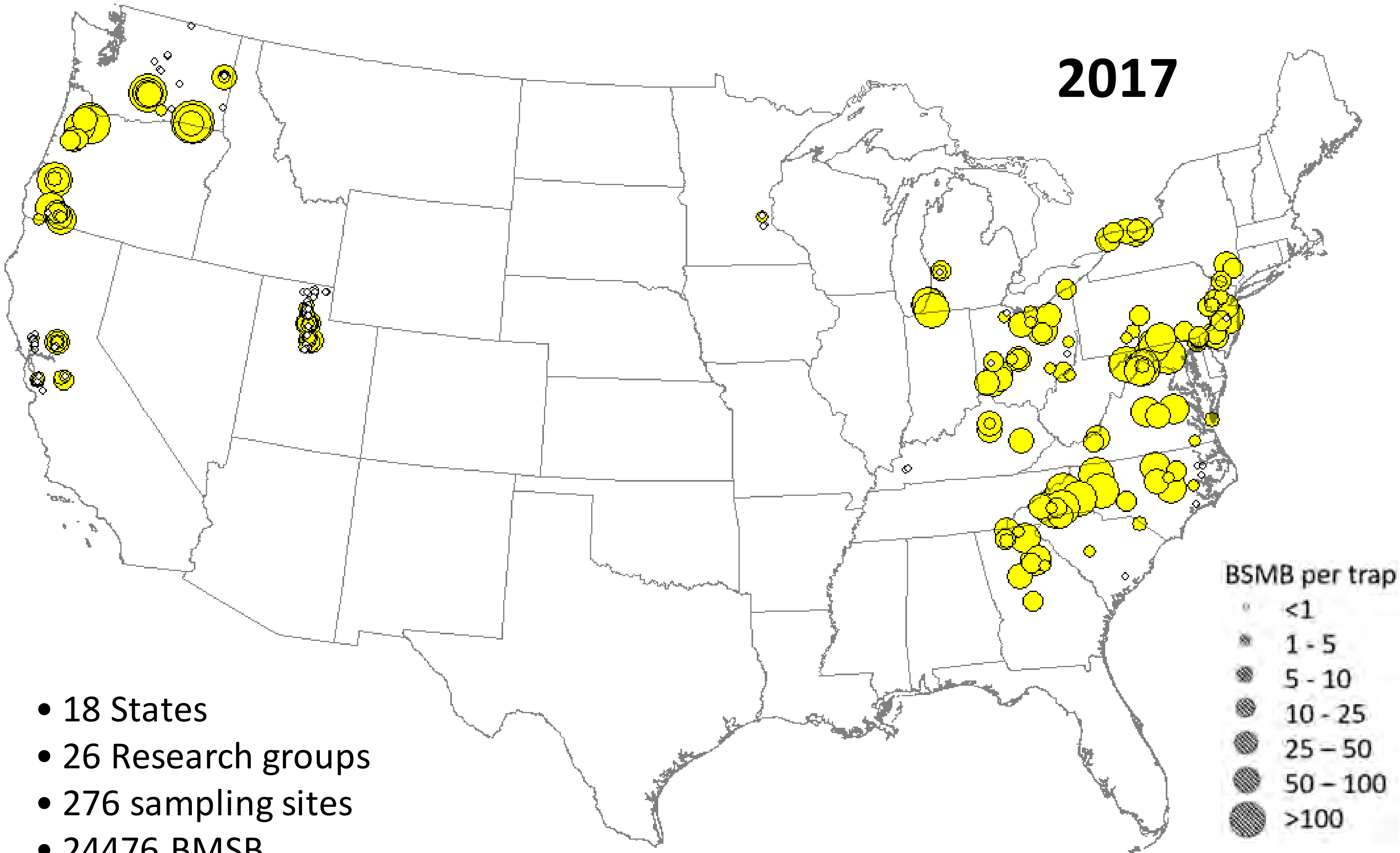
Sampling protocol



Vegetation sampling:

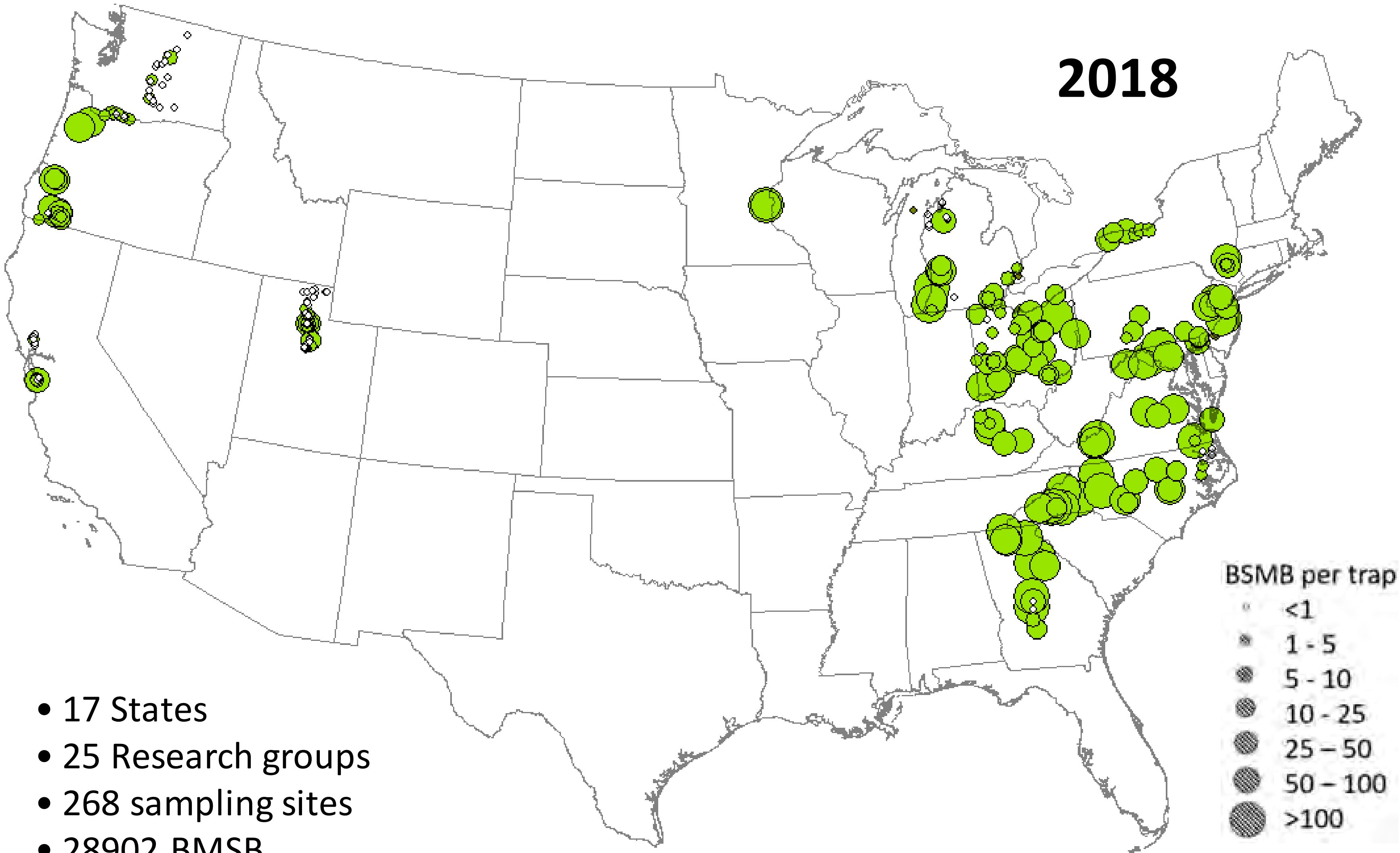
- Presence and abundance of host plants adjacent to traps
- 20 meter (65 ft) length of woods adjacent to each trap
- Once or twice during summer months

Monitoring Network System



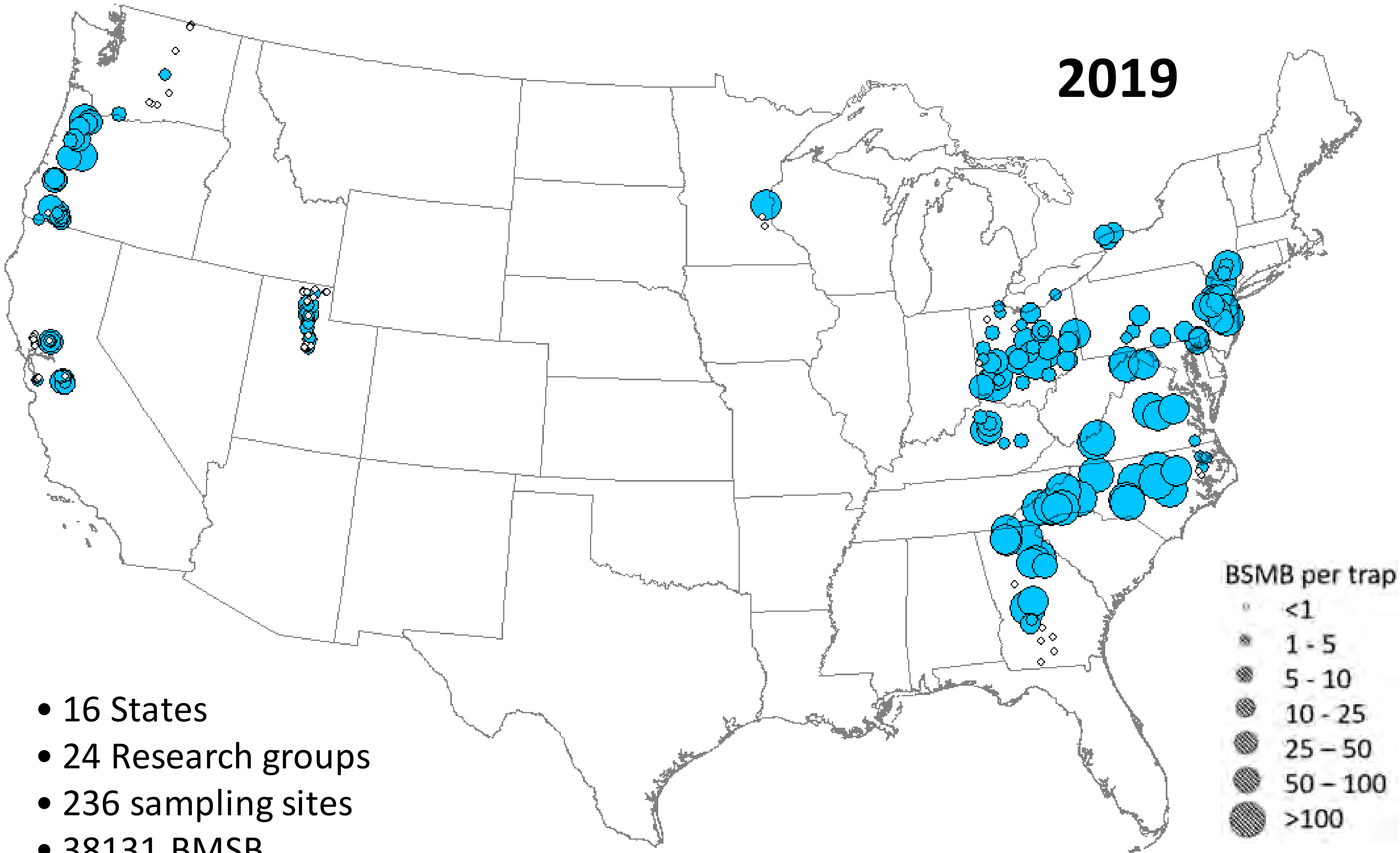
- 18 States
- 26 Research groups
- 276 sampling sites
- 24476 BMSB

Monitoring Network System

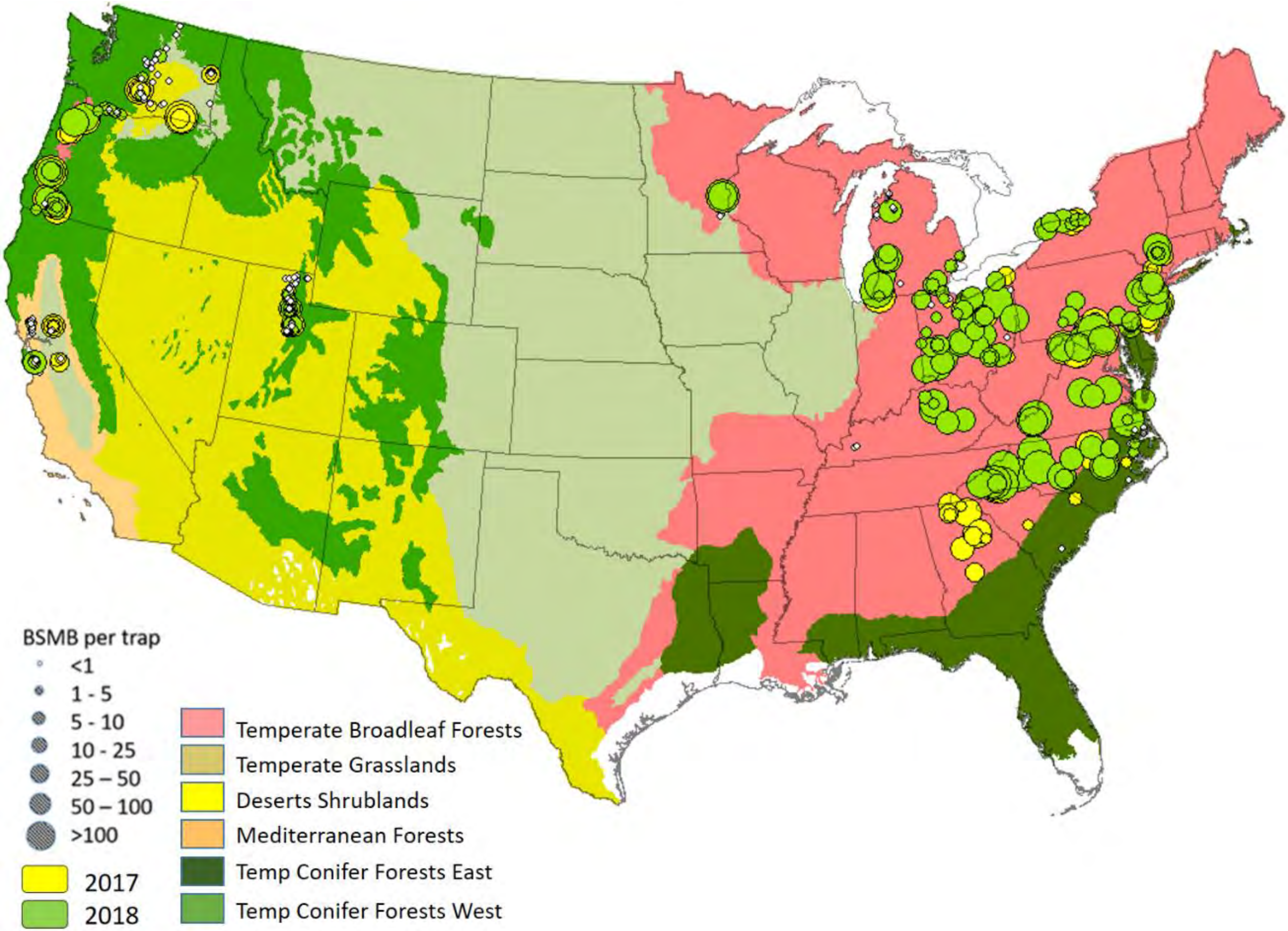


- 17 States
- 25 Research groups
- 268 sampling sites
- 28902 BMSB

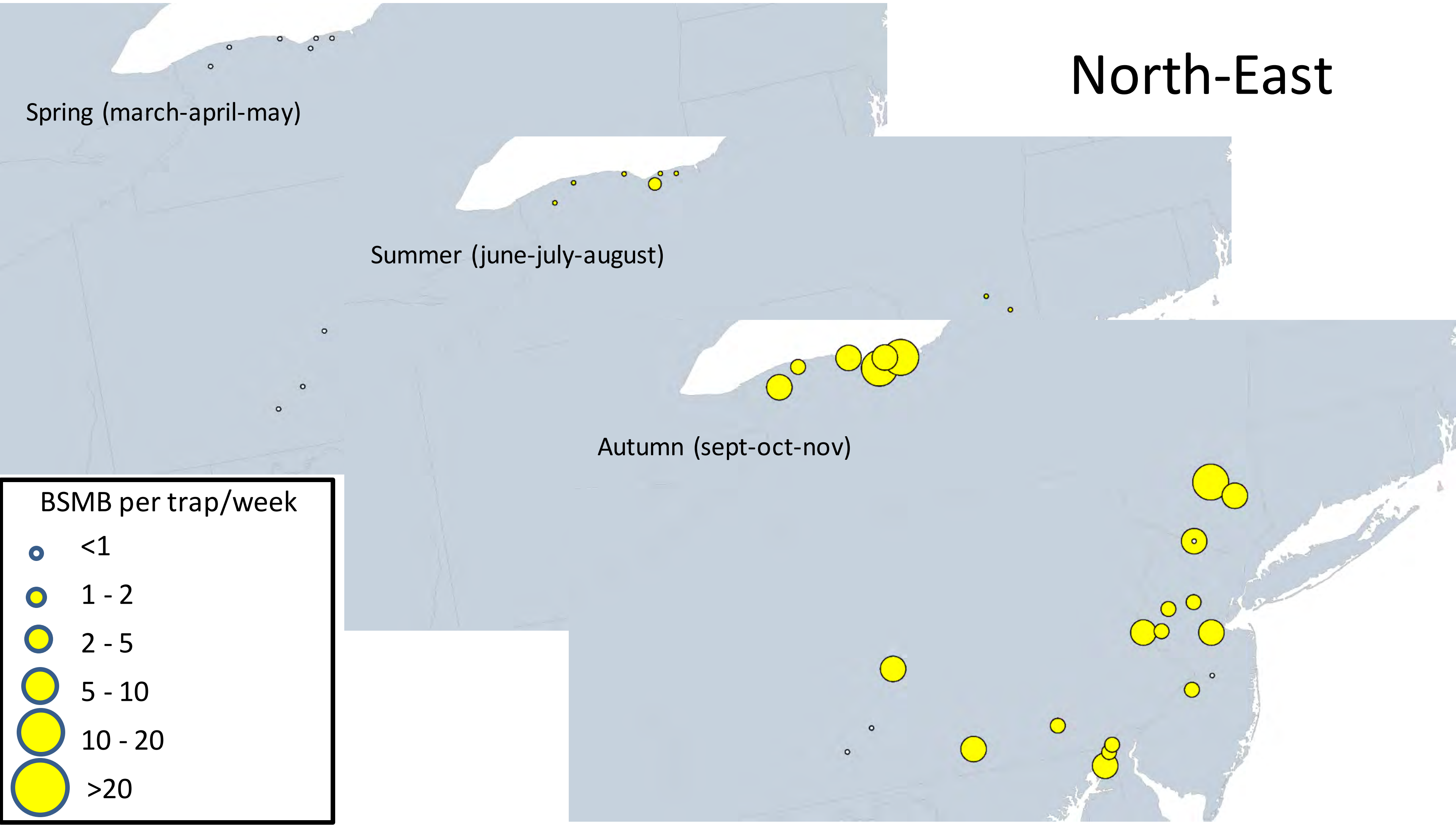
Monitoring Network System



- 16 States
- 24 Research groups
- 236 sampling sites
- 38131 BMSB

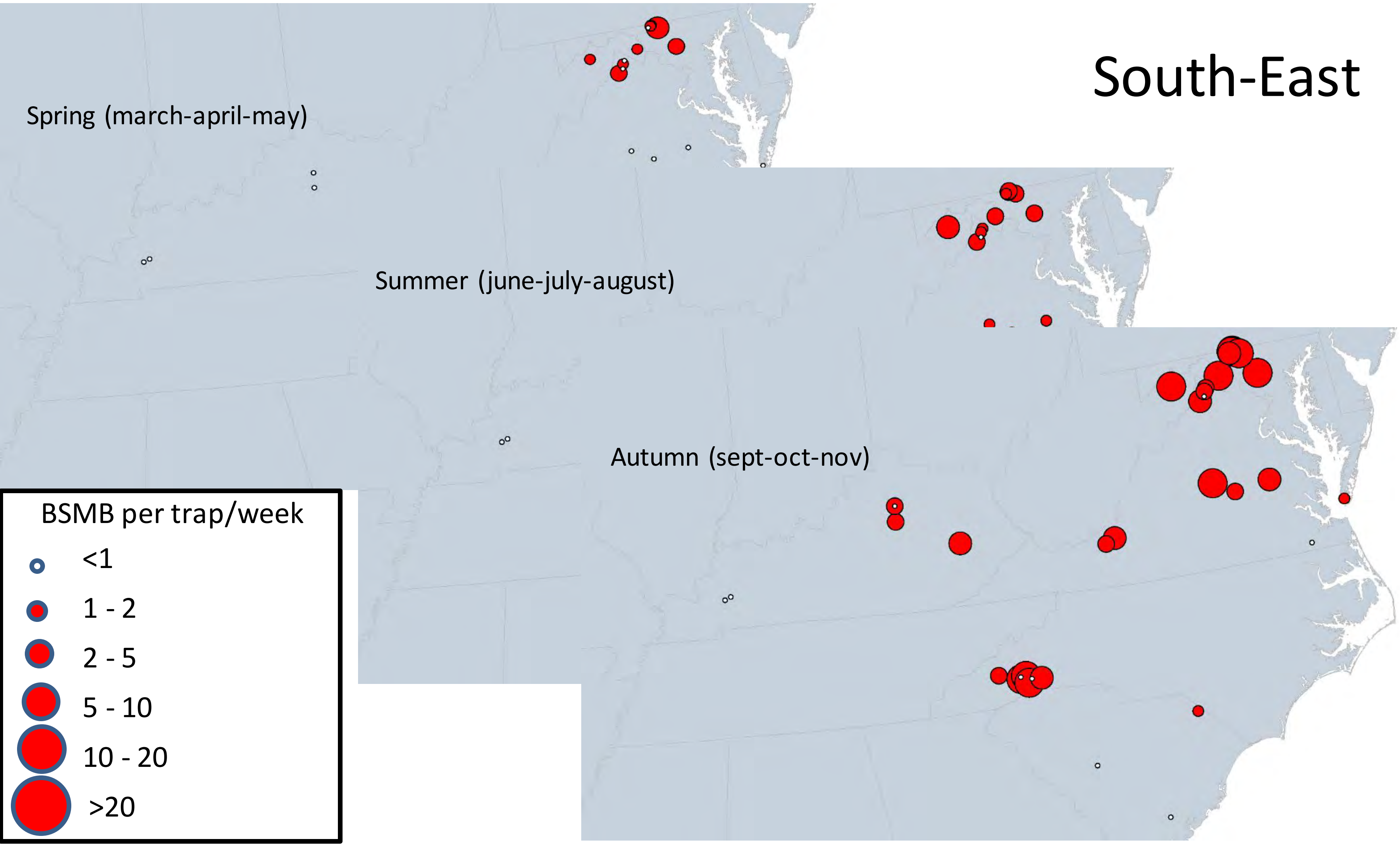

BSMB per trap
<1
1 - 5
5 - 10
10 - 25
25 – 50
50 – 100
>100
2017
2018
Temperate Broadleaf Forests
Temperate Grasslands
Deserts Shrublands
Mediterranean Forests
Temp Conifer Forests East
Temp Conifer Forests West

North-East

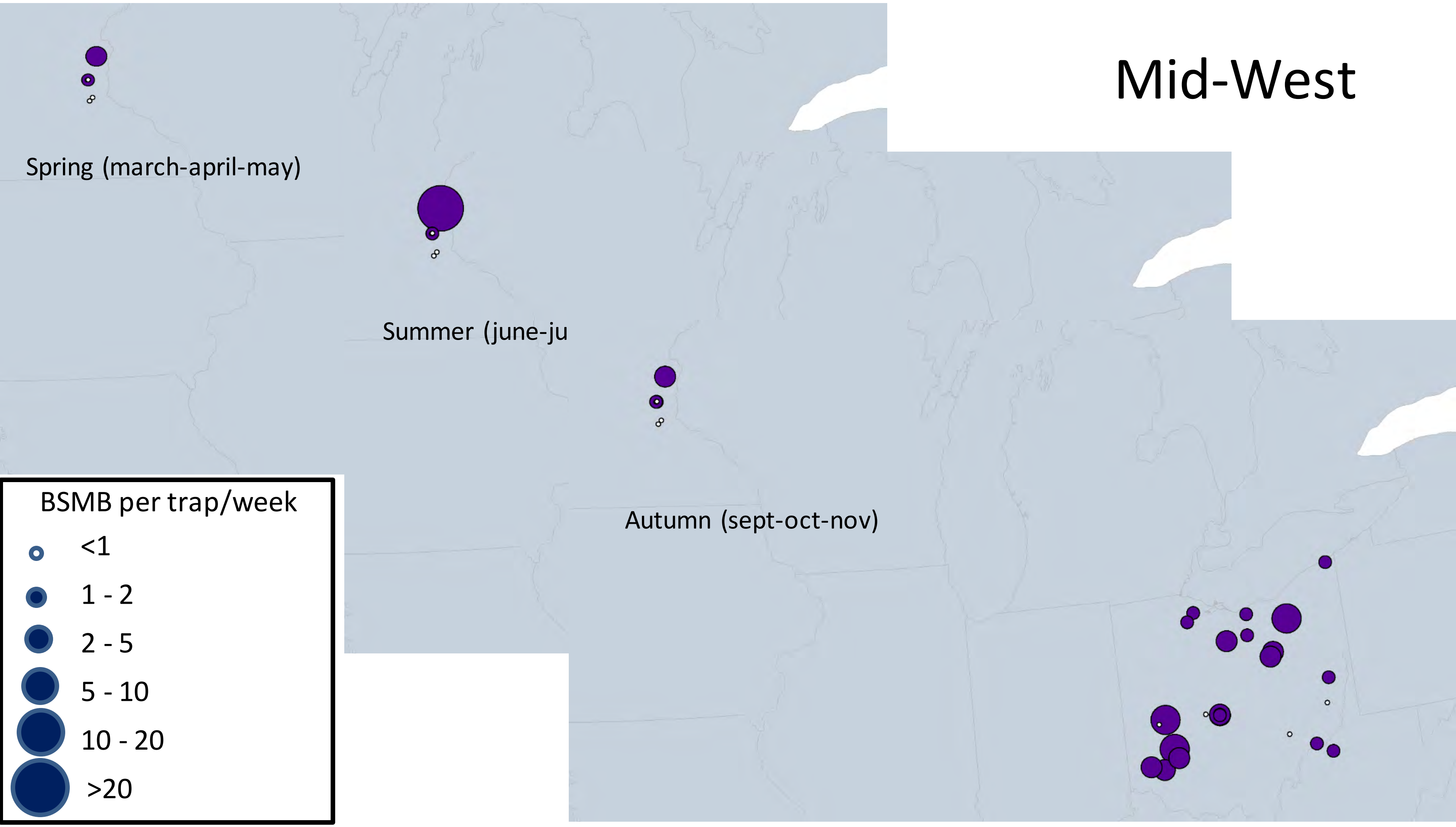


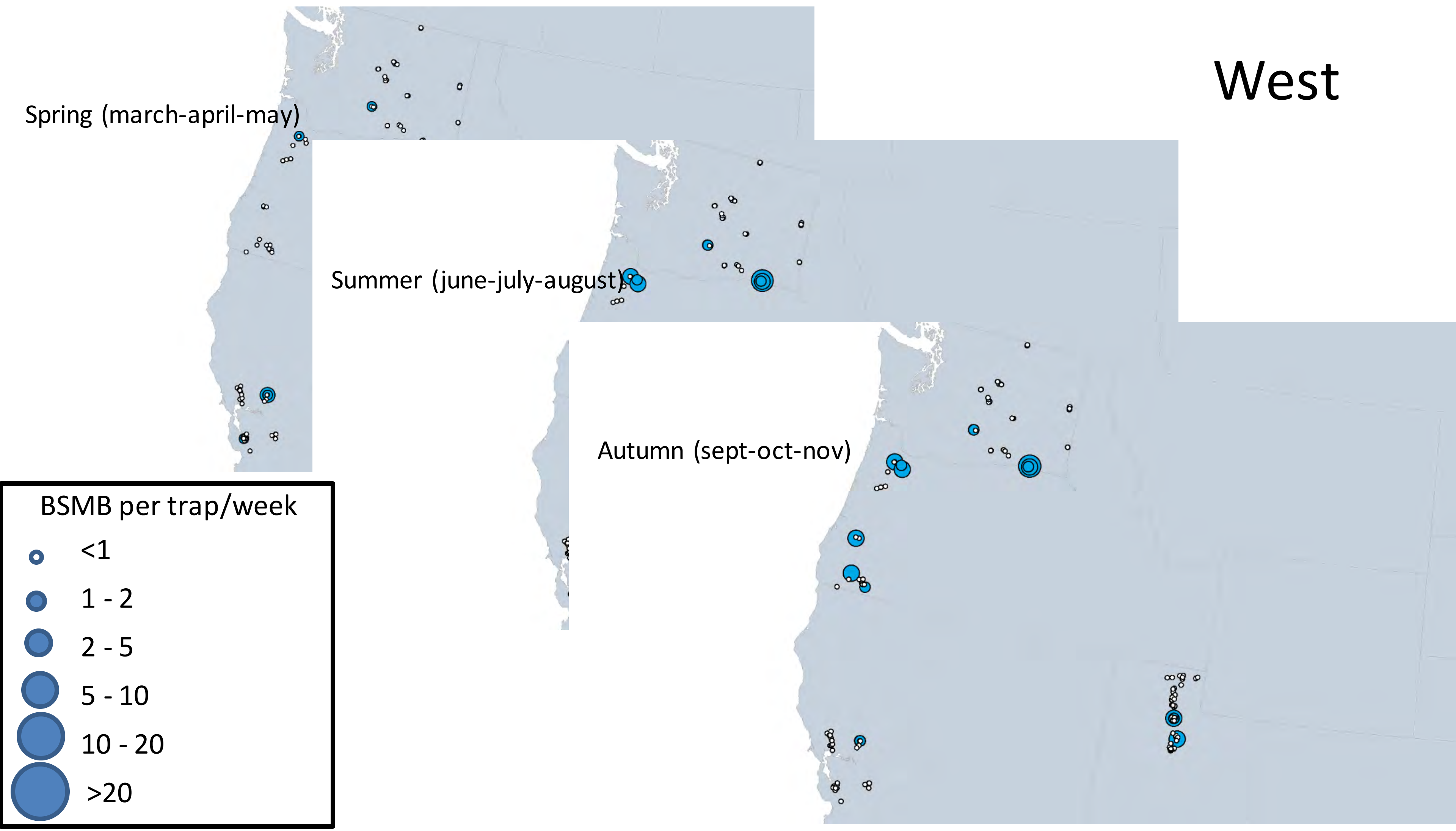
Spring (march-april-may)
Summer (june-july-august)
Autumn (sept-oct-nov)
BSMB per trap/week
<1
1 - 2
2 - 5
5 - 10
10 - 20
>20

South-East


Spring (march-april-may)
Summer (june-july-august)
Autumn (sept-oct-nov)
BSMB per trap/week
<1
1 - 2
2 - 5
5 - 10
10 - 20
>20

Mid-West


Spring (march-april-may)
Summer (june-ju
Autumn (sept-oct-nov)
BSMB per trap/week
<1
1 - 2
2 - 5
5 - 10
10 - 20
>20


West
Spring (march-april-may)
Summer (june-july-august)
Autumn (sept-oct-nov)
BSMB per trap/week
<1
1 - 2
2 - 5
5 - 10
10 - 20
>20

Modeling approach:

- Occurrence models (establishment): **MAXENT**

- Abundance models (impact): **Boosted regression trees** implemented in "gbm" R package.

Predictors

a) **Climatic** (PRISM)

- Max temp summer
- Min temp winter
- Precipitation
- Vapor pressure deficit
- Evapotranspiration
- Growing degree days

Wolrdclim – global climate data, http://worldclim.org/version2

Predictors

a) **Landscape**

- Land-cover
- Distance to water
- Soil ph
- photoperiod

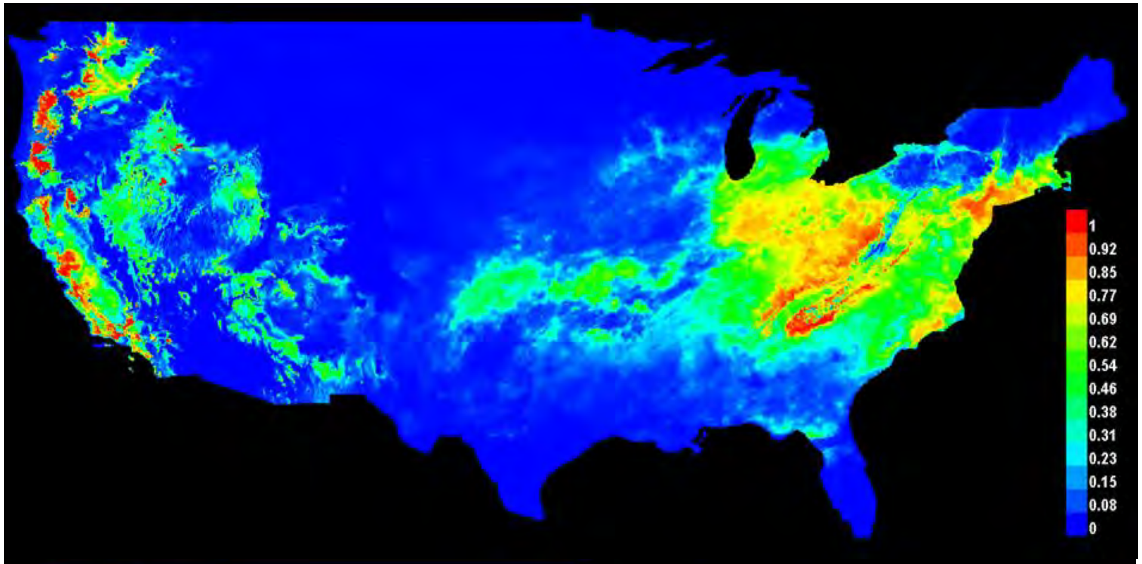
United States Department of Agriculture. National Agricultural Statistics Service, https://www.nass.usda.gov/

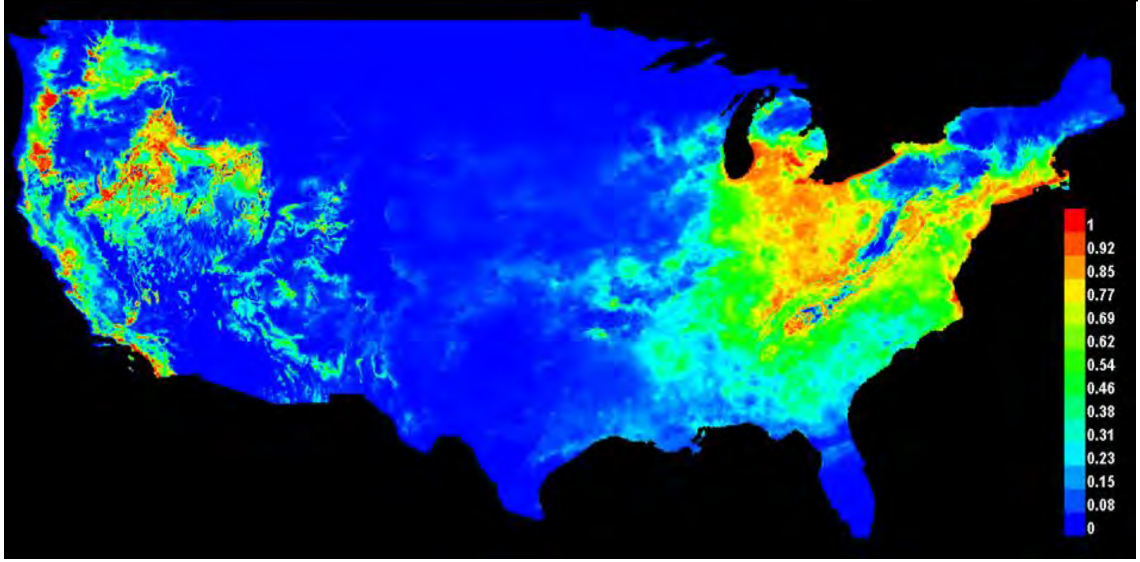
Climatic and landscape variability (among sampling sites)

	2017	2018	2019
Minimum tp winter (ºC)	-2.5 (-14.6 - 6.1)	-4.5 (-16.1 - 7.4)	-2.8 (-16.3 - 6.8)
Maximum tp summer (ºC)	31.2 (25.9 - 36.7)	30.7 (26.2 - 35.2)	30.7 (23.3 - 34.3)
Precipitation (mm)	134.5 (23.7 - 544.7)	67.2 (15.6 - 267.9)	103.3 (11.4 - 326.0)
Elevational range (m)	476.7 (2.1 -1845)	499.5 (2.1 -1845.2)	429.6 (0.5 - 1934)
Land-use classes	27	28	26
Solar_photoperiod	1345.4 (1.2 - 2764.4)	1316.7 (2.8 - 2882.2)	1316.3 (0.2 - 2764.4)
Evapotranspiration	43.1 (16.3 - 73.5)	44.4 (14.5 - 71.9)	45.0 (14.5 – 80.0)
Soil ph	6.2 (5.0 - 8.1)	6.2 (5.0 - 8.1)	6.1 (5.0 - 8.1)
Distance to water	112 (1 - 504)	109 (1 - 498)	112 (1 - 438)

Results

Presence (establishment) models

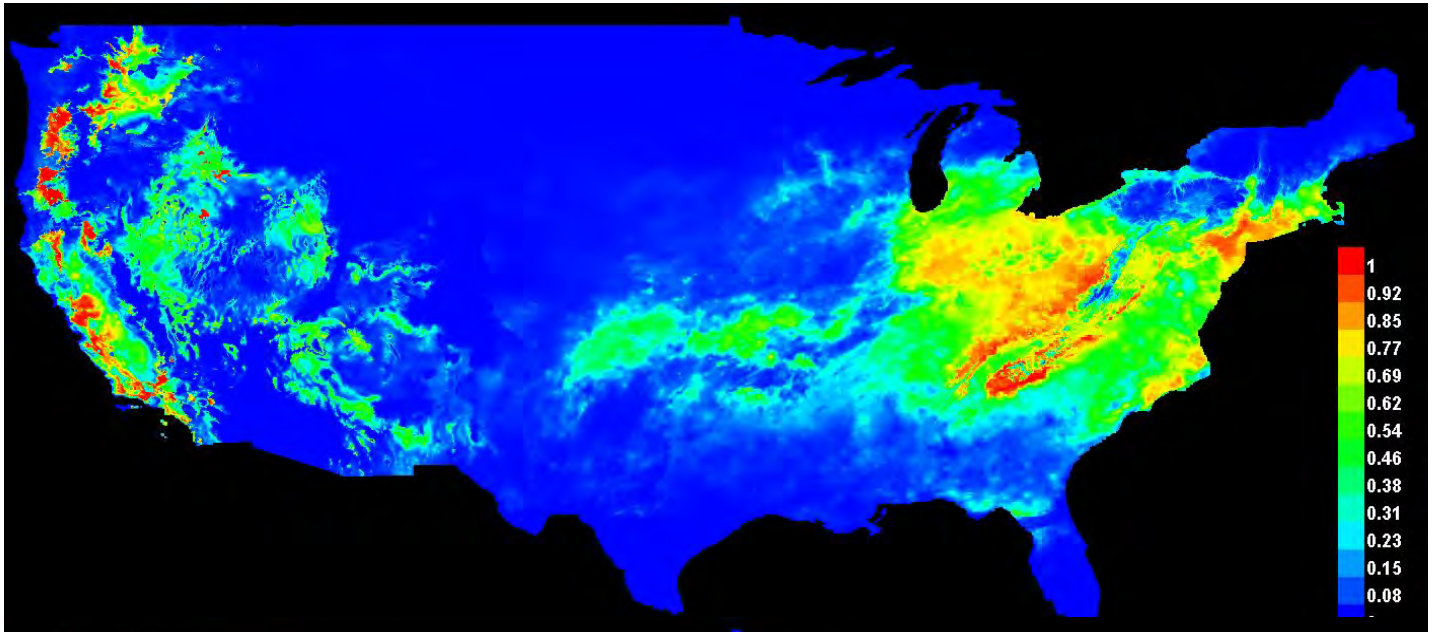


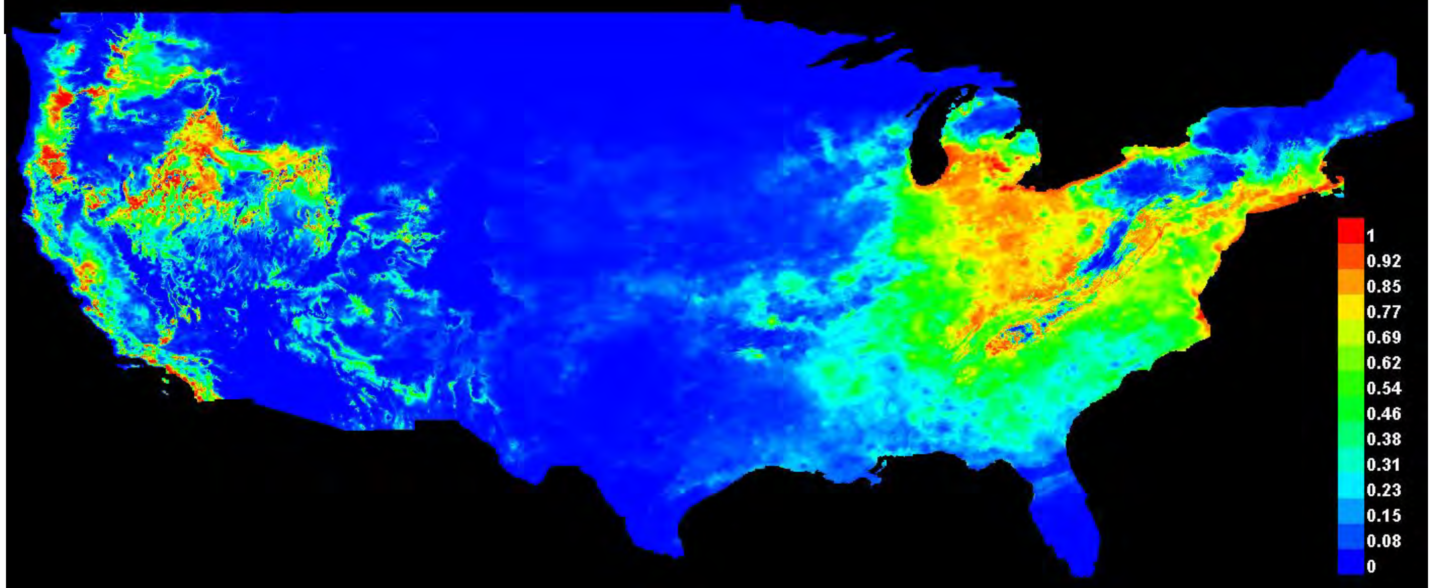


<u>Top climatic predictors</u>:
- winter precipitation
- minimum tp winter
- growing degree days

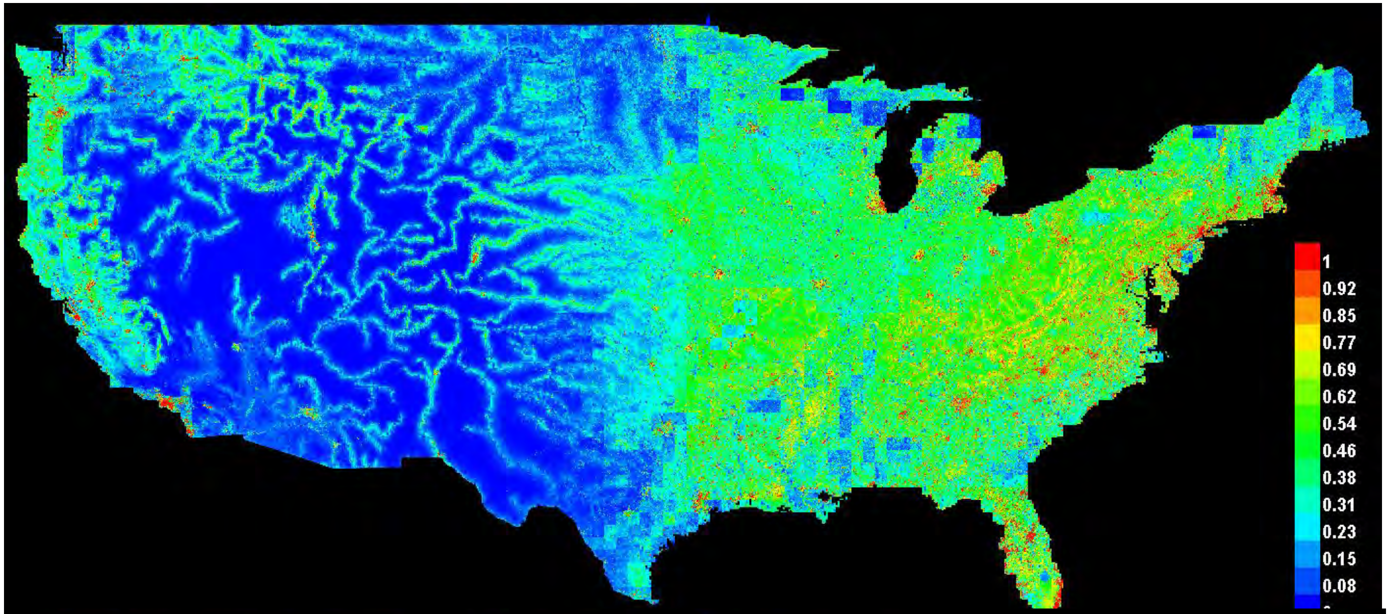
<u>Top landscape predictors</u>:
- land use
- soil ph
- solar photoperiod

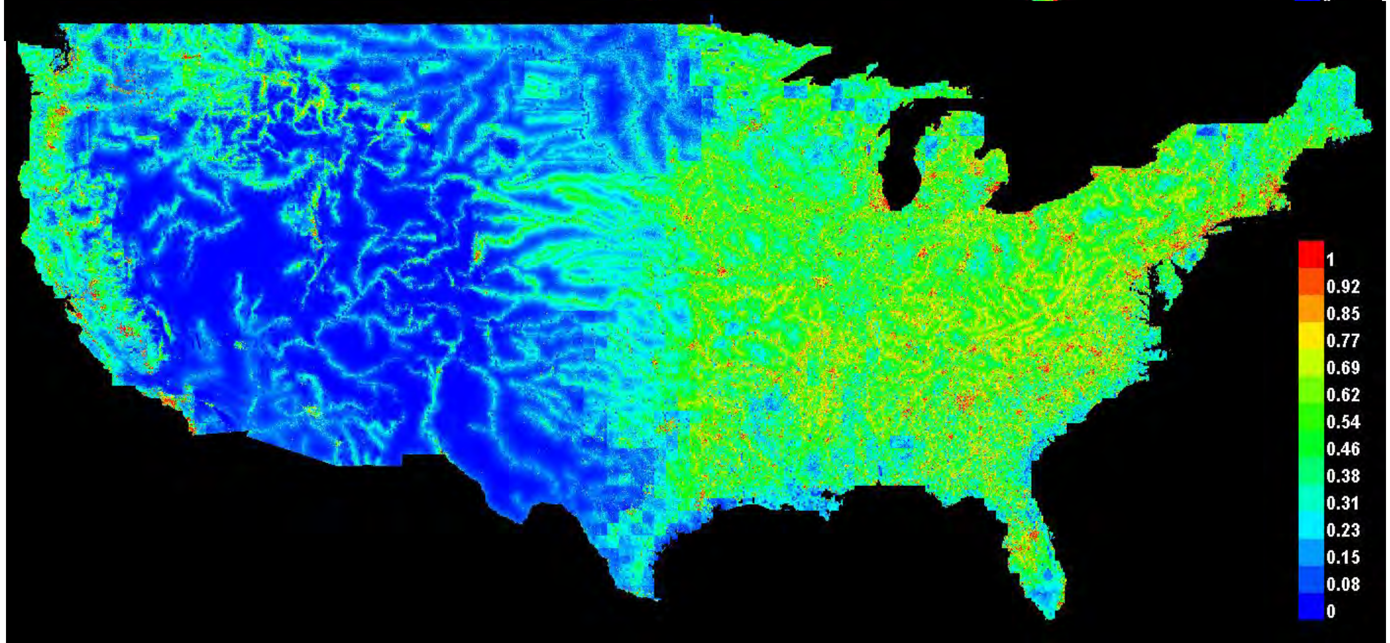
Results – Climate only



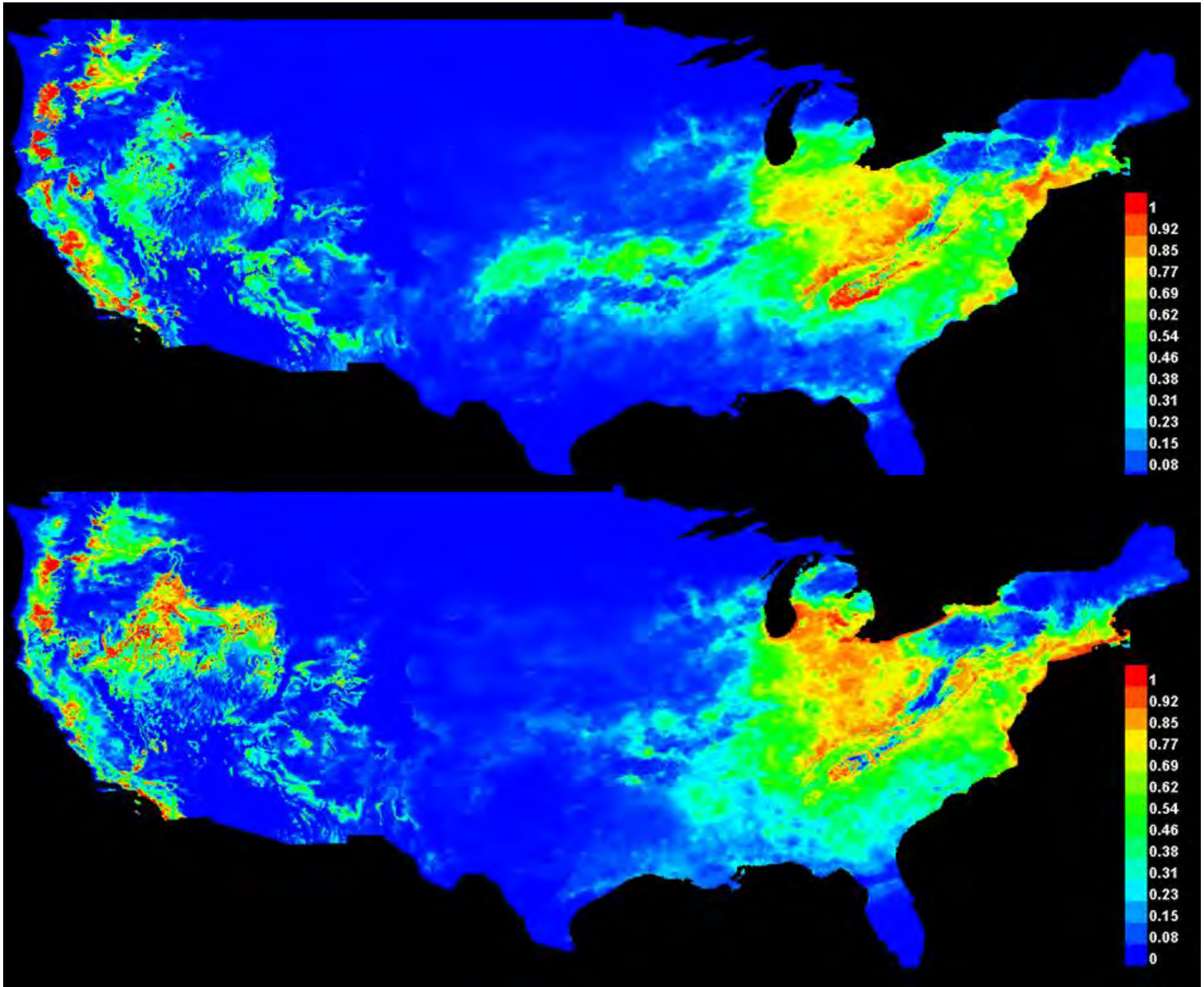


Results – Landscape only

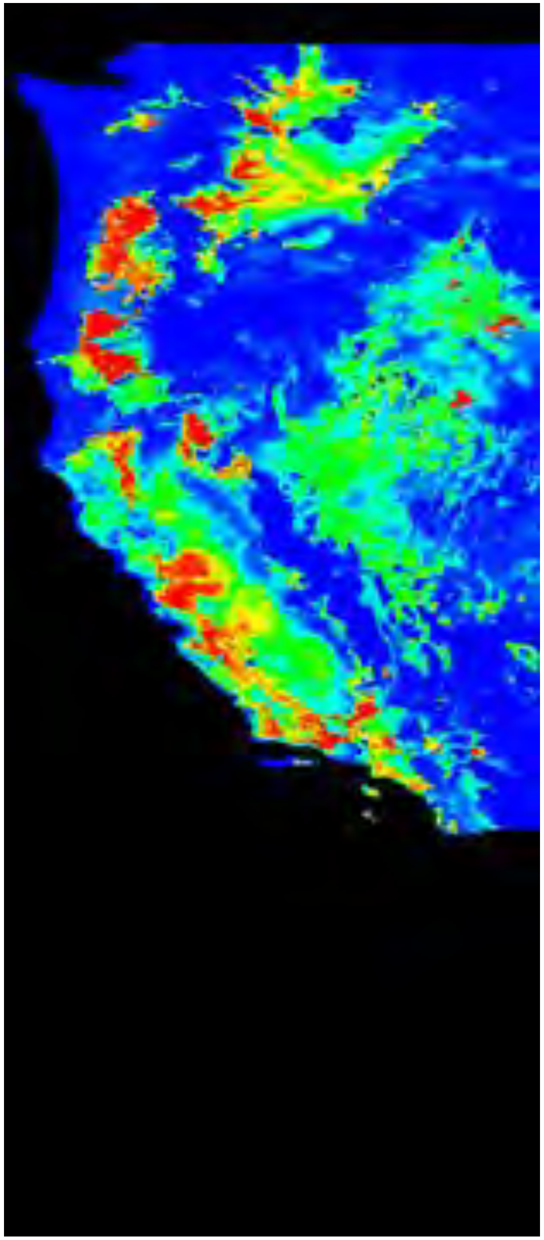




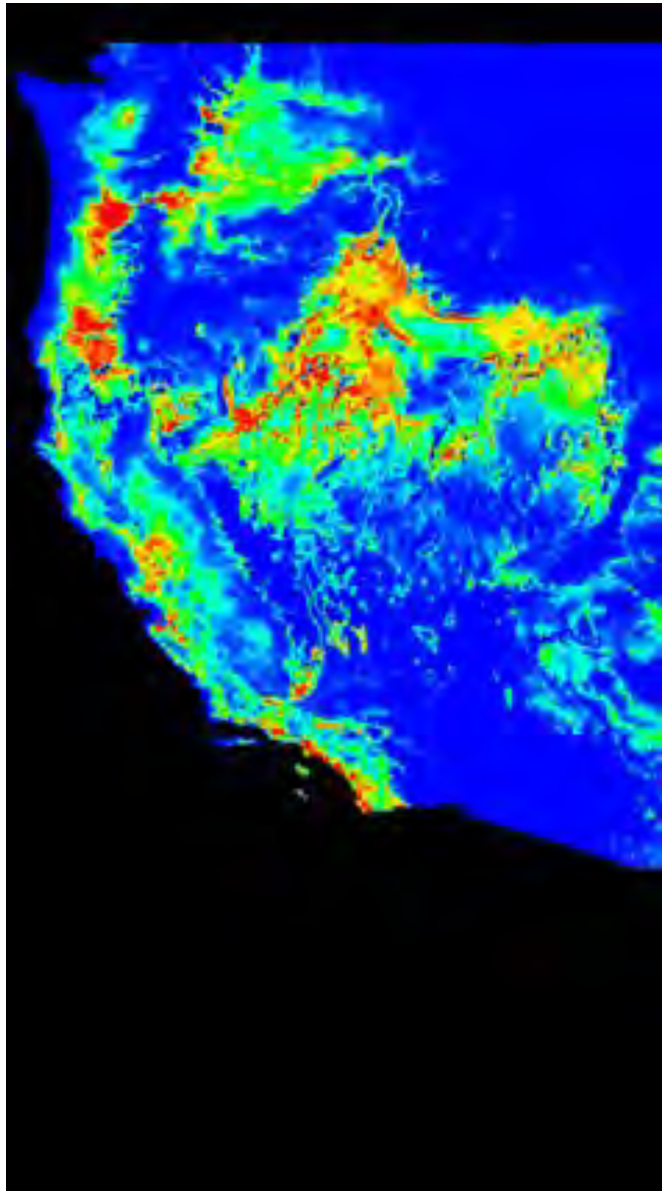
Results – Combined



Results – West Coast 2017



Results – West Coast 2018



Results

Abundance (impact) models

Correlation observed vs predicted abundance:

- Climatic models: Spearman's rho = 0.457; $p<0.001$
- Climatic models: Spearman's rho = 0.522; $p<0.001$

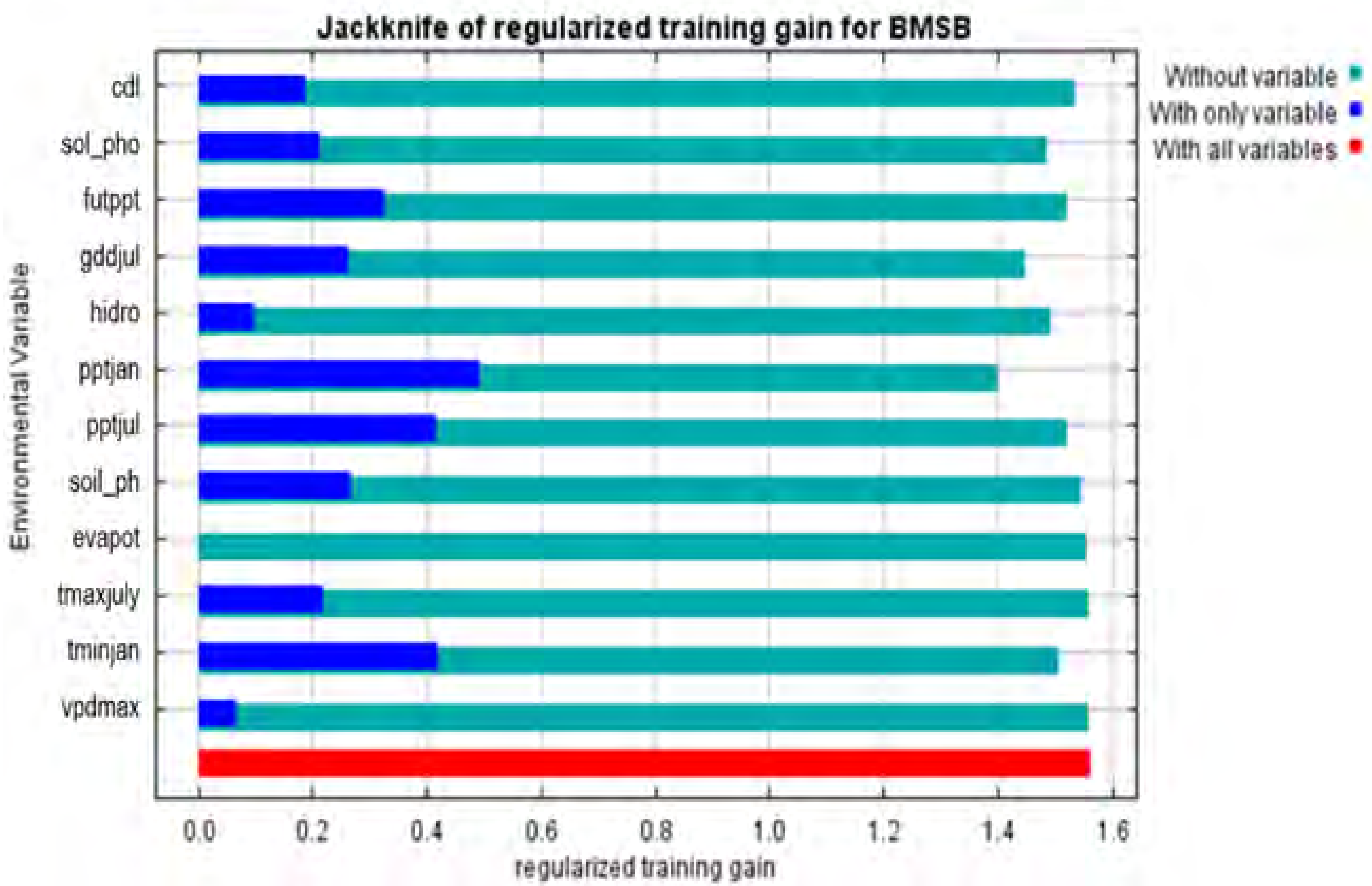
Top climatic predictors:

- minimum tp winter
- evapotranspiration
- summer precipitation

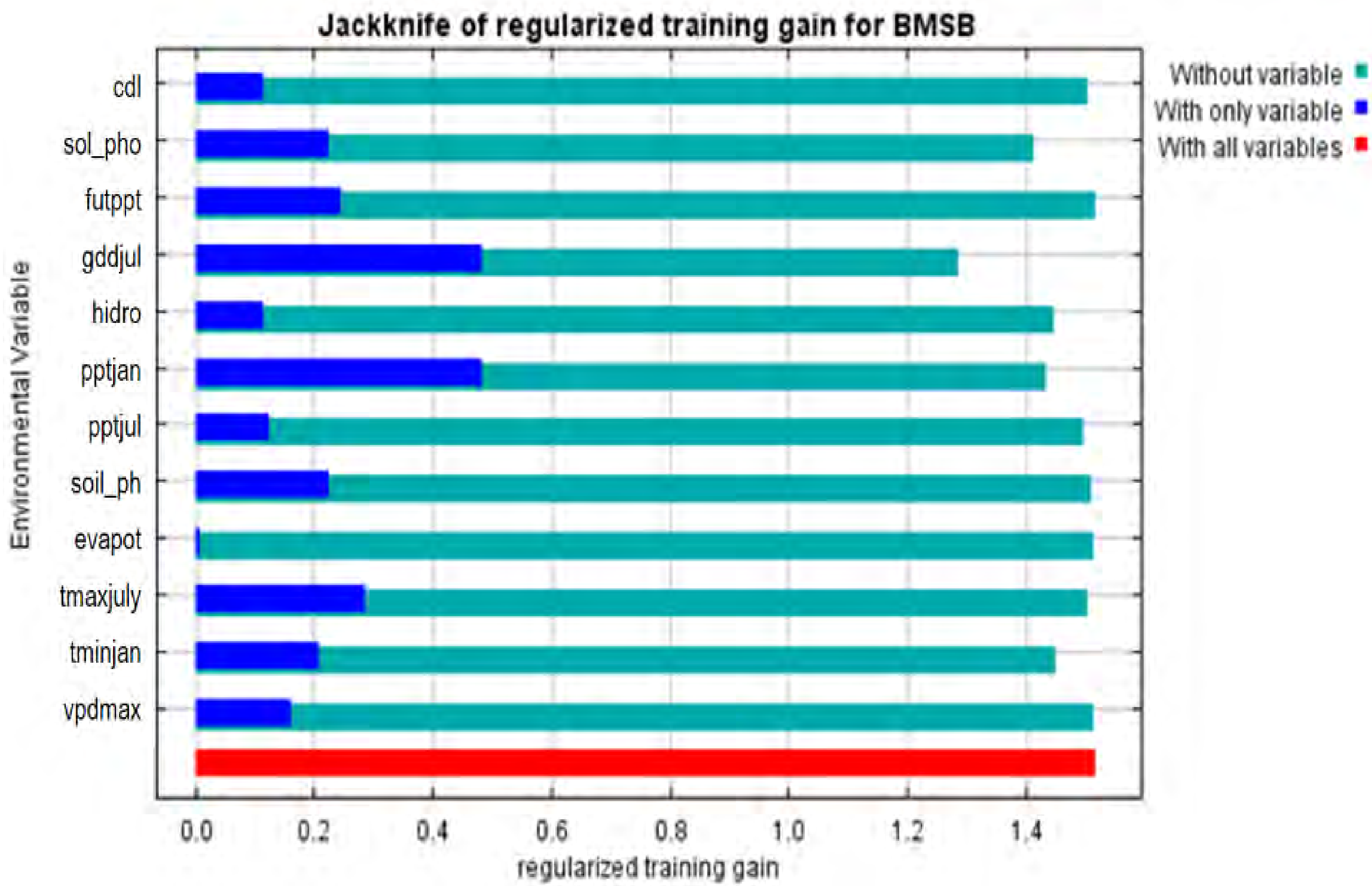
Top landscape predictors:

- solar photoperiod
- soil ph
- distance to water

Results - 2017



Results - 2018



Conclusions

- Our Ecological niche models can accurately describe bot the occurrence and the abundance of BMSB.

- It appears that, while winter conditions are more important for BMSB presence, factors like photoperiod and evapotranspiration are driving BMSB abundance. In both cases, minimum temperature in winter seems to be a limiting factor.

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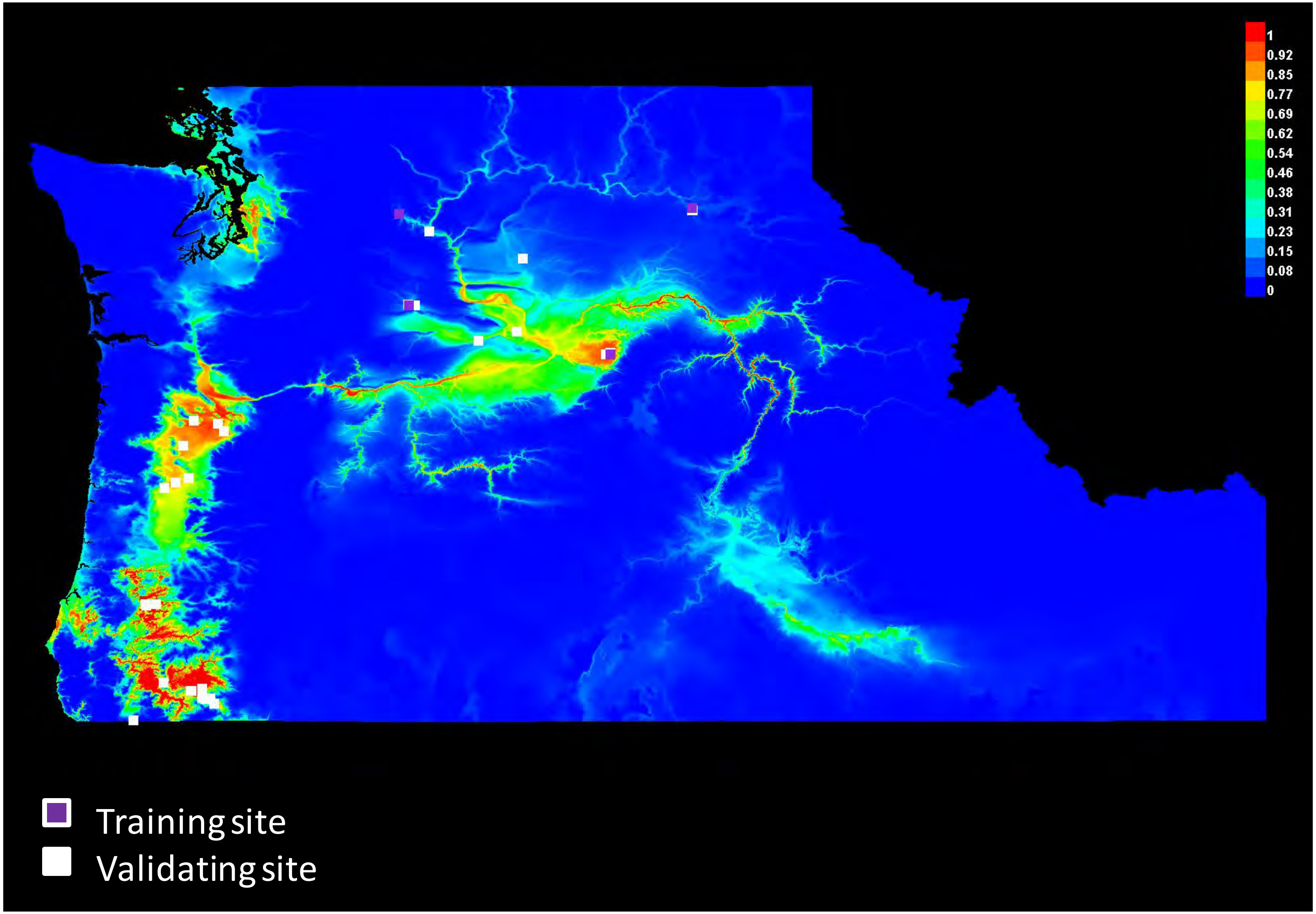
Example of smaller scale (regional) model



BMSB risk of invasion (Climate) 2017/2018 in the PNW

Caveats and further research…

- Results presented here are solely based on adults. Data for larvae instars are available for modelling.

- After previous meetings with participants, new predictors will be considered (e.g. distance to urban areas).

- The temporal aspect has not yet being considered. Phenology models are the next critical step.

- We will calculate predicted change in suitable habitat based in IPCC future climatic scenarios (e.g. moderate climatic scenario: 1.5 ºC and 10% ppt.

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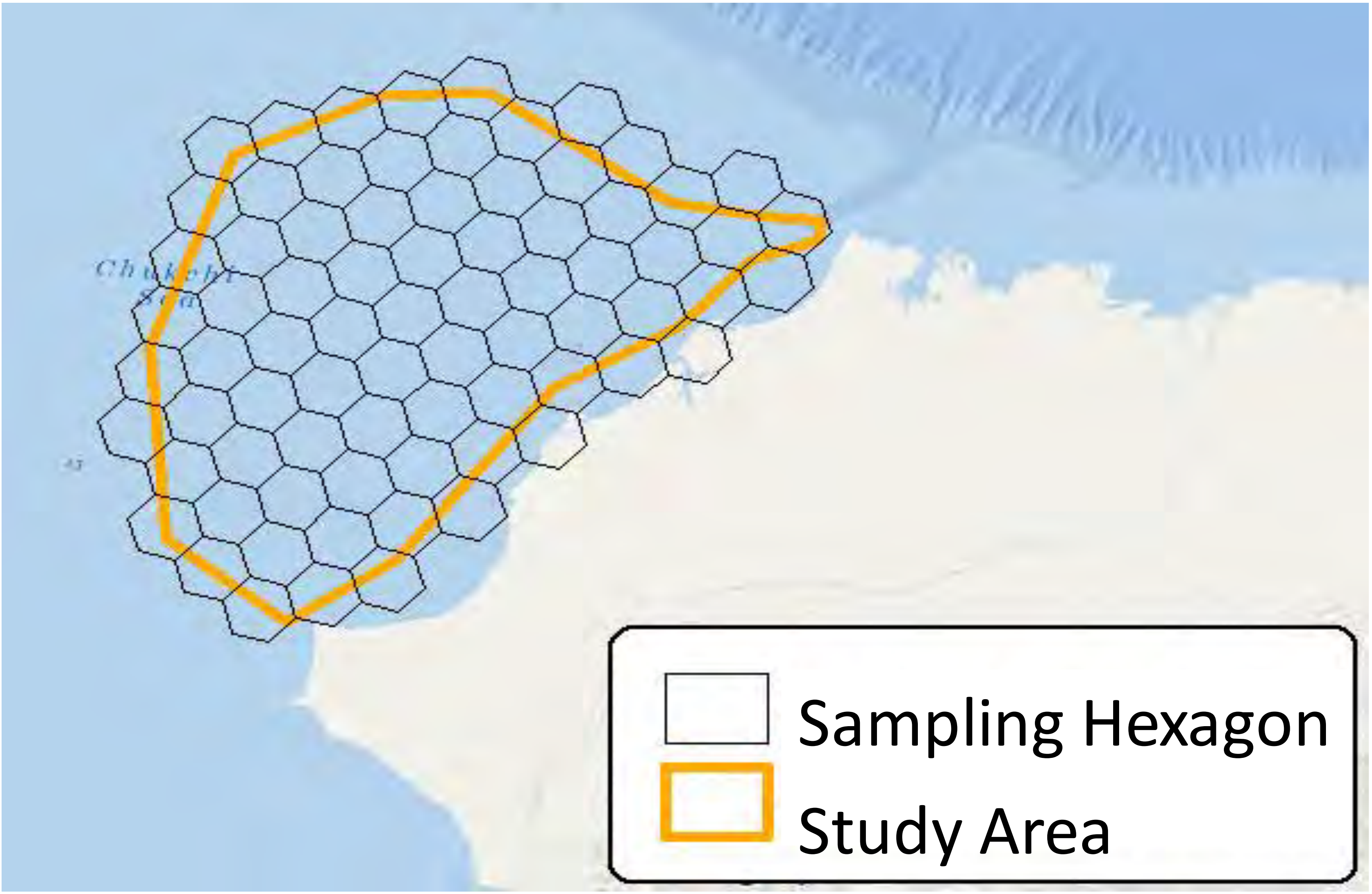
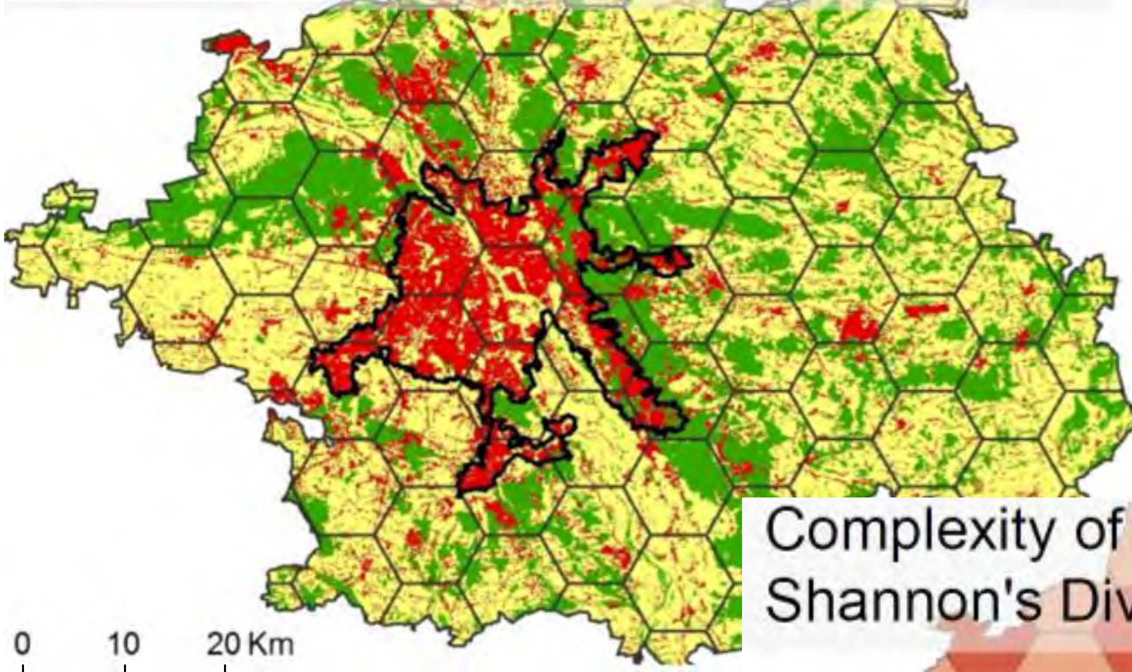
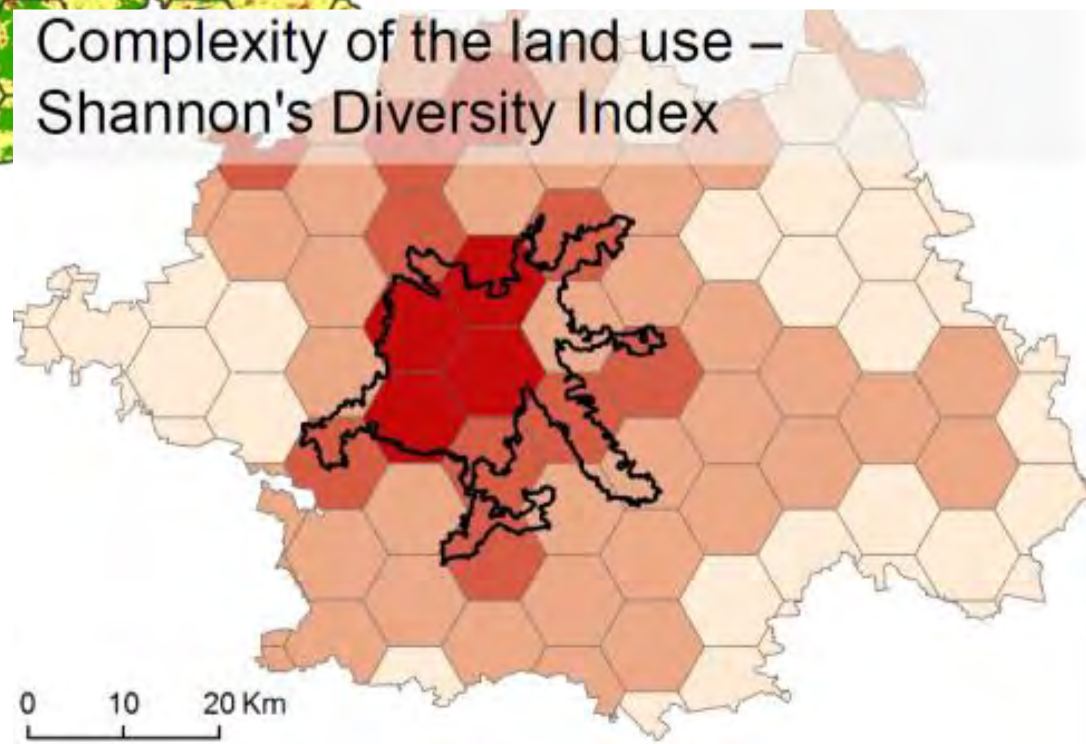
• Landscape structure models are being developed (diversity, fragmentation, connectivity).



Land cover and Hexagons





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Further research (Nosema maddoxi)…

State	% infected	# high infection	# low infection	# uninfected	# total	Degrees W	Degrees N
DE	0.00%	0	0	25	25	-75.742267	39.667969
GA	0.00%	0	0	16	16	-83.738785	32.658514
KY	20.00%	1	5	25	30	-84.536792	38.013029
MD	40.00%	5	3	12	20	-76.75111	38.91111
MD	13.33%	4	0	26	30	-77.43028	39.16556
MD	23.33%	2	5	23	30	-76.132361	39.658991
MI	0.00%	0	0	30	30	-84.788288	42.635395
MI	3.33%	0	1	29	30	-86.513024	42.041258
MI	6.67%	0	2	28	30	-86.381256	41.977244
MI	3.33%	0	1	29	30	-85.789065	42.930614
MN	0.00%	0	0	30	30	-92.995727	45.334428
NC	0.00%	0	0	26	26	-82.9764	35.45366
NC	28.00%	5	2	18	25	-81.047	36.052
NJ	0.00%	0	0	30	30	-75.43337102	39.56705
NJ	13.33%	3	1	26	30	-75.126754	39.615989
NJ	0.00%	0	0	30	30	-74.522188	40.113816
NY	3.33%	0	1	29	30	-73.965735	41.746148
NY	0.00%	0	0	15	15	-76.2074211	42.6041713
NY	0.00%	0	0	30	30	-76.515286	42.541403
OH	10.00%	3	0	27	30	-83.06333	39.98877
OR	0.00%	0	0	25	25	-123.274	44.553
OR	0.00%	0	0	30	30	-122.654448	45.279876
OR	0.00%	0	0	30	30	-122.934975	42.3354722
OR	0.00%	0	0	24	24	-121.5186083	45.6850611
PA	5.00%	0	1	19	20	-77.292468	39.953894
PA	23.33%	4	3	23	30	-77.308069	39.955059
PA	6.67%	0	1	14	15	-76.68038	40.011086
TN	0.00%	0	0	30	30	-88.846325	35.623219
UT	0.00%	0	0	21	21	-111.90633	41.03606
UT	0.00%	0	0	28	28	-112.00829	41.33215
VA	4.00%	0	1	24	25	-78.22492	39.1305
VA	3.33%	1	0	29	30	-80.41778	37.23
WV	19.23%	1	4	21	26	-77.88759	39.35523

Further research…

- Validating model more completely (2020)

  Sampling in novel areas

  More intensive sampling in a few regions

Thank you!

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Funding

USDA United States Department of Agriculture — National Institute of Food and Agriculture

Specialty Crop Research Initiative

Collaborating Institutions

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NC STATE UNIVERSITY
PennState
OSU Oregon State University
University of Maryland
University of Georgia
Washington State University
Northeastern IPM Center
Cornell University
Utah State University
Rutgers University
The Ohio State University
University of Kentucky
UC Davis
University of Minnesota
Virginia Tech
Berkeley
Michigan State University
UC Riverside

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Specialty Crop Research Initiative under award number 2016-51181-25409.