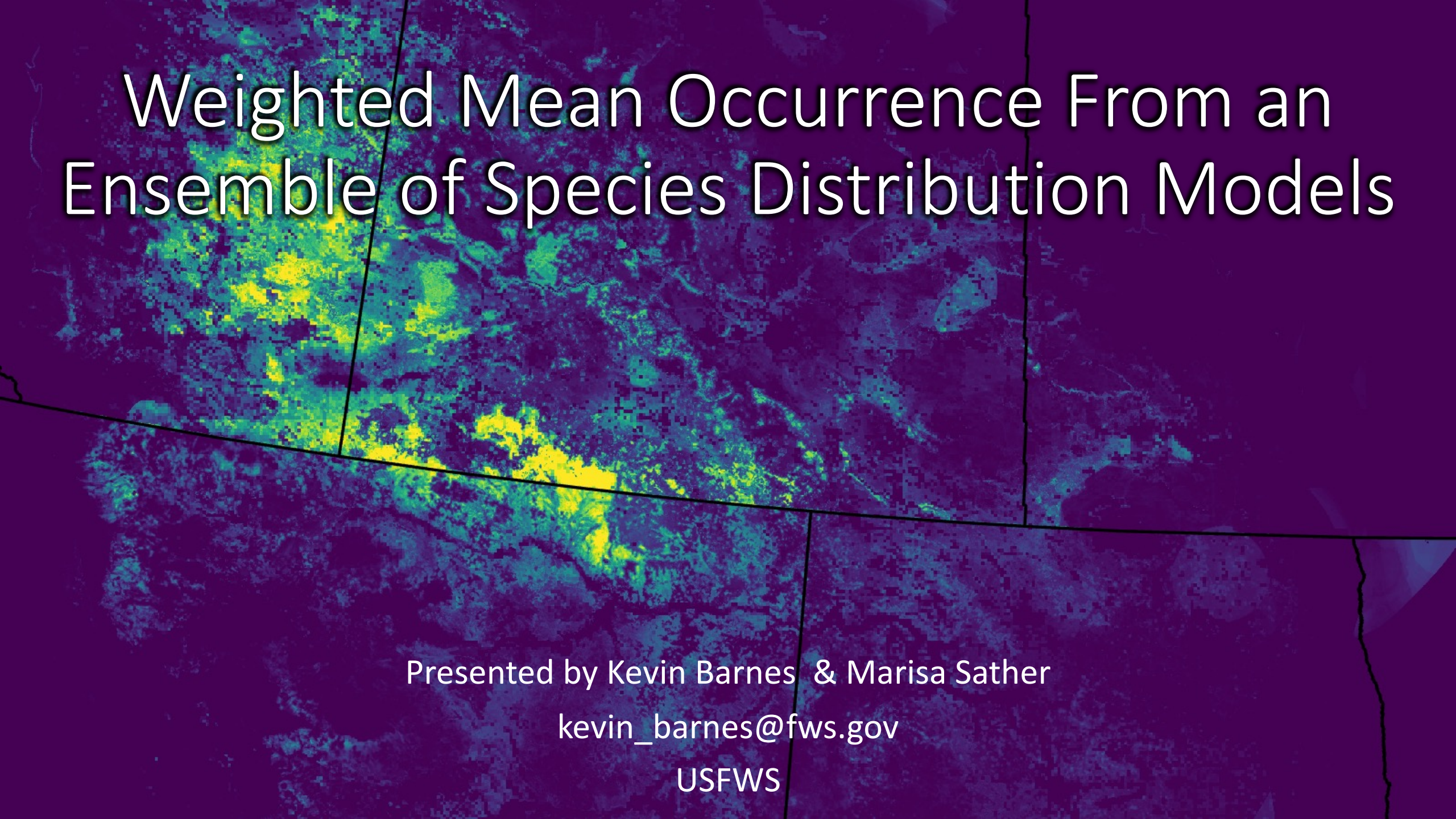
Weighted Mean Occurrence From an Ensemble of Species Distribution Models



Presented by Kevin Barnes & Marisa Sather

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USFWS

Collaborators

- USFWS
  - Marisa Sather (Partners Program)
  - Jason Tack (HAPET)
  - Neal Niemuth (HAPET)
  - Kevin Barnes (HAPET)
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  - Chris Latimer
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  - Barry Robinson
- PHJV
  - Jim Devries

Why are spatial models important?

- Spatial information on **biological value, threats, and cost** are useful for prioritizing landscapes for conservation action
- Relationships identified by models provide direction for specific conservation actions such as protection, restoration, and enhancement

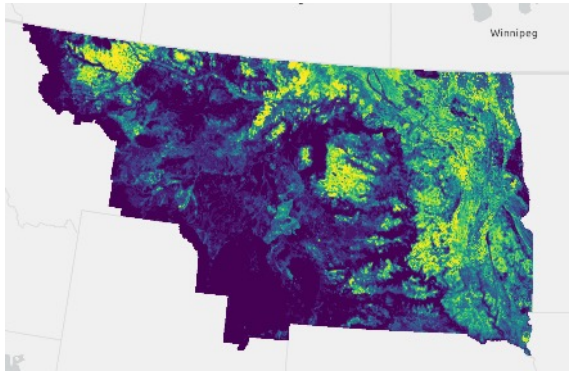
MARXAN
conservation solutions

ZONATION
Conservation planning software

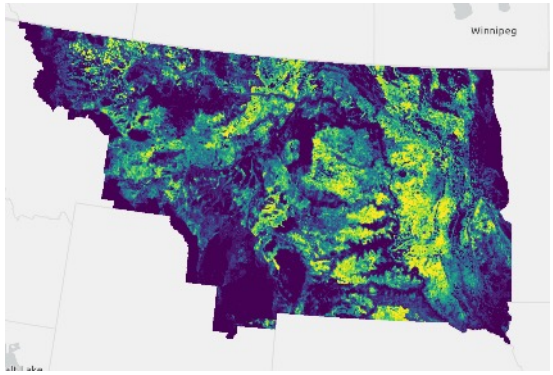
Example

- Wilson et al. (2005) defined vulnerability as having 3 dimensions:
  - Exposure= probability of threatening process
  - Intensity = magnitude threatening process
  - Impact = potential biological loss

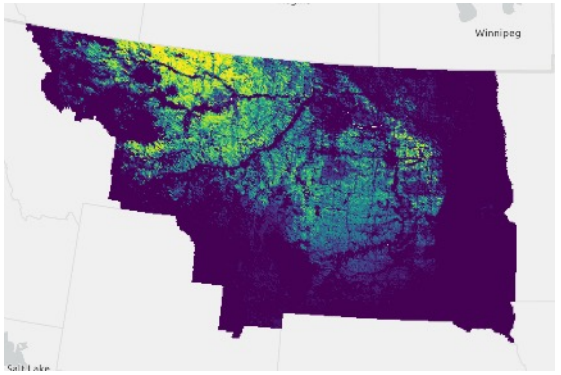
Future Proportion Grassland Loss (Exposure)

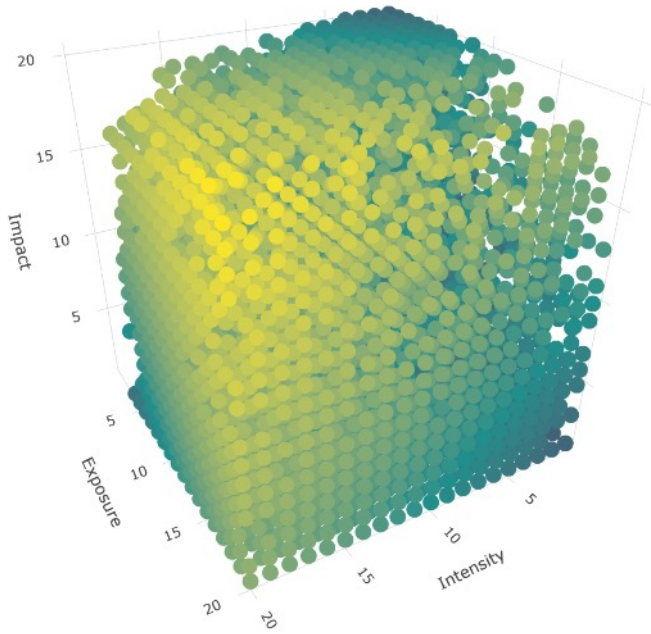


Future Total Grassland Loss (Intensity)

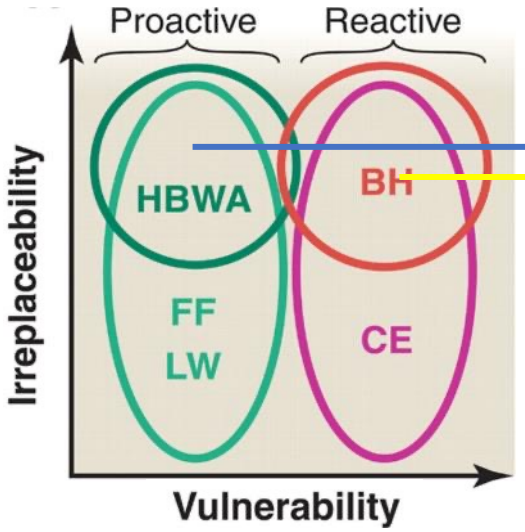


CCLO Abundance Ebird (Impact)



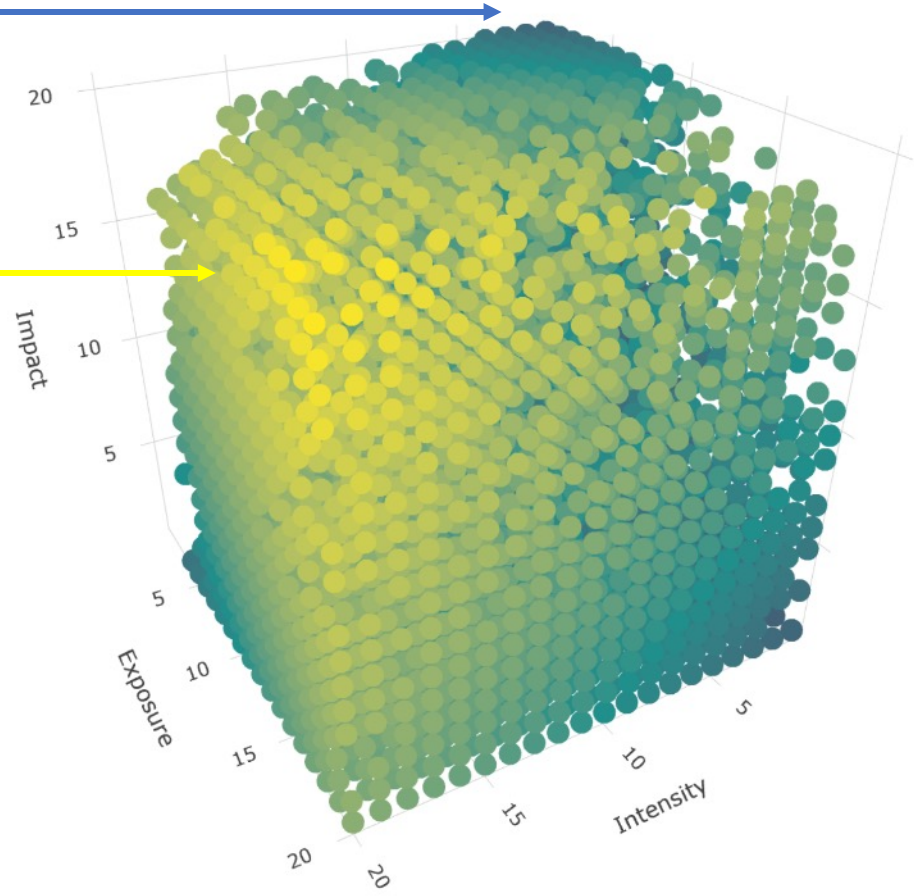


Prioritize to meet your strategy!



Maximize Gains

Minimize Loss



- Incorporate cost to optimize return on investment

Conservation planning

U.S. Fish & Wildlife Service and Prairie Pothole Joint Venture

A Full Annual-Cycle Conservation Strategy for Sprague's Pipit, Chestnut-collared and McCown's Longspurs, and Baird's Sparrow

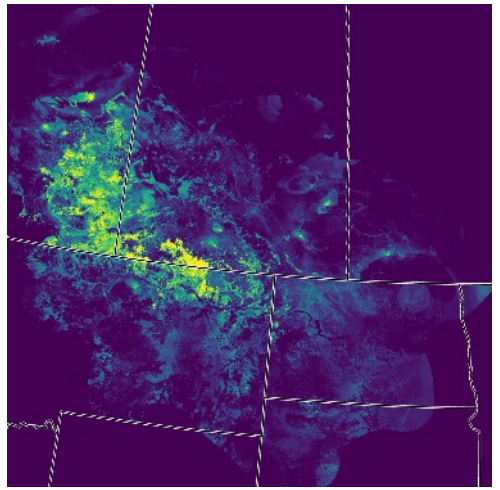
Sprague's Pipit (top, left); Chestnut-collared Longspur (bottom, left); McCown's Longspur (top, right); Baird's Sparrow (bottom, right)

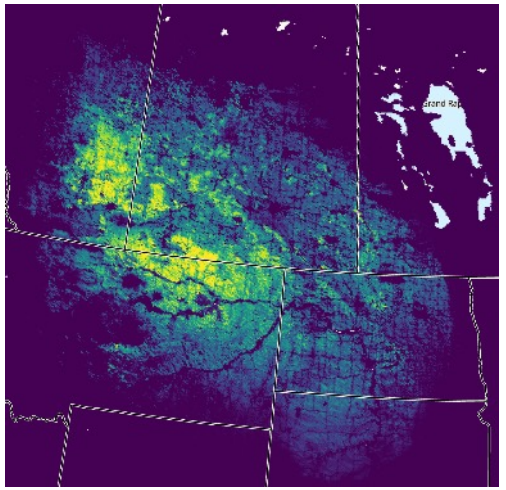
Conservation planning

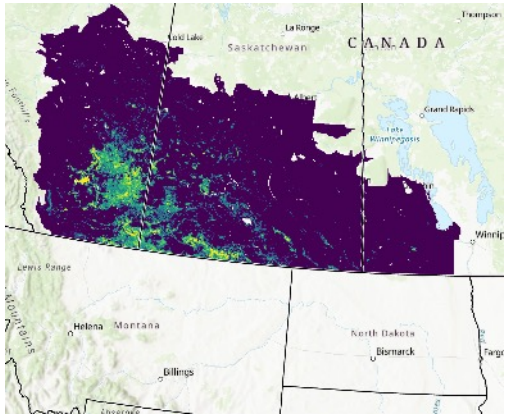
U.S. Fish & Wildlife Service and Prairie Pothole Joint Venture

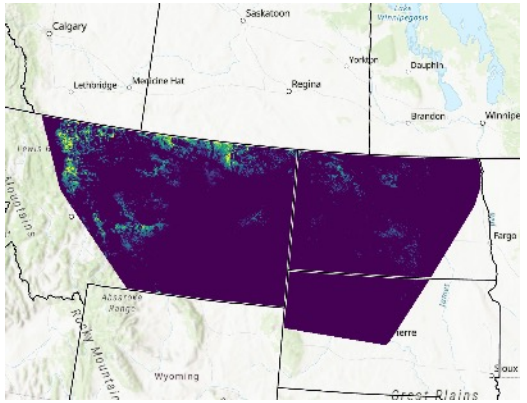
A Full Annual-Cycle Conservation Strategy for Sprague's Pipit, Chestnut-collared and McCown's Longspurs, and Baird's Sparrow

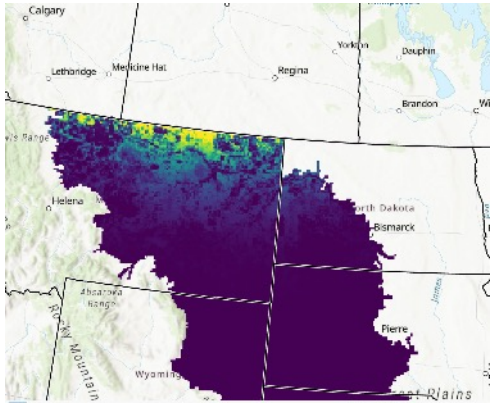
- Do we have models of biological value?
  - Sather et al.
  - Fink et al.
  - Robinson et al.
  - Niemuth et al.
  - Pavlacky et al.
  - Fields et al.
  - Fedy et al.
  - Etc.

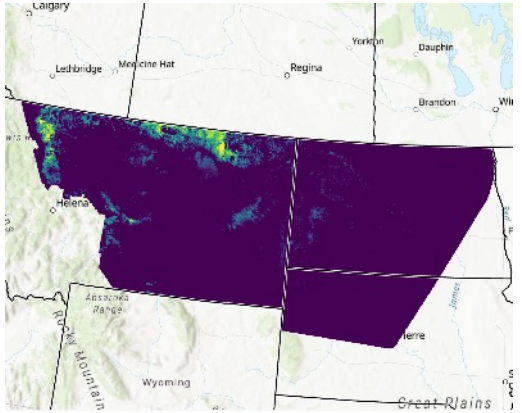






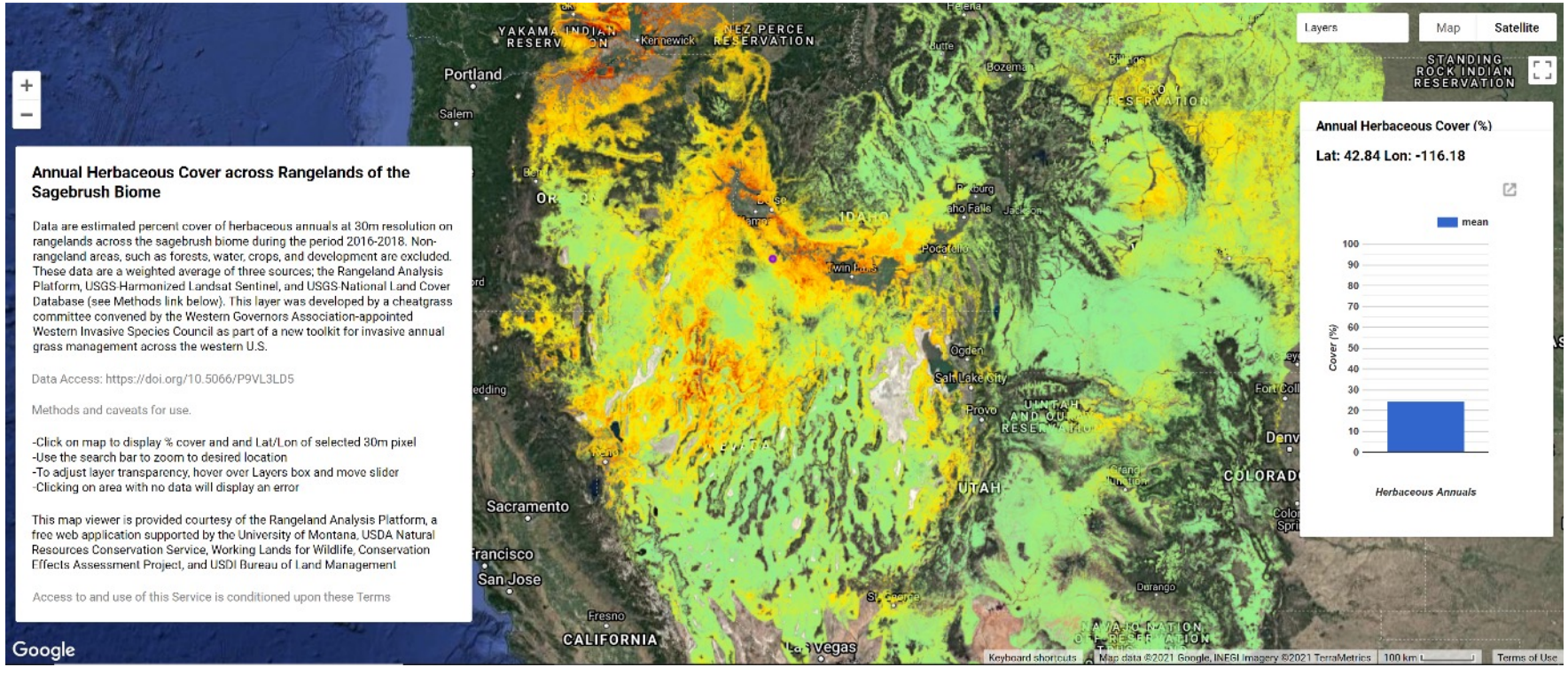






What have other done?

- Western Invasive Species Council developed a weighted average of three cheatgrass models to serve as a threat layer to better prioritize conservation actions.



How did they do it?

- Assign weights to pixel values.
- A model's pixel is weighted less if it is further from the ensemble's mean pixel value, and weighted more if closer.

$$w_t = \frac{1 - \frac{|x_t - \mu|^4}{X}}{\sum_{i=1}^{3} \left(1 - \frac{|x_t - \mu|^4}{X}\right)}$$

Weighting Expression:

$$w_t = \frac{1 - \frac{|x_t - \mu|^4}{X}}{\sum_{i=1}^{3}\left(1 - \frac{|x_t - \mu|^4}{X}\right)}$$

$$X = \sum_{t=1}^{3} |x_t - \mu|^4$$

$$weighted\ mean = \sum_{t=1}^{3} w_t x_t$$

Example:

Pixel Value (Occurrence)	|xt-Mu|^4	1-|x-Mu|^4 / X	Weight	wtxt
0.09	0.00331776	0.9282938272	0.4641469136	0.04177322223
0.12	0.00194481	0.957967158	0.478983579	0.05747802948
0.78	0.04100625	0.1137390147	0.05686950737	0.04435821575
Mean Pixel Value	Sum |x-Mu|^4 (X)	Sum 1-|x-Mu|^4 / X		**weighted Mean**
0.33	0.04626882	2		**0.1436094675**

Potential Issues?

What about different scales and extents?
Solution: resample to minimum mapping unit, use arithmetic mean when 2 available, use any prediction when only 1 available

What about varying state variables? (i.e. not true occurrence?)
Solution: Could rescale values to common metric (std normal distribution? Scale to largest value observed across datasets?) Abundance to Occurence via Royle-Nichols equation.

**0 vs NA (e.g. BBS model NA in CAN)*

Tack, Jason D

Proof of concept: Sprague's Pipit

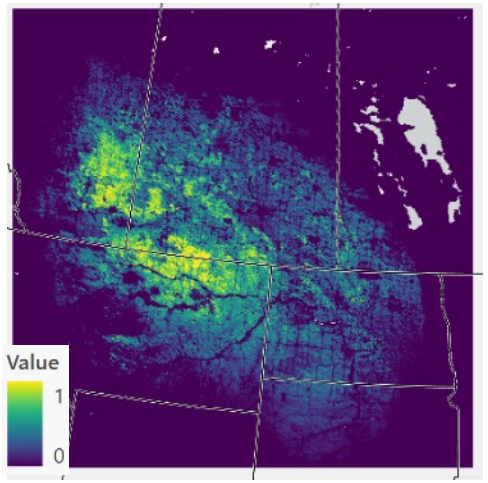
Source	Model	Prediction	Y~ Source	Landcover data	Landscape scales	Resolution	Spatial Extent
Sather et al.	Random Forest	Occurrence	Multiple (2007-2012)	ACI/NLCD	1-10000 m	160 m	Breeding Range
Fink et al.	adaSTEM	Occurrence	eBird (2019)	FAO	1500 m	~3 km	Breeding Range
Robinson et al.	Boosted Regression Tree	Density	Multiple (2009-2019)	ACI	800 m-4000 m	800 m	PPR - Canada
Niemuth et al.	GLMM	Occurrence	BBS Stop (2005-2011)	NLCD	1200 m	30 m	<MT, ND, SD
Fields et al.	GLMM	Density	BBS Stop (2008-2016)	NLCD	1600 m	30 m	<MT, ND, SD

Some decisions we had to make…

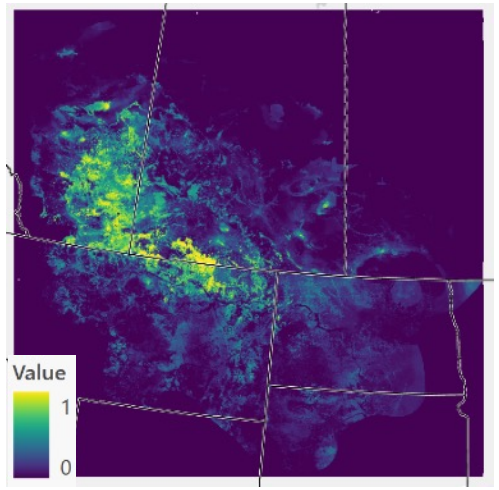
- Common projection & snap
- Transform density to binomial : 1-Exp(density*-1)
- If occurrence < 1; divide by max value
- Process each model at native resolution/extent
- Process composites using maximum extent and minimum resolution

[a] Royle, J. A., and J. D. Nichols. 2003. Estimating abundance from repeated presence-absence data or point counts. Ecology 84:777-790. https://doi.org/10.1890/0012-9658(2003)084[0777:EAFRPA]2.0.CO;2

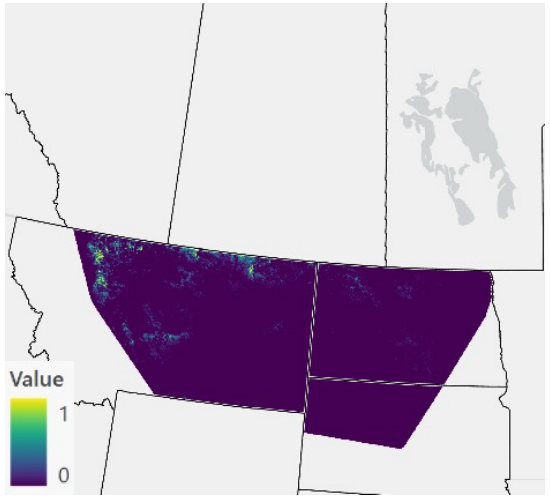
Fink et al. (eBird)



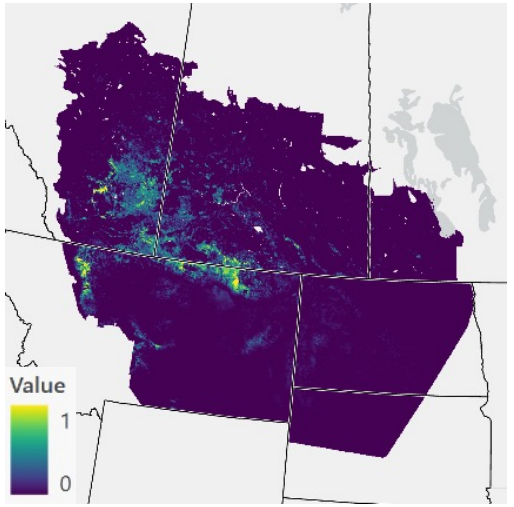
Sather et al.



Niemuth et al.



Robinson et al. – Canada
Fields et al. – US



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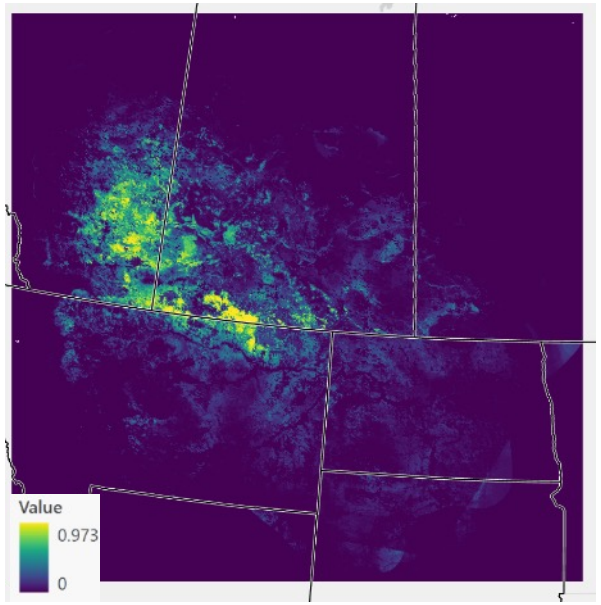
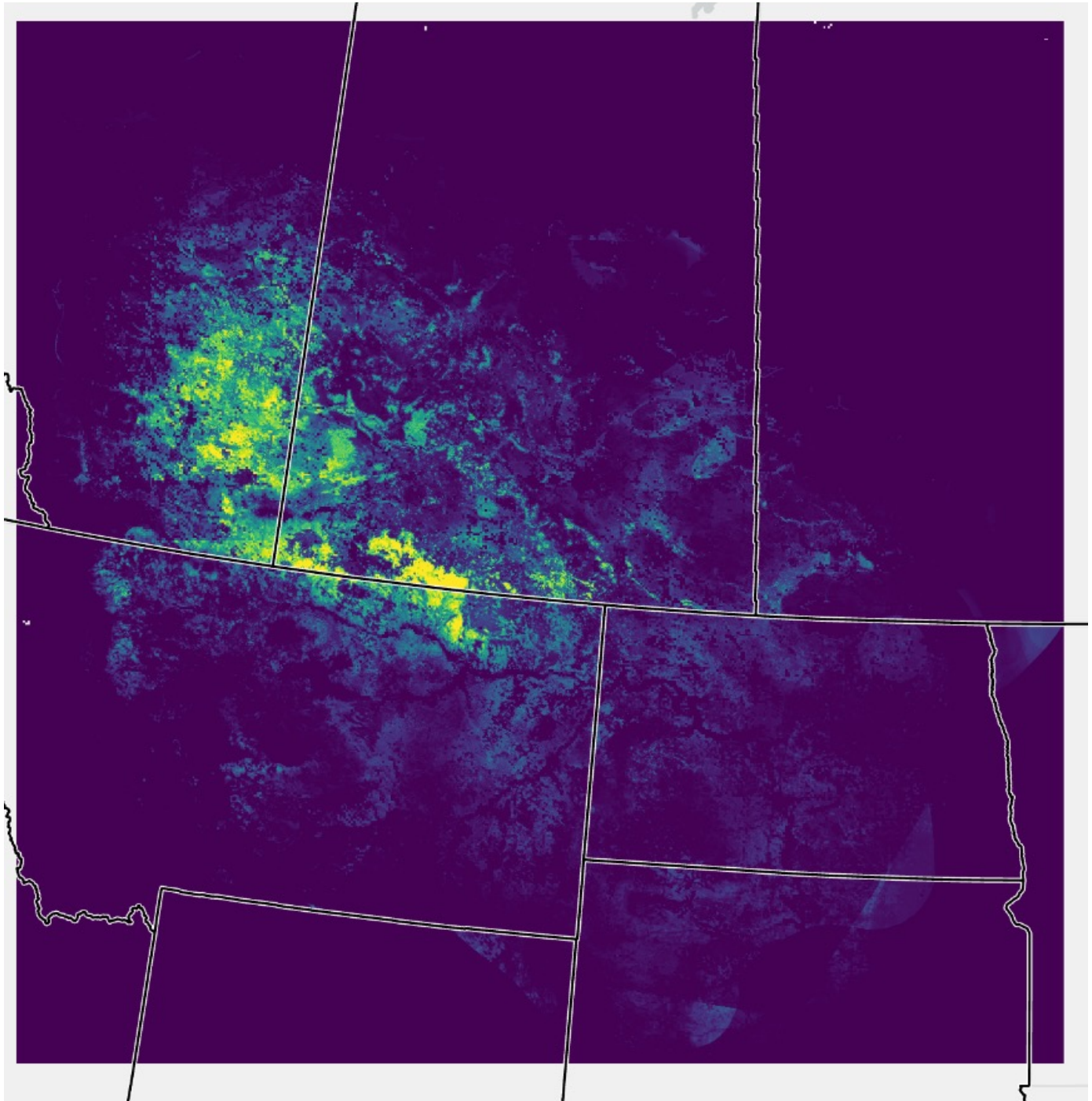


Next steps

- Incorporate models from Fedy et al. and BCR.
- Rerun analyses for SPPI, BAIS, CCLO, TBLO.
- Make outputs & processing scripts publicly available
- Update when necessary



Thank you!

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