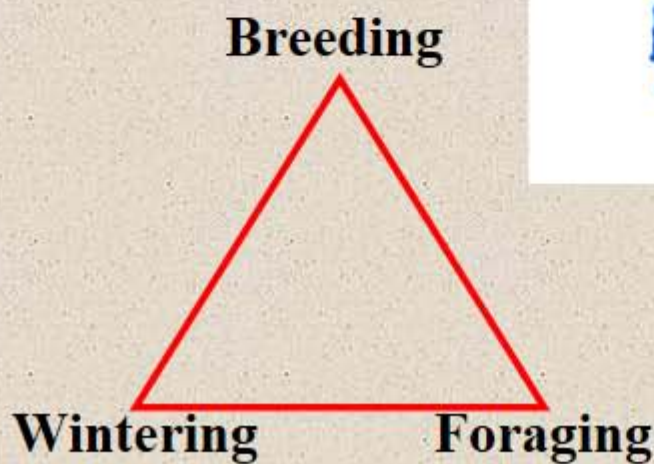
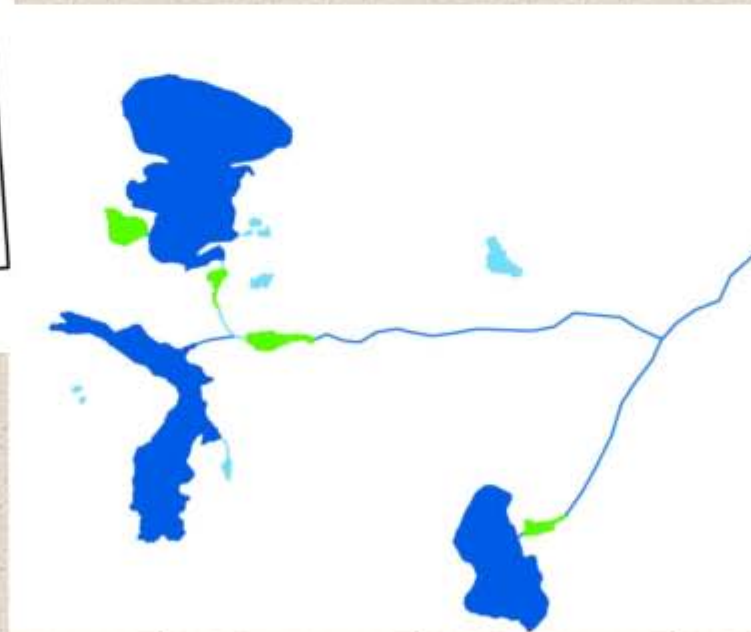
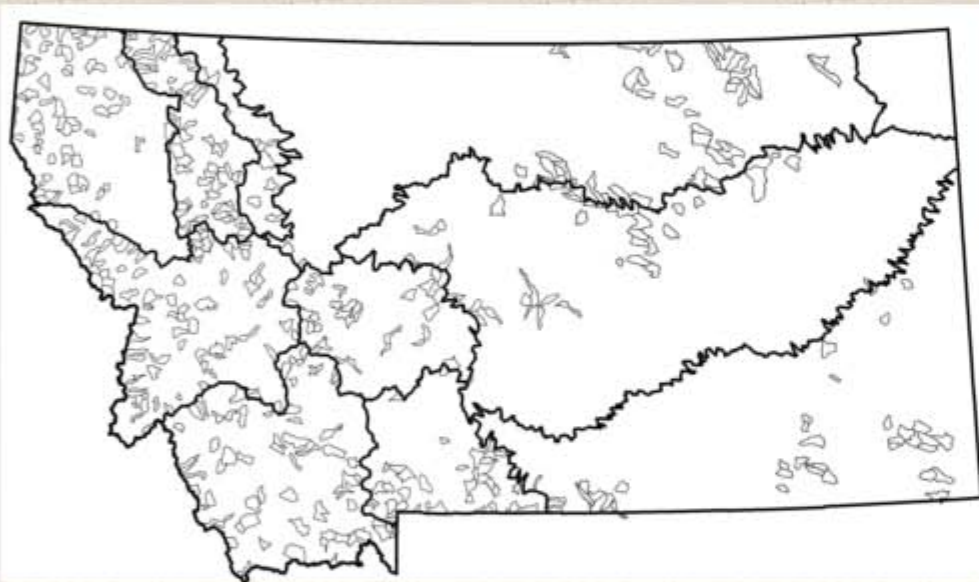


# A Status Assessment and Predicted Distribution and Landscape-level Habitat Suitability Models for Lentic Breeding Amphibians and Aquatic Reptiles

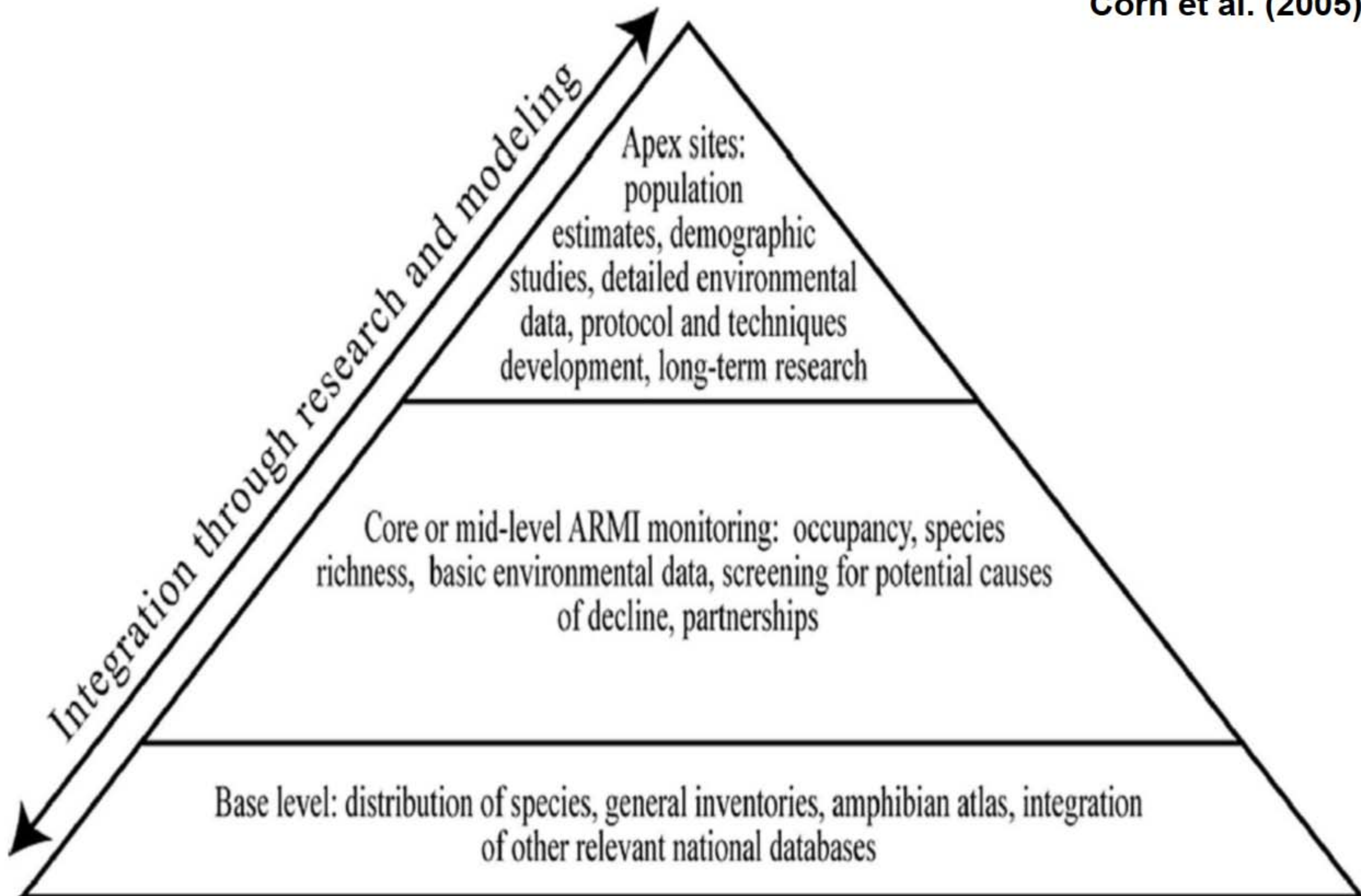
Bryce A. Maxell (see program for coauthors)  
 Montana Natural Heritage Program  
 bmaxell@mt.gov



		FROM STAGE		
		Prejuvenile	Juvenile	Reproductive Adult
TO STAGE	Prejuvenile	0	0	$\left[ \begin{array}{c} \text{F1} \\ \text{Clutch Size x} \\ \text{Probability of Laying x} \\ \text{Adult Survival} \end{array} \right]$
	Juvenile	$\left[ \begin{array}{c} \text{G1} \\ \text{Embryo Survival x} \\ \text{Larval Survival x} \\ \text{Metamorph Survival} \end{array} \right]$	$\left[ \begin{array}{c} \text{P1} \\ \text{Probability of a Juvenile} \\ \text{Staying a Juvenile} \end{array} \right]$	0
	Reproductive Adult	0	$\left[ \begin{array}{c} \text{G2} \\ \text{Probability of a} \\ \text{Juvenile Becoming} \\ \text{an Adult} \end{array} \right]$	$\left[ \begin{array}{c} \text{P2} \\ \text{Adult Survival} \end{array} \right]$

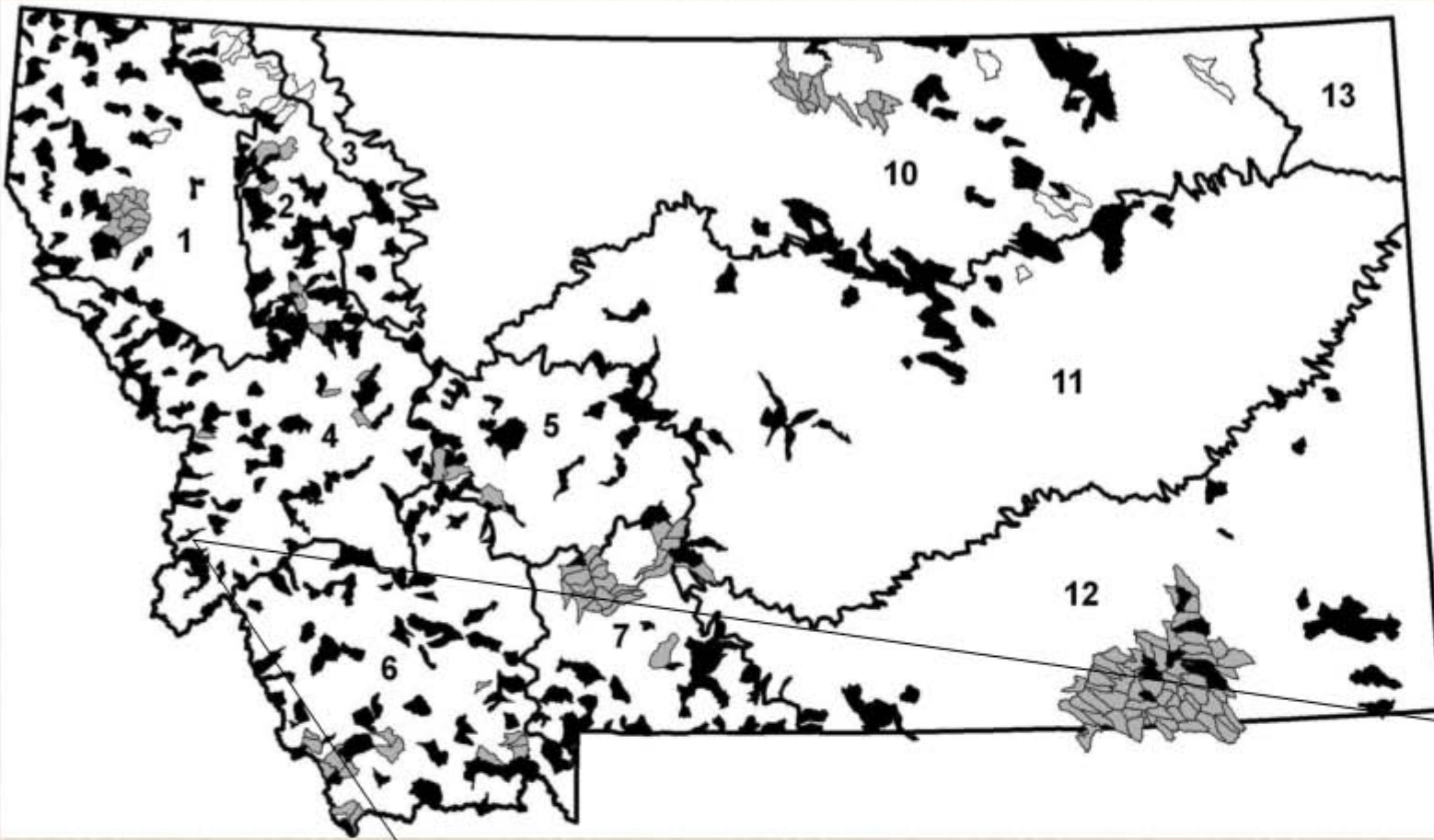
# USGS Amphibian Research and Monitoring Initiative

Corn et al. (2005)



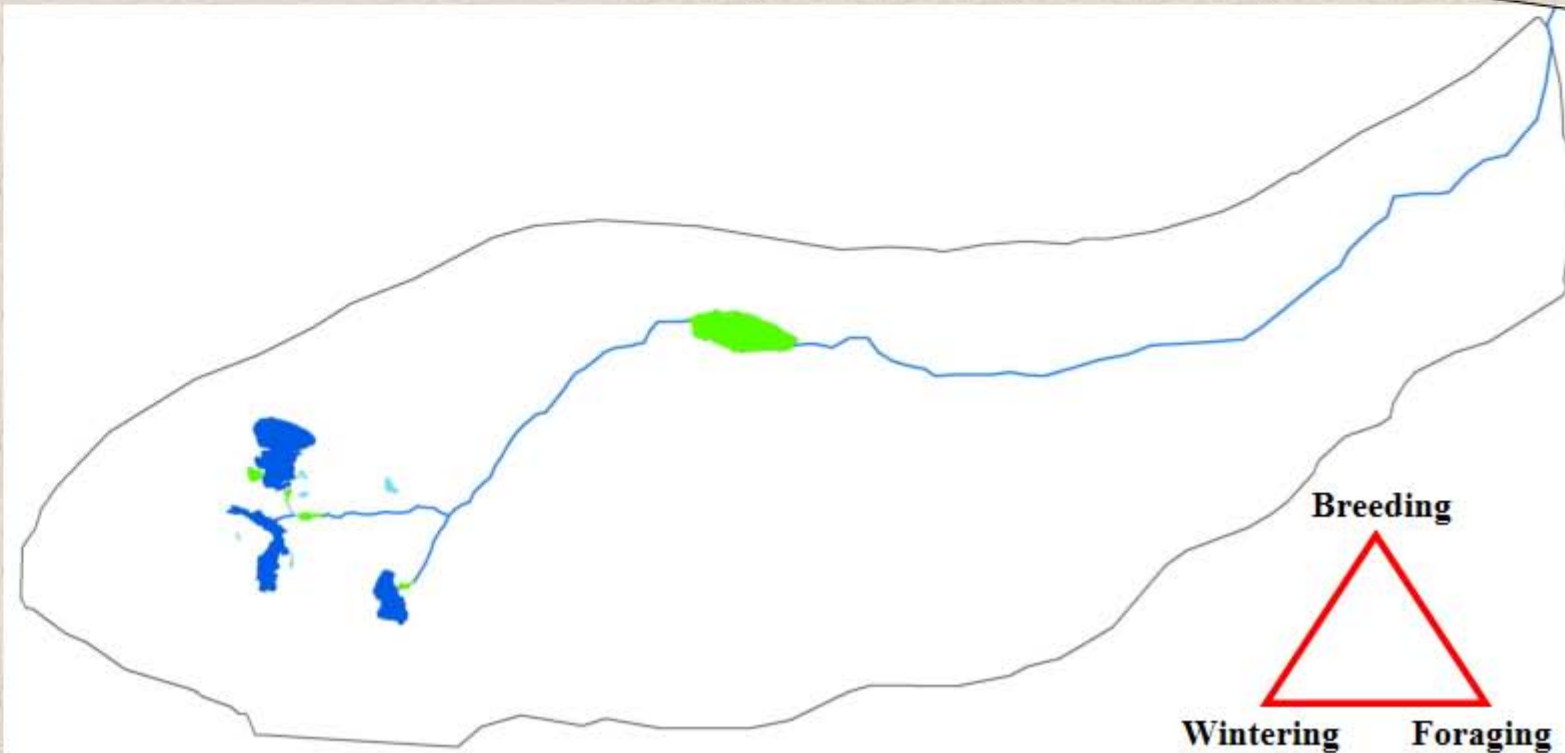


# Watershed & Site Occupancy Sampling Scheme

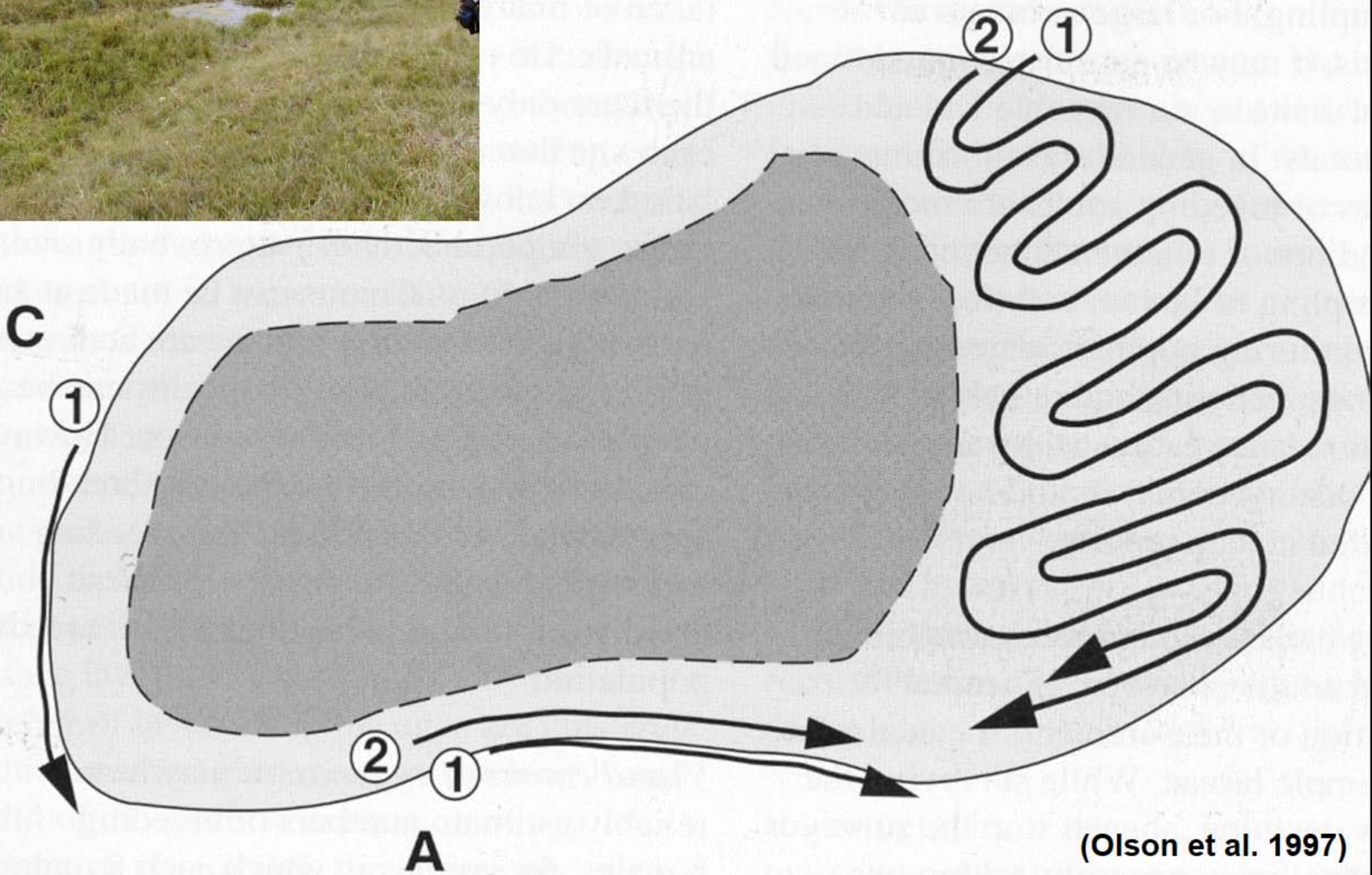


- 11 strata
- 429 watersheds
- 6,741 lentic sites
- ~100 nonrandom watersheds
- ~3,000 nonrandom sites

**Sites per watershed**  
**18.5 (SD = 23.4)**  
**Range (0 – 211)**

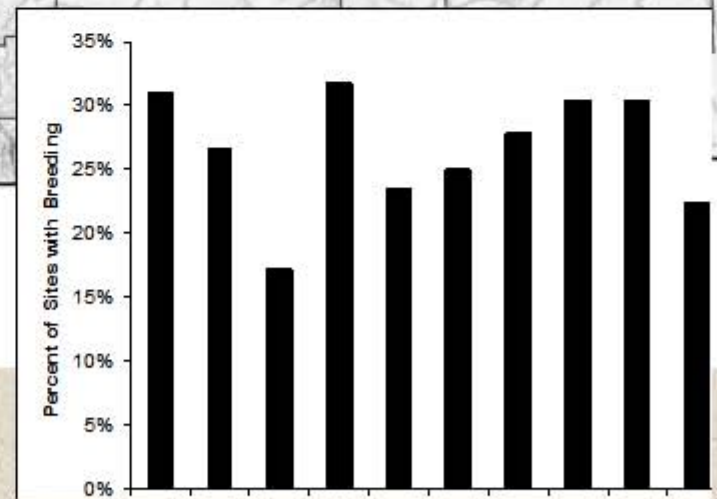
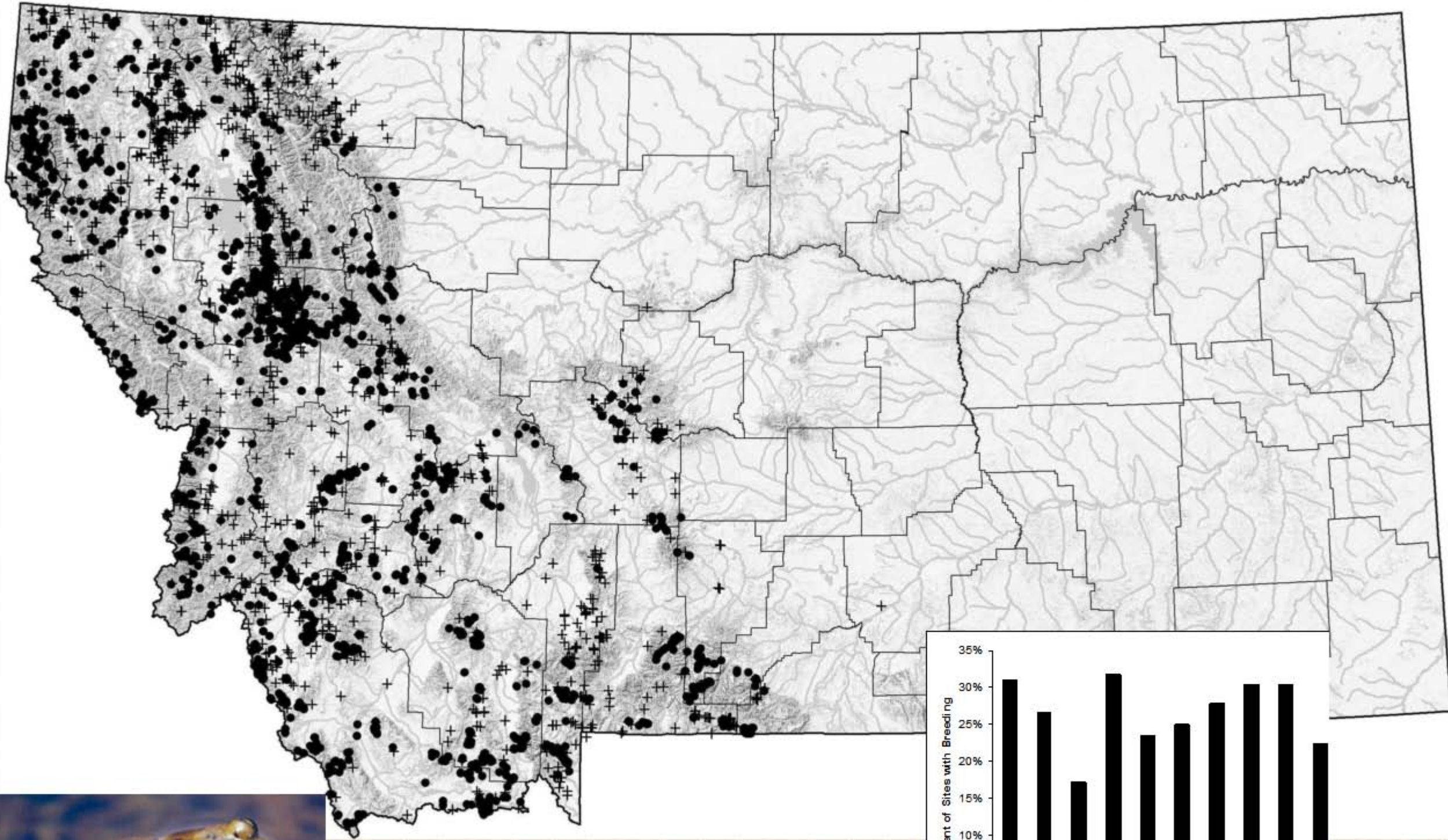


# Timed Visual Encounter (VES) and Dipnet Surveys of Shallow water Habitats

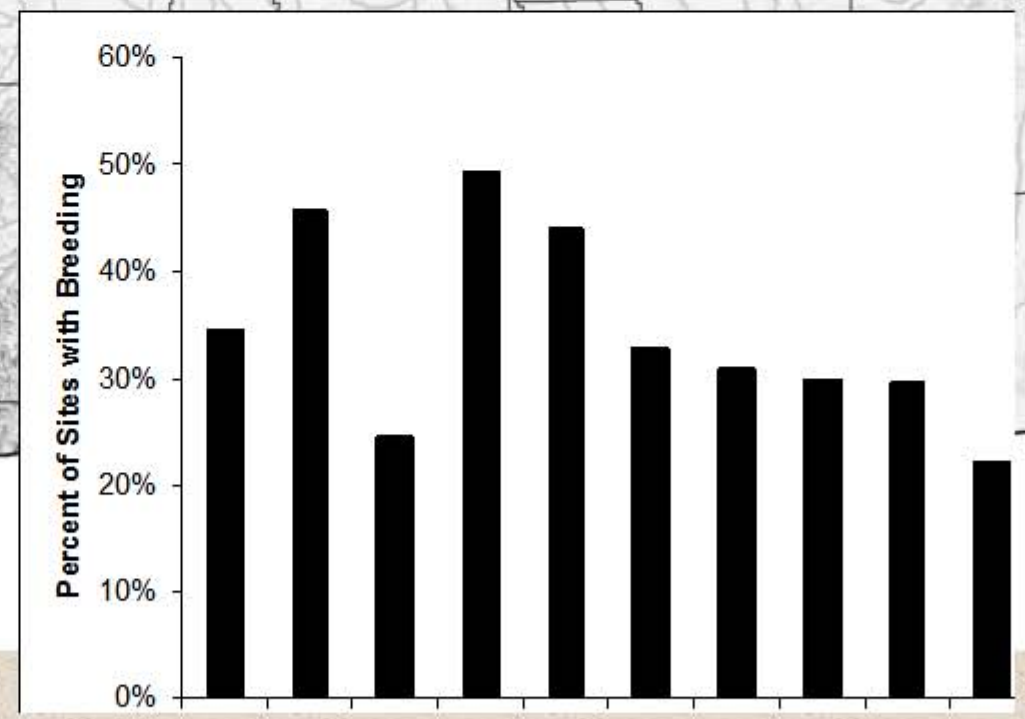
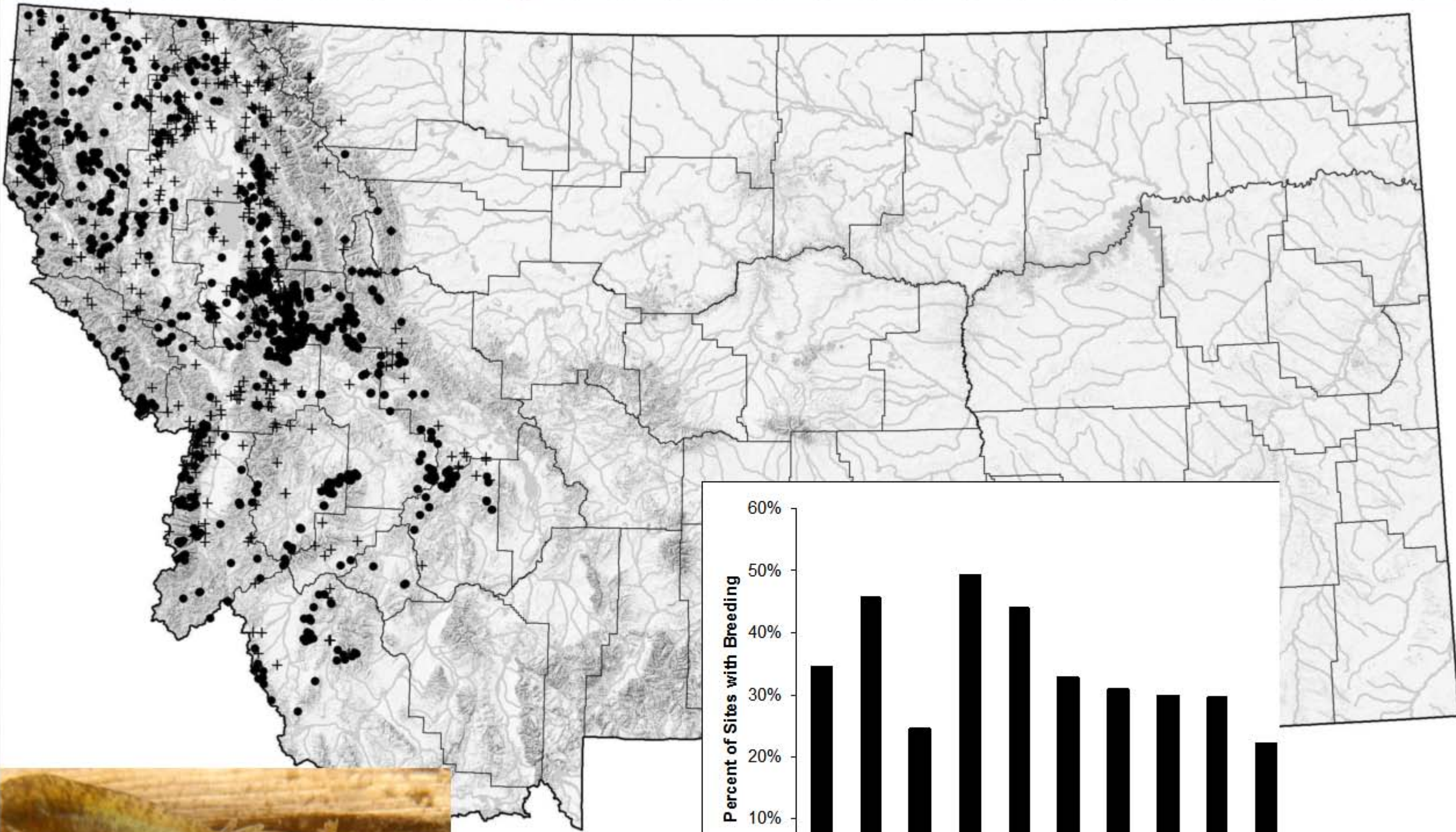


(Olson et al. 1997)

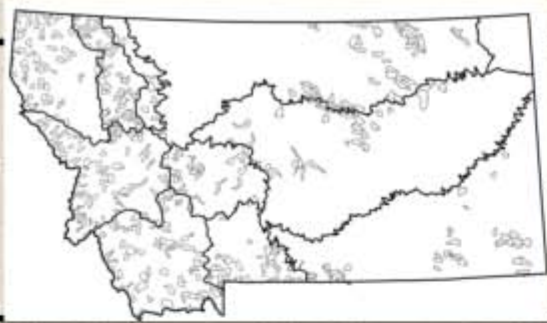
# Columbia Spotted Frog



# Long-toed Salamander



# Watershed / Site Occupancy Rate Summary



	No. Watersheds / Sites	Watershed		Site	
		Percent	95% CI	Percent	95% CI
<b>Long-toed Salamander</b>	<b>185 / 2119</b>	<b>70</b>	<b>64 – 76</b>	<b>34</b>	<b>32 – 36</b>
<b>Tiger Salamander</b>	<b>140 / 2536</b>	<b>64</b>	<b>56 – 71</b>	<b>14</b>	<b>13 – 15</b>
<b>Plains Spadefoot</b>	<b>100 / 1578</b>	<b>19</b>	<b>12 – 26</b>	<b>3</b>	<b>3 – 4</b>
<b>Western Toad</b>	<b>266 / 3357</b>	<b>17</b>	<b>13 – 22</b>	<b>2</b>	<b>2 – 3</b>
<b>Great Plains Toad</b>	<b>96 / 1552</b>	<b>14</b>	<b>7 – 20</b>	<b>1</b>	<b>1 – 2</b>
<b>Woodhouse's Toad</b>	<b>133 / 1543</b>	<b>25</b>	<b>18 – 31</b>	<b>8</b>	<b>7 – 9</b>
<b>Boreal Chorus Frog</b>	<b>167 / 2667</b>	<b>49</b>	<b>42 – 56</b>	<b>26</b>	<b>24 – 28</b>
<b>Pacific Treefrog</b>	<b>132 / 1370</b>	<b>20</b>	<b>3 – 14</b>	<b>4</b>	<b>3 – 5</b>
<b>Columbia Spotted Frog</b>	<b>246 / 2211</b>	<b>67</b>	<b>62 – 73</b>	<b>36</b>	<b>34 – 38</b>
<b>Northern Leopard Frog</b>	<b>90 / 1375</b>	<b>51</b>	<b>42 – 61</b>	<b>15</b>	<b>13 – 17</b>
<b>Painted Turtle</b>	<b>354 / 4961</b>	<b>14</b>	<b>11 – 17</b>	<b>3</b>	<b>2 – 3</b>
<b>Terrestrial Gartersnake</b>	<b>327 / 4182</b>	<b>24</b>	<b>19 – 28</b>	<b>3</b>	<b>3 – 4</b>
<b>Plains Gartersnake</b>	<b>86 / 1522</b>	<b>64</b>	<b>54 – 73</b>	<b>16</b>	<b>14 – 18</b>
<b>Common Gartersnake</b>	<b>315 / 3993</b>	<b>14</b>	<b>10 – 17</b>	<b>3</b>	<b>2 – 4</b>



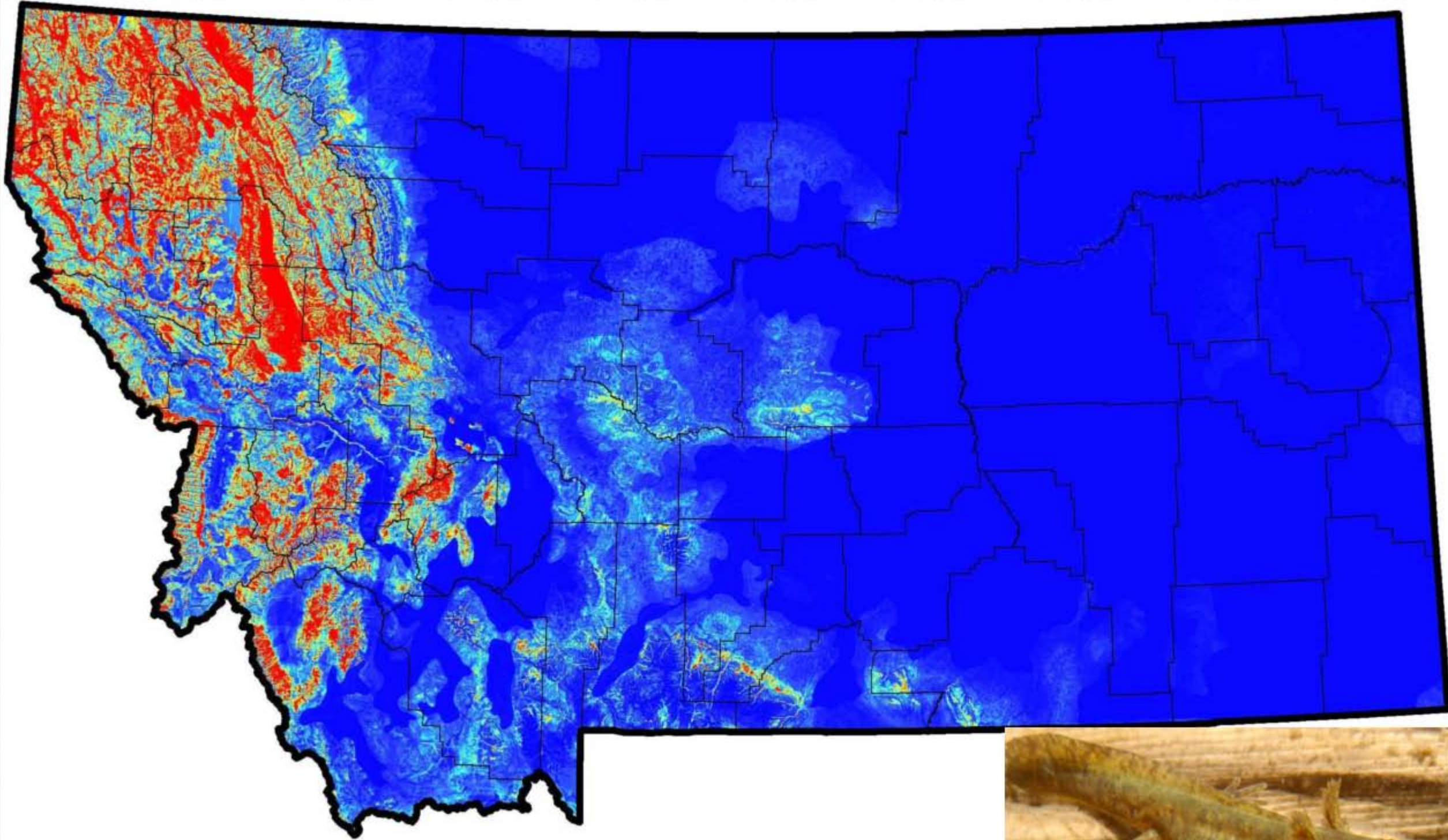
# Predictive Modeling with Maxent

- Ideal for positive data only
- Uses random background points as pseudo-absences
- Recently evaluated as equivalent or superior to other predictive modeling approaches for several hundred species across the globe
- Iterative machine learning approach with deterministic outcomes
- Logistic output interpretable as relative habitat suitability
- Output is generally satisfactory in regions with at least some observation points

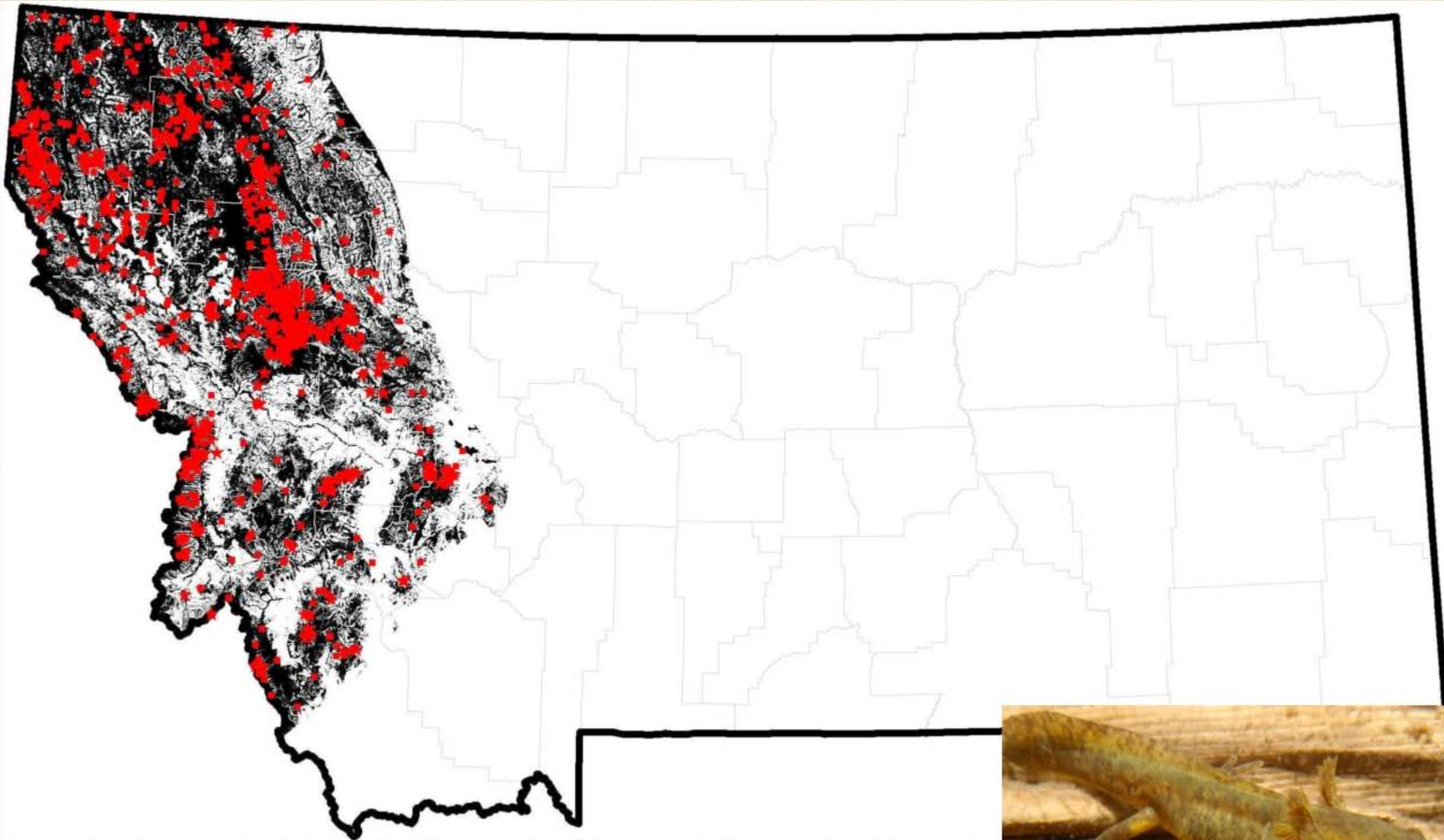
# Environmental Layers

Variable	Type	Description
Aspect	categorical	Dominant degrees of aspect grouped into 9 categories including flat
Elevation	continuous	Elevation in meters from the National Elevation Dataset (NED)
Geology	categorical	931 categories of surficial geology
Land Cover	categorical	1992 National Land Cover Data (NLCD) – 21 classes
Max Temp	continuous	Estimated average maximum daily July temperature in degrees Fahrenheit for 1971-2000
Min Temp	continuous	Estimated average minimum daily January temperature in degrees Fahrenheit for 1971-2000
Precip	continuous	Relative Effective Annual Precipitation (REAP) in 1 cm intervals as an indicator of available soil moisture
Ruggedness	continuous	Vector ruggedness measure (VRM) of local terrain
Slope	continuous	Degrees of slope
Soils	categorical	694 soil mapping units from the state soil geographic data (STATSGO) on general soil associations developed by the National Cooperative Soil Survey
Soil TM	categorical	Soil temperature and moisture regime – 12 categories
Solar E	continuous	Solar radiation index (SRI) at each tenth degree of latitude at the equinox
Solar SS	continuous	Solar radiation index (SRI) at each tenth degree of latitude at the summer solstice
Solar WS	continuous	Solar radiation index (SRI) at each tenth degree of latitude at the winter solstice
Stream ED	continuous	Euclidian distance from major streams in 1 meter intervals

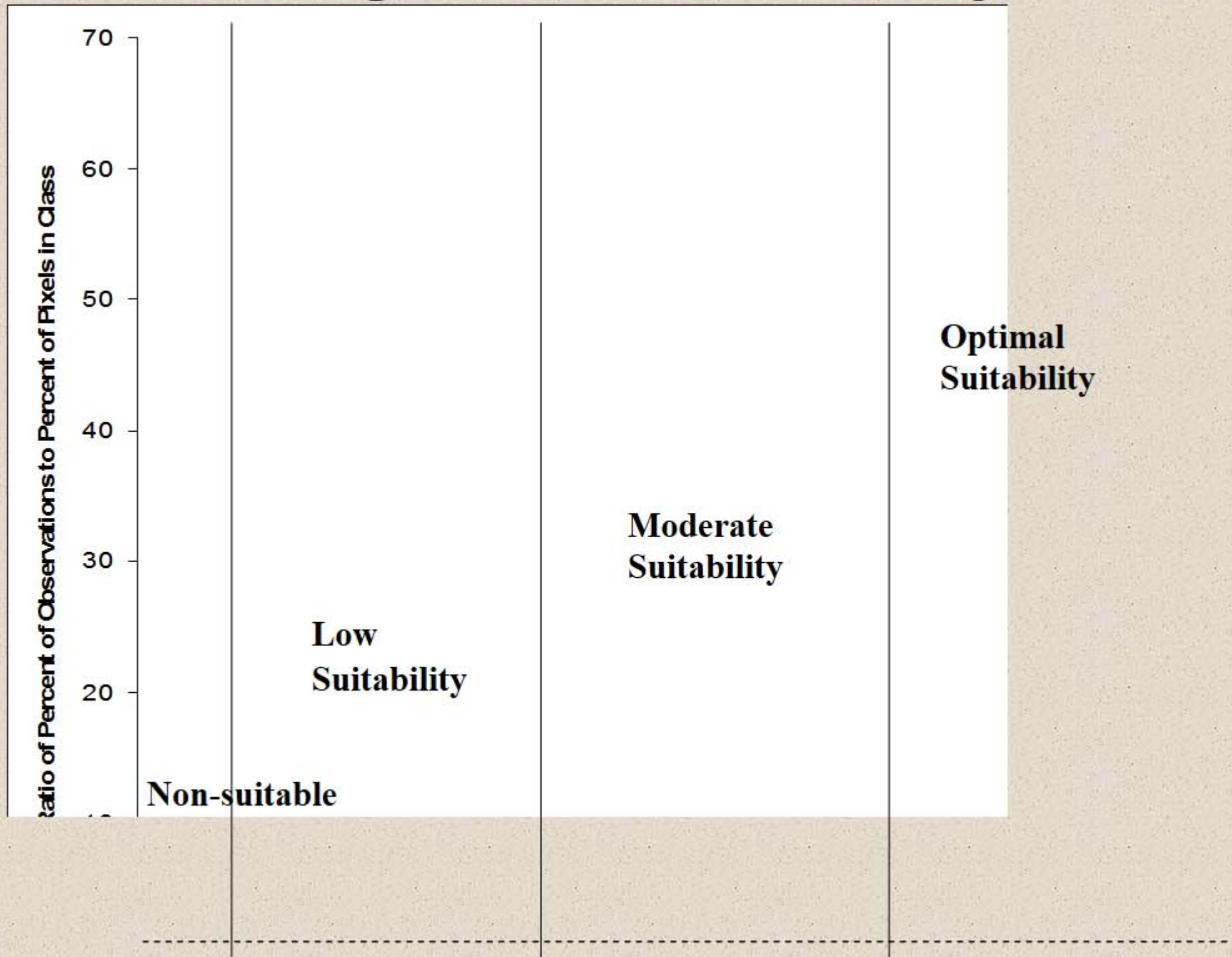
# Long-toed Salamander – Continuous Output



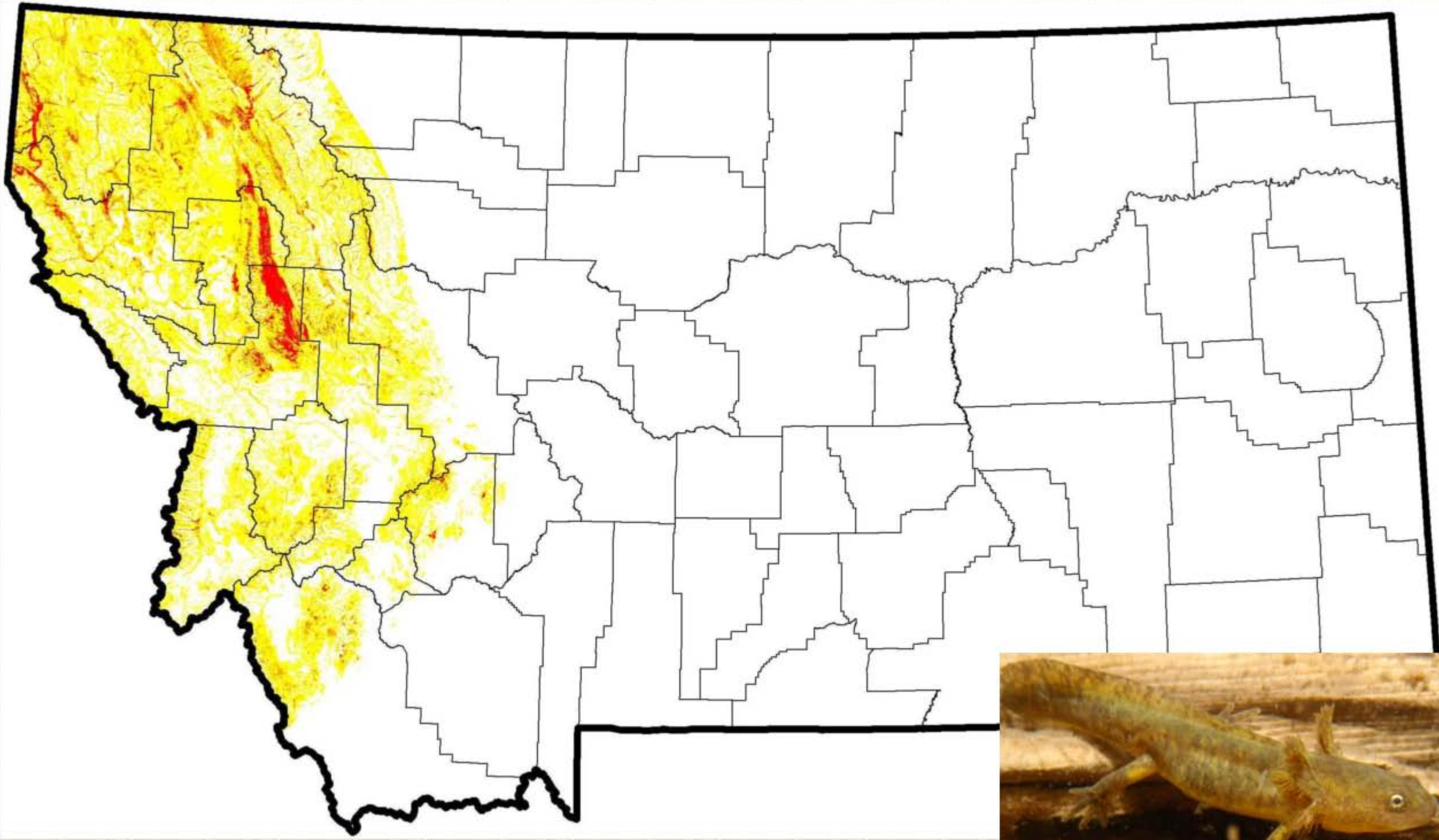
# Long-toed Salamander – Binary Output



# Delineating Habitat Suitability Classes



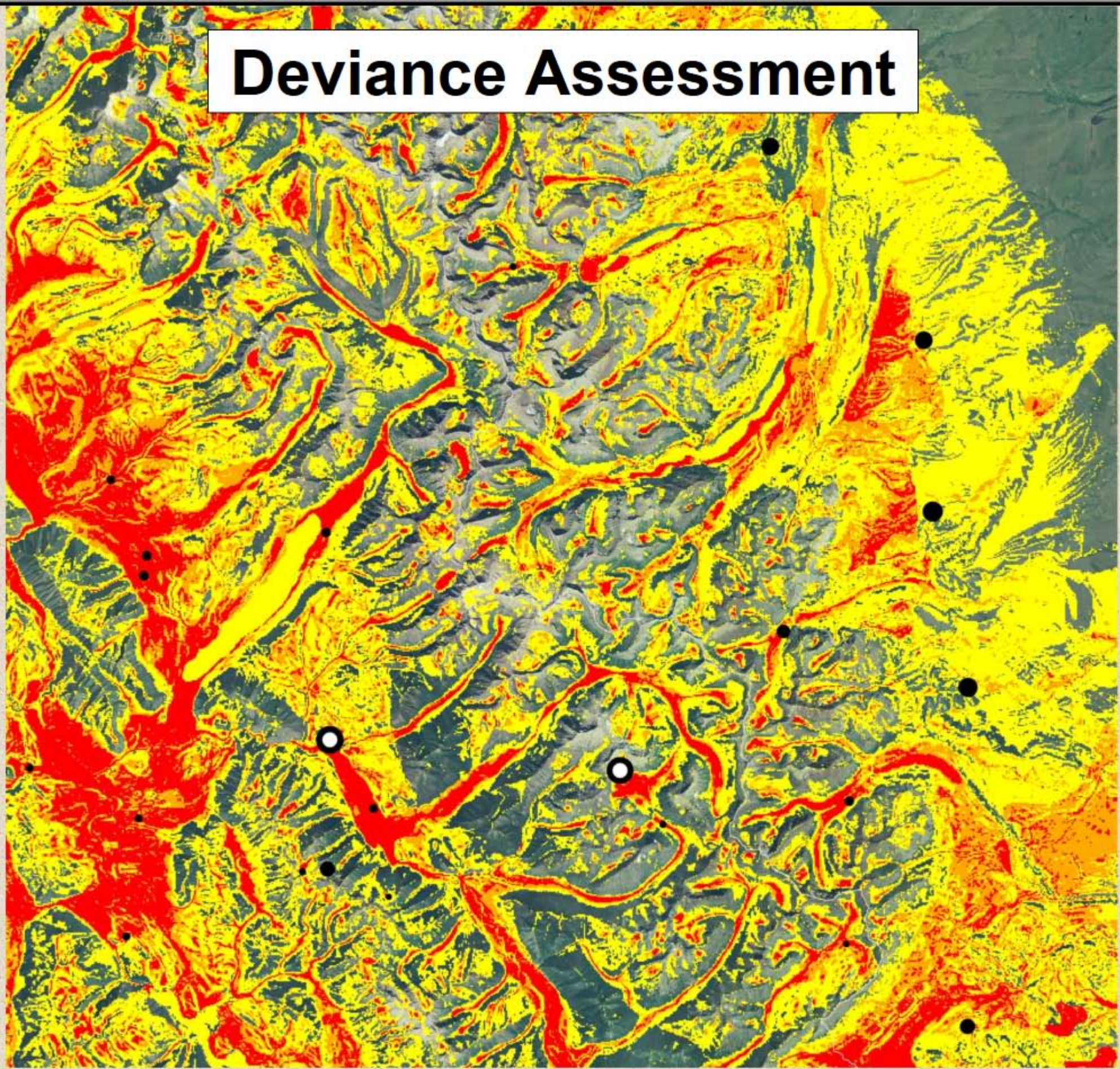
# Long-toed Salamander Habitat Suitability Classes



# Model Evaluation Metrics

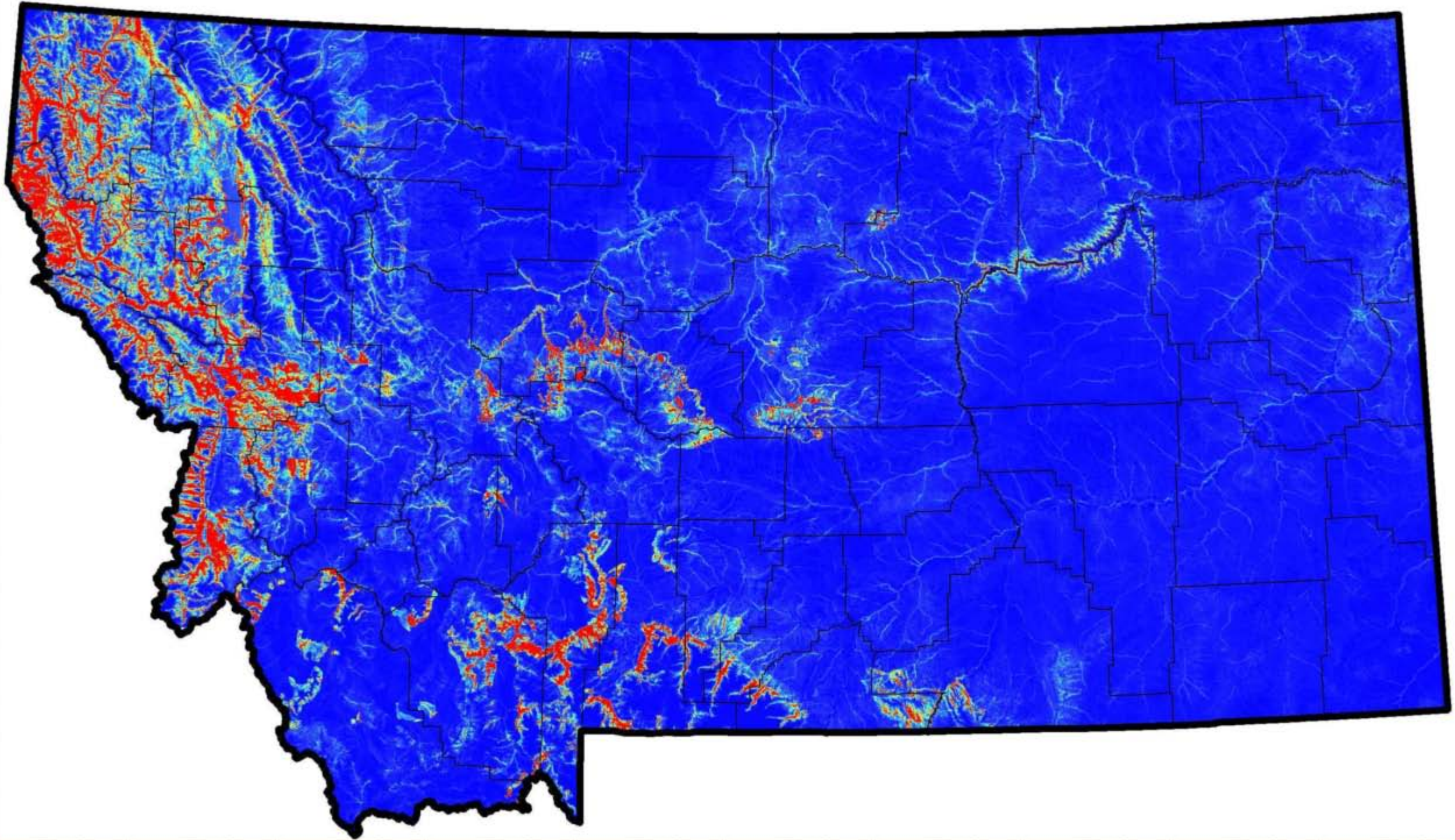
Species	AUC	AVI	GAP AVI	COR	Deviance (SD)
<i>A. macrodactylum</i>	0.909 (0.008)	0.96	0.2	0.47	1.14 (1.16)
<i>A. tigrinum</i>	0.878 (0.013)	0.93	0.98	0.5	1.53 (1.63)
<i>A. montanus</i>	0.889 (0.024)	0.92	0.32	0.59	1.42 (2.01)
<i>S. bombifrons</i>	0.895 (0.015)	0.95	0.96	0.36	2.05 (1.87)
<i>B. boreas</i>	0.888 (0.011)	0.95	0.83	0.48	1.40 (1.62)
<i>B. cognatus</i>	0.877 (0.021)	0.89	0.77	0.47	2.47 (2.24)
<i>B. woodhousii</i>	0.940 (0.008)	0.98	0.92	0.38	1.32 (1.45)
<i>P. maculata</i>	0.884 (0.006)	0.97	0.93	0.39	1.29 (1.18)
<i>P. regilla</i>	0.933 (0.015)	0.97	0.84	0.49	1.15 (1.30)
<i>R. luteiventris</i>	0.936 (0.004)	0.98	0.53	0.38	1.01 (1.07)
<i>R. pipiens</i>	0.923 (0.008)	0.96	0.53	0.43	1.47 (1.46)
<i>C. picta</i>	0.929 (0.009)	0.97	0.22	0.38	1.50 (1.75)
<i>C. constrictor</i>	0.858 (0.020)	0.91	0.91	0.44	2.38 (2.35)
<i>P. catenifer</i>	0.897 (0.013)	0.96	0.89	0.35	1.92 (2.00)
<i>T. elegans</i>	0.909 (0.011)	0.95	0.94	0.42	1.54 (1.74)
<i>T. radix</i>	0.908 (0.011)	0.98	0.85	0.35	1.56 (1.55)
<i>T. sirtalis</i>	0.935 (0.012)	0.91	0.8	0.58	1.77 (2.48)
<i>C. viridis</i>	0.875 (0.017)	0.9	0.92	0.54	1.84 (1.88)

# Deviance Assessment

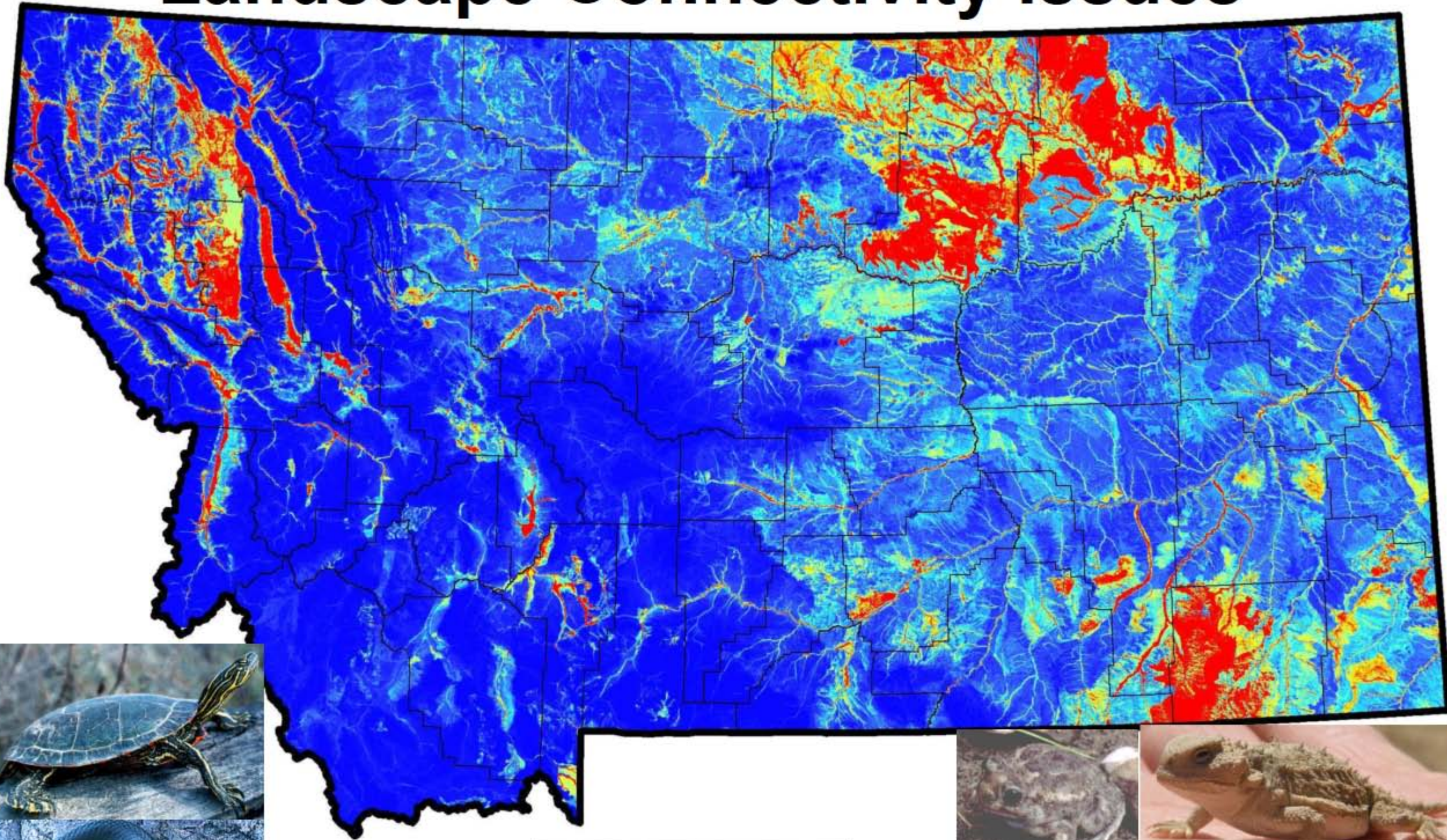




# Rubber Boa



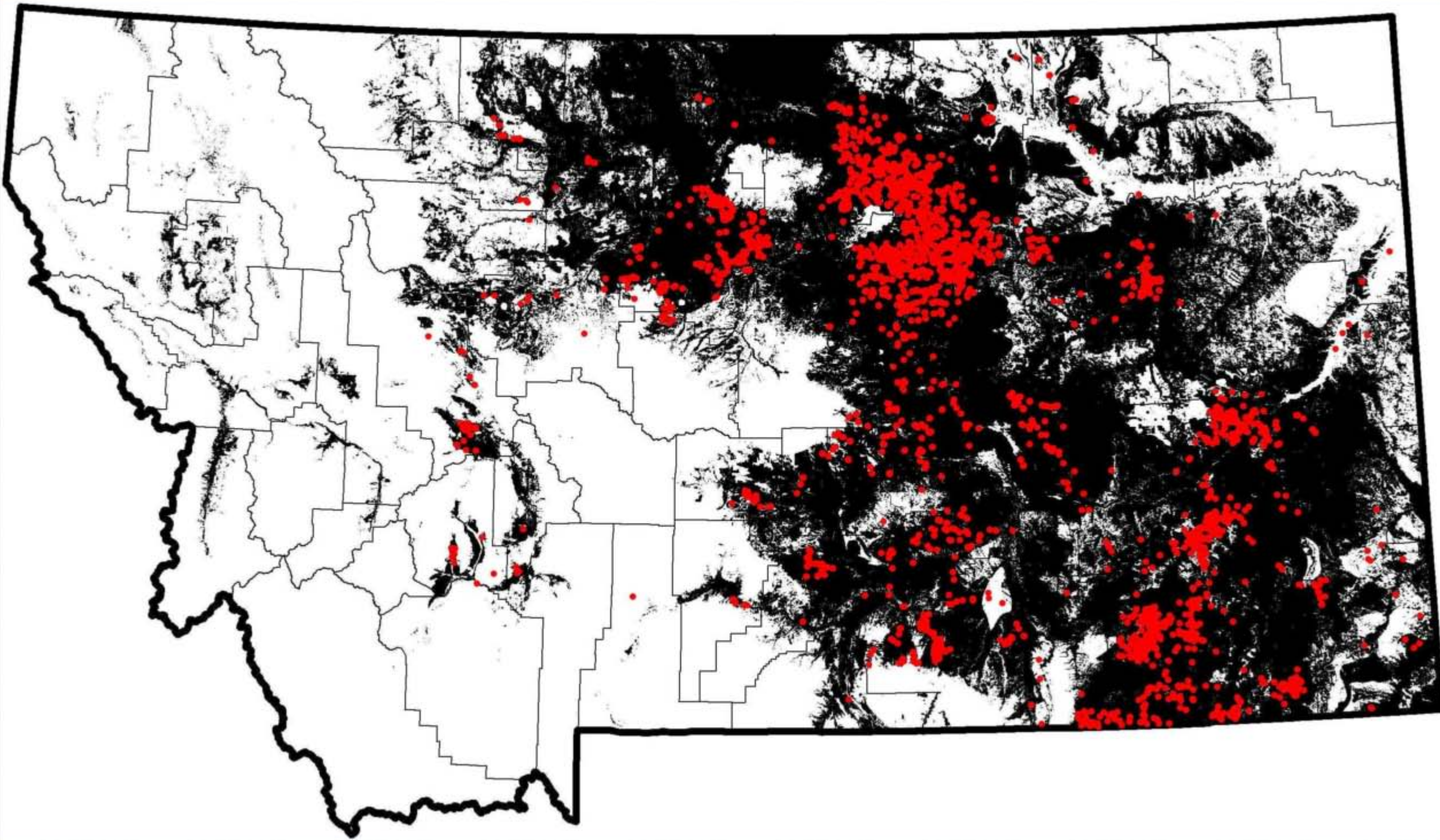
# Landscape Connectivity Issues



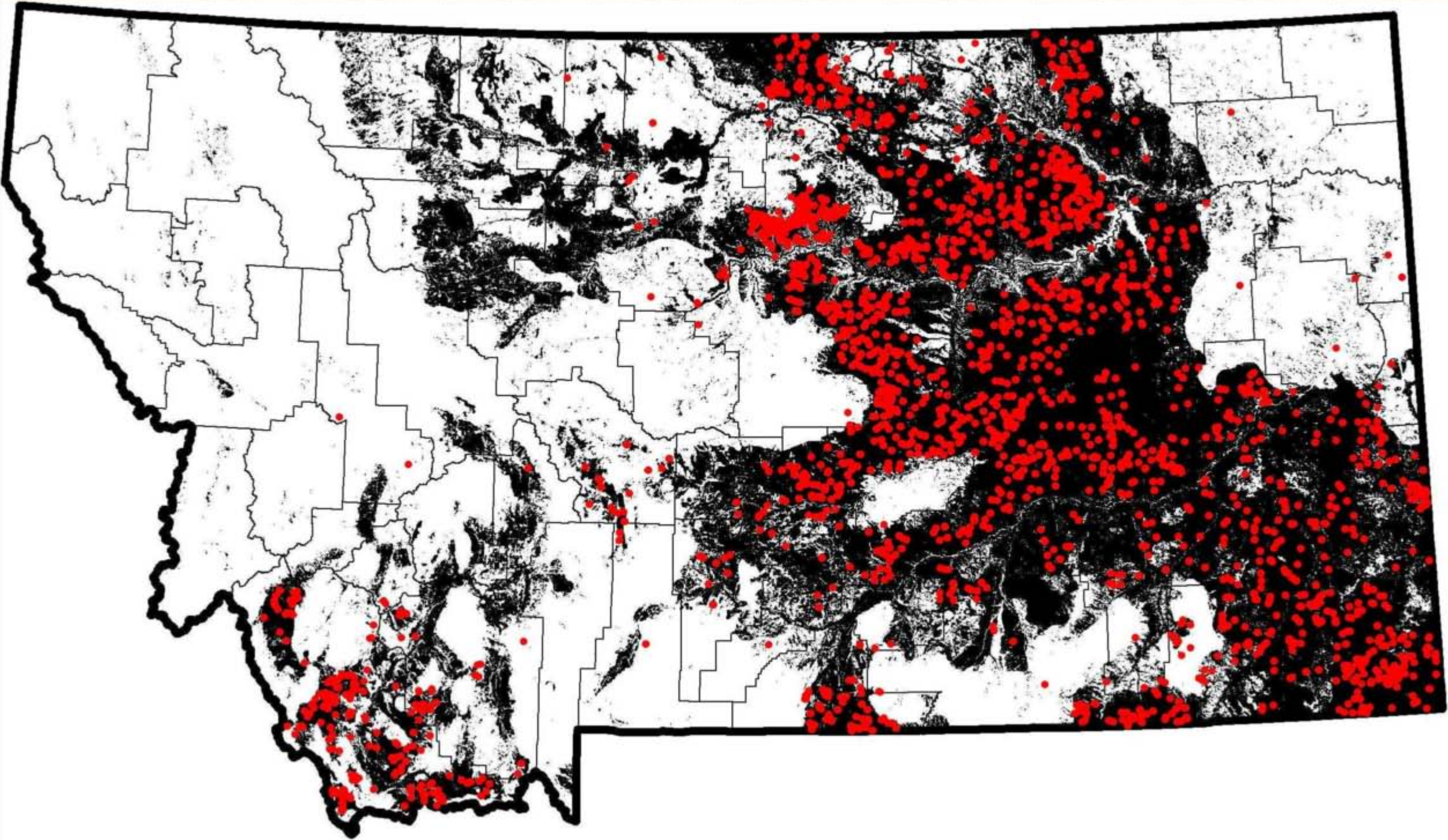
# Canton Valley (Canyon Ferry Reservoir) *circa* 1870



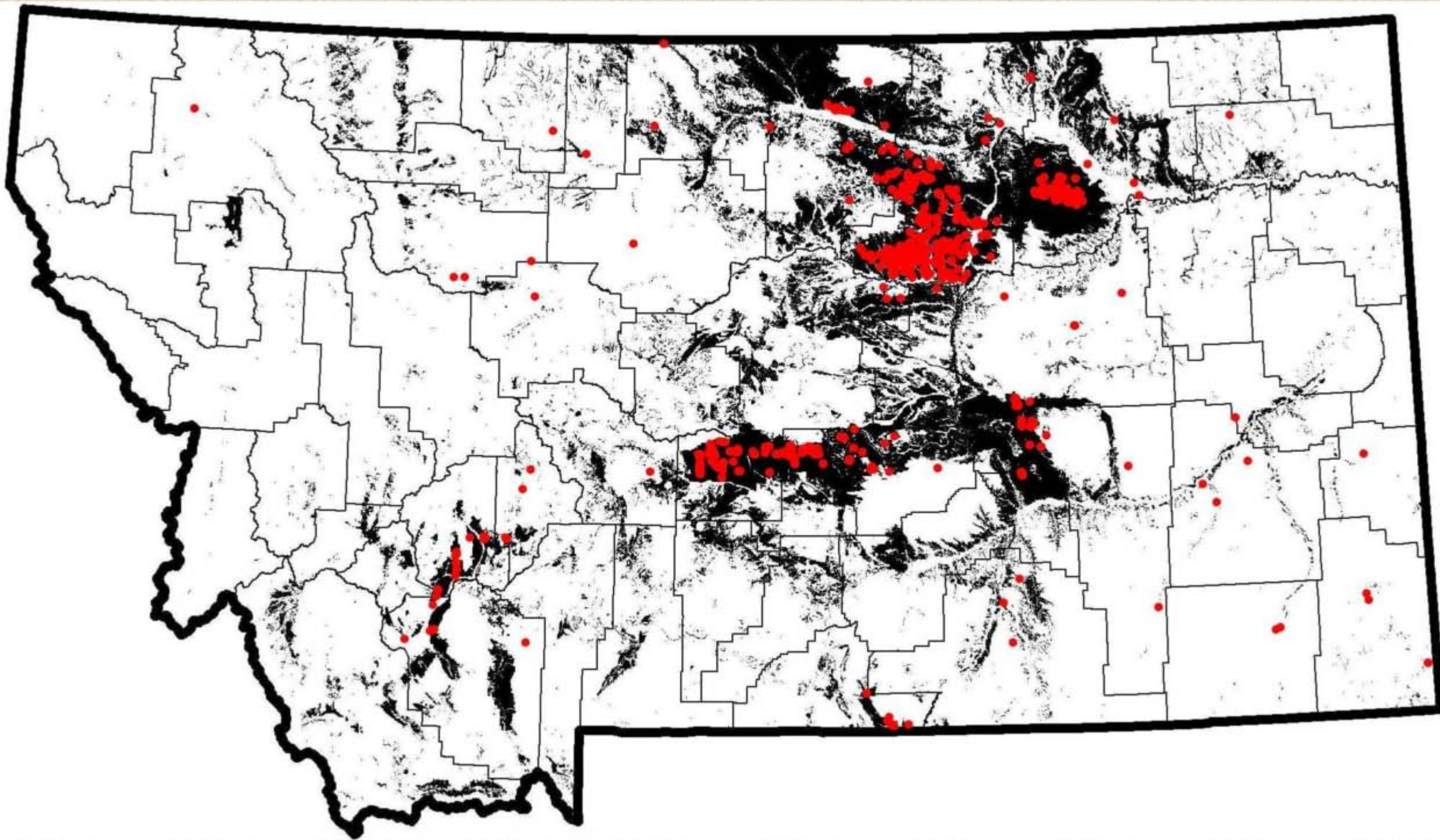
# Black-tailed Prairie Dog



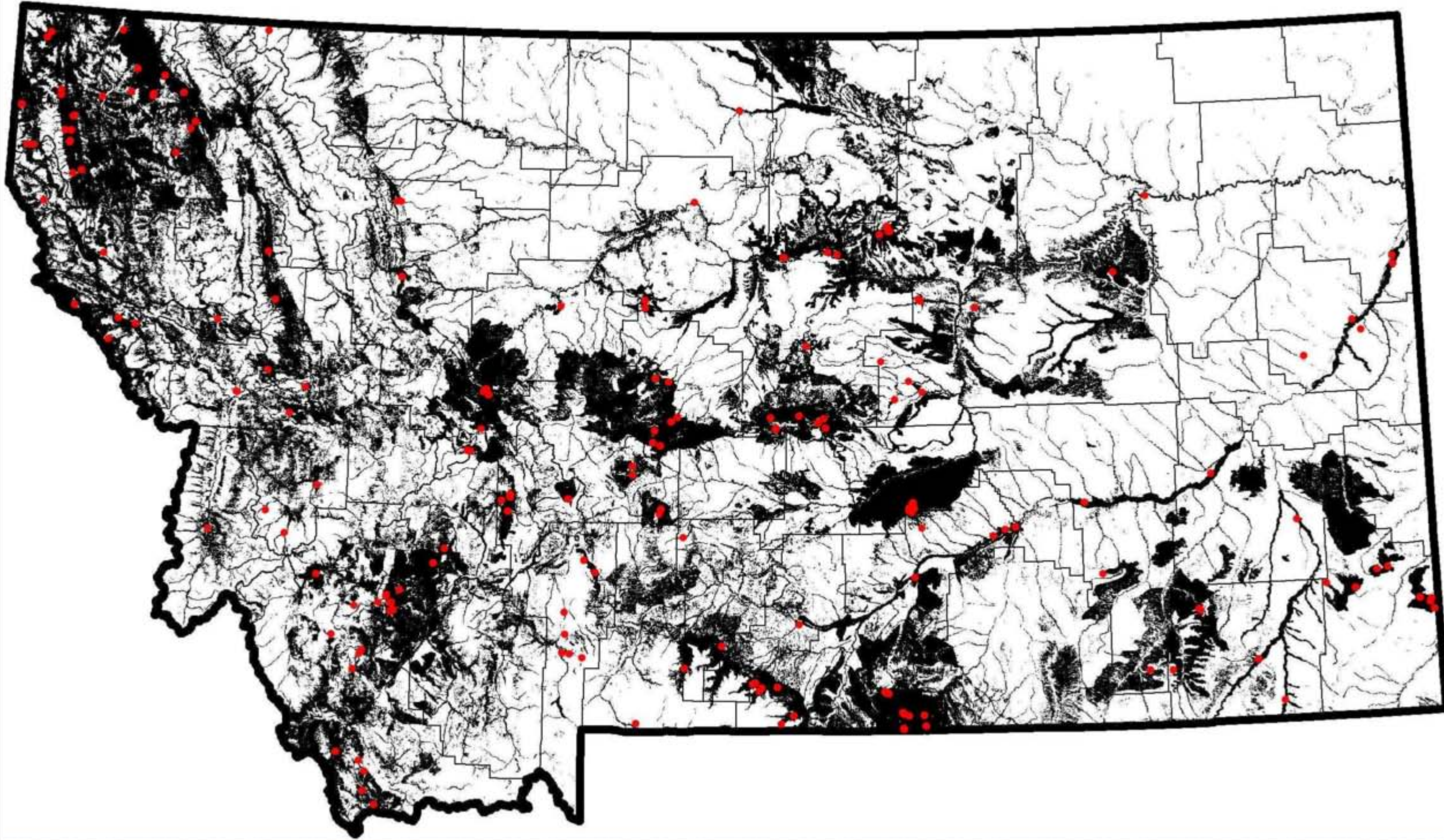
# Greater Sage-Grouse



# Mountain Plover



# Hoary Bat



# CART Models Of Major Habitat Features

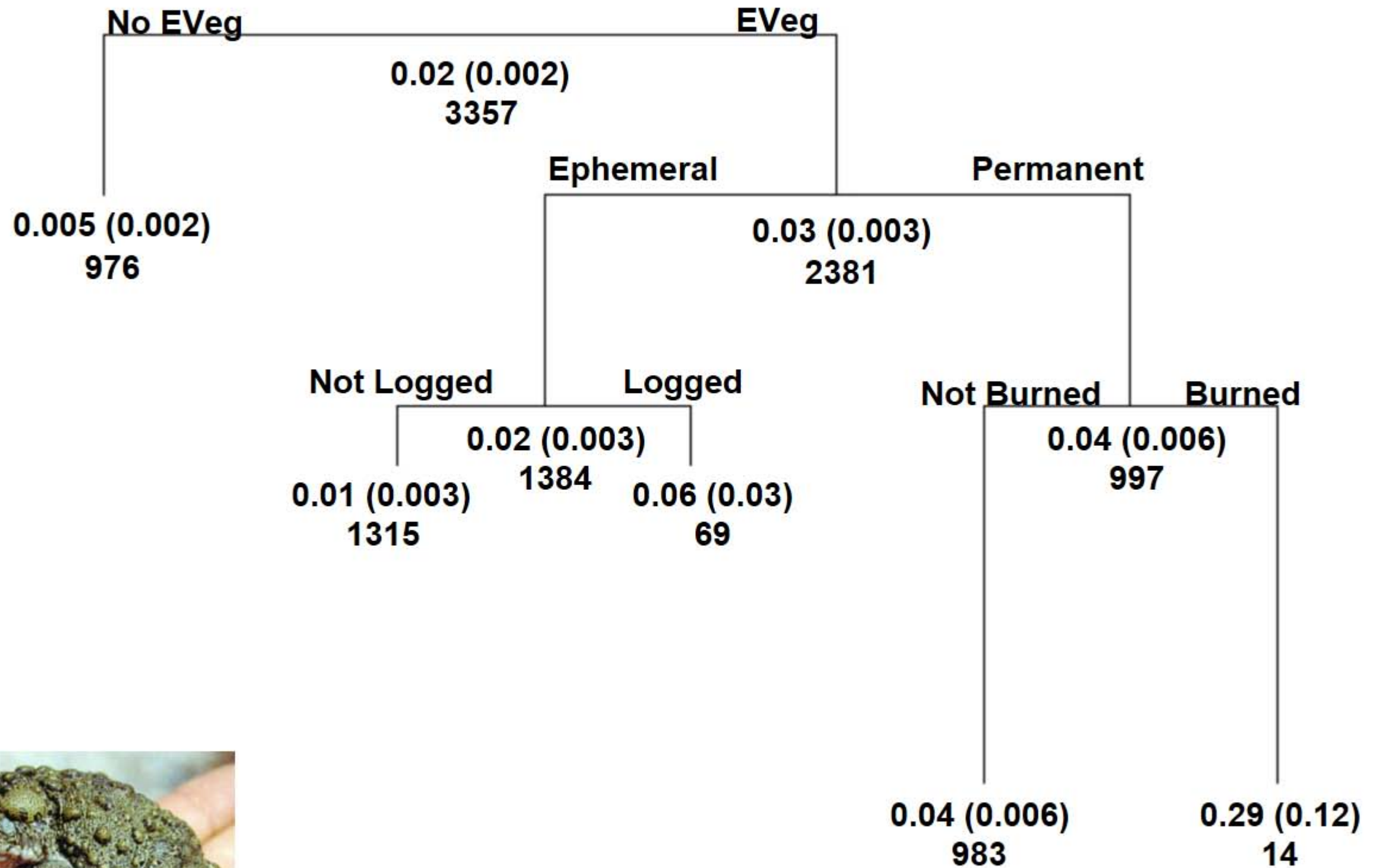
Species	Independent Variables Used in Model
<i>Ambystoma macrodactylum</i>	Permanence + Eveg + Fish
<i>Ambystoma tigrinum</i>	Permanence + Eveg + Fish
<i>Spea bombifrons</i>	Permanence + Eveg + Fish
<i>Bufo boreas</i>	Permanence + Eveg + Fish + Burned + Logged
<i>Bufo cognatus</i>	Permanence + Eveg + Fish
<i>Bufo woodhousii</i>	Permanence + Eveg + Fish
<i>Rana luteiventris</i>	Permanence + Eveg + Fish
<i>Rana pipiens</i>	Permanence + Eveg + Fish
<i>Chrysemys picta</i>	Permanence + Eveg + Fish
<i>Thamnophis elegans</i>	Permanence + Eveg + Fish + J or A Amphibians + L Amphibians
<i>Thamnophis radix</i>	Permanence + Eveg + Fish + J or A Amphibians + L Amphibians
<i>Thamnophis sirtalis</i>	Permanence + Eveg + Fish + J or A Amphibians + L Amphibians



# Long-toed Salamander



# Western Toad



No J or A Amphibians

J or A Amphibians

0.03 (0.003)  
3993

# Common Gartersnake

No EVeg

EVeg

No L Amphibians

L Amphibians

0.02 (0.003)  
3204

0.06 (0.01)  
789

No L Amphibians

L Amphibians

No Fish

Fish

No EVeg

EVeg

0.01 (0.002)  
1057

0.03 (0.004)  
2147

0.12 (0.03)  
110

0.05 (0.01)  
679

Ephemeral

Permanent

0.02 (0.004)  
1371

0.04 (0.01)  
776

0.00 (-)  
37

0.05 (0.01)  
642

0.05 (0.01)  
522

0.02 (0.01)  
254

No EVeg

EVeg

0.00 (-)  
16

0.14 (0.04)  
94

0.15 (0.04)  
84



# Summary of Responses to Fish

<b>Response</b>	<b>Species</b>
<b>Negative</b>	<b>Long-toed Salamander</b>
<b>Negative</b>	<b>Tiger Salamander</b>
<b>Negative</b>	<b>Great Plains Toad</b>
<b>Negative</b>	<b>Woodhouse's Toad</b>
<b>Negative</b>	<b>Pacific Treefrog</b>
<b>Negative</b>	<b>Common Gartersnake</b>
<b>Positive</b>	<b>Terrestrial Gartersnake</b>
<b>Positive</b>	<b>Plains Gartersnake</b>

# Summary of Emergent Vegetation Responses

- **13 of 14 species showed evidence for some positive response to the presence of emergent vegetation.**

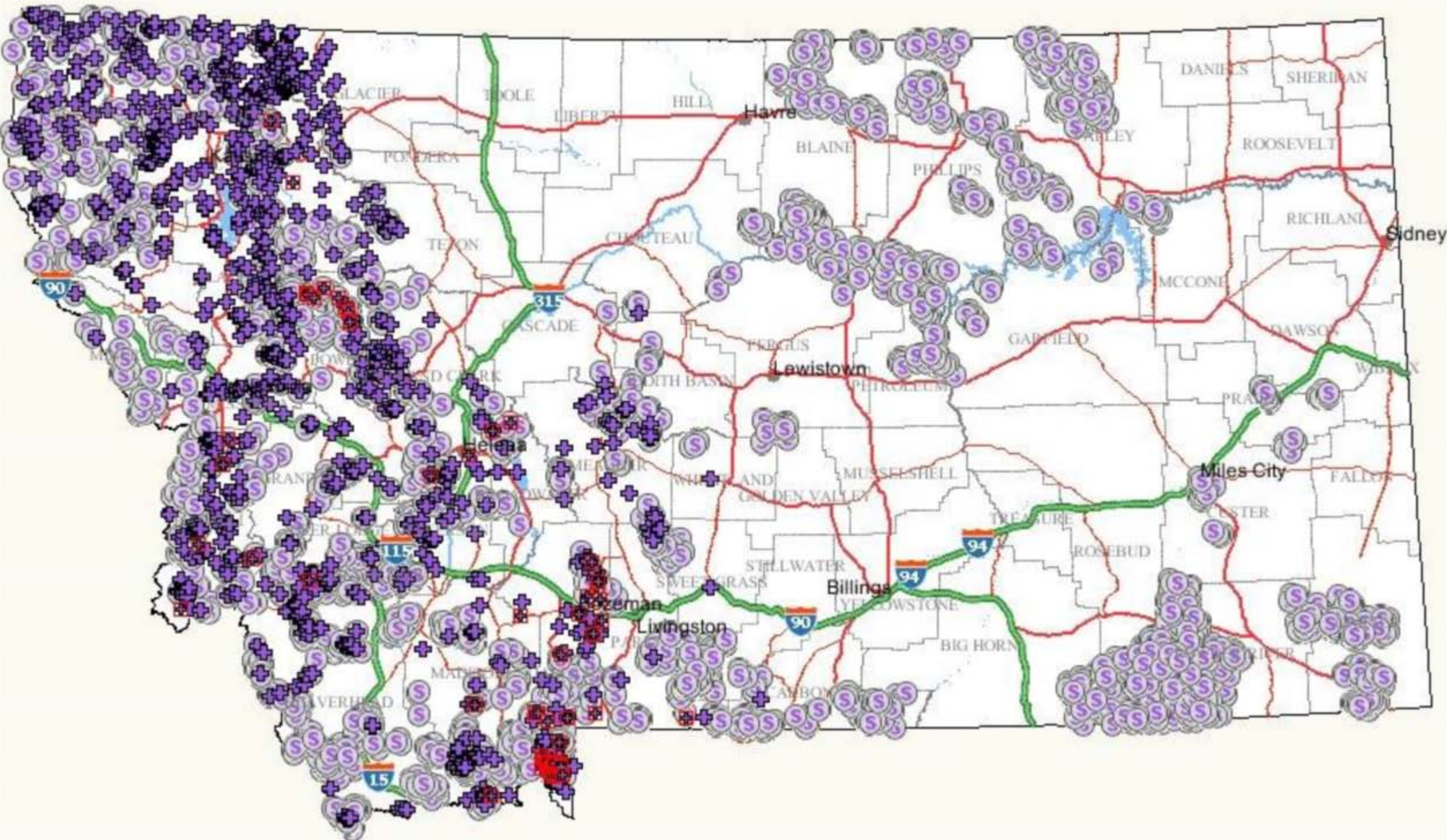
# Access to Information



# Lentic Site Surveys and Observations of Western Toads



# TRACKER



Availability of information 1

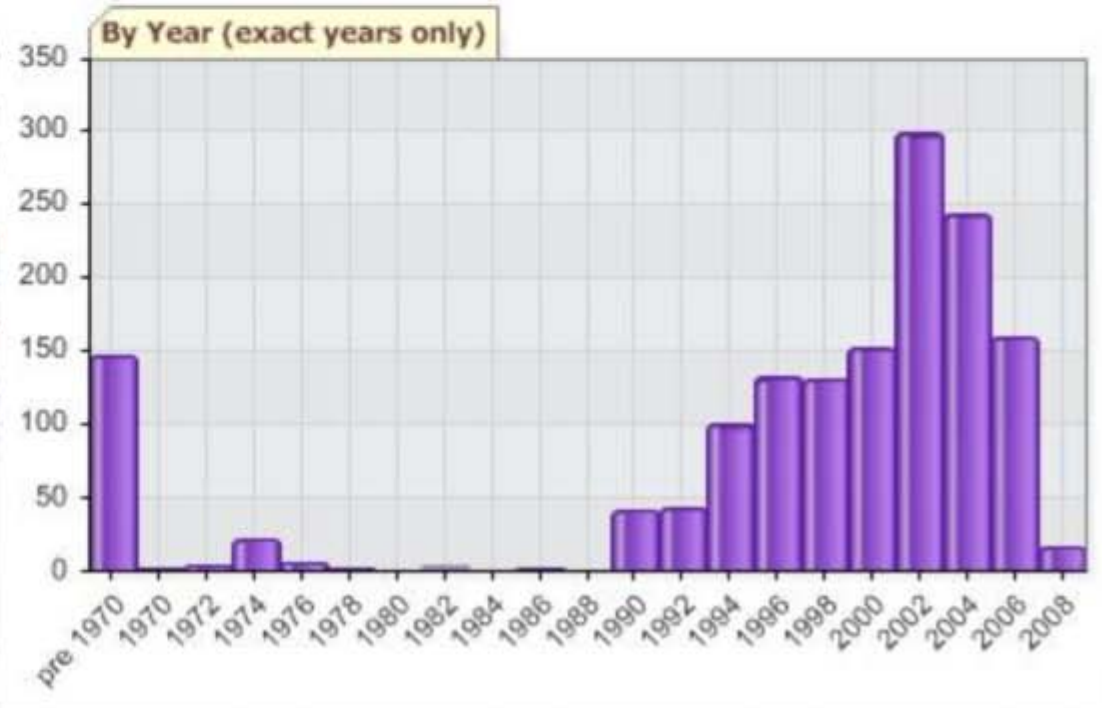
# Lentic Site Surveys and Observations of Western Toads



# TRACKER



TAXA	ID (click to EDIT)	Common Name (Scientific Name)	OBSERVERS	OBSERVATION DATE		LL QLL QQLL	COUNTY	Comments	Spatial Precision (Meters)	TYPE	PENDING	Additional Info		
				MONTH	DAY							YEAR	Notes	Unknown Sex
Amphibians	<a href="#">10588219</a>	Western Toad ( <i>Bufo boreas</i> ) <u>Species of Concern</u>	Bell, Matthew	Jul	13	2008	28A3	Lewis and Clark	7.5 Miles WSW of Hedges Mountain	0	Pending	Unknown Sex	Juveniles	
												Males	Immature	
												Females	1	Eggs
												Pairs		Nest
				Species Observation Notes: 65mm SVL, female seen on trail between parking area and rope swing.										
				Habitat Observation Notes: Tall grasses/vegetation downslope toward lake. Dry, rocky, mostly open ponderosa pine forest upslope.										



Availability of information 2



# View Photos of Sites Surveyed



# TRACKER

NATURAL HERITAGE TRACKER Scale 1:78,393 Lat: 45.32159 Long: -109.91541

Home File Edit View Window Help Sign Out

Reports  
Add Animal Observations  
Photo Viewer  
Photosets  
Amphibian Inventory Photos  
Map Layers

Map Layers

- Towns
- County
- LL / QLL / QQLL
- Highways
- 24K Quads
- Township and Range
- Lakes/Streams
- Conservation Easements
- Special Designation Lands
- Public Lands

Base Map

- Air Photos (color 2005)
- Air Photos (color infrared)
- Air Photos (color 2005 w/ 2004 hi res cities)
- Air Photos (b/w)
- Topographic (hillshade)
- Topographic
- Highway map
- Hillshade
- [No Base Map]

Search for Location

Identify

Lat: 45.2731 Long: -110.11073  
SPX: 552083 SPY: 113900  
Elevation: 2962 meters 9718 feet

Photos

Site = 7038008 - Pond, 1.3 miles S of Lake Mountain  
Date = Aug 13, 2005  
Name = 7\_038\_008.jpg

Site = 7043036 - Pond, 5.4 miles SW of Tumble Mountain  
Date = Aug 13, 2005  
Name = 7\_043\_036a.jpg

Click to view larger image

Site = 7043036 - Pond, 5.4 miles SW of Tumble Mountain  
Date = Aug 13, 2005  
Name = 7\_043\_036b.jpg

Natural Heritage Program  
0 0.65mi

# Acknowledgements

Inspiration and constructive feedback was provided by Steve Corn, Lisa Eby, Chris Funk, Kathy Griffin, Justin Gude, Blake Hossack, Mark Lindberg, Rebecca McAffrey, Scott Mills, David Naugle, Chuck Peterson, David Pilliod, Robin Russell, and Andrew Sheldon. Vanetta Burton, and Darlene Patzer were especially instrumental in managing contracts, accounts, and payrolls. Collaborative funding was provided by Scott Barndt, Jim Brammer, Rob Brassfield, Marion Cherry, Ann Carlson, Jim Claar, Sandy Kratville, Barb Pitman, Brian Riggers, Chris Riley, Don Sasse, Scott Spaulding, Linda Ulmer, Tom Wittinger in the Region 1 U.S. Forest Service; Kristi DuBois, Allison Puchniak, and Heidi Youmans at the Montana Department of Fish, Wildlife, and Parks; Randy Apfelbeck and Lynda Saul at the Montana Department of Environmental Quality; Jo Christenson, Roxanne Falise, Joe Platz, Gayle Sitter, Jim Sparks, and Marc Whisler at the Montana State Office of the Bureau of Land Management; Steve Corn at the Biological Resources Division of the U.S. Geological Survey; and Henning Stabins at Plum Creek Timber Company. Special thanks for field and office assistance is due to: Steve Amish, Matthew Bell, Danielle Blanc, Mickey Bland, Anna Breuninger, Andy Brown, Peter Brown, Sean Burns, Mark Byall, Beth Clarke, Eric Dallalio, Ayla Doubleday, Jessica Easley, Ashton Fink, Sarah Fitzgerald, Matt Gates, Alex Gunderson, Teri Hamm, Chris Hays, David Herasimtchuk, Renee Hoadley, Grant Hokit and his Carroll College students, Letitia Jacques, Phil Jellen, Ryan Killackey, Todd Leifer, Robert Lishman, Patrick Lizon, Gary Maag, Lorraine McInnes, Andrew Munson, Rachelle Owen, Stacy Polkowske, Amy Puett, Thomas Schemm, David Stagliano, Keif Storrar, Tomi Sugahara, Anatole Suttschenko, John Thayer, Allan Thompson, Brian Tomson, Lisa Wilson, Chris Welch, Ryan Zajac, Franz Zikesch, and Alison Zmud.