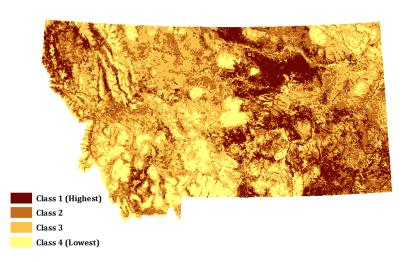




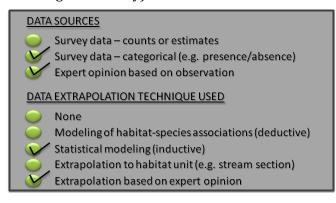
TERRESTRIAL CONSERVATION SPECIES

represents the cumulative expected occurrence of 85 of Montana's vertebrate species. Species inclusion was based on the State Species of Concern (SOC) list. The SOC list includes federally listed Threatened or Endangered species, those



species listed Species of Greatest Conservation Need as part of the Montana Comprehensive, Fish and Wildlife Conservation Strategy, as well as other species deemed in need of conservation by the Montana Natural Heritage Program and cooperating biologists. Several data sources were used to represent species habitat suitability: predictive models based on observation data, deductive models generated as part of the GAP effort, as well as expert opinion informed distributions. Species with greater combined state and global conservation status were given more weight in the cumulative score. **THIS ASSESSMENT DOES NOT INCLUDE INVERTEBRATES OR PLANTS.**

MEASUREMENT UNIT AND MAPPING CONSIDERATIONS: Scores were calculated for each one mile section in Montana. Species occurrence is based on modeling efforts informed by observations for most species. Individual species occurrences were modeled as 90meter pixels and summarized to one-mile sections. Approximately 43,000 points observations were used to inform the modeling process; the number of points used per species ranged from 16 to over 4000. Observations were extracted from the shared FWP/NHP Point Observation Database. Only locations with less than 400 meters of uncertainty were used for modeling (with the exception of bird observations from the Breeding Bird Survey). Observations were not limited to recent observations.



DATA SOURCE(S) / QUALITY: Species habitat suitability was predicted based on species observations and a variety of environmental features such as land cover, elevation, distance to stream, and precipitation. The models were created using MaxEnt software (Phillips et al. 2004; Phillips et al. 2006) and driven by point





observations from the shared Montana Natural Heritage Program (MTNHP) and Montana Fish Wildlife and Parks (FWP) Point Observation Database (POD). Species with few (generally < 20) observations, as well as species for which predictive modeling clearly was not suitable (e.g., waterbirds) were represented using the original GAP models (insert citation) or expert-informed maps (Table 1). Grizzly bear distribution was represented by a layer depicting a 10-mile buffer around recovery areas. Lynx distribution was represented by boundary determined through expert review.

METHODS: All SOC were ranked using a formula that considered the Species of Concern (http://mtnhp.org/SpeciesOfConcern) state rank and the Natureserve global rank as determined by MTNHP and NatureServe, respectively. A model was created for each species that represented presence or absence. All model outputs were clipped to the known range of the species and then all species with the same rank were added together. Each rank group total was subjected to a

multiplier (Table 1) and then the group scores were added to arrive at a final score. Scores were initially represented by 90-meter pixels.

FINAL CATEGORIZATION: All 90-meter pixels in a section were averaged to arrive at the final section score. Section values were broken into four classes using the natural breaks algorithm in ArcGIS; this algorithm finds gaps in the data corresponding to the number of categories desired.

CLASS	RANGE OF VALUES (points)	PERCENT OF STATE		
1 (Highest)	8.0 to 13.75	18 %		
2	6.25 to 8.0	33 %		
3	4.25 to 6.25	34 %		
4 (Lowest)	1 to 4.25	15 %		

Table 1. Conservation species used in this layer (see model representation and footnotes for details).

Species	SRank	GRank	CLIP Rank ¹	# Of Obs. ²	Data Quality Rating ³	Model Representation ⁴
Coeur d'Alene Salamander	2	4	3	142	Moderate	MaxEnt
Idaho Giant Salamander	2	3	2	52	Low	MaxEnt
Western Toad	2	4	3	1735	High	MaxEnt
Great Plains Toad	2	5	3	296	Moderate	MaxEnt
Plains Spadefoot	3	5	4	459	Moderate	MaxEnt
Northern Leopard Frog	1	5	2	1290	High	MaxEnt
Common Loon	3	5	4	536	High	MaxEnt
Horned Grebe	3	5	4		Limited Validation	GAP
Clark's Grebe	3	5	4		Limited Validation	GAP
American White Pelican	3	4	4		Limited Validation	GAP
American Bittern	3	4	4		Limited Validation	GAP
Great Blue Heron	3	5	4	2403	High	GAP
Black-crowned Night-Heron	3	5	4		Limited Validation	GAP
White-faced Ibis	3	5	4		Limited Validation	GAP





Species	SRank	GRank	CLIP Rank ¹	# Of Obs. ²	Data Quality Rating ³	Model Representation ⁴
Trumpeter Swan	3	4	4	29	Low	MaxEnt
Harlequin Duck	2	4	3	425	Moderate	MaxEnt
Bald Eagle	3	5	4	342	Moderate	MaxEnt
Northern Goshawk	3	5	4	375	Moderate	MaxEnt
Ferruginous Hawk	3	4	4	921	High	MaxEnt
Golden Eagle	3	5	4	4309	High	MaxEnt
Peregrine Falcon	3	4	4	360	Moderate	MaxEnt
White-tailed Ptarmigan	3	5	4	300	Limited Validation	OldGap
Greater Sage-Grouse	2	4	3			Handled elsewhere ⁵
Sharp-tailed Grouse	1	4	2			elsewhere ⁵
Yellow Rail	3	4	4		Limited Validation	GAP
Whooping Crane	1	1	1			Only migratory in state
Piping Plover	2	3	2	736	Limited Validation	GAP
Mountain Plover	2	3	2	1784	High	MaxEnt
Black-necked Stilt	3	5	4		Limited Validation	GAP
Long-billed Curlew	3	5	4	1378	High	MaxEnt
Franklin's Gull	3	4	4		Limited Validation	GAP
Caspian Tern	2	5	3		Limited Validation	GAP
Common Tern	3	5	4		Limited Validation	GAP
Forster's Tern	3	5	4		Limited Validation	GAP
Least Tern	1	4	2	221	Moderate	MaxEnt
Black Tern	3	4	4		Limited Validation	GAP
Black-billed Cuckoo	3	5	4			Limited data ⁶
Yellow-billed Cuckoo	3	5	4			Limited data ⁶
Flammulated Owl	3	4	4	414	Moderate	MaxEnt
Burrowing Owl	3	4	4	442	Moderate	MaxEnt
Great Gray Owl	3	5	4	16	Low	MaxEnt
Black Swift	1	4	2	5	Limited Validation	GAP
Lewis's Woodpecker	2	4	3	15	Limited Validation	GAP
Red-headed Woodpecker	3	5	4			Limited data ⁶
Black-backed Woodpecker	3	5	4			Limited data ⁶
Pileated Woodpecker	3	5	4	23	Low	MaxEnt
Alder Flycatcher	3	5	4		Limited Validation	GAP
Pinyon Jay	3	5	4	173	Moderate	MaxEnt
Clark's Nutcracker	3	5	4	3987	High	MaxEnt
Boreal Chickadee	3	5	4	30	Low	MaxEnt
Brown Creeper	3	5	4	839	High	MaxEnt
Winter Wren	3	5	4	2681	High	MaxEnt
Sedge Wren	3	5	4			Limited data ⁶
Blue-gray Gnatcatcher	2	5	3		Limited Validation	GAP





Species	SRank	GRank	CLIP Rank ¹	# Of Obs. ²	Data Quality Rating ³	Model Representation ⁴
Veery	3	5	4	458	Moderate	MaxEnt
Sage Thrasher	3	5	4	294	Moderate	MaxEnt
Sprague's Pipit	3	4	4	1877	High	MaxEnt
Loggerhead Shrike	3	4	4	554	High	MaxEnt
Brewer's Sparrow	3	5	4	2504	High	MaxEnt
Sage Sparrow	3	5	4	2301	111511	Limited data ⁶
Baird's Sparrow	3	4	4	1644	High	MaxEnt
Grasshopper Sparrow	3	5	4	2169	High	MaxEnt
Le Conte's Sparrow	3	4	4	210)	111511	GAP
Nelson's Sparrow	3	5	4	88	Low	MaxEnt
McCown's Longspur	3	4	4	984	High	MaxEnt
Chestnut-collared Longspur	2	5	3	3382	High	MaxEnt
Bobolink	3	5	4	486	Moderate	MaxEnt
Black Rosy-Finch	2	4	3	400	Limited Validation	GAP
Gray-crowned Rosy-Finch	2	5	3		Limited Validation	GAP
Cassin's Finch	3	5	4	2111	High	MaxEnt
Preble's Shrew	3	4	4	2111	підіі	Limited data ⁶
Dwarf Shrew	2	4	3		Limited Validation	GAP
Arctic Shrew	$\frac{2}{1}$	5	2		Limited vandation	Limited data ⁶
Merriam's Shrew	3	5	4		Limited Validation	GAP
Northern Short-tailed Shrew	1	5	2		Limited vandation	Limited data ⁶
	3	4	4			Limited data ⁶
Fringed Myotis Northern Myotis	2	4	3			Limited data ⁶
Eastern Red Bat	2	5	3			Limited data Limited data Limited data
	-	1	4	25.4	Madausta	
Hoary Bat	3 2	5		254	Moderate	MaxEnt
Spotted Bat		4	3	120	N. 1	Limited data ⁶
Townsend's Big-eared Bat	2	4	3	129	Moderate	MaxEnt
Pallid Bat	2	5	3	31	Low	MaxEnt
Black-tailed Jack Rabbit	2	5	3	17	Low	MaxEnt
Pygmy Rabbit	3	4	4	1196	High	MaxEnt
Uinta Chipmunk	3	5	4			Limited data ⁶
Black-tailed Prairie Dog	3	4	4	1411	High	MaxEnt
White-tailed Prairie Dog	1	4	2		Limited Validation	GAP
Idaho Pocket Gopher	2-4	4	3			Limited data ⁶
Great Basin Pocket Mouse	2-3	5	3		Limited Validation	GAP
Hispid Pocket Mouse	1-3	5	2		Limited Validation	GAP
Northern Bog Lemming	2	4	3			Limited data ⁶
Meadow Jumping Mouse	2	5	3	29	Low	MaxEnt
Gray Wolf	3	4	4			Connectivity ⁷
Swift Fox	3	3	3	514	High	MaxEnt
Grizzly Bear	2	4	3		High	Expert Knowledge





Species	SRank	GRank	CLIP Rank ¹	# Of Obs. ²	Data Quality Rating ³	Model Representation ⁴
Fisher	3	5	4			Handled elsewhere ⁸
Black-footed Ferret	1	1	1			Reintroductions ⁹
Wolverine	3	4	4			Handled elsewhere ⁸
Western Spotted Skunk	1-3	5	2		Limited Validation	GAP
Canada Lynx	3	5	4		High	Expert Knowledge
Bison	2	4	3			Few wild populations 10
Snapping Turtle	3	5	4	60	Low	MaxEnt
Spiny Softshell	3	5	4	155	Moderate	MaxEnt
Northern Alligator Lizard	3	5	4	48	Low	MaxEnt
Greater Short-horned Lizard	3	5	4	193	Moderate	MaxEnt
Common Sagebrush Lizard	3	5	4	266	Moderate	MaxEnt
Western Skink	3	5	4	54	Low	MaxEnt
Western Hog-nosed Snake	2	5	3	79	Low	MaxEnt
Milksnake	2	5	3	51	Low	MaxEnt
Smooth Greensnake	2	5	3	43	Low	MaxEnt

¹ Clip Rank was formed by combining SRank and GRank values, lower scores in these two categories led to lower Clip Ranks (greater conservation need).

5These species were included in the Prairie Grouse Layer, a portion of the Terrestrial Game Layer.

⁷This species will be handled under a future connectivity analysis.

⁸These species were included in the Furbearer Layers, a portion of the Terrestrial Game Layer.

⁹This species currently only exists in Montana where experimental reintroductions have occurred.

REFERENCES:

Steven J. Phillips, Miroslav Dudík, Robert E. Schapire. A maximum entropy approach to species distribution modeling. In *Proceedings of the Twenty-First International Conference on Machine Learning*, pages 655-662, 2004.

²Number of observations indicates observations used for inductive (MaxEnt) modeling.

³Data Quality Ratings of Low, Moderate and High apply to inductive models.

⁴Model representation codes: MaxEnt = inductive modeling with Maximum Entropy, GAP = deductive models from GAP efforts at Montana Spatial Analysis Lab.

⁶These species did not have enough observations with sufficient accuracy for modeling nor did they have GAP models. Data for these species is lacking.

¹⁰Populations of this species only occurred in small pockets of Montana currently.





Steven J. Phillips, Robert P. Anderson, Robert E. Schapire. Maximum entropy modeling of species geographic distributions. *Ecological Modeling*, 190:231-259, 2006.

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