Mapping breeding densities of greater sage-grouse:

A tool for range-wide conservation planning

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EXECUTIVE SUMMARY.—A major goal in greater sage-grouse (*Centrocercus urophasianus*, hereafter 'sage-grouse') conservation is to spend limited resources efficiently by conserving large and functioning populations. We used maximum count data from leks (n = 4,885) to delineate high abundance population centers that contain 25, 50, 75, and 100% of the known breeding population for use in conservation planning. Findings show sage-grouse breeding abundance is highly clumped from range-wide to province and state-wide analysis scales. Breeding density areas contain 25% of the known population within 3.9% (2.92 million ha) of the species range, and 75% of birds are within 27.0% of the species range (20.4 million ha). We adopted a spatial organizational framework based on Western Association of Fish and Wildlife Agencies (WAFWA) Management Zones (Connelly et al 2004, Stiver et al. 2006) which are delineated by floristic provinces and used to group sage-grouse populations for management actions. Breeding bird abundance varies by Sage-grouse Management Zones, with Zones I, II, and IV containing 83.7% of all known sage-grouse. Zone II contains a particularly high density of birds which includes 40% of the known population and at least half of the highest density breeding areas range-wide. Despite high bird abundance in Zones I, II, and IV, maintaining current distribution of sage-grouse depends upon effective conservation in each U.S. state and Canadian province. For example, each of the 11 states containing sage-grouse have enough breeding birds across multiple landscapes to meet the 75% breeding density threshold. Federal, state and private lands all play a role in sage-grouse conservation. On average, surface ownership within 75% breeding areas was 60.15% Federal, 33.98% privately owned, and 5.59% State lands. Diversity in surface and subsurface (e.g., mineral rights) ownership within states and provinces will play a major role in the approach used to maintain and enhance priority populations. Maps developed here provide a vision for decision makers to spatially prioritize

conservation targets, but risks and opportunities vary dramatically in each state and province. More importantly, state and provincial game and fish agencies have insights into seasonal habitat usage and local ecology making state and federal cooperation and communication imperative before the implementing of sage-grouse conservation actions. Users are also encouraged to contact their state game and fish agencies for similar state developed planning maps.

INTRODUCTION

Invasive species, disease, overgrazing, tillage, energy development, subdivision, juniper encroachment, wildfire and other stressors portend the conservation challenge for maintaining large and intact western landscapes (Knick et al. 2003). An expanding human footprint in the West has left states, federal agencies and other partners looking for ways to reduce anthropogenic impacts. Conservation practitioners face a growing list of threats in declining habitats, and elevated risk to remaining intact and functioning landscapes, amid ever-present limited budgets. These conditions and constraints demand an overall approach based on 'conservation triage' defined here as the prioritization of landscapes to which limited resources are allocated to maximize biological return on investment (Bottrill et al. 2008, 2009). Triage is a crucial approach to maintaining biological resources, in contrast to providing palliative care to already degraded systems (Schneider et al. 2010). The science of identifying and subsequently delivering conservation in priority landscapes continues to gain support as a prevailing paradigm. Still, some programs implement 'opportunistic conservation' by taking a scattered approach to deciding where to work, and gauging success by the total amount of acres treated or manipulated (Doherty et al. 2010b). Resulting projects may maintain or enhance habitats at the scale of the individual ownership level but still fail to benefit populations amidst an already fragmented landscape. Thus, a major goal of conservation programs is to deliver conservation on scales that maintain large and intact landscapes rather than try to risk recovering small declining populations at the cost of further loss in the best remaining areas.

The objective of this BLM project is to map high breeding densities of greater sage-grouse for use in conservation planning. This completion report provides two deliverables: 1) The analytical framework for evaluating option-alternatives where partners can deliver actions that will yield the highest return on their conservation investment, and 2) The GIS databases delineating high breeding densities of sage-grouse for use by conservation planners. Maps developed here provide a large-scale view of the distribution and abundance of sage-grouse.

METHODS

Study Area and Approach. — The study area includes landscapes within the entire distribution of sage-grouse (Schroeder et al. 2004) including portions of Alberta, California, Colorado, Idaho, Montana, Nevada, North Dakota, Oregon, Saskatchewan, South Dakota, Utah, Washington and Wyoming (Figure 1). The current occupied distribution for sage-grouse in all of North America was delineated by using a combination of lek-survey data, geographic information system (GIS) habitat layers, and locations of radio-marked sage-grouse to delineate (Schroeder et al. 2004). We modified this boundary to include 288 additional known lek locations outside the boundaries suggested by Schroeder et al (2004). We did this by buffering the leks by the area of interest for nesting sage-grouse which is 8.5 km (Holloran and Anderson 2005). We adopted a spatial organizational framework based on Western Association of Fish and Wildlife Agencies Management Zones (Connelly et al 2004, Stiver et al. 2006) which are delineated by floristic provinces and used to group sage-grouse populations for management actions. These include greater Sage-grouse Management Zones: Zone I (Great Plains), Zone II (Wyoming Basin), Zone III (Southern Great Basin), Zone IV (Snake River Plain), Zone V (Northern Great Basin), Zone VI (Columbia Basin), and Zone VII (Colorado Plateau) (Figure 2; Connelly et al. 2004, Stiver et al. 2006). All analyses presented evaluate the relative importance of an individual breeding area to all other breeding areas within the entire distribution of greater sage-grouse, management zones, or individual states and provinces (Figure 1). The utility of these analyses is to present a seamless picture of the distribution of nesting sage-grouse habitat across political or management boundaries. As analysis areas become smaller, such as within states or small portions of a state, addition information may be available at a higher resolution for conservation planning.

Sage-grouse Abundance Data.—Knowledge of high-abundance population centers for priority species represent a starting point to frame regional conservation initiatives, and can direct management to landscapes where actions will have the largest benefit to regional populations (Groves et al. 2002, Sanderson et al. 2002). Techniques such as resource selection functions have been widely used in the absence of large scale survey data to identify critical habitat needs and to map areas with high probabilities of use for a wide range of species (McLoughlin et al. 2002, Boyce et al. 2003, Johnson et al. 2006) including sage-grouse (Aldridge and Boyce 2007, Doherty et al. 2008, Doherty et al. 2010c, Atamian et al. 2010). No seamless habitat coverage is available for sage-grouse to build seasonal models that could form the comparison of the relative biological value of different landscapes. Fortunately, sage-grouse are one of the few species in which extensive data sets on distribution and relative abundance are available across their entire breeding distribution making an analyses of this scale possible (Connelly et al. 2004, Schroeder et al. 2004). The concept of using high abundance centers to define the size, shape, connectivity, replication, and spacing of conservation areas is well documented in other systems (Myers et al. 2000, Groves et al. 2002, Sanderson et al. 2002).

Breeding ground (lek) data have been widely used by agencies to monitor sage-grouse population trends, and are considered a reasonable index to relative abundance (Reese and Bowyer 2007). Each spring displaying males are counted within each state on sage-grouse leks in a large coordinated effort by state, federal, and contract employees across the entire distribution of the species. Agencies try to monitor leks at least three times each spring. Leks are visually surveyed from the air or ground, and displaying males are counted during the early morning. Protocols for counting males at leks were almost identical between states following the recommendations of Connelly et al. (2003), which allowed for comparisons between state populations. However, states are limited by resources and access to lek sites. As a result, survey effort varied between states (Figure 4). Because of the variation in survey effort between states we used the maximum count for the most recent survey within the past 10 years 2000 - 2009.

We used the maximum count of male sage-grouse to identify high abundance areas. Each state wildlife agency assembled and provided us a maximum lek count for each year the lek was surveyed over the past 10 years along with spatial coordinates of lek locations. This maximum count database provided us the ability to map relative abundance of sage-grouse breeding areas. We did not include inactive leks, which we defined as leks where no males were displaying in the most recent consecutive counts (Connelly et al. 2003). However, if there was no visit following a zero count, we used the penultimate lek count from 2000-2009. We analyzed 4,885 active leks with 92,978 males to delineate breeding core regions. We defined active leks as those on which ≥1male was counted in the last year the lek was surveyed.

Mapping Sage-grouse Breeding Areas.—We followed the methods outlined in Doherty et al. (2010a) to quantify sage-grouse breeding areas. Doherty et al. (2010a) used a abundance-weighted simple kernel function to delineate priority nesting areas based on proximity of surrounding leks. Breeding density areas are modeled by assigning an abundance-weighted density (based on number of displaying males) to each lek and, starting with the highest density we then sum the number of displaying males until a given percent population threshold is met. This results in a defined percent of the population being identified in areas of the highest density of breeding sites. Authors circumvented the bandwidth choice problem present when using kernel density functions (Seaman et al. 1999, Kernohan et al. 2001, Horne and Garton 2006) by using known distributions of nesting females around leks to delineate the outer boundaries of breeding areas (Holloran and Anderson 2005, Table B-1 in Colorado Division of Wildlife 2008). Our model output is a grouping of nesting areas shaded by four colors that represent the smallest area necessary to contain 25, 50, 75, and 100% of the nesting sage-grouse populations. Area estimates are inclusive; meaning that 25% population thresholds are included within the boundaries of 50% population thresholds. We replicated this model at 21 different extents which included: 1) the entire sage-grouse range in North America (Figure 1), 2) each of the 7 sage-grouse management zones, and 3) each of the 13 states or provinces that have sage-grouse populations. We did this at range-wide (Figure 1) and management zone levels (Figure 2) to facilitate cross jurisdictional planning, and at the state level (Figure 3) to provide a common format for federal and state agencies to compare state-based models which are similar, but have different methodologies.

Land Ownership within the U.S. Distribution of Sage-grouse.—While sage-grouse in the U.S. are currently managed by state entities, land ownership in sagebrush landscapes is a diverse mixture of state, federal and private. Within states and management zones, we used a land ownership layer (USGS 2004, available at http://sagemap.wr.usgs.gov/WestNA_own.shp) to estimate the area within major surface ownerships within the current occupied range (*as modified from* Schroeder et al. 2004) and within 75% range-wide breeding density threshold.

DATA SYNTHESIS and GENERAL FINDINGS

Sage-grouse breeding abundance was highly clumped at all 3 analysis scales (range-wide, management zone, and state or province; Figures 1 - 3 and Tables 1 - 3). We tallied 92,978 known males on 4,885 leks using the most recent counts to delineate breeding density areas. Abundance of males were clumped in there distribution making it possible to spatially delineate landscapes containing a disproportionately large number of breeding birds within a relatively small amount of area (Figure 1 - 3). Range-wide breeding density areas contained 25, 50, 75, and 100% of the known population within 3.9% (2.92 million ha), 10.0% (7.58 million ha), 27.0% (20.36 million ha), and 54.5% (41.18 million ha) of the global sage-grouse range, respectively (Tables 1 and 2). The current occupied range appended to include leks outside of the published distribution of Schroeder et al. (2004) was 75.51 million ha.

Breeding bird abundance varied by management zones, states, and provinces. Management Zone I, II, and IV, contained 83.7% of all known sage-grouse (Table 1). Sage-grouse Management Zone II contained a particularly high density of breeding birds which included 40.25 % of the known sage-grouse abundance (Table 1), and over half (52.7%, Table 3) of the range-wide 25% breeding density threshold areas. While always supporting the highest density of breeding birds, the relative importance of Management Zones I, II, and IV decline when comparing 75% and 100% breeding density thresholds to 25% or 50% breeding density thresholds at the range-wide scale (Table 3). Despite high bird abundances in Zones 1, II, and IV, maintaining current distribution of sage-grouse will depend upon effective conservation in each U.S. state and Canadian province. Each of 11 states contains ≥1 landscape with enough breeding birds to meet the 75% breeding density threshold (Table 3).

Survey effort varied between states (Table 4, Figure 4). States with relatively small populations generally counted 100% of their population within the most recent 2 years (2008-2009; Table 4). The proportion of leks counted during the 2008-2009 period was lower in states with larger numbers of leks to survey (Table 1) with the exception of Wyoming which had 95.3% of all leks surveyed within the last 2 years (Table 4). On average, states surveyed 89.6% of their respective populations between 2006 and 2009 and all states had ~70% of all known leks surveyed between 2006 and 2009 (Table 4).

Land ownership patterns varied greatly between states. Sage-grouse were located on a diverse mixture of federal, state and private lands (Tables 5 and 6). On average, surface ownership within 75% breeding areas was 60.15% Federal, 33.98% private land, and 5.59% State lands, with similar ownership patterns evident for the range-wide occupied distribution (Table 5). BLM is a primary surface ownership in most instances, but land ownership varies in different states (Table 6). For example, BLM owns 69.69% of the surface within 75% breeding areas in Nevada, but 59.48% of surface is privately owned in Montana (Table 6). Diversity in surface and subsurface (e.g., mineral rights) ownership will also play a major role in our approach to conserving priority habitats to maintain large and intact sage-grouse populations.

Findings show that sage-grouse occupy extremely large landscapes but that their breeding distribution is aggregated in comparably smaller identifiable population concentrations. By prioritizing and strategically focusing resources within high concentrations of birds, larger benefits of conservation efforts for sage-grouse can be realized. Mapping areas of high population concentrations will also help policy makers evaluate trade-offs when making decisions that may negatively impacts populations (Doherty et al. 2010b). Range-wide and management zone-level maps facilitate cross jurisdictional planning, and state-level maps provide a common format for federal and state agencies to compare state-based models which are similar, but have different methodologies. As analysis areas become smaller, such as within states, or small portions of a state, additional information is or may be available at a higher resolution for conservation planning (e.g. Aldridge and Boyce 2007, Doherty et al. 2008, Yost et al. 2008, Doherty et al. 2010c, Atamian et al. 2010). More importantly, state game and fish agencies have additional local-scale knowledge of seasonal habitat needs outside the breeding season and other data useful in decision-making. We encourage federal agencies and other partners to consult the States before implementing sage-grouse conservation actions.

This analysis represents a common starting place for systematic conservation planning and represents a summary of all known greater sage-grouse populations in the World. Mapping important landscapes for sage-grouse represent a proactive attempt to identify a set of conservation targets to maintain a viable and connected set of populations before the opportunity to do so is lost. We explicitly recognize other seasonal habitat requirements are needed in addition to high density breeding areas (Doherty et al. 2008, Atamian et al. 2010). However, building seasonal models at landscape scales requires high quality habitat information which is missing in parts of the sage-grouse range. Future incorporation of seasonal habitats ensures management actions encompass all life history stages and management intended to improve one season does not negatively affect another (Woodward 2006, Doherty et al. 2010c). Further, habitat based nesting models will allow targeted and systematic searching for undiscovered populations of sage-grouse, which will increase the rigor of this tool. The GIS code developed for this contract allows for rapid future reanalysis of high density breeding areas as new leks are found. We hope this analysis facilitates communication and integration in sage-grouse conservation planning across state, federal, and provincial jurisdictional boundaries by providing a common format to begin framing decisions.

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Figure 1. Range-wide sage-grouse breeding density areas represent spatial locations of 25%, 50%, 75%, and 100% of the known breeding population, differentiated by color. Red areas contain 25% of the nesting population in 3.9% of the bird's occupied range. Because colors are additive, red and orange areas combined capture 50% of the population in 10% of the range. Collectively, breeding density areas contain 25% of sage-grouse in 3.9% of the species range (2.9 million ha), 50% of birds in 10.0% of range (7.5 million ha), 75% of birds in 26.9% of range (20.4 million ha), and 100% of the known population in 54.6% (41.2 million ha) the species range.

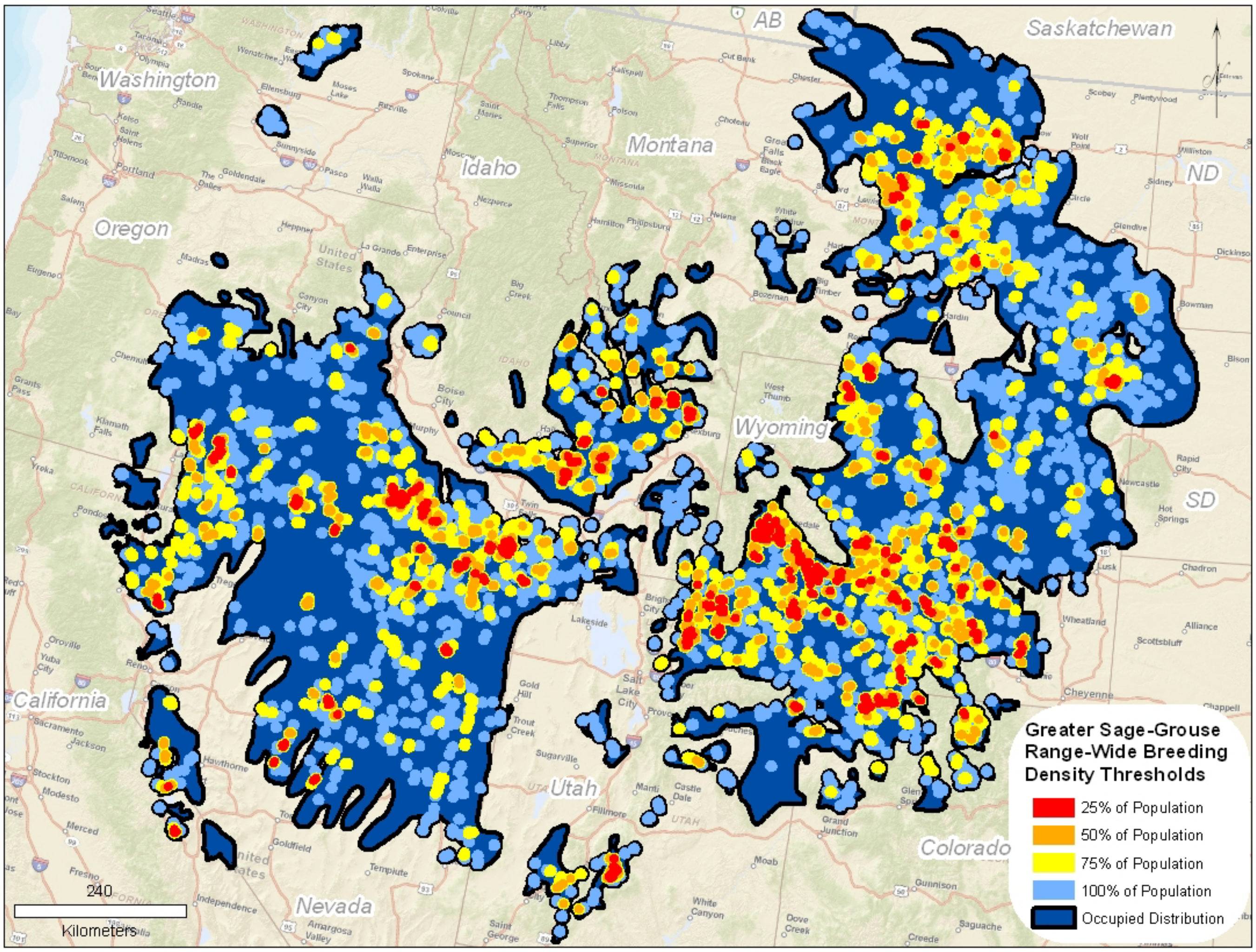

Figure 2. Greater Sage-grouse management zone wide breeding density areas represent spatial locations of 25%, 50%, 75%, and 100% of the known breeding population, differentiated by color within each of the 7 management zones. For example, to obtain 25% of the breeding population in Zone I all red areas within the MZ I boundary need to be added together.

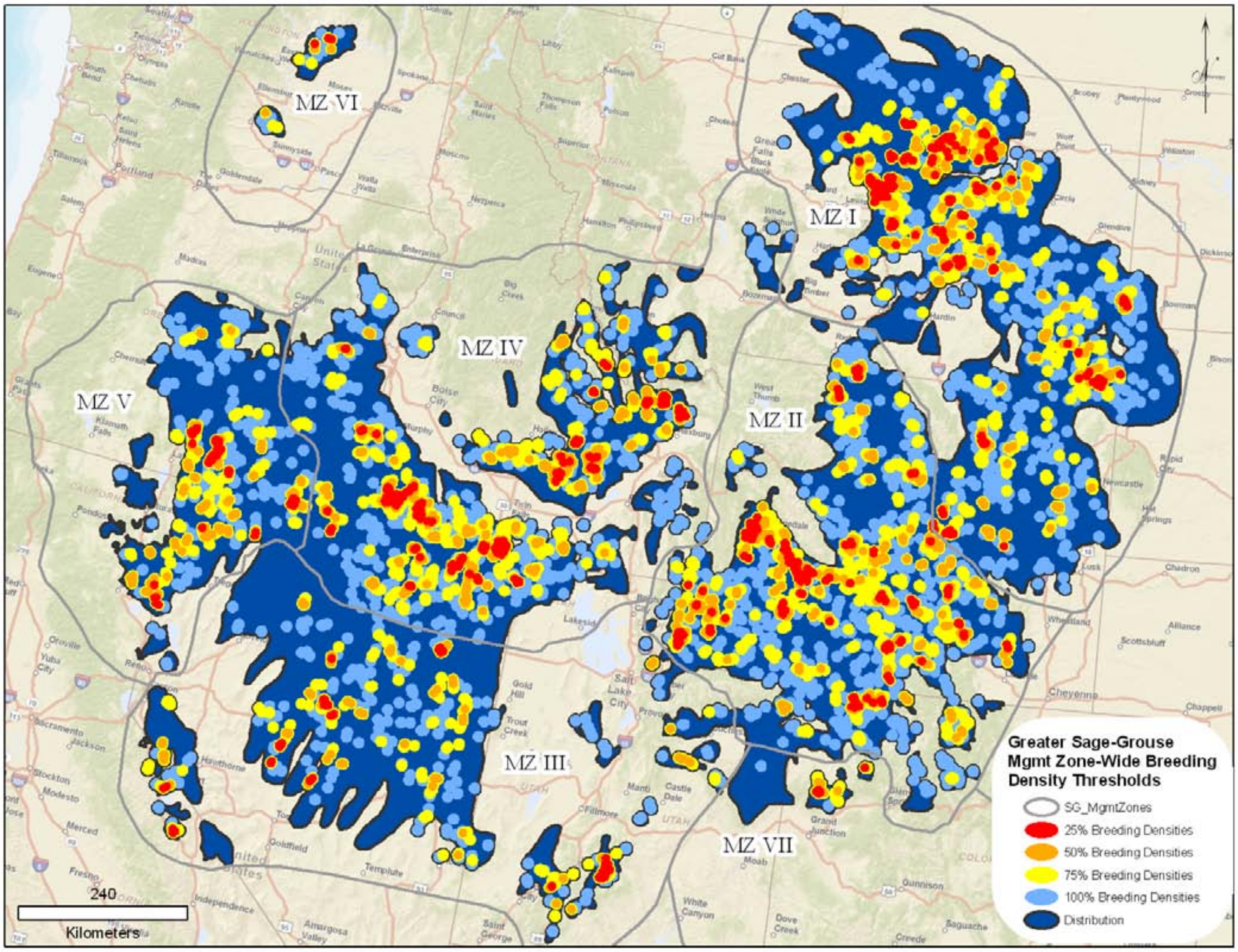

Figure 3. Greater Sage-grouse state wide breeding density areas represent spatial locations of 25%, 50%, 75%, and 100% of the known breeding population, differentiated by color within each of the 13 state and provinces. For example, to obtain 25% of the breeding population in WY all red areas within the WY boundary need to be added together.

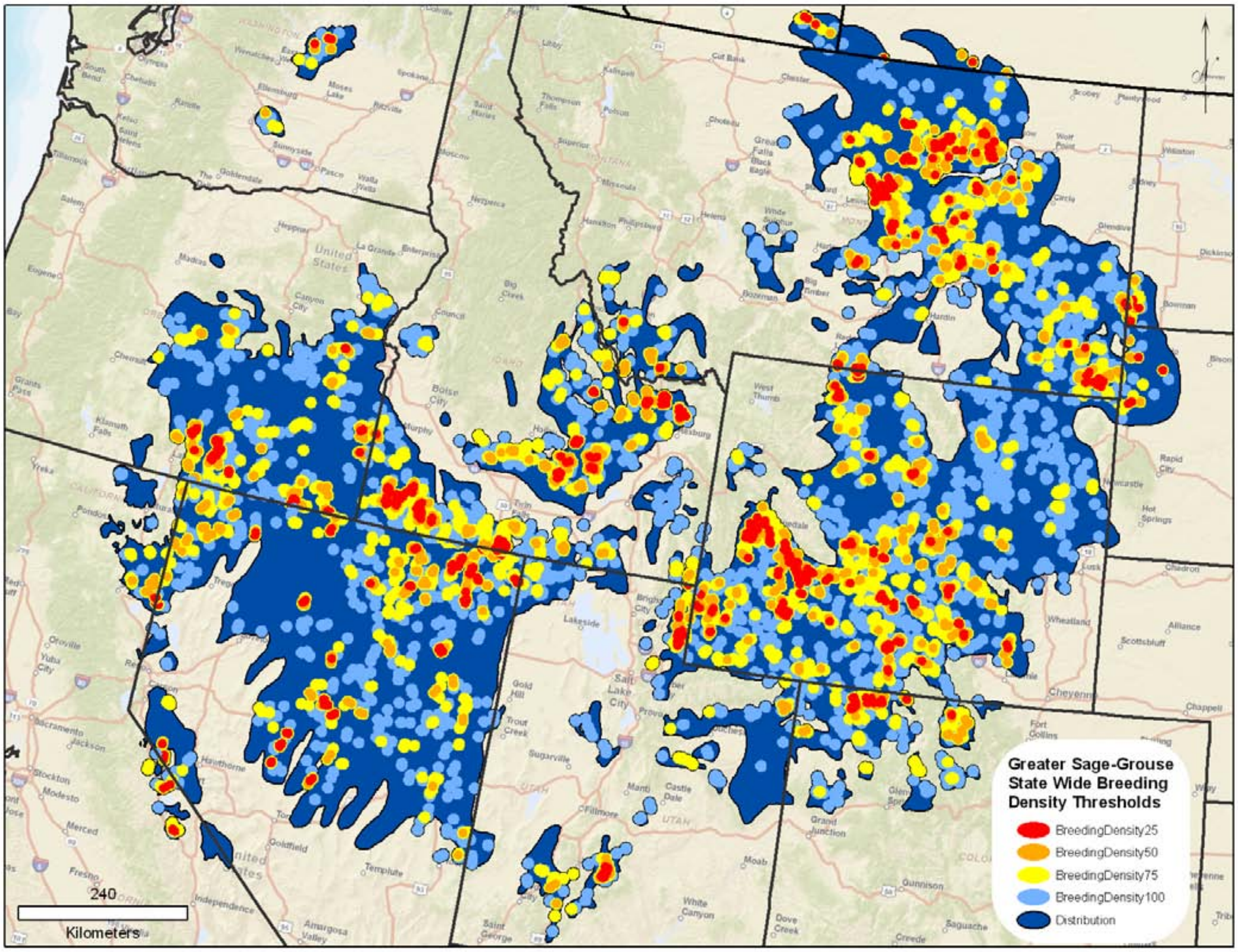

Figure 4. The number of times an individual greater sage-grouse lek was counted at least once within a year during 2000-2009. Leks that were surveyed in the 1-3 year category of the 10 year interval are a result of low effort as well as new leks being found.

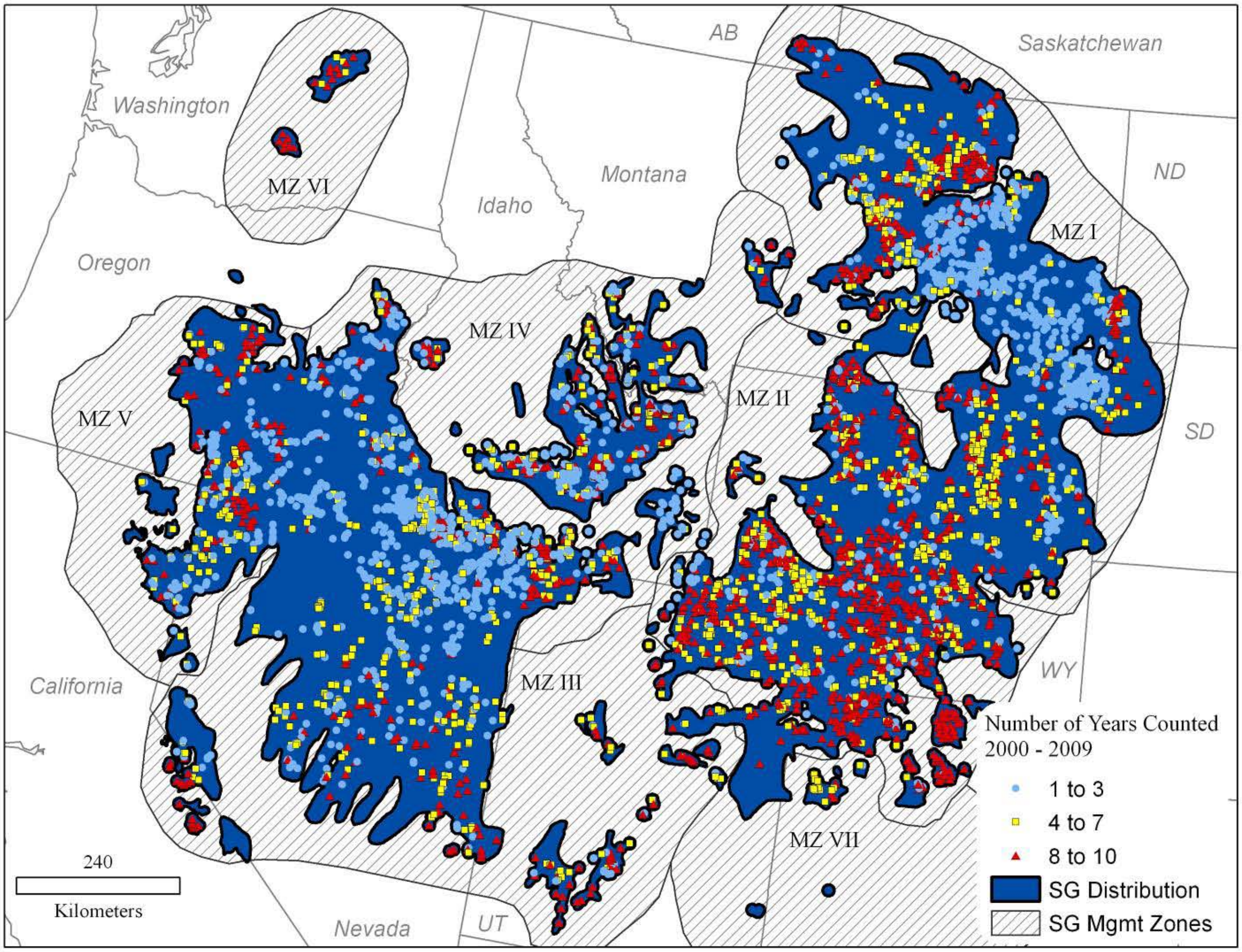

Table 1. Number of leks, average male count (SE), and proportion of the known male population within states and provinces and Sage-grouse Management Zones.

Boundary		# leks	Mean Count (SE)	% Abundance
State and Province				
	Alberta	10	6.60 (1.01)	0.07%
	California	71	17.89 (2.20)	1.37%
	Colorado	207	17.35 (1.30)	3.86%
	Idaho	888	14.66 (0.51)	14.00%
	Montana	992	16.90 (0.49)	18.03%
	North Dakota	22	4.45 (0.69)	0.11%
	Nevada	740	17.43 (0.63)	13.87%
	Oregon	446	13.15 (0.62)	6.31%
	Saskatchewan	6	8.33 (4.24)	0.05%
	South Dakota	20	12.90 (1.65)	0.28%
	Utah	219	18.50 (1.55)	4.36%
	Washington	20	15.55 (2.75)	0.33%
	Wyoming	1244	27.92 (0.82)	37.35%
Management Zone				
	MGMT Z I	1216	15.56 (0.43)	20.35%
	MGMT Z II	1280	29.24 (0.82)	40.25%
	MGMT Z III	457	17.46 (0.84)	8.58%
	MGMT Z IV	1450	14.82 (0.41)	23.11%
	MGMT Z V	435	15.41 (0.69)	7.21%
	MGMT Z VI	20	15.55 (2.75)	0.33%
	MGMT Z VII	27	5.41 (1.16)	0.16%
Rangewide		4885	19.03 (0.30)	100.00%

Table 2. Amount of land area (ha) within 25%, 50%, 75%, and 100% breeding density thresholds within states and provinces and Sage-grouse Management Zones.

	Breeding Density Thresholds (ha)			
Analysis Boundary	25%	50%	75%	100%
State and Province				
AB	32,335	45,137	101,106	168,386
CA	60,702	135,404	414,750	613,918
CO	125,311	282,727	834,916	1,686,170
ID	528,580	1,178,930	3,058,892	5,347,199
MT	904,288	1,966,832	4,726,058	8,603,973
ND	45,214	79,766	171,429	222,870
NV	525,231	1,294,339	3,611,726	7,224,180
OR	227,821	636,047	1,854,179	3,659,214
SK	25,605	51,210	90,329	114,557
SD	45,449	84,848	205,983	335,790
UT	124,679	282,064	861,680	2,228,366
WA	31,527	65,902	186,250	299,143
WY	946,614	2,264,616	5,653,089	11,451,846
Management Zone				
Zone I	1,076,313	2,361,651	5,744,151	11,046,051
Zone II	957,429	2,293,856	5,807,527	11,017,441
Zone III	267,880	778,981	2,392,889	5,109,536
Zone IV	814,839	2,003,357	5,162,853	9,833,337
Zone V	245,677	750,211	1,940,752	3,708,162
Zone VI	31,527	65,902	186,250	299,143
Zone VII	35,693	72,663	172,144	211,754
Range-wide	2,919,166	7,578,205	20,363,261	41,181,031

*Total areas for respective boundaries; i.e., MT 100% contains parts of AB, ND, SD, WY.

**Full occupied range (Schroeder et al. 2004) 75,508,760

Table 3. Land area (ha) within 25%, 50%, 75%, and 100% breeding density areas for greater sage-grouse.

		Land Area (ha) within Range-wide Breeding Density Maps							
		25%		50%		75%		100%	
State and Provinicial Level	AB	0	0.00%	0	0.00%	0	0.00%	159,240	0.39%
	CA	46,508	1.59%	103,395	1.36%	339,651	1.67%	572,823	1.39%
	CO	143,075	4.90%	293,467	3.87%	809,258	3.97%	1,623,918	3.94%
	ID	496,801	17.02%	1,259,136	16.62%	3,078,592	15.12%	5,204,763	12.64%
	MT	279,231	9.57%	1,230,351	16.24%	4,006,235	19.67%	8,454,463	20.53%
	ND	0	0.00%	9,086	0.12%	19,475	0.10%	169,886	0.41%
	NV	328,127	11.24%	850,157	11.22%	3,122,188	15.33%	7,080,915	17.19%
	OR	151,837	5.20%	426,606	5.63%	1,306,449	6.42%	3,604,370	8.75%
	SD	0	0.00%	0	0.00%	9,292	0.05%	355,073	0.86%
	SK	0	0.00%	0	0.00%	0	0.00%	97,247	0.24%
	UT	166,389	5.70%	382,325	5.05%	766,522	3.76%	2,135,641	5.19%
	WA	0	0.00%	0	0.00%	53,113	0.26%	299,143	0.73%
	WY	1,307,198	44.78%	3,023,683	39.90%	6,852,486	33.65%	11,424,453	27.74%
Management Zone Level	Zone I	297,556	10.19%	1,289,545	17.02%	4,504,097	22.12%	11,035,836	26.80%
	Zone II	1,538,960	52.72%	3,407,841	44.97%	7,290,552	35.80%	10,998,424	26.71%
	Zone III	217,506	7.45%	482,221	6.36%	1,824,505	8.96%	5,126,412	12.45%
	Zone IV	691,460	23.69%	1,949,156	25.72%	4,911,130	24.12%	9,801,297	23.80%
	Zone V	173,684	5.95%	449,443	5.93%	1,726,019	8.48%	3,700,282	8.99%
	Zone VI	0	0.00%	0	0.00%	53,113	0.26%	299,143	0.73%
	Zone VII	0	0.00%	0	0.00%	53,845	0.26%	219,637	0.53%

Table 4. Variation in survey effort for leks used in breeding density analysis, 2000 – 2009. Because of variation in survey effort we used the maximum count for the most recent survey. Numbers correspond to the number of leks by bi-yearly interval in which the maximum count was obtained. The proportion of leks counted during the 2008-2009 period was lower in states with larger numbers of leks to survey with the exception of Wyoming which had 95.3% of all leks surveyed within the last 2 years.

Analysis Boundary		2000-2001		2002-2003		2004-2005		2006-2007		2008-2009	
State and Province	AB	0	0.00%	0	0.00%	0	0.00%	0	0.00%	10	100.00%
	CA	4	5.63%	10	14.08%	8	11.27%	12	16.90%	37	52.11%
	CO	2	0.97%	0	0.00%	3	1.45%	9	4.35%	193	93.24%
	ID	69	7.77%	70	7.88%	63	7.09%	118	13.29%	568	63.96%
	MT	92	9.27%	110	11.09%	88	8.87%	179	18.04%	523	52.72%
	ND	0	0.00%	0	0.00%	0	0.00%	5	22.73%	17	77.27%
	NV	34	4.59%	71	9.59%	52	7.03%	355	47.97%	228	30.81%
	OR	6	1.35%	27	6.05%	77	17.26%	59	13.23%	277	62.11%
	SD	0	0.00%	0	0.00%	0	0.00%	0	0.00%	20	100.00%
	SK	0	0.00%	0	0.00%	0	0.00%	1	16.67%	5	83.33%
	UT	1	0.46%	1	0.46%	3	1.37%	3	1.37%	211	96.35%
	WA	0	0.00%	0	0.00%	0	0.00%	0	0.00%	20	100.00%
	WY	1	0.08%	4	0.32%	10	0.80%	44	3.54%	1,185	95.26%
Management Zone	Zone I	92	7.57%	109	8.96%	83	6.83%	175	14.39%	757	62.25%
	Zone II	14	1.09%	3	0.23%	12	0.94%	59	4.61%	1192	93.13%
	Zone III	18	3.94%	32	7.00%	26	5.69%	194	42.45%	187	40.92%
	Zone IV	73	5.03%	118	8.14%	119	8.21%	287	19.79%	853	58.83%
	Zone V	12	2.76%	31	7.13%	63	14.48%	69	15.86%	260	59.77%
	Zone VI	0	0.00%	0	0.00%	0	0.00%	0	0.00%	20	100.00%
	Zone VII	0	0.00%	0	0.00%	1	3.70%	1	3.70%	25	92.59%
Range-wide		209	4.28%	293	6.00%	304	6.22%	785	16.07%	3,294	67.43%

Table 5. Federal, state, and private surface ownership within the sage-grouse range (ha) and within 75% breeding density threshold areas (Canada excluded).

	Range-wide		75% Breeding Density Areas	
	% Ownership	Distribution	% Ownership	Distribution
Federal Lands				
BLM	45.32%	33,562,372	52.48%	10,639,221
USFS	6.50%	4,811,787	4.03%	817,844
BIA	2.27%	1,677,396	1.45%	294,775
USFWS	0.99%	731,505	1.60%	323,584
DOE	0.31%	231,747	0.41%	82,181
DOD	0.22%	165,828	0.00%	428
NPS	0.21%	153,808	0.18%	36,487
Private Lands	39.12%	28,970,565	33.98%	6,888,203
State Lands	5.00%	3,701,220	5.59%	1,132,867

Table 6. Federal, state, and private surface ownership (%) by U.S. state and within 75% breeding density threshold areas.

	Surface Ownership (%)				
	BLM	USFS	Other Federal	Private Lands	State Lands
CA	73.17	9.59	0	14.69	2.55
NV	69.69	11.21	4.03	15.06	0.01
OR	67.51	1.43	6.74	20.76	3.56
ID	63.62	6.83	4.25	19.95	5.35
WY	54.92	1.26	2.74	34.29	6.78
CO	35.91	1.79	1.46	50.83	10.01
UT	35.76	10.20	2.80	39.83	11.42
MT	27.13	0.67	5.47	59.48	6.93
ND	20.19	17.54	0	57.99	4.27
SD	1.44	0	0	98.56	0
WA	0.65	0	0	86.88	12.48

Appendix 1. Meta-data Summary for Shape Files and Coverage Attributes for GIS users.

Range-wide and management zone breeding density area geodatabases are available for download:

Main Page: http://conserveonline.org/workspaces/sagegrouse

Documents: http://conserveonline.org/workspaces/sagegrouse/documents/all.html

Requests for Information on lek locations need to be made to State or Provincial Fish and Wildlife Agencies who retained ownership rights to that data. Due to the proprietary nature of the State Fish & Wildlife agencies data, information on sage-grouse lek locations did not become the property of the BLM or the FWS, nor were lek data used or stored on BLM or FWS computers for this analysis.

To promote direct communication with State Agencies we are not hosting state level GIS Files but have given each state or province a copy of their respective state layers. **We again urge users to contact and develop a working relationship within each state!**

Range-wide Breeding Densities

Metadata also available embedded in Geodatabases

Identification_Information:
Citation:
Citation_Information:
Originator: The Nature Conservancy
Publication_Date: 8/30/2010
Title: Range-wide Breeding Densities
Geospatial_Data_Presentation_Form: vector digital data
*Online_Linkage:*http://conserveonline.org/workspaces/sagegrouse/documents/all.html
Description:
Abstract:
ESRI file geodatabase of greater sage-grouse (Centrocercus urophasianus) range-wide breeding densities at 25% (BreedingDensity25), 50% (BreedingDensity50), 75% (BreedingDensity75) and 100% (BreedingDensity100) of breeding population. The objective of this BLM project is to map high breeding densities of greater sage-grouse for use in conservation planning. This completion report provides two deliverables: 1) The analytical framework for evaluating options on where partners can deliver actions that will yield the highest return on their conservation investment, and 2) The GIS shapefiles delineating high breeding densities of sage-grouse for use by conservation planners. Maps developed here provide a large-scale view of the distribution and abundance of sage-grouse, but risks and opportunities vary widely. State game and fish agencies responsible for sage-grouse conservation and management can provide additional knowledge of sage-grouse habitat needs. We encourage federal agencies and other partners to consult with their respective state wildlife agencies before implementing sage-grouse conservation actions.
Purpose:
A major goal in greater sage-grouse (*Centrocercus urophasianus*, hereafter 'sage-grouse') conservation is to spend limited resources conserving large and functioning populations efficiently. We used lek-count data (n = 4,885) to delineate high abundance population centers that contain 25, 50, 75, and 100% of the known breeding population for use in conservation planning. Findings show sage-grouse breeding abundance is highly clumped from range-wide to province and state-wide analysis scales. Breeding density areas contain 25% of the known population within 3.9% (2.92 million ha) of the species range, and 75% of birds are within 27.0% of the species range (20.4 million ha). We adopted a spatial organizational framework based on Western Association of Fish and Wildlife Agencies (WAFWA) Management Zones (Connelly et al 2004, Stiver et al. 2006) which are delineated by floristic provinces and used to group sage-grouse populations for management actions. Breeding bird abundance varies by Sage-grouse Management Zones, with Zones I, II, and IV containing 83.7% of all known sage-grouse. Zone II contains a particularly high density of birds which includes 40% of the known population and at least half of the highest density breeding areas range-wide. Despite high bird abundance in Zones I, II, and IV, maintaining current distribution of sage-grouse depends upon effective conservation in each U.S. state and Canadian province. For example, each of the 11 states

containing sage-grouse have enough breeding birds across multiple landscapes to meet the 75% breeding density threshold. Federal, state and private lands all play a role in sage-grouse conservation. On average, surface ownership within 75% breeding areas was 60.15% Federal, 33.98% privately owned, and 5.59% State lands. Diversity in surface and subsurface (e.g., mineral rights) ownership within states and provinces will play a major role in the approach used to maintain and enhance priority populations. Maps developed here provide a vision for decision makers to spatially prioritize conservation targets, but risks and opportunities vary dramatically in each state and province. More importantly, state and provincial game and fish agencies have insights into seasonal habitat usage and local ecology making state and federal cooperation and communication imperative before the implementing of sage-grouse conservation actions. Users are also encouraged to contact their state game and fish agencies for similar state developed planning maps.

Time_Period_of_Content:
Time_Period_Information:
Multiple_Dates/Times:
Single_Date/Time:
Calendar_Date: 2000
Single_Date/Time:
Calendar_Date: 2010
Currentness_Reference: 8/30/2010
Status:
Progress: Complete
Maintenance_and_Update_Frequency: As needed
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -123.521047
East_Bounding_Coordinate: -102.404589
North_Bounding_Coordinate: 50.029961
South_Bounding_Coordinate: 36.159012
Keywords:
Theme:
Theme_Keyword: Sage grouse, breeding densities
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dr. Dave Naugle
Contact_Organization: University of Montana , College of Forestry and Conservation
Contact_Position: Associate Professor
Contact_Voice_Telephone: 406-243-5364
Contact_Electronic_Mail_Address: david.naugle@umontana.edu
Data_Set_Credit:
Jeffrey S. Evans, Senior Landscape Ecologist Then Nature Conservancy, Central Science Laramie, Wy 82070
Native_Data_Set_Environment:
Microsoft Windows Vista Version 6.1 (Build 7600) ; ESRI ArcCatalog 9.3.1.3000

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: G-polygon
Point_and_Vector_Object_Count: 241

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Map_Projection:
Map_Projection_Name: Albers Conical Equal Area
Albers_Conical_Equal_Area:
Standard_Parallel: 29.500000
Standard_Parallel: 45.500000
Longitude_of_Central_Meridian: -96.000000
Latitude_of_Projection_Origin: 23.000000
False_Easting: 0.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: coordinate pair
Coordinate_Representation:
Abscissa_Resolution: 0.000100
Ordinate_Resolution: 0.000100
Planar_Distance_Units: meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983

Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222

Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: Range-wide breeding Densities
Attribute:
Attribute_Label: OBJECTID
Attribute_Definition: Internal feature number.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain:
Sequential unique whole numbers that are automatically generated.
Attribute:
Attribute_Label: Shape
Attribute_Definition: Feature geometry.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Coordinates defining the features.
Attribute:
Attribute_Label: Acres
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Acres if polygon
Attribute:
Attribute_Label: Hectares
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Hectares of polygon
Attribute:
Attribute_Label: PopDen
Attribute:
Attribute_Label: Shape_Length
Attribute_Definition: Length of feature in internal units.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Positive real numbers that are automatically generated.
Attribute:
Attribute_Label: Shape_Area
Attribute_Definition: Area of feature in internal units squared.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Positive real numbers that are automatically generated.

Distribution_Information:
Resource_Description: Downloadable Data

Metadata_Reference_Information:
Metadata_Date: 20100830
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: The Nature Conservancy
Contact_Person: Jeffrey S. Evans
Contact_Position: Senior Landscape Ecologist
Contact_Address:
Address_Type:
REQUIRED: The mailing and/or physical address for the organization or individual.
City: REQUIRED: The city of the address.
State_or_Province: REQUIRED: The state or province of the address.
Postal_Code: REQUIRED: The ZIP or other postal code of the address.
Contact_Voice_Telephone: 970-672-6766
Contact_Electronic_Mail_Address: jeffrey_evans@tnc.org
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>

Profile_Name: ESRI Metadata Profile

Generated by mp version 2.9.6 on Mon Aug 30 13:25:14 2010