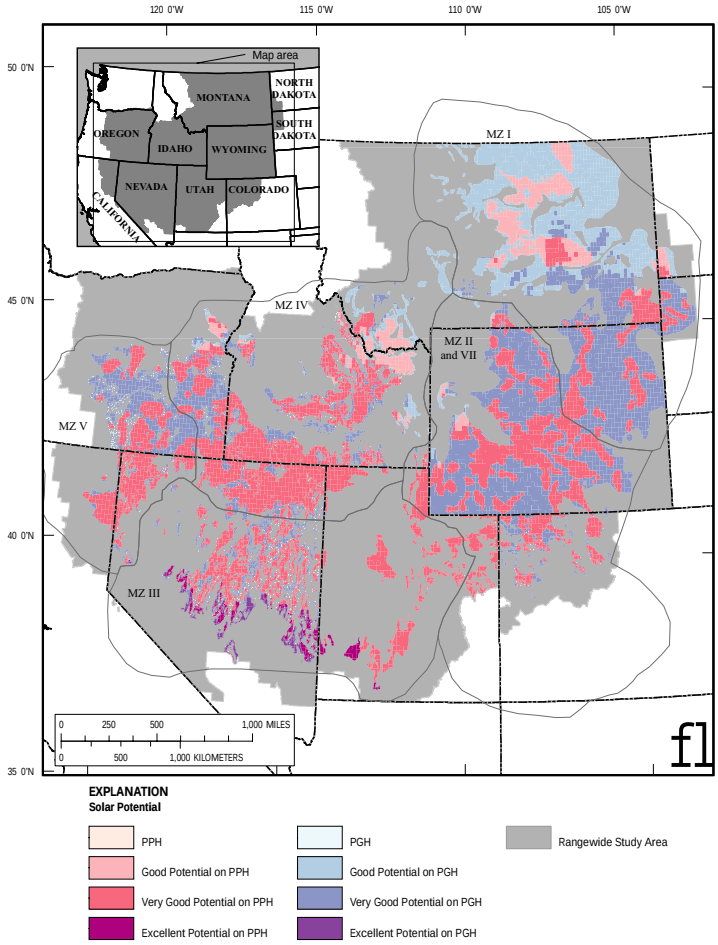

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Figure 20. Summary of the distribution of solar power potential within sage-grouse habitats (PPH and PGH) by Management Zone.

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The primary environmental concerns associated with solar power generation include the large land area required for solar facilities and water consumption. Concentrating solar power systems generally require 5 to 10 acres (2 ha – 4ha) to produce 1 MW, and photovoltaic systems require around 10 acres (4 ha) per MW. Additional impacts will include access roads and transmission lines. Although solar developments themselves are not similar to the infrastructure of energy developments discussed above, impacts to sage-grouse from direct habitat loss, habitat fragmentation via roads and transmission lines, noise, and increased human presence (Connelly et al. 2004) may be similar to those discussed for non-renewable energy development. The information presented in this section as well as a detailed discussion of the technology required for generation of solar-based electricity can be found in the Draft Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States (DES 10-59, DOE/EIS-0403; solareis.anl.gov).

Geothermal

According to the Geothermal Energy Association (geo-energy.org), geothermal energy is defined as heat from the Earth; heat continuously flowing from the Earth's interior is estimated to be equivalent to 42 million megawatts (MW) of power. Geothermal energy production within the range of sage-grouse is primarily within the Southern and Northern Great Basins MZs. As of 2011, approximately 2,000 km^2 (494,200 acres) of sagebrush habitat has been leased for this purpose and an additional 1,140 km^2 (281,700 acres) are pending (Knick et al. 2011). The only type of geothermal energy that has been widely developed is hydrothermal energy, which consists of trapped hot water or steam. However, new technologies are being developed to exploit hot dry rock (accessed by drilling deep into rock), geopressured resources (pressurized brine mixed with methane), and magma (Union of Concerned Scientists; *www.ucsusa.org*) making these developments a consideration of the near future.

Impacts to sage-grouse associated with geothermal energy development have not been assessed because the development has been too recent to identify any immediate or lag effects (Knick et al. 2011), but geothermal power plants are similar to fossil fuel-fired power plants in that resources are exploited in a highly centralized fashion, thus surface impacts could include the footprint of the power plant itself, access roads, and transmission lines. Extraction of geothermal fluids (gasses, steam, and water) for power generation generally requires many of the same infrastructure features for construction and operation as do traditional non-renewable energy resources. As such, impacts of geothermal developments to sage-grouse from direct habitat loss, habitat fragmentation via roads and transmission lines, noise, and increased human presence (Connelly et al. 2004) may be similar to those discussed for non-renewable energy development, with comparable effects on local sage-grouse populations also anticipated.

Although geothermal development occurs throughout MZs III, IV and V, the direct footprint is relatively small with approximately 244,200 acres (0.41%) of sage-grouse habitat directly impacted by geothermal development in these MZs (Table 15, Figure 21). Geothermal developments are widespread in priority habitats in western portions of MZ III in particular. No geothermal development currently occurs in MZs I and II. However, there is potential for geothermal development in a majority of priority and general habitats throughout the range of sage-grouse, and potential development exists for all sage-grouse habitats in MZs IV and V and the Nevada portions of MZ III (Figure 21). Indirect effects of geothermal development were assessed at 19 km (11.8 mi), based on influences estimated for similar infrastructure, suggesting that industrial-scale facilities could influence approximately 16.8% of priority sage-grouse habitats across MZs III, IV and V, if fully developed (however this is currently unlikely). BLM lands account for approximately 72% of priority habitats potentially influenced by geothermal development; therefore, accounting for these facilities may be important for future assessments.

Table 15. The distribution of geothermal leases and facilities across sage-grouse habitats (PPH and PGH) by Management Zone.

	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	19km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	19km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
MZ I - GP	11,636,400	0	0	0.00	0.00	34,663,000	0	0	0.00	0.00
MZ II and VII - WB & CP	17,476,000	0	0	0.00	0.00	19,200,200	0	0	0.00	0.00
MZ III - SGB	10,028,500	72,900	3,312,600	0.73	33.03	3,970,100	52,700	1,722,000	1.33	43.37
BLM	6,309,400	72,600	2,681,400	1.15	42.50	3,199,800	52,100	1,394,000	1.63	43.57
Forest Service	1,236,200	0	351,700	0.00	28.45	356,200	0	176,900	0.00	49.66
Tribal and Other Federal	260,800	0	2,600	0.00	1.00	29,100	0	1,700	0.00	5.84
Private	1,836,200	200	259,300	0.01	14.12	384,800	600	149,300	0.16	38.80
State	385,900	0	17,700	0.00	4.59	200	0	100	0.00	50.00
MZ IV - SRP	21,930,600	58,000	2,579,700	0.26	11.76	10,958,500	17,900	1,286,000	0.16	11.74
BLM	13,710,700	56,400	1,534,400	0.41	11.19	4,928,200	16,600	582,300	0.34	11.82
Forest Service	1,613,800	0	128,800	0.00	7.98	1,113,500	0	88,900	0.00	7.98
Tribal and Other Federal	633,600	0	0	0.00	0.00	522,500	100	10,600	0.02	2.03
Private	4,890,200	1,400	854,400	0.03	17.47	3,516,742	1,300	518,900	0.04	14.76
State	1,019,373	100	61,700	0.01	6.05	846,200	0	84,800	0.00	10.02
Other	62,900	0	400	0.00	0.64	31,400	0	500	0.00	1.59
MZ V - NGB	7,097,200	10,900	651,300	0.15	9.18	5,808,000	31,800	841,800	0.55	14.49
BLM	5,117,500	10,600	489,100	0.21	9.56	4,196,700	31,200	672,300	0.74	16.02
Forest Service	62,200	0	0	0.00	0.00	114,900	0	33,100	0.00	28.81
Tribal and Other Federal	717,100	0	86,100	0.00	12.01	101,800	0	15,800	0.00	15.52
Private	798,000	300	43,800	0.04	5.49	1,199,000	600	104,400	0.05	8.71
State	64,900	0	16,600	0.00	25.58	115,800	0	6,900	0.00	5.96
Other	337,500	0	15,700	0.00	4.65	79,800	0	9,400	0.00	11.78

[*] Data Source: Aggregated from individual BLM State Office Submissions in 2011 and 2012

[1] Indirect influence distance derived from area of identified demographic impact for similar development (Johnson et al. 2011 and Taylor et al. 2012).

[2] For each MZ, calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within a management zone, these were calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.

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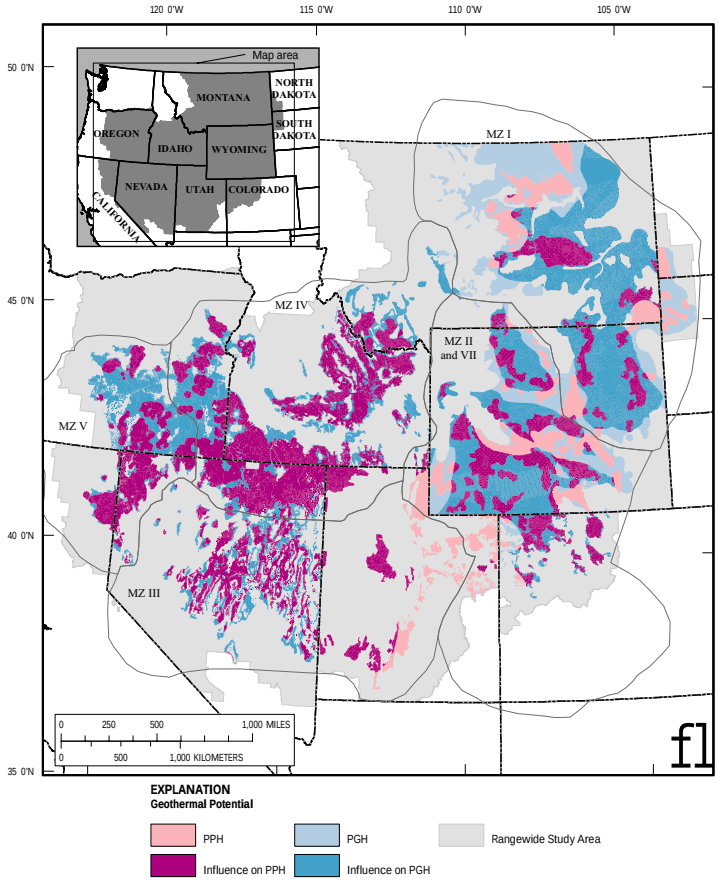

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Figure 21. Overlap of geothermal potential with sage-grouse habitats (PPH and PGH) by Management Zone.

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Air and water pollution, disposal of hazardous waste, siting, and land subsidence are environmental concerns related to geothermal electricity generation; however many of the air and water concerns are eliminated in closed-loop systems (Union of Concerned Scientists **year?**). In addition to these impacts, geothermal energy extraction may cause the release of toxic gasses (carbon dioxide and hydrogen sulfide) and elements (arsenic) into the environment. The type and effect of these substances depends on the geological formation from which energy is being extracted. Large quantities of water may also be required for drilling and condenser cooling (Suter Ii 1978), and if the water used for these purposes depletes the water resources of the surrounding habitat, riparian and brood-rearing habitats may be affected by water table changes. On site water storage may increase potential WNv (West Nile Virus) exposure in the area (Friend 2001, Zou 2006, Walker et al. 2007a, Walker and Naugle 2011).

The only type of geothermal energy that has been widely developed is hydrothermal energy, which consists of trapped hot water or steam. However, new technologies are being developed to exploit hot dry rock (accessed by drilling deep into rock), geopressured resources (pressurized brine mixed with methane), and magma (Union of Concerned Scientists; *www.ucsusa.org*) making these developments a consideration of the near future, making direct and indirect effects on sage-grouse anticipated and logical, but speculative.

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Mining

Besides oil and natural gas development, the major mining activity within sage-grouse habitats has been for coal (Braun 1998b). Coal mines are widespread, but discretely located in sage-grouse habitats throughout MZ I and southern portions of MZ II and VII, and federal leases developed through surface extraction influence approximately 376,500 acres (1520 km^2; 0.45%) of these MZs (Table 16, Figure 22). Additionally, there is potential for coal mining in large portions of priority and general habitats in MZs I and II and VII (Figure 23). Indirect effects of surface coal mines with federal leases

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were assessed using a 19km (11.8 mile) effects buffer based on observations of industrial infrastructure effects on sage-grouse, which suggests influence over approximately 5.9% of priority sage-grouse habitats across the range of the species, and approximately 11.8% of priority habitats in MZs I and II and VII. BLM lands account for approximately 37% of priority habitats across the range of the species indirectly influenced by coal mines. According to the World Coal Association (*www.worldcoal.org*), coal is mined by two methods: surface mining or underground mining; mining method largely determined by the geology of the coal deposit. Surface mining accounts for about 67% of production in the U.S. Coal mining and the use of coal to produce electricity raises a number of environmental challenges including: soil erosion, dust, noise and water pollution, impacts on local biodiversity, acid mine drainage, and primarily air emissions. Burning coal releases oxides (especially of sulfur [SO_x] and nitrogen [NO_x]), trace elements (e.g., mercury) and particulates. Acid mine drainage is metal-rich water formed from the chemical reaction between water and rocks containing sulfur-bearing minerals. Large opencast mines can cover an area of many square kilometers.

The magnitude of the impacts of mining activities on sage-grouse and sagebrush habitats is largely unknown (Braun 1998b), but mining of various federal mineral resources currently directly affects approximately 3.5% of potential sage-grouse habitat with indirect effects potentially affecting large portions of some MZs (Table 17; Figure 23). Development of surface mines and associated infrastructure (e.g., roads and power lines), noise and human activity may negatively impact sage-grouse numbers in the short term (Braun 1998b), and a variety of mineral claims could result in industrial activities that would disrupt the habitat and life-cycle of sage-grouse (Figure24). The number of displaying sage-grouse on 2 leks within 2 km (1.25 mi) of active mines in northern Colorado declined by approximately 94% over a 5-year period following an increase in mining activity (Remington and Braun 1991). However, Braun (1998) reported recovery of populations in Montana, Wyoming and

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Colorado may occur after initial development and subsequent reclamation of mine sites, although populations do not recover to pre-development sizes. Additionally, population re-establishment may take upwards of 30 years (Braun 1998).

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1 Table 16. The distribution of federal managed coal and surface mining development across sage-grouse habitats (PPH and PGH) by Management Zone.*

Management Zone Entity	PPH					PGH				
	SG Habitat (acres)	Direct Footprint (acres)	19km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	19km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
MZ I - GP	11,636,400	67,600	2,118,400	0.58	18.20%	34,663,000	256,800	5,892,000	0.74	17.00
BLM	2,994,300	58,400	769,700	1.95	36	4,524,900	19,300	627,400	0.43	11
Forest Service	292,400	400	117,300	0.14	6	515,300	38,100	278,500	7.39	5
Tribal and Other Federal	219,700	0	20,000	0.00	1	2,427,700	0	60,600	0.00	1
Private	7,132,500	8,700	1,077,800	0.12	51	24,682,800	195,800	4,551,800	0.79	77
State	995,600	0	133,400	0.00	6	2,498,400	3,500	368,700	0.14	6
Other	1,900	0	100	0.00	0	13,900	0	5,000	0.00	0
MZ II and VII - WB & CP	17,476,000	16,400	1,325,000	0.09	7.58	19,200,200	35,700	1,873,200	0.19	9.76
BLM	9,021,200	12,200	567,300	0.14	43	9,012,500	28,100	706,600	0.31	38
Forest Service	162,000	0	0	0.00	0	452,500	0	1,400	0.00	0
Tribal and Other Federal	784,000	2,400	31,000	0.31	2	1,354,600	0	5,700	0.00	0
Private	6,233,900	1,200	663,200	0.02	50	7,394,800	7,500	1,074,400	0.10	57
State	1,244,800	600	63,100	0.05	5	979,800	100	85,000	0.01	5
Other	30,100	0	300	0.00	0	6,000	0	100	0.00	0
MZ III - SGB	10,028,500	1,500	63,300	0.01	0.63	3,970,100	0	0	0.00	0.00
BLM	6,309,400	1,100	22,900	0.02	36	3,199,800	0	0	0.00	0
Forest Service	1,236,200	0	400	0.00	1	356,200	0	0	0.00	0
Tribal and Other Federal	260,800	0	0	0.00	0	29,100	0	0	0.00	0
Private	1,836,200	400	30,800	0.02	49	384,800	0	0	0.00	0
State	385,900	0	9,300	0.00	15	200	0	0	0.00	0
MZ IV - SRP	21,930,600	400	501,100	0.00	2.28	10,958,500	1,200	392,500	0.01	3.58
BLM	13,710,700	0	103,000	0.00	21	4,928,200	600	71,400	0.01	18
Forest Service	1,613,800	400	81,600	0.02	16	1,113,500	600	110,800	0.05	28
Tribal and Other Federal	633,600	0	38,300	0.00	8	522,500	0	400	0.00	0
Private	4,890,200	0	131,200	0.00	26	3,516,742	0	160,000	0.00	41
State	1,019,373	0	147,000	0.00	29	846,200	0	50,000	0.00	13

Management Zone Entity	PPH SG Habitat (acres)	PPH Direct Footprint (acres)	PPH 19km Indirect Influence[1] (acres)	PPH Direct Footprint (%)	PPH Relative Influence[2] (%)	PGH SG Habitat (acres)	PGH Direct Footprint (acres)	PGH 19km Indirect Influence[1] (acres)	PGH Direct Footprint (%)	PGH Relative Influence[2] (%)
Other	62,900	0	0	0.00	0	31,400	0	0	0.00	0
MZ V - NGB	7,097,200	0	0	0.00	0.00	5,808,000	0	0	0.00%	0.00

[*] Data Source: Aggregated from individual BLM State Office Submissions in 2011 and 2012. Direct and indirect impacts are calculated for the surface management entity, however, subsurface mineral rights may be severed from surface rights.

[1] Indirect influence distance derived from area of identified demographic impact (Johnson et al. 2011 and Taylor et al. 2012).

[2] For each MZ, calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within each management zone, calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.

Table 17. The distribution of Federal Mineral resources and (including mineral materials disposal sites) mines across sage-grouse habitats (PPH and PGH) by Management Zone.*

	PPH					PGH				
Management Zone Entity	SG Habitat (acres)	Direct Footprint (acres)	2.5km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)	SG Habitat (acres)	Direct Footprint (acres)	2.5km Indirect Influence[1] (acres)	Direct Footprint (%)	Relative Influence[2] (%)
MZ I - GP	11,636,400	122,900	687,600	1.06	5.91	34,663,000	504,000	1,994,800	1.45	5.75
BLM	2,994,300	65,000	261,000	2.17	38	4,524,900	64,500	226,200	1.43	11
Forest Service	292,400	0	300	0.00	0	515,300	1,200	17,300	0.23	1
Tribal and Other Federal	219,700	0	1,100	0.00	0	2,427,700	0	800	0.00	0
Private	7,132,500	49,000	364,100	0.69	53	24,682,800	430,500	1,602,700	1.74	80
State	995,600	8,900	61,100	0.89	9	2,498,400	7,800	147,800	0.31	7
Other	1,900	0	0	0.00	0	13,900	0	0	0.00	0
MZ II and VII - WB & CP	17,476,000	582,100	2,947,200	3.33	16.86	19,200,200	445,400	2,178,000	2.32	11.34
BLM	9,021,200	484,400	1,922,400	5.37	65	9,012,500	362,200	1,301,500	4.02	60
Forest Service	162,000	2,400	22,900	1.48	1	452,500	700	6,000	0.15	0
Tribal and Other Federal	784,000	0	7,200	0.00	0	1,354,600	2,200	43,200	0.16	2
Private	6,233,900	73,200	754,100	1.17	26	7,394,800	72,500	695,300	0.98	32
State	1,244,800	22,000	238,600	1.77	8	979,800	7,800	132,100	0.80	6
Other	30,100	100	2,000	0.33	0	6,000	0	0	0.00	0
MZ III - SGB	10,028,500	914,800	3,263,900	9.12	32.55	3,970,100	478,800	1,620,700	12.06	40.82
BLM	6,309,400	762,500	2,502,900	12.09	77	3,199,800	377,700	1,285,300	11.80	79
Forest Service	1,236,200	42,400	250,300	3.43	8	356,200	44,200	144,400	12.41	9
Tribal and Other Federal	260,800	100	14,000	0.04	0	29,100	0	6,100	0.00	0
Private	1,836,200	106,400	437,600	5.79	13	384,800	56,900	184,600	14.79	11
State	385,900	3,400	59,100	0.88	2	200	0	200	0.00	0
MZ IV - SRP	21,930,600	719,100	4,321,400	3.28	19.70	10,958,500	330,500	1,872,700	3.02	17.09
BLM	13,710,700	462,100	2,621,200	3.37	61	4,928,200	189,900	900,000	3.85	48
Forest Service	1,613,800	113,700	427,000	7.05	10	1,113,500	56,500	239,900	5.07	13
Tribal and Other Federal	633,600	500	27,900	0.08	1	522,500	400	11,700	0.08	1
Private	4,890,200	139,200	1,116,000	2.85	26	3,516,742	80,200	629,200	2.28	34

Management Zone Entity	PPH SG Habitat (acres)	PPH Direct Footprint (acres)	PPH 2.5km Indirect Influence[1] (acres)	PPH Direct Footprint (%)	PPH Relative Influence[2] (%)	PGH SG Habitat (acres)	PGH Direct Footprint (acres)	PGH 2.5km Indirect Influence[1] (acres)	PGH Direct Footprint (%)	PGH Relative Influence[2] (%)
State	1,019,373	3,600	127,600	0.35	3	846,200	3,400	91,200	0.40	5
Other	62,900	0	1,500	0.00	0	31,400	0	600	0.00	0
MZ V - NGB	7,097,200	74,600	499,400	1.05	7.04	5,808,000	43,200	458,500	0.74	7.89
BLM	5,117,500	70,100	421,100	1.37	84	4,196,700	39,900	345,400	0.95	75
Forest Service	62,200	0	900	0.00	0	114,900	0	800	0.00	0
Tribal and Other Federal	717,100	900	27,100	0.13	5	101,800	300	10,200	0.29	2
Private	798,000	3,500	44,600	0.44	9	1,199,000	3,000	93,600	0.25	20
State	64,900	0	2,600	0.00	1	115,800	100	6,200	0.09	1
Other	337,500	0	3,100	0.00	1	79,800	0	2,300	0.00	1

[*] Data Source: Aggregated from individual BLM State Office Submissions in 2011 and 2012. Direct and indirect impacts are calculated for the surface management entity, however, subsurface mineral rights may be severed from surface rights.

[1] Indirect influence distance derived from estimated spread of exotic plants (Bradley and Mustard 2006).

[2] For each MZ, calculated as the percent of the particular sage-grouse habitat type influenced by the indirect impact of the threat. For management entities within management zones, calculated as the percent of the total indirect impact in the management zone represented by that management entity; i.e. the relative area of indirect influence among management entities.