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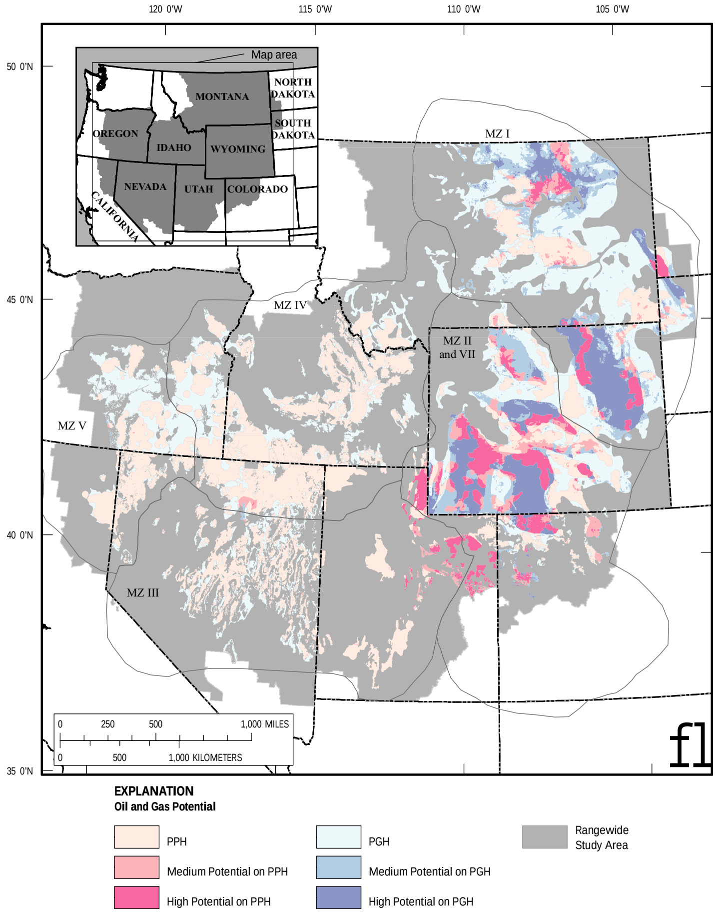

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Figure 16b. Overlap of oil and gas resource exploration and extraction potential with priority (PPH) and general (PGH) sage-grouse habitat designations.

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All 14 studies which assessed impacts of energy development on sage-grouse found negative effects, whereas no studies reported a positive influence of development on populations or habitats (Naugle et al. 2011). Studies consistently reported that breeding populations of sage-grouse were negatively impacted at conventional well pad densities of 4 and 8 well pads/2.6 km^2 (one square mile section), with declines in lek attendance by male sage-grouse ranging from 13 to 79% associated with these well densities (Harju et al. 2010, Naugle et al. 2011). Lek attendance declines have consistently been reported when well pad densities exceed 1 pad/section (2.6 km^2, 1 sq. mile) within approximately 3.2 km (2 mi) of a lek (Naugle et al. 2011). Well pad densities exceeding approximately 0.4 pads/section within 18 km (11 mi) of leks negatively influenced lek trends range-wide (Johnson et al. 2011), and larger leks (>25 males) did not occur in areas where well pad densities exceeded 2.5 pads/section within 12.3 km (7.6 mi) of a lek (Tack 2009). A recent study reported that the probability of lek persistence (i.e., leks remaining active) approached 0% when well pad densities exceeded approximately 6.5 pads/section (Hess and Beck 2012).

A recent summary of studies investigating sage-grouse response to natural gas development reported **that** impacts to leks were most severe when infrastructure occurred near leks and **were** discernible out to distances of 6.2 to 6.4 km (3.8-4 mi, Naugle et al. 2011). However, negative impacts to male counts were observed as far as 12.3 km (7.6 mi) on large leks (>25 males), with additional impacts as far as 18 km (11 mi**;** the largest scale evaluated in literature, Naugle et al. 2011). Stipulations often restricted surface occupancy within 0.4 km (0.25 mile) of a lek during the time of most studies, and leks that had ≥1 pads within this radius had 35 to 92% fewer attending males than did leks with zero wells within this distance (Harju et al. 2010, Naugle et al. 2011). It is worth noting that a 1 km (0.6 mile) restricted surface occupancy buffer is used in many energy fields currently being developed, which may be ineffective as a general pattern was apparent when considering extensively developed

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areas in Wyoming whereby gas and oil infrastructure occurring within smaller radii (≤1.6 to 2 km, 1-1.25 mile) encircling leks was associated with fewer sage-grouse compared to leks at which no infrastructure occurred within these radii (Harju et al. 2010). Additionally, there was a strong negative effect of natural gas development within 0.8 to 3.2 km (0.5-2 mi) on lek persistence in northwestern Wyoming (Walker et al. 2007a). Rates of decline in numbers of males occupying leks increased on leks located relatively centrally within a developing gas field – i.e., producing wells occupying ≥3 directions around leks (Holloran 2005). Peak male attendance (i.e., abundance) at leks experimentally treated with noise from natural gas drilling decreased 29% relative to paired controls (Blickley et al. 2012). Additionally, changes in the number of males occupying leks situated down-wind of drilling rigs were more negative than those witnessed on leks upwind of drilling rigs supporting evidence that increased noise intensity negatively influence male lek attendance (Holloran 2005). A time lag – or a delay between activity associated with energy development and its measurable effects on lek attendance – of 3 to 4 years between the time infrastructure is placed and lek abandonment has been consistently documented (Naugle et al. 2011) making short-term observations potentially misleading. Time lags in response to infrastructure have been documented as short as 2 years or as long as 10 years (Harju et al. 2010).

In general, the research suggests that sage-grouse are negatively affected when well pad densities within approximately 3.2 km (2 mi) of a lek exceed 1 pad/section and when leks become surrounded by infrastructure. Energy development as far as 6.4 km (4 mi) of a lek may negatively influence lek attendance. Anthropogenic noise is a component of energy developments causing declines in male lek attendance; however, all potential causes of declines resulting from energy developments have not been examined empirically. Negative effects of energy development to sage-grouse may occur

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at distances approaching 18 km (11 mi), and the ultimate effects of infrastructure may not become apparent for up to 10 years following the addition of infrastructure to the landscape.

Sage-grouse population declines resulted from avoidance of infrastructure during one or more seasons, reduced productivity, and/or reduced survival (Naugle et al. 2011). A meta-analysis of prairie grouse (i.e., sage-grouse, prairie chickens, sharp-tailed grouse, and black grouse) populations in general suggested moderate to large displacement effects and small to moderate demographic effects of the infrastructure of energy developments; the displacement effect varied by feature type with power lines and roads having the largest effects (Hagen 2010). Yearling female sage-grouse avoided nesting within 950 m of the infrastructure of natural-gas fields (Holloran et al. 2010), and visible wells within a 1 km^2 (247 acres) area negatively influenced female selection of nesting habitats (Kirol et al. 2012). Female early brood-rearing (early June to early July) locations were negatively correlated with the number of visible wells within a 1 km^2 area, and late brood-rearing females (early July through late August) avoided habitats when a surface disturbance (e.g., well pads and improved roads) threshold of approximately 8% of a 5 km^2 (1200 acres) area was surpassed (Kirol et al. 2012). Sage-grouse were 1.3 times more likely to occupy winter habitats within a 4 km^2 (990 acres) area that had not been fully developed for energy (8 pads/section), and avoided habitats within 1.9 km (1.2 mi) of infrastructure during winter (Naugle et al. 2011).

Declines in sage-grouse population growth (21%) between pre- and post-development was primarily attributed to decreased nest success and adult female annual survival; treatment effect (proximity to gas field infrastructure) was especially noticeable on annual survival of nesting adult females (Holloran et al. 2005). Annual survival of individuals reared near gas field infrastructure (yearling females and males) was significantly lower than control individuals that were not reared near infrastructure (Holloran et al. 2010). The probability that males reared near gas fields established a

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breeding territory was half that of control males (Holloran et al. 2010). Fewer females from impacted leks (i.e., leks within 3 km, 1.9 miles, of gas field infrastructure) initiated nests compared to females from non-impacted leks (Lyon and Anderson 2003). The closer a nest was to a natural gas well (that existed or was installed in the previous year), the more likely it was to fail (Dzialak et al. 2011). When a surface disturbance (e.g., well pads and improved roads) threshold of approximately 4% of a 1 km^2 (247 acres) area was surpassed, risk of daily brood loss increased, and risk of chick mortality was 1.5 times higher for each additional well site visible within 1 km (0.6 mi) of brood locations (Naugle et al. 2011, Kirol et al. 2012).

Only one study has empirically examined the response of sage-grouse to explicit changes in conventional natural gas development protocols. In southwestern Wyoming, differences in reactions of wintering sage-grouse to conventional well pads (e.g., liquid by-products stored and collected on-site) and well pads equipped with liquid gathering systems (e.g., liquid by-products piped off-site eliminating the need for tanker trucks to visit the pad; reduced daily traffic volumes to pad from 8 to 3 vehicles/day on average) were examined (Holloran et al. In Review). Sage-grouse avoided suitable winter habitats with high well pad densities regardless of differences in activity levels associated with well pads. However, there was consistent suggestion across analyses that the distance-effect on sage-grouse of well pads equipped with liquid gathering systems may be less than that of conventional well pads. There was a strong positive relationship between distance to drilling rig and average hours spent in an area.

In general, females selecting habitats near infrastructure have demonstrated lower annual survival (resulting in population-level declines in response to development), and females influenced by development activity within 3 km (1.8 mi) of the lek are less likely to initiate a nest. Nesting females avoid areas within approximately 1 km (0.6 mile) of infrastructure, and nests closer to infrastructure are at a higher risk of nest failure. Brood-rearing females avoid areas within approximately 0.5 km (0.3

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mile) of infrastructure, broods reared within 1 km of infrastructure are less likely to be successful, and yearling male and female survival and yearling male fecundity (e.g., probability of establishing a breeding territory) are lower for individuals reared near infrastructure. It is worth noting that a meta-analysis of sage-grouse demographic rates collected range-wide over a 73-year period suggested that female survival, chick survival, and nest success were demographics that had the greatest influence on sage-grouse population growth (Taylor et al. 2012). Sage-grouse during the winter avoid habitats with high well pad densities and avoid areas within 1.9 km (1.2 mi) of a well pad; reduced anthropogenic activity levels at well pads may reduce the scale of indirect winter habitat loss (e.g., may reduce avoidance distance).

Wind Energy Developments

Federal lands in the western United States have significant potential to produce energy from wind power (Connelly et al. 2004). Few wind turbines currently exist within the range of sage-grouse making assessment of this threat challenging; approximately 1,800 acres (0.001%) of sage-grouse habitat are directly influenced by wind turbines throughout the range of the species (Table 14, Figure 17). Indirect effects to sage-grouse from wind energy developments – assessed as the spatial foraging scale of sage-grouse avian predators which may be attracted to turbines (6.9 km, 4.3 mi) – are suggested to influence approximately 0.31% of priority habitats throughout the species range. Private lands account for **most** (approximately 72%) of the priority habitats indirectly influenced by wind turbines; BLM lands account for approximately 21% of these habitats indirectly influenced by turbines. While largely unspecified (most federal lands are not currently leased or developed), the coincidence of wind potential (for energy production) and sage-grouse habitats, including PPH and PGH, is high across sage-grouse range, and especially widespread in MZs I, II, IV (Figure 18). Estimating development potential also includes location and proximity of transmission infrastructure and markets, as well as market trends

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(energy prices), therefore wind potential is only one of several indications of potential and all are not considered here. Development potential is currently greatest where Rights of Way leases have been issued (Figure 18), as development is pending on these lands. Concerns surrounding wind energy development and sage-grouse include noise produced by the rotor blades, sage-grouse avoidance of structure, and mortality to sage-grouse flying into rotors; however the greater influence on sagebrush ecosystems will likely result from the roads and power lines that are necessary to construct and maintain sites used for wind energy (Connelly et al. 2004**). T**hese effects are discussed at length in the previous section (also see Section III.A4. Infrastructure). The only study on specific effects of wind development on sage-grouse was recently completed in south-central Wyoming (LeBeau 2012). The relative **probabilities** of a sage-grouse nest and of a brood failing (all chicks lost between hatch and 35 days post-hatch) increased with proximity to nearest wind turbine. Notably, this study investigated the short-term response of sage-grouse to a wind energy facility; the impacts of a facility may not be realized within 2 to 4 years of the addition of wind turbines due to the time lags associated with responses of sage-grouse breeding populations to infrastructure.

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Table 14. Summary of the distribution of existing wind turbines across sage-grouse habitats (PPH and PGH) by Management Zone.*

Management Zone Entity	PPH SG Habitat (acres)	PPH Direct Footprint (acres)	PPH 6.9km Indirect Influence (acres)	PPH Direct Footprint (%)	PPH Relative Influence¹ (%)	PGH SG Habitat (acres)	PGH Direct Footprint (acres)	PGH 6.9km Indirect Influence (acres)	PGH Direct Footprint (%)	PGH Relative Influence¹ (%)
MZ I - GP	11,636,400	100	122,100	0.00	1.05	34,663,000	800	243,600	0.00	0.70
BLM	2,994,300	0	25,800	0.00	21	4,524,900	0	14,900	0.00	6
Forest Service	292,400	0	100	0.00	0	515,300	0	0	0.00	0
Tribal and Other Federal	219,700	0	0	0.00	0	2,427,700	0	0	0.00	0
Private	7,132,500	100	88,100	0.00	72	24,682,800	700	211,100	0.00	87
State	995,600	0	8,100	0.00	7	2,498,400	0	17,600	0.00	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	0	75,900	0.00	0.43	19,200,200	700	306,700	0.00	1.60
BLM	9,021,200	0	16,500	0.00	22	9,012,500	0	65,700	0.00	21
Forest Service	162,000	0	0	0.00	0	452,500	0	0	0.00	0
Tribal and Other Federal	784,000	0	0	0.00	0	1,354,600	0	0	0.00	0
Private	6,233,900	0	52,900	0.00	70	7,394,800	600	223,000	0.01	73
State	1,244,800	0	6,600	0.00	9	979,800	100	18,000	0.01	6
Other	30,100	0	0	0.00	0	6,000	0	0	0.00	0
MZ III - SGB	10,028,500	0	0	0.00	0.00	3,970,100	0	0	0.00	0.00
MZ IV - SRP	21,930,600	0	11,500	0.00	0.05	10,958,500	200	93,800	0.00	0.86
BLM	13,710,700	0	2,000	0.00	17	4,928,200	0	29,900	0.00	32
Forest Service	1,613,800	0	0	0.00	0	1,113,500	0	0	0.00	0
Tribal and Other Federal	633,600	0	0	0.00	0	522,500	0	2,900	0.00	3
Private	4,890,200	0	9,400	0.00	82	3,516,742	200	57,900	0.01	62
State	1,019,373	0	100	0.00	1	846,200	0	3,100	0.00	3
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: Federal Aviation Administration Digital Obstacles File 2011

[1] Indirect influence distance derived from foraging distances of predators (Boarman and Heinrich 1999, Leu et al. 2008).

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[2] For 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 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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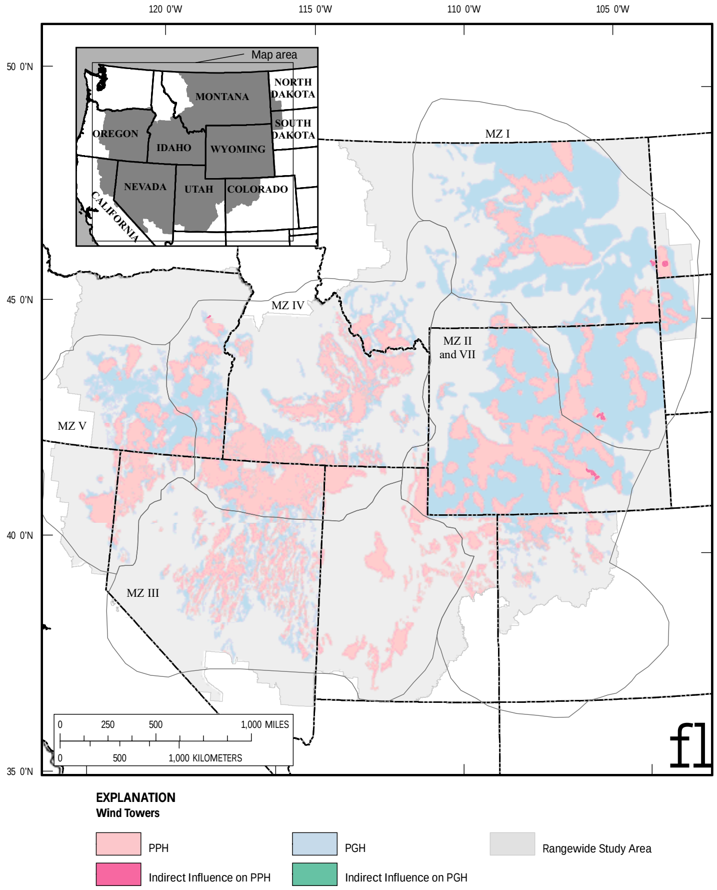

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Figure 17. Current distribution of direct and indirect effects on sage-grouse due to wind-towers.

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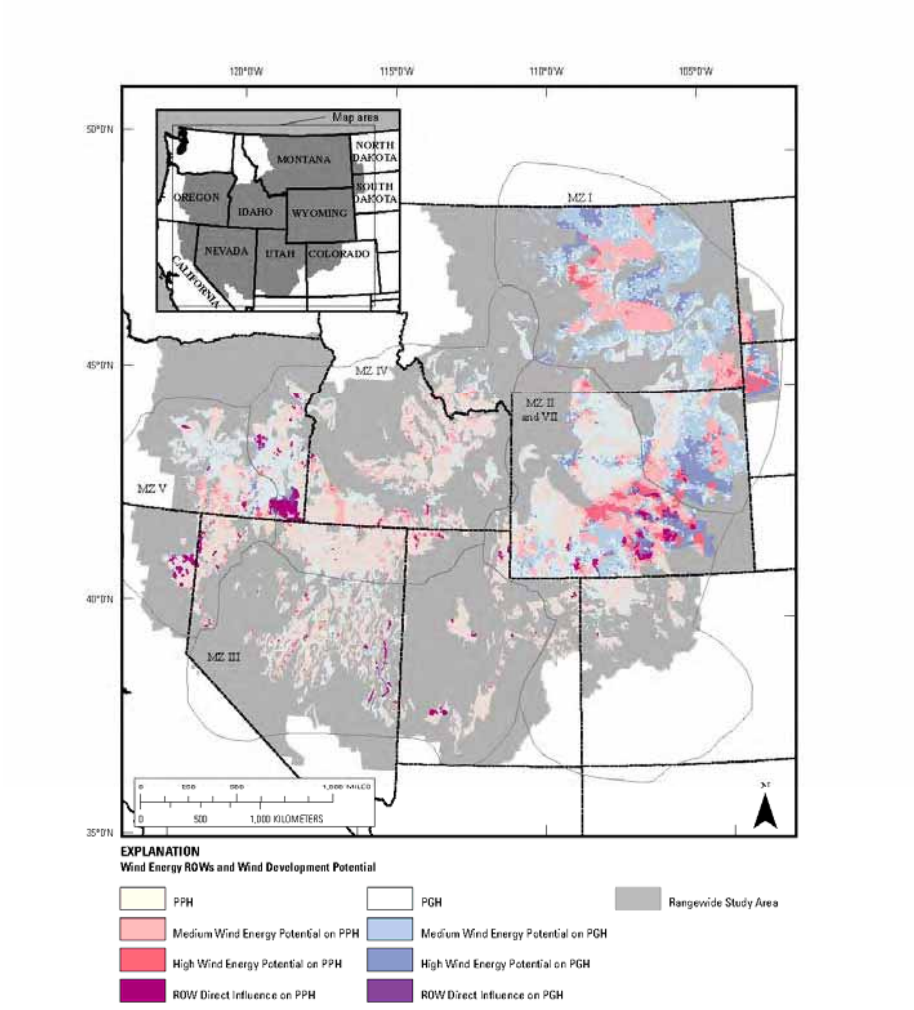

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Figure 18. Overlap of wind potential (based on mean wind speeds) and Right of Way Leases with PPH and PGH across the sage-grouse range.

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In situ uranium

According to the World Nuclear Association (London, United Kingdom; www.world-nuclear.org), in situ recovery (ISR) of uranium in North America involves recovering the minerals from an ore body by injecting solution to dissolve the uranium, pumping the pregnant solution to the surface, and removing the uranium from solution at a processing plant. Several projects are currently licensed to operate in the U.S. including several producing and proposed mines in Wyoming; most of the operating mines date from the 1990s. Uranium deposits are found predominantly in southeastern portions of MZ I (Powder River Basin), throughout MZ II, and in eastern MZ III and western MZ VII (Finch 1996).The design of ISR well fields varies depending on local conditions such as permeability, sand thickness, deposit type, ore grade, and ore distribution. However, whatever the well-field design used, there is a mixture of injection wells (to introduce the leach solution to the ore body) and extraction wells with submersible pumps used to deliver pregnant solution via pipeline to the processing plant. Wells with a common purpose (injection or extraction) are generally spaced 20 to 60 m apart. Wells are typical of normal water bores, and the processing plant is generally situated on-site, creating basic infrastructure of wells, pipelines and a processing plant within a geologically defined area.

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The largest environmental risk with an ISR uranium facility is the potential impacts to groundwater resulting from: (1) residual constituent concentrations in excess of baseline concentrations after the restoration of the production aquifer; (2) a migration of production liquids from the production aquifer to the surrounding aquifers during operation; (3) a mechanical failure of the subsurface well materials releasing production fluids into the overlying aquifers; (4) movement of constituents to groundwater outside the licensed area; and (5) excessive consumption of groundwater (School of Energy Resources, University of Wyoming, Laramie, WY; www.uwyo.edu/ser/). A detailed description of surface disturbance associated with an in situ uranium mine could not be found; however, based on

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pictures provided by Ur-Energy (Littleton, CO), a company developing in situ uranium mines in Wyoming, surface disturbance most closely aligns with that found in a coal bed natural gas field at a localized scale (e.g., wells not distributed across a large landscape, but focused on discrete ore deposits) and minus overhead utilities and substantial water discharge. Beyond potential impacts of water contamination, potential disturbance to sage-grouse could occur during drilling phases of development, from the processing plant, and from roads accessing well fields and the processing plant. Minimal surface disturbance appears to occur within the well field.

Oil shale

Oil shale (a.k.a., oil sands) is fine-grained sedimentary rock that contains relatively large amounts of kerogen, which can be converted into liquid and gaseous hydrocarbons (petroleum liquids, natural gas liquids, and methane) by heating the rock. According to the U.S. Energy Information Administration (*www.eia.gov*), the richest U.S. oil shale deposits are located in Northwest Colorado, Northeast Utah, and Southwest Wyoming, and deposits in these regions are currently the focus of petroleum industry research and potential future production. Current federal leases for oil-shale resources within sage-grouse range are limited to 331 km^2 (81,800 acres) within MZ II & VII (Figure 19a); a majority of these developments are on BLM managed lands (surface) with the remaining portion split between private and state. Development potential extends beyond the current footprint with the richest deposits in NW Colorado overlapping sage-grouse populations in MZ VII (Figure 19b). Given support of technology and market forces, these fields may ultimately produce more than 1 million barrels oil equivalent per acre (2.6 km^2; deposits in Alberta are expected to produce about 100,000 barrels per acre) suggesting that this may be an important factor in sage-grouse habitat conservation in the future.

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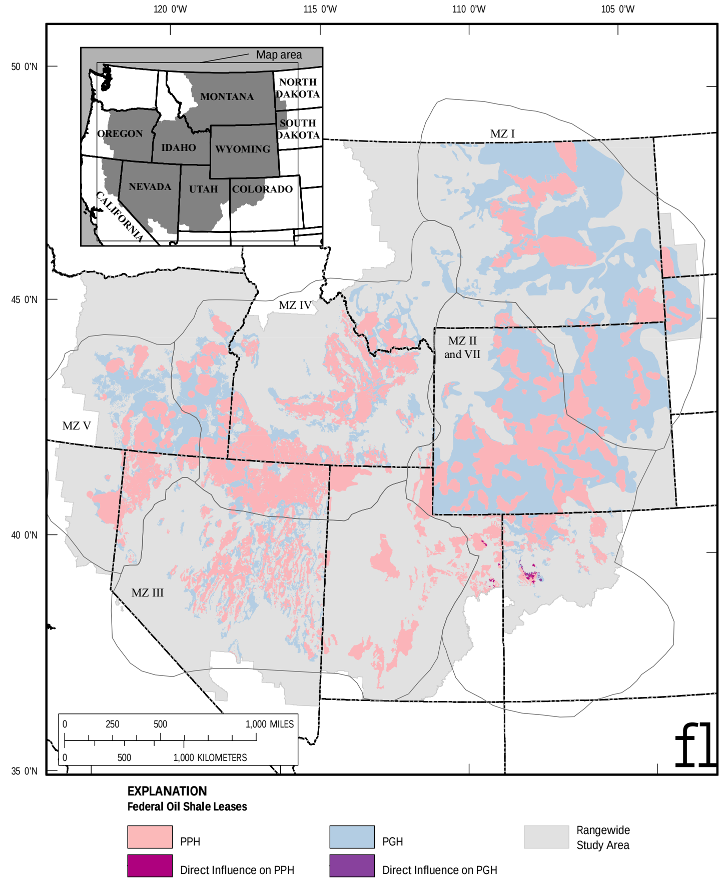

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Figure 19a. Distribution of current oil shale extraction activities across sage-grouse habitats (PPH and PGH) by Management Zone.

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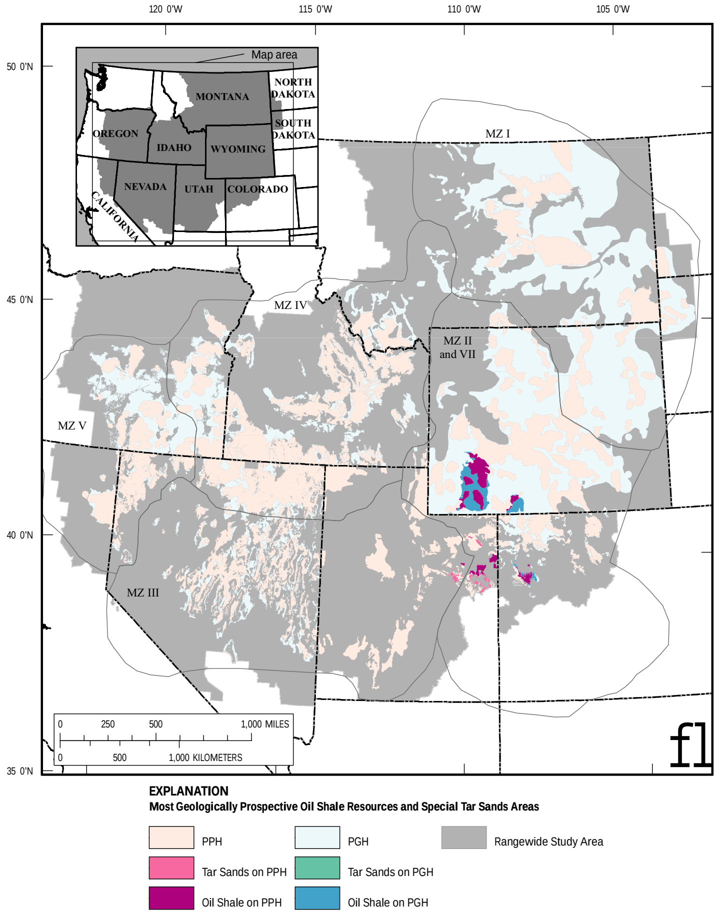

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Figure 19b. Overlap of oil shale development potential with priority (PPH) and general (PGH) sage-grouse habitat designations.

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Techniques for extracting resources from oil shale can be generally categorized as direct or indirect recovery: (1) direct recovery involves the removal of the oil shale from its formation for ex situ processing; and (2) indirect or in situ recovery involves some degree of processing of the oil shale while it is still in its natural depositional setting, leading ultimately to the extraction of just the desired organic fraction. The key steps in processing are retorting and pyrolysis. Retorting is a process that causes thermal decomposition of the organic fraction of the oil shale (kerogen); the recovered organic fraction is then distilled, or pyrolyzed, to produce three products: crude shale oil, flammable gases (including hydrogen), and char (deposited on spent shale). Surface mining techniques (e.g., strip mining and/or pit mining) as well as subsurface mining techniques (e.g., room-and-pillar mining, longwall mining, and other derivatives) have been successfully employed in the recovery of oil shale, however, the BLM considers the potential of surface mining in the future low. Indirect recovery techniques generally cause decomposition of kerogen to liquid and gaseous organic fractions that have sufficient mobility to “flow” through the formation for removal by conventional oil and gas recovery techniques. Surface disturbance most closely aligns with that found in a natural gas field, although well densities may be higher due to the requirement of injection (heat) and recovery wells in relative close proximity. Therefore, sage-grouse will likely respond to in situ oil shale development similarly to conventional natural gas development.

In situ recovery processes currently being researched are regarded by the U.S. Department of Energy as a promising technology. However, although the technical feasibility of in situ retorting has been proved, considerable technological development and testing are needed before any commitment can be made to a large-scale commercial project. Confirmation of the technical feasibility of the processes hinges on the resolution of two major technical issues: controlling groundwater during production and preventing subsurface environmental problems, including groundwater impacts. Of

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special concern in the arid western U.S. is the large amount of water required for oil shale processing; currently, oil shale extraction and processing require several barrels of water for each barrel of oil produced. The Energy Information Administration estimates that the earliest date for initiating construction of a commercial in situ oil shale project is 2017 with the first commercial production occurring probably no sooner than 2023. The information presented in this paragraph as well as a detailed discussion of the technology required for the recovery (i.e., mining), processing (i.e., retorting and pyrolysis of the hydrocarbon fraction), and upgrading of oil shale resources can be found in the Draft Programmatic Environmental Impact Statement and Possible Land Use Plan Amendments for Allocation of Oil Shale and Tar Sands Resources on Lands Administered by the Bureau of Land Management in Colorado, Utah, and Wyoming (BLM-WO-GI-08-005-3900, DOI No. DES 12-01; http://ostseis.anl.gov).

Solar

Solar power generation facilities that are likely to be developed for utility-scale capture of solar energy (i.e., ≥20 MW electricity that will be delivered into the electricity transmission grid) in the U.S. over the next 20 years include concentrating solar power – which includes parabolic trough, power tower, and dish engine systems – and photovoltaic. The main component that all these technologies have in common is a large solar field where solar collectors capture the sun’s energy. In the parabolic trough and power tower systems, the energy is concentrated in a heat transfer fluid and transferred to a power block, where steam-powered turbine systems generate electricity using similar technology to that used in fossil fuel-fired power plants. In contrast, the dish engine and photovoltaic systems are composed of many individual units or modules that generate electricity directly and whose output is combined; these systems do not use a central power block. Solar facilities are likely to have an operational lifetime of 30 years or more, representing long-term effects on habitats where they co-occur.

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While no current facilities affect sage-grouse range measurably, most of the sage-grouse range includes Very Good to Excellent rating for solar potential (excepting MZ I) indicating that, given technological developments, transmission infrastructure, and market forces, many of these lands could be targeted for solar energy facilities in the future (Figure 20).