

CHAPTER 3

NATURAL GAS DEVELOPMENT IMPACTS TO GREATER SAGE-GROUSE POPULATIONS: A SUMMARY OF RESEARCH CONDUCTED IN WESTERN WYOMING WITH THOUGHTS ON MANAGEMENT AND FUTURE RESEARCH OPTIONS.

Natural gas development in western North America has been escalating since the 1960s (Braun et al. 2002, Connelly et al. 2004), and the current U.S. political climate suggests that development of domestic fossil fuels reserves will continue to expand through the first half of the 21st century. Given that reducing the U.S. dependence on foreign sources of petroleum, the use of natural gas (versus oil or coal) as an energy source has air quality benefits, and the protection of natural ecosystems and the wildlife that depend on these habitats are of equivalent importance to the future of the country, it behooves us to develop extractive techniques that minimize extraneous consequences. This study concentrated on natural gas development impacts to a single species, but the results imply potential responses of an array of wildlife populations dependent on sagebrush-dominated landscapes.

Scientific and anecdotal evidence suggest that sage-grouse (*Centrocercus* spp.) leks situated within a developing natural resource field become unoccupied over a relatively short period of time (Braun et al. 2002, Aldridge and Brigham 2003); however, the specific components of a developing field that result in declines, as well as the root causes of lek abandonment, remain unidentified. Remington and Braun (1991) studied the effects of coal mining on breeding greater sage-grouse (*Centrocercus urophasianus*) in North Park, Colorado, and theorized that regional distributions were altered by this disturbance. This displacement theory is supported by several other studies. In Wyoming, Lyon and Anderson (2003) reported that female greater sage-grouse disturbed on a lek by road-related activity in natural gas fields moved farther from leks to nest compared to undisturbed females. Greater sage-grouse in Canada avoided nesting in areas with increased levels of human development and brooding females avoided areas with increased levels of visible oil wells (Aldridge 2005). Lesser prairie-chickens (*Tympanuchus pallidicinctus*) in Kansas selected habitats removed from anthropogenic features (Hagen 2003), and patch occupancy probabilities of Gunnison sage-grouse (*Centrocercus minimus*) in Colorado have been positively correlated with distance to roads (Oyler-McCance 1999). There is also evidence to suggest negative effects at the population scale. Female greater sage-grouse disturbed by natural gas development during the breeding season had lower nest initiation rates compared to undisturbed females in Wyoming (Lyon and Anderson 2003), and chick survival decreased as oil well densities within 1 km of brooding locations increased in Canada (Aldridge 2005). Hagen (2003) reported that a lesser prairie chicken population subjected to

anthropogenic activity in Kansas had population growth rates 21% lower than an undisturbed population, and suggested that the difference was primarily due to decreased nest success and female survival in the disturbed area.

I investigated potential impacts of development of natural gas fields to greater sage-grouse populations in the upper Green River Basin of western Wyoming. The populations and habitats within this area are currently considered internationally significant strongholds for the species (Connelly et al. 2004). Natural gas development throughout the Intermountain West is occurring primarily within the sagebrush-dominated landscapes important for sage-grouse survival (Knick et al. 2003). Our objectives were to investigate several increasingly specific questions: Are breeding greater sage-grouse populations impacted by natural gas development? What aspects of developing fields are influencing breeding populations? Are individuals dispersing from natural gas development or are population sizes declining? Additionally, land management agencies stipulate restrictions on some types of development during breeding and nesting seasons to protect sage-grouse; so I addressed the adequacy of these stipulations. I investigated population and individual bird response to natural gas drilling rigs, producing wells, and main haul roads (i.e., roads accessing at least 5 producing natural gas wells).

I assessed temporal changes in the number of displaying males with respect to distance and direction from leks to drilling rigs, producing wells, and main haul roads, producing well and main haul road densities, and traffic activity levels and timing. I also investigated male survival probabilities, lek tenacity, and habitat selection during the breeding season relative to cumulative levels of gas field development surrounding leks. My investigation of female habitat selection response to energy development concentrated on 2 demographic stages, nesting and early brood-rearing (hatch through 2 weeks post-hatch). I examined distances moved between nests in consecutive years, used versus available nesting and early brood-rearing habitats, and successful (i.e., hatched or survived) versus unsuccessful nests and broods with respect to differing levels of gas field development. Finally, I used matrix population modeling and life-table-response procedures (Caswell 1989, 1996) to investigate the effects of natural gas development on female greater sage-grouse population growth. I compared populations potentially impacted by natural gas infrastructure during the breeding or nesting season to non-impacted populations.

Results

Investigating changes in the number of male greater sage-grouse occupying a lek relative to cumulative gas field development levels using principal components analysis suggested that as the distance from leks to drilling rigs, producing wells, and main haul roads decreased, and as main haul

road densities within 3 km and the number of directions to producing wells within 5 km (i.e., the lek became more centrally located within the developing field) increased, lek attendance by males approached zero. The number of males occupying leks within 5 km of drilling rigs declined relative to non-impacted leks. There did not appear to be visual effects of drilling rigs on lek attendance by males, but the number of males declined on leks east of drilling rigs (i.e., generally downwind based on prevailing wind direction). The number of males occupying leks within 3 km of producing wells also declined. Male lek attendance declined if well densities within 3 km of the lek exceeded approximately 5 wells and if producing wells within 5 km occurred in over half of the directions from leks. Male lek occupancy also declined on leks within 3 km of main haul roads. Rates of decline increased as traffic volumes increased, and vehicle activity on roads during the daily strutting period (i.e., early morning) had a greater influence on attendance compared to roads with no vehicle activity during early morning.

Probabilities of adult male desertion (i.e., males captured from a particular lek and not documented on that lek following capture) were higher from leks impacted by at least 1 gas-field-related factor compared to non-impacted leks, and male breeding season survival probabilities were lower for lightly impacted (i.e., leks impacted by 1 or 2 factors) compared to heavily impacted leks (i.e., leks impacted by more than 2 factors). Additionally, impacted leks had fewer yearling males trapped and earlier peak attendance dates compared to non-impacted leks.

Greater sage-grouse nesting sites were close to wells in areas with low well densities compared to available sites. Temporally, nests were located farther from drilling rigs and gas wells in 2004 compared to available sites, whereas nests were closer to these structures in 2000-2003. Adult females nested within previously selected nesting areas regardless of changes in gas development levels within those areas, but nesting yearlings avoided road-related disturbances. Brooding females avoided producing wells during the early brood-rearing period. The effect of natural gas development on female population growth was generally negative. There were relatively consistent negative contributions to population growth from adult and yearling female annual survival, whereas productivity contributions were generally positive. This suggests that reduced population growth was attributable to decreased annual survival of both adult and yearling females.

Discussion

The evidence suggests that current natural gas development techniques lead to greater sage-grouse population declines. Male lek attendance declined as the distance from leks to drilling rigs, producing wells, and main haul roads decreased and as densities of these features increased. Lek attendance also declined as traffic volumes and potential for greater noise increased, and when well

densities exceeded 1 well per 283 ha within 3 km of leks. Developing natural gas fields simultaneously consists of all the disturbance factors considered plus others not investigated (i.e., well completion activity, compressor stations). Greater sage-grouse breeding populations were probably reacting to a combination of these factors' effects.

Adult male displacement and low juvenile male recruitment appear to contribute to declines in the number of breeding males on impacted leks. Additionally, avoidance of gas field development by predators could be responsible for decreased male survival probabilities on leks situated near the edges of developing fields (i.e., lightly impacted leks). Although site-tenacious adult females did not engage in breeding dispersal in response to increased levels of gas development, subsequent generations avoided gas fields, as suggested by the temporal shift in nesting habitat selection and differences in habitat selection by yearling and adult females. This suggests that the nesting population response is delayed avoidance of natural gas development. The results suggest that male and female greater sage-grouse displacement from developing natural gas fields contributes to breeding population declines.

Population growth differences between impacted and non-impacted populations suggest that natural gas development negatively impacts population growth of females. Most of the variability in population growth was explained by lower annual survival buffered to some extent by higher productivity in impacted populations. Development effect was especially noticeable on annual survival of nesting adults. Seasonal survival differences suggested a lag period between when an individual was impacted by disturbance and when survival probabilities were influenced. Individuals were influenced by natural gas development primarily during the breeding and nesting periods, while differential survival occurred primarily during the early brooding and summer periods. Impacted and non-impacted populations summered in the same general areas, and predators were responsible for most summer mortalities. Increased predation probabilities during the summer suggest increased exposure, possibly through a change in foraging behavior (i.e., spending more time feeding), habitat selection (i.e., selecting areas with greater food resources and reduced cover), or self-preservation behavior (i.e., reduced alertness).

The evidence suggests that breeding population declines and eventual extirpation of leks near disturbances resulted from both displacement and decreased survival. Regional greater sage-grouse population levels as well as population distributions are likely to be influenced negatively by development of natural gas fields.

Management Considerations

To protect breeding greater sage-grouse, the Bureau of Land Management (2000) stipulates the following restrictions to development: (1) no surface disturbance within 0.4 km of a lek; (2) no activity within a 0.8-km radius of active leks between 0000 and 0900 hrs during the breeding season; (3) no construction or drilling activities during the breeding season within 1.6 km of active leks. To protect nesting and brooding females, the Bureau of Land Management (2000) stipulates that gas field related construction activities will be restricted during the breeding and nesting seasons in suitable nesting habitat within 3.2 km of active leks; a suitable habitat designation requires that an active nest be located during an on-site review of the proposed development area. This study suggests that current stipulations are inadequate to maintain greater sage-grouse breeding populations within natural gas fields. The effect-distance from disturbance sources to leks during the breeding season could be conservatively estimated at 3-5 km, especially if that source was located where sound propagation towards a lek was intensified by environmental factors (i.e., prevailing wind direction). Therefore, sound muffling devices installed on noisy gas field structures could reduce the negative consequences on breeding grouse. Declines in lek attendance were positively correlated with traffic levels and vehicular activity during the daily strutting period. Reducing overall traffic volumes (i.e., offsite condensate collection facilities, car-pooling) and isolating the timing and location of traffic disturbance (i.e., restricting travel to and from the gas field to 1 major artery, enforcing daily travel timing restrictions) within gas fields could reduce road effects.

Barring direct disturbance resulting in nest abandonment, the stipulation (Bureau of Land Management 2000) aimed at protecting nesting females protects only philopatric individuals. Basing designations on habitat conditions rather than habitat occupancy could assist in maintaining nesting areas. Although adequate buffer distances are unknown, our findings suggest that areas designated as suitable breeding habitats (Connelly et al. 2000) within 5 km of known leks (Holloran and Anderson 2005) need to be protected and buffered from gas field development. Additionally, nesting females avoided areas with high well densities. Although actual densities resulting in avoidance are unknown, this result suggests that 16 ha well-spacing excludes nesting females. Because a developing natural gas field consists of multiple disturbance sources, all of which potentially influence greater sage-grouse leks and nests, managers need to ensure that all potential factors are addressed concomitantly.

Our results suggest that protection and enhancement of greater sage-grouse populations inhabiting areas adjacent to natural gas fields could be required to maintain regional population levels. Off-site mitigation measures aimed at minimizing the negative consequences of natural gas development on regional populations imply the need for a refugia approach to species conservation. By

protecting and enhancing reservoir populations surrounding developing gas fields, greater sage-grouse could be present to re-colonize the field following reclamation. However, managers need to ensure that these reservoir populations are protected through the life-expectancy of the developing field (minimum life-expectancy of the Pinedale Anticline natural gas field has been estimated at 59 years; Bureau of Land Management 2000). We suggest delaying development of natural gas fields surrounding the original field until populations within the original field following reclamation are substantial enough to re-colonize subsequently developed fields. The staggered development of gas fields across a landscape could not only ensure refugia for wildlife, but could ensure long-term financial stability for states dependent on fossil fuels generated revenue (at least until alternatives to fossil fuels are developed).

Research Needs

Results from this study identified several questions for future research. Of utmost importance is determining natural gas development options that reduce detrimental consequences to greater sage-grouse populations. An investigation of greater sage-grouse population and individual response to differing development strategies in an experimental context is required for accurate conclusions. The study design would need to ensure both adequate pre-treatment data for development threshold identification and spatial independence to guard against potential dispersal consequences. Investigating potential development options in this manner will require substantial cooperation between researchers, land managers, and operators.

Research investigating yearling responses to a developing gas field would improve our understanding of regional consequences. For example: what proportion of the yearling male population does not breed? What is the spatial extent of the area searched by disturbed yearling males prior to establishing a territory on a lek (spatial extent of gas field influence)? Is territorial establishment timing and survival of yearling males influenced by displacement? Future research should further address potential impacts to the yearling female cohort. In addition to the questions asked concerning yearling males, information relative to female seasonal habitat selection and productivity is needed. What is the proportion of the yearling female population displaced from their natal nesting or natal brooding areas? Are vital rates (i.e., survival, nesting initiation and success probabilities, and chick productivity rates) of the yearling females displaced from their natal lek, nesting, or brooding areas negatively influenced?

Research investigating the consequences of dispersal is also needed. If the majority of displaced adult and recruited yearling males are establishing on non-impacted leks surrounding the developing gas field, and the eventual nesting population response is avoidance of natural gas development,

populations surrounding the gas field may be artificially high. Are density-dependant processes occurring that affect greater sage-grouse survival, breeding potential, and productivity in sagebrush habitats with potentially artificially high populations adjacent to natural gas fields (LaMontagne et al. 2002)? And do these processes influence the ability to conduct off-site mitigation for natural gas development?

Finally, investigating long-term impacts of natural gas development is warranted. Do breeding populations reoccupy abandoned leks after development stages are completed and the field enters primarily production phases (i.e., determination of a gas field's temporal extent of influence)? Braun et al. (2002) reported that 2 leks in Canada remained inactive for ≥ 10 years after gas or oil well site reclamation; however, Remington and Braun (1991) suggested that 2 leks where coal mining activity potentially caused substantial male lek attendance declines in the early 1980s recovered to some extent over a 5-year period following the reduction in mining activity in 1985. Research investigating potential cumulative effects (i.e., influence of gas development on predator core-area use patterns, produced water and West Nile Virus prevalence [Naugle et al. 2004]) of natural gas field development is additionally needed. These studies are required to accurately evaluate mitigation options.

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