VIII. ENERGY DEVELOPMENT

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This chapter discusses current energy development (i.e., wind, oil and gas, and solar), and the potential impact to bats and their habitats. The development and technology of each energy sector is introduced, followed by a section that describes possible direct (e.g., collision) and indirect (e.g., habitat degradation) impacts to bats. It is important to understand that within each energy sector the technology being utilized may vary and thus the associated impacts, both actual and potential, may differ as well. For example, solar energy can be produced using photovoltaic (panel) arrays, or heat generation with lenses or mirrors at concentrated solar power systems. Due to size requirements needed to capture the same amount of energy as mirror arrays, photovoltaic arrays may disturb more habitats, an indirect effect on bats. However, mirror arrays have the potential to directly incinerate bats due to the high levels of heat associated with energy transfer. In addition, it should also be considered that mirror arrays have risks associated with high saline water in evaporation ponds and chemical exposure for plants with steam generator designs. We provide some examples of technology types for each energy sector. However, it should be noted that energy development technologies can arise and change rapidly. Therefore, the need for stakeholders to work together to investigate the potential impacts to bats and their habitats from current and future energy development technology will be important.

We address direct impacts, degradation/loss of habitat, combined impacts, and other impacts to bats for three types of energy development in Colorado: wind energy potential and technology, oil and gas potential and technology, and solar potential and technology.

WIND ENERGY POTENTIAL AND TECHNOLOGY

Wind Energy development in U.S. ranks 2nd in the world, with 89,077 MW installed as of 2017 (AWEA 2017a). Through 2016, Colorado was ranked 9th in the U.S. for installed wind energy and 13th in the US for potential wind energy development (AWEA 2017b). Most wind energy potential in Colorado occurs in the eastern plains and foothills of the Rocky Mountains (Fig 8.1). The Colorado Renewable Portfolio Standard (RPS), as modified in 2010, requires investor-owned utilities and cooperatives to provide 30% and 20% of their electricity, respectively, through renewable and/or recycled energy by 2020. As of 2017, Colorado has 26 active wind farms with 3,026 MW of wind

Wind farm in northeast Colorado. Photo by P. Cryan.

capacity, all of which are situated on the Front Range and eastern plains (Fig. 8.2).

Wind energy technologies use the force of the wind to generate electricity, charge batteries, pump water, and/or grind grain (EERE 2014a). The most commonly used wind energy technology is the horizontal axis turbine which is a rotor with 2–3 blades set on a tall tower, typically 80–100 m above ground (Fig. 8.3; EERE 2014b). Other designs are being considered but most are still in the testing phase. An example of a design in the testing stage is a tethered kite that rotates in the wind at approximately 140–310 m above ground, which is being developed by Makani in partnership with Google (Makani 2014).

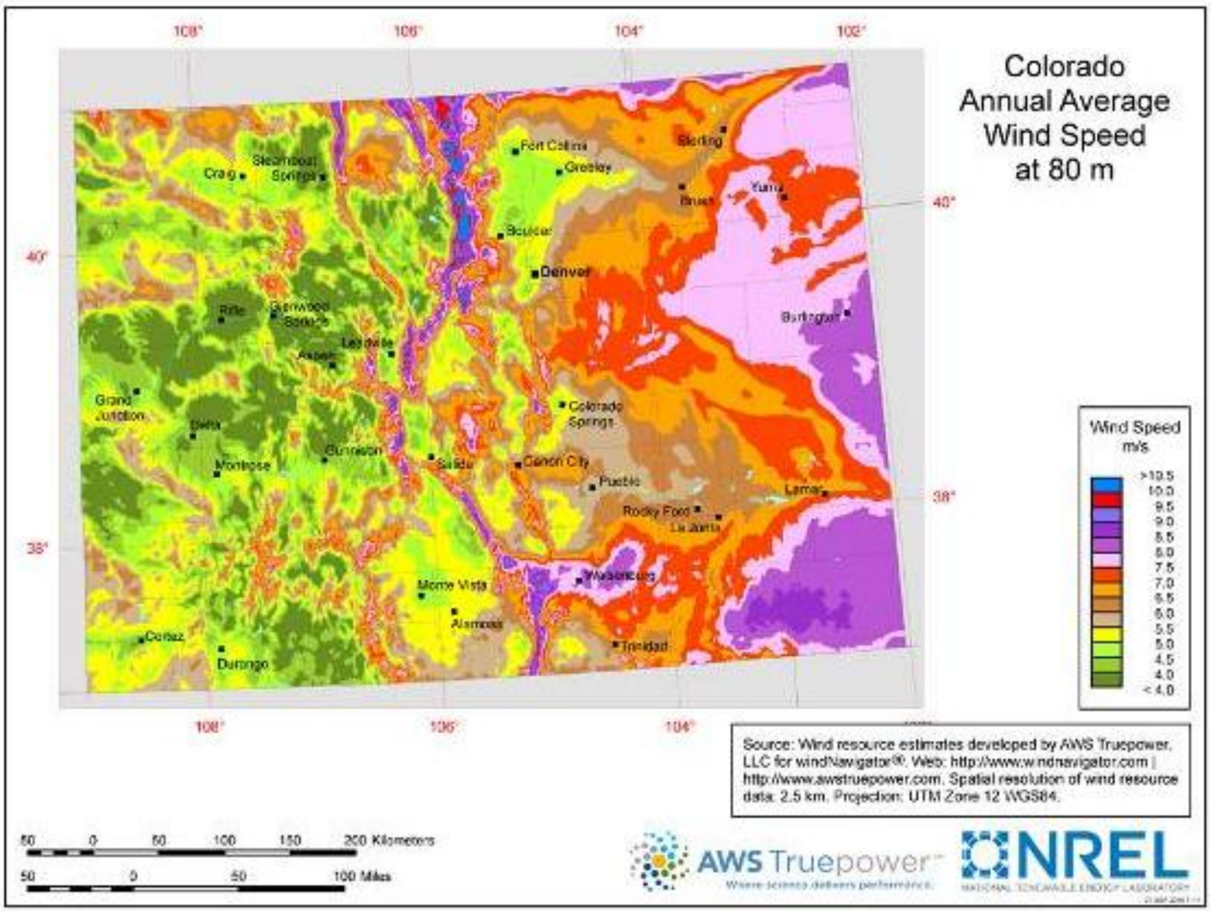

Figure 8.1. Colorado annual average wind speed (80m agl) suggests that the majority of wind development will occur on the Front Range and eastern plains (National Renewable Energy Laboratory, https://windexchange.energy.gov/maps-data/15, Accessed December 2017).

Bat fatalities resulting from strikes with wind turbine blades are well documented and have the potential to impact local and regional bat populations (O'Shea et al. 2016; Hammerson et al. 2017). Unlike other energy sectors, wind development causes consistent, high levels of direct bat mortality, with an estimated 840,486–1,690,696 bats killed between 2000–2011 in the United States and Canada

(Arnett and Baerwald 2013). Migratory bats are heavily impacted as they are likely to be utilizing the same wind paths as those targeted for wind energy development. A number of reasons for bat's approaching turbines have been suggested, including aspects tied to the tallest objects on the landscape, such as mating behavior (Cryan 2008) and roost structures (Cryan et al. 2014). The fatalities themselves may be the result of barotraumas (decompression sickness) from flying too close to the blades (Baerwald et al. 2008), but more often are probably associated with traumatic injuries from the impact of collisions (Rollins et al. 2012). A number of measures to reduce bat fatalities at wind facilities have been studied (Arnett and May 2016), including adjusting turbine operations (e.g., wind speed triggers and blade angle; Baerwald et al. 2009), and placing texture on monopoles to help bats distinguish them from naturally used features (Conley 2017). Using deterrents such as broadband ultrasound broadcasts (Arnett et al. 2013; Lindsey 2017) and ultraviolet illumination (Gorresen et al. 2015; Cryan et al. 2017) may also prove effective in mitigating bat fatalities.

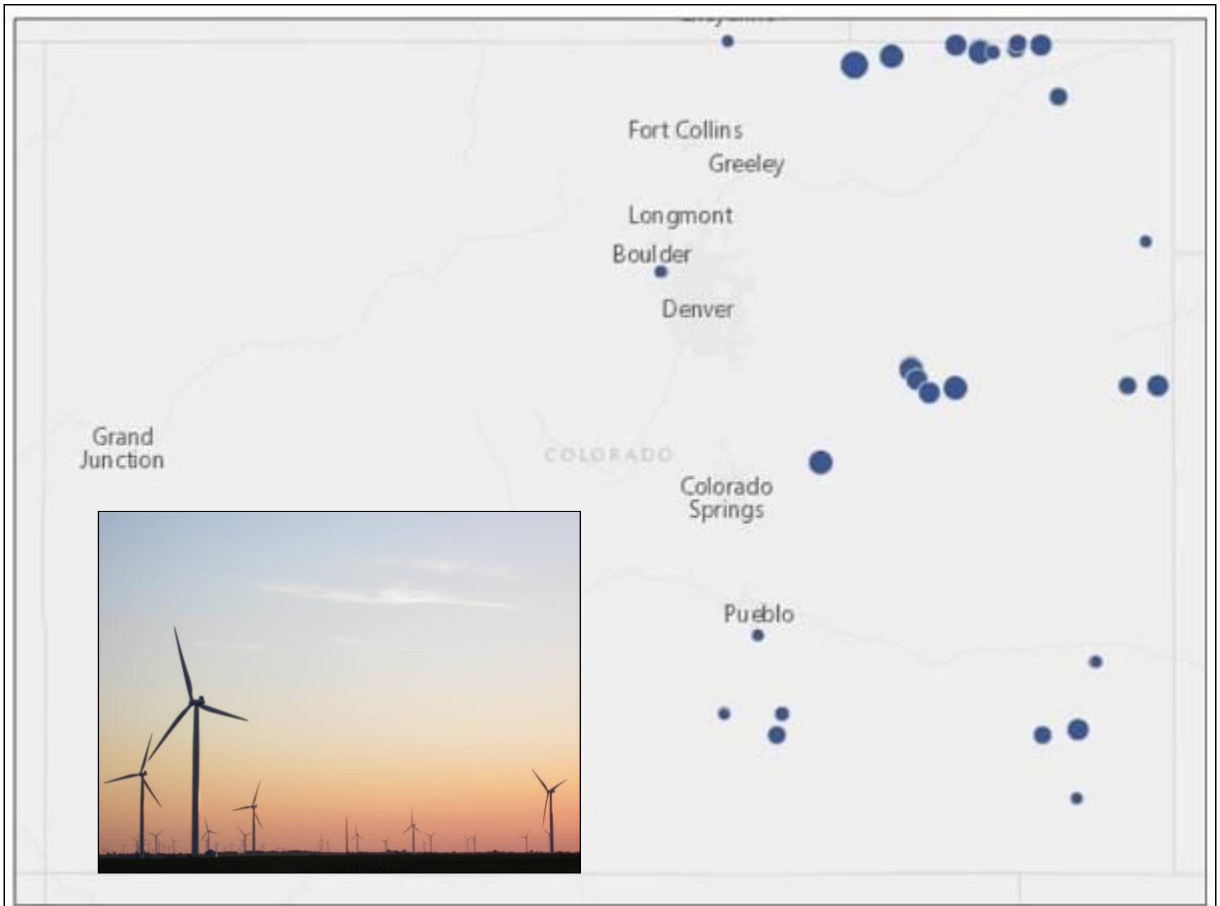

Figure 8.2. Wind farms in Colorado producing energy as of 2017 (AWEA US Wind Industry Map, http://gis.awea.org/arcgisportal/apps/webappviewer/index.html, Accessed October, 2017). Inset photo by P. Cryan.

GOAL

REDUCE THE POTENTIAL FOR BAT FATALITIES ASSOCIATED WITH WIND ENERGY DEVELOPMENT.

Objective 1: Collect data of bat activity prior to construction of wind farms to determine species affected and the level of potential impact to those bat populations.

Objective 2: Consider locating wind farms in areas of low bat activity.

Objective 3: Encourage wind facilities to implement proactive measures that are found to reduce bat fatalities such as turbine adjustments or deterrents.

Objective 4: Conduct post construction surveys for bat fatalities to collect data on species occurrence and to improve species specific mitigation.

RESEARCH NEEDS

- Fund research to develop effective bat deterrents at wind turbines.

Figure 8.3. Horizontal axis wind turbines used to generate electricity in eastern Colorado. Photos by J. Reitz

OIL AND GAS POTENTIAL AND TECHNOLOGY

Nationally, Colorado accounts for 10% of the natural gas reserves and almost 2% of the crude oil reserves. Advancements in horizontal drilling and hydraulic fracturing have allowed access to unconventional reservoirs, such as tight sands, coal bed methane, and shale rock (COGA 2014). Hydraulic fracturing is used in 9 out of 10 natural gas wells in the U.S. Shale gas reservoirs, or plays, are distributed across the U.S. (Fig. 8.4) and generally are found at depths ranging from 152–4,115 m. Growth in shale gas production is expected to increase from 5.0 trillion cubic feet (Tcf) in 2010 to 13.6 Tcf by 2035 (USEIA 2012). Technology used to extract oil and gas varies but the overall concept is to use pressure, either natural pressure or created pressure from pumps, gas, and/or liquid. Extracting natural gas and oil from previously unobtainable plays requires fracturing the rock formation. In hydraulic fracturing operations, water and various chemicals are used to create fractures. Suspended in the fluid is a propping agent, typically sand, which maintains openings and allows gas to flow to the well (Carter et al. 1996; Entrekin et al. 2011). The hydraulic fracturing process requires large amounts of water per well to fracture the shale formation. On average, 2–4 million gallons (can exceed 9 million gallons) are used per operation (Satterfield et al. 2008; GWPC and ALL Consulting 2009; API 2010). Water can be withdrawn from a nearby source or transported by truck or pipeline, and stored on-site in impoundments (GWPC and ALL Consulting 2009). Because ground and surface water are hydraulically connected, these operations could change the quantity and quality of both (Winter et al. 1998).

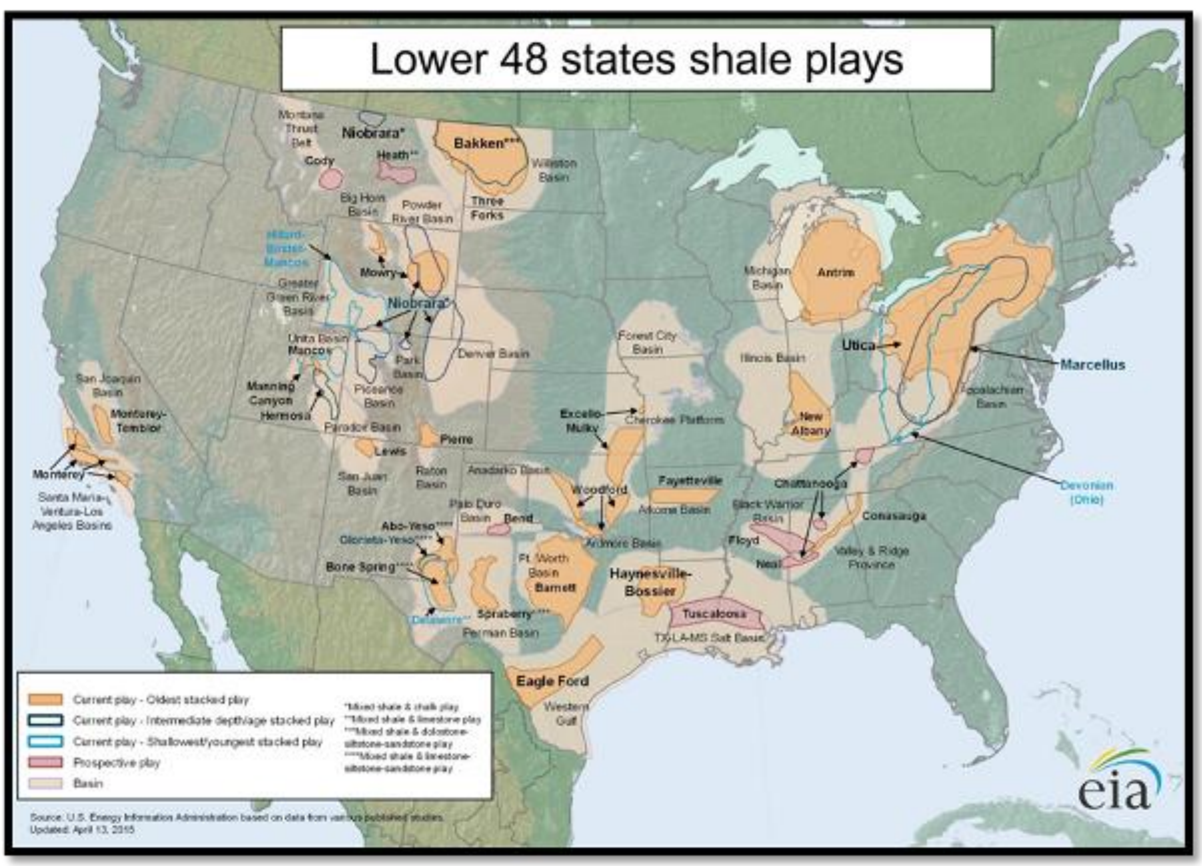

Figure 8.4. Location and size of natural gas reservoirs, or plays, in the United States as of 2015 (US Energy Information Administration, 2015).

DIRECT IMPACTS

A potential source for impacts to bats at oil and gas developments are the pits created to further separate oil from produced water (production skim pits), to store drilling fluids (reserve pits), to vent hydrogen sulfide gas from production wells (flare pits), or to store oil field waste (centralized oilfield wastewater disposal facilities). Pits containing oil or other oil-based drilling fluids can trap bats attempting to drink or pursuing prey (i.e., insects) on the surface (Ramirez 1999). Finley et al. (1983) retrieved 27 dead bats of 6 species from an oil and gas pit near Rifle, Colorado over a 16 month period. Large numbers of insects have been entrapped in oil production pits (Horvath and Zeil 1996; Bernáth et al. 2001), thus leading to a higher possibility of entrapment by bats due to attraction to insect prey. Esmoil and Anderson (1995) documented bats among the wildlife mortalities observed at oil pits in Wyoming. Another impact of these pits is the composition of oil and other toxic compounds that could be ingested by bats (Ramirez 2000). As has been determined for birds (USFWS 2009), bats could ingest toxic amounts of oil, salt, or other chemicals when preening their bodies after contact with the surface or attempting to drink from the pit. Bats may also die from hypothermia if the oil damages the insulation properties of their fur (Ramirez 1999, 2000). Although the annual estimate of migratory bird deaths from oil reserve pits vary from 0.5–2 million (Ramirez 1999; Trail 2006), it is unknown what the cumulative impact is to bats, as monitoring is not occurring and bats may be hard to recover (Ramirez 1999, 2000). In 2008, the Colorado Oil and Gas Conservation Commission (COGCC) adopted rules on pits to mitigate impacts to wildlife. Rule 902 calls for cleaning of pits and removal of oil or condensate in a pit within 24 hours of discovery and that netting or fencing should occur. Because fencing is not considered to deter bats and birds, many land managers on public lands are requiring closed-loop systems that eliminate pits (V. Koehler, pers. comm., 2014; COGCC 2015). These measures may help reduce impacts to wildlife, including bats. It is not known if netting causes bats to become entangled. In addition, the rule does not apply to all pits.

Another potential source of direct mortality at oil and gas developments is open exhaust stacks where bats may roost and be incinerated when the unit is fired up (BLM 1994, 1996). Data gathered by the Bureau of Land Management (BLM) in an assessment of 2,500 wells in the San Juan Basin of New Mexico and Colorado resulted in 252 dead birds and bats (the report did not state the proportion of either; BLM 1995). Dead bats have been observed around exhaust stacks in Wyoming as well (Schwab and DuBois 2006). The cumulative impact to bats is not known because of site variability, the lack of monitoring and/or success in recovering carcasses. The COGGC Rule 604b requires all stacks, vents, or other appropriate equipment to prevent entry by wildlife, including migratory birds (COGCC 2015). This regulation may help mitigate impacts, such as entrapment, to bats as well.

GOAL

REDUCE THE POTENTIAL FOR BAT MORTALITIES ASSOCIATED WITH OIL AND GAS PITS AND EXHAUST STACKS.

Objective 1: Refer developers and operators to existing policies and rules by the COGCC regulating oil and gas development in the state including conserving wildlife and wildlife habitat, and to the BLM and US Forest Service (USFS) for projects being developed on federal lands.

Objective 2: Consult with the Colorado Parks and Wildlife (CPW) per the COGCC's rules or to the BLM and USFS regarding threats to bats when establishing new drill sites.

Objective 3: Provide information and technical support to oil and gas developers and regulatory personnel about sensitive bat species, bat conservation practices, and measures to reduce mortalities, such as locating pits away from known or potential roost sites.

Objective 4: Provide information and technical support to oil and gas developers and regulatory personnel to monitor the success of bat conservation measures.

MANAGEMENT RECOMMENDATIONS

- Refer developers to existing policies for oil and gas development, such as the COGCC's "Migratory Bird Policy," that states screening shall be installed on exhaust stacks and accumulations of oil should be removed from pits as well as netting installed over pits to avoid use by migratory birds. Such policies would also be beneficial to bats by minimizing their use of these facilities and the associated impacts.
- Continue to recommend use of closed-looped systems to reduce likelihood of bats drinking from contaminated water.
- Monitor pits for bat mortalities and develop a plan for reporting and mitigation measures.
- Construct alternative freshwater sources adjacent to permanent pits to provide wildlife with an alternative safe water source and contribute to dietary dilution of toxic compounds.
- Operators should report all dead or tangled bats to CPW and COGCC staff.

RESEARCH NEEDS

- Do bats drink from contaminated waste water sites associated with oil and gas extraction?
- Do the current flagging and net designs required by COGCC keep bats out of contaminated water sources?
- Are the nets themselves, rather than the water source, a cause of bat mortality?
- Are bat mortalities resulting from exhaust stacks associated with oil and gas activities?

LOSS/DEGRADATION OF HABITAT

Habitat loss, degradation, and fragmentation from oil and gas development have been known to affect wildlife populations in a number of ways (Riley et al. 2012; Ramirez and Mosley 2015). Specifically for bats, oil and gas developments have the potential to directly impact bat populations by limiting roosting and foraging habitats (Hein 2012). Fragmentation from oil and gas development could reduce connectivity of habitats used by bats. In addition to physical disturbances, sensory disturbances such as noise and light may also lead to lower activity and habitat use by bats. Due to noise pollution created by drilling activities, areas of oil and gas development on the Piceance Basin of northwestern Colorado were used less by bats than control sites (Warner 2016). Development methods that use large amounts of water could impact bats in already arid environments, particularly lactating females with higher water requirements (Hein 2012; Riley et al. 2012; Ramirez and Mosley 2015). Bats utilizing waste water pits associated with drill sites may accumulate heavy metals in their systems, as noted from other sites with water contamination (O'Shea et al. 2001).

GOAL

PREVENT THE LOSS/DEGRADATION OF HABITAT FROM OIL AND GAS DEVELOPMENTS IN COLORADO.

Objective 1: Refer developers to existing policies and rules by the COGCC regulating oil and gas development in the state including conserving wildlife and wildlife habitat. Consult with CPW per COGCC rules on state lands and to the BLM and USFS for projects being developed on federal lands. Also, reference other supportive guidelines, such as those by the Colorado Mule Deer Association and Colorado Wildlife Federation (2006).

Objective 2: Preserve and improve bat habitat through land use planning. Provide information to land managers and county planners about the importance of these habitats to bats and other wildlife, and conservation strategies to minimize potential impacts to their habitats.

Objective 3: Encourage collection of acoustic bat activity data for development areas prior to drilling.

Objective 4: Based on pre-development data, reduce drilling activity during peak hours of activity for bats in areas where surveys found high bat use.

MANAGEMENT RECOMMENDATIONS

- Consider avoidance of important bat habitat, and mitigate for unavoidable habitat impact.
- Use sound walls at drill pads to dampen noise in areas shown to be important bat habitat by pre-development survey data.
- Consolidate drilling operations in an area, both spatially and temporally, so impacts occur at the same time, leaving other areas undisturbed.
- Consider cumulative habitat loss/degradation (e.g., urbanization, energy development, and agriculture) and mitigate at a landscape scale.

RESEARCH NEEDS

- How do bats move across the landscape in areas where oil and gas development occurs?

- Develop efficient methods of monitoring and reporting sound levels at drill pads.
- Are their important migratory routes for bats in areas of oil and gas development?
- How do multiple oil and gas facilities across the landscape affect bat populations?
- Test a wide range of relevant noise levels to better understand the spatial extent of noise disturbance for bats at drill sites (Warner 2016).
- Investigate technologies to reduce noise generated from the drilling process, such as sound walls, as it relates to bats.
- Test the impacts of light pollution generated at drilling sites (Warner 2016). Do bats avoid lighted drill rigs in areas that would otherwise be dark?
- Do bats forage on insect aggregations around drill pad lights and does this offset potential lowered activity surrounding the site?

GOAL

PRESERVE AND IMPROVE WETLAND/RIPARIAN HABITAT THROUGH LAND USE PLANNING.

Objective 1: Refer oil and gas developers to existing policies and rules by the COGCC regulating oil and gas development in the state, including conserving wildlife and their habitat. Consult with CPW for COGCC rules on state lands, and to the BLM and USFS for projects being developed on federal lands. Reference other supportive guidelines, such as those by the Colorado Mule Deer Association and Colorado Wildlife Federation (2006).

Objective 2: Provide information to land managers and county planners about the importance of these habitats to bats and other wildlife, and promote the conservation of wetlands.

MANAGEMENT RECOMMENDATIONS

- Contact the Army Corps of Engineers for permitting and consult with CPW, Ducks Unlimited, US Fish and Wildlife Service, or other experts for advice regarding wetland management.
- Mitigate for water taken from natural and agricultural sources as required by the state.
- Consider connectivity of roosting, foraging and commuting habitat in relation to water sources.
- Consider climate change impacts on water loss in relation to developmental loss of water.
- Promote construction of alternative freshwater sources for bat use.

RESEARCH NEEDS

- Expand current knowledge of how bats use wetlands/riparian habitat. How do bats find new sources of water? Where and when is water needed most for bats?
- If new water sources are constructed, how successful are they in mitigating the loss of historic water sources or preventing bats from using contaminated sources?

COMBINATION OF MULTIPLE IMPACTS

Fragmentation and water loss could lead to underestimated impacts to bats.

GOAL

PRESERVE/CONSERVE AND IMPROVE BAT HABITAT THROUGH LAND USE PLANNING.

Objective 1: Refer developers to existing policies and rules by the COGCC regulating oil and gas development in the state including conserving wildlife and wildlife habitat, and to the BLM and USFS for projects being developed on federal lands. Also, reference other supportive guidelines, such as those by the Colorado Mule Deer Association and Colorado Wildlife Federation (2006).

Objective 2: Consult with the CPW, the BLM, and USFS to conserve bat habitat using land use planning.

Objective 3: Provide information to land managers and county planners about the importance of these habitats to bats and other wildlife, and conservation strategies to minimize potential impacts to their habitats.

MANAGEMENT RECOMMENDATIONS

- Mitigate for fragmentation and water loss on a landscape scale by working with wetland banking programs and land trusts that purchase easements in Colorado.

RESEARCH NEEDS

- Are there different requirements for different species related to connectivity of water to habitat?

OTHER IMPACTS

Bats could experience reduced fitness or increased mortality due to bioaccumulation of chemicals in insect prey (O'Shea et al. 2001; O'Shea and Johnston 2009). Fresh water storage containers could cause mortality to bats which are unable to escape accidentally falling into containers with lips higher than water level and no escape ramps. It has been documented that hydraulic fracturing can cause seismic activity (McGarr et al. 2015) which has the potential to disturb roosting bats.

GOAL

REDUCE THESE POTENTIAL IMPACTS TO BATS THROUGH RESEARCH AND INFORMATION EXCHANGE.

Objective 1: Refer developers to existing policies and rules by the COGCC regulating oil and gas development in the state including conserving wildlife and wildlife habitat, and to the BLM and USFS for projects being developed on federal lands. Also, reference other supportive guidelines, such as those by the Colorado Mule Deer Association and Colorado Wildlife Federation (2006).

Objective 2: Encourage research into contamination, water storage, and roost disturbance issues to determine and understand the actual impacts to bats.

Objective 3: Disseminate relevant research to the COGCC, CPW, BLM, USFS, and developers/operators through educational workshops to assist in updating oil and gas rules as they relate to bat species.

MANAGEMENT RECOMMENDATIONS

- Require closed-looped systems to limit exposure of insects or wildlife to contaminated water.
- Require and maintain escape ramps for open water containers during consultation for wildlife.
- Avoid development near karst regions or known subterranean habitat as specified by BLM and USFS Environmental Impact Statements.

RESEARCH NEEDS

- Are chemicals being accumulated in bats in oil and gas development areas and what are the sources? How does this affect the fitness of bats?
- How often is water storage units used in current oil and gas development? Do current bat escape ramps work for water storage units?
- Does hydraulic fracturing impact subterranean use by bats and how?

SOLAR POTENTIAL AND TECHNOLOGY

Due to the increasing interest to develop renewable energy alternatives, solar energy is under development throughout the United States with an emphasis in the western U.S. The US Department of Energy's (USDOE) SunShot Initiative estimates solar energy could meet 14% of U.S. electricity demand by 2030, and 27% by 2050 (USDOE 2012). In 2004, Colorado became the first state in the U.S. to adopt a renewable energy standard (RES) which has since been updated to a goal of 30% by 2020, and includes various incentives for solar energy generation (GEO 2010). Colorado currently ranks 8th in the country in installed solar capacity (SEIA 2014). Government-led initiatives to facilitate utility-scale solar energy development on public lands include the programmatic environmental impact statement (PEIS) for solar energy by the BLM and the USDOE in 6 southwestern states, including Colorado (BLM 2010; Fig. 8.5). Under the PEIS, a total of 16,308 acres among 4 sites (solar energy zones) on BLM-administered lands in Colorado were designated for development with the potential for expansion to 95,128 acres under the preferred program alternative. In Colorado, the estimated solar energy potential is highest in the southern half of the state, especially within the San Luis Valley, which also includes the BLM-proposed solar energy zones (Figs. 8.6 and 8.7). However, the majority of utility solar development in eastern

Figure 8.5. Photovoltaic panels at the SunPower power plant in Alamosa County, Colorado. Photo by K. Navo.

Colorado is currently occurring on private lands necessitating a cooperative approach with landowners and utility providers towards education and research needs related to bat interactions with solar development.

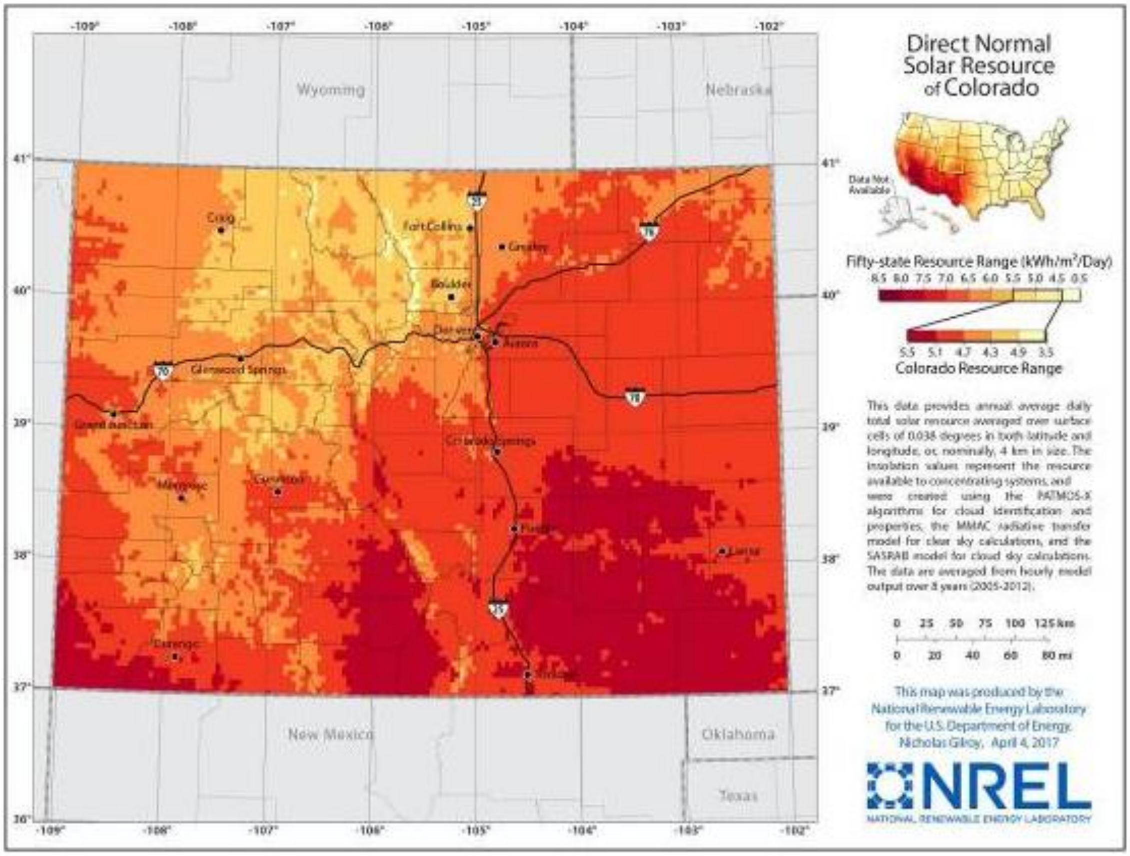

Figure 8.6. The annual average daily total solar resource available for concentrating solar arrays as estimated for Colorado between 2005-2012 (NREL, https://www.nrel.gov/gis/solar.html , Accessed December 2017). Areas depicted with the highest resource range (kWh/m2/Day) are shown in dark red and would be the most likely locations for installation of large solar arrays. Estimates are calculated as the direct normal irradiance, or the amount of solar radiation per unit area received by a surface, such as tracking photovoltaics, that keep sun perpendicular to the panel's surface. This map was created by the National Renewable Energy Laboratory for the US Department of Energy.

The two basic methods of solar technology are photovoltaic (PV) panels and concentrating solar power (CSP). Photovoltaic panels turn sunlight directly into electricity through silicon or thin-film semiconductor material and are typically clustered into rows of panels (Fig, 8.5). Concentrating solar power technologies use heat from the sun to generate electricity and are made up of 3 main types, which include parabolic trough (Fig. 8.8), dish engine (Fig. 8.8), and power tower systems (Fig. 8.9). Direct Normal Irradiance is the amount of solar radiation received per unit area by a surface that is always held perpendicular (or normal) to the rays that come in a straight line from the direction of the sun at its current position in the sky. Typically, you can maximize the amount of irradiance annually received by a surface by keeping it perpendicular to incoming radiation. This quantity is of particular interest to concentrating solar thermal installations and installations that track the position of the sun.

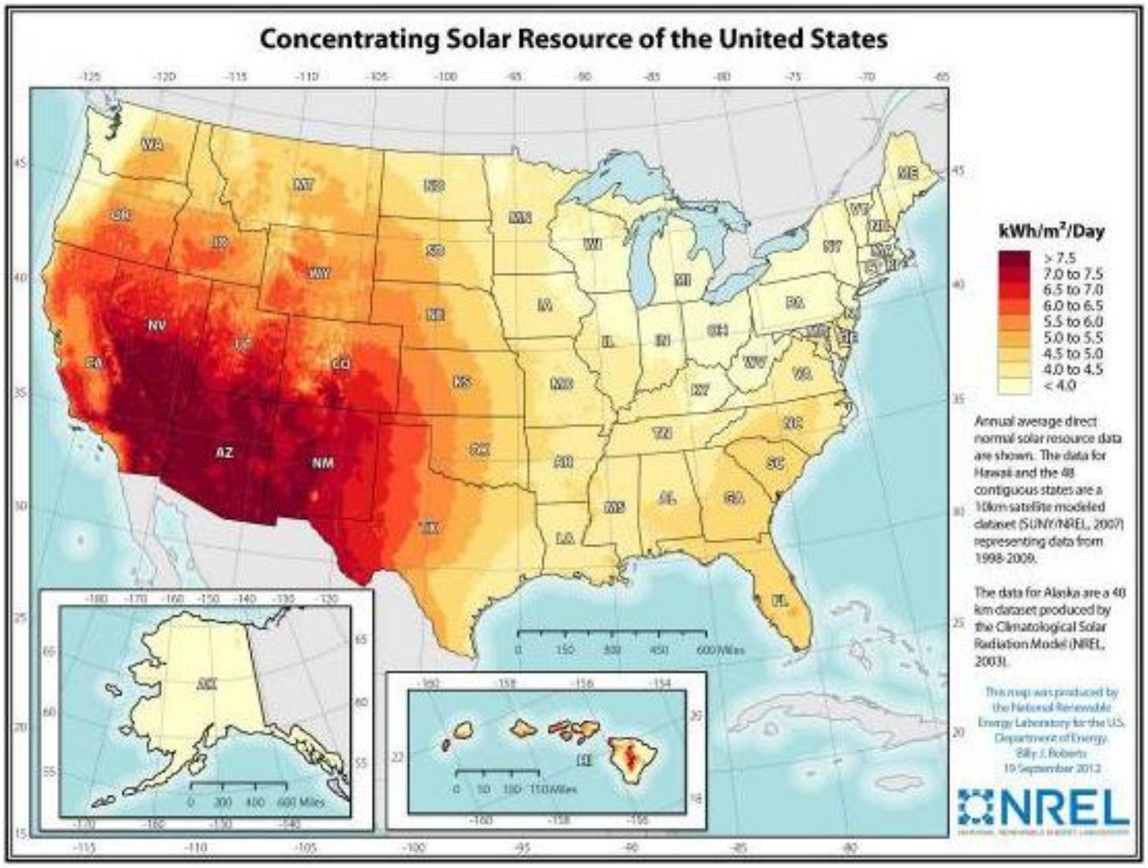

Figure 8.7. Potential for concentrating solar resources in Colorado from 1998-2009 (Renewable Energy Laboratory, https://www.nrel.gov/gis/solar.html, Accessed December 2017).This map was created by the National Renewable Energy Laboratory for the US Department of Energy.

Figure 8.8. Parabolic trough facility in California and dish engine facility in New Mexico. Adapted from BLM (2010).

Although wind energy accounts for the majority of bat fatalities from energy development, there is anecdotal information that solar energy may cause some direct and indirect mortality. For example, a solar energy project in Riverside County, CA found 11 bat mortalities throughout the project area over the 6 month construction period of the facility. It is unclear what caused the fatalities (Tetra Tech 2014). Bird fatalities at similar facilities have resulted indirectly from ingestion of heat transfer chemicals found in evaporation ponds. Concentrating solar power technologies might also cause direct mortality by incinerating birds and bats that pass through these areas of high heat concentration. Consequently, implementation of monitoring plans at these facilities is needed to discern the level of impact they have on bats (Tetra Tech 2014).

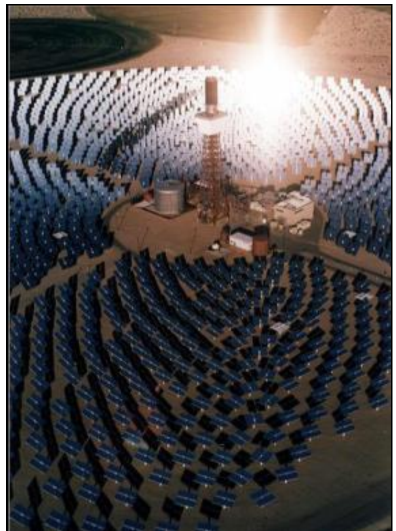

Figure 8.9. Power Tower facility in California. Adapted from BLM (2010).

GOAL

MINIMIZE THE NEGATIVE IMPACTS OR FATALITIES TO BATS FROM SOLAR DEVELOPMENT.

Objective 1: Develop mitigation funds to conduct habitat improvements beneficial to bats in areas adjacent to those lost to large solar array installations.

Objective 2: Avoid construction of solar installations that use mirrors in areas shown to have high bat activity to minimize potential for incineration or chemical contamination of individuals.

MANAGEMENT RECOMMENDATIONS

- Work cooperatively with the solar industry to determine risks to bats either through behavior studies or fatality monitoring at solar facilities.
- Encourage county permitting to request pre and post construction monitoring for bats at sites proposed for large solar arrays.
- If collision is documented, develop guidelines to monitor and understand extent of impacts and provide guidance on avoiding important bat areas, at least until the level of impact is better understood.

RESEARCH NEEDS

- Determine the degree to which bats collide with solar structures. Develop studies to evaluate bat behavior around solar structures such as attraction to smooth surfaces (solar panels), evaporative ponds, and heat sources (concentrated solar towers).

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