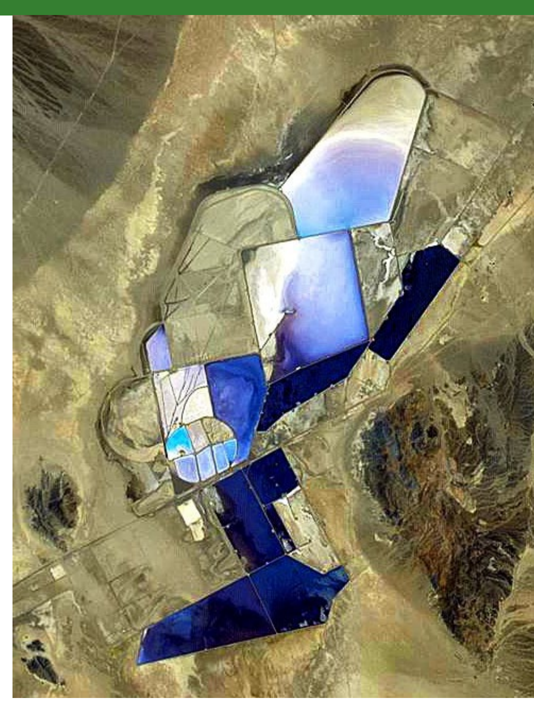
The Nature Conservancy

Potential Lithium Extraction in the United States: Environmental, Economic, and Policy Implications

AUGUST 2022



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PREFERRED CITATION

Parker SS, Franklin BS, Williams A, Cohen BS, Clifford, MJ, Rohde MM, 2022. Potential Lithium Extraction in the United States: Environmental, Economic, and Policy Implications.

Available at: https://www.scienceforconservation.org/products/lithium

SUPPLEMENTAL INFORMATION

Please see: https://tnc.box.com/s/d1d8thktxaohhbb3hwnyjukgxvnusgmk

ACKNOWLEDGEMENTS

We thank the members of The Nature Conservancy's Lithium Team for their participation in gathering information for this report, and for many additional individuals in providing feedback as the report was generated, including: Jason Albritton, Sue Bellagamba, Marybeth Benton, Laura Brannen, Dick Cameron, Laura Crane, Maggie Eshleman, Bob Findling, Lucas Frerichs, Garth Fuller, Heather Gately, Dr. Ryan Haugo, Nicole Hill, Nels Johnson, Dr. Liz Kalies, Mark Kramer, Jaina Moan, Ann Neville, Michael Schindel, Elaine York, and Douglas Zollner. We also thank Andy Zdon and Rachel Maxwell of Roux Associates, Inc., Dr. Naomi Fraga of the California Botanic Garden, and several others for their expertise. A complete list of contributors can be found in Supplemental Information B.

This work was supported by The Nature Conservancy's California Science Catalyst Fund.

Table of Contents

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Global climate change poses an existential threat to the welfare of the planet and its inhabitants, and must be addressed in part by reducing anthropogenic emissions of heat-trapping gases such as carbon dioxide to the atmosphere. Emission reduction policies are spurring renewable energy development and electric vehicle deployment, both of which require rechargeable batteries for energy storage. **Lithium-ion batteries have become the most widely used** in electric vehicles and portable electronic devices, and may be used in grid storage systems as well.

Demand for lithium has grown quickly in recent years, as has interest in expanding the geography of lithium production. As of 2022, less than 1% of global lithium production was occurring in the United States at a single facility located in Silver Peak, Nevada (USGS 2022). Nevertheless, **the U.S. has substantial lithium resources** and could be a major global producer of lithium. In the contiguous U.S., industry interest in pursuing lithium production from lithium-containing rocks, clays, and brines falls within nine states: Arizona, Arkansas, California, New Mexico, Nevada, North Carolina, Oregon, Utah, and Wyoming.

Lithium can be extracted from two main sources (brine and hard rock/clays) using three main extraction methods: direct lithium extraction (DLE) from brine, evaporative concentration from brine, and surface mining. We conducted an assessment that included three components:

1. **An overview of the potential environmental impacts associated with each extraction method, and a detailed analysis of potential environmental impacts at 72 proposed extraction sites;**
2. **An analysis of economic impacts of potential future lithium extraction;**
3. **A policy analysis based on stakeholder input from two locations: Salton Sea, California, and Thacker Pass, Nevada.**

While all extraction methods have the potential for some environmental impact, **DLE has the potential to have a smaller environmental impact than either surface mining or evaporative extraction.**

Following these seven guidelines would help minimize the environmental impacts of lithium extraction:

1. Prioritize projects that **avoid or minimize impacts on species or ecosystems.** Any federal or state incentives should only reward or be offered to the least impactful extraction approaches.
2. **Prioritize projects that use direct lithium extraction from brine. Analyze connectivity between lithium-containing underground brines and other groundwater or surface waters**. Based on findings of the analysis, require implementation of adequate environmental oversight and triggers to prevent ecological harm and groundwater depletion. In the arid west, triggers should be based on modeling given the long lag time between water extraction and natural recharge.
3. Post extraction, **re-inject brine into the same aquifer** from which it was removed.
4. Post-extraction brine should be **contaminant-free** to minimize re-injection risks.
5. Ensure that **water use by all processes at the extraction site can be accommodated** without causing a drop in the water table that would impact species or habitats dependent on groundwater. Water use for lithium extraction must be considered in light of all other uses of water within the region.
6. **Ensure that all waste streams resulting from extraction and processing of brine are properly managed** and that waste does not pose a hazard for human health or wildlife, or result in contamination of air, water, or soils. Ensure reclamation over the long term through bonds or other measures.
7. **Prioritize projects where pre-existing infrastructure is present at the site**, i.e., brine is already pumped and reinjected at the site for some other purpose and adding lithium extraction to the site would not necessitate additional disturbance of lands.

Notably, one cannot rank potential environmental impact by extraction method alone. The environmental impacts of lithium extraction are a function of the extraction method, technology used, the scale of production, and specific ecological and hydrological conditions present at an extraction site. For example, a lithium extraction site using evaporative concentration of brine could potentially be just as impactful to lands and waters as a hard rock pit mine site. Conversely, a strip-mined site might not use much water on-site if clays from a playa are removed and transported elsewhere for processing.

Hundreds of species have been recorded within the 72 proposed lithium extraction sites, including **248 rare and/or special status species**. Wetland habitats occur within extraction sites in all nine states. To engage further in understanding the site-specific risks of lithium extraction, more detailed analyses must be performed. These will require in-depth analyses of hydrogeology, as groundwater issues are key to understanding impacts at a lithium extraction site. Given that many of the species recorded at proposed extraction sites are wetland-dependent, **a future analysis of cumulative impacts on wetland habitats and the species they support is needed** to fully understand the impact of lithium extraction at a regional to continental scale.

For our economic analysis, we found that based on 2021 global lithium demand, **the contiguous United States has enough lithium to potentially supply the world for over a century**. However, the extent to which these lithium resources will be extracted depends on both further development of new techniques such as DLE and economic considerations. **The lithium market is very dynamic**, current demand is increasing rapidly, and prices are very high as demand cannot be fully met by available supply. Increases in supply will occur over a number of years as developing new projects or expanding existing ones can be a lengthy process. Firms will make decisions about whether to pursue individual lithium projects depending on forecasted prices and technical and economic considerations. The concentration of lithium resources considered economically viable will likely fluctuate due to these factors.

In some states, lithium extraction may generate significant economic benefits including increases in state GDP, tax revenue, employment in the mining sector, and strategic advantages such as proximity to electric vehicle manufacturers. However, **local economic benefits may not be impactful if adequate policy guidelines and workforce development partnerships are not in place**. In particular, lithium projects in rural areas may have difficulty finding job candidates trained with the right skills locally and may therefore recruit from outside the region.

Many lithium deposits occur in rural areas and impacts to these economies and communities will be significant. From interviews conducted with a small group of stakeholders in the Salton Sea region, we found that there is a perception of great opportunity posed by the presence of substantial lithium resources in brine. Stakeholders also expressed that there may be less environmental impact when extracting lithium in the Salton Sea when compared with other regions, given the plans to use DLE at the Salton Sea. However, stakeholders also pointed to many unknowns. The Salton Sea region is currently plagued by very poor air quality, and one stakeholder expressed support for a cumulative impacts analysis of extraction in the region through a Programmatic Environmental Impacts Report. Salton Sea stakeholders acknowledged that lithium extraction may economically benefit the community, but they cautioned that benefits would stem from how the federal, state, and local governments administer their plans.

Lithium extraction in the U.S. involves emerging technologies and novel processes. Expertise on these topics is limited in government and industry, and in communities. **The technologies and impacts involved in lithium extraction must be communicated to communities in a manner that is understandable**. Salton Sea stakeholders acknowledged that community engagement has occurred in their region, but they stated that the meeting format did not allow for enough engagement. Additionally, community organizations interviewed noted that the limited amount of information – most sourced directly from industry – was often very technical and not written for non-expert audiences, limiting the amount of information available to advocate for policies on behalf of their communities. Stakeholders for Thacker Pass noted similar concerns.

Beyond developing guidance for minimizing the negative impacts of lithium extraction, it is helpful to take a step back and frame the demand for lithium within the broader context of energy use and societal consumption. Current demand for lithium is driven by efforts to replace internal combustion engine vehicles with electric vehicles, a process that has just begun. Therefore, the demand for lithium is likely to remain high for decades to come. Lithium supply may be increased in part by developing a domestic battery recycling industry. Approaches that consider how lithium factors into the larger context of energy use may not only help meet current and future lithium demand, but could also reduce the use of fossil fuels, and help to address climate change.


Photo © United States Fish and Wildlife Service

Introduction

Global climate change, driven by anthropogenic activities, poses an existential threat to the welfare of the planet and its inhabitants. Disruption of human societies and political structures (Schwartz and Randall 2003; Zhang et al. 2007; Kaniewski et al. 2017) and severe impacts to natural systems (Parmesan and Yohe 2003; Harley et al. 2006) are expected as climate change proceeds. Scientists agree that to avoid the worst impacts of climate change, we need to limit global mean annual warming to 1.5 °C in this century (Tollefson 2018).

Climate change must be addressed in part by reducing anthropogenic emissions of heat-trapping gases such as carbon dioxide (CO_2) into the atmosphere. As a major source of greenhouse gas emissions, fossil fuel combustion underpins the energy, transportation, industrial, commercial, agricultural, and other sectors of most human societies (Day et al. 2018; United States Environmental Protection Agency 2022). The transportation sector represents the largest emitter in the U.S., accounting for 27% of general greenhouse gas emissions in 2020 (United States Environmental Protection Agency 2020). Many nations have made commitments to reduce greenhouse emissions by curbing fossil fuel use (Paris Agreement 2015) and transitioning towards renewable and other lower carbon-emitting sources of energy.

Emission reduction policies have been enacted at national, state, and local levels, and are driving renewable energy development and electric vehicle deployment. In 2021, the United States made a commitment to reduce greenhouse gas pollution by 50% from 2005 levels by 2030 (United Nations Framework Convention on Climate Change 2021). To achieve this target, the U.S. is making public investments in infrastructure such as carbon-free electric grids and electric car charging stations. Finding solutions to transition the transportation sector away from fossil fuel use will be essential to reduce emissions, and technological advances over the last two decades have started to show promise in aiding this transition. For example, electric vehicle registrations in the U.S. grew from 600,000 to 1.8 million between 2016 and 2020 (International Energy Agency 2021), and are expected to grow to 25-30% of the new car market in the U.S. by 2030 (S&P Global 2021).

As nations begin to "decarbonize" (Kueppers et al. 2021) and transition to renewable energy and electric vehicle use, new challenges emerge. Chief among these is the need to rapidly expand the production and use of rechargeable batteries in both transportation and grid energy storage applications. While many battery chemistries exist, lithium-ion batteries have become the most widely used in electric vehicles (Liu et al. 2022) and portable electronic devices (Liang et al. 2019), and may be used in grid storage systems as well (Hesse et al. 2017; Environmental and Energy Study Institute 2019).

Lithium is a soft, white, and light alkali metal that is found in a wide variety of chemical compounds at low concentrations in rock, soils, sediments, and fresh and saline waters. Lithium is mined from rock or clay or extracted from hypersaline brine present in surface and underground water bodies. Once refined, it is incorporated in batteries (Tabelin et al. 2021), where it may be present in either the anode or cathode in combination with nickel, cobalt, and either aluminum and manganese oxides, iron phosphates, or other compounds such as graphite (Stan et al. 2014). Given their widespread use as of 2022, lithium-ion batteries are likely to remain a top choice for vehicle manufacturers over at least the next decade (Federal Consortium for Advanced Batteries 2021).

Long-term projections of lithium demand have increased over the past decade. While an estimated 100,000 tons of lithium metal was needed in 2021 to meet the global demand (USGS 2022), projected demand is set to reach 415,000 tons of lithium metal by 2050 (Tabelin et al., 2021). To meet this demand, the lithium mining industry may require an estimated investment of $10 to $12 billion of private capital over the next decade (Kaunda 2020). Doubts exist as to whether production can meet future demand for alternative vehicles (Martin et al. 2017; Tabelin et al. 2021; Vikström et al. 2013). Consequently, the expansion of existing extraction sites and the development of new sites are required to meet future growth.

Demand for lithium has grown as electric vehicle manufacturing has expanded, leading to speculation and interest in expanding the geography of lithium production, which would expand the geography of lithium mining impacts. As of 2019, lithium was produced primarily in Australia (55%), Chile (23%), China (10%), Argentina (8%), and Zimbabwe (2%) (LaRocca 2020), with less than 1% of production occurring in the United States at a single facility located in Silver Peak, Nevada. Nevertheless, deposits of lithium-containing rocks, clays, and brines are scattered across the contiguous United States (Hammarstrom et al. 2019), and we estimate that Nevada alone has the potential to supply the world with lithium for 85 years at 2021 demand levels (USGS 2022; Karl 2019).

Interest in domestic production of lithium is spurred by a strong and growing demand for electric vehicles (Kittner et al. 2020) and commitments by several U.S. states to 100% renewable energy (Clean Energy States Alliance 2022), which will necessitate grid power storage (Castillo et al. 2014). These activities are crucial for addressing climate change by reducing greenhouse gas emissions, and lithium is critical to that reduction for the foreseeable future. While conflicts between local communities and lithium production have received some attention in the literature (Dorn and Peyré 2020; Deberdt and Le Billon 2021; Jerez et al. 2021), we know of no study that assesses the potential environmental and economic impacts of future lithium production in the United States. By understanding the range of environmental impacts of different lithium extraction methods, we can both achieve lithium production at scale and prioritize the least environmentally harmful methods and technologies first.

Clayton Valley. Photo © Stuart Rankin, cropped version used under a Creative Commons Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0) license.

The environmental impacts of lithium extraction depend on the extraction method, technology used, the scale of production, and specific ecological and hydrological conditions present at an extraction site. Lithium mined from hard rock and clay may result in impacts that are well-documented for strip mining and open-pit mining, including physical disturbance of soils and vegetation (Kosai et al. 2020); air emissions and deposition (Rodrigues et al. 2019); stream sedimentation; potential contamination of soils, sediments, and ground and surface waters (Kaunda 2020); and groundwater and surface water depletion (Schomberg et al. 2021). Water depletion is of particular conservation concern in the face of climate change in the Western U.S., where the majority of domestic lithium resources are located.

Groundwater may be used for a variety of purposes at hard rock and clay mining operations, including dewatering, dust control, and normal domestic and industrial process uses. In some cases, brines may be in hydraulic connection with less saline groundwater supporting wetlands and groundwater-dependent ecosystems. Besides groundwater-level declines, changes in groundwater conditions (due to either extraction, injection, or both), may have the effect of mobilizing poorer quality waters (e.g., saline waters) to impact higher quality groundwater and the ecosystems that the higher quality waters may support.

Lithium extracted from brines may have varied impacts, with the potential for large areas of land, particularly near desert playas, to be disturbed and large amounts of water consumed when brackish groundwater is pumped ("brine pumping") or evaporative ponds are used (Flexer et al. 2018, Kaunda 2020). Studies from South America, such as the Salar de Atacama and Laguna Lagunillas basin, have demonstrated how brine pumping for mineral extraction results in groundwater level declines that disrupt sensitive wetland ecosystems and the organisms al. 2019; Gutiérrez et al. 2022).

Direct lithium extraction from brine (Figure 1), without the use of evaporative ponds, may result in less land disturbance and less water use if the brine is extracted from deep aquifers that are disconnected from freshwater aquifers, surface waters, and vegetation. However, chemical processing and refinement of lithium is still required post-extraction (Warren 2021), independent of whether lithium is derived from hard rock, clay, or brine. Therefore, even direct lithium extraction can result in some impacts to lands and waters if not managed properly. In all cases, preliminary baseline hydrologic data collection and associated analyses are required to evaluate connectivity between groundwater extraction that would occur during lithium mining and the human and natural communities dependent on that water. Given the wide range of lithium deposits and mining techniques, and the uniqueness of groundwater-dependent ecosystems from one location to the next, these connections should be evaluated on a case-by-case basis.

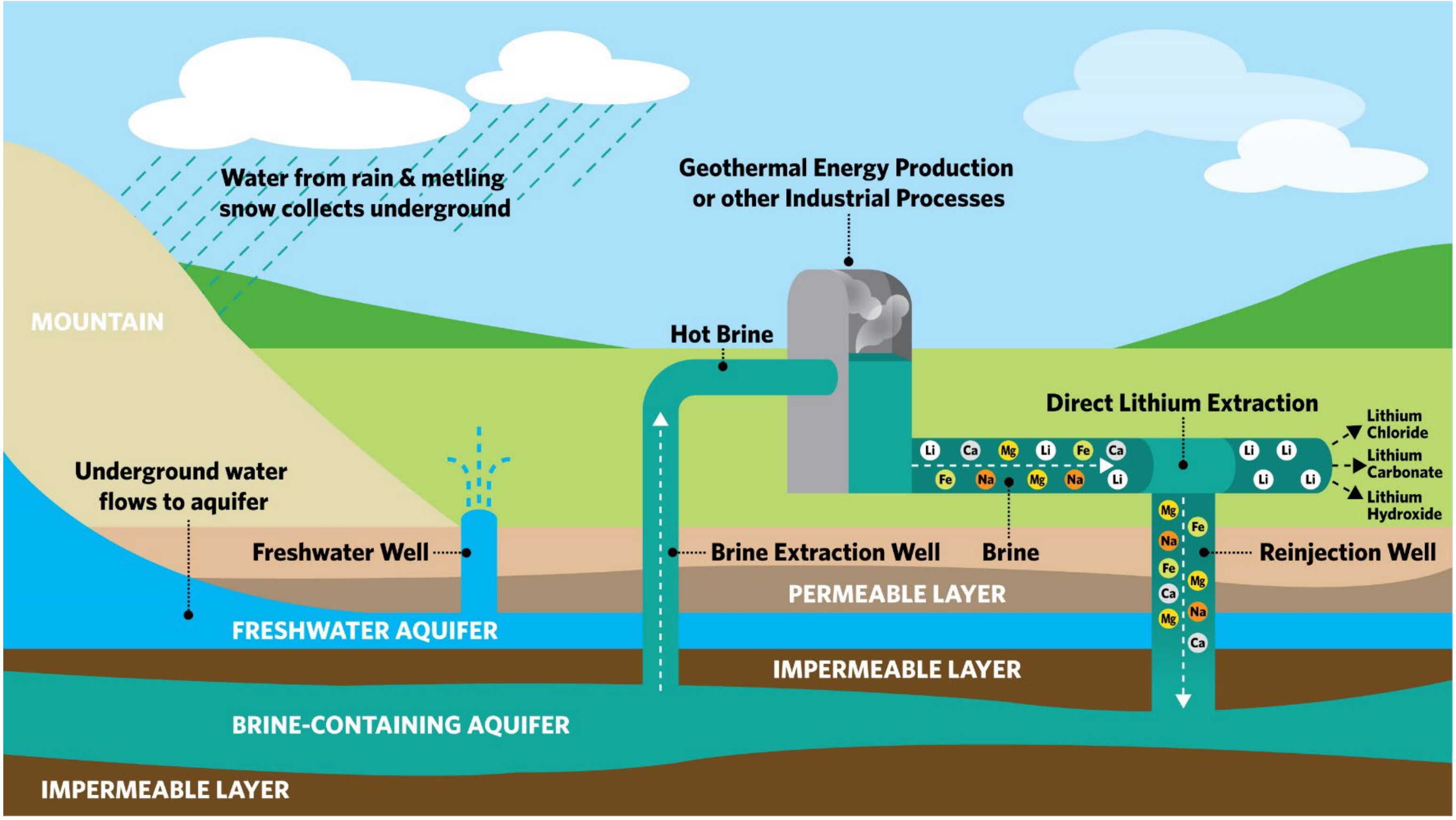

Figure 1. Direct lithium extraction (DLE) from brine

Here we present an assessment of the environmental impacts, economic impacts, and policy implications of potential lithium extraction in the contiguous United States. Our assessment includes an overview of the potential environmental impacts associated with different extraction methods, and a detailed analysis of potential environmental impacts at 72 proposed extraction sites; an analysis of economic impacts of potential future lithium extraction, and a policy analysis based on stakeholder input from two locations: Salton Sea, California, and Thacker Pass, Nevada.

Study Extent and Limitations

Our assessment is focused on the environmental and economic impacts of potential future lithium extraction within the contiguous United States. Within this portion of the U.S., the presence of lithium-containing rocks, clays, or brines, and industry interest in pursuing lithium production, fall within nine U.S. states: Arizona, Arkansas, California, New Mexico, Nevada, North Carolina, Oregon, Utah, and Wyoming (please see Methods for the complete site selection methodology). We acknowledge that new lithium extraction sites are frequently proposed by mining interests, and we are aware of two new sites in Oregon that have been proposed since our assessment was completed in 2022 (please see state-by-state results for Oregon). These two sites are not included in our analysis.

Our analysis does not address several important topics related to lithium production and use in the United States, including the impacts of extraction on cultural heritage and tribal lands, air quality impacts, public health concerns, or environmental justice or socio-economic impacts. Additionally, we only touch on the role of recycling in the lithium supply chain, and we do not cover the potential use of mining waste as a source of lithium or full life-cycle assessments of lithium battery or electric vehicle production.

We acknowledge that considerations related to cultural heritage and tribal lands are of the utmost importance when making land use decisions. We advise against using the results of this assessment without further inquiry into the potential impacts that lithium extraction could have on cultural heritage and tribal lands. Additionally, we recognize that lithium extraction could have negative impacts on air quality and public health, and that there could be environmental justice and socio-economic concerns associated with lithium extraction. We hope that by making the full results of our assessment freely available online, we will enable others with expertise in these topics to conduct impact assessments of their own. We stand ready to collaborate in such efforts.

While not considered in this assessment, recycling may be an important part of the lithium supply chain in the future (Ziemann 2018). Recent research indicates that recycled lithium-ion batteries can perform better than new lithium-ion batteries; researchers have developed a recycling method that generates more charging pore space on the cathode, which allows for a higher lithium chemical diffusion coefficient (they charge faster) and better strain mitigation (they are less brittle and withstand the charging/discharging process better) (Ma et al. 2021). We recognize that other studies provide life-cycle analyses of lithium batteries and electric vehicles (Liang et al. 2017), and that at least one mining company has begun to use waste rock from a boron mining site to produce lithium (Parkinson 2019). However, these topics are not included in our assessment.

Lilac Sunbonnets (*Langloisia setosissima* ssp. *punctata*). Photo © Jim Morefield, used under a Creative Commons Attribution ShareAlike 2.0 Generic (CC BY-SA 2.0) license

Environmental Impacts

Methods

Our assessment of the environmental impacts of potential lithium extraction had two parts: (1) an investigation of the potential impacts of different extraction technologies, and (2) a state-by-state analysis of potential impacts. The investigation of the potential impacts of different extraction technologies was based on literature review and consultation with natural resource experts in the non-profit, academic, and agency sectors. A detailed methodology for the state-by-state analysis is presented below.

Our first step in conducting a state-by-state analysis of the environmental impacts of potential lithium extraction was to determine where lithium may be extracted domestically. We conducted a search of U.S. government online databases for spatial data layers depicting lithium resources in the United States. From the USGS, we used Dicken and Hammarstrom (2020), which provides polygons depicting "focus areas" for domestic sources of lithium. We also used the U.S. Department of Energy's Geothermal Data repository to map locations with various concentrations of lithium in geothermal brine across the lower 48 United States (Figure 2).

Next, we cross-referenced the locations depicted in these two data layers with information gleaned from searches of state geological resource agencies related to mineral claims, press releases, news articles, and industry websites related to lithium production to determine where mining companies have a stated interest in producing lithium domestically. Using this information, we developed a list of 72 proposed lithium extraction sites in the lower 48 United States (see Supplemental Information A). These proposed lithium extraction sites fall within nine U.S. states: Arizona, Arkansas, California, New Mexico, Nevada, North Carolina, Oregon, Utah, and Wyoming (Figure 2).

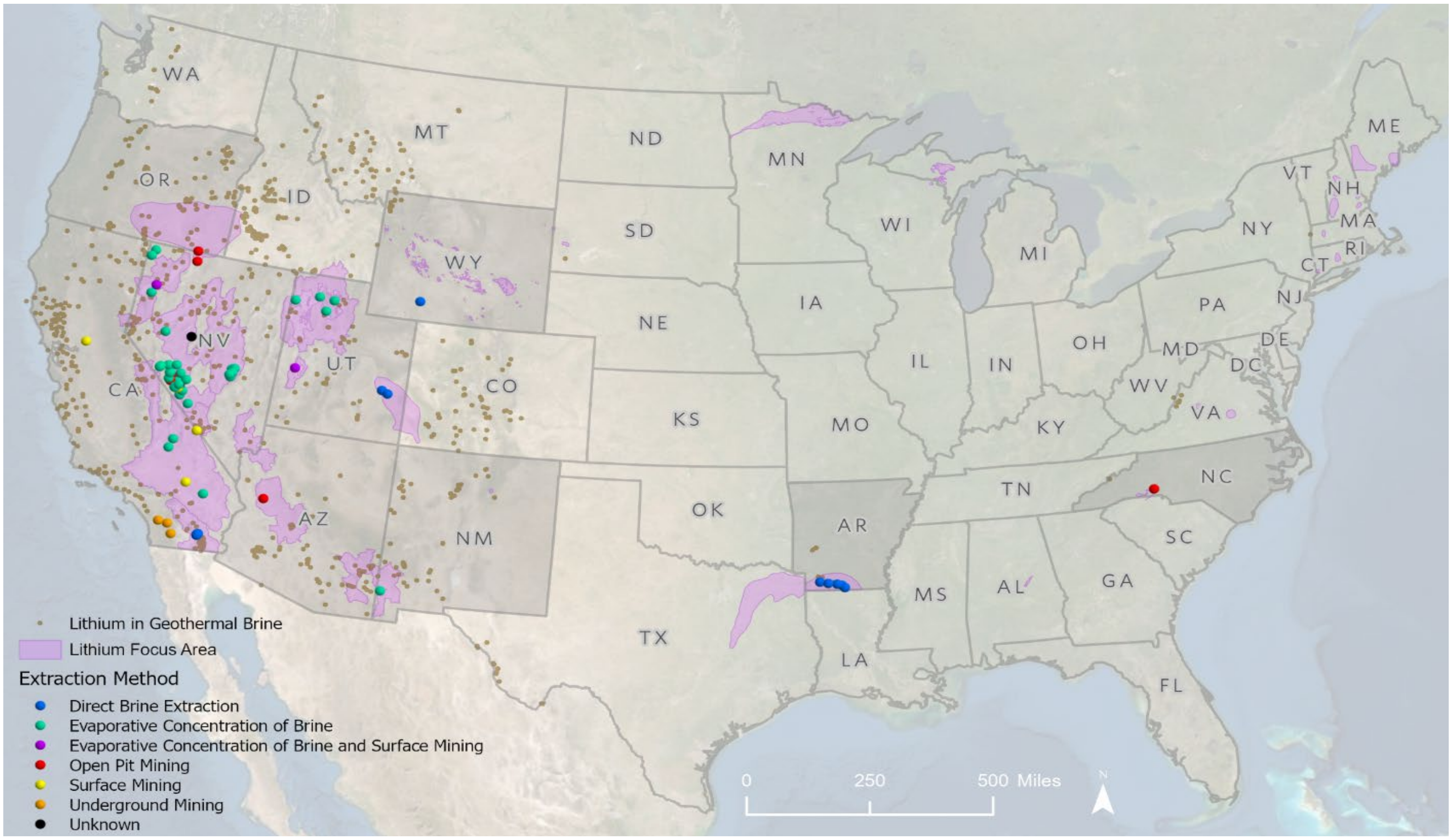

Figure 2. The nine states (Arizona, Arkansas, California, New Mexico, Nevada, North Carolina, Oregon, Utah, and Wyoming) that include 72 proposed lithium extraction sites. The pink regions are Lithium Focus Areas from Dicken and Hammarstrom (2020). The light brown dots depict the location of lithium in geothermal brines, and the colored dots depict different extraction methods.

The list of proposed lithium extraction sites was vetted with our broader research team, which includes individuals working within the TNC chapter within each of the nine states who were familiar with the local conditions. The list was amended using the expertise of these individuals, and that of a broader group of natural resource experts in the non-profit, academic, and agency sectors (see Supplemental Information B).

We deemed each proposed lithium extraction site as a separate "Project" and provided each Project with a unique identifying name and number. We also gathered the following information for each Project:

1. "Project Location" and "Project Site" – Project Locations were mapped in a geographic information system (GIS) using information available from lithium producers, or via claim data from state geological resource agencies. The Project Location was in most cases the boundary of the administrative mining claim, and therefore includes, but is generally larger than, the area where ground disturbance is planned. Where no polygon of a Project Location was available, we mapped the playa or other lithium-related geological feature using input from experts to capture the potential spatial extent of the Project Location. In addition to the Project Location, we mapped the Project Site, which we defined as a polygon drawn by adding a two-mile buffer zone around each Project Location. While the Project Site is meant to capture the potential spatial extent of impacts of the project beyond the administrative claim, the real impacts of any particular project may be greater or smaller than the mapped Project Site. Because the two-mile buffer is always applied, the Project Site to Project Location ratio is much larger for smaller Project Locations (Figure 3).
2. Companies involved in lithium extraction
3. Resource type (hard rock/clay or brine)
4. Extraction method (direct lithium extraction from brine, evaporative concentration of lithium from brine, surface mining, or underground mining)
5. Presence of existing extraction infrastructure at the Project Site

Next, to investigate potential environmental impacts of lithium extraction at each Project Site, we analyzed the overlap between the Project Site and the following GIS layers (see Supplemental Information C for additional details about data sources):

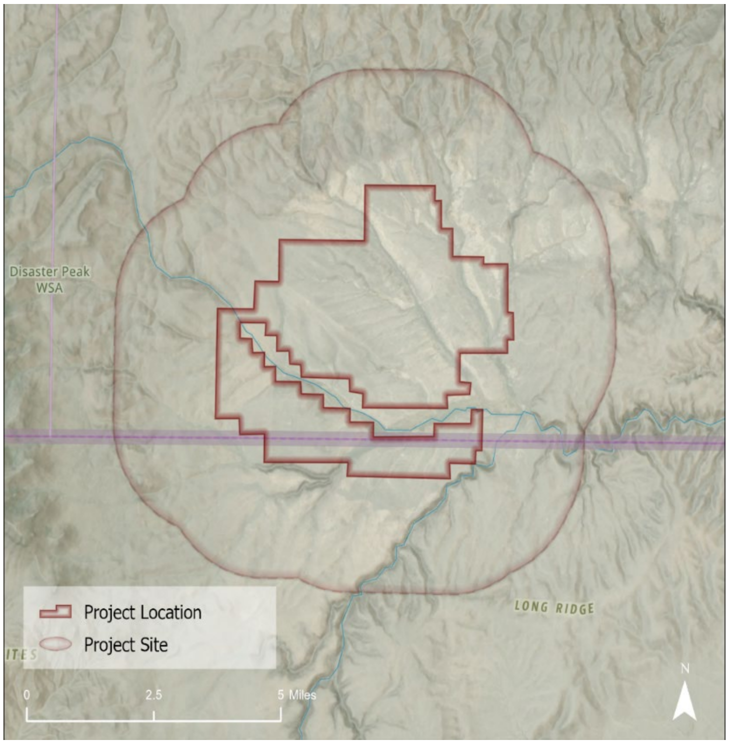

Figure 3. Example of a Project Locations vs. a Project Site

1. Agriculture
    a. Prime Farmland
2. Conservation Value
    a. Important Bird Area
    b. State Conservation Value
    c. TNC Conservation Value
    d. TNC Resilient and Connected Network (RCN): https://maps.tnc.org/resilientland/
3. Habitat
    a. Bald Eagle
    b. Bat
    c. Big Game Habitat
    d. Bighorn Sheep
    e. Connectivity
    f. Critical Habitat
    g. Desert Tortoise
    h. Golden Eagle
    i. Grassland Birds
    j. Grasslands
    k. Intact Habitat
    l. Mule Deer
    m. Prairie Dog
    n. Pronghorn
    o. Sage Grouse
    p. Sagebrush
    q. Vernal Pool
    r. Wetlands

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4. Species and Natural Communities/Features
    a. State Natural Heritage Data
    b. Citizen Science Data
5. Management
    a. ACEC
    b. BLM (Bureau of Land Management) Solar Energy Program
    c. BLM Right of Way Exclusion
    d. BLM SRMA
    e. BLM OHV
    f. Conservation Easement
    g. Existing Conservation and Mitigation Bank
    h. GAP 1 Land
    i. GAP 2 Land
    j. Habitat Conservation Plan
    k. Inyo Exclusions
    l. National Park Service
    m. National Monument
    n. National Wildlife Area
    o. National Conservation Land
    p. National Scenic Trail
    q. National Register of Historic Places
    r. Protected Land
    s. Roadless Area
    t. Scenic Highway
    u. Special Recreation Management Area
    v. State Park
    w. State Wilderness Area
    x. Visual Resource
    y. Wild and Scenic River
    z. Wilderness
    aa. Wilderness Characteristics

While we sought to analyze a wide range of potential impacts on regulated and non-regulated resources from projects, we do not intend for this work to be an alternative to more detailed impact assessments that would precede appropriate permitting and regulatory approvals.

Results

Potential Impacts of Different Extraction Technologies

BRINE

Direct lithium extraction from brine at pre-existing industrial sites

Where industrial facilities already exist, and where underground brine is already pumped to the earth's surface, direct lithium extraction (DLE) activities could be co-located within the existing industrial footprint, and there is the possibility that no additional land would need to be disturbed to extract lithium. As of 2022, several different DLE technologies are being explored by different companies, but there are no commercially viable DLE facilities that are currently operating.

In some cases, DLE could be added to a pre-existing industrial process. For example, brine is currently being processed for the extraction of other chemical constituents, including bromine, at the Smackover formation in Arkansas. At the Salton Sea in California, geothermal brine is used to generate electricity. Each facility already has a significant industrial footprint that includes buildings, roads, and other infrastructure, and additional land disturbance may not be required to accommodate the incorporation of DLE into the current activities at the facility (or the footprint of additional disturbance may be small). In each case, if brine pumped to the surface is subsequently reinjected into the belowground brine reservoir after DLE, then no appreciable amounts of water would be lost through evaporation. However, it is possible that if DLE is conducted on brines from shallow aquifers that changes in salinity could change habitat condition within ecosystems along the edge of salt flats where brackish waters occur. Therefore, DLE at pre-existing industrial facilities may or may not cause significant groundwater or surface water depletion, depending on the position of the water table and groundwater dependence of ecosystems in the vicinity.

DLE occurring in deeper aquifers is less likely to cause adverse impacts to ecosystems than DLE occurring in shallower aquifers; however, it is still possible that other adverse impacts such as land subsidence could occur if significant pumping takes place below clay aquitards. In addition, new groundwater and surface water contamination may also occur, and would depend on the materials used in the DLE process, and the disposal pathways for these materials. Overall, DLE that occurs at pre-existing industrial facilities could constitute the lowest potential impact on both lands and waters of all the currently existing technologies proposed for the extraction of new lithium from the environment, if DLE occurs in deep aquifers that are disconnected from ecosystems, as well as fresh and brackish (Total Dissolved Solids <=10,000 ppm) aquifers that have the potential to provide drinking water supplies for current and future generations (Kang et al. 2020, Warrack and Kang 2021).

DIRECT LITHIUM EXTRACTION (DLE) FROM BRINE

EVAPORATIVE CONCENTRATION FROM BRINE

STRIP MINING

OPEN PIT MINING

UNDER-GROUND MINING

Direct lithium extraction from brine currently undisturbed sites

Where direct lithium extraction from brine is proposed yet no current industrial facility exists, the building of such a facility would constitute a new environmental impact to lands and waters. Vegetation and soils would be removed or damaged by earth-moving equipment and habitat that supports plants and animals would be destroyed as lands are converted from a natural state to an industrial site to accommodate the creation of a new DLE facility. These disturbances may introduce non-native, invasive species to the project site including pests and pathogens, and these may spread beyond the project site and impact surrounding undisturbed lands and waters. Species dependent on hot spring and geothermal spring systems may be put at risk when new geothermal development of an aquifer occurs, as development can cause changes in waterflow, chemistry, or temperature that would make the habitat unsuitable for the species adapted to it. Groundwater and surface water contamination may occur, and would depend on the materials used both in the building of the facility, materials used in the DLE process, groundwater extraction locations and quantities relative to nearby habitat and natural resources, and the disposal pathways for waste materials. Newly disturbed sites are subject to erosion of soils by wind and precipitation, and sedimentation of nearby surface waters and altering of natural hydrology are particular concerns for construction sites. Wind erosion can negatively impact air quality, which may cause harm to plants, animals, and people. The resulting dust issues may require additional groundwater pumping to acquire water for dust suppression and potentially, to desalinize soils or plants. Noise and visual disturbances associated with the building of a new facility may impact wildlife in numerous ways, including the disruption of movement or other behaviors required for survival. Other than the new disturbances to lands and waters caused by the building of a new industrial facility, the impacts of DLE from brine at currently undisturbed sites would be similar to the impacts of DLE from brine at pre-existing industrial sites.

Evaporative concentration of lithium from brine

A project that proposes evaporative concentration of lithium from brine may result in some of the same impacts as those that would occur where direct extraction from brine is proposed. These include the impacts to vegetation, soils, plants, and animals mentioned above, depending on the type of facilities built at the site. The large footprint of the evaporative ponds at existing sites at Silver Peak, Nevada, and elsewhere in the world demonstrates that this extraction technology requires the conversion of many acres of wildlands to industrial use. Additionally, evaporative concentration has the potential to deplete both ground and surface waters. This extraction type is, by necessity, employed in arid areas to facilitate the process of evaporation. Enhancing the evaporative process also has the effect of increasing salinity over time as the fraction of water evaporated is pure H_2O, leaving behind saline waters at the surface with increasing salinity that may affect local ecosystems. These types of operations are typically in desert areas where water is naturally scarce, making consumptive use of water particularly problematic for the plants, animals, and natural communities that depend on groundwater and surface water resources.

HARD ROCK AND CLAY

Surface mining: strip mining and open pit mining

Surface mining removes rocks or clays at the land surface to expose, recover, and extract lithium-containing materials. Surface mining constitutes a dramatic and intense disturbance and conversion of natural lands at the landscape scale. There are a variety of types of surface mining, but those used for the extraction of lithium include strip mining of surface materials, and open pit mining. Each of these may result in different types and intensities of disturbance to lands and waters, and to the plants, animals, and natural communities originally occurring at and around the extraction site. Excavation of material using surface mining may result in some of the same impacts as those that would occur where direct extraction from brine is proposed yet no current industrial facility exists, or where evaporative concentration of brine is proposed. These include the impacts to vegetation, soils, plants, and animals mentioned above, depending on the type of facilities built at the site. Project sites where hard rock or clay is excavated by strip mining of surface materials, or through the creation of an open pit, have the potential to be particularly damaging to the environment.

Because lithium is often available at low concentrations, the amount of material needed to be mined to recover appreciable amounts of lithium can be high. Surface

The Prairie Evening-primrose (*Oenothera pilosella* ssp. *sessilis*). Photo © Eric Hunt, cropped version used under a Creative Commons license: CC BY-SA 4.0

mining exposes rock that has been unexposed for very long periods of time. When previously unexposed rocks are crushed, they can release toxic materials that contaminate air, soil, and both groundwater and surface waters. Additionally, extraction of lithium from rocks or clays may involve roasting and acid leaching processes (May et al. 1979), which require energy, consume water, and produce waste streams that may negatively impact ecosystems.

At some locations, dewatering may be required to successfully mine the extent of the lithium-bearing ore. Pit-dewatering can result in the need to extract substantial quantities of groundwater. In desert areas (e.g., at deposits in California, Nevada, and Arizona), the volume of groundwater extracted may represent a substantial portion of the groundwater budget for a specific area and may be sourced from stored groundwater that resulted from rainfall thousands of years ago. Groundwater pumping can impact multiple aquifers over many miles depending on the depth, rate of pumping, and underlying geology, thus potentially impacting wells, wetlands, and other groundwater-dependent ecosystems over a much larger footprint than the mined area.

Underground mining

Underground mining involves large-scale, mechanical movement and removal of vegetation, soils, and bedrock. In this way, it is similar to surface mining, though the visible, above-ground footprint of underground mining may be smaller. Like surface and open pit mining, it can release toxic materials into the air and water. Underground mining may also lead to tunnel collapses and land subsidence (Betournay 2011). There are few underground mine sites with existing lithium claims; these are all in California and unlikely to be mined in the future.

State-by-State Analysis of Potential Impacts

The complete list of Project Site numbers, names, locations, companies involved, resource types, extraction methods, and presence of existing infrastructure can be viewed in Supplemental Information A. Information on environmental data for all 72 Project Sites, including special status species, can be viewed in Supplemental Information D. Detail about data sources is included in Supplemental Information C.

Photo: Michael Durham/Minden Pictures, BCI

Pallid bat (*Antrozous pallidus*). Used under a Creative Commons license: Attribution 2.0 Generic (CC BY 2.0).

Arizona

Arizona contains one Project Site: Big Sandy Lithium. The Project Site is located in the Big Sandy River Valley in Mohave County, Arizona, about midway between Phoenix and Las Vegas in western Arizona (Figure 4). It is proposed by Hawkstone Mining Ltd. to be an open pit mine. The clay minerals targeted at the Project Site are green lacustrine (former lakebed) sediments. The operation proposes to use sulfuric acid to leach the lithium from the ore at a processing area near Kingman, Arizona potentially resulting in impacts to other locations.

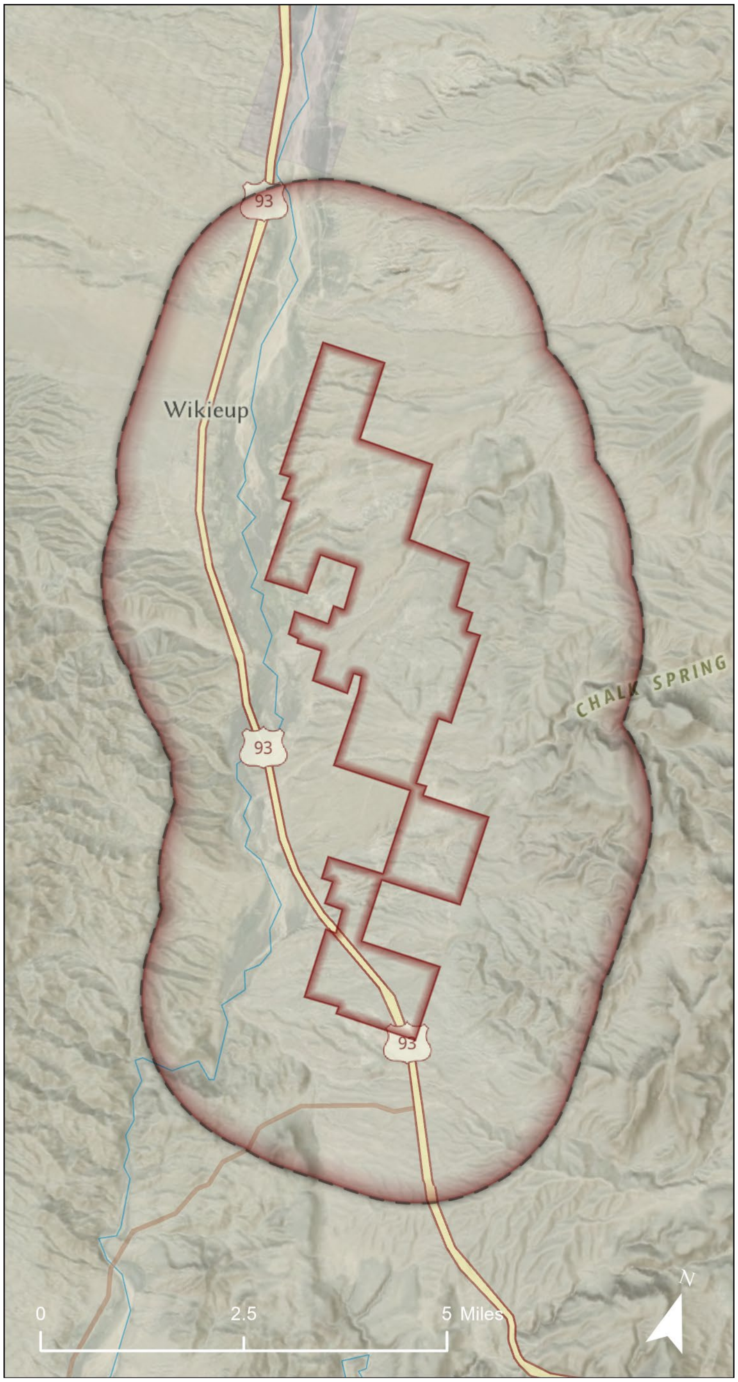


Figure 4. Map of the Big Sandy Lithium Project Location and surrounding Project Site in Arizona.

This Project Site contains BLM (Bureau of Land Management) Solar Energy Program lands, an Existing Conservation and Mitigation Bank, a Scenic Highway, and a Visual Resource. The Project Site includes mapped wetlands and habitat connectivity, critical habitat for sensitive species, and Desert Tortoise and Golden Eagle habitat. It also includes lands denoted for their high conservation value by The Nature Conservancy (TNC), and lands contained within TNC's Resilient and Connected Network (RCN). At least 198 species have been recorded at the Project Site, including one special status species which is considered Near Threatened by the IUCN, the Olive-sided Flycatcher (*Contopus cooperi*) (Figure 5).

There are also springs present in the region, including Cofer Hot Spring, which includes substantial riparian and other groundwater-dependent vegetation. Groundwater extraction resulting from the proposed mine, including dewatering, pumping for mine domestic and dust control use, and for processing (the ore will be mixed with water and piped as a slurry away from the area for processing), could impact features such as Cofer Hot Springs and the plant and animal life that use those resources.

Figure 5. The Olive-Sided Flycatcher (*Contopus cooperi*) is an IUCN Near Threatened species that has been observed at the Big Sandy Lithium Project Site. Photo from Battina Arrigoni, used under a Creative Commons Attribution 2.0 Generic license.

Arkansas

Arkansas contains five Project Sites (Figure 6). All five would involve direct lithium extraction (DLE) from oilfield brine at pre-existing industrial facilities associated with the Smackover Formation. The first three are the Central, South, and West Units of the Lanxess Project, which are proposed by Standard Lithium, Lanxess, and the Great Lakes Chemical Corporation. The fourth is the TETRA Project proposed by Standard Lithium and TETRA Technologies, and the fifth is Albemarle Lithium, proposed by Albemarle Corporation.

Figure 7. The Eastern Box Turtle (*Terrapene carolina*) is an IUCN Vulnerable species that has been observed at the Lanxess Central Unit Project Site. Photo by Jim Lynch, National Park Service. This file is licensed under the Creative Commons Attribution-Share Alike 2.0 Generic license, and a cropped version of the photo is used here.

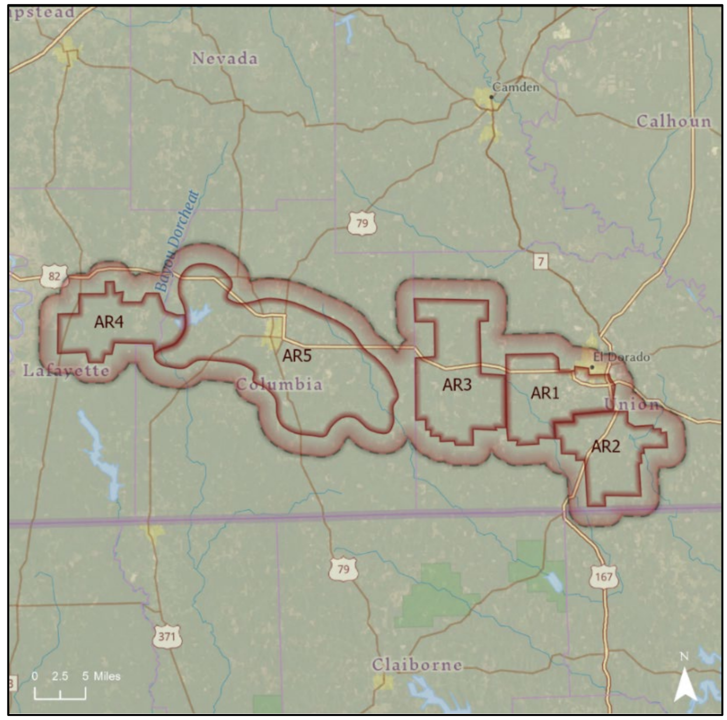


Figure 6. Map of Project Locations and surrounding Project Sites in Arkansas.

ID	PROJECT SITE NAME	COMPANIES INVOLVED
AR1	Lanxess Project Central Unit	Standard Lithium and Lanxess, Great Lakes Chemical Corp.
AR2	Lanxess Project South Unit	Standard Lithium and Lanxess, Great Lakes Chemical Corp.
AR3	Lanxess Project West Unit	Standard Lithium and Lanxess, Great Lakes Chemical Corp.
AR4	TETRA Project	Standard Lithium and TETRA Technologies
AR5	Albemarle Lithium	Albemarle Lithium

The Lanxess Central Unit Project Site includes mapped wetlands and intact habitat, and a colonial nesting site for water birds that is of state concern. At least 287 species and/or natural communities/features have been recorded at the Project Site, including 30 which have a special status. One species, the Red-cockaded Woodpecker (*Picoides borealis*) is federally listed as Endangered.

Common Name	Scientific Name	Source	Federal Status	State Status	G-RANK	S-RANK	IUCN Status
Sprague's Pipit	*Anthus spragueii*	Citizen Science					Vulnerable
Chuck-will's-widow	*Antrostomus carolinensis*	Citizen Science					Near Threatened
Areas of unprotected biodiversity importance		NatureServe					
Soxman's milk-vetch	*Astragalus soxmaniorum*	Natural Heritage			G3	S2	
Salt-marsh bullrush	*Bolboschoenus robustus*	Natural Heritage			G5	S1	
Semipalmated Sandpiper	*Calidris pusilla*	Citizen Science					Near Threatened
Buff-breasted Sandpiper	*Calidris subruficollis*	Citizen Science					Near Threatened
Smooth-sheath sedge	*Carex laevivaginata*	Natural Heritage			G5	S2	
Chimney Swift	*Chaetura pelagica*	Citizen Science					Vulnerable
Long-tailed Duck	*Clangula hyemalis*	Citizen Science					Vulnerable
Colonial nesting site, water birds		Natural Heritage			GNR	SNR	
Northern Bobwhite	*Colinus virginianus*	Citizen Science					Near Threatened
Olive-sided Flycatcher	*Contopus cooperi*	Citizen Science					Near Threatened
Rough Flatsedge	*Cyperus retrofractus*	Natural Heritage			G5	S2	
Rusty Blackbird	*Euphagus carolinus*	Citizen Science					Vulnerable
Hairy Umbrella Sedge	*Fuirena squarrosa*	Natural Heritage			G4G5	S1	
Tie-vine Morning-glory	*Ipomoea cordatotriloba* var. *cordatotriloba*	Natural Heritage			G5T5	S1	
Loggerhead Shrike	*Lanius ludovicianus*	Citizen Science					Near Threatened
Seminole bat	*Lasiurus seminolus*	Natural Heritage			G5	S3	
Bachman’s Sparrow	*Peucaea aestivalis*	Citizen Science					Near Threatened
Red-cockaded Woodpecker	*Picoides borealis*	Natural Heritage	FE		G3	S1	
Crested Fringed Orchid	*Platanthera cristata*	Natural Heritage			G5	S1S2	
Common Grackle	*Quiscalus quiscula*	Citizen Science					Near Threatened
Rufous Hummingbird	*Selasphorus rufus*	Citizen Science					Near Threatened
Cerulean Warbler	*Setophaga cerulea*	Citizen Science					Near Threatened
Blackpoll Warbler	*Setophaga striata*	Citizen Science					Near Threatened
Eastern Meadowlark	*Sturnella magna*	Citizen Science					Near Threatened
Eastern box turtle	*Terrapene carolina*	Citizen Science					Vulnerable
Golden-winged warbler	*Vermivora chrysoptera*	Citizen Science					Near Threatened
Harris’s sparrow	*Zonotrichia querula*	Citizen Science					Near Threatened

The Lanxess South Unit Project Site includes mapped wetlands and intact habitat, and two habitat types that are of state concern: Cattail Marsh, and West Gulf Coastal Plain Seepage Swamp and Baygall. At least 75 species and/or natural communities/features have been recorded at the Project Site, including 14 with a special status. One species, the Red-cockaded Woodpecker (*Picoides borealis*) is federally listed as Endangered.

Common Name	Scientific Name	Source	Federal Status	State Status	G-RANK	S-RANK	IUCN Status
Areas of unprotected biodiversity importance		NatureServe					
Salt-marsh Bulrush	*Bolboschoenus robustus*	Natural Heritage			G5	S1	
Cattail Marsh	*Cattail Marsh*	Natural Heritage			GNR	S1S2	
Chimney Swift	*Chaetura pelagica*	Citizen Science					Vulnerable
Haspan Flatsedge	*Cyperus haspan*	Natural Heritage			G5	S2	
Climbing-hydrangea	*Decumaria barbara*	Natural Heritage			G5	S1	
Hairy Umbrella Sedge	*Fuirena squarrosa*	Natural Heritage			G4G5	S1	
Loggerhead Shrike	*Lanius ludovicianus*	Citizen Science					Near Threatened
Red-cockaded Woodpecker	*Picoides borealis*	Natural Heritage	FE		G3	S1	
Rein Orchid	*Platanthera flava*	Natural Heritage			G4?	S2S3	
Durand's White Oak	*Quercus sinuata*	Natural Heritage			G4G5	S2	
Cerulean Warbler	*Setophaga cerulea*	Citizen Science					Near Threatened
Giant Ladies'-Tresses	*Spiranthes praecox*	Natural Heritage			G5	S1S2	
West Gulf Coastal Plain Seepage Swamp and Baygall		Natural Heritage			GNR	SNR	

The Lanxess West Unit Project Site includes mapped wetlands and intact habitat, and West Gulf Coastal Plain Seepage Swamp and Baygall, a habitat type of state concern. At least 65 species and/or natural communities/features have been recorded at the Project Site, including 11 with a special status. One species, the Red-cockaded Woodpecker (*Picoides borealis*) is federally listed as Endangered.

Common Name	Scientific Name	Source	Federal Status	State Status	G-RANK	S-RANK	IUCN Status
Mole Salamander	*Ambystoma talpoideum*	Natural Heritage			G5	S3	
Sprague's Pipit	*Anthus spragueii*	Citizen Science					Vulnerable
Areas of unprotected biodiversity importance		NatureServe					
Haspan Flatsedge	*Cyperus haspan*	Natural Heritage			G5	S2	
Rusty Blackbird	*Euphagus carolinus*	Citizen Science					Vulnerable
Slenderwrist Burrowing Crayfish	*Fallicambarus petilicarpus*	Natural Heritage			G1	S1	
Hairy Umbrella Sedge	*Fuirena squarrosa*	Natural Heritage			G4G5	S1	
Red-cockaded Woodpecker	*Picoides borealis*	Natural Heritage	FE		G3	S1	
Common Grackle	*Quiscalus quiscula*	Citizen Science					Near Threatened
Swamp Goldenrod	*Solidago patula* ssp. *strictula*	Natural Heritage			G5T5	S1S2	

The TETRA Project Site includes mapped wetlands and intact habitat, Protected Lands, and lands contained within TNC's Resilient and Connected Network (RCN). It also contains a habitat type of state concern: Morse Clay Calcareous Prairie. At least 293 species and/or natural communities/features have been recorded at the Project Site, including 19 with a special status.

Common Name	Scientific Name	Source	Federal Status	State Status	G-RANK	S-RANK	IUCN Status
Sprague's Pipit	*Anthus spragueii*	Citizen Science					Vulnerable
Areas of unprotected biodiversity importance		NatureServe					
Piping Plover	*Charadrius melodus*	Citizen Science					Near Threatened
Rafinesque's Big-eared Bat	*Corynorhinus rafinesquii*	Natural Heritage			G3G4	S3	
Blueberry Hawthorn	*Crataegus brachyacantha*	Natural Heritage			G4	S2	
Sebastian-bush	*Ditrysinia fruticosa*	Natural Heritage			G5	S1	
Sand Spike-rush	*Eleocharis montevidensis*	Natural Heritage			G5	S1	
Bald Eagle	*Haliaeetus leucocephalus*	Natural Heritage			G5	S3B,S4N	
Tie-vine Morning-glory	*Ipomoea cordatotriloba* var. *cordatotriloba*	Natural Heritage			G5T5	S1	
Slender Marsh-elder	*Iva angustifolia*	Natural Heritage			G5?	S1	
Lanius ludovicianus	*Lanius ludovicianus*	Citizen Science					Near Threatened
Melanitta americana	*Melanitta americana*	Citizen Science					Near Threatened
Morse Clay Calcareous Prairie		Natural Heritage			GNR	SNR	
Southeastern Bat	*Myotis austroriparius*	Natural Heritage			G4	S3	
Celestial-lily	*Nemastylis geminiflora*	Natural Heritage			G4	S3	
Prairie Evening-primrose	*Oenothera pilosella ssp. sessilis*	Natural Heritage			G5T2	S2	
Horned Grebe	*Podiceps auritus*	Citizen Science					Vulnerable
Common Grackle	*Quiscalus quiscula*	Citizen Science					Near Threatened
Eastern Meadowlark	*Sturnella magna*	Citizen Science					Near Threatened

Figure 9. The Giant Stag Beetle (*Lucanus elaphus*) is an IUCN Vulnerable species that has been observed at the Albemarle Lithium Project Site. Photo by Christina Butler. This file is licensed under the Creative Commons Attribution 2.0 Generic license.

Figure 8. The Prairie Evening-primrose (*Oenothera pilosella* ssp. *sessilis*) is an IUCN Endangered species that has been observed at the TETRA Lithium Project Site. Photo by Eric Hunt, used under a Creative Commons license: CC BY-SA 4.0

The Albemarle Lithium Project Site includes mapped wetlands and intact habitat, Protected Lands, and lands contained within TNC's Resilient and Connected Network (RCN), and colonial nesting sites for water birds. It also contains several habitat types that are of state concern: Cypress-Tupelo Swamp, Lowland Headwater Stream-Coastal Plain, Lowland Oak-Sweetgum Forest, Lowland Pine-Oak Forest, West Gulf Coastal Plain Mesic Hardwood Forest, West Gulf Coastal Plain Small Stream and River Forest, and Willow Oak Forest. At least 612 species and/or natural communities/features have been recorded at this Project Site, including 39 with a special status. One species, the Red-cockaded Woodpecker (*Picoides borealis*) is federally listed as Endangered.

Common Name	Scientific Name	Source	Federal Status	State Status	G-RANK	S-RANK	IUCN Status
Mole Salamander	*Ambystoma talpoideum*	Natural Heritage			G5	S3	
Chuck-will's-widow	*Antrostomus carolinensis*	Citizen Science					Near Threatened
Areas of unprotected biodiversity importance		NatureServe					
American Bumblebee	*Bombus pensylvanicus*	Citizen Science					Vulnerable
Bayou Bodcau crayfish	*Bouchardina robisoni*	Natural Heritage			G2	S1	
Chimney Swift	*Chaetura pelagica*	Citizen Science					Vulnerable
Piping Plover	*Charadrius melodus*	Citizen Science					Near Threatened
Northern Bobwhite	*Colinus virginianus*	Citizen Science					Near Threatened
Colonial nesting site, water birds		Natural Heritage			GNR	SNR	
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	Natural Heritage			G3G4	S3	
Cypress-Tupelo Swamp	Cypress-Tupelo Swamp	Natural Heritage			GNR	S2	
Sebastian-bush	*Ditrysinia fruticosa*	Natural Heritage			G5	S1	
Goldstripe Darter	*Etheostoma parvipinne*	Natural Heritage			G4G5	S3	
Rusty Blackbird	*Euphagus carolinus*	Citizen Science					Vulnerable
Bald Eagle	*Haliaeetus leucocephalus*	Natural Heritage			G5	S3B,S4N	
Crested-coralroot	*Hexalectris spicata var. spicata*	Natural Heritage			G5T4 T5	S2	
Scarlet Rose-mallow	*Hibiscus coccineus*	Natural Heritage			G4?	S1	
Curtiss' Star-grass	*Hypoxis curtissii*	Natural Heritage			G4?	S1	
Seminole Bat	*Lasiurus seminolus*	Natural Heritage			G5	S3	
Glossy Swampsnake	*Liodytes rigida*	Natural Heritage			G5	S3	
Lowland Headwater Stream-Coastal Plain		Natural Heritage			GNR	SNR	
Lowland Oak-Sweetgum Forest		Natural Heritage			GNR	S1	
Lowland Pine-Oak Forest		Natural Heritage			GNR	S1	
Giant Stag Beetle	*Lucanus elaphus*	Natural Heritage			G3G5	S2	
Black scoter	*Melanitta americana*	Citizen Science					Near Threatened
Southeastern Bat	*Myotis austroriparius*	Natural Heritage			G4	S3	
Red-cockaded Woodpecker	*Picoides borealis*	Natural Heritage	FE		G3	S1	
Rein Orchid	*Platanthera flava*	Natural Heritage			G4?	S2S3	
Horned Grebe	*Podiceps auritus*	Citizen Science					Vulnerable
Common Grackle	*Quiscalus quiscula*	Citizen Science					Near Threatened
King Rail	*Rallus elegans*	Citizen Science					Near Threatened
Eastern Harvest Mouse	*Reithrodontomys humulis*	Natural Heritage			G5	S2	
Giant Ladies'-tresses	*Spiranthes praecox*	Citizen Science			G5	S1S2	
Eastern Meadowlark	*Sturnella magna*	Citizen Science					Near Threatened
Eastern Box Turtle	*Terrapene carolina*	Citizen Science					Vulnerable
West Gulf Coastal Plain Mesic Hardwood Forest		Natural Heritage			GNR	SNR	
West Gulf Coastal Plain Small Stream and River Forest		Natural Heritage			GNR	SNR	
Willow Oak Forest		Natural Heritage			GNR	S2	
Harris's Sparrow	*Zonotrichia querula*	Citizen Science					Near Threatened

California

California contains 15 Project Sites (Figures 10 and 11). The Project Site names, regions, companies involved, resource types, extraction methods, and presence of existing infrastructure are listed in the table on the next page.

Figure 10. Map of Project Locations and surrounding Project Sites in California (north).

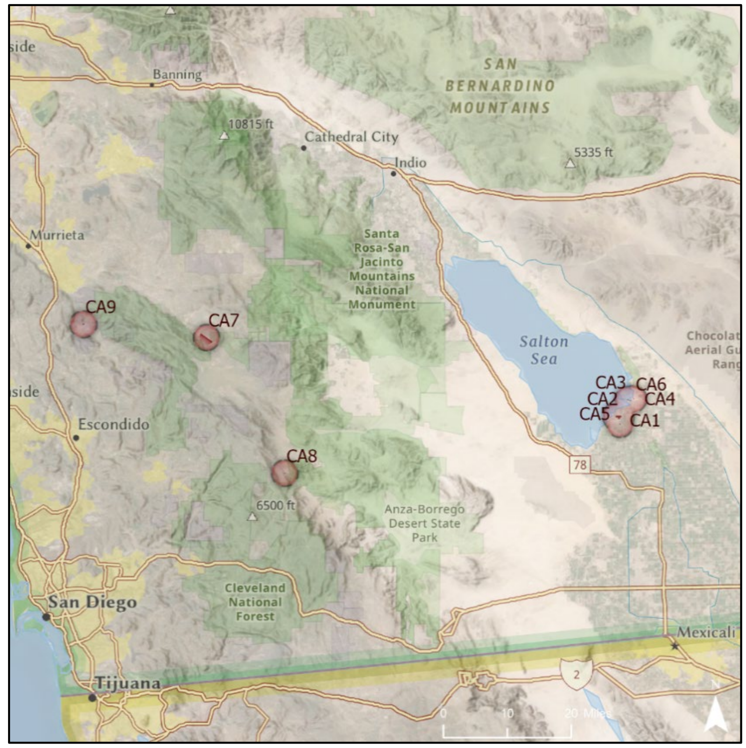


Figure 11. Map of Project Locations and surrounding Project Sites in California (south).

Figure 12. The Tri-colored Blackbird (*Agelaius tricolor*) is an IUCN Endangered species that has been observed at Project Sites in the Salton Sea area. Photo by Alan Vernon, used under the Creative Commons Attribution-NonCommercial-ShareAlike 2.0 Generic (CC BY-NC-SA 2.0) license.

Figure 13. The Mojave Desert Tortoise (*Gopherus agassizii*) is federally listed under the Endangered Species Act as a Threatened Species. It has been observed at the Hector Mine and Panamint Valley Lithium Project Sites. Photo from the United States Bureau of Land Management.

ID	Project Site Name	Region	Companies Involved	Resource Type	Extraction Method	Existing Infrastructure
CA1	Hell's Kitchen Lithium and Power Project	Salton Sea	Controlled Thermal Resources/Lilac Solutions	brine	DLE	unknown
CA2	Imperial Valley Geothermal Plants	Salton Sea	CalEnergy Resources Ltd. (Berkshire Hathaway Energy Renewables)	brine	DLE	unknown
CA3	Imperial Irrigation District No. 1 Well	Salton Sea	unknown	brine	DLE	yes
CA4	River Ranches No. 1 Well	Salton Sea	unknown	brine	DLE	yes
CA5	Sinclar No. 3 Well	Salton Sea	unknown	brine	DLE	yes
CA6	Sportsman No. 1 Well	Salton Sea	unknown	brine	DLE	unknown
CA7	Big Buck Prospect	San Diego Mountains	unknown	rock/clay	Underground mining	unknown
CA8	Royal Mine	San Diego Mountains	unknown	rock/clay	Underground mining	unknown
CA9	Stewart Mine / Pala Gem Mine	San Diego Mountains	unknown	rock/clay	Underground mining	yes
CA10	Hector Mine	Mojave River Valley Basin	Elementis Specialties	clay	Surface mining	yes
CA11	Panamint Valley Lithium Project	Panamint Valley	Battery Mineral Resources Corp.	brine	Evaporative Concentration of Brine	yes
CA12	Searles Valley Minerals	Searles Lake	Searles Valley Minerals/Nirma	brine	Evaporative Concentration of Brine	unknown
CA13	National Chloride Company of America	Bristol Dry Lake	National Chloride Company of America	brine	Evaporative Concentration of Brine	unknown
CA14	Franklin Wells Lithium Project	Amargosa River	Battery Mineral Resources Corp.	brine	Surface mining	no
CA15	Preston Hanford Sand and Gravel	Sacramento	Hanford Sand and Gravel Company	rock/clay	Surface mining	yes

The specific concerns for Project Sites in California related to agriculture, conservation value, habitat, and management are shown in the table below. All Project Sites have multiple concerns, with mapped wetlands and connectivity occurring at all 15 Project Sites. Special status species that are federally or state listed are shown in the table on the next page (a complete list of all special status species occurring at California Project Sites is available in Supplemental Information D). All Project Sites have a record of at least one special status species. The Loggerhead Shrike (*Lanius ludovicianus*), an IUCN Near Threatened species, is the most frequently encountered special status species, and has been recorded at 10 Project Sites in California.

Category	Specific Concern	Recorded at Project Site (CA#)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Agriculture	Prime Farmland	X	X	X	X	X	X	X		X						X
Conservation Value	Important Bird Area	X	X	X	X	X	X	X		X			X			X
Conservation Value	TNC Resilient and Connected Network (RCN)	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Conservation Value	TNC Conservation Value	X						X	X	X	X	X	X	X	X	
Habitat	Connectivity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Habitat	Critical Habitat							X		X	X					
Habitat	Desert Tortoise										X	X	X		X	
Habitat	Golden Eagle								X			X	X	X	X	X
Habitat	Vernal Pool															X
Habitat	Wetlands	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Management	ACEC										X	X	X		X	
Management	BLM Solar Energy Program							X	X		X	X	X	X	X	
Management	Conservation Easement							X		X						X
Management	GAP 1 Land	X	X	X	X	X	X		X	X		X			X	
Management	GAP 2 Land									X	X	X			X	X
Management	Habitat Conservation Plan									X						
Management	Inyo Exclusions											X	X		X	
Management	National Conservation Land										X	X	X	X	X	
Management	National Monument													X		
Management	National Park Service											X			X	
Management	National Scenic Trail								X		X			X		
Management	National Wildlife Area	X	X	X	X	X	X									
Management	Special Recreation Management Area							X				X	X	X		
Management	State Park								X							
Management	State Wilderness Area								X							
Management	Visual Resource										X	X	X	X	X	
Management	Wild and Scenic River											X				
Management	Wilderness											X		X	X	

Common Name	Scientific Name	Source	Federal Status	State Status	Recorded at Project Site (CA#)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Desert Pupfish	*Cyprinodon macularius*	Natural Heritage	FE	SE	X	X	X	X	X	X									
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Natural Heritage	FE	SE									X						
Least Bell's Vireo	*Vireo bellii pusillus*	Natural Heritage	FE	SE									X						
Yuma Clapper Rail	*Rallus obsoletus yumanensis*	Natural Heritage	FE	ST	X	X	X	X	X	X									
Arroyo Toad	*Anaxyrus californicus*	Natural Heritage	FE								X		X						
Vernal Pool Tadpole Shrimp	*Lepidurus packardi*	Natural Heritage	FE																X
Mojave Desert Tortoise	*Gopherus agassizii*	Citizen Science	FT	ST										X	X				
Vernal Pool Fairy Shrimp	*Branchinecta lynchi*	Natural Heritage	FT																X
Mojave Tarplant	*Deinandra mohavensis*	Natural Heritage		SE								X							
Boggs Lake Hedge-hyssop	*Gratiola heterosepala*	Natural Heritage		SE															X
Parish's Meadowfoam	*Limnanthes alba ssp. parishii*	Natural Heritage		SE								X							
Tricolored Blackbird	*Agelaius tricolor*	Citizen Science		ST	X	X	X	X		X									X
Swainson's Hawk	*Buteo swainsoni*	Citizen Science		ST	X	X	X	X	X	X	X				X				X
California Black Rail	*Laterallus jamaicensis coturniculus*	Natural Heritage		ST	X	X	X	X	X	X									
Mohave Ground Squirrel	*Xerospermophilus mohavensis*	Natural Heritage		ST												X			

Figure 14. The Desert Pupfish (*Cyprinodon macularius*) is federally listed under the Endangered Species Act as an Endangered Species. It has been observed at Project Sites in the Salton Sea region. Photo by P.V. Loiselle, licensed under a Creative Commons Attribution-ShareAlike 3.0 Unported (CC BY-SA 3.0) license.

New Mexico

New Mexico contains one Project Site. The Lordsburg Lithium Project Site is located at the northern end of the Animas Valley, in Hidalgo County, which is found in the Southwest corner of New Mexico (Figure 16). Exploration activities are underway by Hawkstone Mining Ltd. at this Project Site, which contains lithium in both clays and brines. It is likely that lithium would be extracted at this Project Site through the evaporative concentration of brine.

Figure 15. Inflorescence of the Fishhook Barrel Cactus (*Ferocactus wislizeni*), an IUCN Vulnerable species that has been observed at the Lordsburg Lithium Project Site. Photo from Susan Lynn Peterson, used under a Creative Commons Attribution 3.0 Unported (CC BY-SA 3.0) license**.**

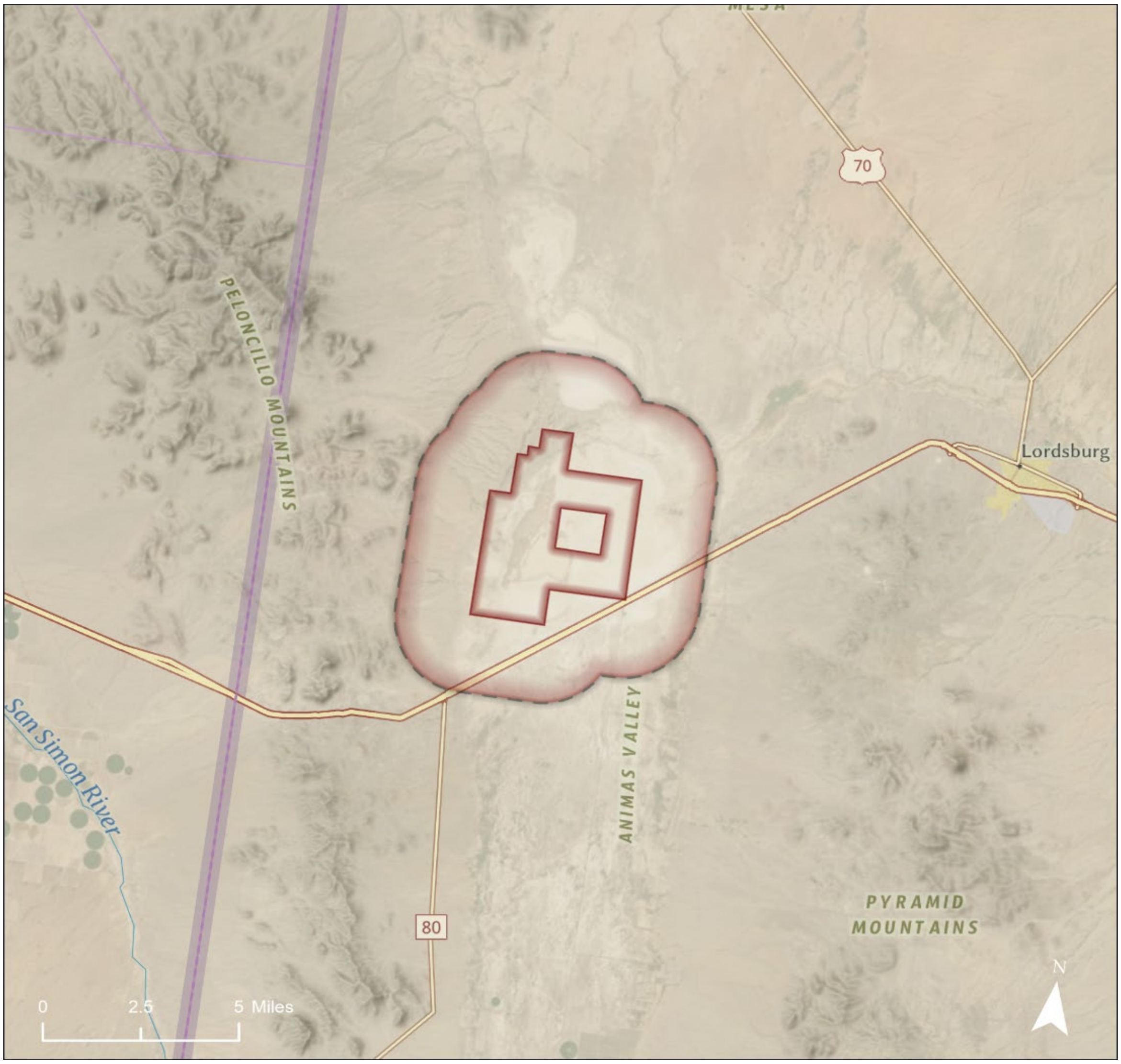


Figure 16. Map of Lordsburg Lithium Project Location, and surrounding Project Site in New Mexico.

Management issues at the Project Site include BLM Solar Energy Program lands and BLM Right of Way exclusions. The Project Site includes mapped wetlands, grasslands and connectivity, and big game habitat. It also includes Prime Farmland, lands denoted for their high conservation value by TNC, lands denoted for their conservation value by the State of New Mexico, and lands contained within TNC's Resilient and Connected Network (RCN). At least 183 species and/or natural communities/features have been recorded at the Project Site. Of these, 18 have a special status (Table X), including five that are considered IUCN Vulnerable, and one S1 species, Chihuahua Scurf Pea (*Pediomelum pentaphyllum*).

Common Name	Scientific Name	Source	Federal Status	State Status	G-RANK	S-RANK	IUCN Status
Areas of unprotected biodiversity importance		NatureServe					
Santa Fe Milkvetch	*Astragalus feensis*	Natural Heritage			G3	S3	
Griffith's Saltbush	*Atriplex griffithsii*	Natural Heritage			G2G3	S2	
Chestnut-collared Longspur	*Calcarius ornatus*	Citizen Science					Vulnerable
Semipalmated Sandpiper	*Calidris pusilla*	Citizen Science					Near Threatened
Mountain Plover	*Charadrius montanus*	Citizen Science					Near Threatened
Snowy Plover	*Charadrius nivosus*	Citizen Science					Near Threatened
Needle Mulee	*Coryphantha robustispina* var. *uncinata*	Natural Heritage		dropped			Least Concern
Orcutt Pincushion Cactus	*Escobaria orcuttii*	Natural Heritage			G3?	S3	
Fishhook Barrel Cactus	*Ferocactus wislizeni*	Citizen Science					Vulnerable
Loggerhead Shrike	*Lanius ludovicianus*	Citizen Science					Near Threatened
Heermann's Gull	*Larus heermanni*	Citizen Science					Near Threatened
Chihuahua Scurf Pea	*Pediomelum pentaphyllum*	Natural Heritage			G1G2	S1	
Night-blooming Cereus	*Peniocereus greggii* var. *greggii*	Natural Heritage			G3G4 T3	S3	
Parish's Alkali Grass	*Puccinellia parishii*	Natural Heritage			G2G3	S1	
Chiricahua Dock	*Rumex orthoneurus*	Natural Heritage			G3	S2?	
Eastern Meadowlark	*Sturnella magna*	Citizen Science					Near Threatened
Bendire's Thrasher	*Toxostoma bendirei*	Citizen Science					Vulnerable

Additionally, eight of the plant species observed at the Project Site are associated with Important Plant Areas in New Mexico (Energy Minerals and Natural Resources Department of New Mexico 2021).

COMMON NAME	SCIENTIFIC NAME
Santa Fe Milkvetch	*Astragalus feensis*
Griffith's Saltbush	*Atriplex griffithsii*
Needle Mulee	*Coryphantha robustispina* var. *uncinata*
Orcutt Pincushion Cactus	*Escobaria orcuttii*
Chihuahua Scurfpea	*Pediomelum pentaphyllum*
Nightblooming Cereus	*Peniocereus greggii* var. *greggii*
Parish's Alkali Grass	*Puccinellia parishii*
Chiricahua Dock	*Rumex orthoneurus*

Nevada

Nevada contains 40 Project Sites (Figures 16, 17, and 18). The complete list of Project Site names, locations, companies involved, resource types, extraction methods, and presence of existing infrastructure can be viewed in Supplemental Information A.

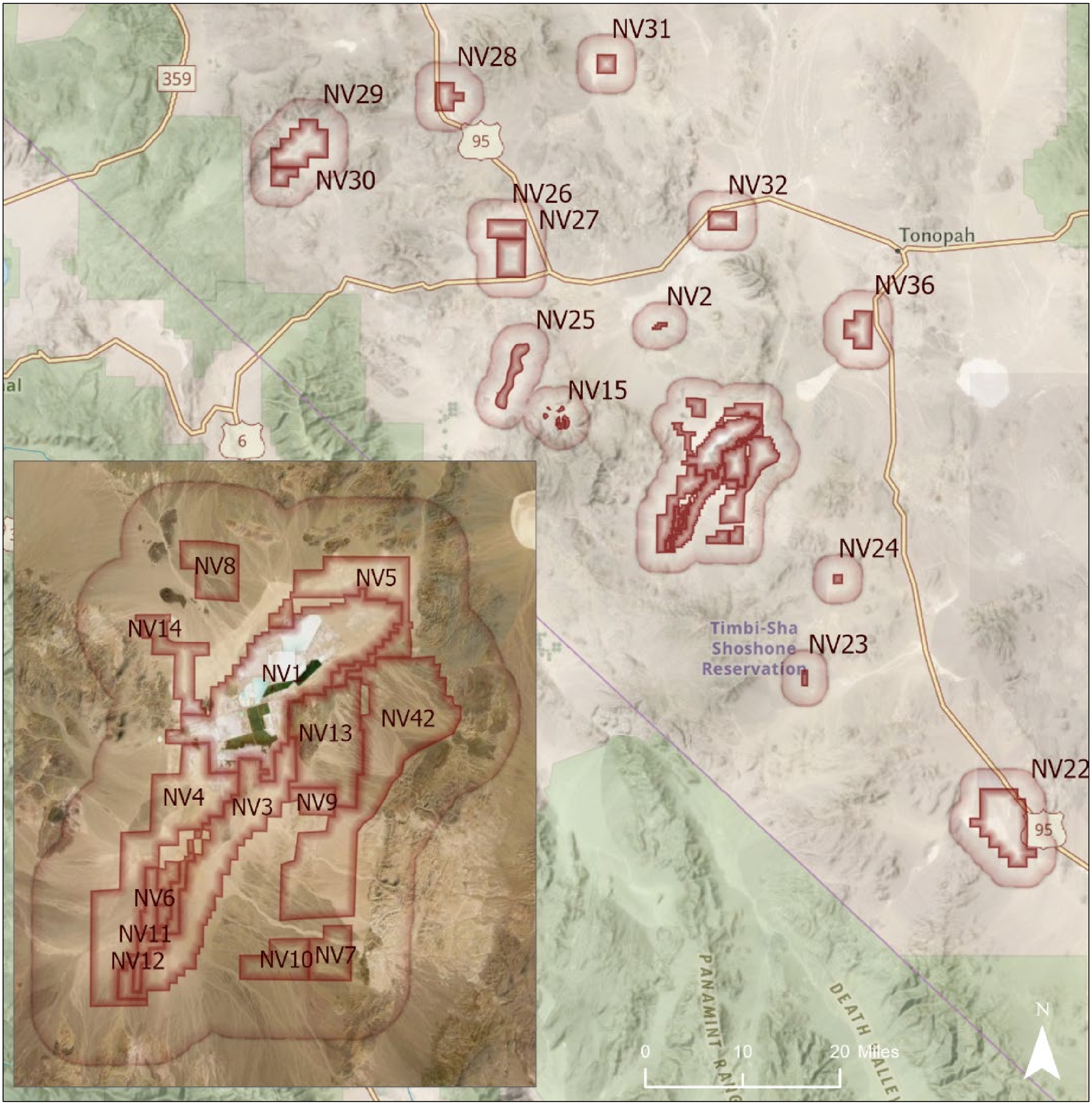


Figure 16. Map of Project Locations and surrounding Project Sites in southwestern Nevada. Inset shows Project Locations and Sites in the Clayton Valley.

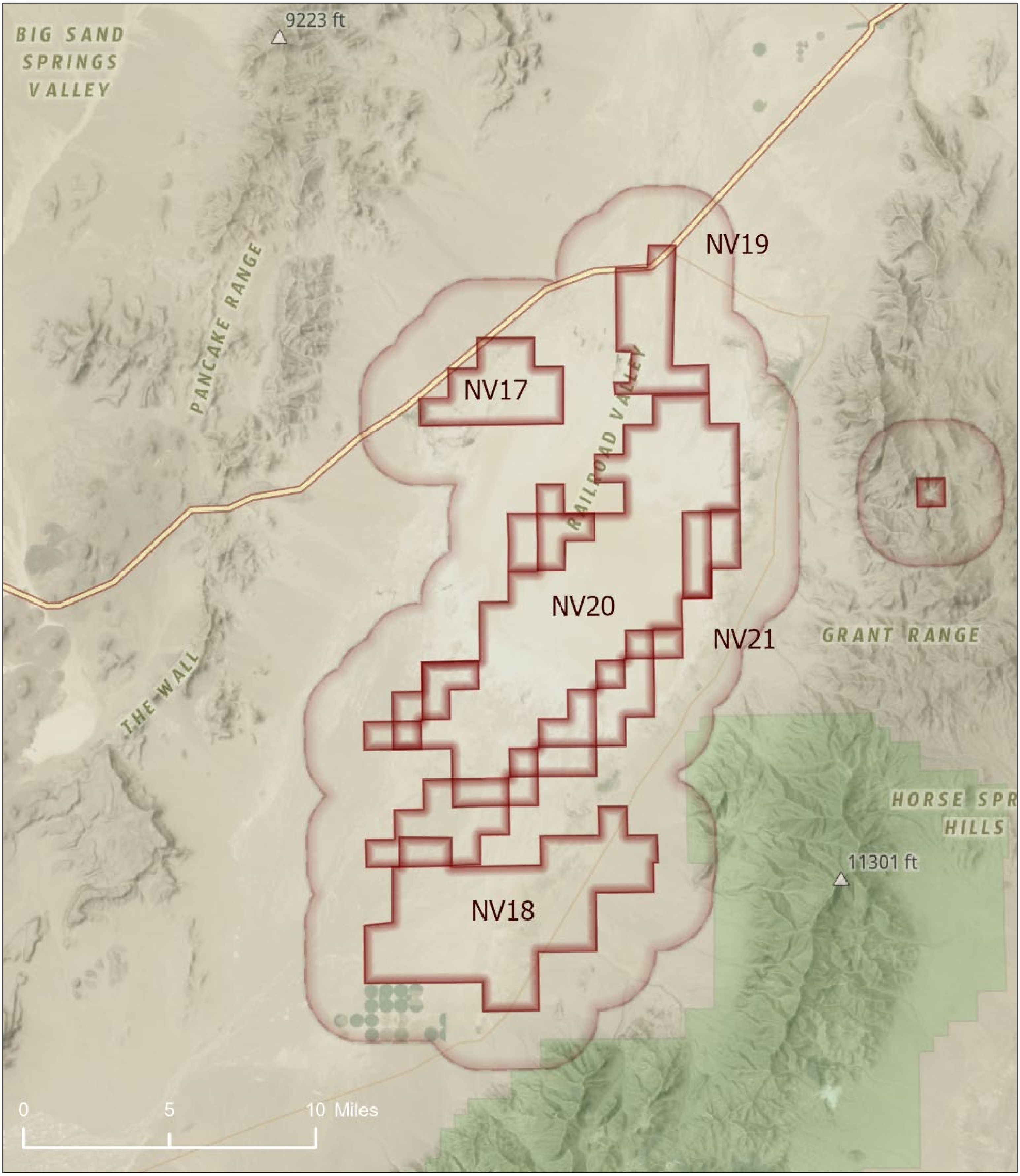


Figure 17. Map of Project Locations and surrounding Project Sites in Railroad Valley, Nevada**.**

Figure 18. Map of Project Locations and surrounding Project Sites in northwestern Nevada.

Specific concerns related to agriculture, conservation value, habitat, and management at Project Sites in Nevada are shown in the table below.

CATEGORY	SPECIFIC CONCERN	RECORDED AT PROJECT SITE (NV#)
Agriculture	Prime Farmland	16,18,33,38,39,40
Conservation Value	Important Bird Area	16,37
Conservation Value	TNC Resilient and Connected Network (RCN)	1,2,4,5,8,13-23,25-30,32,33,35-40,42
Conservation Value	State Conservation Value	1-27,29-33,35-38,42
Conservation Value	TNC Conservation Value	1-21,23,25-30,32,33,35-38,40,42
Habitat	Bighorn Sheep	1,2,4,5,8,14-16,18-22,25-32,35,37,38,40,42
Habitat	Connectivity	1-11,13-33,35-39,40,42
Habitat	Critical Habitat	17
Habitat	Golden Eagle	1-5,7-10,13-16,18,20-33,35-40,42
Habitat	Mule Deer	1,4,14-16,18,20-22,24,25,28,29,31-33,37,38,40
Habitat	Pronghorn	16,17,40
Habitat	Sage Grouse	16,33,37,38
Habitat	Sagebrush	16,37
Habitat	TNC Conservation Value	12
Habitat	Wetlands	1-5,8,9,13,14,16-22,25-33,35,37-40,42
Management	ACEC	37
Management	BLM Right of Way exclusion	1-5,7-10,13-16,18,21-27,31-33,37,38,40,42
Management	BLM Solar Energy Program	1-33,35-40,42
Management	BLM SRMA	37,38
Management	Conservation Easement	33
Management	GAP 1 Land	15,20-22,25,37-40
Management	GAP 2 Land	37,38,40
Management	National Conservation Area	38
Management	National Park Service	33
Management	National Scenic Trail	33,35,38,40
Management	Roadless Area	18,21,33
Management	Scenic Highway	33,35

Figure 19. Nye Pincushion Cactus (*Sclerocactus nyensis)* is a protected cactus species observed at a Project Site in Nevada. Photo from Dornenwolf used under a Creative Commons Attribution 2.0 Generic (CC BY 2.0) license.

State recognized special status species recorded at Project Sites in Nevada are shown in the table below. A complete list of special status species recorded at Project Sites in Nevada is available in Supplemental Information D.

Common Name	Scientific Name	Source	State Status	Recorded at Project Site (NV#)
Mexican Free-tailed bat	*Tadarida brasiliensis*	Natural Heritage	Protected Mammal	35
Nye Pincushion Cactus	*Sclerocactus nyensis*	Natural Heritage	Protected Cactus	36
Pale Kangaroo Mouse	*Microdipodops pallidus*	Natural Heritage	Protected Mammal	3,4,6,21,28,29,35,36
Pallid Bat	*Antrozous pallidus*	Natural Heritage	Protected Mammal	15,29,30,35
Pygmy Rabbit	*Brachylagus idahoensis*	Natural Heritage	Game Mammal	33
Railroad Valley Springfish	*Crenichthys nevadae*	Natural Heritage	Threatened Fish	17,19,20,28
Railroad Valley Tui Chub	*Siphateles bicolor* ssp. *7*	Natural Heritage	Sensitive Fish	20,21
Sand Cholla	*Grusonia pulchella*	Natural Heritage	Protected Cactus	19,20,21,32
Sclerocactus Nyensis	*Sclerocactus nyensis*	Citizen Science	Protected Cactus	1,3,4,6,7,9,10,13,42
Sodaville Milkvetch	*Astragalus lentiginosus* var. *sesquimetralis*	Natural Heritage	Critically Endangered Plant	28
Sonoran Mountain Kingsnake	*Lampropeltis pyromelana*	Natural Heritage	Protected Reptile	18
Spotted Bat	*Euderma maculatum*	Natural Heritage	Threatened Mammal	29,30
Townsend's Big-eared Bat	*Corynorhinus townsendii*	Natural Heritage	Sensitive Mammal	14,15,18,20,21,23,29,30
Yellow-billed Cuckoo	*Coccyzus americanus*	Natural Heritage	Sensitive Birds	35

North Carolina

North Carolina contains one Project Site. The Carolina Lithium Project Site is located west of the town of Bessemer in Gaston County, in the Carolina Tin-Spodumene Piedmont belt that runs north-south through the southwestern part of the state (Figure 20). The hard rock minerals of the site are primarily composed of spodumene, and Piedmont Lithium proposes to extract them using open pit mining.

Management issues at the Project Site include Protected Lands, Protected Areas, and Floodplains. The Project Site includes mapped wetlands. At least 43 species and/or natural communities/features have been recorded at the Project Site. Three of these are special status species, including the Common Grackle (*Quiscalus quiscula*) and Eastern Meadowlark (*Sturnella magna*), which are both IUCN Near Threatened species, and Dwarf-flowered Heartleaf (*Hexistylis naniflora*) (Figure 21), which is federally listed under the Endangered Species Act as a Threatened Species.

Figure 21. Dwarf-flowered Heartleaf (*Hexistylis naniflora*) is federally listed under the Endangered Species Act as a Threatened Species. It has been observed at the Carolina Lithium Project Site. Photo from the United States Fish and Wildlife Service.

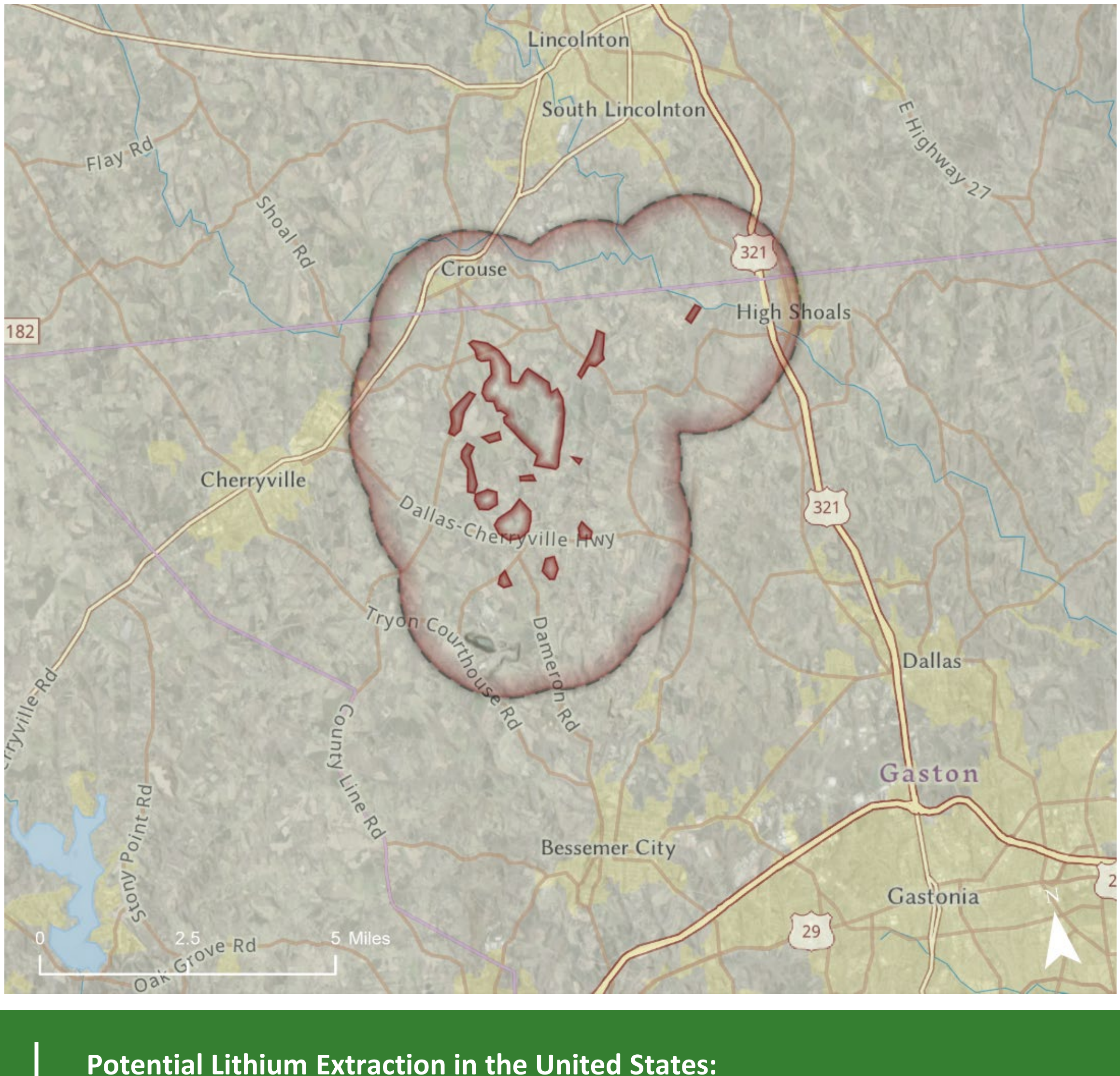


Figure 20. Map of Carolina Lithium Project Location and the surrounding Project Site in North Carolina.

Oregon

Oregon contains one Project Site included in our analysis (two additional potential projects, Warm Springs and Alvord, were discovered after our analysis was completed). The McDermitt Lithium Project Site is located in the southeastern part of the state, near the Nevada border in Malheur County (Figure 22). It is located within the McDermitt Caldera. Exploration activities have been conducted by Jindalee Resources Ltd. (HiTech Minerals Inc.) at this site, and lithium found in the sediments at the site would be extracted using open pit mining.

Management issues at the Project Site include BLM Solar Energy Program lands and BLM Right of Way exclusions, in addition to GAP 1 and 2 lands. The Project Site includes mapped wetlands, sage brush habitat and connectivity, as well as big game habitat and habitat for Bighorn Sheep, winter range deer, Mule Deer, Sage Grouse, and Golden Eagle. It also includes an Important Bird Area, lands denoted for their high conservation value by TNC, lands denoted for their conservation value by the State of Oregon, and lands contained within TNC's Resilient and Connected Network (RCN). At least 70 species and/or natural communities/features have been recorded at the Project Site. One of these is a special status species: Loggerhead Shrike (*Lanius ludovicianus*) (Figure 23) is IUCN Near Threatened.

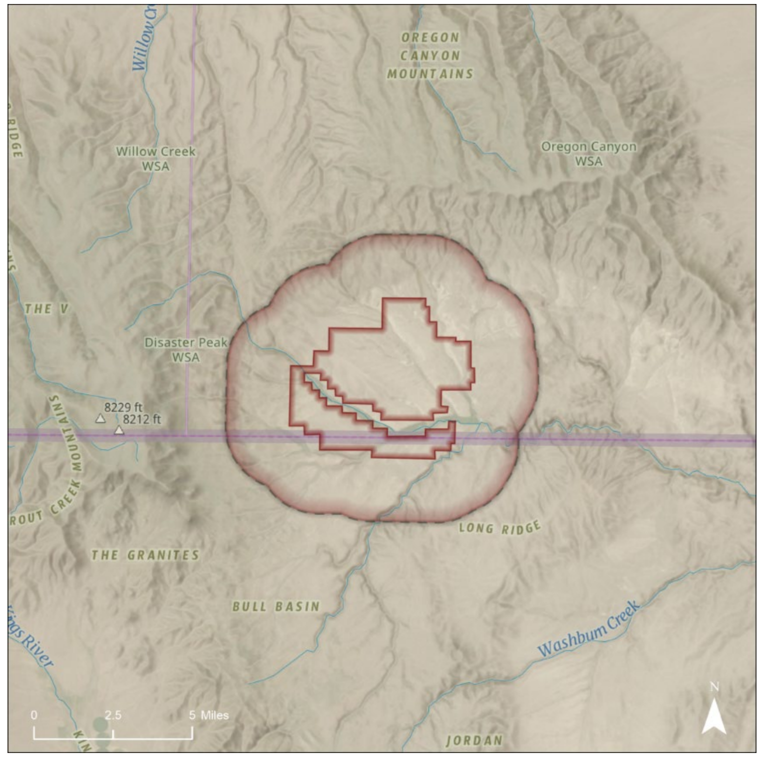


Figure 22. Map of the McDermitt Lithium Project Location and surrounding Project Site in Oregon**.**

Figure 23. The Loggerhead Shrike (*Lanius ludovicianus*) is an IUCN Near Threatened species that has been observed at the McDermitt Lithium Project Site. Photo from Andy Reago and Chrissy McClarren, used under a Creative Commons Attribution 2.0 Generic (CC BY 2.0) license.

Utah

Utah contains seven Project Sites (Figure 24). The Project Site names, locations, companies involved, resource types, extraction methods, and presence of existing infrastructure at the site are listed in the table below.

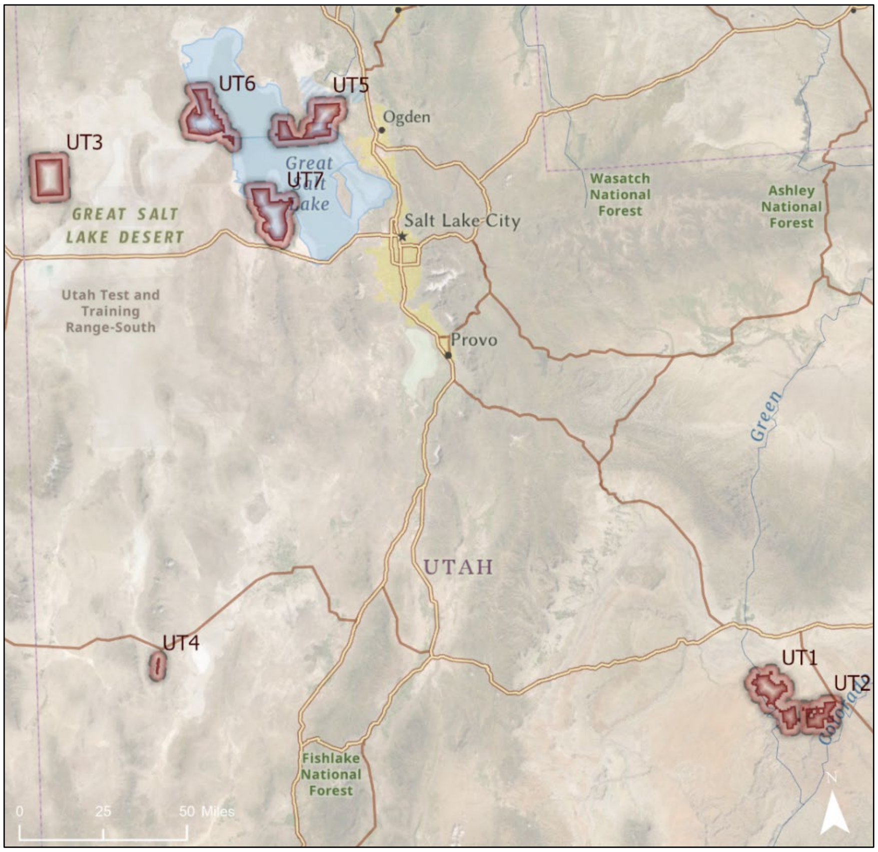


Figure 24. Map of Project Locations and surrounding Project Sites in Utah.

ID	Project Site Name	Region	Companies Involved	Resource Type	Extraction Method	Existing Infrastructure
UT1	New Tech Materials Brine Project	Paradox Basin	American Potash Corp.	brine	DLE	unknown
UT2	Paradox Basin Brine Project	Paradox Basin	Anson Resources	brine	DLE	unknown
UT3	Sal Rica Project	Pilot Valley	Westwater Resources	brine	Evaporative Concentration	unknown
UT4	Tule Valley Lithium Project	Tule Valley	Equitorial Exploration Corp.	brine/clays	Evaporative Concentration; Surface Mining	unknown
UT5	Ogden- North Arm Solar Evaporation Site	Great Salt Lake	Compass Minerals (GSL Minerals Corp.)	brine	Evaporative Concentration	yes
UT6	Northwest	Great Salt Lake	Compass Minerals (GSL Minerals Corp.)	brine	Evaporative Concentration	yes
UT7	Southwest	Great Salt Lake	U.S. Magnesium LLC	brine	Evaporative Concentration	yes

Specific concerns related to agriculture, conservation value, habitat, and management at Project Sites in Utah are shown in the table below.

Category	Specific Concern	Recorded at Project Site (UT#)						
		1	2	3	4	5	6	7
Agriculture	Prime Farmland	X	X			X		
Conservation Value	Important Bird Area	X				X	X	X
Conservation Value	TNC Conservation Value	X			X	X	X	X
Conservation Value	TNC Resilient and Connected Network (RCN)	X				X	X	X
Habitat	Connectivity	X	X	X	X	X	X	X
Habitat	Critical Habitat	X	X					
Habitat	Golden Eagle	X	X		X	X	X	X
Habitat	Greater Sage Grouse			X				
Habitat	Wetlands	X	X	X	X	X	X	X
Management	ACEC	X	X					
Management	BLM OHV	X				X	X	X
Management	BLM Right of Way Exclusion	X						
Management	BLM Solar Energy Program	X		X	X	X	X	X
Management	BLM Special Recreation Management	X						
Management	Conservation Easement			X		X		
Management	GAP 1 Land	X				X		X
Management	GAP 2 Land	X						
Management	National Park Service	X	X					
Management	National Register of Historic Places		X					
Management	National Scenic Trail			X				X
Management	Scenic Highway	X	X	X				
Management	Visual Resource	X	X					
Management	Wilderness Characteristics	X	X	X				
Management	Wild and Scenic River	X						

Figure 25. The Harvard Oak (*Quercus havardii*) is an IUCN Endangered species that has been observed at the New Tech Materials Project Site. Photo from Bryant Olsen, used under a Creative Commons Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0) license.

Management issues at the New Tech Materials Project Site (UT1) include lands with Wilderness Characteristics, Scenic Highway and Visual Resource lands, ACEC and National Park Service lands, GAP 1 and 2 lands, BLM Special Recreation Management lands, BLM OHV lands, BLM Right of Way exclusion lands, BLM Solar Energy Program lands, and a Wild and Scenic River. The Project Site includes mapped wetlands, connectivity, critical habitat, and Golden Eagle Habitat. It also includes an Important Bird Area, lands denoted for their high conservation value by TNC, and lands contained within TNC's RCN.

At least 162 species and/or natural communities/ features have been recorded at the Project Site. Three of these are special status species. Loggerhead Shrike (*Lanius ludovicianus*) is listed as IUCN Near Threatened, Pinyon Jay (*Gymnorhinus cyanocephalus*) as IUCN Vulnerable, and Harvard Oak (*Quercus havardii*) as IUCN Endangered. The Project Site also contains NatureServe Areas of Unprotected Biodiversity Importance.

The Paradox Basin Brine Project Site (UT2) includes prime farmland, and lands with Wilderness Characteristics, Scenic Highway and Visual Resource lands, ACEC and National Park Service lands, GAP 1 and 2 lands, BLM Special Recreation Management lands, BLM OHV lands, BLM Solar Energy Program lands, a State Park, a Conservation Easement, a National Scenic Trail, and lands on the National Register of Historic Places. The Project Site also includes mapped wetlands, connectivity, critical habitat, and Golden Eagle Habitat. At least 253 species and/or natural communities/ features have been recorded at the Project Site, including five that are special status. Loggerhead Shrike (*Lanius ludovicianus*) and Rufous Hummingbird (*Selasphorus rufus*) are listed as IUCN Near Threatened, Pinyon Jay (*Gymnorhinus cyanocephalus*) as IUCN Vulnerable, and Black Rosy-Finch (*Leucosticte atrata*) (Figure 26) as IUCN Endangered. The Project Site also contains NatureServe Areas of Unprotected Biodiversity Importance.

Figure 26. The Black Rosy-Finch (*Leucosticte atrata*) is an IUCN Endangered species that has been observed at the Paradox Basin Project Site. Photo from Tom Benson, used under a Creative Commons Attribution-NonCommercial-NoDerivs 2.0 Generic (CC BY-NC-ND 2.0) license.

The Sal Rica Project Site (UT3) includes a Scenic Highway and National Scenic Trail, Conservation Easement lands, BLM Solar Energy Program lands, and lands with Wilderness Characteristics. It includes mapped wetlands, connectivity, and habitat for Greater Sage Grouse and Golden Eagle. Additionally, it includes lands denoted for their high conservation value by TNC, and lands contained within TNC's RCN. At least 83 species and/or natural communities/features have been recorded at the Project Site, including two special status species, Loggerhead Shrike (*Lanius ludovicianus*) and Olive-sided Flycatcher (*Contopus cooperi*), both of which are listed by the IUCN as Near Threatened.

Management issues at the Tule Valley Lithium Project Site (UT4) include BLM Solar Energy Program lands; mapped wetlands, connectivity, and Golden Eagle habitat; and lands denoted for their high conservation value by TNC, and lands contained within TNC's RCN. There have been at least 21 species and/or natural communities/features recorded at this Project Site; none of them are special status species, but the Project Site does include NatureServe Areas of Unprotected Biodiversity Importance.

The Ogden North Arm Solar Evaporation Project Site (UT5) contains prime farmland, an Important Bird Area, lands denoted for their high conservation value by TNC, and lands contained within TNC's RCN. Management issues include BLM OHV and BLM Solar Energy Program lands, GAP 1 lands, and a Conservation Easement. The Project Site contains mapped wetlands, connectivity, and Golden Eagle habitat. At least 173 species and/or natural communities/features have been recorded at the Project Site. The special status species recorded at the Project Site are Loggerhead Shrike (*Lanius ludovicianus*), Rufous Hummingbird (*Selasphorus rufus*), Semipalmated Sandpiper (*Calidris pusilla*) (Figure 27), and Snowy Plover (*Charadrius nivosus*), all of which are IUCN Near Threatened species.

The Northwest Great Salt Lake Project Site (UT6) contains an Important Bird Area, lands denoted for their high conservation value by TNC, and lands contained within TNC's RCN. Management issues include BLM OHV and BLM Solar Energy Program lands, and the Project Site contains mapped wetlands, connectivity, and Golden Eagle habitat. At least 23 species and/or natural communities/features have been recorded at the Project Site, including one special status species, Snowy Plover (*Charadrius nivosus*), which is IUCN Near Threatened.

Management issues at the Southwest Great Salt Lake Project Site (UT7) include BLM OHV and BLM Solar Energy Program lands, GAP 1 lands, and National Scenic Trail lands. The Project Site contains an Important Bird Area, lands denoted for their high conservation value by TNC, and lands contained within TNC's RCN. Additionally, the Project Site contains mapped wetlands, connectivity, and Golden Eagle habitat. At least 174 species and/or natural communities/features have been recorded at the Project Site. Three special status species have been recorded at the Project Site: the IUCN Near Threatened Loggerhead Shrike (*Lanius ludovicianus*), Semipalmated Sandpiper (*Calidris pusilla*), and Snowy Plover (*Charadrius nivosus*).

Figure 27. The Semipalmated Sandpiper (*Calidris pusilla*) is an IUCN Near Threatened species that has been observed at several Project Sites in Utah. Photo from Gregory "Slobirdr" Smith, used under a Creative Commons Attribution-Share Alike 2.0 Generic (CC BY-SA 2.0) license.

Wyoming

Wyoming contains one Project Site. The Rock Springs Uplift area of southwestern Wyoming has been proposed as a location where lithium could be extracted using existing oil and gas infrastructure (Figure 28). While no companies are actively proposing a plan for extraction, a Project here could involve direct lithium extraction (DLE) from oilfield brine at pre-existing industrial facilities associated with the Rock Springs Uplift.

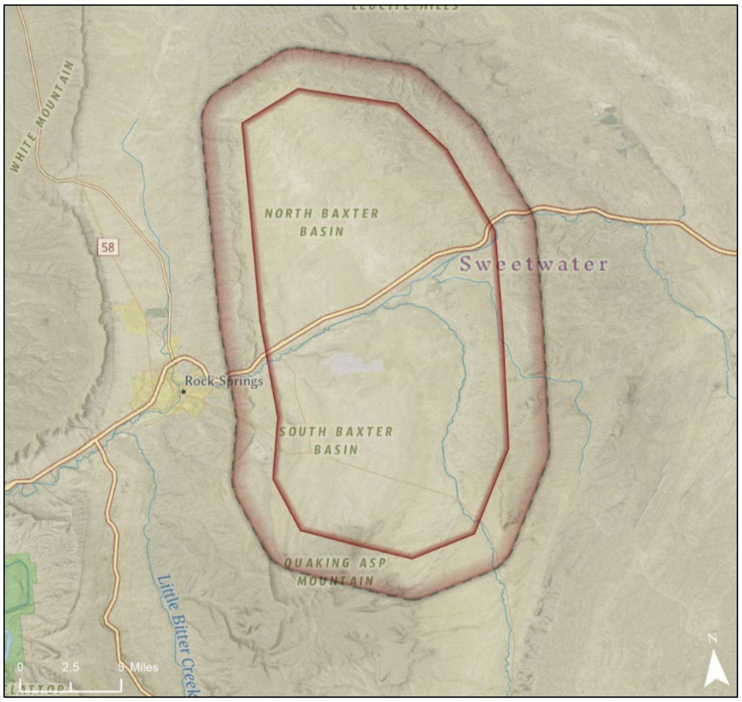


Figure 28. Map of Rock Springs Uplift Project Location and surrounding Project Site in Wyoming.

Management issues at the Project Site include ACEC lands, GAP 2 lands, and lands with visual resources. The Project Site includes mapped wetlands and lands important for connectivity, as well as big game habitat, grassland bird habitat, and habitat for bats, Mule Deer, Prairie Dog, Pronghorn, Sage Grouse, Golden Eagle, and Bald Eagle. It also includes lands denoted for their high conservation value by TNC and lands contained within TNC's Resilient and Connected Network (RCN). There are at least 93 species and/or natural communities/features that have been recorded at the Project Site, including 50 that have a special status. These include the Black-footed Ferret (*Mustela nigripes*) which is federally listed as Endangered Species, the Little Brown Myotis (*Myotis lucifugus*), which is an IUCN Endangered Species and is under review for listing by the United States Fish and Wildlife Service. For a complete list of all special status species occurring at the Rock Springs Uplift Project Site, please see Supplemental Information D.

Figure 29. The Black-footed Ferret (*Mustela nigripes*), shown here chasing a Prairie Dog (*Cynomys* sp.), is federally listed under the Endangered Species Act as an Endangered Species. It has been observed at the Rock Springs Uplift Project Site. Photo from the United States Fish and Wildlife Service.

Summary and Cumulative Impacts

Hundreds of species have been recorded within the 72 proposed lithium extraction sites, including 248 rare and/or special status species. Of these, eight are federally listed under the Endangered Species Act as Endangered Species, two are federally listed as Threatened Species, and 59 are listed by states as Endangered, Threatened, or some other special status. The remainder of the 248 species are IUCN-listed as Near Threatened, Vulnerable, or Endangered, or are state-tracked for some other purpose. Birds were the most commonly recorded taxonomic group, and appeared across the broadest geographic range of sites. As two examples, Loggerhead Shrike (*Lanius ludovicianus*) was recorded at 27 Project Sites across California, Nevada, New Mexico, Oregon, Utah, and Wyoming, and Golden Eagle (*Aquila chrysaetos*) at 26 Project Sites across California, Nevada, and Wyoming. A complete list of special status species is available in Supplemental Information D.

Wetland habitat was the most commonly occurring mapped habitat type; it was recorded at Project Sites in all nine states. All methods of lithium extraction have the potential to impact wetlands and species that are dependent on groundwater and surface water. Therefore, a cumulative impacts analysis focused on this habitat type is necessary to determine the true impacts of lithium extraction on wetland habitat and the species it supports. Specifically, the saline lakes in the western United States provide a system of feeding and resting sites for inland shorebird migration in a north and south pattern. The health of this poorly understood complex of open water and wetlands has huge implications for the survival of bird populations, especially shorebirds, in the Pacific Flyway (Anderson et al. 2021; Murray et al.2018). The cumulative impacts of lithium extraction on or near these saline lakes and small perennial wetlands, combined with climate change aridification, may result in a more serious long-term impact in bird populations than what may be suggested at each extraction site individually.

Economic Analysis

Panamint Valley. Photo © Adam Reeder, used under Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0) license

GLOBAL MARKET

The global market for lithium metal and key lithium compounds used in rechargeable batteries, including lithium carbonate and lithium hydroxide, is changing rapidly. Prices for these commodities have surged from Jan 2021 to May 2022; the price of lithium metal and lithium carbonate have increased approximately 547% and 781% respectively from Jan 2021 to May 2022 (Investing.com 2022) (Figure 30). Global supply is currently not keeping up with rapidly increasing demand, which is driven by electric vehicle adoption and has accelerated due to a sharp increase in oil prices. While lithium has other industrial and medical applications, the electric vehicle market accounts for nearly 80% of global lithium demand (Saefong 2022).

The surge in prices has created enormous incentives to bring new lithium supplies to market, including marginal sources that were previously not economically viable, but development of new lithium projects may take a decade or more depending on the project. Furthermore,

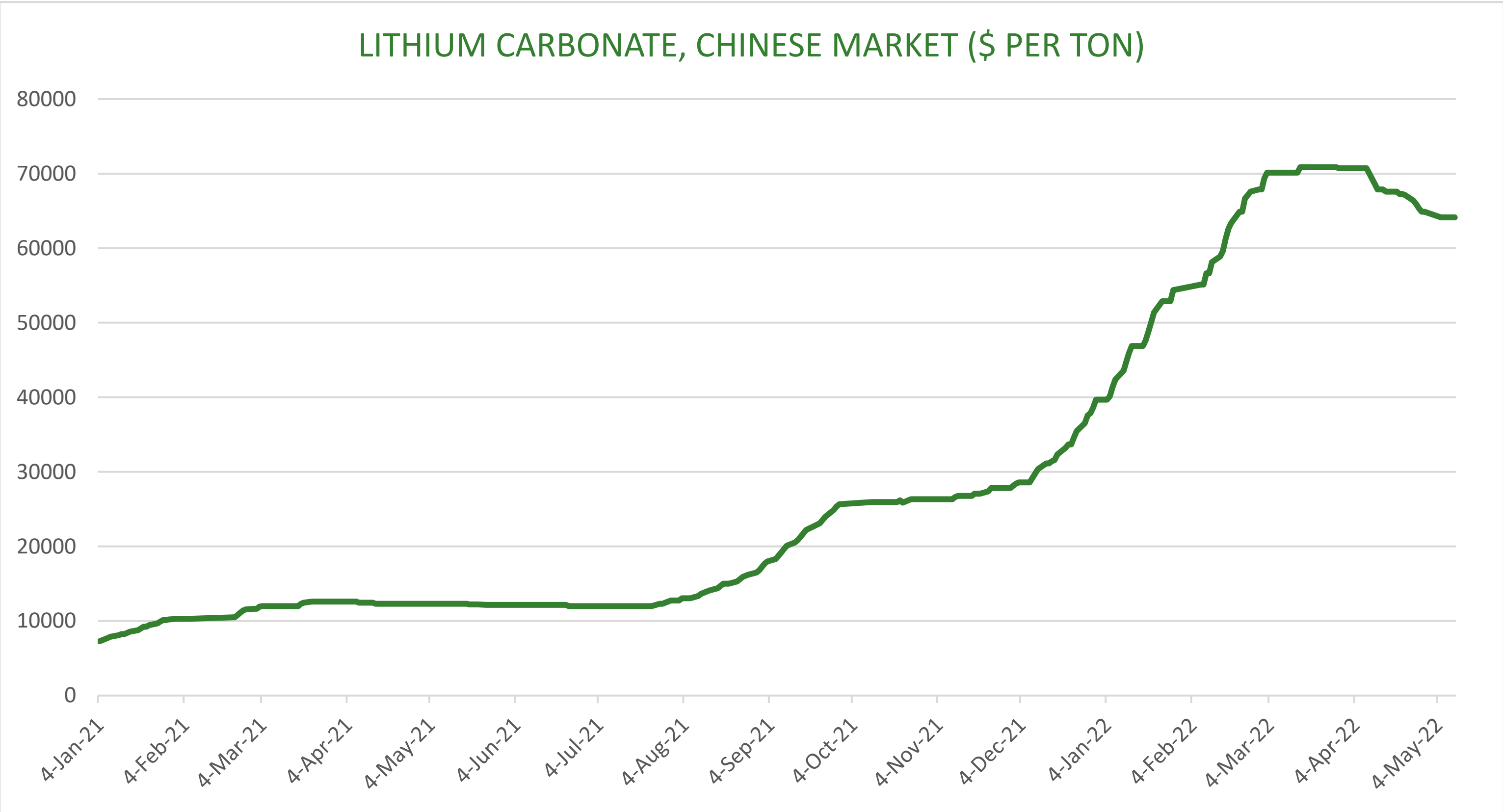


Figure 30. Lithium Carbonate prices on Chinese market (Source: investing.com)

disruptions due to COVID are likely to hinder lithium production in the short run, especially since the vast majority of lithium processing occurs in China (IER 2020). Fundamentally, the lithium market can be summarized in terms of supply and demand as seen in Figure 31. Due to electric vehicle adoption, the demand for lithium has increased, which is captured by the shift from the downward-sloping line passing through point A to the one passing through point B. In the short run, supply is essentially fixed, which is captured by vertical supply curve. This means that the amount of lithium available is not able to immediately adjust to high lithium prices. The net effect is that market equilibrium has shifted from point A to point B, causing a dramatic increase in prices. Eventually, more lithium will become available, and the supply curve will shift to the right, leading to a decrease in price, assuming growth in demand levels off. However, industry forecasts indicate that prices are unlikely to decrease significantly for the next year or so and that demand will keep multiplying for the foreseeable future (Saefong 2022).

GLOBAL AND U.S. PRODUCTION

Currently, lithium production is dominated by Australia, Chile, Argentina, and China as seen in Figure 32. U.S. lithium production is currently limited to the brine extraction site at Silver Peak, NV and constitutes less than 1% of world supply (USGS 2022). The USGS estimates that the U.S. has 9.1 million metric tons (MMT) of identified lithium resources, which is roughly 10%

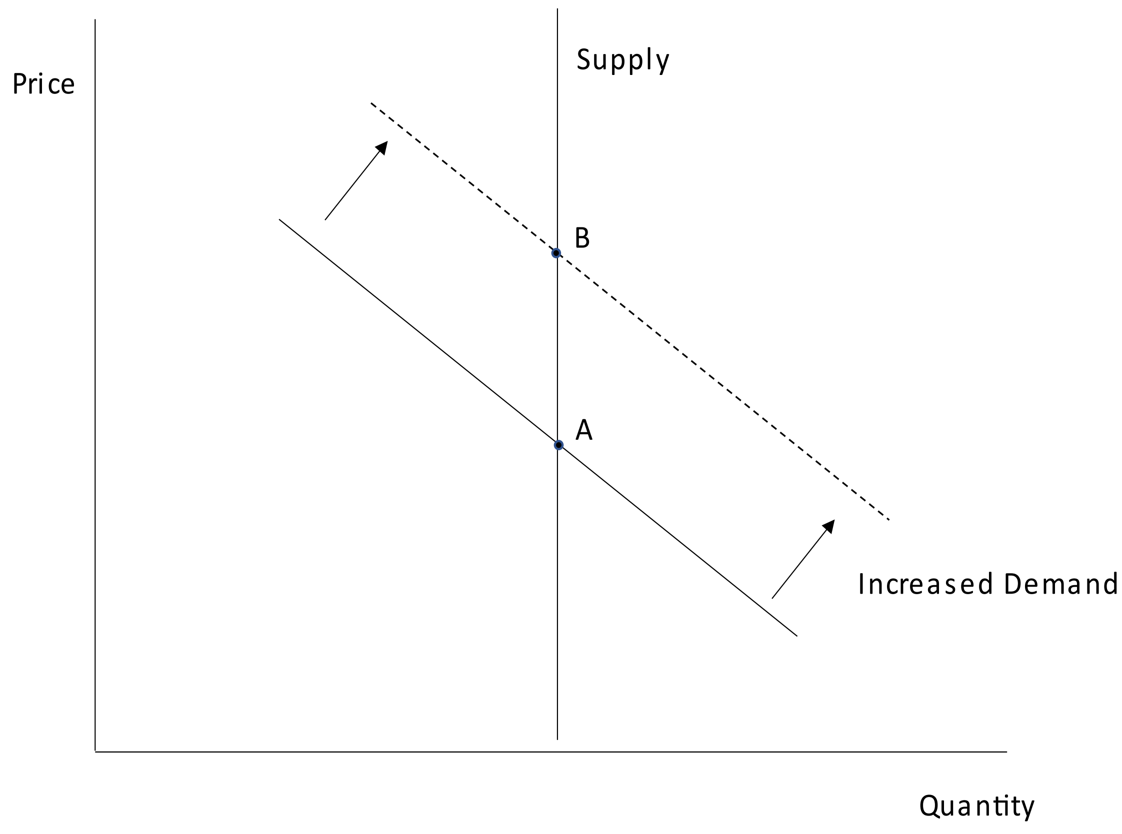


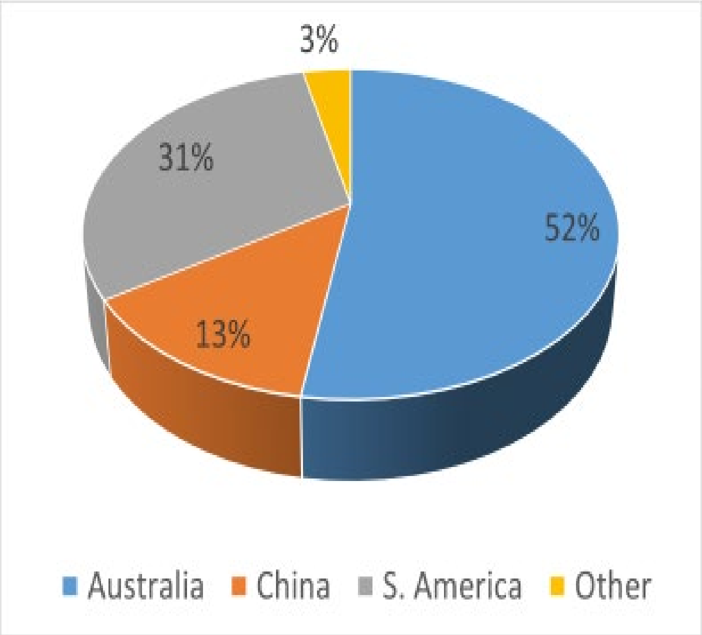
Figure 31. Lithium supply and demand. Demand has increased while, in the short-run, supply is essentially fixed, which results in price increases.

of the global total of 89 MMT (USGS 2022). However, the USGS estimates rely on estimates from the scientific literature and do not incorporate the latest studies. New studies coming available, including industry-funded studies, estimate that U.S. sources could be much higher than found in USGS reports. For example, preliminary estimates from an ongoing study of lithium resources beneath the Salton Sea indicate that there may be 1-6 MMT of lithium metal there alone (M. McKibben, personal communication, May 14, 2022). The USGS estimates that there was 100,000 metric tons of world production in 2021 (USGS 2022), which implies that the Salton Sea could meet global demand for 10-60 years at 2021 levels. Similarly, industry estimates from the 9 states covered in this report indicate greater potential lithium availability than estimated by the USGS. For example, recent studies at the Big Sandy site in Arizona estimate resource availability of 60,000 metric tons (Arizona Lithium 2021).

Given the extremely high prices at present, industry has strong incentives to conduct further studies, which will likely result in further increases in estimated lithium resources in the near future. We therefore consider USGS estimates to be fairly conservative and use the maximum site-level estimate from the USGS dataset (2019) in the analysis that follows.

Using USGS estimates of availability at sites with over 15,000 metric tons of lithium resources, we examine the state-level distribution and value of lithium across the top 5 states (Karl 2019). These include Nevada, California, North Carolina, Arkansas and Utah in descending order of lithium resources. Nevada has an estimated 8.5 million metric tons (MMT), followed by California with 1.1 MMT, North Carolina and Arkansas with approximately 0.4 MMT each and then Utah with 0.3 MMT (Figure 33). In total, these states contain over 10 MMT of lithium. This implies they could supply the world for over a century at 2021 levels. By this measure, Nevada alone could supply the world for 85 years. Projected future global demand may rise to approximately 376,000 tons of lithium metal by 2030, nearly quadruple 2021 levels (S&P Global 2022). At those levels, these 5 states could potentially meet global demand for 29 years.

To capture a sense of the potential economic importance to these 5 states, we estimate the value of state lithium resources in terms of current market conditions relative to state GDP estimates from the U.S. Bureau of Economic Analysis (US BEA). Using the ratio of potential value to GDP, we derive an estimate of the number of years' worth of state GDP that could hypothetically be generated if all lithium was extracted at current market prices, which is not realistic but provides an indication of the degree of urgency that may be felt to expedite major lithium projects. By this metric, Nevada is once again the top state with 19.5 years' worth of GDP.



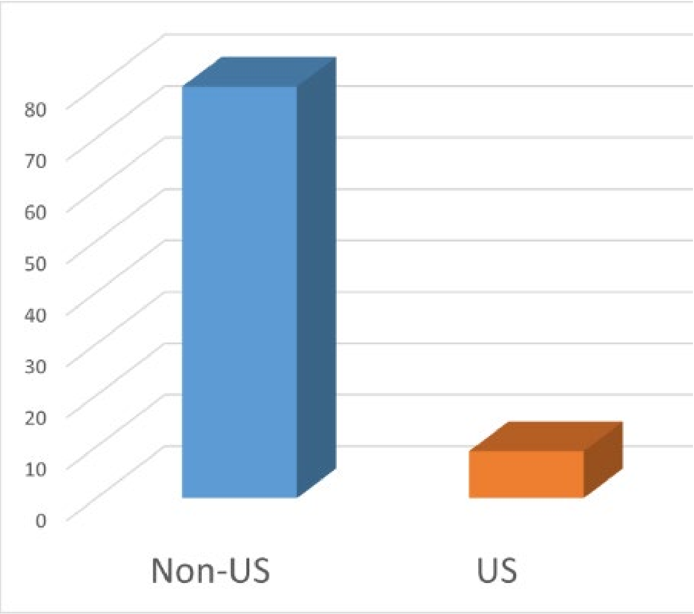


Figure 32. Top: Percentage global lithium production by region
Bottom: Global lithium resources available, million metric tons
(Source: USGS)

Nevada is followed by Arkansas with 1.2 years, then Utah (0.6 years), North Carolina (0.3 years), and lastly California (0.1 years) (Figure 34). Although California has the second largest amount of lithium, it has by far the biggest state economy and therefore has the least to gain economically in terms of direct lithium value. However, other considerations such as the development of new domestic processing and recycling facilities, proximity to major domestic manufacturing sites using lithium, and proximity to major ports for shipment to foreign processing facilities all add economic and strategic reasons why a given state may seek to expedite local lithium projects. For example, the California Energy Commission (CEC) has convened the Lithium Valley Commission to "review, investigate, and analyze opportunities and benefits for lithium recovery" (CEC 2022).

INDIVIDUAL EXTRACTION PRODUCTS

The decision to open a new lithium extraction site or to expand an existing one depends on a number of factors, which are known with varying degrees of certainty. Years of planning and large capital expenditures are typically required before a site is operational. The associated costs vary dramatically by site depending on factors such as technical requirements, regulatory compliance, and the availability of public infrastructure. The extraction method, end product (lithium carbonate, lithium hydroxide lithium metal, etc.), and the degree of processing capacity on site can dramatically alter the level of investment required and the operating expenses once the project begins production. Sterba et al. (2019) outlines the economics of major lithium extraction projects from across the world.

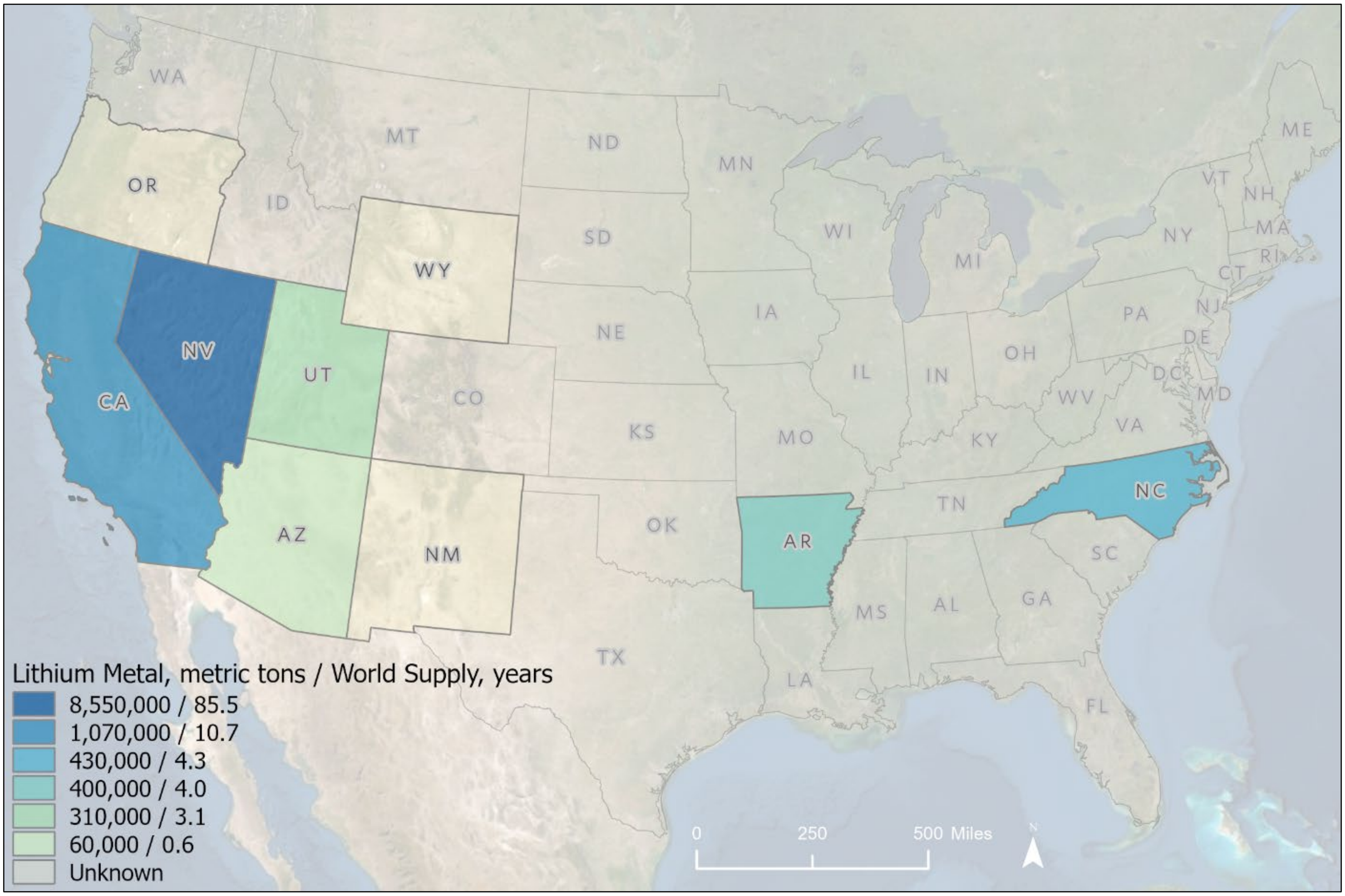


Figure 33. World supply of lithium metal by state.

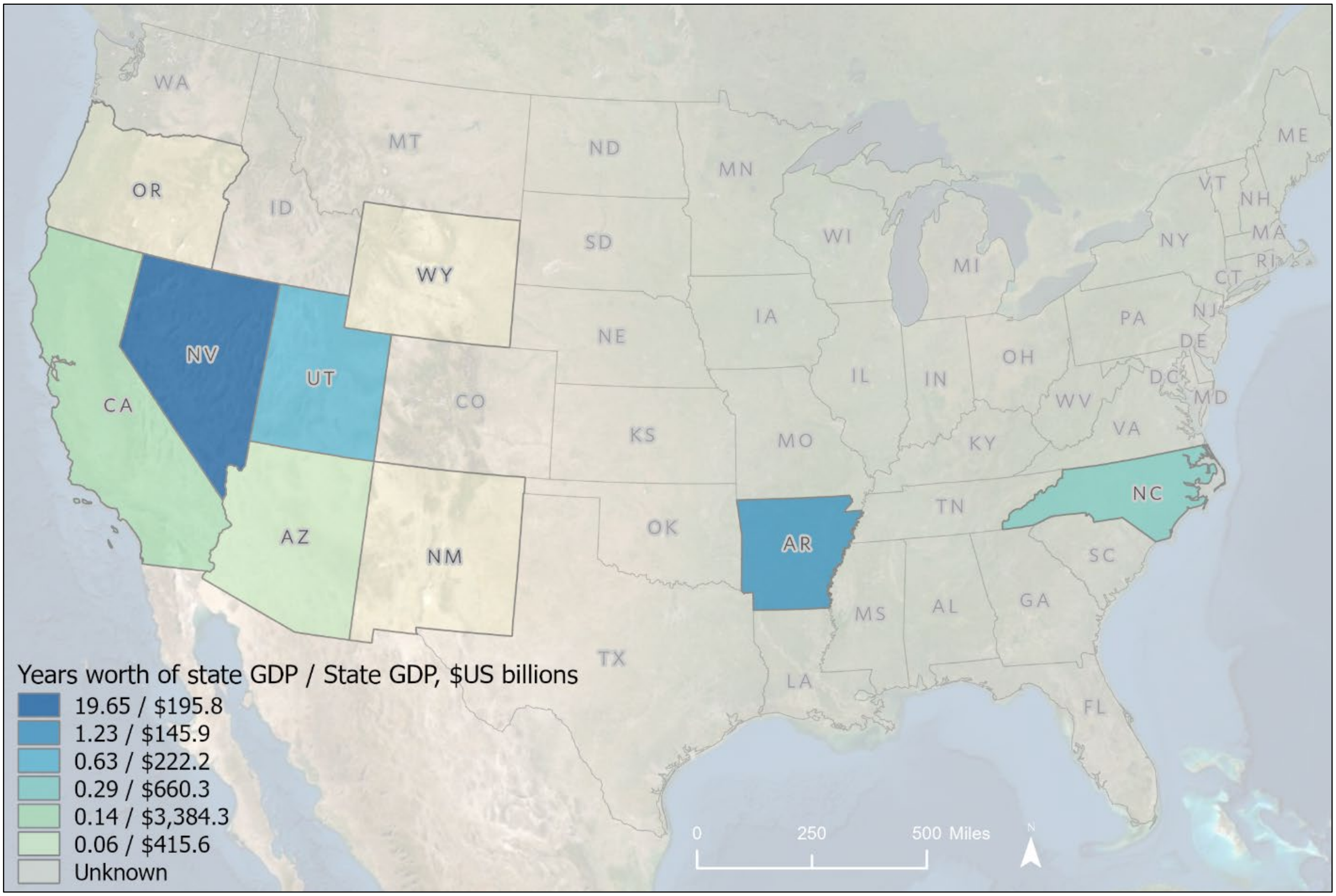


Figure 34. Years worth of state GDP by state (in billions $US).

Lithium prices also vary across projects based on a number of factors including lithium product, lithium content and quality, and the price negotiated in long-term contracts (S&P Global Market Intelligence, 2022). Tax incentives and royalties due to the government can also dramatically affect the profitability of individual projects. Therefore, it is difficult to generalize across the economics of individual lithium operations. Ultimately, the decision to pursue a given project is made based on the factors outlined above in conjunction with assumptions such as the average price of lithium over the life of the project, the productivity of the operation at different stages, and the discount rate applied.

LOCAL ECONOMIC IMPACTS

New lithium extraction projects will provide benefits to local economies but there are significant questions about the magnitude of those impacts, how broadly the benefits will be distributed, and what policy measures may be needed to balance economic and environmental factors and ensure equitable outcomes for local communities. Potential economic benefits from investment and ongoing operations at lithium extraction and processing facilities would include increases in direct and indirect expenditure in the local economy, the creation of jobs that are likely well-paid relative to average local wages, and increases in local tax revenue.

The lithium extraction sites considered in this report are predominantly located in rural areas at least an hour's drive from major metropolitan areas. Such areas typically have lower tax bases and fewer employment opportunities than urban areas. For that reason, the potential local economic impact is likely to be high and there may be intense lobbying for approval of projects by federal, state, and local governments. For example, the Salton Sea lies in Imperial and Riverside Counties of California, which in terms of per capita income rank 54th and 50th respectively out of 59 counties in the state (US BEA 2022).

Similarly, in Nevada, the state with the most lithium resources, 11% of jobs in rural areas include work in mining or forestry (Aguero 2020). In these areas, hundreds to thousands of new jobs may be created by lithium projects. However, in these areas and elsewhere, there may be labor market problems due to a lack of trained local candidates. The result may be that jobs are taken by candidates recruited from outside the region, who may or may not become long-term residents of the area. To ensure that jobs are matched to local candidates, it is likely that public funding and private-public partnerships will be needed for local workforce development. For example, in the Salton Sea region, Berkshire Hathaway Energy has been donating to local high schools for STEM education and funding scholarships for STEM students enrolling at Imperial Valley College (J Weisgall, personal communication, June 11, 2022).

Evaporating Ponds, Silver Peak Lithium Mine. Photo © Ken Lund, cropped version used under an Attribution-ShareAlike 2.0 Generic Creative Commons (CC BY-SA 2.0) license.

Policy Analysis

Photo © Bryant Olsen, cropped version used under a Creative Commons Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0) license.

INTRODUCTION

A project entitled "Lithium Extraction Policy in the Salton Sea and Thacker Pass: A Critical Analysis of Emerging Regulatory and Multi-Sectoral Complexities" was completed by Andrew Williams as a capstone project in partial fulfillment of the requirements for the degree of Master of Urban and Regional Planning (MURP) at UCLA's Luskin School of Public Affairs. The Nature Conservancy served as the client for this project. The findings and conclusions represented here are the author's own. The report drafted from that effort has been edited for inclusion here. For additional information about this capstone project, please visit: https://murpcapstone2022.pory.app/record/recBbGqr7etsLqt5q?sId=JcbEJpBle26j

The objective of this study is to gauge policy recommendations from stakeholders using the Salton Sea in California and Thacker Pass in Nevada as case studies. Potential policy guidelines were developed using a semi-structured multi-stakeholder interview approach. The results that follow indicate that a nuanced set of policies are needed to support multi-benefit lithium extraction. Given that the lithium operations at the Salton Sea and Thacker Pass are still in development, potential policy solutions remain speculative and are contingent on the processes and outcomes of successful lithium production.

Conversations with stakeholders suggest that lithium operations at the Salton Sea and Thacker Pass will affect local and regional environments. This is evitable and is likely the case at any extraction site, but there are varying levels of impact with each location and extraction technology. Ultimately, new state and federal policies are needed to generate sought-after outcomes, including the alteration of regulatory schemes, the expansion of government capacity, the fostering of widespread community engagement, and the delivery of equitable benefits for local communities.

The following sections provide an overview of the research design used to develop questions, select stakeholders, and analyze collected data. Each case study is analyzed on its own to examine associated impacts, evaluate current policies, and assess the relationships between stakeholders and policy decisions. In closing, a set of policy recommendations and areas for further research are discussed.

Tiehm's Buckwheat (*Eriogonum tiehmii*)
Photo © Patrick Donnelly/Center for Biological Diversity

RESEARCH DESIGN

Semi-structured interviews with lithium extraction stakeholders were targeted in both the Salton Sea in California and Thacker Pass in Nevada (Figure 35). These locations were selected because of their large lithium deposits, the difference in proposed extraction technology to be employed, and concerns surrounding environmental impacts. Commercial production of lithium in these areas is expected in the mid-2020s, making timely environmental analyses imperative to the creation of new policies to guide extraction. Even though projects within these regions will use different extraction technologies and will follow different regulatory models, both areas highlight contrasting engagement strategies and offer insights on two emerging lithium production methods that may revolutionize the lithium industry.

The semi-structured interview approach allows for an in-depth exploration of the hazards and opportunities presented by lithium production in different physical and political environments. Ultimately, the purpose of the interviews is to answer the question: what state and federal policies could be enacted that would best promote lithium extraction and allow for environmental protection, while also supporting economic development and other social and public health benefits?

To dig deeper into the fundamental nature of this question, a stakeholder-driven approach was used to:

1. **Assess environmental impacts** on local and regional environments including but not limited to the impact on water quality and use, air quality, disposal of toxic substances, human population health, and the health of endangered flora and fauna.

2. **Evaluate current regulatory policies and identify new policies** on state and federal levels to safeguard against negative environmental impacts.

3. **Assess the relationships between stakeholders and policy decisions**, including the balance of economic development, community benefits, and sustainable production practices.

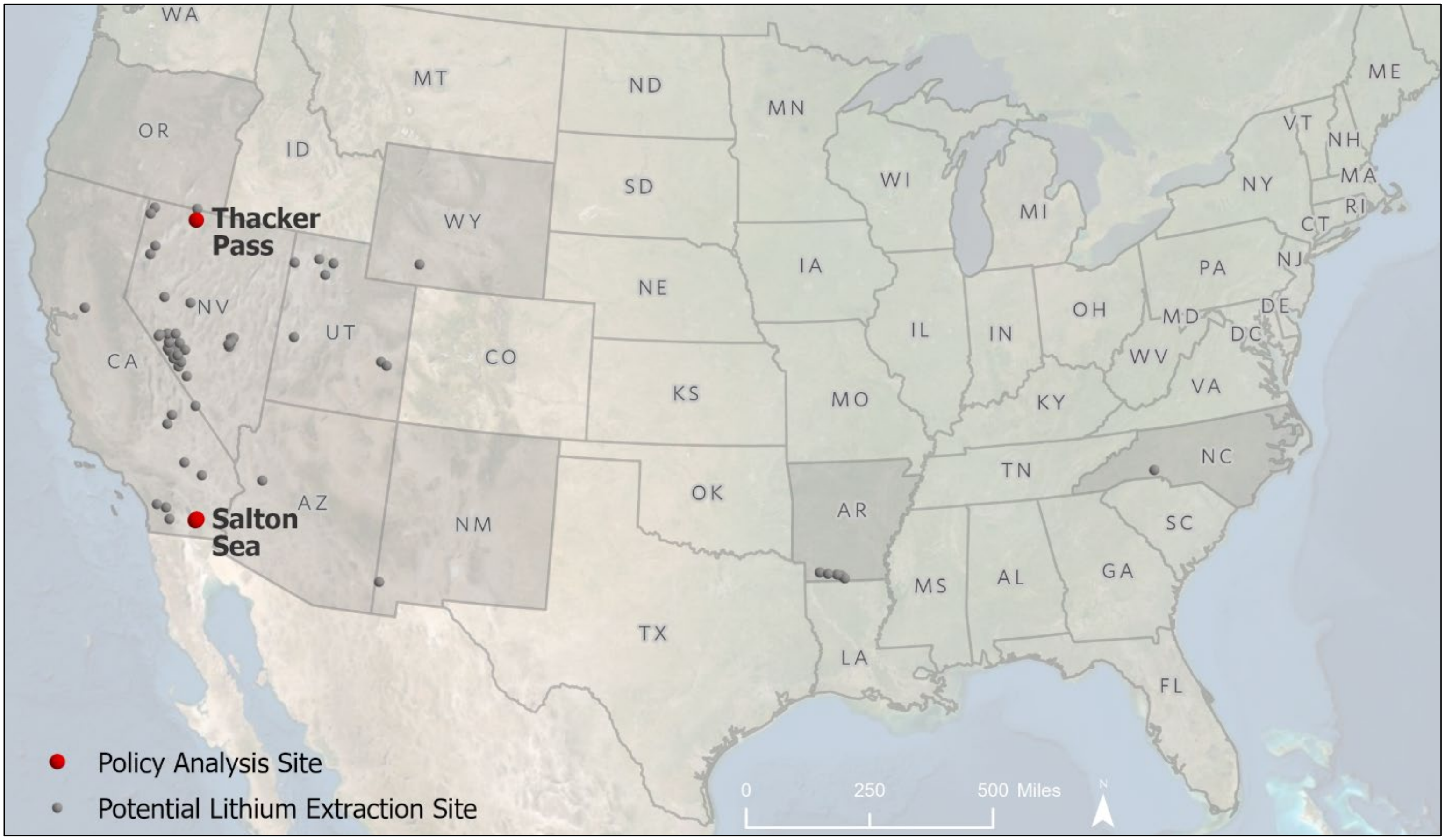


Figure 35. Location of Thacker Pass and Salton Sea potential lithium extraction sites.

Seven questions were generated to represent these research aims, with dozens of prodding questions crafted to dig deeper into specific stakeholders' disciplines and areas of expertise (see Supplemental Information E). All questions were evaluated by The Nature Conservancy, UCLA faculty, and UCLA peers from the Master of Urban and Regional Planning Program before they were finalized.

An initial cohort of stakeholders for interviews were chosen through their connection to either lithium extraction, the surrounding communities of Thacker Pass or the Salton Sea, or their advocacy and expertise in issues that connect to lithium processing or its supply chain. Stakeholder groups consisted of the mining and energy industries, environmental and environmental justice organizations, community organizations, tribes, government officials, and academic researchers. Interviews were conducted over Zoom or on the phone and lasted anywhere from 30 to 60 minutes. Interviews began in January and ended in May. After interviews commenced, a "snowball" method was employed to gain introductions to additional stakeholders. An effort was made to balance the variety of organizations and interests to include as many perspectives as possible.

Out of 65 invited stakeholders representing 30 organizations, 14 stakeholders responded to interview requests. There were 6 stakeholders for the Salton Sea and 8 for Thacker Pass. Stakeholders from the Salton Sea consisted of two community and environmental justice organizations, two environmental organizations, one industry consultant, and one academic researcher who also provides consultation to DLE industry research. Thacker Pass stakeholders consisted of four environmental organizations, one advocacy group, two government officials, and one industry consultant. After each interview, the conversation was transcribed and coded to highlight common themes surrounding the research question and aims. Regulatory frameworks for California, Nevada, and the federal government were used to ground observations. Each geographic area was analyzed on its own given the disparate nature of the two sites.

This methodology allowed for direct input from those most affected by state and federal government policies. The open nature of semi-structured interviews allowed participants to discuss freely, and in detail, what was most important to them.

However, there are weaknesses of this design. First, the number of participants was limited given the time parameters of this study. The effort to balance perspectives meant more time spent attempting to contact unresponsive stakeholders, and this contributed to a lower participation rate. Further, the two case study areas differ significantly, having their own niches, meaning more time was needed to understand the nuances of extraction technology, regulatory policy, ecosystems associated with each site, and the different community identities and histories of the Salton Sea and Thacker Pass. Additionally, extraction at each site is not in operation yet. This resulted in uncertainty about associated impacts, making the policy recommendations more speculative.

RESULTS AND ANALYSIS

This section provides detailed stakeholder responses by site. Although the questions posed to stakeholders were almost identical, thematic responses varied greatly between the two sites. This again is a function of different extraction technologies, governing regulatory frameworks, ecosystems associated with each site, and the different community identities and histories. Insights from stakeholders in the Salton Sea center on the community impacts of energy and industrial expansion. The project at Thacker Pass represented a more contentious environmental battle according to stakeholders, with ongoing litigation to stop lithium mining by environmental organizations and three tribes. To address these differences, each case study is presented separately below, allowing for a closer look at associated environmental impacts, regulatory insights, community engagements, economic impacts, and broader societal implications. An abbreviated version of results is shown in the table on the next two pages. Policy dimensions are represented throughout each subsection.

	Salton Sea	Thacker Pass
Site Context	• Known for environmental hazards as the result of agricultural policy and receding water lines. • Three different projects piloting extraction using novel direct lithium extraction (DLE) techniques. • Companies include Controlled Thermal Resources, EnergySource Minerals, and Berkshire Hathaway Energy.	• Located in the northwestern edge of Nevada in the McDermitt Caldera. • Extraction would use traditional hard rock mining methods in clay. • Lithium Nevada, a subsidiary of the Canadian owned Lithium Americas, is the sole operator of the Thacker Pass project.
Environmental Impact	• DLE impacts local environments to a lesser extent than other extraction methods. • Will grow geothermal energy production • Concerns over extensive water, air quality, and toxic waste disposal. • Air quality needs to be addressed before other industries move to the region • Cumulative impacts unknown.	• Concern for multiple plant and wildlife species that are fragile to environmental change • Danger from groundwater pollution that may span over 300 years. • Efforts to reduce carbon footprint and impacts as well as water use by industry.
Environmental Review Processes	• Frustration over lack of capacity of federal and state agencies. • Permitting processes can put unnecessary tensions between the industry and community. • Trust in CEQA and California regulations • Concern over CEQA exemptions • Desire for more community consultation in review processes.	• Industry anchors and begins projects using their own resources without extensive oversight, which may incentivize firms to mine regardless of impacts. • Lack of capacity and technical expertise from government agencies. • Questions of regulatory capture of state and federal agencies. • Mining laws in Nevada have gradually evolved to increase environmental protections, though some stakeholders say this is insufficient. • Misaligned General Mining Law of 1872.
Community Engagement	• More inclusive and representative community involvement. • Concerted efforts to engage communities but can be inaccessible given format for engagement. • Desire more transparency from both government and industry entities. • Strong need for more community education on impacts and extraction processes.	• Inconsistent community engagement during the COVID-19 pandemic. • Yet, there is ongoing engagement between industry, government officials, and communities. • Interactions with the plurality of tribes in the area was minimal by the BLM. • Technical expertise and support to communities has been limited, limiting community resources to participate.

	Salton Sea	Thacker Pass
Economic Impacts	• May offer tangible benefits to communities that feature higher unemployment and health burdens. • Battery industries may co-locate in the region. • Concern over who will have employment opportunities • Projects may rebrand the region and help mitigate environmental hazards from the Salton Sea. • Infrastructure needs could be addressed.	• Mine creates economic opportunities that will amplify throughout the region. • Increases U.S. energy and security independence in the face of a global supply deficit of lithium • Reduces global supply chain emissions by producing processing lithium on-site.
Other Voiced Concerns	• Global Context: Seen as a crucial piece to alleviate impacts of climate change. • Development Model: Opportunity to include communities in a meaningful way and develop a more equitable model.	• Sacrifice: stakeholders raised questions on who is bearing the price of sacrifice and at what cost for new lithium demand. Much of larger society does not have to shift its habits or culture. Instead, the burden of transition is placed on frontline communities.

Desert bighorn (*Ovis canadensis nelson*). Photo © Andrew Cattoir/NPS

Salton Sea

The commercial viability of direct lithium extraction (DLE) in the Salton Sea remains unsettled, though academic researchers providing consultation to the lithium the industry believe use of DLE is inevitable based on current progress. However, the environmental history of the Salton Sea in conjunction with underrepresented communities in the region present a tense dynamic with industry forces. The success or failure of lithium production will likely be judged by the demonstration of commercial extraction, community benefits, and Salton Sea restoration. In the six interviews conducted, multiple themes emerged, including issues on environmental impacts, environmental review processes, community engagement, economic impacts, and questions about whether lithium extraction would follow typical resource extractive models. Although there are three major projects, in addition to government grants funding extraction research, much of the perceived impact is speculative and will remain so until larger scale pilots are successful. Policy recommendations were largely focused on the impact of industry expanding in the area, which will come with its own housing, infrastructure, and environmental concerns.

ENVIRONMENTAL IMPACTS

Interviewed stakeholders expressed a mixture of enthusiasm and hesitancy about environmental impacts from geothermal expansion and lithium production. It was important for stakeholders to discuss lithium in context to other areas, potential negative externalities, and Salton Sea restoration and public health. Most stakeholders thought impacts would be relatively small. However, several community and environmental organizations still had reservations about the unknown cumulative impacts of expanded industry on the region.

Lithium Extraction in Context

For stakeholders aware of the potential for DLE at the Salton Sea, it was important to contextualize three points—the potential smaller footprints of DLE in comparison to other extraction methods, the total lithium reserves available at the Salton Sea, and using the area to expand renewable energy sources. One researcher noted, "the traditional ways of mining lithium are really thrashing the environments in other countries. In contrast, the footprint of geothermal lithium extraction is very small, it's 100 times smaller than a solar deposit in Chile and it's at least 10 times smaller than a typical open pit mine in Australia." Although DLE holds promise in reducing cumulative emissions and could serve as a vital source of lithium, multiple stakeholders remained cautious of large-scale commercial impacts in the Salton Sea, citing the unknown cumulative impact on the region.

Environmental Concerns

The existing state of the Salton Sea was described as "dire" by one environmental stakeholder, commenting the water levels had declined significantly over the past decade. Concerning the potential impact of industry moving into the Salton Sea, they went on to say, "geothermal and lithium are moving into an area that isn't exactly pristine, but they are moving into an area that is fraught with a history and decades of environmental damage and degradation, and a population that is the most severely impacted in the state." Still, explicit environmental concerns for those interviewed included impacts on water usage, air quality, waste disposal, and emissions from the associated transportation of lithium products.

Community organizations raised concerns about water usage, a divisive topic in the arid Salton Sea region. A community group stated that DLE could use about 2,400 acre-feet of water per year. But when speaking to both lithium researchers and environmental stakeholders on the overall water impact of DLE on the Salton Sea, they viewed water usage as trivial. An environmental stakeholder indicated that if as much as 150,000 acre feet a year are consumed by geothermal and lithium production, that amount is insignificant compared to the water already used in the region. According to the Imperial Irrigation District (IID), 2.5 million acre feet were used in 2020 (IID 2022). One researcher stated that 90% of current IID water goes directly to the agriculture industry, with only 2% going to geothermal. They suggested water conservation efforts should be aimed at the agriculture industry to increase efficiency and reduce waste. Comments from the Imperial Irrigation District indicated that it remains optimistic about balancing the future water needs of lithium extraction with those of agriculture.

Air quality is a serious concern, as geothermal plants produce steam. An environmental stakeholder commented that if steam is 99% water vapor, the other 1% is potentially significant in terms of total pollutant loading from the estimated large quantities of geothermal and lithium production. They noted, “whatever is downwind will be affected. If it blows over a habitat, it’s going to affect species.” Transportation emissions are an additional concern. Imperial county already has some of the worst air quality in the state (Singh 2021). Adding diesel emissions could further exacerbate air quality. There was also concern about the waste products generated from DLE, if waste is toxic, and how it would be disposed. Questions about air quality and waste disposal remain unanswered to many community and environmental groups. The totality of impacts may not be known yet, with one environmental stakeholder indicating, “we don't know what the actual environmental impacts could be or how much. There are a lot of questions that have not been answered and won't be answered until they actually get these demonstration projects up and running.” Another stakeholder also mentioned that since DLE technologies are not being disclosed, how could they analyze environmental impacts associated with extraction technologies?

In sum, several of those interviewed saw the overall impacts of lithium extraction in the Salton Sea region as potentially small. Environmental stakeholders did not believe extraction was entirely benign, but still believed any issues could be properly mitigated. Not knowing the overall impacts associated with extraction, they were curious as to what those impacts were going to be and how the state and industry would mitigate them. As one environmental consultant concluded, “these associated industries can be developed in a way where they mitigate their impacts but we need to figure how to contain it, how to reduce the risks associated for communities, and be honest about it.”

Salton Sea Restoration and Human Health

The lingering consequences of the Salton Sea’s receding shoreline, combined with mismanaged agricultural policy, are detrimental to both human health and economic livelihoods in the region. According to some stakeholders, lithium extraction could play an active role in the rehabilitation of the Salton Sea. Several stakeholders were even optimistic about opportunities to link restoration, industry, and the state into a broader deal that would improve conditions in the region. However, environmental stakeholders cautioned that geothermal and lithium producing entities were not responsible for the poor condition of the Salton Sea region. They noted, “the burden for solving that health issue shouldn't be placed solely on the backs of the geothermal or lithium industries, because they're not responsible. We need to look at the agricultural industry.”

Even though environmental restoration was seen as important for stakeholders, it was seen as a lower priority than human health and economic development. However, restoration could become a priority if lithium extraction gains a strong foothold, as the battery manufacturing industry may seek to co-locate in the Imperial or Coachella Valleys. As one stakeholder noted, “you can’t have the industry in the area if you don’t fix the health situation, we can’t bring thousands of people here and give them all asthma.” Multiple stakeholders, including all community and environmental stakeholders, indicated it should be the state’s responsibility and wanted the state to take a more active role in habitat restoration.

Review Processes

Stakeholders expressed a variety of opinions on the current regulatory framework and review process, expressing trust in the system while maintaining that the state needs more capacity and needs to follow its own rules. The review process itself is unfolding now, so ideas and policies about the process are still in formation. There is a strong level of trust in the California Environmental Quality Act (CEQA) and National Environmental Protection Act (NEPA) processes. One community advocate commented, “one of the best protections will have been, among others, CEQA and NEPA. It gives the community the power to file suits if we find that there are failures in the decisions of the permitting process. The communities need to maintain that power.” Another researcher stated, “we don’t need more laws, we just need to enforce the laws we have.”

Still, stakeholders indicated the process could be improved. One environmental stakeholder commented that the permitting process creates tension between industry and the community, stating, "it seems as though CEQA and NEPA are inefficient, but the inefficiency is government who doesn't put in the sufficient manpower to get these processes done quickly." Commenting on potential industry resistance, one environmental stakeholder noted it should not be a larger issue and said that if an industry rises or falls on a CEQA analysis, that industry has much bigger problems. In terms of community engagement, which is covered in greater depth below, most stakeholders believed CEQA could be done in a way to instill greater community confidence and support.

With specific regard to permitting for the Salton Sea, one environmental stakeholder thought a programmatic environmental impact report (EIR) would make more sense as it would analyze the cumulative effects of extraction more holistically rather than producing an EIR for each project. They further explained there could be a "menu of mitigation measures" for industry to choose from. In such a scenario, other EIRs would likely not be needed; a negative declaration or an environmental assessment would suffice. Overall, it would result in much more work on the front end but could allow for a more efficient process and save time in the future.

Multiple interviewees expressed concern about special exemptions from CEQA that allow the industry to circumvent regulatory codes. One environmental organization indicated that Imperial County is asking for multiple environmental waivers and said they would likely oppose them all. Given the large economic impact of lithium extraction and the potential of the lithium-ion battery industry coming to Imperial County, there is concern that the state government will focus less on potential threats and their adverse impacts. The same environmental group that said it would likely oppose any exemptions also said that now was the time to ensure the government was doing their due diligence. They stated, "now really is the time to start raising these questions and getting requirements in place because we don't know if [DLE] is actually going to work. If it does work and the government says it's all systems go, we will have missed our opportunity."

Beyond potential exemptions and the CEQA process, there is concern about a report from the Lithium Valley Commission coming out in October 2022 to the California Legislature addressing extraction impacts. One last concern expressed by an environmental stakeholder included a transparent data collection process for air monitoring. Currently, geothermal companies self-collect and self-report their data. The stakeholder suggested that there needs to be sufficient funding for objective state staff to do the monitoring, and then create genuine sanctions when regulations are violated. Overall, there appears to be trust in the processes of the state, with the caveat that the state follows its own rules. However, the inability to prioritize permitting processes and limited government capacity to handle environmental protection remain lingering concerns.

COMMUNITY ENGAGEMENT

The bulk of concern from interviewees representing organizations focused on community engagement and how the community would be impacted by lithium extraction. This section is further divided into community interactions and needed technical expertise. As a whole, stakeholders expressed that there was a lot of caution on the behalf of the community about ongoing geothermal and lithium projects. They also commented community perceptions were never static, but always evolving.

Community Interactions

As lithium extraction activities ramp up in the Salton Sea region, interactions between community members, government, and industry could represent a new chapter of more inclusive engagement, but issues still plague the process. As an environmental justice advocate emphasized, "one of the largest barriers that exist within government is the fact that government is not very good at engaging communities. They lack policies, they lack expertise, they lack capacity building. This is now starting to change, but we're not there yet."

A more inclusive process was initiated with the creation of the Lithium Valley Commission (LVC) that includes members from Alianza Coachella Valley, Comite Civico del Valle, Audubon California's Salton Sea Program, the Torres Martinez Desert Cahuilla Indians, and the Quechan Indian Tribe. Their inclusion has enabled a variety of groups to participate in decision-making. However, questions arise from stakeholders as to the quality of engagement, and whether this representation is sufficient. Multiple issues were raised by community and environmental stakeholders. Although there is representation of the community, one person interviewed thought it was more "grass tops versus grass roots," suggesting a disconnection between representatives and the community. This may be an indication of a lack of capacity within the LVC as well as some underlying tension between Riverside and Imperial Counties. The network of environmental and community organizations surrounding the Salton Sea is small. The groups involved with the LVC are also partners with other organizations attending meetings questioning lithium extraction's impact. Another stakeholder commented that the LVC is verging into the territory of not effectively engaging communities. Part of their concern resides in the lack of sufficient transparency in the decision-making process.

According to multiple community stakeholders, communities in the region believe that industry and government are not often going to have communities' best interests in mind. Even in the context of more representation on the LVC, there is a level of uneasy trust. The relationships between community, industry, and the government are seemingly improving, though building relationships takes time, and any existing barriers and concerns are not removed overnight. One environmental justice advocate remained resolute that the government and industry needed to address community concerns. They stated, "is extraction really that safe? OK, show us. Is there economic opportunity here? OK, well let's see it. I would even go so far as asking is this something that's favorable to our community, to help alleviate the harm that's been done to our community." They went on to say, "the legacy of harm that some communities are living with and will continue to live with needs to be considered." Although community opinion is not static, community advocates emphasized they want to be part of the discussion and understand the implications of a new industry in the region and how it's going to affect them.

LVC meetings have also been a point of dispute. The LVC meets publicly once a month and provides additional context to the project and addresses issues brought up. In an early 2022 LVC meeting, community organizations noted that LVC staff brought in food, coffee, Spanish translation, and made efforts to engage community members. However, some community advocates were less than enthusiastic about the overall quality of these meetings, indicating that translation services were inadequate and suggesting the format was inaccessible. They went on to say, "the community needs a space to really react and share their thoughts and questions. The monthly five-hour meetings are not appropriate for that." Stakeholders suggested additional meetings to give the community the proper space in addition to the current monthly meetings.

As a whole, community interaction with the LVC appears mixed, with a more inclusive approach representing a milestone in itself. This is a stark comparison to previous community engagement and represents a completely different methodology in comparison to Thacker Pass. Still, greater levels of transparency about ongoing projects remain a notable frustration.

Technical Expertise

One of the largest barriers according to both lithium extraction researchers and community organizations is the technical nature of DLE and enabling community members and environmental groups to identify DLE processes and impacts. One researcher suggested, "a big failing of that whole process with the CEQA and NEPA sequence is laying things out in a way that's digestible by the general public, and not leaving them frustrated and feeling like they don't have a voice in the whole thing." Consequently, stakeholders said community members feel discouraged in commenting on reports and listening in on LVC meetings. For example, the draft EIR produced by EnergySource is over one thousand pages long. The EIR speaks to some issues like waste disposal and water use that are concerns for community members, but its format remains inaccessible.

One stakeholder who has been meeting with other environmental organizations and explaining the impacts laid out by the EnergySource EIR, said it's almost impossible for the lay person to read such documents and gather information. Nonetheless, only one of three companies piloting DLE need to produce an EIR. Multiple stakeholders suggested it should be the job of companies to explain the technical details in language that is non-scientific. According to community organizations interviewed, some of the best information about geothermal and lithium production has come directly from the industry. Communities say this is not enough. This also raises questions about the impartiality of geothermal and lithium firms if they are explaining their own impacts. Objectivity from an independent source would allow communities an impartial perspective. Yet, given the nascent and proprietary connections to DLE research, along with limited government capacity to produce objective opinions, there are few other sources besides environmental nonprofits to assist with such efforts. The community organizations interviewed suggest the limited amount of accessible information about DLE hampers their ability to advocate for policies on the behalf of community members.

STRATEGIC AND ECONOMIC BENEFITS AND CONCERNS

The economic benefits of a nascent and burgeoning lithium-ion battery industry have regional implications. Despite the possibility of new industries and a new labor market, there are strong skeptics about how and if lithium production can bring about environmentally safe and equitable outcomes for the region.

Expanding Economy: Lithium Valley Agglomeration

There were mixed reactions from stakeholders to the expansion of geothermal energy and lithium production in the Lithium Valley, characterized by a combination of optimism and caution. As a county with one of the highest levels of poverty in the state (Public Policy Institute of California 2021), stakeholders explicitly said Imperial County needs more employment opportunities. A mineral and extraction researcher working on multiple DLE projects noted, “we could produce thousands of pretty high paying jobs down there which would benefit those communities tremendously.” Going further they said, “the tax revenues, both at the local, county, state, federal levels, could be funneled back into those communities to help them with their underlying issues including infrastructure needs.” These jobs would be in geothermal and lithium production, but more importantly in battery manufacturing, which will provide more jobs. One European battery manufacturer has already signed an agreement that they will build and locate a $4 billion 54-gigawatt-hours battery factory in the Imperial Valley (Shultz 2022).

Multiple stakeholders suggested extraction and battery manufacturing were just the beginning of the lithium industry in the region. Such jobs would be contingent on workforce development programs to train new workers, and to retrain older residents to transition from existing occupations. Stakeholders familiar with the Imperial Valley Economic Opportunity Investment Plan, which outlines potential industry growth in the future, suggest key policies from the government should focus on workforce development programs and the return of revenue flow to the communities. Across all stakeholders interviewed, all believed there is a real benefit to the community but cautioned that those benefits stem from how the federal, state, and local governments administer their plans.

Infrastructure and Economic Distribution Concerns

The geothermal and lithium extraction industries will increase the industry footprint in the region, though a much larger impact will exist if the lithium-ion battery industry emerges in the area. Imperial County and the surrounding region have preexisting infrastructure concerns, an issue noted by almost every stakeholder interviewed. These include housing and basic welfare needs. The Imperial Valley Economic Opportunity Investment Plan has asked for funds from the federal and state government to support transportation improvements in roadways and railways, power grid line improvements, and associated impacts that come with the anticipated growth in jobs from geothermal, lithium, and battery production. Several stakeholders indicated financial support from multiple layers of government will be necessary to accommodate for anticipated growth.

Although there is promise of economic opportunity and growth, community and environmental organizations expressed concern and caution about who will benefit from the creation of employment opportunities. One environmental advocate noted that there were a host of social justice concerns, including job availability for local residents and the quality of those jobs. Another community advocate said the promise of new jobs is almost disrespectful. They stated, “it's not really clear to us what new employment opportunities really means, if it will be accessible to us; we’re not just a labor force.” Community organizations and the LVC are discussing what jobs and how many jobs will be available. However, much of this still remains unknown and is thus speculative. Neither the LVC nor the industry have provided specific job numbers, which is a function of the uncertainty surrounding commercial lithium production and to what degree lithium-ion battery industries will co-locate in the area. Nonetheless, workforce development programs and infrastructure enhancements will also take time to implement and build, adding to the complexity and tension of the situation.

The actual impacts of industries on communities are also of concern. The relationships between communities in the Inland Empire bring up a mydaid of issues. One stakeholder said, “we already have this fear of the logistics industry moving closer to our communities. And we were told by the Energy Commission they are looking at the Eastern Coachella Valley as part of their plan, but what does that mean to our community? What is it going to become?” There is also skepticism about the implementation of economic development plans, as community members have experienced broken promises previously. An environmental justice advocate warned, “I worry that it's going to just be another industry where there are some jobs, but the high stuff will be developed in other communities.” Further, with the expansion of the battery industry and potential infrastructure development, there are additional questions and concerns on the environmental impacts of such growth. Even though it was not discussed extensively by the stakeholders, the associated development could have a significant impact on the area’s resources.

GLOBAL COMPARISONS AND NEW DEVELOPMENT MODELS

Most stakeholders connected extraction to global conversations about lithium production and climate change. Stakeholders expressed the necessity of reducing global emissions to fight against climate change and saw the Salton Sea as part of the solution. Additionally, there was recognition of the social and political ramifications of placing industries in the U.S. rather than relying on other nations who do no not have the same set of environmental protections. Reflecting on U.S. consumption of resources, one interviewee stated, “the U.S. has a very high standard of living, and we consume a lot of resources, and in doing that, we thrash the environment of other countries.” Although several stakeholders commented on how a domestic lithium supply would be better for the environment over using lithium from other countries, stakeholders still had reservations and questions about how the U.S. would proceed with extraction, especially in the Salton Sea. One commented, “we are at an inflection point here, the choices we make will have real repercussions for the Salton Sea, the communities, and how the industry is perceived.” They went on to say, “we need to do it right, in a green way which still has its own issues, but we can do it better and part of that hinges on how the community is involved.”

Thacker Pass

As with the Salton Sea, lithium extraction in Thacker Pass is complex and multi-dimensional. In the eight interviews conducted with stakeholders, multiple themes emerged. The challenges posed by the Thacker Pass project are all interconnected and cross-cutting. The largest issue confronting the mine site is whether the project should continue or not, with some environmental organizations vehemently opposed to lithium mining. Stakeholders spoke to environmental impacts, environmental review processes, community engagement, economic impacts, and raised questions concerning domestic and global lithium demand.

ENVIRONMENTAL IMPACTS

Stakeholders from environmental organizations raised issues about the potential impacts to the ecosystem of the McDermitt Caldera. Stakeholders from the County government and the industry conversely felt environmental impacts are properly mitigated. The dynamic between the two groups plays throughout this this section. The main concerns are manifested in land use, plants and wildlife, and specific water concerns that are intertwined with the first two.

Land Disturbance

One of the first issues the majority of environmental stakeholders discussed was the overall land disturbance that would result from a lithium mine at Thacker Pass. According to environmental groups, the environmental consequences of the mine would last generations, affecting everything in the region including water, soil, the organisms and bacteria deep within the earth, and the plants and wildlife that populate the area. The Reclamation Permit given to Lithium Americas from the Department of Conservation and Natural Resources indicated the total land disturbance is registered at just below 5,600 acres (2020). However, the acreage is likely an underestimate. The acreage pertains to just the project site, with stakeholders indicating that damages encircle a much wider geography.

As such, several organizations asserted the land impact from a mine would categorially alter the ecosystem. One stakeholder questioned the ability for land to return to its natural state after mining: “I don't know that mining here is commensurate with healthy landscapes on a site-specific level. And I don't know that once you tear it all apart, that you can actually put it back together again; we're not that smart.” Nonetheless, Humboldt County officials pushed back on this narrative, claiming the impacts were an exaggeration: “resistance to the mine makes it seem like going back to what we used to see in the 1930s and 40s and we're going to be washing away the mountainside and we're going to be polluting streams and groundwater. Nothing could be farther from the truth.” County officials maintained the integrity of Nevada’s mining laws and were to some degree perplexed by the focus on the Thacker Pass lithium mine given other mines developed in Humboldt County, Nevada.

Plants and Wildlife Protection

According to environmental organizations representing litigation to stop Thacker Pass mining operations, the mine presents a fairly extensive danger to plants and wildlife. Again, while the current project site is listed at 5,600 acres, the impacts of the mine operations could extend beyond the parameters of the mine site, affecting a wider area and a larger number of species. Several environmental organizations commented that the McDermitt Caldera is characteristic of Nevada’s landscapes and is a region full of endemic plants and wildlife.

Noted wildlife deemed at-risk include the Kings River pyrg (an endemic freshwater snail), pygmy rabbit, greater sage-grouse, and golden eagle. Losing any of these species would have downstream repercussions, according to one environmental representative. A mine would potentially negate the work done by conservationists to protect species, preventing them from needing to be listed under the Endangered Species Act (ESA). For example, the Kings River pyrg has been listed twice (in 2005 and 2012) in the Nevada Wildlife Action Plan as a “Species of Conservation Priority” (Great Basin and Resource Watch 2019; Nature Reserve 2022). Additionally, the greater-sage grouse has been the subject to one of the largest conservation efforts in U.S. history to prevent listing on the ESA (Kershaw 2015). The golden eagle also requires protection and is typically shielded by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Further, the golden eagle is a sacred animal to surrounding tribes. Concerns about plants and wildlife extend beyond the noted few here but serve to represent larger thematic issues at Thacker Pass.

According to one environmental stakeholder, the larger problem is that despite being imperiled, many species do not have regulatory protection and should be listed under the ESA. They noted that protecting species under the ESA is difficult and can take more than a decade (Puckett et al. 2016). Stakeholders warned there was a strong chance of mining wiping out a number of species before any federal protection can be provided. Due to the General Mining Law of 1872, the ESA is one of the few laws that can assist in conserving wildlife when a mine is proposed. The mining law serves as the foundation for current U.S. mining practices and essentially allows a mine claim to supersede other uses of the land, circumventing some regulations.

Other stakeholders held a different view of the proposed impact of mining. One of the stakeholders interviewed, a wildlife biologist, noted the area was the "Holy Land" for species like the greater-sage grouse, meaning the region has some of the best-known habitat for the sage grouse. They acknowledged the mine would impact the habitat for most wildlife, but they stated the County had been in discussions with Lithium Nevada to ensure there was a minimal impact on flora and fauna. County officials also claimed they felt confident and comfortable with the plan moving forward as the mining operation had considered and planned around their impact on wildlife, specifically in regard to greater sage-grouse habitat.

Water and Air Concerns

Directly associated with land disturbance and longevity of species in the region are environmental concerns around water quality and usage. To have sufficient water, the project will use high volumes of water from the Quinn River Valley aquifer. Lithium Nevada is also buying water rights in the surrounding area to accommodate the needs of the project (Lithium Americas 2021a). One environmental stakeholder warned that this would impact the water table, potentially limiting the water availability to local farmers and ranchers. The degree of water use is predicated on technical modeling processes. Lithium Nevada reported the mine will use 2,600 acre-feet of water/year for the first four years and 5,200 acre-feet of water/year after four years. The amount equates to 9% of the perennial supply for the Quinn River Valley. For context, irrigation consumes just under 83,000 acre-feet/year in the Quinn River Valley (Lithium Americas 2021b). Lithium Nevada has also stated that their project is designed with significant water recycling technologies to minimize water consumption by using the same water over and over again. Still, some stakeholders have disputed the figures produced by Lithium Nevada.

There are also serious concerns related to backfilling the mine with tailings after mining has occurred. Tailings are a by-product of mining, consisting of mineral particles and water. Dry stacking of tailings is used to process and store tailings to reduce impacts on the environment. Two stakeholders expressed concern about the storage plan of dry tailings in Lithium Nevada's operational plans. Without proper storage of these by-products, the tailings could seep into groundwater resources, posing a risk of arsenic and antimony contamination. Further, the stakeholder noted there was no analysis on the neutralization of the tailings. Without effective treatment, the tailings will still have acid in them and could impact water quality. This is a point of contention where environmental groups have singled out the lack of detailed plans to assess whether or how ground water quality downgradient would be effectively mitigated (Western Watersheds Project v. U.S. Department of the Interior 2021). The EIR indicated groundwater quality could exceed the standards for antimony, arsenic, sulfate, and TDS (BLM 2020; Penn et al. 2021). Thus, there is concern on the effectiveness of the current mitigation plan and a lack of transparency about the details of the plan itself.

Additionally, tailings noted above will be treated with sulfuric acid. Due to the scale of the mining operation at Thacker Pass, plans include the building of an on-site sulfuric acid plant. Some stakeholders believed this was a minor issue because Lithium Nevada would be mitigating their impact with new technology, emitting less than 40 tons of SO_2 per year, which amounts to 2% of current SO_2 emissions from the nearby North Valmy power planted located in Valmy, Nevada (Lithium Americas 2021). Still, because of the extensive amount of sulfuric acid used on site, there are concerns from multiple environmental groups about air and water quality. Regardless of Lithium Nevada's technology, several stakeholders maintained the constant air pollution would have cumulative effects and the air quality in the area would decrease significantly.

ENVIRONMENTAL REVIEW PROCESSES

The quality and extent of environmental analyses are major point of friction between stakeholders at Thacker Pass. The largest issues center on the normative standards of review, the environmental impact statement (EIS) produced for Thacker Pass, and reclamation policy.

Issues with Normative Standards

Several stakeholders thought current regulations and policies at the state and federal level lacked impartiality and the necessary rigor to perform an effective environmental review. The process of developing a mine starts with industry investigating the availability of mineral resources and committing its own financial resources to a proposed project. According to one environmental advocate, industry involvement at the beginning of the process is the first flaw. As a consequence, the same stakeholder noted, "the more money that's invested, the more likely a company will be unwilling to walk away from a project, even if it has fatal flaws. Instead, these companies double down." To fix this process, a stakeholder recommended that environmental reviews occur much earlier in the process, which would better inform decision making about whether or not a firm should pursue mining. Currently, industry is the often the first party to provide information to communities about a project. Another stakeholder stated, "the [company looking to mine] essentially come in with a sales pitch to the community. It can be ultimately and genuinely helpful, but really seems like an effort to assuage opposition. There is no sense of independent assessment."

When it comes to the EIS, there are significant concerns according to the majority of environmental stakeholders. One stakeholder commented that the EIS review process lacks the rigor it deserves: "it's an opportunity for developers and for the BLM [Bureau of Land Management] to check a box and say they did it." The stakeholder further commented this may also represent a lack of capacity and technical expertise by the government to perform these tasks. The issue of government capacity was brought up by each environmental organization that participated in this study. According to one stakeholder, agencies do have expertise on some, but not all, aspects of a project. Consequently, there are gaps. Another concern is regulatory capture from federal agencies. Two stakeholders stated the BLM was too lenient with industry and the priorities of mining companies, neglecting their duty to administer public lands. This raises the questions of government agencies' objectivity and ability to provide an independent assessment.

Other stakeholders pushed back on the negative assessment of the environmental review processes by the state and federal government. County officials stated that the system as a whole is currently designed to meet the demands of all parties and believed the EIS and the Nevada mining permitting process is administered fairly. Another stakeholder maintained the integrity of the environmental review process, and also explained regulations are constantly morphing to meet current demands. They cited the Clean Air Act, the Clean Water Act, and National Environmental Protection Act (NEPA) as pieces of legislation that evolve and work to protect the environment. Despite the poor record of mining contamination in Nevada noted by every stakeholder, several stakeholders state that Nevada now has some of the most protective rules in the U.S. and the most responsible reclamation policy on the planet. However, there are still shortfalls in regulatory policy according to those interviewed. Some cited the lack of consistency within government agencies such as the BLM. They said the same set of rules, regardless of a project, should be applied and that the process should be transparent. Another stakeholder commented that there can and always will need to be improvements, noting recent work on a bad actor mining bill that would disqualify any actor with a blemish on their record from violating environmental laws.

Thacker Pass Processes

While environmental stakeholders are concerned about the overall process of environmental approvals related to mining, there are specific concerns related to Thacker Pass. All environmental organizations expressed concern about the pace of the permitting by the BLM through the EIS. The Trump Administration expediated the permitting process to six months, with final approval given approval in January of 2021, just before the Biden Administration took office. The process typically takes on average 3.4 years (deWitt and deWitt 2008). Now there is concern from all environmental stakeholders interviewed that Thacker Pass will be used as a standard for future mining projects, with a stakeholder commenting, "the way this was permitted and rolled-out sets an enormously bad example." County officials refute the idea that the EIS was fast-tracked, citing that Lithium Nevada had been reporting their findings to the BLM for the past seven years. To the County, the permitting process was not the six months of action from the EIS, but the years of preparation and mitigation planning. However, no environmental organization interviewed accepted this rationale and commented the EIS was of poor quality. All stakeholders noted that consistency across federal administrations representing opposing political parties is an underlying point of contention within government agencies.

Further, there is concern that given the urgency of climate change combined with the current federal administration's efforts to reduce emissions, the state and federal agencies will not hold Lithium Nevada as accountable for environmental compliance as they should. One environmental stakeholder believed more weight needs to be put on holistic approaches and long-term impacts, putting an emphasis on performing environmental reviews correctly so that ecosystems and people are not harmed as we attempt to address climate change.

Reclamation Strategies

Stakeholders agree that as an open pit mine, the Thacker Pass project will disturb the land and landscape. Still, the consequences of long-term impacts are disputed and raise questions about what the reclamation process will look like and how long will parties be responsible for the land itself. Two stakeholders explicitly mentioned that the mitigation plans for mine reclamation and closure appear to be a box-checking exercise for the BLM and industry. They noted that a new framework is needed so that, "perpetual treatment would extend liability for decades to centuries, not just years. Previous efforts to return land back to its previous state have been terrible." Another stakeholder mentioned the legacy of mining in the Intermountain West: "you can't go fishing in some streams and rivers because of the mercury. This is the legacy of mining in the 1800s." The stakeholder went on to ask, "Was this mining really worth all those metals? To be pulled out back then? Where we are now is no different". Again, County officials referred to Nevada's new mining policies, pointing to the work of the Reclamation Branch of Nevada's Nevada Department of Environmental Protection (NDEP). As to not perturb the landscape drastically and leave an open scar in the land, Lithium Nevada plans to fill in the mine as they work for the next 41 years.

The Larger Issue: Federal Legislation

At odds with current conservation efforts at Thacker Pass is the larger framework that supports mining in the US, whose foundations rest on the General Mining Law of 1872 and the Mineral Leasing Act of 1920. Multiple stakeholders referenced the 1872 Mining Law as the cornerstone of how industry and society has approached mining for 150 years. According to these stakeholders, the law allows industry to follow a different set of rules that prioritizes "mining claims" over other land uses and environmental consequences. One stakeholder noted that the law was written in a different time and reflects different values, and that the U.S. sees mining and conservation differently today: "the real issue is on the concentration of resources, but 'resources' is never interpreted as environmental resources, but solely as mineral resources. We need to broaden the scope of interpreting that law". This relates to the Mineral Leasing Act of 1920 that prioritizes mining as the highest and best use for public land. In following these precedents, a stakeholder commented, "nothing else matters." Still, other federal and state legislation is used to guide permitting processes and protect water, air, and the surrounding environment. In sum, without changing federal legislation, environmental stakeholders believe the U.S. will be caught in a cycle where mining outweighs all other potential land uses and allows industry to evade stronger regulations.

COMMUNITY ENGAGEMENT

The community engagement efforts of Lithium Nevada, Humboldt County, and BLM are described as insufficient by multiple stakeholders. While community engagement related to lithium extraction was raised as a stakeholder concern within the Salton Sea region, the level of outreach and inclusion noted at the Salton Sea stands in stark contrast to perceptions about the processes surrounding the Thacker Pass project. Common themes expressed by environmental stakeholders include limited interactions, objections to the degradation of cultural sites, and the inability of industry and government to convey the technical aspects and impacts of mining.

Interactions

The style and depth of interactions varied widely between Lithium Nevada, BLM, and the NDEP with community groups and tribes. The most significant concern for engagement was during the preparation of the EIS, which occurred during the global COVID-19 pandemic. Environmental groups described the interactions as minimal and strongly feel that a pause was necessary given the ongoing public health crisis. According to multiple stakeholders, limited capacity to participate in public forums, and the added challenge of a global pandemic, almost nullified the prospect of meaningful engagement.

Interactions with local and regional tribes appear to be especially problematic according to some interviews. Stakeholders noted that the engagement with local and regional tribes was more limited than would be effective, noting three letters submitted to tribes as the scope of engagement witnessed (Aadland 2022). Most environmental stakeholders interviewed believed that tribes were not properly consulted: “if they [BLM] want to do this right, they need in-person engagement over a longer-period.” One environmental stakeholder stated, “do we talk to the 30 or 40 people who are resisting this project, or do we talk to the 60 or more people who have submitted job applications for the mine. There’s no clear answer here.”

Several stakeholders noted the comment period was fairly limited at 30 days. One interviewee commented, “it was just ridiculous, having such a short time to review all those documents and then comment on them.” Nevertheless, there is dispute within the community about what should be done and who should be approached to address these issues. Outside the EIS, there were also various levels of community engagement and support based on geography. Some stakeholders noted that Lithium Nevada currently holds regular meetings with the Fort McDermitt Paiute and Shoshone Tribe and the City of Orovada that have changed as community concerns evolved. Larger questions about city infrastructure arose; some communities wanted to minimize industry impact while others sought to benefit from a larger presence of industry. In short, community interest is not monolithic, and outreach appears uneven. Nonetheless, one environmental stakeholder thought it was likely that most of the community would support the mine. The stakeholder also discussed the dynamic of community interests versus the priority of preserving land and wildlife and argued that preserving the land itself is more important than community interests.

Cultural Objections

There are objections over the use of the project site because of the cultural and historical significance of the area. One such issue revolves around reports of a Native American massacre having occurred at the project site, which is contested (Flin, 2021). The presence of the mine site has been contentious among and within tribes, with varying levels of support or disapproval (Bosler, 2021; Penn et al., 2021). Several stakeholders expressed concern about the site of a massacre, in addition to the cultural significance of the area for local tribes. Ultimately, they believed Thacker Pass should be off limits, noting that, “with cultural sites there’s really no kind of mitigation. You can’t move what’s sacred.”

Several tribes are engaged in the process of talking with Lithium Nevada, and others are engaged in a lawsuit over the project. The Reno-Sparks Indian Colony, the Northern Paiute group Atsa Koodakuh wyh Nuwu (the People of Red Mountain), and Winnemucca Colony filed a complaint against the BLM, alleging that the agency violated federal laws when issuing permits to Lithium Nevada. Among the complaints, the tribes allege that the BLM failed to identify historic properties on the Thacker Pass site (Rothberg, 2022; Scheyder, 2021; Turner, 2021). Although tribal considerations are important aspect of the Thacker Pass project, it must be noted that no tribal stakeholders were interviewed as part of this study, despite efforts to set up interviews. Thus, the multitude of voices from different tribes about this historical site and the prospect of mining are not represented here.

Additionally, there is another potential cultural site with artifacts from pioneers from the 19th century. An industry stakeholder commented that there was a team conducting a study of the area related to cultural sites, and would follow the required protocols, especially if human remains were found that could include potential remains from the aforementioned massacre.

Technical Expertise

Another component of community engagement is centered on the limited amount of digestible technical information that is available to communities. Every stakeholder, from environmental groups to industry members, commented on this issue. The responsibility of informing the public about the technical aspects of the project and its impacts most often falls to the industry itself. As mentioned previously, a problematic dynamic may exist if the companies presenting the information are also the ones benefiting from the mining operation.

Stakeholders shared several ideas in changing this dynamic and providing more education to community members. Multiple stakeholders used superfund sites as an example for how to move forward. Through the Comprehensive Environmental Response, Compensation, and Liability Act, communities can apply for technical support to get an analysis on some aspect of a site. A similar model could be adopted at Thacker Pass, as one stakeholder said, “what this really comes down to is the community needs to get good information.” The challenge of this process relates to the initial exploration, assessment, and presentation of initial information by the mining company. Two different stakeholders called for an independent assessor to present the technical aspects, as they felt the industry and BLM were incapable of providing objective insights. Payment for this independent assessment would either come from the mining company or from a general royalty fund provided by the federal government through previous mineral extraction funds. Alternatively, the potential to use a nonprofit organization as an independent source of information was discussed. As a consequence of the current system, community members do not understand the details of mining processes and cannot advocate for themselves.

Those familiar with Lithium Nevada’s operation and engagement commented that Lithium Nevada is attempting to be forthright and educate the community, with efforts still ongoing. They also commented that there is a general shortage of experts from a workforce perspective in these kinds of operations as lithium exploration booms across the state and globe. Even though Lithium Nevada has been working on the conceptual idea of Thacker Pass lithium mining for several years, the implementation and production of the technical aspects of the project have occurred more recently.

BENEFITS: LOCAL SOURCES OF LITHIUM AND EMPLOYMENT OPPORTUNITIES

County, industry, and a few environmental stakeholders noted that there are significant opportunities tied to lithium extraction at Thacker Pass. The two biggest benefits center on the large amounts of lithium production in the face of climate change, and the economic opportunities production would bring to the entire region. As one environmental stakeholder commented, “lithium is the most essential single ingredient for a rapid transition away from fossil fuels.” They admitted the impact of mining would completely alter the area, and they also acknowledged that lithium from Thacker Pass would help the U.S. shift away from importing lithium and batteries from countries that have less stringent environmental laws. Another stakeholder said projects like Thacker Pass are essential for the U.S. to have energy independence and security, cautioning that the U.S. relies too much on other sources for lithium.

The economic benefits of Thacker Pass could provide opportunities for the region according to county officials. Humboldt County currently has proposed two major operations that will help grow the local economy—the Thacker Pass project and a salmon farm. Both would result in around 300 jobs according to the County. County stakeholders expressed optimism about the benefits this would create for the region, meaning there would be additional ancillary businesses and general services that would grow from Thacker Pass and the salmon farm. Humboldt County officials said the projects presented an opportunity to build better infrastructure, grow new business, and stabilize the County’s economy. Additionally, they said it would allow the economy to diversify to let residents work in new fields and help retain families and college graduates from the area. An industry stakeholder posited that the jobs at Thacker Pass were not typical mining jobs, but technical positions with salaries that would start at $60,000 and average $100,000 per year. For context, the median salary for Humboldt County in 2019 was $58,820 (U.S. Bureau of Labor Statistics 2022). However, stakeholders noted that government support is needed to help economic expansion—both in infrastructure and workforce development.

BIGGER QUESTIONS

A larger theme emerged from conversations with stakeholders that largely focused on which communities were "being sacrificed" to meet domestic and global lithium demand, and the necessity to reduce demand for lithium and other raw materials. These concerns relate to larger socio-ecological considerations.

Sacrifice

In discussions with stakeholders about lithium mining, a common theme of sacrifice emerged—sacrifice of land, ecology, and people, some willingly and others not. As one stakeholder commented, "we're trying to decide how to design this economy of the future, it seems like we're going to use the same corporate extractive colonial models that we've built in the past and that's not going to solve our problems right now." Another commented, "what we're doing with the energy transition and the so-called critical minerals is that we're putting the burden of the transition upon the hand of communities." Some stakeholders insinuated rural communities were a sacrificial lamb to feed the ongoing needs of lithium demand. There is tension in this idea with disagreement on how much extraction is tolerable moving forward. One environmentalist warned "we have to accept some collateral damage as we transition because right now the entire planet is suffering." An industry stakeholder also said the U.S. is entering a phase where people want minerals like lithium, but society does not want the impacts of those materials. They expounded further that if the U.S. wants to take meaningful action to go electric or reduce emissions as soon as possible, the materials for that infrastructure will bring some negative environmental impacts and potentially take a decade or more to build.

This brings out the dichotomy of needing to extract lithium to combat climate change versus protecting the environment at the cost of supplying a viable alternative to fossil fuels. However, multiple stakeholders rejected this idea, calling it a false choice. Rather, they said lithium extraction should be done elsewhere, just not at Thacker Pass. Yet, there was disagreement on this with some supporting direct lithium extraction (DLE), some just opposing Thacker Pass, and yet others calling for minimal or no extraction whatsoever. Still, one environmentalist commented, "we accept the ravages of mining because we feel that we need to have our devices and our cars." They went on to say that without an internal reflection from society, communities and ecosystems will keep hurting.

Reduced Demand

Demand for lithium comes from societal and individual needs, including transportation, energy storage, and small technological devices like cell phones and laptops. At Thacker Pass, stakeholders made repeated calls for finding ways to reduce the societal demand for raw materials by changing energy habits and the design of cities, and by recycling lithium-ion batteries. One stakeholder thought attention should shift from lithium extraction to society itself. Rather than embracing mining, they commented, the U.S. should be adopting stronger conservation codes. One stakeholder commented on inverting the sacrifice required by communities: "we're all responsible for what's happening with changing climate, and we all need to take a hit in some way. I think we all need to say there's got to be some kind of shared sacrifice here." Some supporters of the mine commented on the importance of embracing these policies, but also acknowledged that there is a significant time gap in having more transit-oriented cities, retrofitting buildings, and the emergence of a circular economy. The idea of changing consumptive habits in a privileged society like the U.S. is almost intractable. Those opposed to mining at Thacker Pass counter that drastic change is unlikely if something is not done immediately to embrace the gravity of the moment.

Greater Sage Grouse (*Centrocercus urophasianus*). Photo ©Ken Miracle

POLICY RECOMMENDATIONS

The aim of this study was to answer the question: what state and federal policies could be enacted that would best promote lithium extraction at the Salton Sea and Thacker Pass that allow for environmental protection, while also supporting economic development and other social and public health benefits? It is a question that asks whether extraction can be done differently, whether policies can simultaneously facilitate low to no environmental impact, alleviate greenhouse gas emissions, achieve equitable economic outcomes, and ensure tangible community benefits. Can lithium extraction have it all? Given the divergent perspectives of stakeholders and complexity of issues raised during the stakeholder interview process, arriving at a simple answer to this question would be an oversimplification and still remains speculative.

The policies and frameworks that govern and guide lithium extraction at the Salton Sea and Thacker Pass, as well as the rest of the US, involve multiple spheres. Each extraction technology and extraction location have different needs. It seems multi-benefit lithium extraction is possible on different scales but is contingent on the action and implementation of federal, state, and local policies. This is further predicated on more abstract questions: what levels of environmental impacts are acceptable, and who and how much should different communities, industries, and other entities benefit? Nonetheless, stakeholders identified several areas where improvements could generate sought-after outcomes. Specific recommendations include the following:

1. Prioritize direct lithium extraction (DLE):

Assuming that impacts associated with DLE in the Salton Sea would remain minimal as this technology type scales up, and that scaling up DLE is feasible, DLE appears to offer the lowest impacts of available extraction technologies. The use of geothermal energy offers additional benefits in the production of a consistent source of renewable energy. Locations like the Salton Sea Geothermal Field offer vast quantities of lithium that would help address U.S. and perhaps global demand for lithium production. Other areas, such as Nevada and Arkansas, should be looked at for potential sites for DLE. Focusing on DLE could help assuage demand for lithium in other areas that are more resource intensive and have stronger environmental impacts like evaporation technology or surface mining.

2. Enhance federal and state environmental agency capacity

Associated with the previous point, every stakeholder commented on the time-consuming approvals process and the lack of capacity of both federal and state agencies. Regulations are helpful in ensuring projects safeguard against adverse impacts. However, with limited capacity and technical expertise, the process is back-logged and uneven across projects. Government agencies need more capacity to perform a more robust environmental analysis and engage communities in a more widespread fashion. Agency budgets are dictated by the current federal administration. To ensure consistent, effective governance over time, some mechanism is required to shield agency budgets from the pivot swings of federal elections. What this mechanism could be remains unknown and requires further research.

For the Salton Sea region, the need for enhanced governmental capacity is concentrated in local air monitoring districts, water districts, and the governments of Imperial and Riverside Counties. At the state level, California needs to enhance the capacity of the Lithium Valley Commission and the California Energy Commission. In Nevada, agency support is needed on several levels including the Bureau of Mining Regulation and Reclamation, the Nevada Department of Wildlife, and funding to help enhance tribal agency capacity. On the federal level, the need is most acute at the U.S. Department of Energy and the BLM.

3. Encourage inclusive community economic development through government support:

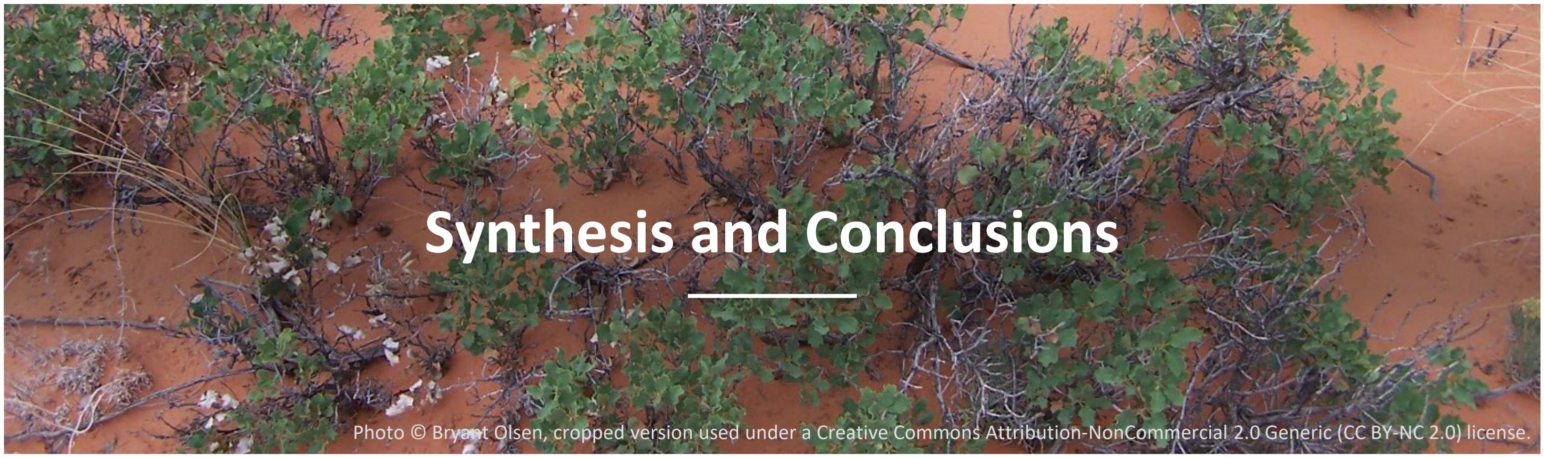
All aspects of communities should be included in providing a guiding voice in the development of industry that directly impacts their homes and livelihoods. This is taking place in some form in the Salton Sea, though it should be repeated elsewhere and expanded on given noted shortcomings in transparency and engagement strategies. If lithium battery-related industries locate in a region, then federal government assistance is needed to provide financial support to expand and improve infrastructure that minimizes environmental impacts and ensures current residents benefit from infrastructure upgrades. Government assistance is also needed to bolster workforce development programs and ensure local residents have opportunities to access quality jobs with livable wages.

4. Incentivize recycling and push for a circular economy:

One of the most pressing issues confronting lithium extraction and the energy transition is the exponentially growing demand for lithium and other critical mineral resources. Lithium recycling could become a priority to reduce demand. In the next 10 years, the U.S. will face its first surge of used lithium-ion batteries from electric vehicles that could be repurposed for grid storage or re-used in automotive transportation. Federal policy should require two actions: funding for urban mining research and development and economic incentives for battery re-use. Additional grant funding is necessary to support nascent industries and extend current research. Without federal intervention, there is no incentive for battery manufactures and automakers to recycle materials. Potential actions to address this issue could either penalize firms for not recycling their lithium-ion batteries or pay firms to recycle them. In doing so, the U.S. could commit to a circular economy, preserving land and alleviating tension on raw material demands.

FUTURE DIRECTIONS

The recommendations above serve as potential solutions, as recommended by stakeholders, to the challenges associated with lithium extraction. Additional stakeholders from the Salton Sea and Thacker Pass should be interviewed, particularly those representing government agencies, industry, and tribes. Additionally, stakeholders working within geographies with other prominent lithium deposits should also be interviewed. While Nevada and California will drive government and industry standards related to lithium extraction, other states with less regulatory oversight require attention as well. Future interviews could focus on policy and regulatory processes to build a more robust analysis of competing and complementary demands. One point of focus could be to illicit feedback on how to address gaps in the NEPA permitting process. Of additional importance is the developing field of lithium-battery recycling. Policy recommendations should be assessed on their own to enlighten their effectiveness, constraints, and viability.



Synthesis and Conclusions

To reduce greenhouse gas emissions, the United States will need to shift away from fossil fuels as the major energy source. Lithium-powered batteries are the most economical source for storing energy at multiple scales (e.g., cell phones, vehicles, industrial power plants). Currently, nearly all lithium is produced outside the U.S., which has only one operating lithium extraction site. However, there are documented lithium resources in nine states, which have the potential to produce over 100 years of the current global lithium demand. Of these states, Nevada has the largest lithium resources, followed by California and North Carolina. There is also interest in locally produced lithium, which would provide sources closer to the end-product and has the potential to streamline the battery supply chain and reduce international shipping. Additionally, current lithium production occurs in several developing countries with less restrictive environmental regulations than the U.S. Producing lithium in the U.S. may help protect important conservation areas in other countries and shift the environmental impacts closer to communities benefiting from the lithium batteries.

There are two dominant forms of lithium resources, brines and hard rock/clays, and three main types of extraction processes: direct lithium extraction (DLE from brine, evaporative concentration of brine, and surface mining. The science of extraction techniques is rapidly evolving as global lithium demand increases along with electric vehicle adoption. Proven extraction techniques such as surface mining and evaporation ponds require significant land area (hundreds if not thousands of acres depending on the project) for the extraction process and typically result in the complete removal of native vegetation. DLE, which is still in development for commercial applications, would require fewer acres of land (perhaps tens of acres at a given site) for the extraction process. DLE could also be combined with existing infrastructure such as geothermal plants, oil and gas facilities, or other extractive facilities that pump and process brine and have already disturbed the land surface. From an environmental perspective, extracting lithium on disturbed sites is preferable to disturbing new lands.

Understanding the conservation impacts of lithium extraction at any particular site would require an in-depth assessment of the operation plan, which is outside the scope of this report. This report does however provide a guide to the potential impacts of lithium extraction based on extraction technology, and a high-level, area-by-area assessment of each documented lithium mining claim and its potential site impacts on habitat and wildlife.

Following these seven guidelines will help minimize the environmental impacts of lithium extraction:

1. Prioritize projects that **avoid or minimize impacts on species or ecosystems**. Any federal or state incentives should only reward or be offered to the least impactful extraction approaches.
2. **Prioritize projects that use direct lithium extraction from brine. Analyze connectivity between lithium-containing underground brines and other groundwater or surface waters**. Based on findings of the analysis, require implementation of adequate environmental oversight and triggers to prevent ecological harm and groundwater depletion. In the arid west, triggers should be based on modeling given the long lag time between water extraction and natural recharge.

3. Post extraction, **re-inject brine into the same aquifer** from which it was removed.
4. Post-extraction brine should be **contaminant-free** to minimize re-injection risks.
5. Ensure that **water use by all processes at the extraction site can be accommodated** without causing a drop in the water table that would impact species or habitats dependent on groundwater. Water use for lithium extraction must be considered in light of all other uses of water within the region to evaluate if it is likely to have a detrimental impact on other existing uses of water by people and nature.
6. **Ensure that all waste streams resulting from extraction and processing of brine are properly managed** and that waste does not pose a hazard for human health or wildlife, or result in contamination of air, water, or soils. Ensure reclamation over the long term through bonds or other measures.
7. **Prioritize projects where pre-existing infrastructure is present at the site**, i.e., brine is already pumped and reinjected at the site for some other purpose and adding lithium extraction to the site would not necessitate additional disturbance of lands.

It is critical for lithium interests in the U.S. to properly balance extraction with community and environmental concerns. Shifting away from fossil fuels to renewable energy is driving the increased interest in lithium extraction. However, caution should be taken to avoid losses of biodiversity or conservation value in the pursuit of reducing greenhouse gases. Conservation of natural lands and waters, and the biodiversity they contain, remain important components of a holistic, sustainable plan for addressing climate change. Any resource development plan that results in the disturbance of natural lands and waters, or the loss of biodiversity, is self-defeating.

Because most lithium resources are located in wildlands or in rural communities, these communities will bear the greatest impacts of lithium extraction. The policies developed by governments will be critical to ensuring appropriate environmental compliance. Governments must also significantly increase their capacity and expertise in lithium extraction techniques so that the public review period is transparent and includes all relevant information.

A well-prepared government will be better able to inform and educate communities impacted by lithium extraction. Well-educated communities can, in turn, make their voices heard in decisions on individual projects that directly impact their lives. Overall, interest in lithium and other critical minerals has increased dramatically over recent years and pressure for these metals will likely continue increasing due to economic and policy drivers. Holistic and robust analyses will be required to understand the environmental, cultural, and economic impacts at multiple scales for extracting the necessary material to shift away from an economy that is reliant on fossil fuels, reduce greenhouse gas emissions, and address climate change.

Red-cockaded Woodpecker (*Leuconotopicus borealis*). Photo used under a Creative Commons license: Attribution-NonCommercial-NoDerivs 2.0 Generic (CC BY-NC-ND 2.0).

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Supplemental Information

Please see: https://tnc.box.com/s/d1d8thktxaohhbb3hwnyjukgxvnusgmk