Identifying the roots of Green Civil War over utility-scale solar energy projects on public lands across the American Southwest

Article *in* Journal of Land Use Science · August 2017

DOI: 10.1080/1747423X.2017.1379566

1 author:

Dustin R Mulvaney
San Jose State University

Taylor & Francis
Taylor & Francis Group

Journal of Land Use Science

ISSN: 1747-423X (Print) 1747-4248 (Online) Journal homepage: http://www.tandfonline.com/loi/tlus20

Identifying the roots of Green Civil War over utility-scale solar energy projects on public lands across the American Southwest

Dustin Mulvaney

JOURNAL OF LAND USE SCIENCE, 2017
https://doi.org/10.1080/1747423X.2017.1379566

Taylor & Francis
Taylor & Francis Group

ARTICLE

Identifying the roots of Green Civil War over utility-scale solar energy projects on public lands across the American Southwest

Dustin Mulvaney

Bill Lane Center for the American West, Stanford University, Palo Alto, CA, USA; Department of Environmental Studies, San Jose State University (on sabbatical 2016–17), San Jose, CA, USA

ABSTRACT
Utility-scale solar energy (USSE) development is an emerging cause of land use change across the American Southwest. Many proposed projects in the region have encountered resistance from environmental groups because of concern about endangered, threatened, and special status species. Projects have also faced resistance from impacted local communities and Native American tribes. This research documents land use conflicts that surfaced during the initial wave of USSE development from 2009 to 2015. The goal is to identify potential roots of land use conflict over renewable energy development, to help explain why there is consistent support for renewables in general, but widespread opposition to projects during the proposal and development stages. The primary data presented include public comments to formal rule-making processes, semi-structured interviews conducted from 2009 to 2013, and various media sources. The paper concludes describing emerging planning frameworks that identify sites for USSE with fewer land use conflicts.

ARTICLE HISTORY
Received 30 May 2017
Accepted 24 August 2017

KEYWORDS
Land use change; land use policy; renewable energy; solar

1. Introduction

The transition from subterranean fossil fuels to renewable energy resources collected on the surface of the Earth will almost inevitably lead to social and environmental conflicts due to changing land use patterns (Smil, 1984). The American Southwest faces this new conservation challenge – 'energy sprawl' (McDonald, Fargione, Kiesecker, Miller, & Powell, 2009) as renewable portfolio standards (RPSs) and direct renewable energy purchases by organizations are driving new utility-scale solar energy (USSE) developments (Hernandez, Hoffacker, & Field, 2014). Over the past decade nearly 600 USSE projects greater than 5 Megawatts (MW) in capacity were proposed, are under construction, or are already operating in the six southwestern states of the USA: California, Nevada, Arizona, New Mexico, Utah, and Colorado.[1]

As of 2017, California is the top procurer of electricity from photovoltaics (PV) (~13 GW) and concentrated solar power (CSP, ~2 GW) in the USA, some of which is imported from facilities in Nevada and Arizona. California investor-owned utilities (IOUs) generated 27% from renewables in 2016.[2] Renewable energy growth was spurred by investments that began after a 2002 state Senate bill established the RPS and substantially increased it four years later with the Global Warming Solutions Act (California Energy Commission, 2016a). In 2008, California Governor Schwarzenegger raised the RPS target to 33% by 2020, and in 2015 Governor Brown extended it to 50% by 2030 (California Energy Commission, 2016b).[3] All states across the American Southwest have RPS laws or commitments, though with less ambitious or voluntary targets.

CONTACT Dustin Mulvaney Dustin.mulvaney@sjsu.edu Bill Lane Center for the American West, Stanford University; Department of Environmental Studies, San Jose State University (on sabbatical 2016–17)

Starting around 2006, USSE developers acquired land and land rights where there were rich solar energy resources within reach of the California market, particularly extensive public lands made available by the Bureau of Land Management (BLM). With project locations secure, developers could sign power purchase agreements (PPAs) with IOUs and submit project proposals to regulators and permitting agencies. Renewable energy projects, particularly wind farms (Thayer & Freeman, 1987), have a long history of controversy in Southern California (Pasqualetti & Butler,1987; Pearson,1986). During the initial wave of large-scale USSE projects on public lands, many proposed projects were immediately mired in controversy over ecological and cultural resource issues. In a handful of cases, major environmental organizations such as the Sierra Club, Center for Biological Diversity, and Defenders of Wildlife, and local ones such as Basin and Range Watch and the Western Watersheds Project, filed lawsuits, became official interveners in public hearings, or submitted detailed public comments on environmental and cultural resource impacts. Projects slated for fast-track status to maintain eligibility requirements for financing from the 2009 U.S. American Recovery and Reinvestment Act (ARRA) were particularly controversial. Table 1 lists fast-tracked projects on public lands in California.

Land use change from USSE facilities can impact wildlife and lead to habitat loss and/or fragmentation (Lovich & Ennen, 2011). USSE projects can also impact Native American cultural resources (Lipschutz & Mulvaney, 2013) and nearby rural communities (Trabish, personal communication, March 10, 2012). Numerous USSE proposals in California, including Genesis, Ivanpah, Panoche Valley, Imperial Valley Solar, attracted strongly worded complaints in public comment letters from tribes to the Department of Interior and BLM. Some claims became the basis for lawsuits arguing the agency did not adequately pursue prior consultation and offered only limited opportunities for participation in cultural resource assessments. Previous research on renewable energy controversies suggests that increased public participation and more informed energy land use planning can lessen the frictions of siting controversies (Wolsink, 2007a). By identifying key social and environmental tensions that emerged early in these controversies, this research documents potential impacts and describes subsequent mitigation efforts for better USSE land use decisions. The objective is to provide policy-makers and USSE developers with a better understanding whether and how to avoid land use conflicts.

The most controversial USSE projects across the American Southwest were proposed on public lands. The public lands attribute broadened the base of stakeholders to environmental organizations with conservation missions across the West, as well as recreationists, ranchers, developers, and other public lands and open space advocates. Additionally, some public comments questioned the legitimacy of privatizing publically-owned federal lands, adding a political dimension not present in developments on private lands. For these reasons, land use conflicts over USSE development across the American Southwest may have more complicated explanations for social resistance than other regions. The attribute of being *public* lands – collectively owned and managed by the BLM for the highest and best use – contours the debate in ways that fundamentally differ from developments that occur on private lands. The history of public lands (and more broadly federal lands) in the USA contains many instances of dispossession in the national interest (Wilson, 2014), and BLM policy towards USSE development appears to follow patterns seen with other energy industries according to public lands advocates. But, due to changes in public lands policy in the latter half of the 20th century, today there are more advocates and users of public lands. This political constituency is less visible in renewable energy developments on private lands.

The BLM leases public lands to solar developers by granting right-of-way (ROW) permits under the Federal Land Policy Management Act (FLPMA). This federal decision triggers the National Environmental Policy Act (NEPA), which subjects projects to environmental and cultural resource review under the Endangered Species Act, the Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act, as well as various other federal, state, county, and local laws. In California, the two most important laws are the Environmental Quality Act (CEQA) and California Endangered Species Act, which superceed their federal analogs. These legal opportunities to engage in USSE

Table 1. Fast-tracked solar projects sited on public lands in the California desert.

Project Name	Developer	Technology Type	MW	Public Lands	DOE loan?	Status
Ivanpah Solar Electric	BrightSource Energy	Power Tower	370	3,472 ac. (4,073)	$1.6 billion	Operating
Blythe SolarPower Project	Solar Millenium &Chevron Energy	Parabolic Trough (2007) switched to photovoltaic (2014)	968	6,300 ac. (7,025)	$2.1 billion (declined)	Operating
Desert Sunlight Solar Project	First Solar Development	Photovoltaic	550	4,144 ac.	$1.46 billion	Operating
Genesis/ Ford Dry Lake Solar Energy Project	Next Era Energy Resources	Parabolic Trough	250	1,950 ac.	$852 million	Operating
Solar One	Stirling Energy	Stirling Engine	850	8,230 ac.	No	Approved, Withdrawn
Solar Two	Stirling Energy	Stirling Engine			No	Approved, Withdrawn
Calico Solar Project	K Road Power	Stirling Engine	663.5	4,604 ac.	No	Withdrawn
Imperial ValleySolar Project	Stirling Energy Systems	Stirling Engine	709	6,360 ac.	No	Withdrawn
Desert HarvestSolar Farm	EDF Energy	Photovoltaic	100	930 ac.	No	Under construction
Palen SolarPower Project	Solar Millennium/Chevron Energy	Parabolic Trough	484	3,075 ac. (5,176)	No	Withdrawn
McCoy SolarEnergy Project	Next Era Energy Resources	Photovoltaic	750	7,700 ac.	No	Withdrawn
Lucerne Valley Solar	Chevron Energy Solutions	Photovoltaic	45	516 ac.	No	Approved, Withdrawn
Stateline Solar Farm	First Solar Development	Photovoltaic	300	2,000 ac.	No	Operating
Ridgecrest SolarPower Project	Solar Millennium	Parabolic Trough	250	3,920 ac.	No	Withdrawn
Rio Mesa Solar Electric Facility	BrightSource Energy	Power Tower	750	unknown	No	Withdrawn

developments can make projects on public lands more vulnerable to opposition. Even as these laws pertain to projects on private lands as well, the muliple constituencies and "high and best use" considerations for public lands can encumber or block USSE projects.

Policy-makers understood that BLM's solar policy combined with the RPS law could lead to land use conflict. As California's RPS laws were set to take effect in 2008, the state legislature passed the Desert Renewable Energy Conservation Plan (DRECP) to develop a planning framework for projects proposed in the California Desert Conservation Area (CDCA). Congress established the CDCA in 1976, ushering in a new land management regime and offering protection to 25 million acres of desert wilderness for environmental and cultural resource conservation. As a result, public lands in the California deserts – across Imperial, Inyo, Kern, Los Angeles, Riverside, San Bernardino, and San Diego counties – have higher environmental protections than those in other states.

The purpose of the DRECP – a multi-agency collaboration between the California Energy Commission, California Department of Fish and Game (DFG), US Fish and Wildlife Service (FWS), and the district and national BLM offices – is to help federal agencies and land managers inform and plan a balanced approach to USSE development and ecological conservation in the California deserts. The DRECP blueprint aims to help developers navigate the NEPA or CEQA process by identifying public lands with the fewest resource conflicts. Most major environmental organizations are supportive of putting the DRECP into the region's planning framework. But some local environmental organizations claim that by zoning some areas for industrial solar development, these landscapes will undergo transformations that run contrary to the goals of the CDCA.

The DRECP goals are aligned with the federal Western Solar Plan, an undertaking initiated by the Department of Interior (hereafter 'Interior') to identify areas for development areas called Solar Energy Zones (SEZs). SEZs are lands described by BLM as 'previously disturbed' or 'of low biological value,' with appropriate slope and access to transmission – meaning they are 'solar ready' and less likely to encounter biological or resource conflicts. Agency staff produced the SEZs through the Solar Energy Development Programmatic Impact Statement ('Solar PEIS') process, which Interior developed in parallel with the DRECP. The Solar PEIS covers six southwestern states and evaluated 21.5 million acres of public lands that were originally open to USSE development in 2005. That federal process originally identified 24 SEZs covering 677,385 acres across six southwestern states in 2008. The acreage and land use designations made under the DRECP are listed in Table 2.

After substantial outreach, expert and public feedback, including 80,000 public comments (Lovich & Ennen, 2011), BLM finalized the Western Solar Plan with 19 SEZs in 2013 capable of fitting up to 27 GW across much lower acreage (Table 3). Parcels in SEZs would be available by competitive auction, another key change in the solar program. While the Western Solar Plan allows USSE development both within and outside SEZs, the BLM retained authority to deny projects through administrative review before entering into the full NEPA process (or CEQA where state jurisdiction or a joint action is needed in California).

Between 2009 and 2016, BLM approved 60 renewable energy projects on public lands including 36 USSE facilities (Bureau of Land Management, 2016b). These first 60 approvals coincided with the PEIS and DRECP processes. Of the 36 USSE projects, only 19 (52.8%) are operating or under construction. Developers withdrew most others due to financial or technology considerations or public pressure; four were technically denied by BLM. Early identification of intractable issues or

Table 2. Land allocations in California's Desert Renewable Energy Conservation Plan.

	Acres
Development Focus Areas	388,000
Variance Process Lands	40,000
Total BLM LUPA Conservation Designation	6,527,000
Recreation Management Areas	3,595,000
General Public Lands	419,000
Total	10,818,000

Table 3. Acreage of solar energy zones proposed in 2008 and included in the record of decision in 2014 across six western states.

Solar Energy Zone	State	Status	Proposed acres (2008)	Approved acres (2014)	Reduction in SEZ (2008–2014)
Brenda	Arizona	Developable Area	3,878	3,348	14%
Bullard Wash	Arizona	Withdrawn	7,239	0	100%
Gillespie	Arizona	Developable Area	2,618	2,618	0%
Imperial East	California	Developable Area	5,722	5,717	0%
Iron Mountain	California	Withdrawn	106,522	0	100%
Pisgah	California	Withdrawn	23,950	0	100%
Riverside East	California	Developable Area	202,896	147,910	27%
Antonito Southeast	Colorado	Developable Area	9,729	9,712	0%
De Tilla Gulch	Colorado	Developable Area	1,522	1,064	30%
Fourmile East	Colorado	Developable Area	3,882	2,882	26%
Los Mogotes East	Colorado	Developable Area	5,918	2,650	55%
Amargosa Valley	Nevada	Developable Area	31,625	21,888	31%
Delamar Valley	Nevada	Withdrawn	16,552	0	100%
Dry Lake	Nevada	Developable Area	15,649	5,717	63%
Dry Lake Valley North	Nevada	Developable Area	76,875	25,069	67%
East Mormon Mountain	Nevada	Withdrawn	8,968	0	100%
Gold Point	Nevada	Developable Area	4,810	4,596	4%
Millers	Nevada	Developable Area	16,787	16,534	2%
Afton	New Mexico	Developable Area	77,623	29,964	61%
Mason Draw	New Mexico	Withdrawn	12,909	0	100%
Red Sands	New Mexico	Withdrawn	22,520	0	100%
Escalante Valley	Utah	Developable Area	6,614	6,533	1%
Milford Flats South	Utah	Developable Area	6,480	6,252	4%
Wah Wah Valley	Utah	Developable Area	6,097	5,867	4%
Total			677,385	298,321	56%

lands with expensive mitigations could have resulted in a reduction of agency staff time as well as costs to developers. Instead, many projects became embroiled in public controversies while the planning processes were underway in parallel. Arguably, had the Solar PEIS been initiated in 2005, when the BLM mandate becam law, many of the worst conflicts could have been avoided.

The contribution of this analysis is to a better understanding of how energy transitions will impact landscapes of the American Southwest. Land use conflicts will be a feature of energy transitions. An area of research called social planning for energy transitions seeks to add to technical and economic analyses of energy transitions by exploring issues of governance and public policy, human behavior, or socio-ecological change (Miller & Richter, 2014). These researchers aim to inform transitions to more sustainable energy systems, identify emerging new relationships with energy, assess impacts of energy pathways on communities, enable public engagement and participatory decision-making over energy futures, and propose mechanisms and policy principles to govern energy transitions. Topical areas in this research include energy policy and governance, innovation systems, the path dependency of energy system, incentives, and behavior and energy use (Araújo, 2014).

One area of important energy transitions research topic is social resistance to renewable energy projects. The 'social gap' in renewable energy deployment is the space between the widely documented public support for renewable energy and the entrenched local resistance to particular renewable energy projects (Bell, Gray, & Haggett, 2005). While lay interpretations focus on NIMBY ('not-in-my-back-yard') explanations, research shows that opposition to renewable energy in particular locations are attributed more nuanced factors (Wolsink, 2000). NIMBY explanations fail to account for the complexity of motivations from various stakeholders and the role of political, cultural, and institutional factors that better explain social resistance and the production of negative attitudes (Wolsink, 2007b). The social gap framework helps explain why some land use conflicts receive so much opposition.

What primary environmental and cultural resource issues shape social opposition to USSE projects in the California deserts? A more complete understanding of impacts and lessons learned from renewable energy transitions in the American Southwest are important for several reasons related to interrelated policies that connect energy, innovation, land planning, and natural resource conservation issues. The American Southwest is an ideal setting to identify and compare solar-land use conflicts due to the widespread presence of public lands with different regimes of land conservation governance and dramatic growth in USSE.

2. Socio-ecological impacts from utility-scale solar projects in california

2.1. *USSE technologies*

Two classes of USSE technologies are concentrated solar power (CSP) and photovoltaics (PV). Of 230 operating solar power plants greater than 5 MW built since 2009 in California, Nevada, Arizona, Utah, New Mexico and Colorado, 9 are CSP (representing about 1.5 GW) and 221 are PV. Electricity from PV is made using semiconductor devices that directly absorb photons and covert them to electrical energy using the photovoltaic effect. CSP technologies take heat and make motion via stream or pressure, most commonly using parabolic mirrors to heat a parallel pipe containing a transfer fluid. Another CSP technology is the solar power tower, where heliostats (arrays of mirrors) concentrate heat flux toward a central receiver that makes steam to power a turbine.

CSP comprised 90% of the hundreds of USSE applications initially seeking ROWs with the new BLM solar policy (Pasqualetti & Haag, 2011). The bankruptcy of key players, problems with technologies, and steep price declines with the rise of PV module manufacturing capacity in East Asia, shifted developers to PV. By 2015, no CSP projects were proposed, leaving only photovoltaic USSE facilities on the horizon. Industry experts contend that CSP will compete only where storing electricity in molten salts is a value proposition. In 2016, the California Independent System

Operator introduced 'ramping' and 'curtailment support' products into electricity markets that work favorably for economics of energy storage, because of a rising rate of renewables curtailment – up to 8 GW in spring 2017 – and the 'duck curve' problem – 13 GW of ramping power needed to make up for lost solar power after the sun sets. Nearly all analysts assume photovoltaics will remain the dominant solar technology.

2.2. *The social opposition to renewable energy projects*

Researchers of socio-technical change explain how the public can be a political actor in shaping the direction and specific outcomes of projects, and thus transitions more generally. Research on public attitudes towards renewable energy facilities identifies frictions and means to lessen controversies or mitigate impacts (Batel & Devine-Wright, 2015). Research into impacts from and attitudes towards USSE facilities are far less represented in this literature, owing in part to their small size and low visibility until the past decade; also because wind-land use controversies date back to the late 1970s (Thayer & Freeman, 1987). Surveys routinely show that public opinions in the American Southwest overwhelmingly support the growth of USSE (Carlisle, Kane, Solan, Bowman, & Joe, 2015). Yet, numerous proposed projects in the American Southwest faced organized opposition from environmental groups including those engaged in climate change action advocacy, prompting *New York Times* editors to call the debate over solar projects 'Green Civil War' (New York Times, 2010).

One of three explanations offered for persistence of the social gap – the 'democratic deficit' hypothesis – suggests local stakeholders oppose projects because they are far removed from the decision-making locus (Van Der Horst, 2007). Community groups, organizations, or citizens resist local developments because of inadequate public participation in the process. When the public is involved in renewable energy project planning there is less friction over developments even when communities hold divergent views (Phadke, 2013). A second explanation – the qualified support hypothesis – is based on the premise that people offer support, but with qualifications (Bell, Gray, Haggett, & Swaffield, 2013). These people support renewables generally, but only when they know at least some particulars (Bell et al., 2005). Research on wind farm controversies at San Gorgonio Pass near Palm Springs, California, show qualifications include local economic benefits such as job creation and expanded local tax base (Pasqualetti, 2001). There is also strong evidence for decreased community friction resulting from claims about benefits such as increased economic activity and tax abatements elsewhere in the American Southwest (Brannstrom, Jepson, & Persons, 2011). Finally, the 'self-interest' or NIMBY explanation is that opposition stems from a project's impact on an individual's interests, property or otherwise.

Factors that explain social resistance in other research include socio-demographics, political beliefs, perceived impacts, environmental concerns, attachment to place, scale of development, ownership patterns, proximity and spatial context, fairness of the development process, distribution of impacts, and levels of trust with institutions. Data from telephone surveys of California desert residents suggests that proximity to project development influences the degree of opposition (Carlisle, Solan, Kane, & Joe, 2016). Socio-political acceptance can also hinge on the effectiveness of an insider-outsider frame by project opponents. Describing solar energy developers as 'big solar' groups those industries with powerful energy sectors like the very powerful "big banks and 'big oil.' The moniker 'big wind' is used to position developers as outsiders not sensitive to local concerns (Phadke, 2011). People more familiar with the open spaces and desert ecosystems of the American Southwest may also better sympathize with concerns about USSE developments on undisturbed desert lands because they may better understand the conservation challenges facing the region.

Local resistance to renewable energy may be because groups do not appreciate the imperative of climate change relative to other concerns like jobs and cultural change (Firestone & Kempton, 2007). A lack of familiarity with renewable energy facilities may also cause negative perceptions

(Moula et al., 2013). Public referenda and collaborative spatial planning may help fill the social gap as poor communication and mistrust are primary points of conflict in opposition to wind farms (Wolsink, 2007a). Research on opposition to renewable energy projects suggests many opponents are articulate and well-reasoned (Michaud, Carlisle, & Smith, 2008), and much can be learned from place-based approaches to understanding the roots of opposition (Batel & Devine-Wright, 2015). Incorporating local knowledge, experiential learning, and access to information into project proposals could reduce social opposition (Van Der Horst, 2007). Visual simulations of impacts – sometimes required in NEPA EIS documents – may offer opportunities to reduce conflicts. Redistributing benefits and providing a sense of ownership to community member also reduces social gap frictions (Walker, Cass, Burningham, & Barnett, 2010). Tolerance maps, spatial planning, and decision support systems may help minimize conflicts where resolving aesthetic issues (Wu, Torn, & Williams, 2015). Pubic involvement in planning can foster a more collaborative spirit around renewable energy proposals, suggesting possibilities for community collaboration to find acceptable outcomes even if sides are not in agreement with the final results entirely; such processes are key to satisfying elements of energy justice (Phadke, 2013). Considering multiple landscape values in public deliberations can help identify more equitable and fair outcomes (Mason & Milbourne, 2014).

3. Methodology

3.1. *Study area*

The arid states of the American Southwest – California, Nevada, Arizona, Utah, New Mexico and Colorado – are the scope of this study. There is a strong focus on the California deserts and western Arizona and Nevada because these areas face greater development pressure. These areas are within reach of the transmission corridors that deliver electricity to California investor owned utilities and the inland desert metropolises of Phoenix and Las Vegas. The American Southwest is an excellent site to study social-ecological conflicts because of the significant presence of public lands, which are managed for multiple-use such as conservation, resource development, grazing and recreation.

3.2. *Data collection*

Qualitative data were collected from semi-structured interviews, public comments received during the environmental impacts assessment (EIA) process for siting USSE, media and journalistic accounts, and participant observation at public meetings. Case studies used to illustrate key impacts focused on projects with a federal or state regulatory nexus such as federal loans or public lands as this offers more opportunity for data gathering from public comments and participant observation. Semi-structured interviews with local residents, ecologists and wildlife biologists, land managers, policy-makers and other concerned citizens were conducted from 2009 to 2013. These interviews aimed to understand how stakeholders perceive their voices were heard in public venues on matters of energy and land use policy, and whether concerns were integrated in to specific recommendations to project developers. A list of interviewees was initially populated with names and organizations working on USSE development or familiar with potential wildlife conflicts over solar, and snowball sampling was used to add additional interview subjects until new information provided by interviewees became repetitive.

Public comments to the Solar PEIS and California's DRECP, two important assessment and planning processes with a considerable public participation component, and public comments from specific project proposals were analyzed. Public comments were coded with keywords to identify points of contention and to tie comments to particular proposed projects. Finally, some quotes and information were taken from journalist publications and press releases from environmental and Native American groups. Public comments from wildlife conservation experts were used to document some of the environment impacts not listed in EISs, DRECP, or the Solar PEIS.

4. Spatial and contextual explanations for opposition to USSE

The specific location of USSE projects determines the severity of socio-ecological impacts. California's desert land types most commonly disturbed for USSE facilities are schrublands and scrublands (26%) and less than 15% of facilities are sited on 'compatible' lands (Hernandez, Hoffacker, & Field, 2015; Hernandez, Hoffacker, Murphy-Mariscal, Wu, & Allen, 2015). A spatial risk assessment simulated 8.7 GW of solar in the California desert by 2040 and found that most compatible lands with USSE are in the western Mojave Desert and Salton Sea areas (Stoms, Dashiell, & Davis, 2013). Yet, most USSE development occurs in the eastern Mojave Desert and Lower Sonoran Deserts, though that is changing as projects move toward California's Central Valley.

While prior research describes high-level land use change risks associated with solar development on arid lands, these studies often lack data characterizing existing facilities, on specific species or ecosystems, and particular harms from existing projects. Turney and Fthenakis (2011) find that the biodiversity of desert scrubland rivals forest ecosystems, but claim only minimal environmental impacts of installing and operating USSE. They describe arid ecosystem habitat as grasslands, desert scrubland, and 'true desert,' limiting the relevance of these findings to planning efforts in the American Southwest, where a different nomenclature is used for land use classification. Experience from proposed projects in the American Southwest challenges the claim that 'true desert' – sand dunes lacking vegetation – lacks any biodiversity (Turney & Fthenakis, 2011, Figure 1, p. 3263). One USSE project proposed near the Big Dune area in Western Nevada would have impacted habitat for the Giuliani's big dune scarab beetle (*Pseudocotalpa giulianii*), a threatened species under the ESA since 1978, and three other beetles of conservation concern. The flat-tailed horned lizard (*Phrynosoma mcallii*) lives in sand dunes east of the proposed Imperial Valley Solar Project and depends on that habitat.

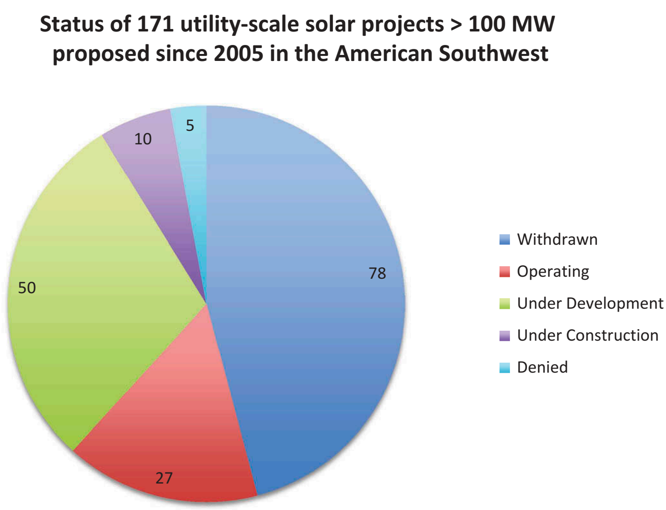

Figure 1. Status of 171 Utility-solar projects (>100 MW) proposed on public lands from 2005–2016.

Wildlife impacts from USSE include mortality during construction or during operation, including by collisions with modules, arrays, fences, and vehicles. In California, the most controversial wildlife issue with solar development was over mortality to Agassiz's desert tortoise (*Gopherus agassizii*) from USSE site preparation and construction. Desert tortoise impacts raise alarm with wilderness and conservation organizations in the region because the species, which is found north and west of the Colorado River to the eastern fringe of the Mojave Desert, overlaps with areas attracting USSE proposals. The reptile's population has declined dramatically over the past century and the species was listed as threatened under the ESA in 1990 (Alagona, 2013).

In the broader planning processes, organizations working on issues related to desert tortoise were specifically concerned about solar development at Iron Mountain, Chuckwalla Valley, McCoy Wash, Pisgah Crater, and Ivanpah Valley. BLM forecasts 161,943 hectares (ha) of Agassiz's desert tortoise habitat could be directly impacted by USSE development across the American Southwest (Lovich & Ennen, 2011). More federal agency dollars were spent from 1996 to 2006 on desert tortoise conservation than the grizzly bear, grey wolf, and bald eagle (Stark, 2009). Desert tortoise conservation also faces other threats – mining, grazing, urbanization – and climate change will likely shift the tortoise's habitat range as temperature and precipitation patterns change (Barrows, 2011; Todd et al., 2016). More than 90% of tortoise habitat occurs on BLM lands, so agency decision-making could profoundly affect the species' future.

Desert tortoises found onsite at USSE projects are translocated to other lands, usually adjacent, as a mitigation measure for the incidental take. This technique receives considerable disapproval from environmental organizations and well as research communities in conservation biology and as they suffer high rates of mortality (Germano et al., 2015). Public comments consistently mentioned a recent failed translocation at a military base expansion at Fort Irwin that resulted in the death of hundreds of tortoises (Department of Energy and Bureau of Land Management, 2008). Since 2009, six USSE built on public lands have required desert tortoise translocations, with at least three projects requiring translocation of greater than 100 tortoises (author's data). Project developers with impacts to tortoise are required to monitor and invest in mitigation measures and some companies voluntarily donate to tortoise conservation science.

The most controversial project with impacts to desert tortoise was BrightSource Energy's Ivanpah solar power tower project. Despite the concerns with impacts to desert tortoise and several other biological issues raised by environmental organizations and scientific experts during a series of evidentiary hearings convened by the California Energy Commission, the regulatory body overseeing CSP, BLM processed the Ivanpah ROW permit. In preparation for a formal environmental impact statement (EIS), BrightSource hired biologists to survey the site for desert tortoise. The reptile spends 90% of its an average 50-year life in burrows (Germano, 1992), and in this relatively dry year, biologists found only 17 tortoises onsite during surveys according to the initial assessment. Fish and Wildlife Service (FWS) estimated only 32 were on the site, suggesting a low tortoise density and contradicting opponents' claims that the site contained important tortoise habitat. FWS used this evidence as the scientific basis for their Biological Opinion to advise the use of the translocation method to move tortoise to mitigation sites (BLM, 2009).

Later during 2009, biologists contracted by BrightSource cleared the Ivanpah project site, discovering 80 adult and 93 juvenile tortoises. This count was far above the permitted amount of up to 38 tortoise incidental takes and suggested that the area was high quality habitat after all. BLM temporary suspended project activities, momentarily throwing the project's loan into question; projects receiving financing from ARRA needed to demonstrate they could break ground before 2011 to maintain 'shovel-ready' status. BrightSource required a second Biological Opinion, during which BLM released a report suggesting impacts to thousands of desert tortoises over the project's lifetime. BrightSource countered that the tortoise pens that temporarily housed tortoises before translocation would result in increased populations in receiving areas.

The Ivanpah dispute was widely reported in popular media outlets such as *Forbes*, the *Wall Street Journal, New York Times*, and the *Los Angeles Times*, and covered by local journalists such as Chris Clarke and various reporters from the *Las Vegas Sun, Las Vegas Review-Journal* and Palm Spring's *The Desert Sun*. Detailed naturalist-oriented descriptions on the threats posed by USSE by wilderness advocates at Basin and Range Watch and contributors to the *Mojave Desert Blog*. Most environmental organizations submitted public comments – some prepared by staff lawyers or biologists – to the Ivanpah Valley EIS. Only one organization took legal action to stop the project – the Western Watershed Project. The Center for Biological Diversity considered a lawsuit, but concluded better protections could be gained for the desert tortoise by focusing efforts elsewhere (Center for Biological Diversity, 2011). Organizations may have resigned to accept that renewable energy would have to be sited somewhere and that areas would be better defended through other planning processes such as the Solar PEIS and DRECP (Bureau of Land Management, 2016a).

The Western Watershed Project, a watchdog organization focused on 'private abuses of public lands,' filed the lone lawsuit arguing that the FWS relied only on the project proponents' contractor-scientists for a 'woefully underestimated' account of tortoise impacts. They also argued the BLM should have examined connected actions like the Eldorado-Ivanpah Transmission Line required to link to project to the grid. Electricity transmission and distribution infrastruture can be habitat for ravens that prey on juvenile desert tortoise (Boarman, 1993, July 11–16). Despite these claims, the lawsuit was eventually denied in the U.S. Ninth Circuit Court of Appeals and Ivanpah was operating by February 2014.

Adjacent to BrightSource's project in Ivanpah Valley, were two thin-film photovoltaic projects Silver State and Stateline, built by First Solar covering nearly six and half square miles of tortoise habitat. The Stateline project was thrown into the tortoise controversy because it overlapped with receiving site for the translocated population from Ivanpah. Biologists would have to move these tortoises once again once clearing for the new project commenced (Ironwood Consulting, 2012). The Center for Biological Diversity filed suit and argued in court that the BLM did not adequately consider the FWS's Biological Opinion in its decision to grant the ROW, but the courts rejected the argument.

The tortoise population at Ivanpah had the most translocations of any USSE project, although the project at Moapa is believed to have similar numbers. Bureau of Indian Affairs data submitted to the FWS suggest over 156 were found in 2013, and an additional 13 since (First Solar, 2015; Bureau of Indian Affairs, 2016). BrightSource and NRG have spent nearly $60 million on tortoise on mitigations and research about the behavior of translocated and resident tortoises at Ivanpah. One research team is studying the space-use patterns and habitat-use of translocated tortoises and the receiving population using radio-telemetry data (Farnsworth et al., 2015). So far research suggests short distance translocation is more effective than longer distances (Brand et al., 2016). Finally, there is a great deal of confusion about the use of translocation for conservation versus its use in mitigation. The former is used in the restoration or ecological enhancement of land previously disturbed, while the latter is used to compensate from a development impact such as with USSE deployment. Some in the scientific community have concluded that, 'mitigation translocations often represent a misguided conservation strategy' (Germano et al., 2015). Hence, reference to tortoise translocation as conservation in the context of USSE developments is a mischaracterization.

Once in operation, the Ivanpah project became ensnared in another ecological controversy. Solar power towers create a focal area of heat flux that damages the feathers and skin of birds (Kagan, Viner, Trail, & Espinoza, 2014). One FWS official stated on the public docket that solar power towers could be an ecological 'mega-trap,' luring insects and birds towards their demise (Ibid.). Bird mortality at USSE also occurs from collisions with PV arrays, heliostats, or fences (H.T. Harvey & Associates, 2015). Bird mortality is known from a solar power tower in near Daggett, California in the 1980s, though early studies concluded a minimal impact on avian species (McCrary, McKernan, Schreiber, Wagner, & Sciarrotta, 1986). During the CEC proceeding to approve several power tower projects, including Ivanpah, expert witnesses from conservation organizations noted that the science underlying the research undercounted bird mortality. FWS biologists coined the term 'streamers' at the Ivanpah site to describe birds singed by solar flux that left a trail of vapor. The solar flux is most problematic in 'stand-by' mode when the heat flux is midair above the power tower receiver to reduce power. Later surveys from Ivanpah raised the bird death totals upwards, with just under half of the deaths due to the heat flux (H.T. Harvey & Associates, 2015). One public comment submitted by the FWS's Chief Biologist in the Palm Springs BLM District Office asked that the CEC not approve any solar power towers until data can be collected on the impacts on avian ecology. 'It would be beneficial to the permitting process for pending and future projects, including Hidden Hills and Rio Mesa, to gather monitoring data that answer some of the questions about avian physiological tolerance and behavioral response to power towers, from already approved projects, before approving more projects,' (Sorenson, 2014).

Existing USSE facilities kill between 16,200 and 59,400 birds annually according to one study of Southern California (Walston, Rollins, LaGory, Smith, & Meyers, 2016). The issue began to garner attention when a peregrine falcon was killed at Ivanpah and several journalists reported on aquatic bird collisions at the Desert Sunlight Solar Farm in Desert Center, California (Clarke, 2013). A wide variety of bird types have suffered mortality at USSE (Smith & Dwyer, 2016). Two endangered Yuma clapper rails (*Rallus longirostris yumanensis)*, a population with less than 1,000 extant individuals, were killed at Desert Sunlight. At two solar power plants in the California desert (one PV farm and a CSP-parabolic trough), over 20 birds associated with aquatic habitat – yellow headed blackbirds (*Xanthocephalus xanthocephalus*), great blue heron (*Ardea herodias*), eared grebes (*Podiceps nigricollis*), western grebes (*Aechmophorus occidentalis*), pied-billed grebes (*Podilymbus podiceps*), surf scoter (*Melanitta perspicillata*), red-breasted merganser (*Mergus serrator*), bufflehead (*Bucephala albeola*), black-crowned night heron (*Nycticorax nycticorax*), double-crested cormorants (*Phalacrocorax auritus*), American coots (*Fulica americana*), and brown pelican (*Pelecanus occidentalis*) – were found dead far from any sources of water with apparent injuries due to colliding with panels and mirrors (Clarke, 2013).

Some avian biologists have hypothesized a 'lake effect' caused by USSE that attracts birds towards an ecological trap (American Bird Conservancy, 2015). Glass is an anthropogenic source of polarized light pollution, and cues may lead birds to see USSE facilities as lakes, although there is no evidence that birds actually see poliarized light. A handful of USSE facilities have onsite ponds that may be a source of attraction in arid environments. To date, there is no research on avian vision and how birds see USSE facilities. Polarized light cues cause aquatic insects to prefer to lay eggs on photovoltaic modules than in water, prompting interest in research on polarized light pollution and insect, bat, and bird behavior near USSE sites since water bodies are the only sources of polarized light in nature (Horvath et al., 2010). Some renewable energy advocates minimize the consequences of USSE on bird mortality by comparing it to other sources such as cats, buildings, automobiles, and other energy sources, although this incommensurate framing neglects that impacts are cumulative, not trade-offs, and does not distinguish between mortality to different types of birds. The solution to mitigating USSE impacts on avian species will require greater scientific understanding of birds' perceptions and use of USSE facilities.

Another concern raised in interviews and public comments is habitat fragmentation, which can occur with USSE projects because vegetation is typically removed and projects are surrounded by fencing that restricts some wildlife movement. In Panoche Valley, a USSE under construction will cover about half of the valley floor in one of three critical habitat recovery areas for the San Joaquin kit fox. On the Carrizo Plain, a second of these habitat recovery areas, solar developers worked with an organization named Dogs for Conservation to identify where kit fox moved through the proposed solar farm site, and built artificial kit fox dens and passes through the fencing as a mitigation. Personal communications with wildlife biologists report early success with these artificial kit fox dens.

At a broader ecological scale, a number of projects and the cumulative impacts of the SEZs raised concerns about bighorn sheep (*Ovis Canadensis*) movement and gene flow. This prompted biologists Edward O. Wilson and Thomas Lovejoy to publicly advocate stopping the Soda Mountain Solar project. 'We're all for solar projects. We need more of them. But not in this place' (Wilson & Lovejoy, 2015). Their op-ed followed a similar call earlier by bighorn sheep ecologists John D. Wehausen and Clinton W. Epps. Large developments can impede movement of bighorn sheep across otherwise open basins to neighboring ranges. While data collected for the Soda Mountain EIS suggested infrequent bighorn sheep visitation, and identified the major interstate as the major barrier, scientists argued that the site was an important restorable corridor for bighorns moving between the Mojave National Preserve and Death Valley National Park (Wehausen & Epps, 2015).

In arid areas, USSE development can damage soils. Heavy land disturbance can impact caliche – cryptobiotic soil crusts that are an assemblage of cyanobacteria, lichens, mosses and fungi (Schlesinger, 1985). The amount of time required to return arid systems to 'pre-disturbance conditions' is estimated at two-three years for grasslands and 'decades' in desert environments (Lovich & Bainbridge, 1999). USSE development can also impact aeolian sand transport critical to the geomorphology of sand dune ecosystems. Aquatic ecosystems are put at risk where development causes prolonged drying of ephemeral water bodies or where water courses are altered (Grippo, Hayse, & O'Connor, 2015).

Some public comments alluded to the importance of even the common plants that occur on these landscapes. *Yucca schidigera* (Mojave Yucca/Spanish dagger) is considered a keystone plant in the Mojave Desert, as it leaves behind burrows after it decays, which are used by tortoise, ground squirrel, kix fox, and burrowing owl. Threats to plant habitat or risks to plant species from USSE are not fully catalogued because the Eastern Mojave is not thoroughly documented by botanists (Andre, 2008). Pointing to the absence of records in Consortium of California Herbaria records in Southern California for the desert regions, one distinguished research botanist points out that, '…roughly five to ten percent of the plant species in the Eastern Mojave have not yet been described…how can we document the impacts when we don't know what's there?' (Andre, 2010a). One project, later cancelled and now part of the Mojave Trails National Monument, threatened to disturb one of the few populations of the endangered white-margined beardtongue (*Penstemon albomarginatus*), threatening to cause its extinction in California (Andre, 2010b). The Mohave ground squirrel (*Spermophilus mohavensis*) is another species that depends on habitat connectivity to prevent inbreeding depression and the key species of concern for several USSE projects in the western Mojave Desert. Along California's central coast range and San Joaquin Valley, on mostly private lands, the blunt-nosed leopard lizard (*Gambelia sila*) and San Joaquin kit fox dominated the concerns raised by local conservationists, opponents of the USSE, and even wildlife officials in the biological opinions of EISs. Along the U.S.-Mexico border, the flat tailed horned lizard triggered ESA concerns, as the reptile was under consideration for listing (it was later denied).

Road construction is an overlooked impact from USSE development. The impacts from road construction include new barriers to movement and sources of wildlife mortality and dust. Roads may open pathways for high-risk weed species invasions such as Sahara mustard (*Brassica tournefortii*) and cheat grass (*Bromus tectorum*), which can shift fire regimes once established. Permitting agencies may require weed management plans from USSE developers (SolarReserve, 2011).

Mitigations for impacts are relatively common in USSE projects that disturb wildlands, are built on federal lands, or are taken out of conservation easement. Some developers purchase mitigation land or buy into conservation easement banks. In California, a state Senate bill from Alex Padilla, which allowed USSE developers to meet the ARRA deadlines while complying with the California Endangered Species Act, allows mitigations to occur by contributing to a fund used by wildlife agencies to purchase lands. One of the challenges with accepting mitigations is that some areas purchased as mitigations are not necessarily under development pressure, meaning that they are unlikely be developed irrespective of their purchase as mitigation. A mitigation proposed to offset the habitat loss from the Panoche Solar Power Plant in San Benito County was 10,000 acres of a nearby ranch. In addition to having very different habitat qualities (steep mountainous terrain versus flat, open fields frequented by kit fox and giant kangaroo rats), BLM staff noted at a public

Table 4. Water use at CSP and PV USSE in California.

Activity	annual water use(acre-feet/year)	water use/capacityacre-feet/year-MW	Notes
Mirror washing	47.4	0.11	CSP
Module washing	4,000	4.3	PV
Potable water for workforce	0.01–0.02	4×10^{-5}	PV & CSP
Cooling (dry)	1,646	6.5	CSP
Fugitive dust control – construction	1,600–18	6.7–2.9.2 x 10^{-2}	PV & CSP
Fugitive dust control – operations	0–100	1.0	PV & CSP
Boiler feedwater (CSP)	0.08	2.1×10^{-4}	CSP
Boiler blown down (CSP)	0.02	5.0×10^{-5}	CSP
Hydrostatic testing (CSP)	0.14	3.7×10^{-4}	CSP
Fire fighting	0.46	1.3×10^{-3}	PV & CSP

hearing that they were already raising funds to acquire that land. Mitigations on paper can be false mitigations in practice, but other land purchases do stave off development. Questions about benefits derived from mitigations need case-by-case treatment.

Onsite water use is an impact area described in several public comments, particularly where USSE projects require groundwater for cleaning or dust control. Table 4 describes various site activities that require freshwater. A large volume of water is used at both CSP and PV USSE facilities for fugitive dust control, which is typically required due to removal of the top layer of soil surface and road construction on fragile soils. Not all USSE facilities require water for fugitive dust control, but it is common in the arid American Southwest during construction activities and for roads during operation. Figure 2 shows how the water use at USSE can decline several order of magnitude after construction activities. Cleaning heliostats or PV modules during operation is another large water use requirement (Bureau of Land Management, 2010). The highest water use for USSE facilities overall is for CSP plants that use wet cooling (Congressional Research Service;

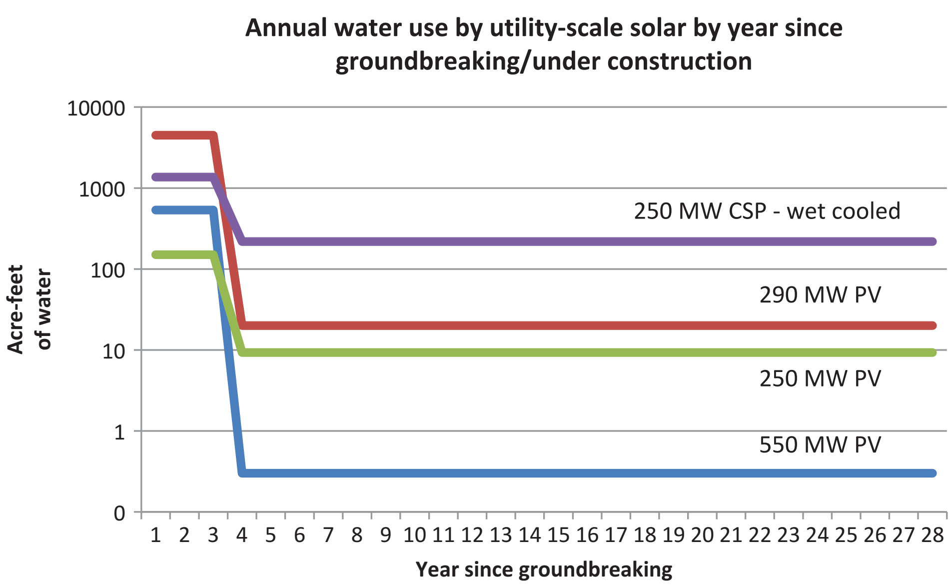

Figure 2. Water demands at CSP and PV USSE constructed from 2010 to 2015.

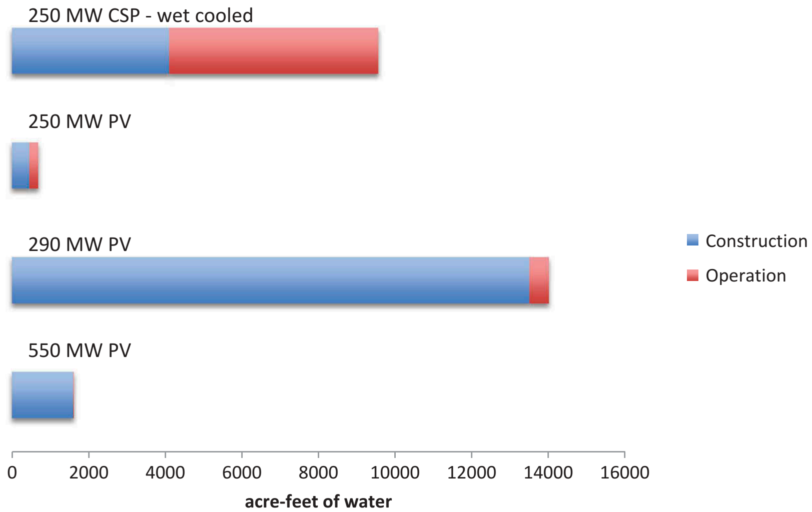

Figure 3. Share of water use between construction and operation for four USSE facilities.

Carter & Campbell, 2009). This first bar in Figure 3 shows the water use during operation at a wet-cooling CSP built in Arizona. Although after 2011, no more wet cooling CSP were proposed across the western states, as dry cooling technologies are cost competitive considering the expensive water in the region. CSP requires small volumes of water for boiler blowdown and hydro-static testing of the piping (from EIS reports). Small quantities of water are needed for a workforce's potable drinking water and other services; the number of construction workers can be two orders of magnitude higher during construction. Several USSE also proposed demineralizing systems to remove impurities such as boron from groundwater to avoid salt build-up in soils and on solar devices. Despite this high variability in the amount of water it takes to produce a unit of electricity from USSE, impacts on freshwater supplies is minimal compared to the region's availability (Frisvold & Marquez, 2013) and water use remains for lower than other sources of electricity (Fthenakis & Kim, 2010).

Groundwater depletion impacts vegetation and aquatic species such as the endangered desert pupfish (*Cyprinodon macularius*) and Moapa dace (*Moapa coriacea*), which depend on aquatic habitat sustained by historic water table-levels. Project developers will continue seek ways to reduce water use onsite water at USSE facilities across the American West. Particularly in California, where the Sustainable Groundwater Management Act could alter the availability and cost of water for USSE, as could changes to the Colorado River Compact, water district adjudications, or the availability of private sources. A number of start-up solar firms specialize in automated, water-less USSE panel washing technologies.

Fugitive dust emissions from heavy disturbance to vegetation and underlying soils can be sources of air pollution from USSE. The 280 MW Antelope Valley Solar Ranch project fell out of compliance with the Antelope Valley Air Quality Management District (AVAQMD) after a series of windstorms caused severe white-out conditions that contributed to automobile pileups on roads near Lancaster, California in the western Mojave Desert (Trabish, personal communication, March 10, 2012). These emissions exceeded those permitted under the Clean Air Act and caused considerable community outrage over land stewardship. The AVAQMD forced construction to stop, and for several days there was speculation that the project might miss an important ARRA milestone (Ibid.).

In the public comments to nearly every USSE EIS proposed in arid regions there was concern raised about 'valley fever,' an illness caused by exposures to soil-borne fungal spores. It was voiced at an open house for the 550 MW Topaz Solar Farm in 2010, where several concerned citizens raised the emerging public health issue and how it may be magnified by the cumulative impacts of Topaz and nearby 250 MW California Valley Ranch, both just a mile north of Carrizo Plain National Monument. Both the developer and construction companies were cited multiple times by Cal/OSHA for failing to reduce exposures to airborne dust (California Department of Industrial Relations, 2013). Several year later, 42 workers working at these two USSE farms were exposed to dust containing spores of *Coccidioides immitis* (Wilken et al., 2015), presenting a potential emerging occupational hazard important to solar energy transitions. Although, the occupational health and safety hazards faced by solar industry workers are far fewer than other energy sources.

Land use change for USSE could change the surface reflectivity or albedo, making the facility act like a heat island, changing surface temperature and regional weather patterns (Millstein & Menon, 2011). Public comments from a biologist noted that solar power plants could affect the thermo-regulation of reptiles such as desert tortoise (Sinervo, 2014). In urban areas, because of changes to the thermal mass that absorbs solar radiation, photovoltaic and solar hot water panels can reduce the heat island effect depending on the prior land use (Masson, Bonhomme, Salagnac, Briottet, Lemonsu, 2014). Changes to albedo from USSE are site dependent. Land use change and albedo can cause changes to microclimate patterns. Increased energy from albedo or surface flux change could facilitate the formation of more energetic weather.

Changing surface reflectivity can cause glare that impairs the vision of drivers and pilots. There is also evidence that the reflective glare from heliostats can have non-permanent ocular impacts on human vision (Ho, Sims, & Christian, 2015). The pilots union from Las Vegas McCarran International Airport, near to the Ivanpah plant, filed a complaint with the compliance officer at the California Energy Commission (Department of Aviation, 2014). They described the reflection from Ivanpah as 'blinding.' Another pilot taking off from an airport in Boulder City, Nevada, described being 'nearly blinded' after take off (Ibid.).

Natural disasters can also cause USSE facilities to be a source of broken glass. A tornado struck the Desert Sunlight Solar Farm, near Desert Center, California, damaging 154,843 PV modules and requiring the cleanup of hazardous materials scattered within and around the power plant footprint that required extensive cleanup in 120-degree temperatures (personal communication, NextEra). Some of the broken glass was commingled with small rocks and dirt and was disposed of at a hazardous waste facility.

5. Procedural and cultural resource issues

Across the American West there is evidence of past peoples and civilizations. The Fort Mohave, Chemehuevi, and Quechan are just some of the Colorado River tribes that expect prior consultation from developers and the BLM. Failing to do so could lead to costly legal actions or project delays. The public lands used for solar development must comply with the National Historic Preservation Act. Tribes and Native American organizations claimed BLM only conducted cursory consultations during the siting of fast-track projects, failing to keep tribal leaders informed. BLM revised its practices of consultation considerably since 2010. Cultural resource consultations are complicated by the fact that some Native American groups consider living species as culturally significant. At one early project fast-tracked by BLM, Quechan tribal leaders complained in a public comment that, 'the flat-tailed horned lizards is essential to our creation story.' Harm to an individual flat-tailed horned lizard meant damage to Quechan culture. The La Cuna de Aztlan Sacred Sites Protection Circle filed suit against six solar power plants on BLM lands shortly after the Interior Secretary approved them for similar reasons.

According to Native American historian, Alfredo Figueroa, the initial developers of the Blythe CSP Project bulldozed a geoglyph of Kokopilli and a sun geoglyph on public lands shortly before they went bankrupt, leaving the spot vacant until construction commenced on a different PV farm in 2014. The courts denied a hearing for any of the six lawsuits, though some projects were never built due to financial or technical considerations. During my interview with Figueroa, standing at the foot of the McCoy Mountains, he pointed toward the Palen Mountains and noted that the lands adjacent ancient watering hole near the site almost certainly contained the remains of their ancestors, who would frequently convene and reside near water sources along trails that connect the Colorado River to the Pacific. The next year in 2011, at the construction site for the Genesis CSP project site, grinding stones and a charcoal layer that Colorado River tribes believe is an ancient cremation site were uncovered during construction resulting in a lengthy construction delay. One tribal elder was quoted in the *Los Angeles Times*, saying the project '…disrupted the peace of our ancestors and our relationship with the land. There is no mitigation for such a loss' (Sahagun, 2012). The place of Native Americans in the socio-ecology of North American warrants their input and influence on land use policy in response to global climate change. These considerations extend beyond the deserts of the American West, as lands rich in solar resources everywhere are facing pressures across the arid parts of the world including dispossession and socio-ecological change (Rignall, 2016).

Aesthetic considerations and damage to amenity values are also USSE impacts. Across the American West, there are many iconic landscapes either wild or rural in character, and the loss of these aesthetics is important to visitors as well as landowners whose property values may be partly derived from a viewshed. One rancher decried at a public hearing, 'land that we grow food on and make a living off. Gone. Forever.' Exurban residents are moving into these rural regions and many USSE projects compromise some of those amenity values. One public comment from a resident read, 'Please don't grab and close this land. There is alot of history here and it also is an enjoyable place for many recreationalists. There are currently too many land closures going on around the country, it would be a shame to see another.'[4]

6. Institutional drivers of the solar land rush of 2005–2009

6.1. *Securing markets, virtual land privatizations, socializing financial risks*

To understand why early USSE proposals led to Green Civil War in some places, it is important to situate the broader economic context for the large number of projects proposed on public lands. Planning efforts by Interior and Department of Energy to develop USSE on public lands were underway by 2003. However, no policy actions were taken until two years later when the BLM began a solar development program. Interior Secretary Dirk Kempthorne initiated the Solar PEIS in 2008. At the time, BLM was inundated with over 1 million acres of USSE farms proposed on public lands.

Three major policy initiatives aligned across several federal and state agencies and programs drive USSE development on public lands. The RPS created mandatory markets where IOUs had to buy renewable electricity. This signaled to investors that solar power plants had markets for solar electricity, with guaranteed contracts – power purchase agreements (PPAs) that lasted 20 to 25 years. This helped raise the capital needed to build the USSE project. Prior to the RPS, nine CSP plants built in the 1980s – the Luz I-IV, which remained the largest collection solar power plants in the world well into the 21st century – went bankrupt when natural gas prices plummeted. RPS programs protect USSE developments from market fluctuations through long-term contracts.

The second major policy was the availability of ARRA capital through loan guarantees and cash grants. Expanding the loan guarantee program introduced by Congress in the 2005 Energy Policy Act to clean technologies (Section 1705) became a vehicle to deliver $13 billion in loans for solar manufacturing and power plants. The Department of Treasury's Section 1603 cash grants in lieu of the Investment Tax Credit deductions offered another $26 billion in capital to build some of the world's largest USSE facilities. The Modified Accelerated Cost Recovery System added further tax equity benefits by allowing depreciation of equipment.

The third major policy driver was the BLM's mandate to build 10 GW of renewables on public lands and expedited environmental review. BLM's mandate let developers apply for ROWs to any parcel size across 22.5 million acres of public lands in what amounted to virtual land privatizations. In 2009, the US did not have any USSE projects larger than 100 MW. These policies set into motion the development of a dozen solar power plants, 100 MW or larger. In 2016, there are 20 operating USSE over 100 MW across the American Southwest with 5 currently under construction. Executive Order 13212 (2001) allowed expedited 'fast-track' environmental review for energy projects in order to receive Treasury grants and loans. Signed into law in 2001, after recommendations from the Cheney energy task force; it reads '…agencies shall expedite their review of permits or take other actions as necessary to accelerate the completion of such projects, while maintaining safety, public health, and environmental protections' (EO 13212). These policies together created the institutional inertia that led to the most controversial USSE proposals on public lands.

6.2. *Explaining the roots of land use conflict over USSE*

Several factors explain the social resistance to USSE projects across the American Southwest. Using public lands for USSE raises important ecological questions because many of these lands are in conservation by default from a lack of use. For some groups and citizens, social resistance is based on opposition to 'big solar,' projects owned by some of the world's largest multinational corporations. However, several major USSE mega-projects of similar size that did not require public lands, did not elicit the same level of outcry during development. In fact, several projects on private land did not require an EIS and were approved simply with an Environmental Assessment and there is no record of formal protest. Others see USSE facilities as another mistreatment of rural areas by cities. The general lack of scientific evidence collected and used to inform and support decision-making is an important consideration for some actors in the controversy.

Much like other studies of social resistance to renewables, this research finds that many of the opponents found procedural aspects of the siting process deeply problematic. Not only were early projects lacking in collaborative planning and consultation, many project developers missed out on important lessons already known from scholarship about community engagement and public participation (Phadke, 2013). Here too, public lands differ from private ones in that Native American groups are required to have early consultation with BLM to identify cultural resource issues. To Native American groups, many of these public lands are also sacred lands; industrialization is an assault to their culture.

Yet, not all opposition stemmed from concerns about the process per se, as some made science-based arguments based on the impacts described above. Some wildlife and ecosystem scientists argued in public comments that projects proposed and developed in green spaces were fundamentally misguided, as these open spaces are important for conservation as they provide habitat and linkages for species and landscapes of concern, and even carbon storage. This is why public lands, which are often adjacent to natural reserves and provide habitat for endangered species, have engendered such controversy.

7. Conclusions and recommendations

The first wave of USSE development in the American Southwest was accompanied by land use controversies. This large expanse of arid public lands rich in solar resources will continue to face USSE development pressures as utilities meet RPS quotas and organizations directly source renewables. This article highlights the impacts of USSE and sources of social friction in emerging energy landscapes across the American Southwest. It examines the ultimate drivers of land use change and describes the policy responses that attempt to minimize the impacts. While the focus on six western states in the USA limits the applicability of the particular issues to that region, some general themes apply to arid regions globally.

At the height of the controversy a 'technomanagerial eco-consensus' (Rignall, 2016) agreed that the fight against climate change is worth the sacrifice of lands that provide habitat for endangered species. Interior policy rationalized ROWs for USSE as a good use of public lands in the fight against climate change. This exploration of social resistance to USSE development on public lands raises questions that deserve deeper investigation. Does the DRECP and the Western Solar Plan present a model policy to balance habitat conservation and USSE development? Or is Interior's commitment to the 'all-of-the-above' approach – extending the offer of public lands, used historically by the fossil fuel industries, to renewables – destined to foment conflict owing to their history and ecology? Is the mandate to locate USSE projects on public lands in the face of alternatives sites and distributed energy choices forcing energy policy into a false choice of conservation versus USSE development?

As of 2016, the solar energy program yielded about $22 million annually in rent from lease payments (BLM, 2016a). These financial incentives to industry aim to help at the margins early in a new technology's development. But so long as federal agency revenues from leasing programs continue to rise, there will be critics that say these programs simply exist to generate federal revenue. Critics of federal lands policy point out that federal fossil fuel leasing provides the second most income to the federal government after the Internal Revenue Service.

Because public lands remain so controversial, energy policy-makers and land use planners should broaden the considerations for alternative places to site USSE as well as the balance between distributed PV versus centralized USSE. Large amounts of private and previously disturbed lands remain available for USSE in areas such as the San Joaquin Valley (Pearse, Strittholt, Watt, & Elkin, 2016). The EPA RE-powering America's Lands program maintains a spatial database identifying brownfields, abandoned mines, Resource Conservation and Recovery Act sites, and retired landfills that are close to transmission and do not have land use conflicts or shading problems. They identified 1.7 million 'solar-ready' acres in California. While there remain a few obstacles to brownfield development, including issues of liability, they are likely less controversial (Spiess & De Sousa, 2016). 'Floatovoltaics' – USSE sited on surface water such as reservoirs, ponds, wastewater treatment infrastructure, aqueducts, or offshore areas present win-win siting solutions as shading water could reduce evaporative losses (Hernandez, Easter, et al., 2014), reducing the embodied energy of water. There are also opportunities for colocation of USSE and agricultural production that look promising for resource use efficiency (Ravi et al., 2016).

The DRECP's scientific advisory panel recommendations emphasize that to maintain compatibility between USSE and desert ecosystem conservation, development must proceed with a 'no regrets' approach; proceed with an abundance of precaution where there is the potential to compromise species or ecosystems, or infringe on the rights and sensibilities of Native Americans. This requires a participatory, collaborative, science-based planning approach. Finally, photovoltaics are the only electricity source that can be widely deployed over human developments and infrastructure. Land use change impacts from distributed PV in urban areas are essentially zero and there are benefits to siting closer to load. Photovoltaic canopies can provide shade for parked cars lowering vulnerable populations exposure to heat stress and reduce the heat island effect. Better incentives and emphasis on distributed generation in grid design can present an opportunity to reduce the need for USSE.

The Green Civil War over USSE and public lands is explained through an understanding of its socio-ecological context and procedural aspects. Projects sited on public lands attracted criticism from experts in conservation about particular parcels with specific ecological features rather than self-interest or aesthetic considerations. Changes to land ownership also influenced opponent's views; privatization of public lands is not often listed as a factor in research on the social gap in renewable energy. Projects selected for fast-track status point to the ways that procedural aspects can make projects more controversial as well. At the height of the controversy, policy-makers favoring fast-tracking environmental review were caught between a deadline to finance projects with ARRA money and the time it takes to complete an EIS. U.S. public lands managers also have a unique procedural relationship with Native Americans, making cultural resource issues a more significant consideration than is often the case for projects on private lands. For both ecological and cultural resource assessment and planning, land managers decision-making is made better through participation and collaboration as the DRECP and

Solar PEIS illustrate. The number of land use controversies involving USSE and public lands has dramatically declined since their implementation, although so has the number of ROW applications. These cases of land use conflict across the American Southwest point to the need for more careful planning for energy transitions. As society gets increasing amount of electricity from the sun, lessons learned from particular projects should inform best practices in order to develop solar energy responsibly.

Notes

1. Based on author's database collected from various government and industry sources since 2008. See supplemental information for the complete list.
2. California does not count large-scale hydroelectric in its renewable energy reporting.
3. The electric utility serving the San Francisco Bay Area, Pacific Gas and Electric (PG&E), will provide 55% of the state's electricity by 2031, owing to an agreement between ENGOs NRDC, Sierra Club, and the Friends of the Earth, and the utility to shut down Diablo Canyon Nuclear Power plant.
4. Public comment from a concerned citizen to the Solar PEIS.

Disclosure statement

No potential conflict of interest was reported by the author.

Funding

This research was Funded by a National Science Foundation Division of Science, Technology, and Society Postdoctoral Scholarship. SES-0924991. Innovation and Environmental Justice in the Clean Tech Space: Measuring Performance and Anticipating Risks of Renewable Energy Technologies.

References

Alagona, P.S. (2013). *After the grizzly: Endangered species and the politics of place in California*. Berkeley: University of California Press.

American Bird Conservancy. (2015). Position paper: Solar energy. Retrieved from https://abcbirds.org/wp-content/uploads/2015/05/PP-Solar-Energy.pdf

Andre, J. (2008, December 6–7). California's desert flora: Will we know what we lost? *Desert Report*.

Andre, J. (2010a, March 25). In-person interview. *Sweeney Granite Mountain Reserve*, 2010.

Andre, J. (2010b). *Rebuttal testimony in the matter of the application for certification for the Calico Solar Project, Defenders of Wildlife*. Public Docket 08-AFC-13. Sacramento: California Energy Commission.

Araújo, K. (2014). The emerging field of energy transitions: Progress, challenges, and opportunities. *Energy Research & Social Science*, *1*, 112–121. doi:10.1016/j.erss.2014.03.002

Barrows, C.W. (2011). Sensitivity to climate change for two reptiles at the Mojave–Sonoran desert interface. *Journal of Arid Environments*, *75*(7), 629–635. doi:10.1016/j.jaridenv.2011.01.018

Batel, S., & Devine-Wright, P. (2015). A critical and empirical analysis of the 'national-local gap' in public responses to large-scale energy infrastructures. *Journal of Environmental Planning and Management*, *58*(5–6), 1076–1095. doi:10.1080/09640568.2014.914020

Bell, D., Gray, T., & Haggett, C. (2005). The "social gap" in wind farm siting decisions: Explanations and policy responses. *Environmental Politics*, *14*(4), 460–477. doi:10.1080/09644010500175833

Bell, D., Gray, T., Haggett, C., & Swaffield, J. (2013). Re-visiting the social gap: Public opinions and relations of power in local politics of wind energy. *Environmental Politics*, *22*(1), 115–135. doi:10.1080/09644016.2013.755793

Boarman, W. (1993, July 11–16). Predation on turtles and tortoises by a "subsidized predator". *Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles* (pp. 103–104), State University of New York.

Brand, L.A., Farnsworth, M.L., Meyers, J., Dickson, B.G., Grouios, C., Scheib, A.F., & Scherer, R.D. (2016). Mitigation-driven translocation effects on temperature, condition, growth, and mortality of Mojave Desert tortoise (*Gopherus agassizii*) in the face of solar energy development. *Biological Conservation*, *200*, 104–111. doi:10.1016/j.biocon.2016.05.032

Brannstrom, C., Jepson, W., & Persons, N. (2011). Social perspectives on wind-power development in West Texas. *Annals of the Association of American Geographers*, *101*(4), 839–851. doi:10.1080/00045608.2011.568871

Bureau of Indian Affairs. (2016). Moapa solar project final environmental impact statement. Retrieved from http://www.moapasolarenergycentereis.com/

Bureau of Land Management. (2009, December). Biological assessment of the ivanpah solar electric generating system project. New York, NY: Prepared by CMH2Hill.
Bureau of Land Management. (2010). Genesis final environmental impact statement. *Environmental consequences*. Retrieved from http://energy.gov/nepa/downloads/eis-0455-final-environmental-impact-statement
Bureau of Land Management. (2016a, September). *Executive summary for the record of decision for the land use plan amendment to the California desert conservation plan, bishop resource management plan, and bakersfield resource management plan*. Record of Decision, BLM/CA/PL-2016/03+1793+8321.
Bureau of Land Management. (2016b). Approved renewable energy projects. Retrieved from http://www.blm.gov/ca/st/en/prog/energy/Approved_Projects.html
California Department of Industrial Relations. (2013). Notable citations issued. Retrieved from: http://www.dir.ca.gov/dosh/citation.html
California Energy Commission. (2016a). "Tracking progress" Retrieved from http://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf
California Energy Commission. (2016b). "California renewable energy overview and programs." Retrieved from http://www.energy.ca.gov/renewables/
Carlisle, J.E., Kane, S.L., Solan, D., Bowman, M., & Joe, J.C. (2015). Public attitudes regarding large-scale solar energy development in the U.S. *Renewable and Sustainable Energy Reviews*, *48*(C), 835–847. doi:10.1016/j.rser.2015.04.047
Carlisle, J.E., Solan, D., Kane, S.L., & Joe, J. (2016). Utility-scale solar and public attitudes toward siting: A critical examination of proximity. *Land Use Policy*, *58*, 491–501. doi:10.1016/j.landusepol.2016.08.006
Carter, N., & Campbell, R. J. (2009, June 8). *Water issues of concentrating solar power (CSP) electricity in the U.S. Southwest* (Report no. R40631). Washington, DC: Congressional Research Service.
Center for Biological Diversity. (2011, August 8). Questions and answers related to the settlement agreement between the Center for Biological Diversity and BrightSource Energy, Inc. Regarding the Ivanpah Solar Electric Generating System Project in the Mojave Desert. Fact Sheet.
Clarke, C. (2013). *Water birds turning up dead at solar projects in the desert*. KCET. Retrieved from https://www.kcet.org/redefine/water-birds-turning-up-dead-at-solar-projects-in-the-desert.
Department of Aviation. (2014, March 10). *Letter re: Pilot complaints of visual impacts from Ivanpah solar electric generating system*. Sacramento: California Energy Commission, 09-AFC-07C.
Department of Energy and Bureau of Land Management. (2008, October). *Summary of public scoping comments received during the scoping period for the solar energy development programmatic environmental impact statement*. Biological assessment of the ivanpah solar electric generating system project. New York, NY: Prepared by CMH2Hill.
Executive Order 13212. (2001). Actions to expedite energy-related projects. Retrieved from http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/Executive_Order_13212.pdf
Farnsworth, M.L., Dickson, B.G., Zachmann, L.J., Hegeman, E.E., Cangelosi, A.R., Jackson, T.G., & Scheib, A.F. (2015). Short-term space-use patterns of translocated Mojave Desert tortoise in Southern California. *PLoS ONE*, *10*(9), 1–18. doi:10.1371/journal.pone.0134250
Firestone, J., & Kempton, W. (2007). Public opinion about large offshore wind power: Underlying factors. *Energy Policy*, *35*(3), 1584–1598. doi:10.1016/j.enpol.2006.04.010
First Solar. (2015, December 11). *Moapa Southern Paiute Solar update, desert tortoise monitoring update* (Unpublished memo). U.S. Bureau of Indian Affairs.
Frisvold, G.B., & Marquez, T. (2013). Water requirements for large-scale solar energy projects in the West. *Journal of Contemporary Water Research & Education*, *151*(1), 106–116. doi:10.1111/j.1936-704X.2013.03156.x
Fthenakis, V.M., & Kim, H.C. (2010). Life-cycle uses of water in U.S. electricity generation. *Renewable and Sustainable Energy Reviews*, *14*(7), 2039–2048. doi:10.1016/j.rser.2010.03.008
Germano, D.J. (1992). Longevity and age-size relationships of populations of desert tortoises. *Copeia*, *1992*, 367–374. doi:10.2307/1446197
Germano, J.M., Field, K.J., Griffiths, R.A., Clulow, S., Foster, J., Harding, G., & Swaisgood, R.R. (2015). Mitigation-driven translocations: Are we moving wildlife in the right direction? *Frontiers in Ecology and the Environment*, *13*(2), 100–105. doi:10.1890/140137
Grippo, M., Hayse, J.W., & O'Connor, B.L. (2015). Solar energy development and aquatic ecosystems in the Southwestern United States: Potential impacts, mitigation, and research needs. *Environmental Management*, *55*(1), 244–256. doi:10.1007/s00267-014-0384-x
H.T. Harvey & Associates. (2015, April). *Ivanpah Solar Electric Generating System avian & bat monitoring plan* (2013–2014 Annual Report). Sacramento: California Energy Commission, public docket.
Hernandez, R.R., Easter, S.B., Murphy-Mariscal, M.L., Maestre, F.T., Tavassoli, M., & Allen, E.B. (2014). Environmental impacts of utility-scale solar energy. *Renewable and Sustainable Energy Reviews*, *29*, 766–779. doi:10.1016/j.rser.2013.08.041
Hernandez, R.R., Hoffacker, M.K., & Field, C.B. (2014). Land-use efficiency of big solar. *Environmental Science & Technology*, *48*(2), 1315–1323. doi:10.1021/es4043726
Hernandez, R.R., Hoffacker, M.K., & Field, C.B. (2015). Efficient use of land to meet sustainable energy needs. *Nature Climate Change*, *5*, 353–358. doi:10.1038/nclimate2556

Hernandez, R.R., Hoffacker, M.K., Murphy-Mariscal, M.L., Wu, G.C., & Allen, M.F. (2015). Solar energy development impacts on land cover change and protected areas. *Proceedings of the National Academy of Sciences*, *112*(44), 13579–13584. doi:10.1073/pnas.1517656112

Ho, C.K., Sims, C.A., & Christian, J.M. (2015). Evaluation of glare at the Ivanpah Solar Electric Generating System. *Energy Procedia*, *69*, 1296–1305. doi:10.1016/j.egypro.2015.03.150

Horvath, G., Blaho, M., Egri, A., Kriska, G., Seres, I., & Robertson, B. (2010). Reducing the maladaptive attractiveness of solar panels to polarotactic insects. *Conservation Biology*, *24*(6), 1644–1653. doi:10.1111/j.1523-1739.2010.01518.x

Ironwood Consulting. (2012). *Biological resources technical report*(BLM case file number CACA-48669). Redlands, CA: Stateline Solar Farm Project.

Kagan, R.A., Viner, T.C., Trail, P.W., & Espinoza, E.O. (2014). *Avian mortality at solar energy facilities in Southern California: A preliminary analysis*. Ashland, Oregon: National Fish and Wildlife Forensics Laboratory.

Lipschutz, R., & Mulvaney, D. (2013). The road not taken, round II: Centralized v. distributed energy strategies and human security. In H. Dyer & M.J. Trombetta (Eds.), *International handbook of energy security* (pp. 483–506). Northampton, MA: Edward Elgar.

Lovich, J.E., & Bainbridge, D. (1999). Anthropogenic degradation of the Southern California desert ecosystem and prospects for natural recovery and restoration. *Environmental Management*, *24*(3), 309–326. doi:10.1007/s002679900235

Lovich, J.E., & Ennen, J.R. (2011). Wildlife conservation and solar energy development in the Desert Southwest, United States. *BioScience*, *61*(12), 982–992. doi:10.1525/bio.2011.61.12.8

Mason, K., & Milbourne, P. (2014). Constructing a "landscape justice" for windfarm development: The case of Nant Y Moch, Wales. *Geoforum*, *53*(C), 104–115. doi:10.1016/j.geoforum.2014.02.012

Masson, V.R., Bonhomme, M., Salagnac, J.-L., Briottet, X., & Lemonsu, A. (2014). Solar panels reduce both global warming and urban heat island. *Frontiers in Environmental Science*, *2*(24), 1–10. doi:10.3389/fenvs.2014.00014

McCrary, M.D., McKernan, R.L., Schreiber, R.W., Wagner, W.D., & Sciarrotta, T.C. (1986). Avian mortality at a solar energy power plant. *Journal of Field Ornithology*, *57*(2), 135–141.

McDonald, R.I., Fargione, J., Kiesecker, J., Miller, W.M., & Powell, J. (2009). Energy sprawl or energy efficiency: Climate policy impacts on natural habitat for the United States of America. *PLoS ONE*, *4*(8), e6802– e6811. doi:10.1371/journal.pone.0006802

Michaud, K., Carlisle, J.E., & Smith, E.R. (2008). NIMBYism vs. environmentalism in attitudes toward energy development. *Environmental Politics*, *17*(1), 20–39. doi:10.1080/09644010701811459

Miller, C.A., & Richter, J. (2014). Social planning for energy transitions. *Current Sustainable/Renewable Energy Reports*, *1*(3), 77–84. doi:10.1007/s40518-014-0010-9

Millstein, D., & Menon, S. (2011). Regional climate consequences of large-scale cool roof and photovoltaic array deployment. *Environmental Research Letters*, *6*(3), 1–9. doi:10.1088/1748-9326/6/3/034001

Moula, M.M.E., Maula, J., Hamdy, M., Fang, T., Jung, N., & Lahdelma, R. (2013). Researching social acceptability of renewable energy technologies in Finland. *International Journal of Sustainable Built Environment*, *2*(1), 89–98. doi:10.1016/j.ijsbe.2013.10.001

New York Times. (2010, January 12). *Green civil war: Projects v. preservation*.

Pasqualetti, M.J. (2001). Wind energy landscapes: Society and technology in the California desert. *Society and Natural Resources*, *14*, 689–699. doi:10.1080/08941920117490

Pasqualetti, M.J., & Butler, E. (1987). Public reaction to wind development in California. *International Journal of Aambient Energy*, *8*(2), 83–90. doi:10.1080/01430750.1987.9675521

Pasqualetti, M.J., & Haag, S. (2011). A solar economy in the American Southwest: Critical next steps. *Energy Policy*, *39*(2), 887–893. doi:10.1016/j.enpol.2010.11.013

Pearse, D, Strittholt, J, Watt, T, & Elkin, E. (2016). *A path forward: Identifying least-conflict solar PV development in California's San Joaquin Valley*. Berkeley, CA: Berkeley Law.

Pearson, D.C. (1986). The desert tortoise and energy development in southeastern California. *Herpetologica*, *42*, 58–59.

Phadke, R. (2011). Resisting and reconciling big wind: Middle landscape politics in the new American West. *Antipode*, *43*(3), 754–776. doi:10.1111/j.1467-8330.2011.00881.x

Phadke, R. (2013). Public deliberation and the geographies of wind justice. *Science as Culture*, *22*(2), 247–255. doi:10.1080/09505431.2013.786997

Ravi, S., Macknick, J., Lobell, D., Field, C., Ganesan, K., Jain, R., … Stoltenberg, B. (2016). Colocation opportunities for large solar infrastructures and agriculture in drylands. *Applied Energy*, *165*, 383–392. doi:10.1016/j.apenergy.2015.12.078

Rignall, K.E. (2016). Solar power, state power, and the politics of energy transition in pre-Saharan Morocco. *Environment and Planning A*, *48*(3), 540–557. doi:10.1177/0308518X15619176

Sahagun, L. (2012, April 24). Discovery of Indian artifacts complicates Genesis solar project. *Los Angeles Times*. Retrieved from http://articles.latimes.com/2012/apr/24/local/la-me-solar-bones-20120424

Schlesinger, W.H. (1985). The formation of caliche in soils of the Mojave Desert, California. *Geochimica Et Cosmochimica Acta*, *49*(1), 57–66. doi:10.1016/0016-7037(85)90191-7

Sinervo, B. (2014). *Prospects for Gopherus: Demographic and physiological models of climate change from 65 million years ago and the future projections under the impact of solar development*. Ontario, California: Proceedings of the Desert Tortoise Council.

Smil, V. (1984). Views: On energy and land: Switching from fossil fuels to renewable energy will change our patterns of land use. *American Scientist*, *72*(1), 15–21.

Smith, J.A., & Dwyer, J.F. (2016). Avian interactions with renewable energy infrastructure: An update. *The Condor*, *118*(2), 411–423. doi:10.1650/CONDOR-15-61.1

SolarReserve, (2011, November 11). Weed management plan for the Rice solar energy project. Retrieved from: http://www.energy.ca.gov/sitingcases/ricesolar/compliance/submittals/WMP_110711.pdf

Sorenson, P. (2014). *Public comment on Hidden Hills SEGS*. Sacramento: California Energy Commission, Docket 11-AFC-02.

Spiess, T., & de Sousa, C. (2016). Barriers to renewable energy development on brownfields. *Journal of Environmental Policy & Planning*, *18*(4), 507–534. doi:10.1080/1523908X.2016.1146986

Stark, M. (2009, January 20). Mojave Desert tortoise: Endangered species list's high roller. *Huffington Post*, A1.

Stoms, D.M., Dashiell, S.L., & Davis, F.W. (2013). Siting solar energy development to minimize biological impacts. *Renewable Energy*, *57*(C), 289–298. doi:10.1016/j.renene.2013.01.055

Thayer, R.L., & Freeman, C.M. (1987). Altamont: Public perceptions of a wind energy landscape. *Landscape and Urban Planning*, *14*, 379–398. doi:10.1016/0169-2046(87)90051-X

Todd, B.D., Halstead, B.J., Chiquoine, L.P., Peaden, J.M., Buhlmann, K.A., Tuberville, T.D., & Nafus, M.G. (2016). Habitat selection by juvenile Mojave Desert tortoises. *Journal of Wildlife Management*, *80*, 720–728. doi:10.1002/jwmg.1054

Turney, D., & Fthenakis, V. (2011). Environmental impacts from the installation and operation of large-scale solar power plants. *Renewable and Sustainable Energy Reviews*, *15*(6), 3261–3270. doi:10.1016/j.rser.2011.04.023

van der Horst, D. (2007). NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Policy*, *35*(5), 2705–2714. doi:10.1016/j.enpol.2006.12.012

Walker, G., Cass, N., Burningham, K., & Barnett, J. (2010). Renewable energy and sociotechnical change: Imagined subjectivities of "the public" and their implications. *Environment and Planning A*, *42*(4), 931–947. doi:10.1068/a41400

Walston, L.J., Jr, Rollins, K.E., LaGory, K.E., Smith, K.P., & Meyers, S.A. (2016). A preliminary assessment of avian mortality at utility-scale solar energy facilities in the United States. *Renewable Energy*, *92*(c), 405–414. doi:10.1016/j.renene.2016.02.041

Wehausen, J.D., & Epps, C.W. (2015). Protecting desert bighorn sheep migration corridors in Mojave Desert. *Inland Valley Daily Bulletin*. January 15, 2016. Retrieved from http://www.dailybulletin.com/opinion/20150112/protecting-desert-bighorn-sheep-migration-corridors-in-mojave-desert-guest-commentary

Wilken, J.A., Sondermeyer, G., Shusterman, D., McNary, J., Vugia, D.J., McDowell, A., … & Materna, B.L. (2015). Coccidioidomycosis among workers constructing solar power farms, California, USA, 2011–2014. *Emerging Infectious Diseases, Centers for Disease Control*, *21*(11), 1997–2005.

Wilson, E.O., & Lovejoy, T. (2015, September 9). A Mojave solar project in the bighorns' way. *New York Times*. Retrieved from http://www.nytimes.com/2015/09/12/opinion/a-mojave-solar-project-in-the-bighorns-way.html

Wilson, R.K. (2014). *America's public lands: From Yellowstone to Smokey bear and beyond*. New York, NY: Rowman & Littlefield.

Wolsink, M. (2000). Wind power and the NIMBY-myth: Institutional capacity and the limited significance of public support. *Renewable Energy*, *21*, 49–64. doi:10.1016/S0960-1481(99)00130-5

Wolsink, M. (2007a). Wind power implementation: The nature of public attitudes: Equity and fairness instead of "backyard motives.". *Renewable and Sustainable Energy Reviews*, *11*(6), 1188–1207. doi:10.1016/j.rser.2005.10.005

Wolsink, M. (2007b). Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. *Energy Policy*, *35*(5), 2692–2704. doi:10.1016/j.enpol.2006.12.002

Wu, G.C., Torn, M.S., & Williams, J.H. (2015). Incorporating land-use requirements and environmental constraints in low-carbon electricity planning for California. *Environmental Science and Technology*, *49*(4), 2013–2021. doi:10.1021/es502979v