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Chapter

A Multi-Disciplinary Undergraduate Pedagogical Experience Looking at Attitudes Towards Solar Development in the Mojave Desert

Jennifer Moore Bernstein, Cameron Audras, Charmaine Dalisay and Jennifer Swift

Abstract

This research project aimed to integrate geography, spatial analysis, environmental studies, and social psychology to understand conflicts over solar development in the Mojave Desert region. A second objective was to empower the participating undergraduate student researchers with a deep-learning experience using multidisciplinary tools. This project ran from 2019 to 2021 under the Undergraduate Research Associates Program (URAP) at the University of Southern California. The students conducted site suitability analysis, survey research, interviews, and field studies. Results combined spatial analysis, attitudinal surveys, mapping, and detailed accounts of the students' learning experiences. An important conclusion of this project was the discovery of a discrepancy between broad support for solar development at the state and national level, and a suspicion at the local level. The student researchers went on to present multiple conferences and receive awards, and based on this project, both decided to attend graduate school in environmental studies and sciences. Recommendations for further research include interpolation of attitudes toward solar development, conducting a demographically representative survey, and participatory mapping. This approach can serve as a pedagogical strategy for other institutions, as students are increasingly eager to address environmental problem solving from the perspective of both the natural and social sciences.

Keywords: pedagogy, field studies, interdisciplinarity, solar power, undergraduate, Mojave

1. Introduction

Bombay Beach, near the Salton Sea in southeastern California, is a unique place. It was once a popular resort town in the 1950's and 1960's, attracting the residents of Los Angeles to a beach in the middle of the desert. But the Salton Sea, it itself a human

accident, became increasingly polluted with agricultural runoff, and with the smell of the dead fish that would wash up on shore and the algal blooms, tourism decreased dramatically. The resident population of Bombay Beach aged or left. But within the last 10 years, artists and writers have begun to re-inhabit the census designated place (population 295 as of 2010), turning dilapidated trailers into gallery spaces and creating huge installations by the water. Harkening back to the town's past is the only restaurant for miles, called the "Ski Inn", though jet skis have long since skied out.

The project featured in this chapter does not focus on tourism in the Mojave Desert. Rather, it was designed to help undergraduate students understand the complexities of the attitudes of area residents towards different types of solar development in the Mojave Desert. Namely, what is the proper place for solar development? How do residents feel about it? Why is there such a strong discrepancy between attitudes towards residential and industrial scale solar? So why, on one of our field visits, did we (an undergraduate researcher and the Principle Investigator) spend half a day at Bombay Beach and the Salton Sea?

Most solar developments, in the Mojave Desert and elsewhere, begin with site suitability analysis. A number of variables – slope, aspect, parcel size, zoning- are overlaid using a Geographic Information System (GIS), and ideal locations for solar are identified. However there is a history of community opposition to solar development in the very regions it makes the most technical sense. Much of the opposition to solar installations in the Mojave, industrial and residential, comes down to government policies, corporate management, and (of particular applicability to this project), attitudes of local residents. These attitudes are not easily attributed to the pejorative concept of NIMBYism ("Not in my Backyard") or attitudes towards renewable energy itself.

The reason the Principal Investigator chose to visit Bombay Beach was to better understand the broader geographic and historical context in which any type of development takes place. While not directly related to solar development, these types of appropriation of land by corporations has a long history that is deeply rooted in the local psyche. Thus, when trying to understand attitudes towards one type of development, one must understand the region as a whole. This visit was part of a larger pedagogical approach with sought to provide students with firsthand readings of the landscape, in addition to a multi-methodological analysis of attitudes towards development, especially solar, across the Mojave desert.

Geographers interpret places not as entities in and of themselves with a fixed set of characteristics, but rather as nodes through which various flows intersect- economic, human, transportation, environmental- and shape the ongoing evolution of a place. Students are increasingly aware of and concerned about the intersection of human and environmental communities, and looking for skill sets to be able to gather multiple types of data to solve a problem. Providing students with the tools to address environmental problem solving, be they analytical, technical, or quantitative, comprises a critical aspect of contemporary environmental studies and sciences/geography pedagogy.

This project, while rooted in geography and spatial science, has very explicit connections with the field of environmental studies and sciences. The Association for Environmental Studies and Sciences (AESS; ESS) is the prominent professional higher-education field encompassing ESS, and explicitly states that "broad advances in environmental knowledge require disciplinary, interdisciplinary, and transdisciplinary approaches to research and learning". Student demand for programs at the undergraduate and graduate level is steadily increasing [1]. Though many programs in natural resource management have experienced a slight decline in the last 20+ years, this is likely due to individual departments capitalizing on the broader environmental

concerns of their student population and shifting to a less extractive framing [2]. Other programs have “rebranded” their identity and restructured their content, often using sustainability as a uniting factor across disciplines. The number of active sustainability groups on campuses has skyrocketed. Many geography departments have added “environment” to their name. This all represents an incredible opportunity for educators to facilitate students becoming effective problem solvers and suggests that more students will be seeking the tools needed to have a viable career addressing both the human and the biophysical aspects of environmental problems.

As ESS has grown, there has been a robust discussion about how to best structure, teach, and assess the programs in the name of academic rigor [3]. Multidisciplinary pedagogy, in which this project is grounded, attempts to create students equipped to wrestle with complex problems. The approach recognizes the way in which all disciplines are partial. Soulé and Press [4] received ample criticism and pushback when they suggested that the increasing interdisciplinarity and multiple perspectives of ESS programs threatened careful scholarship, leaving students with a grab bag of skill sets and broad and shallow fields of knowledge. However Soulé and Press, as Maniates and Whissel argue, make a key oversight in assuming that interdisciplinary teaching, thinking, and learning inherently creates conflict. Soulé and Press’s argument has since been largely seen as a straw man. In the years since, the field has cohered around the concepts offered by the National Council for Science (NCSE)’s report, “Interdisciplinary Environmental and Sustainability Education on the Nation’s Campuses 2012: Curriculum Design” [5]. This includes the following concepts. “(1) The ideal ESS curriculum builds on diverse forms of knowledge; (2) This diverse knowledge can be organized into major curricular models; and (3) sustainability integrates these curricular models” [6]¹. Others have demonstrated that despite these goals, syllabi are not diverse enough. In their review of undergraduate environmental studies syllabi, Kennedy and Ho [7] found three major discourse typologies, though some were over-represented while others were under-represented. They ultimately advocate that faculty consistently monitor their own blind spots and ideological prejudices, allowing students to come to their own conclusions about approaching environmental challenges.

In addition to interdisciplinarity thinking and problem solving, a key component of ESS is field work. For many reasons, including that there is a field-based component in many ESS professions, fieldwork has long been understood to be an integral component of ESS curricula [8, 9]. While part of this is content-based, much of it is affective. Students increase information retention, and also simply enjoy field trips, increasing recruitment. Fieldwork has also been associated with the principles of deep learning through experience [10]. That said, fieldwork is not without its critics. For example, within the field of geography the pedagogical benefits have been challenged. A number of factors, both logistical, and financial, have made fieldwork much more difficult for institutions of higher education to facilitate, even when they value its educational merits [11].

One of the most critical impediments beginning in 2020 has been the COVID-19 global pandemic. Social distancing, avoiding indoor spaces, remaining home as much as possible, and masking all placed huge strains on fieldwork, if not making it outright impossible. Equally challenging is the inability to effectively plan for fieldwork, given the amount of work, financial commitment, and logistics that go into the simplest of field excursions. A number of researchers have suggested ways to work through these

¹ Note that Proctor also argues that this study lacks theoretical depth and demonstrates conceptual leaps.

challenges, including contingency planning, recognizing the role of the virtual world as our contemporary “field”, and the ways to incorporate citizen science in data collection. Many of these trends existed far before the advent of COVID-19, and perhaps researchers being pushed out of their comfort zones will help develop them further [12].

These approaches—interdisciplinarity, field work, multi-methodological research tools—are housed under the larger umbrella of critical geography. Within the field of spatial science, the last 20 years have shown exponential growth in the world of “big data”, with ever more accessible tools for processing and visualizing data. While hugely beneficial for researchers and citizens (and often quite lucrative) some have argued that geography is increasingly done on a screen [13]. A researcher could come to normative conclusions and policy descriptions for a location without ever having visited, thus bypassing citizen engagement, local knowledge, and a general “sense of place”. The methods we chose for this project, including fieldwork, surveys, participatory mapping, and interviews, were intended to engage deeply with the actors involved in this issue, in an attempt to avoid a detached and mechanized view of the region.

This project ran from 2019 to 2021 under the umbrella of the Undergraduate Research Associates Program (URAP) at the University of Southern California. The URAP program is intended to expose undergraduates to research opportunities typical of graduate level research, namely “learning as inquiry”. This program is of particular interest to students pursuing graduate school, as they will be better prepared to develop research questions, conduct independent research, and draw well-reasoned conclusions. Faculty mentor small groups of students, or even one student at a time, providing them with an invaluable learning and research experience. The Primary Investigator is given a small stipend allotted to funding students, with a small portion available for supplies.

Students associated with the Spatial Sciences Institute (SSI) at USC are provided with a number of URAP projects, which faculty have already applied for and had funded. Within the Spatial Sciences Institute, students rank the projects they would most like to work on. Both years, this project was highly popular, demonstrating the demand from students for research involving environmental problem solving, multi-disciplinarity, and field-based research. One student was selected each year, though the first student (a co-author of this article) remained involved in the project during the second year of its iteration. At the completion of the project, both students went on to present at a number of academic conferences, which will be discussed later in the chapter.

2. Project background

Americans are increasingly concerned about climate change, and one of the most widely championed ways to address it is through renewable energy [14, 15]. According to pollsters, Americans are highly supportive of solar power. In a Gallup poll, solar energy was endorsed by the public more than any other alternative energy source. In the same poll, solar energy was backed by a large majority in each political party, and even more so in the West than in other regions of the country [16]. In 2016, the Renewable Energy Action Team—the California Energy Commission, California Department of Fish and Wildlife, the U.S. Bureau of Land Management, and the U.S. Fish and Wildlife Service—identified potential renewable energy development areas in Southeastern California based on multiple criteria, including quality of resources, land ownership, slope, access, transmission, and capacity for production. These criteria were mapped and used as a guide for locating future solar energy installations (See **Figure 1**).

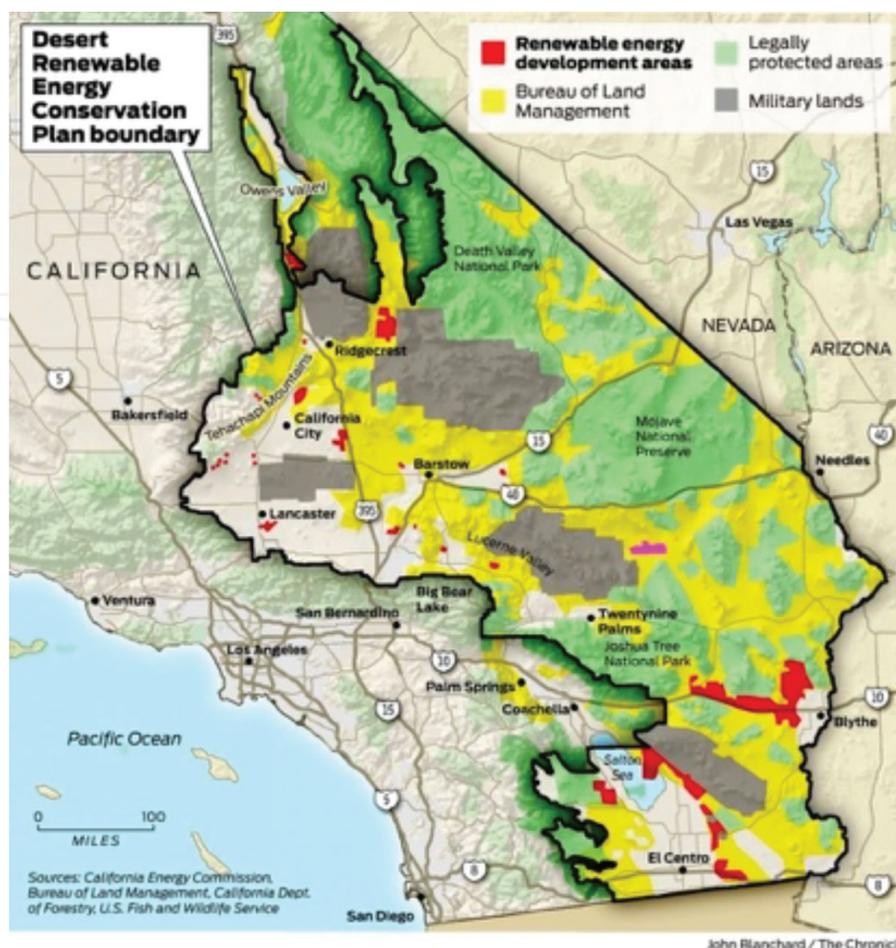


Figure 1.
DRECP boundary and land use.

The importance of eliminating fossil fuels from the global energy portfolio has been well-established. However, the local consequences of doing so deserve attention as well. Despite the Mojave being a desert region with little precipitation, it contains over two thousand species, with 15–18% more to be discovered. One species is the desert tortoise (*Gopherus agassizii*), listed as threatened under the Endangered Species Act. Desert tortoises are “ecological engineers” who create burrows in the ground that provides shelter for many other animal species, allowing them to escape the heat of the desert. They are an **umbrella species**, meaning that they provide protection for other plants and animals in their area.

At present, there are 744 industrial scale solar plants operating in California. Some of the largest are in the Southeastern desert region of the state. Some of the largest plants in southeastern California are listed below (**Table 1**).

The map in **Figure 1** includes typical variables related to site suitability analysis, and this is certainly the first step in the appropriate siting of industrial-scale solar. But it does not include a key variable- the attitudes of area residents towards alternative energy development. Even with the identification of the correct slope, aspect, parcel size, and more, oftentimes projects are hamstrung due public opposition rather than site suitability. In the Mojave, many industrial-scale solar projects have been effectively halted by the general public, with many failing to get approval (e.g., a 3 mw plant in Landers; a 20 mw plant in 29 Palms). Recently, the President’s Interior Department decided that Palen Solar would be built just south of Joshua Tree National Park. Palen would/will be a 3100 acre, 500-megawatt power plant able to deliver power to 17,000 residents in Palm

Name	Location	Type
Ivanpah	Nipton, CA	Concentrated solar thermal
Genesis	Blythe, CA	Parabolic trough (curved solar thermal collector)
McCoy	Blythe, CA	Photovoltaic
California Valley Solar Ranch	Santa Margarita, CA	Photovoltaic

Table 1.
Largest solar plants in California.

Springs, California. With this project, there is a general attitude of distrust between alternative energy developers, community residents, and government authorities. But little systematic assessment has been conducted as to the specific attitudinal variables affecting opposition to solar development.

The construction of solar installations can be problematic for local and global ecosystems, as well as workers along the commodity chains. For one, solar panels are made up of rare earth elements that are difficult to extract and find and whose extraction have major ecological consequences. Most of these elements, such as lithium and cobalt, are resourced from China. Another factor that contributes to the surface disturbance of desert land is the cooling technology used in industrial-scale solar. Water is scarce in the desert, so therefore dry and wet-cooling systems are utilized for concentration. Despite their efficiency, they use copious amounts of water per kilowatt hour. A dry cooling system has a large carbon footprint. Industrial solar sites also transform the land through the construction of roads and infrastructure, including the removal of vegetation and grading. Construction produces dust, which can alter ecological processes such as the fertility and water retention possibilities of soil. It can also damage plant species due to root exposure, burial, and abrasion to their leaves and stems. This damage can reduce production and will indirectly affect the wildlife that depend on these plants for food. When bulldozing a site, developers often clear ancient creosote. Road construction also impacts wildlife corridors, dividing animal habitats. All in all, despite the positive impact of solar development globally, often local ecosystems and communities are negatively affected in the process.

This project did not set out to demonize or valorize industrial scale solar. Rather, it took the approach that “education is not indoctrination” (Proctor 2016, personal communication), allowing students to wrestle with the pressing need to decarbonize *and* impacts of solar development on ecosystems and communities. Solar development, in all forms, is often assumed to be unequivocally good [17]. Those who advocate for solar development must be fully cognizant of its broader ramifications, and recognize the need for cleaner supply chains, workers’ rights, and incorporation of local voices in installation location decisions.

3. Project methodology

As discussed, the methodology employed in this project had two objectives. The first was to attempt to integrate geography, spatial analysis, environmental studies, and social psychology to better understand (and ideally help solve) conflicts over solar development in the Mojave desert region. The second was to empower students

with a deep-learning experience using multidisciplinary tools, and develop skills that they could carry into their academic and professional lives.

Throughout the course of the URAP, students met weekly with the Primary Investigator and other USC faculty associated with the project. Each student had a high degree of agency in developing their own goals and timelines based on their academic and professional interests. While a schedule was developed at the beginning of the academic year, the schedules were modified as the students' interests grew and developed.

3.1 Spatial analysis

Both students conducted spatial analysis to better understand the dynamics influencing solar development in the Mojave. Spatial analysis is the computation of geographic data to visualize and solve spatial questions and phenomenon. This required that students identify data sets, process and clean them, and learn how to use software to answer key research questions. For this project, both students used Esri ArcGIS. The 2019–2020 mapped the spatial overlap between biodiversity and electric substations, as well as other phenomenon. The 2020–2021 student mapped favorability towards residential and industrial-scale solar by zip code. These exercises enabled students to understand components of the broader landscape (location of alternative energy facilities, endangered/threatened species, climate, slope and aspect, etc.) as well as their connection with the attitudes of residents.

3.2 Interviews

Interviews are a means of gathering information that allows for in-depth responses to key research questions. This project recruited participants via various Mojave desert Facebook groups, including “Explorers of the Mojave Desert,” “What’s Really Happening in the Desert – Coachella Valley & Hi-Desert,” “NO Dollar General in Joshua Tree,” “Victorville, Buy Sell, Trade, Advertise,” “Twenty-nine palms buy/sell/trade/advertise,” “Coachella Valley Buy/Sell/Trade,” “29 palms/Joshua tree/Yucca Valley-Yard Sales,” “Joshua Tree’s Totally Unofficial Tourism Bureau,” “Henderson Nevada, (Buy, Sell or trade),” “What’s really going on in 29 Palms,” “Mysterious Mojave Desert and Southwest USA,” “Save Red Rock Canyon,” and “Friends of Joshua Tree.” The 2019–2020 student conducted 8 interviews with stakeholders, each of which lasted approximately 30 minutes. One interview with a key stakeholder was conducted in February 2021. While the researchers offered a face-to-face opportunity for interviews, the COVID-19 pandemic prohibited travel to the regions. Interviews were conducted via phone and videoconferencing. Question items asked about attitudes towards solar development, proximity, local impacts, and climate change, as well as basic demographics.

3.3 Survey

The researchers developed and fielded a convenience survey, distributing it via the Facebook groups mentioned above, as well as the Mojave Desert Land Trust (MLDT) listserv. While this survey was not demographically representative, it provided a quick, expedient means of gathering information on the topic. The survey replicated many of the question items deployed by Carlisle [18] on public attitudes regarding large-scale solar, especially with respect to perceptions of appropriate proximity. The survey ($n = 106$) was fielded in 2020 between the months of November and December, and again in January 2021. Respondents' demographics are described in

Demographics		
Age	19-24	3%
	25-34	8%
	35-44	14%
	45-54	14%
	55-64	33%
	65+	28%
Race/ethnicity	White/Caucasian	86%
	Hispanic/Latino	6%
	Biracial	3%
	Other/Missing	6%
Education	High school or less	5%
	Some college	28%
	Vocational/Trade school	3%
	Completed college	39%
	Masters/JD/PhD	26%
County of residence	Arizona (NV)	5%
	Inyo	2%
	Kern	16%
	Los Angeles	10%
	Nevada (NV)	5%
	Orange	3%
	Riverside	4%
	San Bernardino	49%
	Other (CA)	8%

Table 2.
Demographics of survey respondents (n = 106).

Table 2. Because the full survey data wasn't fielded until late in the second year of the project, only basic descriptive statistics and simple correlations were analyzed and visualized.

3.4 Field work

As discussed in the introduction, field work can be a profound aspect of research. It enables a sense of deep learning that is harder to access within a classroom setting, and within the fields of geography, environmental studies, and spatial science, it is especially important. Objections to the field of spatial science often involve the “view from above”, wherein analysts come to conclusions about a place without ever having spoken to people in the region, or experienced the landscape firsthand. Field research is an opportunity for active learning, where students and involved in inquiry and engaged in their learning process.

During the 2019–2020 school year, the URAP student participated in two visits to the field, both with a USC professor. The first trip, in January 2020, toured the San Geronio Pass wind farm, one of the largest wind farms in California. The second trip, conducted with the same student but a different faculty member, occurred in February 2020. This involved a number of activities intended to expose the student to the broader landscape of the Mojave, including site visits to the Salton Sea, Bombay Beach, Joshua Tree National Park, art installations, and of course, solar farms. Originally, the researchers planned to interview residents face-to-face while in the field, but temporal and geographic constraints proved prohibitive.

The COVID-19 pandemic prevented the 2020–2021 URAP student from engaging in a field-based experience. The challenges of the pandemic for fieldwork are not unrecognized, and many researchers are reassessing a landscape in which there may never be a “return to normal” [19]. Thus, researchers must not rush to return to fieldwork in potentially risky situations, but rather develop new protocols to facilitate engagement without sacrificing safety. The 2020–2021 URAP student conducted phone interviews, reached out to community members virtually, and attempted to understand the landscape through other means.

3.5 Student feedback

At the conclusion of the project, both students responded to a series of open-ended questions regarding the project. These covered skills gained, their experience with fieldwork, multi-methodological research, and the impact of the project on their academic and professional trajectories.

4. Discussion: key findings

4.1 Attitudinal research

As previously stated, the survey ($n = 106$) was a convenience sample distributed via various Facebook pages (see list in “Interviews” section). The results of this survey should be interpreted as suggestive.

The demographics of this survey are not representative of the U.S. population, but they are suggestive with respect to the demographic composition of the Mojave desert region. For one, many of the respondents skewed older than the general population. This may be due to a combination of the high population of individuals who retire to the region, as well as the tendency of retirees to have more free time and thus engage in volunteer work and as other advocacy issues. Racially, the vast majority of respondents identified as Caucasian, and notably under-represented are people of color. The sample was highly educated, with 65% being college educated or more. With respect to county of residence, San Bernardino residents comprised nearly half the sample. Given the overlap between the Mojave desert region and San Bernardino county, this is understandable.

4.1.1 Survey findings

The survey was analyzed with respect to basic descriptive statistics, as well as the degree to which there were inter-item correlations. There were a number of suggestive

correlations between question items. Supporters of solar are consistent with respect to the ways in which they would accept solar development in close proximity to their residence because of the jobs and general benefit would bring to the area. Further, there appears to be a second set of related attitudes regarding the siting of solar away from different factors deemed as valuable, such as wetlands, wildlife habitat, wildlife migration routes, and recreation areas (**Table 3**).

4.2 Mapping and spatial analysis

Both students conducted spatial analysis using a number of data sets. The 2019–2020 student used spatial analysis to develop a number of illustrative maps for a publicly available story map, including the relationship between alternative energy installations and wildlife habitat, for example (See **Figures 1** and **2**).

The 2020–2021 student used the survey data to create an index of support for solar, both residential and industrial. They went on to map the data by zip code and visualize the results via an Esri ArcGIS map. In general, the map demonstrated the way in which pro-solar attitudes are clustered in urban areas, far away from where the industrial scale installations are located (**Figure 3**).

4.3 Student feedback

Both students responded to a set of open-ended questions developed by the Primary Investigator. These questions were designed to assess the pedagogical effectiveness of the URAP project and get a sense of how the project could be modified to better fulfill student goals and objectives.

Item 1	Item 2	Correlation
Support for industrial solar	Support for solar development near residence	.81
Support for industrial solar	Benefit of large solar facilities in the area	.66
Industrial solar would be good for the area	Support for solar development near residence	.72
Employment from large scale solar would help the area	Support for solar development near residence	.77
Solar distanced from wildlife migration routes	Solar distanced from nesting sites/breeding grounds by wildlife	.88
Solar distanced from wetlands	Solar distanced from areas of cultural or historical importance	.66
Solar distanced from wildlife migration routes	Solar distanced from areas of cultural or historical importance	.68
Solar distanced from wildlife migration routes	Recreation areas	.71
Solar distanced from wetlands	Recreation areas	.75
Solar distanced from wildlife migration routes	Wetlands	.85

Table 3.
Selected correlations between survey question items.



Figure 2.
 Solar installations (green points) and highways (red) in relation to desert tortoise habitats (pink).

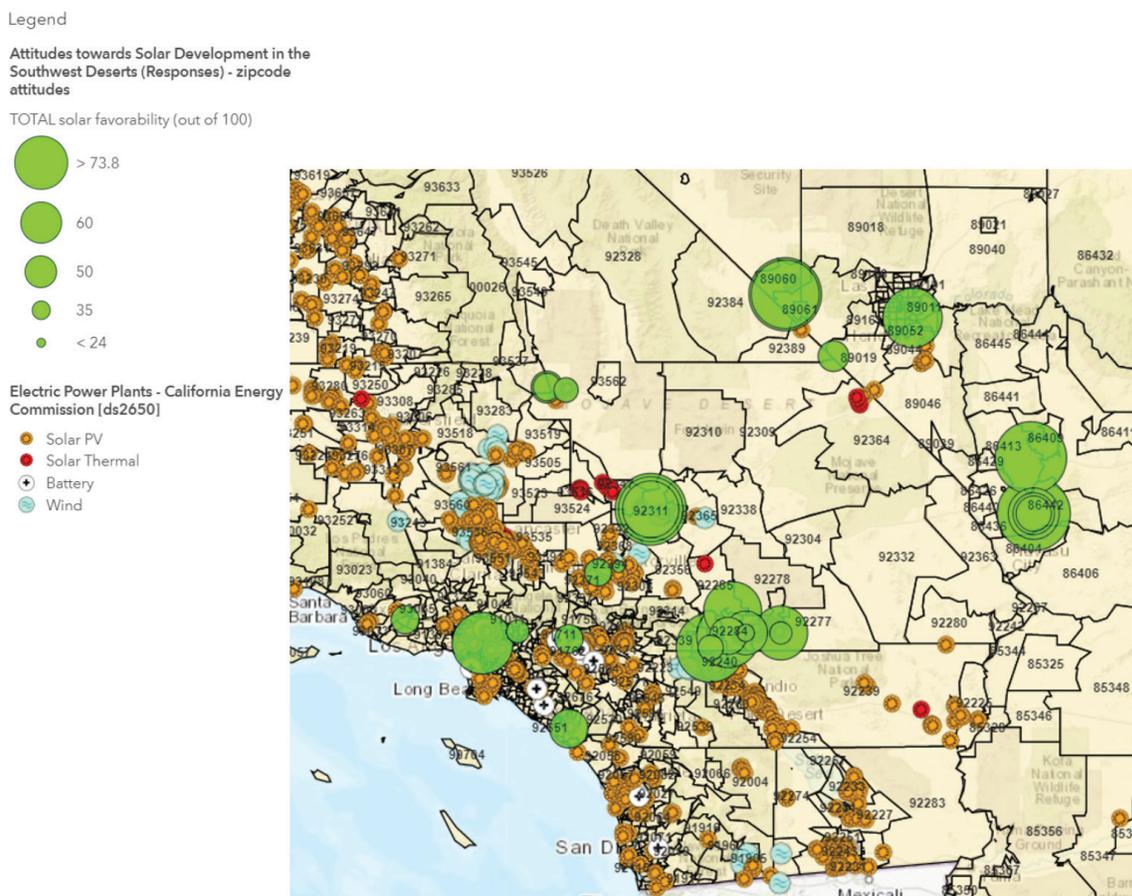


Figure 3.
 Support for solar development by zip code.

4.3.1 Skills gained

The student researchers were asked as to the skills they gained from this experience. Both students reported that they gained critical thinking skills, which facilitated their understanding of interdisciplinary thinking.

“Since we did multiple methods of gathering information (reading academic papers, visiting solar sites, interviews, and surveys), I developed my critical thinking skills to become more interdisciplinary.” – 2019–2020 URAP Student.

In the spirit of science communication, many of the technical science fields attempt to use social science methods to broaden the reach of their research and get a better understanding of their audience. But oftentimes, surveys are undertaken without an understanding of proper methodology, which has been long standardized and vetted within the social sciences. Just like in the “hard” sciences, there are ways to design data collection to be less likely to gather poor quality data. Both students were rooted in the spatial and environmental sciences, and thus were initially less well-versed in social science research methods at the start of the project. They both stated that the methodologies they gained throughout the course of the project enabled them to better understand the social sciences, including surveys and interviews. Related, one student mentioned that the skill set acquired by applying for and presenting at conferences made them better able to communicate their research findings to a broad audience.

One additional skill that was reported by a student was the ability to interact with different types of stakeholders using different forms of communication (written, verbal, etc.). This was executed during the recruitment of interview participants and participatory mapping. The practices involved developing email requests, interview scripts, and ultimately facilitating interviews. These skill are undoubtedly important within the realm of science communication.

4.3.2 Fieldwork

As previously discussed, the first year of this project (2019–2020) allowed for field visits, while the second year (2020–2021) did not due to the COVID-19 pandemic. This was not ideal, but allowed for the opportunity to explore the ways in which fieldwork has been irrevocably changed in the context of global pandemics. Other factors such as climate change will inevitably force researchers to identify ways to gather the type of data that one might in the field in other ways.

Even without a global pandemic, however, fieldwork—wherein a primary researcher and students have funding to go out into the field for months or even years on end—is becoming increasingly unrealistic. For one, Masters and PhD students are ever more non-traditional, meaning that the structure of their lives do not harbor the flexibility of many students in their late teens and early twenties. Further, funding issues, scheduling, and other logistics can make site visits a challenge. In the spirit of looking for a silver lining, the pandemic forced students and faculty to become more proficient in alternate means of exploring regions, doing what is possible to achieve the benefits of a field experience in a virtual or hybrid space. Thus, this project had to be flexible and nimble in achieving its original goals.

The student who was able to incorporate a field component felt as though they developed a new perspective on the place versus the one that had gathered through

spatial analysis alone. They felt as though visiting the region, meeting people, and seeing the landscape allowed for them to understand the local perspective, insofar as that the desert is not simply a barren wasteland on which corporations can project whatever vision they have for their bottom line. Similarly, on the field trip, this student recognized that the desert was far from an ecologically and biologically bereft region. The student wrote:

“I realized that many people actually do not understand that the desert is not barren. Prior to going to the desert, I had the same idea. Seeing the rich biodiversity of the Mojave gave me an idea for how I wanted to start my StoryMap – with the importance of desert biology and what it means to residents.” - 2019–2020 URAP student.

Without visiting an area and exploring the local ecology, especially in an arid area where flora and fauna are subtle, it may be easier for stakeholders to see the landscape as interchangeable or dispensable. This student found an increased appreciation for the biodiversity of the ecosystem, thus better understanding why residents felt so strongly about protecting the local ecology, as well as contributing to the way they saw the controversial local issues.

The 2020–2021 student was unable to incorporate a field component due to the COVID-19 pandemic. However, as previously discussed, the purely field-based model will no longer be practical in years to come, for multiple reasons. The skills gained by this student will thus facilitate their resilience in an increasingly uncertain future. They wrote about the ways in which they became more adaptable. In particular, their written and verbal communication skills became more sophisticated, as well as their use of virtual tools that became increasingly popular during the pandemic. While not fieldwork per se, they enabled the student to engage with residents in the region and made them more nimble with respect to changes in research directions.

4.3.3 Multi-methodological research

Both students believed that they could not have fully understood the topic to the extent that they eventually did without using multiple methodologies. Said a student:

“I have never used quite the range of disciplines and tools that this project has exposed me to, especially to answer a singular question. Having different lenses allowed me to exercise my visual and auditory learning skills and feel much more deeply engaged in the topic.” - 2020–2021 URAP student.

Both reported that using multiple methods enabled them to better understand the range of opinions informing the topic.

4.3.4 Impact on academic career

Both students presented their research at a number of academic conferences, including the Association of American Geographers annual meeting, the University Consortium for Geographic Science, the Association for Environmental Studies and Sciences conference, and the Los Angeles Geospatial Summit. This involved developing project abstracts tailored to a particular conference theme, identifying appropriate panels, and creating presentations designed for wide and expert audiences.

Perhaps most profoundly, both students independently reported that the project strongly influenced their decision to apply (and be admitted to) graduate school in environmental studies and sciences. Further, both students stated that their approach to environmental problem solving had become multidisciplinary, recognizing the importance of both the environmental and social sciences. This experience invigorated students to think differently about their academic and professional careers, as well as how they will approach these spaces with a methodological toolbox capable of environmental problem solving in a complex world.

5. Conclusions

This research project provided a case study wherein undergraduate students used multidisciplinary research to better understand conflicts in the Mojave Desert around solar development. Overall, there were some key conclusions drawn about the topic area generally. The driving question examined in this project was why there was a discrepancy between a broad support for massive solar development at the state and national level, and a suspicion or downright opposition at the local level. Each student in this project came to a different conclusions about this situation. One student emerged highly skeptical of industrial scale solar development, given the way in which it impacts local flora and fauna. The second student completed the project thinking about the ways in which historical development in the region influences certain attitudes. Namely, this student felt as though residents were more suspicious of corporate agency over the region than industrial scale solar itself. Each student expressed this in the outcomes from the project, including the Esri StoryMap and at conference presentations. That both students came away from the project with a different skill set and different understandings of solar development in the Mojave region means that the project achieved one of its primary pedagogical goals, which was to enable students with the data- quantitative and qualitative- to better understand the issue and come to their own conclusions.

At the end of the day, the fact that the two student researchers completed the project with multiple conference presentations and awards under their belts is telling. As previously discussed, during the process both found the desire to attend graduate school, specifically in the project's related fields of geodesign and alternative energy. This speaks to the way in which self-directed, multidisciplinary projects can light a fire in students, motivating them to pursue environmental problem solving from a unique perspective.

We hope that this study can inform other researchers. The pedagogical approaches here—active learning, deep learning, multidisciplinary/interdisciplinary research—were effective in providing students with professional opportunities in the form of conference presentations and publications, as well as direction with respect to their own life choices. Further, both students better understood the ways in which solar siting is not just an issue related to aspect, slope, and radiation. Rather, human attitudes must be understood as a critical component of decision-making. Pedagogically, both students learned how to integrate technical approaches with attitudinal research. There remains much left to be done.

6. Recommendations for further research

There is ample room for future research. One critical component that was not executed was the interpolation of attitudes across space. While interpolation of

physical factors, such as elevation, have relatively straightforward approaches, interpolating attitudes is immensely more complicated to perform correctly. Further, interpolating attitudes across space, especially in rural areas, can result in erroneous interpretations. While this project did some basic mapping, much more work in this space is critical.

Also, it would be important to conduct a demographically representative survey. In a region where county sizes differ dramatically and population density is extremely variable, this type of data collection is complex. This would require substantive funding. But there is still work that could be done with the survey data that has already been collected. For one, attitudes towards industrial solar and residential solar should be analyzed separately, given that the interview data suggested that they may be inversely correlated. Second, basic factor analysis and Cronbach alpha reliability testing could be conducted on the survey question item responses. This would suggest what attitudes track together, thus enabling stakeholders to better understand how local respondents feel towards a suite of issues, rather than individually.

Another aspect of the project which did not come to fruition was participatory mapping by elected representatives on behalf of their stakeholders. This was conceived of as a proxy for surveying residents that would be much less expensive and easier to execute. While the student researcher sent out more than 150 emails, only one response was received. The reason for this is uncertain, but the researchers identified some possibilities. For one, represented officials have multiple demands on their time. Further, while clear directions as to how to use the participatory mapping project were given, there was a registration process that may have impeded participation. Also, some representatives may simply not be informed as to the attitudes of their constituencies with respect to solar development. All of these factors should be considered when attempting to investigate further questions about attitudes towards solar development in the future.

Author details

Jennifer Moore Bernstein^{1*}, Cameron Audras², Charmaine Dalisay¹ and Jennifer Swift¹

¹ Spatial Sciences Institute, Trousdale Parkway, Los Angeles, CA, United States

² Bren School of Environmental Science and Management, University of California, Santa Barbara, CA, United States

*Address all correspondence to: janja.zupan@ffa.uni-lj.si

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