Resource-conflict analysis:

A geospatial approach to assessing energy development threats to landscapes in the Southwest

By Dan McGlothlin, Peter Budde, and Kirk Sherrill

Abstract

Responding to cumulative impacts with consistency across park and regional boundaries at landscape scales requires establishing an objective, consistent, and proactive approach to identifying adjacent or proximal areas with explicit or potential connection to NPS-administered resources. Use of available geospatial data and analytic tools to assess potential risks of proposed external land use actions represents a viable approach for dialogue among National Park Service managers, other agencies, and groups proposing land use actions. Our response to the Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States highlights the benefit of adopting this approach for addressing potential resource conflicts across broad geographic extents. This resource conflict analysis engaged multiple levels in the NPS organization and incorporated authoritative resource data. Moreover, the experience highlights the potential to respond in a consistent and timely manner, acting as an initial screening procedure.

Key words

broad-scale assessment, geospatial analysis, protection of landscapes, resource conflict analysis, solar energy, solar energy development exclusions, utility scale

ANALYZING AND MITIGATING CUMU- lative environmental, social, and economic impacts for the protection of national park resources and values is a difficult task that is made more complex when landscape-scale actions may affect multiple parks and regions. In order for the National Park Service to respond with consistency to these types of situations a bureau-wide methodology needs to be established. Use of available geospatial data and analytic tools to assess potential risks of proposed land use actions external to parks presents a viable approach for stimulating a critical dialogue among NPS resource management specialists and with groups proposing land use actions. The recent process outlined in the *Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States* (Solar PEIS) highlighted the benefit of adopting this approach to addressing potential resource conflicts across broad geographic extents (fig. 1, next page). The geospatial resource conflict analysis (RCA) approach we report here engaged multiple levels in the NPS organization and incorporated authoritative resource data sources (see sidebar "Data sources," page 25) in the assessment. Moreover, the experience highlighted the potential for the National Park Service to respond in a way that minimizes park-by-park variability in evaluation of risk and consistently reflects bureau-wide policy and program decisions.

Solar energy development in the Southwest

Efforts in the United States to reduce dependence on imported energy supplies with increased development of renewable domestic sources is a large part of an ongoing dialogue about balancing economic growth with lessened strain on the nation's natural resources. A 2006 report of the U.S. Department of Energy (DOE) projects that by 2030, the U.S. population, and correspondingly electricity demand, will increase by 70 million and 50% respectively. Much of this growth is expected to occur in the American Southwest (DOE 2006). The potential for solar energy power generation is a large part of this dialogue, because the solar power industry is ideally situated to help achieve U.S. renewable energy goals by deploying utility-scale power generation plants in this region where insolation levels are ideal for solar energy. Utility-scale solar energy plants are electricity-generating facilities and present siting challenges similar in most respects to those of traditional coal, natural gas, and nuclear thermo-electric plants. The main difference between a solar energy plant and a traditional plant is the larger overall land area required for utility-scale solar power installations (Glennon and Reeves 2010). Unlike traditional plants that often are strategically located near energy customers and transmission lines, solar energy facilities are located where conditions are most ideal to capture the sun's energy, including remote areas near national parks and monuments, and other special places administered by the National Park Service, such as

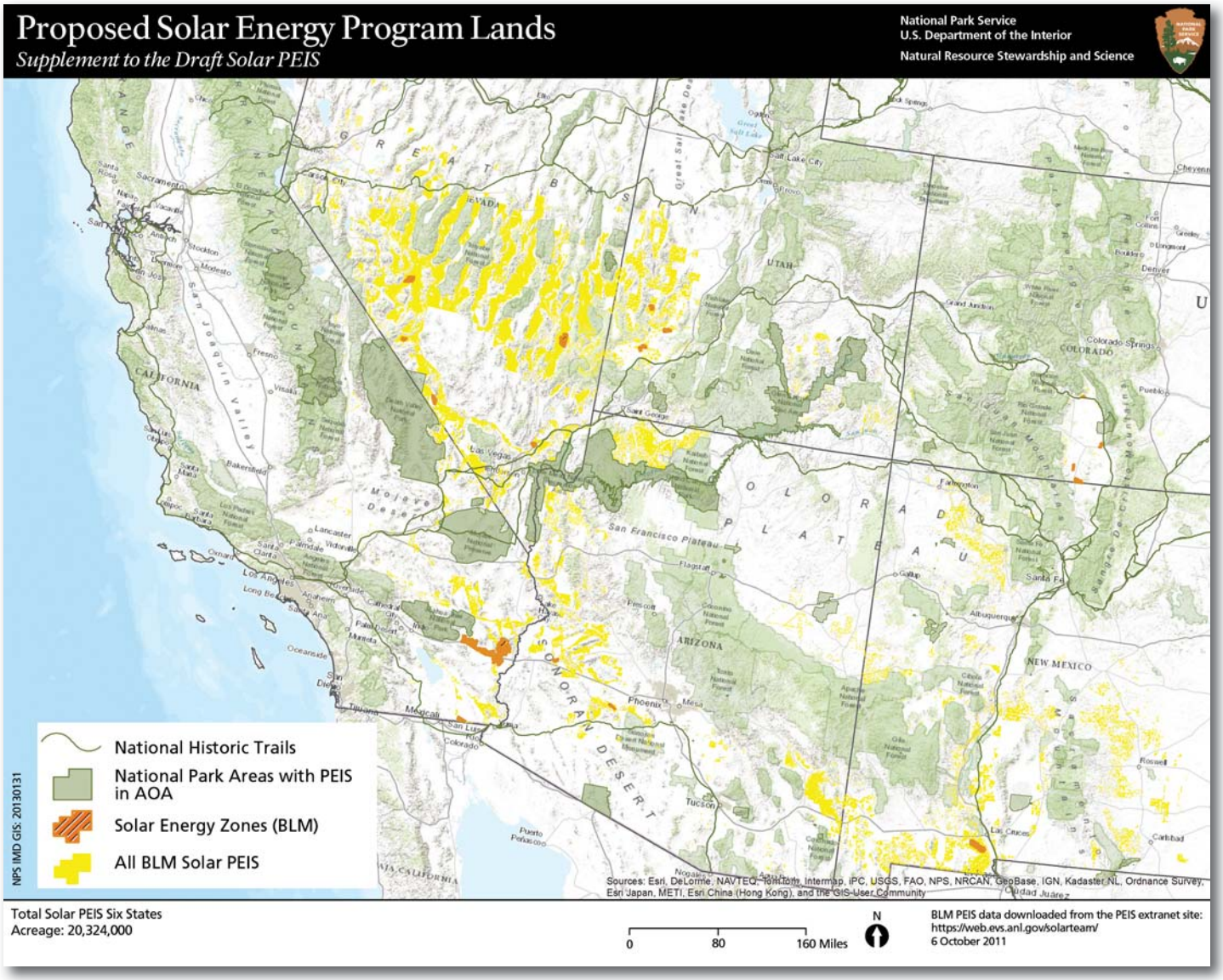

Figure 1. This map depicts lands in the Supplement to the Draft Solar PEIS preferred alternative as potentially available for utility-scale solar development.

national historic trails or national historic or natural landmarks. Thus, numerous recent utility-scale solar facilities have been proposed in locations far from urban areas on undeveloped public lands, accompanied by infrastructure upgrades such as interconnecting electric transmission lines and transportation routes. Collectively this increased development across the landscape represents considerable potential for impacts on a variety of natural, visual, and cultural resources.

Solar PEIS overview

The U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) and the U.S. Department of Energy are taking actions to facilitate utility-scale solar energy development in six southwestern states. The Solar PEIS defines utility-scale development as a facility that produces greater than 20 megawatts (MW) of electricity. One megawatt (106 watts) of electricity can provide instantaneous power to 1,000 homes. The Solar PEIS evaluates a range of potential environmental, social, and economic effects and comprehensive policies for authorizing this development on public lands. The Solar PEIS identifies BLM-administered lands that are suitable for solar energy development and DOE guidance for advancing this development in Arizona, California, Colorado, Nevada, New Mexico, and Utah and a comprehensive solar energy program responsive to various federal mandates, including state-generated Renewable Portfolio Standards for a certain percentage of a

The Solar PEIS analyzes proposed policies that establish national consistency for the implementation of application review requirements and criteria for environmentally

state's electricity capacity requirements to be supplied from renewable sources (e.g., solar, wind, geothermal, or biomass). The Solar PEIS analyzes proposed policies that establish national consistency for the implementation of application review requirements and criteria for environmentally responsible renewable energy development on public lands. The solar energy program creates (1) areas of public lands that are excluded from utility-scale development in the six-state area; (2) priority areas, called solar energy zones (SEZs), that are best suited for production of solar energy; (3) a process for considering solar facilities outside these zones; (4) facility design and mitigation requirements; and (5) amendments to BLM land use plans. The Bureau of Land Management anticipates that ongoing and future solar energy development decisions, such as land use plan amendments, may result in further refinements of the program footprint (BLM and DOE 2011).

Scale of potential development on public lands and implications

Depending on its location, a single solar facility adjacent to a national park area can produce large, irreversible impacts on park resources. To describe the full range of potential environmental impacts under the assessed alternatives, the Solar PEIS analyzes reasonably foreseeable development for the next 20 years and estimates the potential solar power production on BLM-administered lands to be 24,000 MW by the year 2030. To attain this goal, the PEIS initially identified 20.3 million acres (8.2 million ha) of public lands (called solar program lands) (fig. 1), including designated SEZs, needed to accommodate states' renewable power production goals. The reasonably foreseeable development of 24,000 MW translates to an estimated land requirement of 214,100 acres (86,670 ha), or about 1% of the land area available under the solar energy program.

The solar program lands are represented as areas possessing optimal solar development potential, with direct normal insolation values greater than or equal to 6.5 kilowatts per square meter per day (5.4 kW/sq yd), and with slopes less than or equal to 5%. Four types of utility-scale solar technologies are evaluated in the Solar PEIS: parabolic trough and power tower systems (hereafter referred to as concentrating solar power [CSP]), dish engine systems, and photovoltaic (PV) systems. These systems cumulatively consist of the solar field where solar collectors capture and convert the sun's energy to thermal energy (CSP systems) or directly into electricity (dish, PV systems). Considerable ancillary infrastructure is required, including power-block, steam-cooling, waste-management, thermal-storage facilities, connecting transmission lines, and access roads.

To illustrate the imprint a typical solar energy facility may have on land and water resources, a 250 MW CSP facility employing a power tower design requires a total plant area of about 2,250 acres (911 ha) and 4,700 acre-feet (about 6 million cubic meters) per year of operational water use (BLM and DOE 2010).[1] The facility would require the complete removal of vegetation, produce a visually impaired skyline (e.g., the Solar PEIS analyzes visual resource impacts for a power tower height of 650 feet [198 m]) seen from a great distance, and use significant amounts of water in a desert environment. It is worth noting that not all solar facilities require a high tower or consume large quantities of water.

1 The CSP technologies operate like coal, natural gas, or nuclear plants with one exception: they use the sun's heat instead of heat from coal, nuclear fuel, or natural gas to boil water and initiate the power generation cycle.

NPS involvement

Because of the significant land area and resource consumption requirements, the broad-scale development of solar energy on public lands throughout the American Southwest poses a substantial potential for cross-boundary conflict with resources administered by adjacent land management agencies, including the National Park Service. For this reason the Park Service became a cooperating agency in the preparation of the Solar PEIS to ensure that specific solar energy program policies and requirements are designed to avoid adverse direct and indirect impacts on park lands and resources. In our analysis of the Draft Solar Energy PEIS, we determined that more than 40% of the proposed solar energy program footprint is located near 53 National Park System units and six national historic trails (hereafter referred to as national park areas). The proximity of solar program lands to these special places raises concern about the potential direct and cumulative adverse effects in these areas. Because the Solar PEIS is programmatic in scope and not designed to authorize site-specific projects, the National Park Service embarked on a project to identify solar energy program lands that represent a high potential for conflict with natural, visual, and cultural resources administered by the Service. The Service's goal was to advise the Bureau of Land Management of program land adjustments that would more fully protect park-specific landscapes.

To effectively communicate park-specific alterations to the program, the National Park Service needed to develop a process to identify areas within the program footprint that pose a high potential for conflict with NPS-administered natural, visual, and cultural resources. The process needed to be capable of providing the Bureau of Land Management with a first-order approximation of those areas where additional screening must be performed

to ensure appropriate information is gathered for making future solar facility siting decisions. The desired outcome of the process was to demonstrate a resource conflict–based analysis, by which exclusion of the available program lands is needed to avoid high potential cross-boundary effects at both landscape and local scales. The objective of the process was to apply the best available science-based information from credible sources that enables a defensible description of the potential conflicts.

Generally speaking, there is minimal park-scale information about resource conditions external to areas administered by the National Park Service. Typical park-level data only cover the extent of a park's administered lands and are too detailed for landscape-level analyses, or are inconsistent from park to park. As a result, the project relied on geospatial information available at regional levels or other surrogate information to represent NPS interests or concerns. Using geographic information systems (GIS) to capture available natural, visual, and cultural resource information at the park level, we embarked on a project to develop a methodology using a park's geographic context to assess implications of solar energy development on the proposed solar program lands near parks. To establish a reasonable area of analysis (AOA), we examined resources from 0 to 25 miles (40.2 km) from each of the 53 parks' boundaries.[2] This mapping process revealed generalized resource conditions external to the parks, and allowed analyses based on park-specific knowledge to determine whether utility-scale solar development would produce a high potential for conflict with park resources and values.

2 Because more extensive data collection and analysis would have been required, the Solar PEIS did not allow for a resource conflict assessment of the six identified national historic trails.

Analysis approach and methods

We used a geospatial resource conflict analysis (RCA) in a pilot effort to develop a systematic and objective methodology for identifying solar program lands having the potential for direct and landscape-scale cumulative impacts on national park values and resources. The analysis involved two primary processes: (1) *examination of select resource conditions*, and (2) *determination of potential resource conflicts, which form a basis for recommended exclusions*.

An *analysis of resource conditions* was the initial RCA step. This involved identifying the proposed solar program lands that were adjacent to and within the NPS area of analysis, and searching for the best available landscape- to regional-scale, resource-based geospatial data for use in the RCA (see "Data sources"). Given that development of utility-scale solar energy facilities creates the potential for landscape- and local-scale resource conflicts, the RCA focused on the following cross-boundary potential effects:

- Increased loading of particulate air pollutants and reduced visibility in Class I and sensitive Class II air quality areas
- Vulnerability of sensitive cultural sites and landscapes and loss of historical interpretive value through destruction or vandalism
- Altered water quality and quantity, including the frequency and magnitude of floods, and reduced levels of groundwater
- Reduced habitat quality and integrity, and wildlife movement along migration corridors; increased isolation and mortality of key species
- Fragmentation of natural landscapes
- Diminished wilderness, scenic viewsheds, and night sky qualities on landscapes within and beyond boundaries of areas administered by the National Park Service
- Diminished cultural landscape qualities within and beyond boundaries administered by the Service

We used these potential cross-boundary effects in the next step to gather input from an interdisciplinary cross section of NPS Natural Resource Stewardship and Science (NRSS) staff for indicators of potential resource conflict. We developed a "potential resource conflict–geospatial data matrix" to identify the geospatial data-resource relationships (table 1, next page). We then identified and harvested geospatial data from readily available data sources in order to assess the potential resource conflicts within each area of analysis. One source of data was the NPScape landscape dynamics monitoring project, which provides landscape-level data, maps, analyses, and interpretations to help direct natural resource management and planning at local, regional, and national scales (Monahan et al. 2012). Another source of landscape data and analysis logic was the BLM's Mojave and Central Basin and Range Rapid Ecoregional Assessments (REAs) (BLM 2013). REAs have been initiated by the Bureau of Land Management to address climate change and other landscape-level ecological drivers, such as renewable energy development in seven large ecoregions in the western United States.

Cumulatively, the data-harvesting exercise resulted in the compilation of 12 geospatial data sets that were intended to indicate a range of potential resource conflicts (see "Data sources"). Data sets included critical habitat, landownership, landscape permeability, a naturalness index, nighttime lights, protected areas, roadless natural areas, upstream watersheds, viewsheds, wetlands, and water and wind erodibility. Data were processed into park-specific geospatial databases and map products. (Further data source information and

Table 1. Potential resource conflict analysis matrix

	Potential Resource Conflict													
Geospatial Data	**Air Quality**	**Cultural Landscape**	**Flood Potential**	**Fugitive Dust**	**Habitat Connectivity**	**Habitat Quality**	**Historic Integrity**	**Landscape Fragmentation**	**Scenic Views**	**Visitor Experience**	**Water Quality**	**Water Quantity**	**Wildlife Migration**	**Wildlife Mortality**
Critical Habitat					x	x		x					x	
Land Ownership		x			x		x	x					x	
Landscape Permeability		x			x			x					x	x
Naturalness Index		x				x		x						
Nighttime Lights						x	x		x	x				
Protected Areas					x	x	x	x						x
Roadless Natural	x	x		x	x		x	x	x				x	x
Upstream Watersheds			x								x	x		
Viewsheds		x					x		x	x				
Water Erodibility			x		x	x					x	x		
Wetlands			x			x					x	x		
Wind Erodibility	x			x	x	x								

Note: Key resource data definitions and descriptions are found at https://irma.nps.gov/App/Reference/Profile/2175854.

products are available from the NPS Data Store at https://irma.nps.gov/App/Reference/Profile/2175854.)

The *determination of potential resource conflicts and recommended exclusions* involved distributing park-specific key resource GIS data and cartographic maps to parks for review and feedback. Using local park management and resource specialist expertise and knowledge, parks were tasked with delineating areas of high potential resource conflict using the provided key resources GIS data and other local data sources (when available). The solar program lands intersecting these areas were attributed as recommended areas for exclusion from the proposed solar energy program lands.

In the final step, recommended exclusions were spatially referenced and justified with descriptive narratives. For consistency, park-recommended exclusions and justifications were compiled by Intermountain Region, Pacific West Region, and NRSS Solar PEIS team members into a single GIS database with standardized park-specific maps cross-referenced to justifying narratives. In January 2012 we submitted the maps and narratives to the Bureau of Land Management as part of the NPS response to the Supplement to the Draft Solar PEIS (BLM and DOE 2011), to assist the BLM in its final decision on the preferred alternative in the Solar PEIS. Figures 2a and 2b illustrate a compiled park map and cross-referenced geospatial attributes and justifying narratives. We also provided the geospatial data with GIS polygons representing discrete single or combinations of multiple resources reflecting a high potential for conflict.

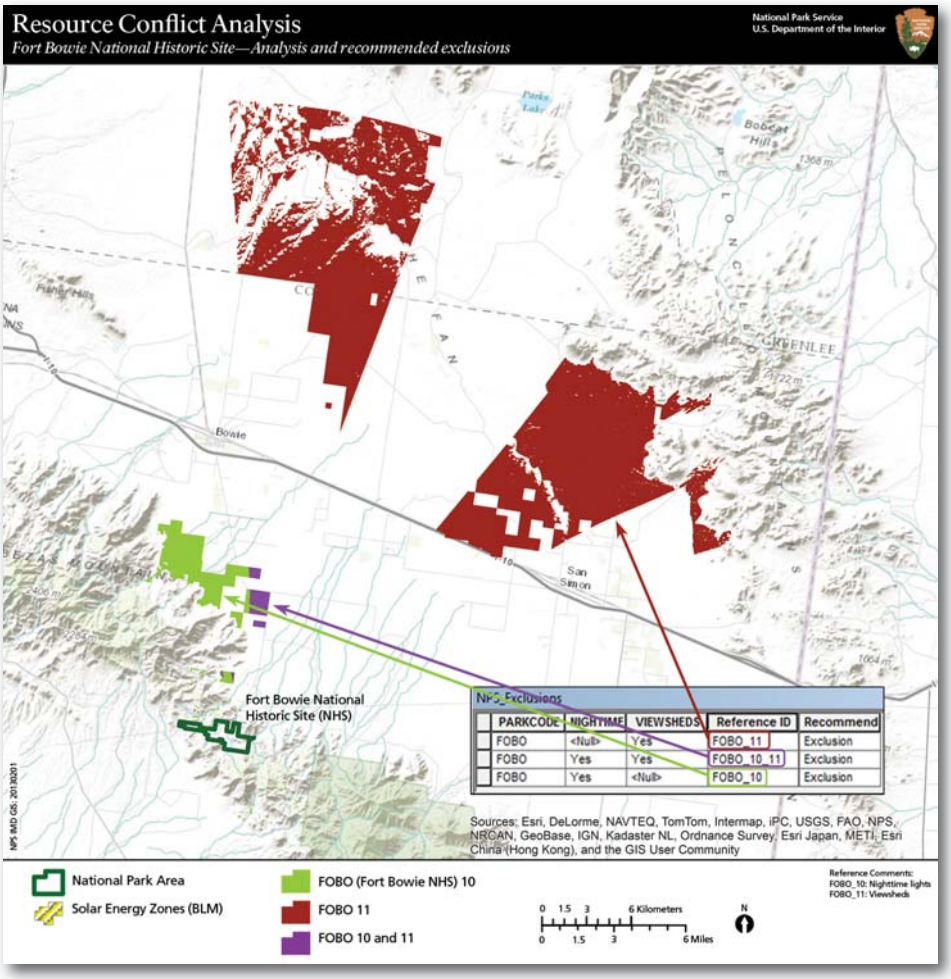

Figure 2a. This map is excerpted from the January 2012 National Park Service response to the Supplement to the Draft Solar PEIS requesting development exclusions. The map delineates GIS polygons with discrete single and combinations of overlying potential resource conflicts. The accompanying descriptive narratives in figure 2b (below) apply to the nongray-shaded areas.

Park Name: Fort Bowie NHS (FOBO)

Resource of Concern	Spatial Reference ID#	Resource Conflict Justification
Nighttime Lights	FOBO_10	All lands 10–15 miles from the park have significant night sky values for the park. Variance lands north and south of the park for 20 miles from the park are in an area of particular dark skies too. Lands farther to the northwest have night sky potential impacts for the park but lie closer in alignment with a significant light source in that direction. NPS requests areas north and south of the park be excluded, and the BLM considers the lands to the northwest of the park as acceptable to the NPS if adequate light mitigation is applied.
Viewshed	FOBO_11	Narrow cones of viewshed exist to the north-northeast from the park, intersecting variance lands proposed for solar development. These areas would be of lower priority from a viewshed sense than the lands identified below, but they still maintain their value as high-priority night sky lands. Two variance areas immediately west-northwest of the park lie within 1–4 miles of the park boundary and are within the viewshed from the park. We would expect potentially significant viewshed impacts from these lands, as the utility-scale solar development would be a unique, large, man-made structure, with possible reflectance potential visible by park visitors. We request those areas be excluded.

Figure 2b. This text is excerpted from the January 2012 NPS response to the Supplement to the Draft Solar PEIS and provides an example of a descriptive narrative for requested exclusions based on the high potential for resource conflicts near Fort Bowie National Historic Site (Arizona), as shown in figure 2a (top), with geospatial data cross-references.

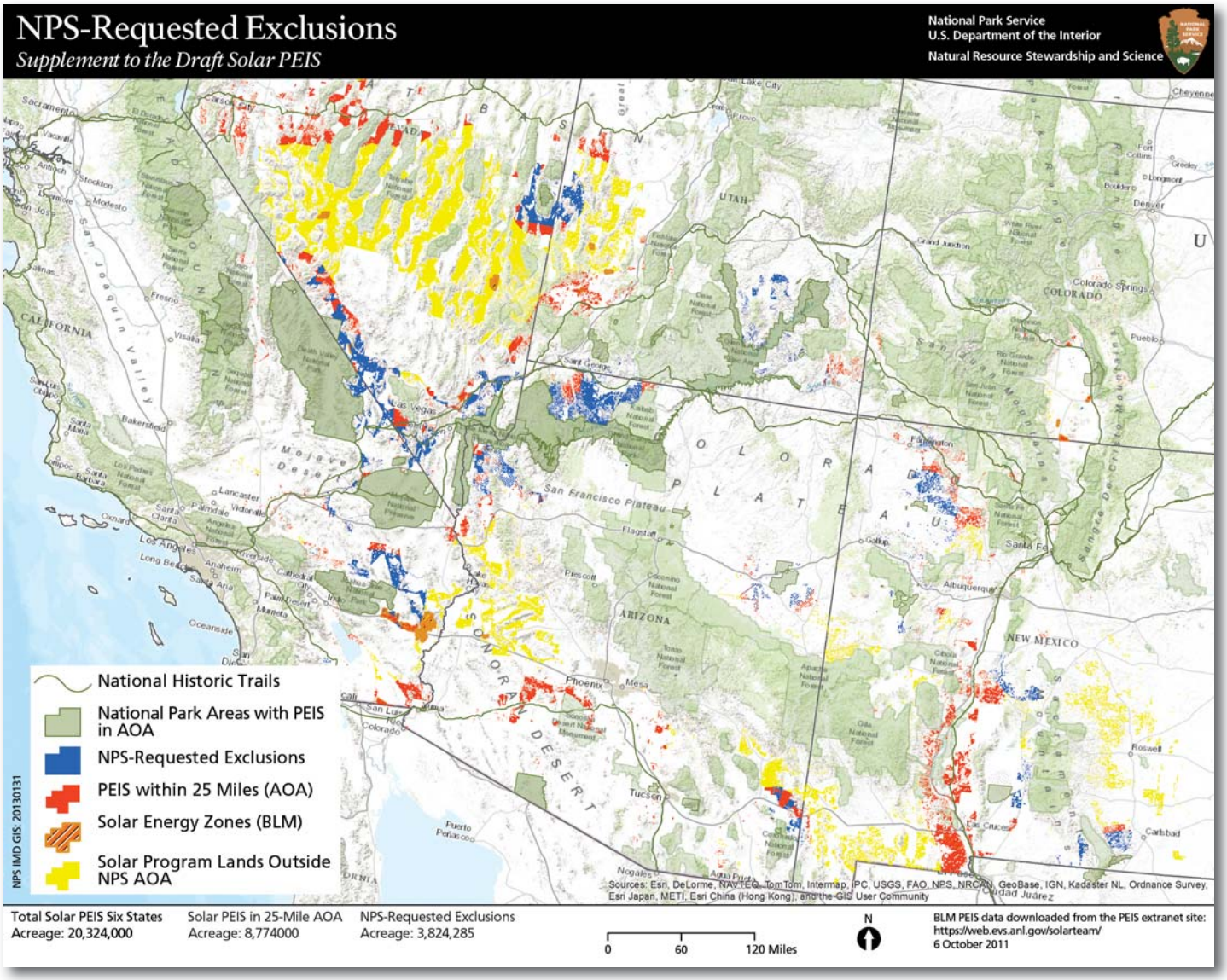

Figure 3. This map depicts the areas requested by the National Park Service in January 2012 for exclusion from the solar energy program. Areas requested for exclusion are shaded in blue; orange-shaded areas represent solar program lands within 25 miles of an NPS-administered area that were not requested for exclusion.

Results of analysis

Resource-based data from authoritative sources facilitated data use and subsequent decision(s) based upon the best available resource management information, scientific knowledge, and local understanding of resource conditions. Within the 20.3 million–acre (8.2 million ha) footprint of the proposed solar energy program the *analysis of resource conditions* process identified 5.6 million acres (2.3 million ha) (28%) of proposed solar program lands as being within the NPS-defined area of analysis.

The *determination of high potential resource conflicts* with national park resources and values resulted in a request to exclude 3.8 million acres (1.5 million ha) of proposed program lands from the Solar PEIS (fig. 3, blue areas). Acreage distributions of NPS-requested exclusions, represented as areas of high potential for resource conflicts, by GIS key resource type are shown in figure 4. Though not an indication of resource conflict priority, wind erodibility and nighttime lights GIS data sources had the most requested exclusion acreage at 2.25 and 2.02 million acres (0.91 and 0.82 million ha), respectively.

The identification of proposed solar energy program lands where utility-scale solar energy development produces a high potential for conflict with resources administered by the National Park Service was a critical step in the Bureau of Land

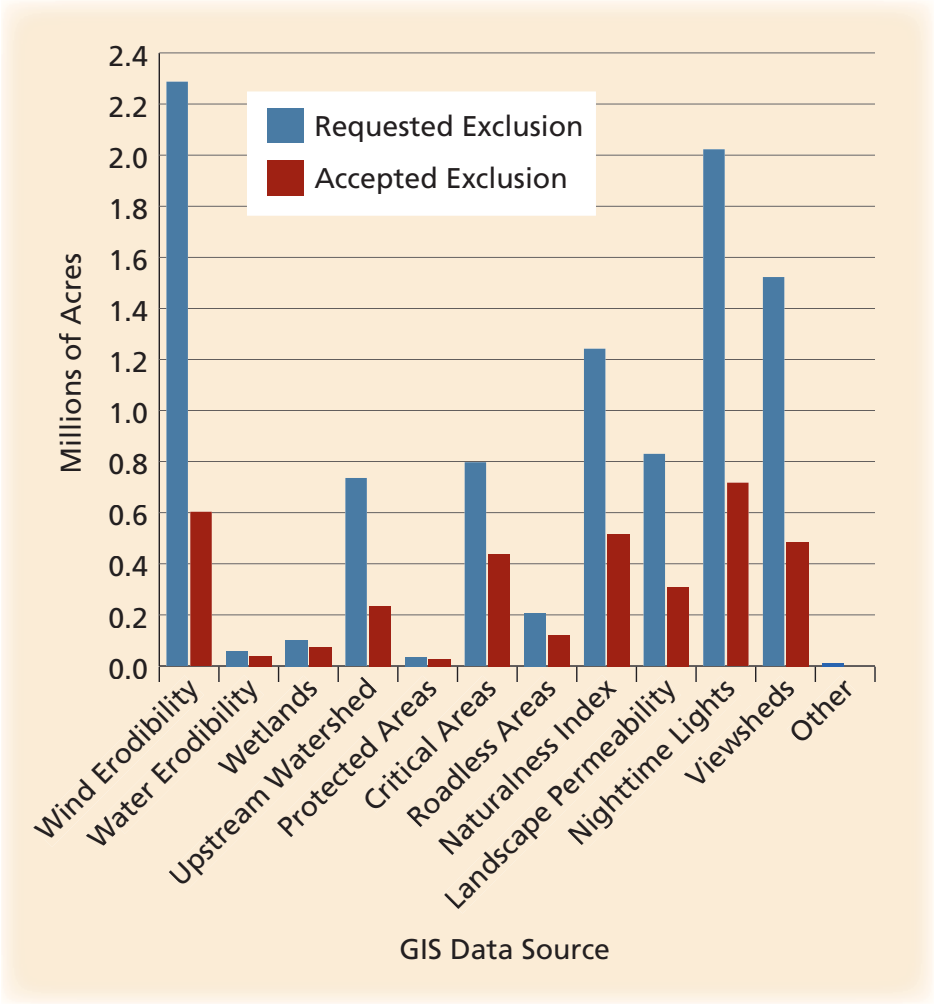

Figure 4. National Park Service–requested and BLM-accepted solar program exclusion acreage by GIS data source.

Management's final determination of the footprint for the proposed solar energy program. The BLM response to the National Park Service comments on the Supplement to the Draft Solar PEIS resulted in the exclusion of more than 800,000 acres (324,000 ha) of program lands that coincide with NPS-identified areas of high potential for conflict (fig. 5, next page, red areas). The remaining 3.02 million acres (1.22 million ha), or about 16% of the lands potentially available for solar energy development—not excluded from the solar energy program—were identified by the BLM as areas of high potential for resource conflict (fig. 5, blue areas) and carried forward to the Final Solar PEIS. These maps will be referenced by the BLM solar energy program in the screening and siting of proposed solar energy projects. Applicants for solar energy projects on lands identified as having a high potential for resource conflict will be required to demonstrate that project development can avoid or minimize resource impacts. The distribution of NPS-requested and BLM-accepted Solar PEIS exclusions by resource reveals that nighttime lights and wind erodibility GIS data sources were associated with the largest accepted exclusion acreage values (fig. 4).

Lessons learned from case study

With increasing energy development and external threats to national parks in the foreseeable future, there is need and opportunity for continued expansion and development of a systematic approach for the resource conflict analysis process to evaluate proposed external development actions. With the methodology we employed in this study, a well-reasoned and defensible resource-specific conflict analysis approach was presented and used to inform the Solar PEIS decision. However, there is ample opportunity for the development and adoption of more robust analytic tools and methodologies. The National Park Service should focus on developing and adopting qualitative thresholds (i.e., high, medium, and low resource conflicts) and quantitative methods (metrics) to refine conflict criteria and resource indicator data in order to further evolve NPS resource conflict analysis capabilities. Refinements would support a range of analysis requirements to accommodate local-scale park and project-centered to broader regional landscape-scale analyses. The goal of any refinement is to strengthen the validity of resulting end products and recommendations. Additionally, the continued compilation and development of readily available key resource geospatial data would be beneficial for subsequent RCA projects.

Lands administered by the National Park Service are established in areas throughout the country where the Park Service is authorized to protect and preserve outstanding, nationally significant natural and cultural resources. In many cases these locations, along with their attendant remote setting, high potential for neighboring development opportunities, or proximity to outstanding recreational, cultural, and scenic resources, create the increasing potential for incompatible

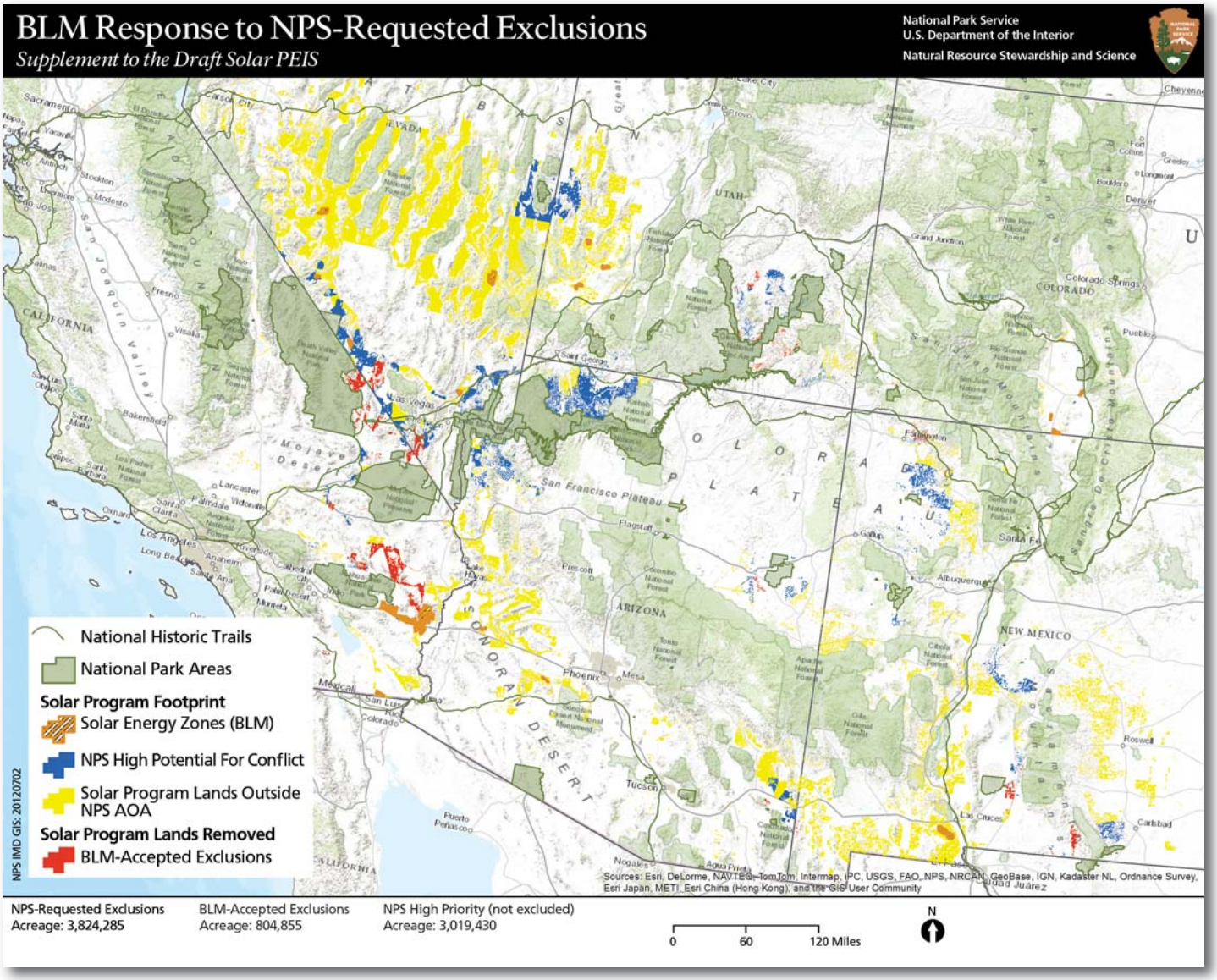

Figure 5. This map depicts the distribution of BLM-accepted exclusions from the solar energy program (orange) and high potential for conflict areas (blue) that are subject to further analysis. The accepted exclusions were carried forward into the Final Solar PEIS. (Final solar energy program acreage may vary slightly in the Final Solar PEIS.)

adjacent land use activities. The National Park Service needs to develop an objective, consistent, and proactive approach to identifying adjacent or proximal areas that have an explicit or potential connection to resources it is entrusted to maintain for future generations.

Traditionally, the National Park Service assesses the implications of adjacent land use development on a site-specific (i.e., park-by-park and project-by-project) basis. Within a park-centered geographic context, these analyses provide valuable information for assessing project development effects and responding with appropriate recommendations. As the geographic extent of land use decisions becomes increasingly broad (scale) and diverse (complex), tools for assessing landscape-level effects must be capable of examining cumulative, far-reaching impacts. As a result the National Park Service is increasingly required to perform rapid, broad-scale assessments to determine the potential consequences of development actions across numerous landscapes affecting a diverse array of resource conditions. While park-specific analyses are necessary to confirm site-level conditions, this case study highlights the need for the Park Service to adopt analytical tools and information sources that can be used to better understand and communicate potential cumulative, cross-boundary impacts on resources and values of National Park System areas.

Conclusion

Over a two-year period NPS staff at national, regional, and park levels performed an unprecedented, labor-intensive analysis of potential resource conflicts in the Southwest. The pilot RCA project explicitly assessed the benefit of incorporating this methodology in an external programmatic energy policy setting. From a tactical perspective, the results produced valuable information for the National Park Service and the Bureau of Land Management to assess policy-level implications of the BLM-proposed solar energy program. Results also confirm the strategic advantage of using geospatial-based resource conflict analysis as a policy-level decision support tool to provide first-order approximations of potential external threats to NPS-administered resources for a broad spectrum of park resources and settings. Furthermore, the applied methodology demonstrates the potential usefulness of this application in other venues, such as local or regional land use, renewable energy, and other planning activities. The method is resource- and science-based and provides a credible starting point from which more focused data and analyses can be performed as needed.

For purposes of the BLM solar energy program, the maps and data from the NPS resource conflict analysis will be used to direct the siting of solar energy development in the most appropriate places in six southwestern states. During the formulation of the Solar PEIS, the information developed by the National Park Service was applied by the Bureau of Land Management to refine the footprint of the program by removing certain high-solar-potential lands. The maps and data will also be used to further prioritize development and facilitate identification of monitoring and mitigation protocols in the proposed solar energy zones. More importantly, the maps and data will be relied upon to inform industry and the Bureau of Land Management in the pre-application review phase of the need for focused data and analyses for projects located outside the solar energy zones. Through the solar energy program's rigorous pre-application screening phase, prospective projects located outside the designated solar energy zones will be required to demonstrate that a project represents a low potential for conflict with sensitive natural, visual, and cultural resources, that is, it avoids a higher level of potential for conflict. The documentation provided by the applicant must be sufficiently detailed to allow the Bureau of Land Management and the National Park Service to confirm that a low potential for resource conflict is likely to occur and impacts on sensitive resources can be minimized through alternative project design, mitigation, or project relocation.

The National Park Service's ability to better understand consequences of potential cross-boundary effects in multiple landscapes and diverse resource conditions requires readily available tools to perform rapid, broad-scale assessments. Given the magnitude of the decisions to be made (such as those manifested through the Solar PEIS planning process), we have demonstrated our ability to identify and express a broader perspective for NPS resource protection concerns. Based purely on the experiences of the NPS response to the Solar PEIS planning process, the BLM was able to exclude more than 800,000 acres (324,000 ha) of high-resource-potential lands from future solar energy development and identify more than 3 million acres (1 million ha) where the National Park Service will be engaged in the screening of proposed solar energy projects. The precedent for future applications of an RCA approach has been established.

Literature cited

Bureau of Land Management. 2013. Rapid Ecological Assessments (REAs). Accessed 29 January 2013 at http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.html.

Bureau of Land Management (BLM) and U.S. Department of Energy (DOE). 2010. Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States. BLM/DES 10-59, DOE/EIS-0403. BLM and DOE, Washington, D.C., USA. Available at http://solareis.anl.gov/documents/dpeis/index.cfm#vol1.

_____. 2011. Supplement to the Programmatic Environmental Impact Statement in Six Southwestern States. BLM/DES 11-49, DOE/EIS-0403D-S. Available at http://solareis.anl.gov/documents/supp/Supplement_to_the_Draft_Solar_PEIS.pdf.

Glennon, R., and A. M. Reeves. 2010. Solar energy's cloudy future. Arizona Journal of Environmental Law and Policy 1(1):91–137. Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1722241.

Monahan, W. B., J. E. Gross, L. K. Svancara, and T. Philippi. 2012. A guide to interpreting NPScape data and analyses. Natural Resource Technical Report NPS/NRSS/NRTR—2012/578. National Park Service, Fort Collins, Colorado, USA.

U.S. Department of Energy (DOE). 2006. Energy Demands on Water Resources: Report to Congress on the Interdependencies of Energy and Water. U.S. Department of Energy, Washington, D.C., USA. Available at http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.

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