Initial Recommendations

of the

Desert Renewable Energy Conservation Plan (DRECP)

Independent Science Panel

Based on Review of Draft DRECP Materials

August 2012

A panel of 15 independent science advisors met June 25-27, 2012, to review draft documents prepared for the California Desert Renewable Energy Conservation Plan (DRECP) and develop recommendations for ensuring the plan's scientific defensibility. This was the second formal convening of an independent science advisory panel for DRECP. The first produced a science recommendations report (DRECP Independent Science Advisors [ISA] 2010), which provided early guidance to the plan in the form of scientific principles and detailed recommendations for conserving desert resources while developing utility-scale renewable energy projects. The second panel (ISP 2012) retained some members from 2010 and added new members.[1] One task of ISP 2012 was to review how well DRECP has followed the ISA 2010 recommendations.

ISP 2012 is deeply concerned with the scientific quality of DRECP products and processes we reviewed, a lack of adherence to recommendations from ISA 2010, and inadequate answers by plan participants to questions we raised about methods, documentation, and other plan elements. The panel unanimously concluded that *DRECP is unlikely to produce a scientifically defensible plan without making immediate and significant course corrections*, including strengthening leadership of the scientific program, increasing transparency in decision-making and documentation, improving scientific and technical foundations and analyses, and improving integration and synthesis of all analytical processes and products. ISP 2012 recommends that the DRECP add scientific expertise from outside institutions to help achieve these improvements.

[1] ISP 2012 included four members from ISA 2010 plus 11 new members. Dr. Steven Schwarzbach, USGS (Lead Advisor); Dr. Wayne Spencer, Conservation Biology Institute; Dr. Scott Abella, UNLV; Dr. James Strittholt, Conservation Biology Institute; Dr. Kristin Berry, USGS; Dr. Todd Katzner, West Virginia University; Mr. Ted Weller, US Forest Service; Dr. Lesley DeFalco, USGS; Dr. Julie Yee, USGS; Dr. David Stoms, PIER; Dr. David Bedford, USGS; Dr. Ted Beedy, Beedy Environmental Consulting; Dr. Dan Cayan, USGS and Scripps Institute; Dr. Ken Nussear, USGS; and Mr. Scott Haase, National Renewable Energy Laboratory. Collectively ISP 2012 represents substantial scientific expertise in desert ecology, conservation biology, renewable energy technology, computer mapping, ecological modeling, climate change, and related fields.

ISP 2012 identified the following major topic areas where improvements are needed[2]:

1. **APPLICATION OF SCIENCE ADVICE.** To ensure the plan's scientific defensibility, planners should strive to apply scientific information and recommendations in a more substantive way than demonstrated to date, and to clearly explain why specific recommendations of independent science advisors were not, or won't be, followed. Although a number of important ISA 2010 recommendations have been embraced (e.g., develop an interconnected reserve network, use statistical species distribution models and objective reserve-selection algorithms), the majority appear to have been handled inadequately or ignored. Simply obtaining or mapping a particular data set or discussing an issue in a Biological Baseline Report is not equivalent to *actively applying this information toward achieving plan goals*. As just a *subset of examples*[2], we found little evidence that the following foundational recommendations from ISA 2010 have been meaningfully applied:

   - Seek continual scientific input and review of data, models, maps and other analytical tools and products. We noted numerous examples where earlier, more frequent science review and advice could have prevented costly errors (see Topic 2 below and Section 3.6 of ISA 2010).
   - Make all analyses and decision-making processes as transparent and understandable as possible (see Topics 4 and 5 and pages 5-6 of ISA 2010).
   - Match the scale and resolution of each analytical task to the scale and resolution of the issues being addressed. As one example, all statistical species distribution models we reviewed used the same input resolution and modeling extent rather than adjusting them to fit the biology and distribution of each species (see Topics 6 and 7 and pages 6 and 55 of ISA 2010).
   - To the greatest degree possible, site all developments on previously disturbed land. The plan appears to be attempting this by mapping disturbed areas as one input to the process for identifying Development Focus Areas (DFA); however, ISP 2012 was not provided with DFA delineation methods, datasets, or maps, because the REAT agencies decided this was outside the scope of our review. Consequently ISP 2012 cannot determine whether and how this recommendation is actually being followed (see Topics 5 and 9 and Section 4.3 of ISA 2010).
   - Subdivide the planning area into ecologically relevant units as appropriate for various tasks. Although the Baseline Biology Report (Dudek and ICF 2012) maps ecoregions and ecological subsections, it is unclear whether these are being used in any substantive way for reserve selection and design or other purposes (see Sections 2.2 and 4.2.2 of ISA 2010).
   - Develop an adaptive management framework up front rather than as an afterthought to plan development, and begin monitoring studies and implementing adaptive management

[2] More detailed reviews, recommendations, examples, information sources, and justifications will be included in our full technical report, to be drafted by August 31, 2012.

actions immediately during planning to reduce uncertainties and to inform plan decisions (see Topic 12 and Section 6.1 of ISA 2010).

- Implement and improve on conservation actions identified by existing conservation and recovery plans. DRECP documents indicate that consultants reviewed existing plans for information relevant to covered species and communities, but they do not describe how DRECP is applying these previous plans to help achieve conservation goals (See Section 4.2.1 of ISA 2010).

2. **SCIENTIFIC EXPERTISE AND SENIOR SCIENCE LEADERSHIP.** We recommend that DRECP immediately create a process that provides ongoing, senior scientific leadership to the consultants and agencies and promotes more frequent and substantial engagement with the scientific community, perhaps in the form of a technical advisory committee to guide all scientific tasks and their integration and documentation in the plan. Ultimately the DRECP should have a clearly defined structure and process that employs feedback from monitoring and research studies to continually improve the plan and its implementation in an adaptive management framework. This was also a recommendation of the ISA 2010 report. Our review of consultant work products suggests that the scientific expertise of the consulting team is deficient in some key areas (e.g., desert ecology, ecological modeling, fire science, climate science). As a result, occasional independent science input and peer review (e.g., ISA 2010 and ISP 2012) does not appear sufficient to ensure that the plan is scientifically defensible and schedule-efficient. An ongoing technical advisory structure is needed to provide more frequent interactions between consultants and subject area experts, and *for outside experts to perform some analyses that are outside the consulting team's expertise*. The DRECP should therefore establish active, ongoing partnerships with scientists at academic institutions, science-based NGOs, USGS, or other institutions to assist with or to perform scientific tasks, and to provide advice and review on a more continuous basis. Such arrangements could have prevented a number of costly missteps we observed during our review, such as having to rerun models and recreate maps due to faulty assumptions or inappropriate data or methods. In addition, the science program or technical advisory committee should be *led by one or more scientists having solid scientific credentials and a broad understanding of scientific planning processes* to ensure that analysts fully understand the context and goals of their work, maintain quality control, clearly document data, assumptions, uncertainties, decisions, and methods, and interpret, synthesize, and apply results effectively to problem solving.

3. **ANALYTICAL FRAMEWORK AND SCIENCE COMPONENT INTEGRATION.** We recommend immediately developing and vetting a more clearly thought-through analytical framework and system-integration strategy that will explicitly guide how plan components will be synthesized into a defensible, coherent plan that can be refined over time through adaptive management. The "DRECP Conservation Strategy Roadmap" (ICF/Dudek 2012a) and associated documents we reviewed (e.g., Section 3 and Appendix B) describe numerous planning components and processes, but are unclear about how these will be integrated into a defensible plan or achieve DRECP goals. For example, ISP 2012 does not understand, from the information we were provided, how the parallel tracks of "Conservation Strategy Process" and "DFA Identification and Impact Analyses" are to be integrated into a final conservation strategy. Ad hoc inclusion of key scientific and planning components and

analyses (e.g., species models, Marxan conservation targets, DFA alternatives, climate change analyses, adaptive management framework) in the hope that they will all come together at the end is likely to produce a plan that is disjointed, simplistic, and scientifically unsound. Essential to a solid analytical framework is a set of practical decision-support tools (e.g., project siting tools, mitigation calculators, conceptual models for species management and monitoring) that can be used during planning and, perhaps more importantly, throughout plan implementation. These tools require monitoring of carefully chosen indicators to track progress and to provide a practical mechanism to include new data and understanding fundamental to making the effort truly adaptive. Failure to integrate scientific decision-making tools into a transparent, cohesive and practical analytical framework increases uncertainties, may undermine plan support by stakeholders and lead to future conflicts, and is likely to result in poor conservation performance.

4. **DOCUMENT CLARITY.** All plan documents, including all supporting technical documents and appendices, should be *clear, concise, informative, complete, and accurate*; and *each document and section should provide a clear contribution toward plan goals*. At this stage in plan development, there was no comprehensive plan document for ISP review, and it was unclear to us how the various components we reviewed are intended to fit together into an integrated plan (see Topic 3). Many of the draft documents vaguely describe planning components and processes, with no clear depiction of the strategic vision or goals they are intended to attain, how they relate to other plan components, how various goals or actions may compete with one another, or the rationale, data, methods, and uncertainties involved (see Topic 5). For example, although the Biological Baseline Report (Dudek and ICF 2012) compiles ample useful information, it provides no clear direction on how that information is to be applied as a foundation for planning, and indeed we saw little evidence that important plan components (e.g., species models, reserve selection and design, adaptive management) adequately incorporated such information. Each section of the report should state upfront goals that link back to the overarching goals and context of the plan.

   Much of the writing we reviewed in consultant work products was wordy, redundant, and confusing. A technical editor with a strong background in ecology should be employed to purge unnecessary verbiage, ensure consistency of terms, and ensure that all essential information is presented as clearly and concisely as possible. A more concise, strategic, goal-directed approach to documenting the plan will convey an impression of crisp competence, and increase confidence by readers that this plan is well conceived and constructed.

   Furthermore, maps are an extremely important communication device for the plan, and it is essential that all tell a clear and compelling story. We found many draft maps difficult to read and understand due to poorly discriminated colors, confusing overlays, confusing legends, and similar issues.

5. **TRANSPARENCY.** All key decisions in the planning process, and all scientific methods and assumptions, must be clearly documented to conventional scientific standards of transparency such that the rationale behind each decision is clear and the results of all analyses could be independently reproduced. Specifically, it is critical to document the many decision points about data, models, assumptions, parameters, expert judgment, spatial and

temporal scale, and use of peer review so that a reviewer or planner could understand what was done, how, and why and where the greatest sources of uncertainty remain. Our review of draft documents found a pervasive lack of transparency about many such key decisions from the process used to identify Covered Species to the methods used to define Development Focus Areas despite the fact that transparency was also a foundational recommendation of ISA 2010. The documents often identified data that were used without describing what efforts were made to search for the best available data, how data were processed, what QA/QC procedures were used, and specifically which sources of data were used in any given analysis. We frequently found it difficult to identify key assumptions, and even in cases where they were clearly stated, most were not justified by citing literature or an identified, credible expert. Many decisions were based on expert judgment without making it readily apparent whom the experts were, how their input was acquired and integrated, and whether they subsequently approved of the methods and results. Each of the decision points introduces uncertainty that is propagated into the plan. The risk of insufficient transparency is that stakeholders may question whether the best available science was truly used, which could lead to delays in plan approval and permitting. This outcome is possible even if the planning process met high scientific standards but was documented poorly.

6. **COVERED SPECIES AND COMMUNITIES.** ISP 2012 recommends a thorough review and revision of the Covered Species and Natural Communities list pursuant to ISA 2010 and ISP 2012 recommendations as soon as possible. Consequences of these list selections will propagate throughout all subsequent planning steps, such as species distribution modeling, reserve selection, reserve design, and design of the adaptive management and monitoring program. As Covered Species are central to the conservation strategy as well as the regulatory context of DRECP, it is essential that the criteria and process used to select them be transparent and scientifically defensible, but these were not described in documents we reviewed (see Transparency, Topic 5). Moreover, we have deep concerns about the inclusion of some species and the exclusion of others. The current list of 77 Covered Species appears to be a draft work-in-progress, although numerous significant DRECP tasks have been based on it (e.g., reserved selection and design). The current list disproportionately represents species associated with desert wetlands, riparian habitats, and agricultural areas, and omits many desert-dependent special status species (e.g., CDFG Species of Special Concern and BLM Sensitive Species). It includes some species unlikely to be significantly affected by plan actions (e.g., mountain plover, California black rail), and excludes other species of conservation concern that may be affected (e.g., McKittrick pocket mouse, badger, gray vireo, Bendire’s thrasher, Crissal thrasher). Rare and endemic invertebrates were completely ignored in determining the list, despite ISA 2010 recommendations and detailed guidance on how to consider them. We recognize that the Covered Species list will continue to evolve as the plan develops (e.g., some species could be removed if analyses show that they will not be affected) but it is prudent to keep the list of potentially Covered Species inclusive until the plan is finished to avoid having to add species and redo tasks late in the process. ISP 2012 is therefore not recommending that any particular species be dropped from the list at this time. At the very least, the rationale for not including California Species of Special Concern must be clearly documented, because the purpose of this designation is to recognize that these species require conservation actions to prevent them from being listed as Threatened or Endangered. Potential consequences of an indefensible Covered Species list are highly

significant, including inadequate reserve design, misdirected adaptive management and monitoring actions, and loss of biological diversity.

The process for designating Natural Communities was similarly not clearly described, and ISP 2012 finds the current DRECP communities far too coarse and scientifically indefensible to be useful. Vegetation types were inappropriately lumped into very broad "communities" that encompass extreme variations in vegetation structure and composition, climate and soil conditions, supported wildlife species, and ecological processes. For example, combining all chaparral, coastal scrub, and desert scrub types (each of which encompasses a wide diversity of macrogroups, groups, alliances, and associations) into a single "scrub and chaparral" community is ecologically meaningless and analytically useless especially since this "community" covers a majority (55%) of the plan area. Chaparral differs from desert scrub communities in highly significant ways for purposes of reserve design, species coverage, and land management. Chaparral vegetation has, for example, been *strongly shaped by fire* as an ecological process, with natural fire-return intervals generally on the order of 30 to 100 years by extensive crown fires that naturally consume nearly all above-ground biomass ("stand-replacing fires"). So long as the fire-return intervals are not too short, chaparral recovers readily following such fires from root sprouts and seed banks (Keeley et al. 2011). In contrast, desert scrub communities evolved with the *near total absence of fire*, and have historically been characterized by small, patchy ground fires until the recent invasion of *Bromus* species that provide fuel continuity. Many desert shrubs have little capacity to recover from high-severity burns. The lumped-together "Chaparral and Scrub Community" is thus so simplistic as to be useless for reserve planning, representation analysis, adaptive management, or other purposes and similar comments can be made on most other Natural Communities as currently defined in draft DRECP documents.

7. **SCIENTIFIC FOUNDATIONS, DATASETS, AND ANALYSES**. ISP 2012 is concerned about apparent lack of knowledge about California's desert regions in some of the documents we reviewed and insufficient incorporation and treatment of important datasets in many analyses as a result. In addition to concerns about the Covered Species and Natural Communities lists (Topic 6), ISP 2012 found significant deficiencies in, for example, the treatment of special features, gradients, and ecological processes (such as fire) in plan documents. It also appeared that some available datasets were not included in plan analyses (e.g., some protected areas and species locality data). Such issues undermine confidence in the scientific foundations and analyses of the plan and, unless corrected, may result in an unsound reserve design and misdirected conservation, management, and monitoring actions.

   Accurate, fine-resolution vegetation base maps are essential for plan development and refinement (ISA 2010) and we are aware that vegetation mapping at a finer resolution is ongoing, with intent to incorporate it into future analyses. However, we are deeply concerned with the current use of the very coarse Macrogroup and Group data in models, reserve design, and analyses. For example, the Group "Lower bajada and fan Mojavean-Sonoran desert scrub" represents a huge area (38% of the plan area) without distinguishing significant ecoregional differences in vegetation assemblages among Mojave, Sonoran and Colorado Deserts.

   It is unclear to ISP 2012 how much due diligence was used in reviewing all available datasets and assembling the most useful and reliable data into the DRECP database. Some important protected areas do not appear to be represented in maps and models we reviewed, such as the Desert Tortoise Research Natural Area. Moreover, designating "rural lands" based on acreage and road criteria ignores private lands already purchased for conservation. Collectively, such oversights risk undermining the reserve design process by providing insufficient protection to communities structured by unique functional processes.

8. **SPECIES DISTRIBUTION MODELS.** ISA 2010 recommended careful application of species distribution models (SDM), provided detailed guidance for using both statistical and "expert-based" models, and urged DRECP to tap expertise from appropriate institutions to assist with model development because "learning-while-doing is inefficient and error-ridden." While ISP 2012 was pleased to see some attempts to follow these recommendations such as identifying species having suitable data for statistical (e.g., Maxent) models we noted serious flaws in modeling procedures, including deficiencies in input data selection, QA/QC, and processing, inattention to scale and resolution issues, inappropriate "one-size-fits-all" model extents, and lack of appropriate uncertainty metrics and optimization methods (e.g., unconventional use of "Jenks Natural Breaks" to define suitability thresholds; see Liu et al. 2005). As a result, the species models we reviewed likely over-predict habitat suitability and species distribution for most species while providing a false sense of confidence in the results. This has potentially serious consequences for reserve design, because modeled species distributions are a key input to the reserve-selection and design process. Due to inappropriate methods, the Maxent models provide inflated metrics of model fit to the data (e.g., AUC values) and no metrics of model uncertainty (Lobo et al. 2008, Phillips et al. 2006, Raes and Steege 2007, Warren and Seifert 2011).

   ISP 2012 questions whether proper QA/QC methods were used in compiling and treating species locality data. There appeared to be inconsistencies between localities included on maps provided with species accounts and those used for SDMs, and some localities used for SDMs represent historic sightings in areas that are now developed and therefore inappropriate for this use (e.g., Mohave ground squirrel, Barstow woolly sunflower, coast horned lizard). There was also no documentation of whether coarse-resolution or inaccurate locality points were filtered out before modeling. Data resolution should be finer than model resolution.

   ISA 2010 also recommended carefully identifying the environmental factors most likely to affect each species' distribution and how these factors interact, and deriving meaningful variables from available data (e.g., using an insolation index based on slope, aspect, and elevation; Dubayah and Rich 1995). Instead, a single set of environmental predictors appears to have been used for all species, with no clear ties to their specific ecological needs. This "kitchen sink" approach is vulnerable to model over-fitting, inflated statistical confidence, and decreased utility for projecting future distributions under climate change. SDM modeling should start with key habitat constituents for each species (Guissan and Thuiller 2005) and use iterative modeling to identify and remove environmental variables that contribute little to the model's predictive power. Maxent has excellent analytical tools to assist with such decisions, and Akaike Information Criterion (AIC) methods can be implemented to aid in model optimization (Warren and Seifert 2011).

   ISA 2010 also recommended matching the scale and resolution of the environmental variables to the biology of each species. Input variables (e.g., land cover or road density) are often averaged at a resolution appropriate to habitat selection for each species, for example averaging over a circular moving-window based on home range size or seed dispersal distance (e.g., Spencer et al. 2011). The model extent (the geographic area covered by a model) should also be set individually for each species to maximize discrimination between selected versus unselected areas; for example, by limiting it to the union of all ecological sections or subsections occupied by the species. However, it appears that all the Maxent models we reviewed used the same input resolution (the raw resolution of available variables?) and modeling extent (using the DRECP boundary) regardless of species biology. These decisions contribute to grossly inflated estimates of model accuracy and reduced discrimination. For example, for species like arroyo toad, whose range is mostly outside of DRECP, using the DRECP boundary as the modeling extent provides a false depiction of model certainty (AUC = 0.999 despite only 23 training points) but with poor discrimination of their actual distribution in the plan area.

Expert models were used for species having insufficient locality data for Maxent modeling. The assumptions behind these models are more difficult to understand, and transparency is essential. From the draft documents it is difficult to connect the habitat needs from species accounts to the variables used in models (e.g., how were SSURGO or NRCS soil classes translated into habitat variables for sand-dwelling species?). Also, it did not appear that climate variables were used in the expert-based SDMs, which is important if they are to be used to forecast future distributions under climate change. Variables that confound with climate (e.g. elevation, slope, and aspect) should be excluded from climate-based predictive models as they will obscure the influence of climate change.

We recommend having all models redone by entities having appropriate modeling and biological expertise. If available, existing published models could also be used.

9. **RESERVE SELECTION AND DESIGN.** ISA 2010 recommended identifying (1) areas important to conservation and (2) areas *not* important to conservation, where developments could be preferentially sited. The DRECP *appears* to be following these recommendations via the two separate paths of reserve design and DFA delineation, but it is not clear to ISP 2012 how these two paths are to be integrated into a final conservation design (see Topic 3). We were asked to review methods being used for reserve design, but we were not provided with, nor asked to comment on, the methods, data, or results of the process for delineating DFA alternatives.

The consultants have followed ISA 2010 recommendations to apply objective site-selection algorithms and modify the outputs using well-established reserve-design principles. They appropriately used Marxan with Zones and developed a rational set of scenarios with incremental changes in assumptions. However, the documents we reviewed do not adequately describe the methods, assumptions, and key decision points such that they could be replicated. For example, assumptions for estimating zone-specific conservation and energy values and costs were unstated, and no interpretation of the scenario analyses was provided to illustrate the impact of each additional constraint. The reserve selection and design steps will need to be repeated using revised species distribution models and other adjustments, and should be done in collaboration with experienced conservation planners.

The ISP also recommends a more careful review and integration of additional datasets on protected lands, because we noted some important protected lands that appeared to be missing from those considered, such as the Desert Tortoise Research Natural Area. Finally, we note that reserve selection and design are strongly driven by Covered Species concerns, which may not adequately account for broader goals of biodiversity conservation. ISA 2010 recommended identifying Planning Species, for which permit coverage is not required but that may be useful for achieving other plan goals, such as reserve design and adaptive management. This recommendation has not been followed to date, and ISP 2012 recommends reconsidering whether adding some Planning Species may be useful. For example, including additional desert-dependent species along with Covered Species in the reserve-design modeling process may help accomplish a more balanced plan-wide reserve system. Cameron et al. (2012) used 521 plant and animal taxa and 44 vegetation communities and Marxan with Zones to identify 740,000 ha of land in the Mojave that could be suitable for meeting renewable energy project requirements and that were of low conservation value.

10. **INTERACTING STRESSORS AND FUTURE CONDITIONS**. The ISP recommends that the reserve-design process more explicitly consider interactions between various processes that affect desert ecosystems and species, and how they are likely to change in the future. This is more than just addressing how the climate is changing, because numerous other processes (e.g., fire, invasive species, hydrogeology) already interact to affect desert ecosystems, and this interacting set of processes will change along with climate, development, and other factors. Thus, although climate change is clearly a stressor that must be addressed, it cannot be treated in isolation of the following other factors:

    Fire Increasing fire frequency, coupled with invasive plants that increase fire risks, is a strong stressor on desert communities, and how fire will affect the location, quality, and management of reserves needs to be addressed. Spatial models of fire susceptibility and fire history (see maps by Randy McKinley of USGS EROS data center) should be considered during reserve design to assess current and future habitat condition related to fire. Fire management should be a key focus of the adaptive management plan

    Invasive Species Invasive species, particularly annual grasses, have the ability to change desert fire regimes, compete for limited resources, and alter ecosystem dynamics. Subsidized predators, such as ravens, cats, dogs, and coyotes (ISA 2010) that increase due to human changes to the environment also pose a continuing threat to desert tortoise and other species (Esque et al. 2010). Reserve design and adaptive management techniques are needed to minimize invasives, pests, disease, and human-commensal species that may harm native resources in and near reserves.

    Surface Hydrology Surface flows in perennial and ephemeral stream channels have a significant impact on water availability and are likely to change with the climate. Consideration of various soils, their distribution in reserve design, and their ecohydrologic function under future climate should also be considered.

    Urbanization/Suburbanization Urbanization and suburbanization can impair ecosystems through a variety of processes, including surface disturbances, invasive species, and predator subsidies. Projections of urban/suburban growth should be considered in reserve design to better predict how cumulative effects of urban growth may affect reserves and potential management requirements to maintain the reserves.

Dust Dust generation from existing surface disturbances as well as future Covered Actions needs to be addressed for impacts on energy generation efficiency, local ecosystems, human health, and far-ranging impacts (e.g., Rocky Mountain snowpack effects).

11. **CLIMATE CHANGE.** The DRECP should thoughtfully and thoroughly address how climate change will alter the desert environment and account for this as fully as possible in designing the reserve and adaptive management plan. It appears that reserve selection and design and DFA alternatives are based on current conditions, and it is unclear how and to what degree future climate-change effects will be integrated into the process.

    The partial draft of a proposed climate-change vulnerability assessment for Covered Species and Natural Communities we reviewed (ICF/Dudek 2012b) needs improvements. Uncertainties concerning future climate change effects were unevenly evaluated. As yet climate change effects have not yet been modeled at an appropriate regional scale for the DRECP area, which the ISP recommends be done using a consistent climate-change ensemble approach to better deal with uncertainties, and based on the most recent available IPCC Assessments (the 4^{th}, completed in 2007, or the 5^{th}, due in 2014). Temporally dynamic ensemble models should be used to address temporal variability and trajectories at appropriate scales. The analysis extent should extend beyond the DRECP boundary to account for surrounding areas likely vital to species' range shifts, connectivity, and refugia. The species vulnerability analysis should be redone in more detail than the present matrix form, with a more comprehensive consideration of climate-change effects, and with input by an expert panel of desert ecologists to assist with defining the assumptions and methods to be used in evaluating sensitivity and exposure to climate effects. The vulnerability "screening" process used by ICF/Dudek (2012b), while a valid concept, is flawed by unjustified and simplistic assumptions, such as the assumption that wetland species are necessarily more vulnerable than non-wetland species. Also, ecological dependencies were not properly taken into account. For example, golden eagle was assumed to be tolerant of predicted climate changes; however, vegetation changes due to climate change may decrease the availability of eagle prey species and hence eagles.

    Scenarios of climate change should be consistently applied and evaluated across the different plan elements (species mortality, invasive species, wildfire, etc.), and the associated uncertainty should be quantified. Key considerations also include the scale and velocity of predicted changes (trends) as well as *variability* in climate conditions (e.g., severity and length of droughts and other extreme events). This can only be achieved by producing and analyzing time series data that are summarized monthly, because multi-year averages will not expose these types of events. To the extent possible, climatic thresholds that delineate critical ecosystem and species responses should be identified and evaluated as the climate varies over time. Climate monitoring should be integrated into the monitoring and adaptive management plan with a clearly defined process for evaluating climate change impacts on ecosystems and species, updating vulnerability assessments, and refining management actions as conditions change and new issues emerge.

12. **ADAPTIVE MANAGEMENT AND MONITORING**. Consistent with ISA 2010 recommendations, ISP 2012 considers a *well-designed adaptive management plan to be the most critical element of a successful DRECP*. ISA 2010 strongly recommended developing

key aspects of the Adaptive Management and Monitoring Program at the beginning of plan development, and initiating some monitoring actions early, rather than waiting until the conservation plan is drafted. Unfortunately, this recommendation has not been followed, the critical adaptive management framework is only partially drafted, and opportunities to collect and learn from monitoring data have been missed.

Desert ecosystems are less well studied than other biomes, which elevates uncertainties and the importance of adaptive management. For example between 2000 and 2011 most scientific publications in ecology focused on forest biomes (67%) as compared with desert systems (9%) (Durant et al., 2012). Due to huge uncertainties about the effects of development and management actions in the deserts, ISA 2010 recommended treating the DRECP as a large land management "experiment" where we can learn how to implement renewable energy projects to minimize environmental impacts and to improve management of desert landscapes in the face of fire, climate change, invasive species, and other stressors (see Topic 10). Section 6 of ISA 2010 provided a comprehensive summary of complementary information-gathering approaches that can aid adaptive management, ranging from before/after-control/impact (BACI) monitoring designs for energy projects and management actions, to targeted hypothesis-driven research to address key knowledge gaps. This information-gathering remains essential to effective implementation of DRECP, and an implementable plan is needed for how to accomplish effective information gathering, analysis, and decision-making. The BACI approach especially requires sampling simultaneously in the control and impact areas, for a period sufficient to establish regional baselines, and prior to any project impacts or management treatments. The importance of obtaining pre-construction data cannot be overemphasized. This underscores the *urgency of initiating monitoring as soon as possible*, especially in those areas being considered for development and in appropriately matched control areas.

In addition to Section 6 of ISA 2010, three other key resources on adaptive management should be consulted: Department of Interior's Adaptive Management Technical Guide and Applications Guide (both available at http://www.doi.gov/initiatives/AdaptiveManagement/documents.html), and Atkinson et al (2004). The DOI Technical Guide suggests that an adaptive management plan have three kinds of monitoring: (1) compliance or implementation monitoring, (2) effectiveness monitoring, and (3) targeted studies. The DRECP Adaptive management plan should identify management uncertainties affecting the achievement of specific conservation goals and objectives, develop simple conceptual models with testable hypotheses, design targeted monitoring to inform the uncertainties and test the hypotheses of the conceptual models, measure progress in achieving objectives, set up a process and institutional structure to adjust management actions, and finally conduct all of these activities within the legal framework of the permitting process for alternative energy development.

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