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> DOCKET
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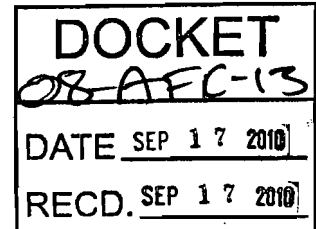
California Energy Commission
Attn: Docket Office, 08-AFC-13
1516 Ninth Street
Sacramento, CA 95814

Re: Calico Solar; Docket No. 08-AFC-13

Dear Docket Clerk:

Please process the enclosed CURE EXHIBITS 461- 465 , Revised Sequential Exhibit List and Revised Topic Exhibit List, conform the copy of the enclosed CURE Exhibits, and return the copy in the envelope provided.

Thank you.

Sincerely,

Loulena A. Miles

LAM:dw
Enclosures

2309-110b

STATE OF CALIFORNIA

California Energy Commission

In the Matter of:

The Application for Certification for the
CALICO SOLAR PROJECT
(Formerly SES Solar One)

Docket No. 08-AFC-13

CALIFORNIA UNIONS FOR RELIABLE ENERGY
4th REVISED SEQUENTIAL EXHIBIT LIST
FOR THE CALICO SOLAR PROJECT

September 17, 2010

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2309-111d

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STATE OF CALIFORNIA
California Energy Commission

In the Matter of:

The Application for Certification
for the **CALICO SOLAR PROJECT**

Docket No. 08-AFC-13

**ADDITIONAL REBUTTAL TESTIMONY OF SCOTT CASHEN
ON BEHALF OF CALIFORNIA UNIONS FOR RELIABLE ENERGY
ON THE APPLICANT'S PROPOSED SCENARIOS 5.5 AND 6
FOR THE CALICO SOLAR PROJECT**

September 17, 2010

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I.   Introduction

On September 3, 2010, the Committee notified the Applicant that it could not approve the Calico Solar Project as proposed, due to, among other things, the scope and scale of high quality habitat affecting desert tortoises and bighorn sheep that would be lost in order to construct and operate the project. However, the Committee expressed a willingness to consider further evidence on project proposals with reduced footprints that exclude the highest quality tortoise habitat. The Applicant subsequently submitted six reduced footprint alternatives, two of which have been looked at more closely, termed Scenario 5.5 and Scenario 6. This testimony identifies the impacts the Applicant's two proposed Project alternatives would have on biological resources.

The Applicant's two new footprints still eliminate thousands of acres of habitat occupied by desert tortoises, burrowing owl, golden eagles, kit fox, badger, Mojave fringe-toed lizards, bighorn sheep, white-margined beardtongue, and numerous other sensitive biological resources. Whereas new configurations would reduce the Project's direct impacts on *some* sensitive species and their habitat, they would not alleviate the adverse landscape-level impacts that a large development project would have on the functions of an intact ecosystem. The sensitive biological resources that occur in the proposed Project area are dependent on these ecosystem functions, many of which would be lost or dramatically altered if a Project is approved at this site. **Therefore, if the Committee hopes to promote the long-term conservation and recovery of the desert tortoise, bighorn sheep, and other sensitive biological resources in the Project region, it must think beyond the static numbers presented in the Applicant's most recent proposal, and instead acknowledge the ecological consequences of a massive (4,613 acres under Scenario 5.5 and 4,244 acres under Scenario 6) development project in a relatively undisturbed essential connectivity area.** Even the reduced footprints presented would cause unacceptable ecological consequences that simply render the site an inappropriate location for large-scale renewable energy development.

II.   The Reduced Footprint Alternatives are Inconsistent with Long-Term Conservation and the Recommendations from the Independent Science Advisors for the California Desert Renewable Energy Conservation Plan

On August 15, 2010, an independent group of science advisors released recommendations on the California Desert Renewable Energy Conservation Plan (DRECP). The DRECP will serve as a California Natural Community Conservation Plan under the California Endangered Species Act.   The Applicant's proposed Project alternatives conflict with many of those recommendations. For example:

> "[w]e also understand that time is of the essence, and that fully complying with all of our recommendations prior to plan completion could cause significant delays. *This should not be used as an excuse to either ignore recommendations or to delay the plan to implement all recommendations…We therefore strongly advocate using "no regrets" strategies in the near term—such as* <u>*siting developments only in already disturbed areas*</u>[1]—*as more refined analyses become available to guide more difficult decisions.*"[2]

The proposal to develop the Project on relatively pristine land is unquestionably in conflict with this overarching recommendation. It is also contrary to the actions needed to conserve the desert tortoise and

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[1] Defined in the report as "areas where grading, grubbing, agriculture, or other actions have substantially altered vegetation or broken the soil surface."

[2] [DRECP] California Desert Energy Conservation Plan Independent Science Advisors. 2010 Aug. Recommendations of the Independent Science Advisors for The California Desert Energy Conservation Plan. Public Review Draft. Produced by the Conservation Biology Institute, San Diego. p. 2. [emphasis added].

disregards many of the specific recommendations articulated by the independent science advisors, as further explained herein.

III.   The Project Would Severely Fragment the Landscape

Habitat fragmentation and impediments to wildlife movements are among the greatest threats to desert communities and species; maximizing habitat connectivity is essential in adapting to the impacts from climate change.   California's deserts have already experienced a large amount of fragmentation.   As a result, the science advisors recommended that the DRECP to embrace a primary goal of "avoiding and minimizing any additional habitat loss or fragmentation."   Unfortunately here, the proposed Project represents one of the more insidious types of habitat loss and fragmentation given the effects it would have on perforating a relatively undisturbed landscape within a network of important ecological preserves.

The Applicant's analysis of the impacts to desert tortoise under the two new footprints was directed primarily at estimating the number of tortoises (i.e., adults, juvenile, and eggs) within the area encompassed by each of these. Reliance on this type of static data is often misleading. Species' ranges are dynamic, and populations naturally fluctuate and shift on the landscape over time due to natural and anthropogenically affected climatic shifts, species interactions, and stochastic population processes.[3] **As a result, the DRECP science advisors have recommended "conserving large areas that encompass broad environmental gradients (e.g., a wide range of latitudinal, longitudinal, elevational, climatic, and geological conditions) within an interconnected reserve network (to allow the greatest potential for range shifts), and that it [the DRECP] maximize conservation of ground and surface waters, riparian areas, and washes to maximize resiliency in the face of climate change."**[4] As with the previous plans, the Applicant's new proposals lack any recognition or analysis of these larger issues. Furthermore, the only maps that the Applicant provided of the reduced footprints do not enable the Commission to assess the alternatives in relation to environmental gradients, or in relation to the existing reserves in the region.

Because desert tortoises occupy large home ranges, the long-term persistence of extensive, unfragmented habitats is essential for the survival of the species.[5] The loss or degradation of these habitats to urbanization, habitat conversion, and the other landscape-modifying activities that would result from the project place the desert tortoise at increased risk of extirpation.[6] I recommend the Committee adopt the DRECP science advisors' recommendation that renewable energy projects "avoid contributing to habitat fragmentation adjacent to or in proximity of reserve areas or important habitat areas, including National Parks, ACECs, [and] Wilderness Areas".[7] The Project as currently proposed is amongst the Pisgah ACEC, the Cady Mountains Wilderness Study Area, and the Ord-Rodman Desert Wilderness Management Area. Project construction would therefore fragment the connectivity between these vital areas. The reduced footprints proposed by the Applicant do not reduce these fragmentation impacts and the Committee should therefore deny the Project.

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[3] *Id*, 39.
[4] *Id*, p. 57.
[5] U.S. Fish and Wildlife Service. 2008. Draft revised recovery plan for the Mojave population of the desert tortoise (*Gopherus agassizii*). U.S. Fish and Wildlife Service, California and Nevada Region, Sacramento, California. 209 pp. p. vi.
[6] U.S. Fish and Wildlife Service. 2008. Draft revised recovery plan for the Mojave population of the desert tortoise (*Gopherus agassizii*). U.S. Fish and Wildlife Service, California and Nevada Region, Sacramento, California. 209 pp. p. vi.
[7] DRECP, p. 71.

a.　　Loss of Connectivity

An earlier Staff Assessment concluded that implementation of the proposed mitigation measures would not offset Project impacts to the north-south movement corridor.[8] Neither Scenario 5.5 nor 6 would alter Project impacts to the north-south movement corridor. Maintenance of a north-south movement corridor is important to the long-term viability of many plant and animal species, especially given climate change. It is also critical to the maintenance of species that exhibit a metapopulation structure, such as bighorn sheep. On 5 August 2010, Dr. Vernon Bleich testified that metapopulation function for bighorn sheep is contingent upon continued connectivity.[9] Dr. Bleich further testified that the Project site is on a direct line between the south end of the Cady Mountains and the north end of the Rodman Mountains. The Applicant's new proposal would continue to disrupt metapopulation function and movement from the Cady Mountains to the south, and equally importantly, from the Rodman Mountains northward to the Cady Mountains. Dr. Bleich's expert opinion was that this obstruction would further constrain opportunities for bighorn sheep to recolonize vacant habitat from which they may become extirpated in the future (e.g., as the result of disease), and that it would certainly have an impact on transfer of genetic material from geographic area to geographic area.[10]

In his opening testimony, the Applicant's consultant, Dr. Mock, testified that sheep sign detected during survey efforts was located outside of the project site and that the project presents no impediments to bighorn sheep movement in the project vicinity.[11] In his most recent testimony, Dr. Mock testified that the sightings of Nelson's bighorn sheep and other evidence indicate that the likely routes for Nelson's bighorn sheep inter-mountain movement are east of the 850 MW Project site.[12] **In assessing the direct impacts of a reduced project footprint on desert tortoise, I discovered evidence that the Applicant had detected bighorn sheep sign in an area that is within both of the reduced footprint alternatives, and considerably south of the Cady Mountains.[13] To the best of my knowledge, the detection of bighorn scat was never mapped or otherwise addressed by the Applicant.** Attached to this testimony (Attachment A) is a map showing the location of the scat and a few of the other sensitive biological resources detected during the Applicant's 2010 desert tortoise surveys (but never mapped by the Applicant). The detection of sheep scat considerably south of the Cady Mountains supports Dr. Bleich's testimony, and my professional opinion, that the Project site serves as a sheep movement corridor between the Cady and the Rodman Mountains.

The independent science advisors stated that a key focus of the DRECP should be maintaining or improving landscape-level linkages that meet the niche requirements of all covered communities and species.[14] In addition, testimony from several parties has referenced the *California Essential Habitat Connectivity Project* (i.e., Spencer et. al 2010), which concluded that the Project site is located within an "Essential Connectivity Area."[15] Information from the *California Essential Habitat Connectivity Project* is available to the public on the BIOS website, managed by the California Department of Fish and Game. Through use of this website, I investigated the attributes of the Essential Connectivity Area associated with the Project site to determine how connectivity would be affected by the reduced footprint

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[8] SA, p. C.2-95.
[9] *See* 2010 Aug 5 Transcript, p. 307.
[10] *Id.*, p. 311.
[11] Opening testimony of Dr. Patrick Mock, p. 5.
[12] Testimony of Dr. Patrick Mock, 2010 Sep 13. Item #7.
[13] *See* URS. 2010 May 17. Results of 2010 Desert Tortoise 10m Transect Survey for Calico Solar Project. Appendix A-2. p 21. Object ID #5.
[14] DRECP, p. 39.
[15] SSA, p. C.2-98.

alternatives. I also used the website to generate a large-scale map that could be used for interpretation.[16] I have attached a copy of the map to this testimony (Attachment B). **The map illustrates two important issues relevant to the reduced footprint alternatives: (1) both alternatives would eliminate much of the Essential Connectivity Area; and (2) both alternatives occupy the most permeable portions (i.e., most conducive to wildlife movement) of the Connectivity Area.**

      b.   <u>Sediment Transport and Function</u>

The ecological effects of projects that disturb desert soils can extend far beyond the areal footprint of the development itself due to downslope effects on hydrology and downwind effects on eolian processes, among other effects.[17] Movement of soil particles (sand, silt and clay) by wind is one of the dominant processes in dryland environments (Breshears et al. 2003). Soil movement affects ecosystem function by altering soil texture, depth, and chemistry, which can strongly affect plant and animal communities. Alteration of natural soil movement processes by construction or other human effects can have long-lasting impacts that reach far beyond the footprint of the project—for example by increasing atmospheric dusts or by disrupting eolian processes that maintain sand dune communities.

Although there are some soil surface types that are inherently unstable (e.g., playa margins, dry wash bottoms), contrary to common belief, most desert surfaces are very stable and produce little sediment in the absence of disturbance (Marticorena et al. 1997). Natural armoring of the soil surface is provided by rocks, physical and biological soil crusts, plants, and plant litter (van Donk et al. 2003). Construction that disturbs these features can greatly increase soil movements and deposition of soil particles in other locations. Loss of soil via wind erosion leaves behind a coarser textured soil with lower fertility and water-holding capacity. Fine particles (silt and clay) can move great distances on the wind, even around the globe, and degrade air quality and visibility. Deposition of dusts can alter soil fertility and water-holding capacity and therefore plant community composition (Reynolds et al. 2001) often favoring non-native annual grasses (Miller et al. 2006). Dust accumulation on leaves and stems of desert plants can reduce physiological performance, plant growth and seedling establishment (Sharifi et al. 1997, 1999). Fine soil particles can also transport and deposit toxic elements, such as mercury and arsenic, onto plants and watersheds (Chaffee and Berry 2006).[18]

To the best of my knowledge, the Applicant has not provided analyses of the amount of soil disturbance that would occur under the two reduced footprint alternatives. However, both scenarios involve removal of the detention basins, which were originally proposed to intercept and slow the flow of sediment laden runoff.[19] The Applicant has recently submitted testimony that suggests the basins are not needed to control sedimentation and erosion. In my opinion, the conclusions that were made in the testimony do not provide a reliable prediction of the sediment transport processes that will occur if the Project is constructed. Regardless of whether the detention basins are removed, the Applicant's proposed reduced footprints would involve an extensive amount of soil disturbance that inevitably will affect downslope and downwind areas (e.g., the Pisgah ACEC) occupied by desert tortoises, Mojave fringe-toed lizards, and other sensitive biological resources.

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[16] Natural Landscape Blocks and Essential Connectivity Areas mapped for the California Essential Habitat Connectivity Project (Spencer et al. 2010). Links to download the report, maps, and GIS data are at <u>www.dfg.ca.gov/habcon/connectivity/</u>.
[17] DRECP, p. 44.
[18] *Id,* p. 38.
[19] Huitt-Zollars. 2009. Drainage Erosion & Sediment Control Plan for Solar One. p. 4-1.

      c.   <u>Other Indirect Impacts Associated with the Reduced Footprint Alternatives</u>

Even with the reduced footprints, any Project at this site would dramatically increase several major threats to the persistence and recovery of desert tortoise populations. These include the spread of invasive plants, increased predator densities, and increased human access to tortoise habitat.

      d.   <u>Conclusion</u>

Any dedicated proposal to reduce Project impacts to biological resources must address the needs of whole, intact, natural communities and mosaics of communities at the landscape scale.[20] The Applicant's testimony ignored this standard, and thus the long-term ecological effects of the Project. Instead, it focused almost exclusively on the short-term impacts to just one species (i.e., the desert tortoise). This is not an acceptable solution to the Committee's concerns. The Committee would do well to keep in mind that staff concluded in the Supplemental Staff Assessment that:

> "[r]egion-wide, the cumulative impacts of past, present, and foreseeable future large-scale habitat conversions to desert tortoise habitat and connectivity are cumulatively significant, even with these conservation efforts [establishment of reserves]. Such effects can only be addressed through a regional and coordinated effort. Ongoing collaborative efforts by federal and State agencies to develop a <u>Desert Renewable Energy Conservation Plan</u> and BLM's Solar Energy Development Programmatic EIS provide an appropriate vehicle for such a regional mitigation approach."[21]

Since release of the first of several Supplemental Staff Assessments, the independent science advisors have released their recommendations for the Desert Renewable Energy Conservation Plan. The Calico Solar Project conflicts with almost all of these recommendations. I strongly urge the Committee to reject the Project in conformance with the advisors, and adopt a "no regrets" strategy until more refined analyses of Project alternatives are available.

IV.   The Applicant has yet to Resolve the Issues Associated with the Desert Tortoise Translocation Plan

Inherently a reduced footprint alternative would involve moving fewer tortoises off the Project site than the originally proposed Project. Regardless, tortoises will need to be moved off the site and the Applicant has yet to resolve the numerous deficiencies with its Draft Translocation Plan.

I have provided substantial testimony on the numerous deficiencies associated with the Applicant's translocation plan. Additionally,

1.   Dr. Kristin Berry, a well-recognized expert in desert tortoise ecology, expressed her opinion that the "translocation plan seems to be hastily assembled, lacks basic and careful science, and it's not a rigorous, thoughtful plan."[22]

2.   Ashleigh Blackford from the U.S. Fish and Wildlife Service (USWFS) stated "there's quite a bit of acreage left to be evaluated in the Ord-Rodman DWMA", and that "after you gather that information are we only able to proceed with that translocation."[23]

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[20] DRECP, p.12.
[21] SSA, p. C.2-135. [emphasis added]
[22] *See* 2010 Aug 25 Transcript, p. 75.
[23] *See* 2010 Aug 25 Transcript, p. 121.

3. Chris Huntley (Energy Commission Staff) stated "[a]s the translocation plan stands now, staff does not consider it adequate."[24]

4. Tonya Moore from the California Department of Fish and Game submitted written comments that stated that "[t]he Department does not currently have enough information to analyze the impacts to the recipient population", and that the translocation areas should meet several criteria (that she subsequently listed) to meet the Department's full mitigation criteria.

These issues have not been resolved by the Applicant's reduced footprint proposals (or testimony). As a result, the Committee has no further evidence to conclude the Applicant has done the analysis required to identify significant impacts to offsite populations and developing mitigation prior to moving tortoises off the Project site.

Even if the Project were to be approved, tortoise will soon begin entering their winter burrows, which are relatively deep and difficult to determine occupancy. During the 18 August 2010 hearings, Chris Otahal from the Bureau of Land Management testified that hibernation was weather dependent, and "the assumption is that if it's before October 30th, that they're not in hibernation yet."[25] Mr. Otahal's testimony is not supported by scientific research, which concluded: (1) that there was not a statistically significant relationship between temperatures and the onset of hibernation; and (2) that tortoises in most populations in the northeastern Mojave Desert began hibernation by mid-October.[26]

The recommendations issued by the independent group of science advisors for the DRECP addressed the issue of tortoise translocation. They stated:

> "One action that we generally do **not** endorse as mitigation *per se*—except perhaps under certain rare circumstances where scientific evidence suggests it may be warranted—is animal translocations out of proposed development areas into reserve areas. This is often done but rarely effective—a "feel-good" measure that has dubious ecological benefits and potential to do more harm than good."[27]

The Applicant's Desert Tortoise Translocation Plan proposes exactly what the advisors caution against – moving the tortoises out of the Project area and into a preserve. The Applicant's proposal will have serious environmental consequences in the preserves that have not been analyzed or mitigated.

V. The Applicant's Statements Regarding Desert Tortoise Habitat Quality Remain Unsupported

To support the reduced footprint proposals, the Applicant claims that both Project scenarios would reduce impacts to the highest quality desert tortoise habitat in the Project area. According to the testimony of Theresa Miller, "[b]ased on a desktop habitat model, extensive site evaluations and protocol level surveys on the entire site, URS determined that the site includes a diversity of soil types, slopes, vegetation, and other features that create a variety of desert tortoise habitat, ranging from high quality to low quality. Using accepted criteria and best available data, URS mapped the quality of the habitat

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[24] *Id.*, p. 180.

[25] *See* 2010 Aug 18 Transcript, p. 352 and 355.

[26] Nussear KE, TC Esque, DF Haines, CR Tracy. 2007. Desert Tortoise Hibernation: Temperatures, Timing, and Environment. Copeia, No. 2: 378-386.

[27] DRECP, p. 75.

found on both the Project site and on the potential translocation recipient sites."[28] I have the following comments related to Ms. Miller's testimony:

1. Despite several requests, the Applicant has not provided any information that enables an assessment of the validity of the "desktop habitat model" that was apparently used. In response to the Sierra Club's Motion to Compel, the Applicant is now stating:

> "Sierra Club appears to be claiming that the only way that the Applicant could have evaluated the quality of the desert tortoise habitat on the site is by following some unspecified habitat modeling effort which is not required by any agency protocol nor is a generally accepted approach. The simple answer is that the data and information that Sierra Club appears to be seeking does not exist in the form that they would like and is therefore not available."

The methods the Applicant used to delineate desert tortoise habitat quality now appear to be less reliable than ever. Based on all the information provided to date (including the Applicant's written and oral testimony, the Applicant's written reports, the desert tortoise data sheets, and the Applicant's response to the Sierra Club's Motion to Compel), **it is apparent the Applicant's delineation of habitat quality was made without any quantitative field data or scientific foundation.** Instead, the Applicant simply drew arbitrary lines of a map "based upon the location of the desert tortoise sightings and the desert tortoise locations."[29] Such an approach is not a valid technique for evaluating the impacts of a reduced footprint Project, nor is it an approach acceptable to the USFWS. During the August 18, 2010 evidentiary hearings, Ms. Blackford from the USFWS stated:

> "habitat quality cannot truly be measured at this time…We go out quite frequently with the tortoise experts and see habitat that we think as humans looks like great habitat and we find very low density of tortoise in that area. And we can go out the areas [*sic*] that from our perception seems to be low quality habitat and we find extremely high numbers of Desert Tortoise. So having really saying that [*sic*] the high quality, low quality, and medium quality is not -- you know, I know that we so, oh, it has a lot of tortoises, so it must be high quality habitat or it has few tortoises so it must be low quality, but there's -- many people would know there's an abundance of factors that could be coming into play for that density."[30]

Through its inability to provide data and statements made in its response to the Motion to Compel, the Applicant has demonstrated that it relied on techniques that Ms. Blackford confirmed cannot be used to establish desert tortoise habitat quality.

1. According to the soils map that the Applicant provided as part of its Application for Certification, the majority of the Project site contains one soils type, not a diversity of soil types as suggested by Ms. Miller.[31] Consequently, the Applicant has not provided any reliable information on soils in the Project area to support a conclusion that a reduced footprint Project would avoid the highest quality desert tortoise habitat.

2. According to Ms. Miller's own testimony, "[a]ll of the 6215 acre, 850 MW project, as well as Scenarios 5.5 and 6, were in areas with slopes less than 20%."[32] The Applicant's Erosion

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[28] Testimony of Theresa Miller, p. 1.
[29] Applicant's response to Sierra Club Motion to Compel, p. 6.
[30] *See* 2010 Aug 18 Transcript, p. 337-338.
[31] AFC, Figure 5.4-1.
[32] Testimony of Theresa Miller, p. 4.

Control Plan reported "slopes range from 2% to 5% across the site."[33] This should not be considered a diversity of slopes as suggested by Ms. Miller. Consequently, the Applicant has not provided any reliable information on slopes in the Project area to support a conclusion that a reduced footprint Project would avoid the highest quality desert tortoise habitat.

3. According to the vegetation map generated by the Applicant, one vegetation type (Mojave Creosote Bush Scrub) characterizes almost the entire Project site.[34] This is not a diversity of vegetation as suggested by Ms. Miller. Consequently, the Applicant has not provided any reliable information on vegetation in the Project area to support a conclusion that a reduced footprint Project would avoid the highest quality desert tortoise habitat.

According to Ms. Miller's own testimony, "we did a qualitative assessment, we did not do a quantitative binary assessment of the habitat."[35] These are not "accepted criteria" or what could be considered the "best available data." To the contrary, the only "data" presented by the Applicant are completely indefensible and lack any scientific merit. As a result, they provide no value in assessing the impacts of a reduced footprint Project.

a. Habitat Models and Input Data

Ms. Miller's testimony indicates "[s]urvey leads were tasked with assessing the habitat found within each survey cell by (1) noting the soil type and substrates, (2) assessing the presence and amount of scrub cover, (3) noting and evaluating the quality and density of forage present; (4) observing the amount of native v. non-native vegetation; (5) looking for desert tortoise and assessing the heath of any desert tortoise observed; (6) looking for desert tortoise sign, and (7) identifying and evaluating the quality of all burrows located on the site. During the surveys, surveyors completed general data sheets and tortoise observation surveys. URS then compiled the information from the surveys and used it to ground-truth the desktop modeling."[36]

I have the following comments related to this portion of Ms. Miller's testimony:

1. Despite my request, URS has not provided the model algorithm. Furthermore, URS has not discussed the consistency between the model's prediction and field-verification data, nor how field-verification data were used to improve the model.

2. Despite several requests and Ms. Miller's earlier testimony that the data were collected, URS has been unable to provide any data to substantiate Ms. Miller's testimony.[37] These data are essential to assess the various qualities of habitat that would be impacted (and avoided) by the Applicant's reduced footprint alternatives.

3. The Applicant's use of survey leads to assess habitat within each survey cell has two critical flaws: (1) it has produced data that is unreliable; and (2) it has introduced bias due to inherent inconsistencies among surveyors tasked with making subjective evaluations. Boarman (2002) provided an excellent summary of data obtained through professional judgments:

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[33] Huitt-Zollars. 2009. Drainage Erosion & Sediment Control Plan for Solar One. p. 2-3.
[34] Biological Assessment, Figure 2.
[35] *See* 2010 Aug 18 Transcript, p. 334.
[36] Testimony of Theresa Miller, p. 4.
[37] *See* 2010 Aug 25 Transcript, p. 209.

"[w]hen the proper research has not been conducted or completed, or time or expertise is not readily available, managers often rely on the professional judgments of staff biologists or other scientists. Reliance on professional judgement requires managers to use data that are unreliable if only because they cannot necessarily be independently evaluated or examined. The judgments may involve unsupported speculation, data that have been improperly or incompletely analyzed, or may involve faulty recall of the facts. On the other hand, professional judgments may be very sound, reliable, and based on an objective evaluation of the information available. The manager may not be able to separate good from poor judgments because there is generally too little information to evaluate. Judgments solicited from several competent professionals is advisable when possible. Also, the professionals chosen to provide input should provide citations and critical analyses of the data they are using to make the judgment. They should clearly state where the strengths and weaknesses in their judgments lie."[38]

b.   USGS Habitat Model

According to Ms. Miller's testimony, "[t]o identify and evaluate potential desert tortoise habitat, URS used the USGS' desert tortoise habitat suitability model (USGS 2009)…using this model, the project site received a score of 0.9 for the majority of the site, and a score of 0.8 in areas south of the railroad tracks."[39] Figure 12 in the Applicant's Draft Biological Assessment depicts areas south of the railroad tracks that also received a score of 0.9. Furthermore, the Applicant has not explained why its habitat evaluation is inconsistent with the USGS', why the Applicant's "desktop" model would provide a more reliable prediction than the model generated by the USGS, or how the models were used to derive the habitat quality conclusions presented in the Applicant's testimony (e.g., were both models given equal weight?).

c.   Soils

According to Ms. Miller's testimony, "during the desert tortoise surveys, the surveyors gathered site specific information and made general habitat assessments based upon qualitative observation, including soil type. On the Calico site, the surveys revealed that there is a transition between very sandy soils near the railroad tracks to rocky and cobbly soils further north. The demarcation between the sandy soils in the south and the more rocky and cobbly was one of the factors which was [sic] used to draw the boundary line between the higher quality and medium quality habitat shown on Figure 9 of the Desert Tortoise Translocation Plan."[40]

I have the following comments related to this portion of Ms. Miller's testimony:

1.   "[g]eneral habitat assessments based upon qualitative observation" cannot be used to ground-truth a desktop model. By definition, a model produces non-qualitative data (although the input may be qualitative).

2.   Ms. Miller's testimony is not supported by the Applicant's soils map or the information presented on the desert tortoise data sheets. I agree with Ms. Miller's testimony that soil type is important because desert tortoise burrow in the ground.[41] However, because desert

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[38] Boarman WI. 2002. Threats to Desert Tortoise Populations: A Critical Review of the Literature. U.S. Geological Survey, Western Ecological Research Center. Sacramento (CA): 86 p.
[39] Testimony of Theresa Miller, p. 3.
[40] *Id,* p. 4,5.
[41] *Id*, p. 4.

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tortoises dig *subsurface* burrows, the composition of surface soils may not provide a good indication of the soil's ability to support burrows. Ms. Miller previously testified that the survey team did not dig the soil pits that would be necessary to evaluate the soil's ability to support tortoise burrows.[42]

d.   Vegetative Cover

According to Ms. Miller's testimony, "[a]n area that has a high diversity and dense coverage of annual and perennial species for foraging is characteristic of higher quality habitat whereas medium and lower quality habitat is more sparse. Likewise, dense coverage of scrub (50-70%) is considered higher quality habitat, which was observed in the area identified as high quality habitat on the project site."[43] Ms. Miller fails to quantify desert tortoise cover requirements or provide appropriate citations for her conclusions. Although desert tortoises rely on both shrubs and burrows for cover,[44] they are known to prefer areas with *sparse shrub cover* because it promotes growth of herbaceous plants, their preferred food.[45] Furthermore, Ms. Miller's testimony is inconsistent with the Applicant's Erosion Control Plan, which reported the Project area as having "poor vegetative cover (approximately 20%)", and the testimony of Robert Byall, who indicated "vegetation on and uphill from the Project site is sparse enough that I do not expect significant debris along the fence line."[46]

e.   Tortoise Distribution

According to Ms. Miller's testimony, "[s]urvey results showing higher numbers of tortoises and burrows indicated higher quality habitat. The locations of actual tortoise and burrow sightings were consistent with the expectation based upon the modeling and the previous observations on the site." Ms. Miller's testimony is misleading. Figure 8 of the Applicant's Draft Biological Assessment depicts a "concentration of tortoise or tortoise sign" over virtually all of the Project area north of the railroad tracks. This suggests that the Applicant has not provided an accurate assessment of the desert tortoise habitats that would be avoided through one of the reduced footprint projects.

VI.   Conclusion

In my previous written testimony I presented several conclusions pertaining to a 6,215-acre Project. These included that the Project would (1) have an unmitigated, significant impact on the State and federally threatened desert tortoise and it would cause further decline of the species; (2) have a significant adverse impact on numerous other special-status plant and animal species, including species protected by the Endangered Species Act and West Mojave Plan; (3) jeopardize the continued existence of at least two special-status plant species; (4) cause irreparable damage to a healthy desert ecosystem; and (5) compromise the ecological integrity of the surrounding conservation areas (e.g., Pisgah ACEC, Ord-Rodman DWMA, and Cady Mountains Wilderness Study Area). **None of my conclusions on the significant environmental impacts of the Project have changed.**

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[42] *See* 2010 Aug 5 Transcript, p. 98. (The transcript incorrectly attributes the testimony to Ms. Bellows).
[43] Testimony of Theresa Miller, p. 5.
[44] Schamberger ML, FB Turner. 1986. The application of habitat modeling to the desert tortoise (*Gopherus agassizii*). Herpetologica 42:134-138.
[45] U.S. Fish and Wildlife Service. 1994. Desert Tortoise (Mojave Population) Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon.
[46] Testimony of Robert Byall, p. 3.

Declaration of Scott Cashen
Calico Solar Project

Docket 08-AFC-13

I, Scott Cashen, declare as follows:

1)   I am an independent biological resources consultant. I have been operating my own consulting business for the past three years. Prior to starting my own business I was the Senior Biologist for TSS Consultants.

2)   I hold a Master's degree in Wildlife and Fisheries Science. My relevant professional qualifications and experience are set forth in the attached testimony and are incorporated herein by reference.

3)   I prepared the testimony attached hereto and incorporated herein by reference, relating to the biological resource impacts of the Calico Solar Project.

4)   I prepared the testimony and maps attached hereto and incorporated herein by reference relating to the distribution of solar energy generation infrastructure in San Bernardino County.

5)   It is my professional opinion that the attached rebuttal testimony and maps are true and accurate with respect to the issues that they address.

6)   I am personally familiar with the facts and conclusions described within the attached testimony, and if called as a witness, I could testify competently thereto.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and belief.

Dated: _____9-17-10_____   Signed: _____

At: Walnut Creek, CA

Attachment A

MFTL

Owl pellet

Buow pellet

Sheep Scat

2150

2090

2253

1980

WM 2030

BM 196

BM 1937

BM 1988

BM 1998

BM 2016

2125

2055

HECTOR 2   UNDERGROUND

UNDERGROUND

PIPELINE

BM 2068

BM 2095

WASH

STEEL

WASH

BM SWBL 2202

T9N / T8N   T9N / T8N   WASH

2   1   6   5   5

11   12   7   8   8

14   13   18   17   17

MN (12.4° E)

Data Zoom 13-0

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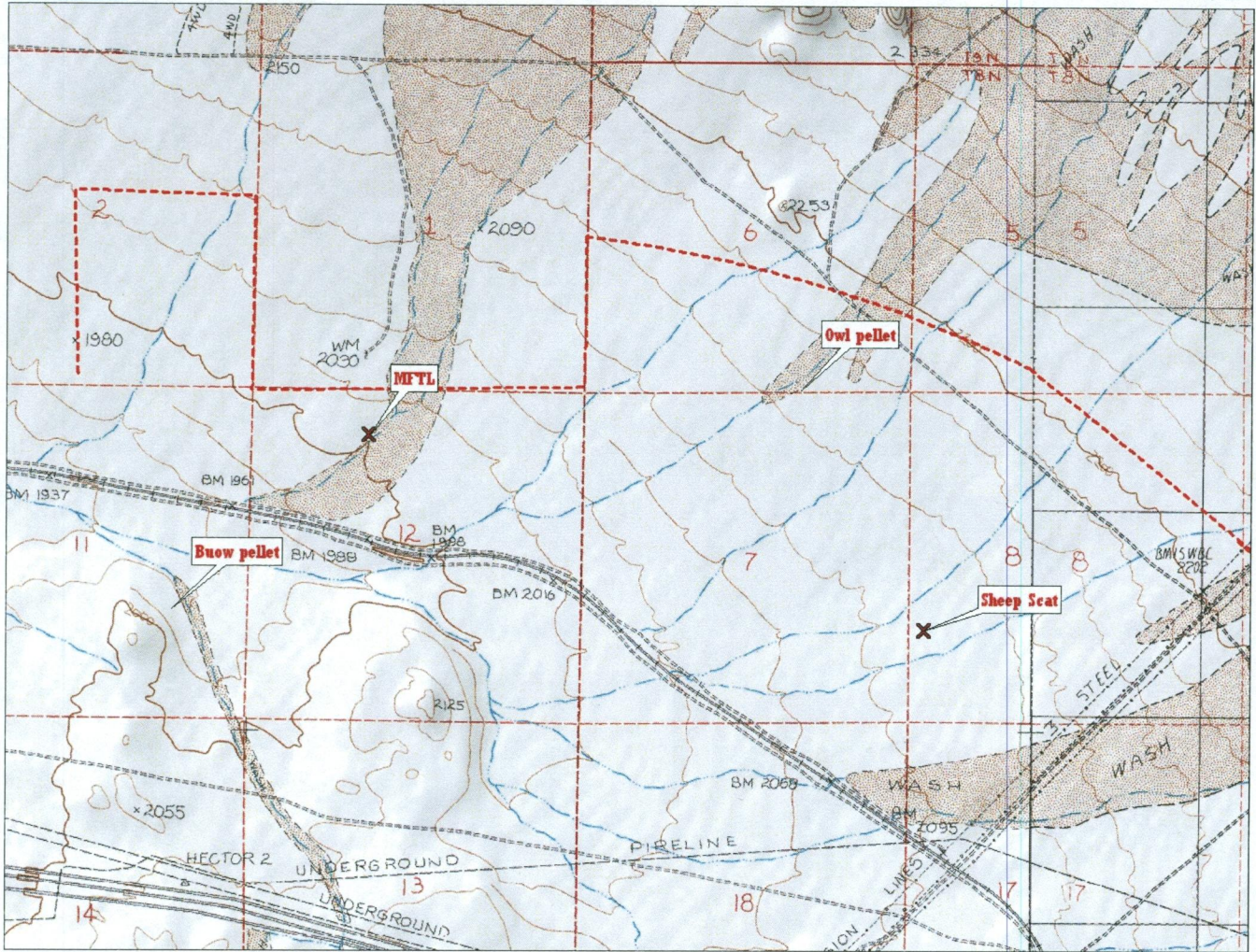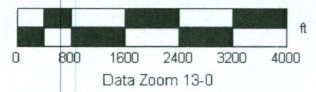
Attachment B

Enter Title Here

Info: Site available at http://imaps.dfg.ca.gov

Author: Enter Name Here
Date: 9/15/2010 11:39 PM
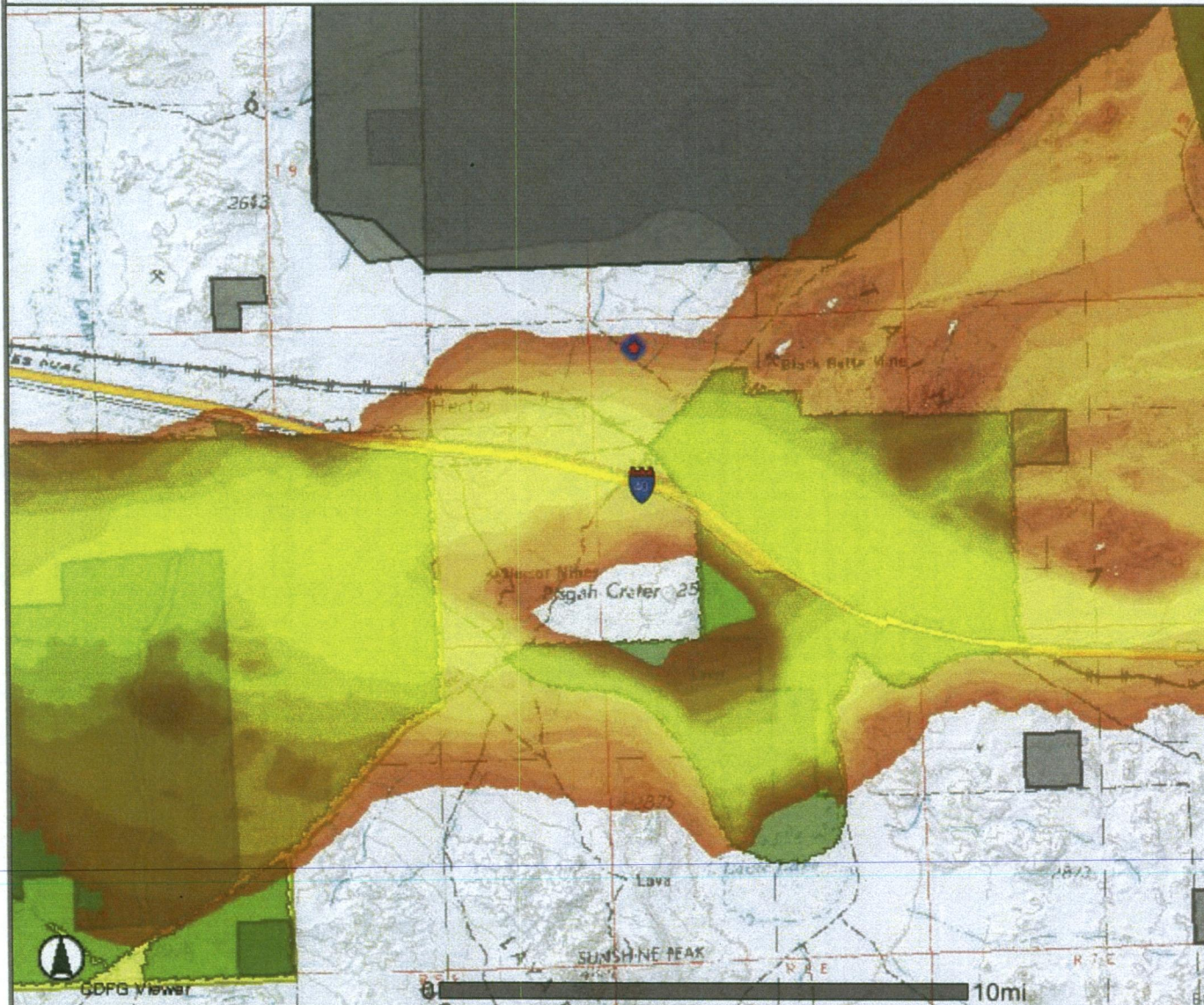
Map Legend

Essential Connectivity Areas - CEHC [ds623]

More Permeable

Less Permeable

Potential Riparian Connections - CEHC [ds622]

Natural Landscape Blocks - CEHC [ds621]

Environmental Yellow Areas (RETI) [ds497]

Environmental Blackout Areas (RETI) [ds496]

★ **Cities**

Highways

Interstate
US Highway
State Highway

Western States

Mexico

10mi

EXHIBIT 462

Desert Tortoise Hibernation: Temperatures, Timing, and Environment

KENNETH E. NUSSEAR, TODD C. ESQUE, DUSTIN F. HAINES, AND C. RICHARD TRACY

This research examined the onset, duration, and termination of hibernation in Desert Tortoises (*Gopherus agassizii*) over several years at multiple sites in the northeastern part of their geographic range, and recorded the temperatures experienced by tortoises during winter hibernation. The timing of hibernation by Desert Tortoises differed among sites and years. Environmental cues acting over the short-term did not appear to influence the timing of the hibernation period. Different individual tortoises entered hibernation over as many as 44 days in the fall and emerged from hibernation over as many as 49 days in the spring. This range of variation in the timing of hibernation indicates a weak influence at best of exogenous cues hypothesized to trigger and terminate hibernation. There do appear to be regional trends in hibernation behavior as hibernation tended to begin earlier and continue longer at sites that were higher in elevation and generally cooler. The emergence date was generally more similar among study sites than the date of onset. While the climate and the subsequent timing of hibernation differed among sites, the average temperatures experienced by tortoises while hibernating differed by only about five degrees from the coldest site to the warmest site.

DESERT Tortoises (*Gopherus agassizii*) are distributed in desert and subtropical regions of the southwestern United States and northern Mexico (Germano et al., 1994). The northern extent of this distribution is a temperate zone where some environmental temperatures in winter can be inhospitable or even lethal to Desert Tortoises. Tortoises avoid cold temperatures in the winter by using underground cover sites (hibernacula), which generally consist of burrows (excavated in soil) or dens (natural rocky caves; Burge, 1977; Bulova, 1994). Hibernacula generally have higher temperatures than the open environment during the winter and provide substantial buffering from the daily temperature fluctuations present in the environment. Thus, hibernacula provide tortoises with protection from potentially lethal temperatures in winter.

Research on the timing and temperature of reptile hibernation has focused on snakes (Viitanen, 1967; Sexton and Hunt, 1980; Blouin-Demers et al., 2000), lizards (Garrick, 1972; Etheridge et al., 1983; Wone and Beauchamp, 2003), and turtles (Grobman, 1990; Litzgus et al., 1999; Plummer, 2004), but few studies have focused on tortoises (Vaughan, 1984; Bailey et al., 1995; Rautenstrauch et al., 1998). Understanding the timing of hibernation of Desert Tortoises could have important management implications for this sensitive species (Rautenstrauch et al., 1998).

In the northeastern extent of their range, tortoises may hibernate for up to six continuous months (Woodbury and Hardy, 1948; Bury et al.,

1994). Little is known about the mechanisms cuing the onset and termination of hibernation behavior or the amount of variation that should be expected to occur within the timing of this behavior. Potential cues for hibernation onset include reduced day length/photoperiod, cooler environmental temperatures, reduced forage availability, and timing of precipitation events (Gregory, 1982). Hibernation is thought to be advantageous by facilitating a reduction of metabolism during a time of the year with few resources. Tortoises, like other ectotherms, may be able to conserve energy by hibernating, as there is a concomitant reduction of metabolism with decreased body temperatures (Bennett and Dawson, 1976; Gregory, 1982). Tortoises may further reduce their metabolism by inverse acclimation or other mechanisms of metabolic depression (Gregory, 1982). This could allow tortoises to conserve energy during seasons with essentially no food resources. Alternatively, hibernation may be induced by endogenous cues. There is relatively little literature on endogenous mechanisms cuing hibernation, but observations of behavior such as declining appetite and shelter-seeking behavior under differential exposure to external cues suggest that the hibernation of some reptiles may be influenced by endogenous rhythms (Gregory, 1982). Although intriguing, this hypothesis is beyond the scope of the work we describe here.

In this study we examine correlations between the onset, duration, and termination of hibernation in Desert Tortoises in relation to potential exogenous cues over several years at multiple

sites in the northeastern portion of their range. We report the temperatures experienced by Desert Tortoises and their associated behavior during winter hibernation.

MATERIALS AND METHODS

Study sites.—We studied hibernation in Desert Tortoises at four sites in the northeastern Mojave Desert. The sites were located in the Mojave Desert scrub biome (Turner, 1982). The City Creek Site was located in Washington County north of St. George, Utah (37°9'00"N, 113°35'24"W), and ranged in elevation from 975 m to 1067 m, with highly variable topography: flat areas, dry washes up to 2 m deep, dunes, rocky cliffs and steep hills. The predominant substrate was red Navajo sandstone interspersed with ancient lava flows, sand dunes, and cryptobiotic soils (Esque, 1994). The Littlefield Site was located in Mohave County north of Littlefield, Arizona (36°55'48"N, 113°54'36"W), and ranged in elevation from 576 m to 622 m. The topography was generally flat (2–5% slope), with numerous dry washes up to 3 m deep (Esque, 1994). The substrate was shallow sandy/gravelly loam up to 0.6 m deep with an underlying calcium carbonate (caliche) hardpan layer. The Lake Mead site was located in Clark County, Nevada (36°29'24"N, 114°21'00"W). The site was at the northern end (Overton arm) of the Lake Mead National Recreation Area, near Overton, Nevada. The site elevation ranged from lake level (approximately 325 m) to 597 m and consisted of the top and steep cliff sides of a mesa bordered on three sides by water. The soil consisted of coarse alluvium consolidated by calcium carbonate, interspersed with patches of windblown sand. The Bird Spring Valley site was also in Clark County, Nevada (BSV 35°58'12"N, 115°20'24"W). The valley was an extensive bajada ranging from 900 m to 1300 m in elevation and was of relatively even terrain with shallow arroyos lined by occasional caliche caves. The substrate was sandy/gravelly loam up to 0.75 m deep with an underlying hardpan layer composed of caliche. Mountainous peaks bordered Bird Spring Valley to both the east and west.

Tortoise body temperatures.—We used miniature data loggers (Stowaway #STEB16, Onset Computer Corporation, Pocasset, MA) to record body temperatures during hibernation of wild Desert Tortoises at the City Creek and Littlefield sites. Data loggers were 26.5 g and came encased in a plastic rectangular housing (4.6 × 4.8 × 1.5 cm). They were calibrated in water baths at temperatures over a range of 0 to 45 C before and after use in the field. Data loggers were programmed to record temperatures once per hour. For protection from the environment, they were wrapped in a layer of paper and covered with a layer of duct tape followed by a coating of epoxy (which served as weather-proofing). Each data logger was attached with 5-minute epoxy gel to a location on the anterior half of the carapace to avoid potential interference during copulation. Data loggers were placed on animals prior to the expected onset of hibernation and were removed within several weeks after emergence from hibernation. Temperatures recorded by the data loggers at these two sites were the temperatures measured inside the plastic casing of the data loggers, not body temperatures of the tortoises. Nevertheless, the data from the loggers could be used to discern the timing of hibernation (see below), and temperatures of the loggers were likely similar to body temperatures while the animals were in hibernacula (Gregory, 1982).

Body temperatures of tortoises at the Lake Mead and Bird Spring Valley sites were measured using StowAway™ TidbiT™ temperature data loggers (Onset Computer Corporation, Pocasset, MA), customized by Onset from their standard design (TBICU108; −20 C to +70 C). These were 25 mm in diameter, 14 mm thick, and weighed approximately 15 g. They had a weather-resistant thermistor at the end of a 150-mm wire, which was affixed using fast-setting glue and silicone between the tail and the carapace of the tortoise (Nussear et al., 2002). This location has been shown to approximate cloacal temperatures of Desert Tortoises (Nussear et al., 2002).

Timing of hibernation.—We recorded data on hibernating tortoises over the course of four winters from 1995 to 1998 at the City Creek and Littlefield sites, and for one winter (1998–1999) at the Lake Mead and Bird Spring Valley sites. At City Creek we studied nine animals during the winter of 1995, ten animals in the winter of 1996 and 1997, and six animals in the winter of 1998. At Littlefield we studied four animals in the winter of 1995, six animals in the winter of 1996, 11 animals in the winter of 1997, and five animals in the winter of 1998. During the winter of 1998 we added tortoises at the Bird Spring Valley and Lake Mead sites to the study. We studied seven animals at Bird Spring Valley and nine animals at Lake Mead.

Onset, duration, and termination of hibernation were interpreted from graphs of hourly body temperatures by locating the date when the amplitude of the daily fluctuations became noticeably reduced or increased. The accuracy of this interpretation was verified by weekly

observations of the tortoises in the field. Patterns of temperatures of the data loggers at the City Creek and Littlefield study sites were clearly different when the tortoises were in and out of burrows. We defined onset of hibernation as the Julian date after which a tortoise did not emerge from its hibernaculum for at least 14 days. Likewise, the termination of hibernation was defined as the Julian date when a tortoise emerged from the hibernaculum, without returning for at least 14 days. The ''14-day'' criterion allowed for a consistent quantification of the onset and termination dates for animals that had false onsets or brief emergences during hibernation. These criteria are similar to those used by Bailey et al. (1995). Some data loggers became overloaded with data and stopped recording temperatures before the tortoise emerged from hibernation. This was due to logistical constraints encountered when changing the recording intervals of the dataloggers from active season intervals (15 min) to winter intervals (60 min). Thus, for some individuals, duration and termination of hibernation could not be calculated, although hibernation start dates were recorded.

We defined ''average hibernation temperature'' as the mean temperature of all measurements while an animal was hibernating. The ''mid-hibernation temperature'' was defined as the average temperature during the week of the winter solstice (i.e., week 51), and the ''minimum temperature'' as the lowest temperature experienced by the animal at any time during the hibernation period.

We compared Julian dates of onset and termination, duration of hibernation, and the mean, minimum, and mid-hibernation temperatures using ANOVA with site and year as factors. Repeated measurements of animals were accounted for by using a nested, split-plot design with tortoises nested within site treated as a random effect in order to allow for independent contrast analyses of the interaction term. Multiple comparisons to discern differences within significant effects were conducted using Tukey's-HSD.

Thermal buffering categories.—Cover sites were classified by the degree of thermal buffering that they provided as interpreted by the daily and biweekly patterns in body temperature. The greatest buffering was represented by a pattern in which the body temperature was nearly constant, with a difference of less than 1 C between the daily maximum and daily minimum temperatures for each tortoise. In addition, the average of the differences of absolute minimum

and maximum temperatures for all successive 14-day periods throughout the hibernation period was <1.5 C. Less buffering resulted in body temperatures that still retained differences of daily maximum and minimum temperatures of less than 1 C. However, the body temperatures were influenced by local weather patterns when examined over longer time periods. In this category the average of the differences in the absolute maximum and absolute minimum temperatures for successive 14-day periods was greater than 1.5 C. The least buffering resulted in body temperatures that fluctuated greatly on a daily basis where the difference between the maximum and minimum daily temperature was more than 1 C. Analyses of the degree of thermal buffering of hibernacula were conducted for Littlefield and City Creek for the four years studied and among all four sites for the winter of 1998–1999 using Fisher's exact tests for contingency tables.

Meteorological data.—Climate data for the study sites were obtained from (1) City Creek: St. George, Utah, weather station 4 km south of the City Creek site, (2) Littlefield: Littlefield 1 NE station 10 km north of the Littlefield site, (3) Lake Mead: Overton station 1 km northwest of the site, and (4) Bird Spring Valley: Red Rock Canyon weather station 4 km northeast of the site (National Oceanic and Atmospheric Administration, 1998). Soil temperatures during the winter of 1998 at Bird Spring Valley were measured at a central location at the site using a CR-10 weather station (Campbell Scientific, Logan, UT) and type K thermocouples (Omega Engineering, Stamford, CT) at the surface and buried 70 cm below the surface, just above the caliche layer. Air temperature data for all four years were not available for the Littlefield site. We conducted regression analyses of the average air temperatures for the months of October and March on the average onset and termination dates of hibernation for each site to examine correlates of regional climate and hibernation patterns.

RESULTS

City Creek and Littlefield.—There was no overall difference for the average date of hibernation onset between tortoises at City Creek and Littlefield ($F_{1,32} = 3.26$; $P = 0.08$; Fig. 1). There were differences in the onset date among years. The average date of onset in the fall of 1995 (3 Nov. ± 1 SD = 12 d) was approximately nine days later than the average date of onset in the fall of 1996 (25 Oct. ± 1 SD = 8 d; Tukey's HSD
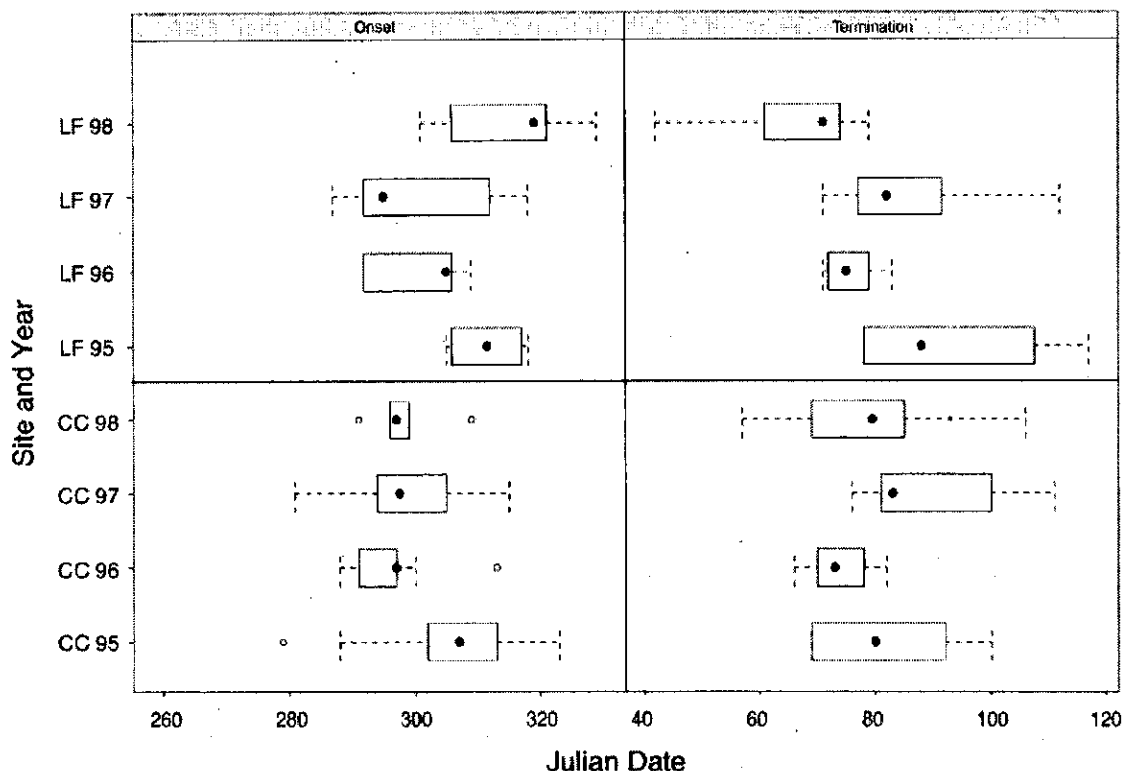
Fig. 1. Onset, duration, and termination of hibernation at the City Creek and Littlefield sites for the four winters from 1995 through 1998. The four winters at Littlefield are in the top half of the figure; City Creek is given in the bottom half. Years are sorted from bottom to top in each panel and listed as the year in which each hibernation period began. The distance between the onset and termination dates is the duration of hibernation. The median onset and termination dates for each site are shown as filled circles. The box surrounding the filled circle depicts the 25th and 75th quartile. The range of values for each measure is given by the dotted lines ("whiskers") outside of each box, and possible outliers are given by the open circles outside the box.

$Q = 2.72$; $P < 0.05$). The onset dates for all other years were statistically indistinguishable from one another. There were no site-by-year interactions for onset date ($F_{3,29} = 0.65$; $P = 0.59$).

Tortoises at the City Creek and Littlefield sites spent a similar number of days in hibernation, ranging from 106 to 182 days ($F_{1,23} = 2.22$; $P = 0.15$; Fig. 1). The duration of hibernation varied among years coincident with a twenty-one day difference in duration of hibernation in the winters of 1997–1998 and 1998–1999 (154 ± 1 SD = 21 vs. 133 ± 1 SD = 21 days, respectively; Tukey's HSD $Q = 2.73$; $P < 0.05$). The durations of hibernation for all other years were statistically indistinguishable from one another. There was a significant year-by-site interaction due to animals at Littlefield during the 1998–1999 season having a shorter duration (134 ± 1 SD = 40 days) than the City Creek or Littlefield animals in the 1997–1998 season (154 ± 1 SD = 17 and 155 ± 1 SD = 25 days respectively; Tukey's HSD $Q = 3.27$; $P < 0.05$; Fig. 1).

The ending date for hibernation in the spring did not differ between the two sites and ranged between 11 February to 27 April ($F_{1,23} = 0.07$; $P = 0.79$; Fig. 1). There were significant differences in the termination date among years. In particular, the termination of hibernation (averaged for both sites) was earlier in the spring of 1996–1997 (15 March ± 1 SD = 5 d), and in the spring of 1998–1999 (14 March ± 1 SD = 17 d) than in the spring of 1995–1996 (25 March ± 1 SD = 15 d) or 1997–1998 (1 April ± 1 SD = 19 d; Tukey's HSD $Q = 2.72$; $P < 0.05$). There was a marginally non-significant site-by-year interaction for termination date ($F_{3,29} = 2.76$; $P = 0.06$).

There were no differences found in the average hibernation body temperature between City Creek and Littlefield ($F_{1,23} = 1.52$; $P = 0.23$; Table 1), but there were differences among years ($F_{3,30} = 6.86$; $P = 0.0012$). The average hibernation body temperature of tortoises during the winter of 1996–1997 (12 C) was approximately two degrees cooler than either 1997–1998 (14 C)

TABLE 1. TORTOISE BODY TEMPERATURES DURING HIBERNATION FOR THE WINTERS OF 1995–1999 AT CITY CREEK (CC), LITTLEFIELD (LF), BIRD SPRING VALLEY (BSV), AND LAKE MEAD (LM).

Year/site	Mean temperature (°C) ± 1 SD	Minimum temperature (°C) ± 1 SD	Mid-hibernation average (°C) ± 1 SD
1995			
CC	12.2 ± 1.1	8.2 ± 2.3	10.3 ± 2.4
LF	16.0 ± 3.8	9.7 ± 6.0	16.3 ± 6.4
1996			
CC	11.4 ± 1.5	6.5 ± 2.4	10.2 ± 1.4
LF	12.1 ± 1.5	7.9 ± 3.4	11.3 ± 2.2
1997			
CC	13.4 ± 2.0	9.3 ± 2.2	10.7 ± 3.2
LF	14.9 ± 4.4	10.1 ± 5.4	12.7 ± 6.3
1998			
BSV	14.7 ± 3.3	9.4 ± 4.6	10.0 ± 3.5
CC	11.9 ± 3.1	8.1 ± 3.4	8.9 ± 3.9
LF	12.8 ± 4.9	8.3 ± 6.6	11.4 ± 6.1
LM	15.2 ± 1.9	9.9 ± 4.29	12.7 ± 2.5

or 1995–1996 (14.2 C; Tukey's HSD $Q = 2.72$; $P < 0.05$). There were no significant site-by-year interactions ($F_{3,30} = 1.33$; $P = 0.29$). The mid-hibernation temperature did not differ between the two sites ($F_{1,23} = 1.89$; $P = 0.18$). There were differences among years in that the animals' temperatures during the 51st week of 1998 (9.88 C) were significantly cooler than during the same week in 1995 (13.13 C). The average minimum temperature experienced did not significantly differ for either site ($F_{1,23} = 0.17$; $P = 0.68$) or year ($F_{3,30} = 2.79$; $P = 0.058$).

We categorized the degree to which tortoises were insulated from environmental variation in temperature into three distinct patterns (Fig. 2). The numbers of animals that used hibernacula with these patterns differed among sites during three of the four winters of our study (Table 2). In those three years, tortoises at City Creek were mostly found in hibernacula with medium buffering (Fig. 2B), whereas tortoises at Little-field occupied either no hibernacula in that category (1995) or had a more even distribution among categories (1997, 1998).

Four-site comparisons.—All four study sites were monitored in the winter of 1998–1999, allowing comparison of regional differences in tortoise hibernation characteristics. There were significant differences in the beginning of hibernation among sites ($F_{3,21} = 10.10$; $P = 0.003$; Fig. 3). Tortoises at Bird Spring Valley (onset date = 15 Oct. ± 1 SD = 15 d) entered hibernation earlier
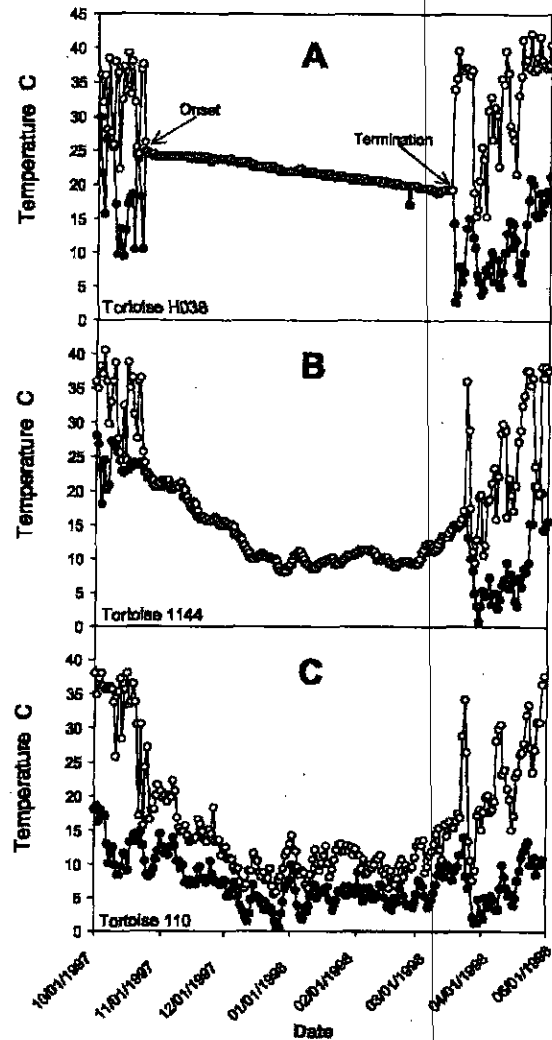

Fig. 2. Three examples of tortoise body temperatures prior to, during, and following hibernation. Data are presented as the daily minimum (filled circles) and maximum (unfilled circles) temperatures (C). Panel A is an example of a high buffering in the body temperature pattern. Panel B demonstrates a medium level of temperature buffering during hibernation. Panel C is an example of a low temperature buffering.

than tortoises at either Lake Mead (10 Nov. ± 1 SD = 7 d) or Littlefield (11 Nov. ± 1 SD = 11 d). The onset date for tortoises at City Creek (25 Oct. ± 1 SD = 6 d) did not differ significantly from the onset dates at the other sites.

There were also significant differences in the duration of hibernation among sites ($F_{3,15} = 5.96$; $P < 0.007$; Fig. 3). The animals at Lake Mead (114 ± 1 SD = 18 days) and Littlefield (115 ± 1 SD = 14 days) hibernated for significantly fewer days than animals at City Creek (146 ± 1 SD = 13 days). Hibernation duration at Bird

TABLE 2. THE NUMBER OF ANIMALS IN EACH TEMPERATURE BUFFERING CATEGORY FOR THE HIBERNACULA SELECTED BY ANIMALS AT CITY CREEK (CC) AND LITTLEFIELD (LF) SITES FOR THE FOUR WINTERS (1995–1998).

Year/site	High (n)	Medium (n)	Low (n)	P
1995				
CC	0	7	2	0.01
LF	2	0	2	
1996				
CC	0	8	2	1.0
LF	0	5	1	
1997				
CC	0	10	0	0.035
LF	3	6	2	
1998				
CC	0	6	0	0.044
LF	0	4	5	

TABLE 3. THE NUMBER OF ANIMALS IN EACH TEMPERATURE BUFFERING CATEGORY FOR THE HIBERNACULA SELECTED BY ANIMALS AT CITY CREEK (CC), LITTLEFIELD (LF), BIRD SPRING VALLEY (BSV), AND LAKE MEAD (LM) FOR THE WINTER OF 1998–1999.

Site	High	Medium	Low
CC	0	6	0
BSV	0	4	3
LF	0	4	5
LM	0	4	5

April 1999. There were no differences among sites in the average hibernation temperatures ($F_{3,23} = 1.61$; $P = 0.21$), minimum temperatures ($F_{3,23} = 0.87$; $P = 0.76$), or mid hibernation temperatures ($F_{3,21} = 1.23$; $P = 0.32$).

Fifty-eight percent of the hibernacula provided medium buffering from thermal environments, while 42% had low buffering, and none provided high levels of buffering. The distribution of animals in each of these patterns did not differ among the four sites for this year ($P = 0.12$; Table 3). Animals at the sites were relatively evenly distributed between medium and low buffering patterns, with the exception of tor-

Spring Valley (131 ± 1 SD = 7.7 days) did not differ significantly from the other sites. The four study sites did not differ in termination date for hibernation ($F_{3,17} = 1.40$; $P = 0.28$; Fig. 3). The termination dates ranged from 11 February to 16
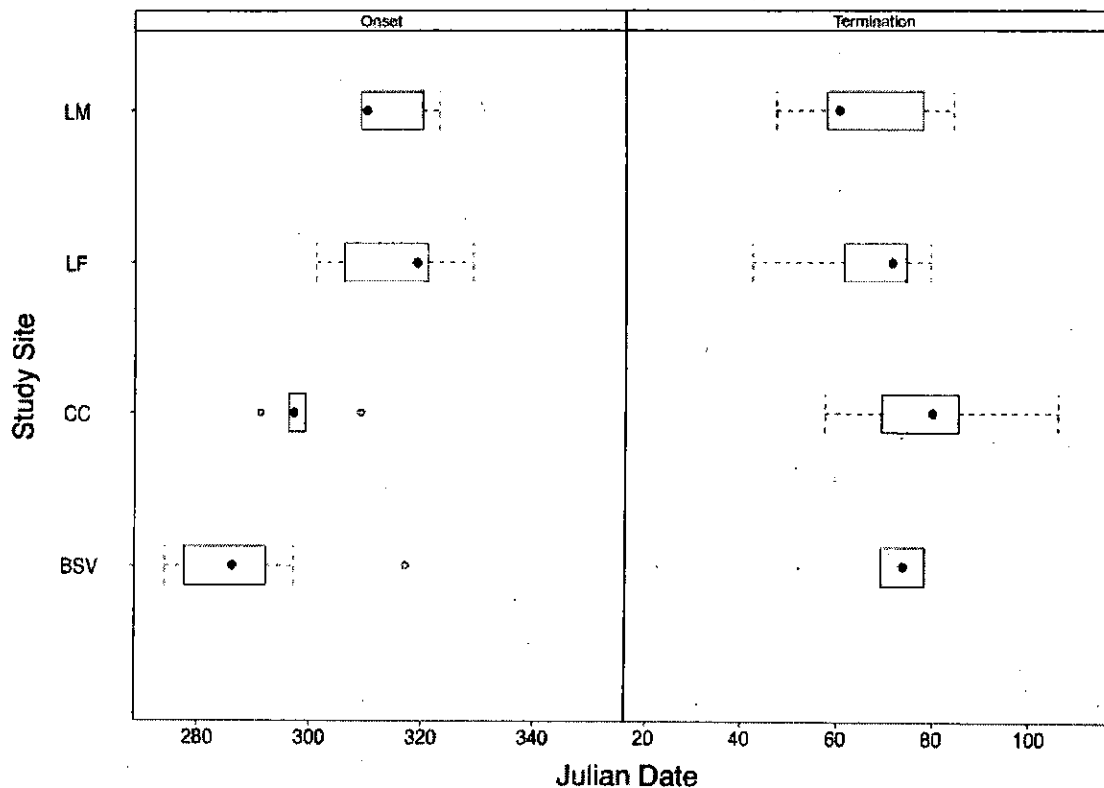

Fig. 3. Onset, duration, and termination of hibernation at the City Creek, Littlefield, Lake Mead, and Bird Spring Valley sites for the winter of 1998–1999. See Fig. 1 for figure explanation.

toises at the City Creek site, at which all animals were categorized as medium.

Meteorological data.—Average air temperatures near the City Creek site indicated differences among years in the temperatures during the fall when tortoises are entering hibernation, and during the spring when animals are terminating hibernation, which were the two periods of specific interest to this study. The two warmest fall periods were during the fall of 1995 and 1997, while the fall months of 1996 and 1998, in contrast, were cooler by about 10 C. Spring temperatures also differed by about 10 C among years during the spring months of March and April when tortoises are typically exiting hibernation. Data for the Littlefield site were available from the spring of 1997 and later. This site had warmer and more consistent temperatures than the City Creek site. A regression analysis of the average date of entry into hibernation at City Creek as a function of the average October air temperatures yielded a non-significant correlation of these two variables ($r = 0.74$; $F_{1,3} = 2.5$; $P = 0.26$). There were not sufficient climate data available to include Littlefield in the analysis. A mixed model analysis of termination date versus average air temperatures in March with Site entered as a random effect to account for repeated measurements was non-significant ($F_{2,6} = 1.5$; $P = 0.33$).

Average air temperatures among the four sites during the 1998–1999 hibernation season differed among sites by as much as 10 C in the fall, but only by about 5 C during the spring months. A regression analysis of onset date as a function of average October temperatures yielded a non-significant correlation between the two variables ($r = 0.70$; $F_{1,3} = 1.9$; $P = 0.3$). A similar analysis of termination date on average March air temperatures yielded a non-significant correlation ($r = 0.46$; $F_{1,3} = 0.54$; $P = 0.54$).

DISCUSSION

There was great individual variation in the timing and duration of hibernation. Exogenous mechanisms did not appear to dictate hibernation patterns at any site or within any year. This leads us to question whether exogenous cues drive hibernation behavior at a population level for this species, or if hibernation behavior is more likely driven by the endogenous conditions of the individuals in association with broad scale seasonal changes in climate.

Among all of our sites and for all years of our study, there was great individual variation in the onset date of hibernation. The onset of hiberna-

tion was only weakly correlated with interannual temperature variation, with cooler temperatures associated with earlier onset of hibernation. Onset dates for both the City Creek and Littlefield sites combined were earlier in 1996 than in 1995, which corresponded with an average air temperature in the fall that was 10 C cooler at City Creek, but no significant correlation between onset of hibernation and average October temperatures for 1995–1998 at City Creek was observed. When all four sites were compared within a single year, tortoises appeared to enter hibernation earlier at the sites with cooler fall temperatures, which is consistent with earlier observations (Woodbury and Hardy, 1948; Rautenstrauch et al., 1998). However, this tendency was not statistically significant.

Decreases in air or ground temperature in the fall are the most frequently suggested cue for the onset of hibernation (Gregory, 1982). For example, tortoises were observed to begin hibernation in Kern County, California, when surface temperatures fell below 20 C (Voigt, 1972). We found that daily averages of soil surface temperature at the Bird Spring Valley site fell below 20 C on 27 September 1998, and the first tortoise entered hibernation three days later. However, the last tortoise entered hibernation at the site on 13 November; at that time the temperature of the surface had fallen to approximately 12 C. Thus, soil surface temperature did not appear to be a strong cue driving the onset of hibernation.

Other studies on hibernation in snakes (Viitanen, 1967; Aleksiuk, 1976; Sexton and Hunt, 1980) suggest that reversals in the soil temperature gradient from surface to deep burrow temperature may cue the onset of, and emergence from, hibernation. We also observed tortoises entering hibernation when surface soil temperatures fell below deep soil temperatures; however, the onset of hibernation ranged over a 44-day period, suggesting that this cue has a very weak influence at best.

Increasing photoperiod is hypothesized as an exogenous cue for the emergence of animals from hibernation (Gregory, 1982). During the 35-day range over which individuals terminated hibernation in the spring, the photoperiod would have become approximately 1.5 hours longer. If photoperiod were an important cue for terminating hibernation, we would expect tighter correlation of the termination dates among individuals.

Surface temperatures of the substratum have also been suggested as a cue that influences the timing of emergence. For example, Desert Tortoises in the west Mojave reportedly did not emerge from hibernation until surface temperatures reached 20 C (Voigt, 1972). Moreover,

Terrapene carolina and *T. ornata* in Missouri reportedly emerge from hibernation after five consecutive days of subsurface (10–20 cm) temperatures of 7 C or higher (Grobman, 1990). We did not observe a relationship between subsurface temperatures and the termination of hibernation at our sites.

Differences between air and surface temperatures in the fall and the spring have also been suggested as a cue for animals to begin or end hibernation (Sexton and Hunt, 1980; Gregory, 1982). However, to make such measurements, hibernating Desert Tortoises would be required to approach the surface and "test" the temperature for comparison with deep temperatures, and our results indicate no such behavior. For example, the animals at Littlefield that were in highly buffered hibernacula had no variation in body temperature while hibernating, not even just before they emerged (Fig. 2A). Thus, these animals were not apparently experiencing any external cues and were not sampling the environment, yet they emerged from hibernation at about the same time as other animals. We found that the dates of emergence from hibernation were not statistically correlated with the spring air temperatures at City Creek and Littlefield, with emergence date varying by 35 days at the sites. The average termination date was highly variable and not statistically different among the four study sites during the winter of 1998.

While there were large differences in the air temperatures at the four sites among years, the hibernacula chosen by the tortoises had similar thermal properties, and the average hibernation temperatures were well above outside air temperatures. It should be noted that tortoises chose one of the warmest microclimates in the environment for hibernation, which reduces the likelihood that hibernation is strictly an energy conservation strategy for these animals. Hibernating Desert Tortoises at Rock Valley, Nevada, had a similar duration as found in this study and had low metabolic costs and almost no loss of body mass during hibernation (Nagy and Medica, 1986), which is consistent with other reports for this species (Peterson, 1996; Henen et al., 1998). Tortoises in sites that had colder climates sought shelters that were deeper, and therefore had more stable temperatures as they were more buffered from the environment (Woodbury and Hardy, 1948). Some of the animals at the Littlefield site had body temperatures that had almost no fluctuation, not only on a daily basis, but also over the course of the entire winter.

The temperatures of reptile hibernacula have been previously reported to range between 1 and 15 C (Gregory, 1982). Our data generally fall within this range; however, some individuals chose hibernacula that had temperatures above it. The mean minimum and maximum hibernation temperatures in our study were similar to those observed in the San Pedro Valley, Arizona (Bailey et al., 1995). The female tortoises in Arizona, however, had lower minimum temperatures than did males, while there were no apparent differences in hibernation temperatures between the sexes of our study animals.

Our ability to quantify environmental variability and animal behavior has increased dramatically due to advances in micro-technology. The application of small temperature loggers allowed us to thoroughly examine hibernation behavior and temperatures and to test whether exogenous cues are likely driving hibernation behavior in Desert Tortoises. We found that the timing of hibernation behavior was sufficiently variable that we doubt this behavior is driven predominantly by exogenous cues. Hibernation may prevent tortoises from being exposed to extreme temperatures and potentially lethal ones in the winter, but the onset of hibernation, while variable within a site, was certainly always early enough to avoid this problem at our sites. It may be that endogenous conditions are more important drivers of hibernation than exogenous cues for this species.

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EXHIBIT 463

Public Review Draft

Recommendations of
Independent Science Advisors
for
The California
Desert Renewable Energy Conservation Plan
(DRECP)

Prepared For
Renewable Energy Action Team:

California Department of Fish & Game
U.S. Fish & Wildlife Service
U.S. Bureau of Land Management
California Energy Commission

Prepared By
The DRECP Independent Science Advisors

August 2010

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APPENDICES

1 Introduction

This report summarizes recommendations from a group of independent science advisors[1] for the California Desert Renewable Energy Conservation Plan (DRECP). DRECP will be a Natural Community Conservation Plan (NCCP) under California's NCCP Act of 2003. It may also serve as one or more Habitat Conservation Plans (HCP) under Section 10 of the U.S. Endangered Species Act. The NCCP Act requires input from independent scientific experts to ensure that plan decisions are informed by best available science. The advisors include experts in desert ecology, conservation biology, and other fields pertinent to informing how to conserve natural ecological communities and species in the planning region. Appendix A provides brief biographies of the advisors.

To ensure objectivity, the advisors operate independent of the plan applicants, their consultants, and other entities involved in the plan. Our recommendations are not legally binding on agencies or individuals involved in planning or implementing DRECP.

Contents of this report reflect the advisors' review of available information and maps of the DRECP process and planning area, results of a two-day science advisors' workshop, and subsequent research and discussions amongst the advisors. The science advisors met April 22-23, 2010, to hear the concerns of plan participants and begin formulating recommendations. Advisors were also encouraged to seek expert input from other scientists. We also reviewed various questions and comments submitted by agencies, stakeholders, and other interested parties before, during, and after the April 2010 science workshop (available at http://www.energy.ca.gov/33by2020/documents/). However, we made no attempt to specifically address submitted questions in a question-answer or response-to-comments format. Instead, we have attempted to address appropriate questions and comments intrinsically within our recommendations.

In general, our recommendations are organized to address four sets of principles for which the NCCP Act requires independent science input: principles for addressing data gaps and uncertainties; principles for conservation and reserve design; principles for conserving specific target species and natural communities; and principles and framework for an adaptive management and monitoring program. We also address certain aspects of the plan scope, including the geographic area, time period, species, natural communities, and actions that the plan is to cover. A previous draft of this report was circulated to other scientists for peer review, and comments received from four reviewers[2] are reflected in this draft.

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[1] Dr. Wayne Spencer, Conservation Biology Institute (Lead Advisor); Dr. Scott Abella, UNLV; Dr. Cameron Barrows, UC Riverside; Dr. Kristin Berry, USGS; Dr. Todd Esque, USGS; Kimball Garrett, Natural History Museum of LA County; Dr. Christine A. Howell, PRBO Conservation Science; Robin Kobaly, The SummertTree Institute; Dr. Reed Noss, U Central Florida; Dr.Richard Redak, UC Riverside; Dr. Robert Webb, USGS; Ted Weller, US Forest Service.

[2] Dr. Paul Beier, Northern Arizona U; Dr. James Patton, UC Berkeley (Emeritus); Dr. David Bedford, USGS; Mark Jorgensen, Anza Borrego Desert State Park (retired).

1.1 Philosophy and Approach

The advisors strongly agree that increasing the U.S. and California supply of renewable energy can yield numerous environmental and societal benefits, and that California's deserts have great potential for wind, solar, and geothermal energy production. However, siting and developing renewable energy developments must be done carefully, guided by best available science, to avoid undue damage to fragile desert ecosystems. Despite a widespread perception that our deserts are relatively pristine and secure, many desert species, natural communities, and ecological processes are already severely stressed by myriad human-induced changes to the landscape (Lovich and Bainbridge 1999, Berry and Murphy 2006, Bunn et al. 2007, Pavlik 2008, Webb et al. 2009a). Additional stress from direct and indirect effects of energy developments, in concert with a changing climate, portends further ecological degradation and the potential for species extinctions. Our intent is therefore to provide science-based recommendations for minimizing the adverse effects of energy developments on desert ecosystems and for contributing to the conservation and recovery of desert biota and ecosystem functions.

We understand that there are differences in the nature of impacts and mitigation actions among the various types of energy technologies, and that these technologies continue to evolve. However, we are not experts in renewable energy development, and our recommendations should be seen as one critical set of considerations for siting and designing renewable energy developments and mitigating adverse effects. We therefore have strived to allow for some flexibility in applying our recommendations.

We also understand that time is of the essence, and that fully complying with all of our recommendations prior to plan completion could cause significant delays. *This should not be used as an excuse to either ignore recommendations or to delay the plan to implement all recommendations.* We assume that in reviewing our recommendations, the planning team will determine which of them can and should be implemented immediately, and which can and should be implemented incrementally during planning, or even during plan implementation, as part of the recommended adaptive management process. For example, although we recommend a variety of field surveys and GIS-based modeling approaches to address information gaps, not all of these could feasibly be implemented in the near term, before important plan decisions must be made about siting developments or conservation actions. *We therefore strongly advocate using "no regrets" strategies in the near term—such as siting developments only in already disturbed areas—as more refined analyses become available to guide more difficult decisions.*

Finally, human understanding of desert ecosystems and species, and how they may be affected by various conservation, management, and development actions, is constantly evolving. We strongly encourage planners to recognize the dynamic nature of scientific knowledge and to seek and embrace continuous scientific input throughout the planning process and beyond. In essence, the plan should be treated as a huge environmental experiment with many uncertain outcomes. *This requires that the plan be developed and implemented incrementally in an adaptive management framework—with continuous monitoring and scientific evaluation to reduce uncertainties and improve plan actions over time.*

1.2 Overarching Issues and Recommendations

The advisors want to emphasize several overarching concerns and recommendations that permeate the more detailed recommendations that follow:

General Assumptions and Recommendations

- *Our recommendations only apply to a plan to facilitate renewable energy developments and their appurtenant facilities, and conservation and mitigation actions for biological resources;* they do *not* apply to other sorts of development, such as urban expansion, golf courses, or biofuels production (i.e., agricultural development). Such actions could fundamentally alter our assumptions and recommendations and would therefore require additional scientific input. Our recommendations also do not address other environmental impacts of renewable energy development, such as to cultural or scenic resources.

- *Every effort should be made to avoid and minimize any new disturbance of soil surfaces in the siting, design, construction, and maintenance of any and all project features.* Arid ecosystems are strongly shaped by characteristics of soils and other geological surfaces that develop over millennia and that cannot be replicated by human actions. *Therefore, ecological impacts of projects that alter surficial geology should be presumed permanent, despite any good intentions or promises to decommission renewable energy projects at the end of their useful life and restore what came before.* This does not mean that well-conceived efforts to decommission, restore, and revegetate have no ecological value, however—only that such actions can never be assumed to replicate original nature, and therefore cannot be considered full mitigation for the original impact.

- *Obtain additional independent scientific input and review of data, models, maps, and other analytical tools and products* at important milestones during the planning process. Given the huge scope of the plan, the complexity of the issues, and the limited time we've had to research and prepare this report, we suggest that additional scientific input and review of interim products will help reduce uncertainties, avoid costly errors, build support, and increase the potential to meet DRECP goals. For example, we recommend convening independent scientists to review any environmental data layers to be used for planning or analysis (e.g., new or revised vegetation maps or species distribution maps). Scientists should also provide guidance to, and review of, any models to be used during the process, including GIS overlay models, species distribution models, population models, reserve-design algorithms, and climate change models. An important function of periodic scientific review of conservation plans is to ensure that planners followed the recommendations of earlier independent scientific input—or provide valid reasons for not having followed earlier recommendations—and to make course corrections if necessary before it is too late.

Data and Analytical Tools

- *Invest in completing a seamless, up-to-date, high-resolution, hierarchical vegetation (or landcover) map* as soon as possible to support conservation planning, renewable energy facility siting, and conservation analyses. The lack of a comprehensive and dependable land-cover base map—which is an essential data layer for spatially explicit models, maps, and analyses—is a key information gap faced by the plan. This hinders the ability to reasonably

predict the plan's effects on target species and communities and to locate appropriate conservation and mitigation actions. The State Mapping Program (headed by Dr. Todd Keeler-Wolf, CDFG) has been mapping large areas of the state using the National Vegetation Classification System (NVCS) tailored for California, and represents the best available database. However, the program has only mapped about 60% of the Mojave Desert in California, and further progress is apparently hindered by funding constraints. This mapping effort should be funded, with *priority given to completing mapping for the rest of the DRECP planning area as soon as possible*. To allow the plan to make progress while this detailed mapping is completed (an estimated 18 months, given adequate funding), we recommend creating an "interim" or mid-level vegetation map by compiling new and existing vegetation maps, reformatting to allow for standardized representation at a mid-level hierarchy (e.g., using vegetation alliances or alliance groups), and edge-matching appropriately with adjoining states and Mexico.

- *Avoid using species observation locality data (e.g., from the California Natural Diversity Data Base, CNDDB) as a primary foundation for siting developments or conservation actions, and do not assume that absence of species observations means absence of the species.* Although CNDDB data are valuable, there are limitations to how they should be used to avoid misunderstandings. The advisors do not have faith in the interpretation of the "species sensitivity ranking" maps prepared by the Renewable Energy Action Team (REAT) that "the darker the color the higher the sensitivity." In part this is because we were not provided details concerning the ranking methods and criteria, and in part because CNDDB data were apparently the primary inputs. CNDDB data (and many other sorts of resource locality data) are presence-only data, and one cannot assume that areas lacking locality data (or "lighter in color") represent absence of species or low biological value. Moreover, CNDDB data exclude numerous available species locality data sources, do not reliably track taxa not considered rare, and generally do not differentiate among subspecies. This is important because there are many subspecies of conservation concern in the DRECP planning area that cannot be reliably located using CNDDB. Finally, for species or subspecies only recently designated as being of conservation concern, there may be few or no CNDDB entries. *CNDDB data are best used as inputs to spatially explicit distribution models (see below) or as supplements to other information sources rather than as primary predictors of species distribution and especially species absence.*

- Related to the preceding recommendation, *use appropriate, spatially explicit, dynamic, probabilistic maps and models to address information gaps* to the degree feasible. Examples include empirical (statistical) models of a species' probability of occurrence across the landscape based on survey data (e.g., Spencer et al. In Press)—or where survey data are inadequate, scientifically defensible habitat distribution models (e.g., Early et al. 2008); dynamic maps of ecological shifts expected under climate change (e.g., Stralberg et al. 2009, Wiens et al. 2009); and spatially explicit population models (e.g., Carroll et al. 2003, Carroll et al. In Press, Spencer et al. In Press) for select covered species having sufficient data (such as desert tortoise and bighorn sheep). Subject all such models to scientific peer review, sensitivity analysis, and quality assurance procedures to ensure reliability.

- *Make all analyses and decision-making processes as transparent and understandable as possible, and avoid maps that compile multiple data inputs into a single data layer without adequate documentation and justification.* For example, the advisors reviewed maps

prepared by the REAT showing "conservation opportunity areas" that were described as supporting "key populations or connections between key populations." Compositing this information into a single map color without differentiating the various species populations or connections comprising it, and without explaining the methods used to produce the composite, made it difficult for advisors (or the public) to understand the potential value or application of these maps. Moreover, this makes it impossible to compare differing biological values or constraints on different parts of the map, which is essential to insightful prioritizing or phasing of conservation actions. Future maps should clearly differentiate, for example, existing reserve areas, unconserved areas, habitat connectivity areas, species' ranges, or other important inputs to inform decision making. If a single summary or composite map is desired for simplicity (e.g., for public outreach), the individual data layers and how they were derived and treated in the composite should still be made available, and the compositing criteria and methods clearly articulated.

- *Match the scale and resolution of each analytical task to the scale and resolution of the issues being addressed.* Some aspects of the conservation design and analysis of plan effects could be performed over the entire planning area at relatively coarse resolution—such as a "GAP analysis"[3] of existing protected areas—whereas other issues—such as how the plan may affect populations of select covered species—should be performed at finer resolution over smaller portions of the planning area to increase their sensitivity and reliability. *Do not attempt "one-size-fits-all" approaches for designing and analyzing all aspects of the plan.*

- Related to the preceding recommendation, we recommend *subdividing the planning area into ecologically relevant planning subunits* that account for heterogeneity in climate, vegetation, geology, etc., across the region. Subdivisions could be based, for example, on the Ecological Sections and Subsections delineated by the USDA and USDI (Miles et al. 1998) or the units delineated for the Mojave Desert by Webb et al. (2009a). Ecologically relevant subdivisions can help account for geographic variations in, for example, the habitat affinities and physiological tolerances of species when using habitat suitability or climate-change sensitivity models. They can also help focus mitigation measures appropriately within areas where impacts occur. It would therefore be desirable for individual planning units to contain one or more clusters of proposed renewable energy projects or zones.

Siting and Mitigation Recommendations

- To the degree possible, *site all renewable energy developments on previously disturbed land* (areas where grading, grubbing, agriculture, or other actions have substantially altered vegetation or broken the soil surface); and *site all linear facilities within or alongside existing linear rights-of-way, paved roads, canals, or other existing linear disturbances, so long as this does not create complete barriers to wildlife movements or ecological flows.* Habitat fragmentation and impediments to wildlife movements are among the greatest threats to desert communities and species, and maximizing habitat connectivity is essential to climate change adaptation. The plan should embrace a primary goal of *avoiding and minimizing any additional habitat loss or fragmentation.* "Bundling" of developments along

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[3] A Gap Analysis is a quantitative, spatial assessment of how well a network of reserves protects elements of biodiversity. The "gaps" are those areas or elements not adequately represented within the reserve system.

such features as existing roads, transmission lines, and canals will help minimize additional fragmentation impacts, although there is potential for this to increase barrier effects of existing features to wildlife movement or ecological flows. The combined effects of both new and existing (or bundled) linear features on wildlife movement should be mitigated with appropriate crossing structures or corridors to facilitate wildlife movement, coupled with appropriate fencing to minimize roadkill and funnel wildlife to crossing structures.

- *Implement and improve on conservation actions identified by existing conservation and recovery plans in the planning area*, such as the Western Mojave Desert Plan, the Northern and Eastern Mojave Desert Plan, the Northern and Eastern Colorado Desert Plan, and the Desert Tortoise Recovery Plan. Considerable scientific input has already been applied in these plans to delineate important conservation areas and design specific conservation and mitigation actions to preserve and recover sensitive desert species and communities. However, most of these conservation actions have never been fully implemented, due to funding and staffing constraints at the responsible agencies (Bunn et al. 2007). *Mitigation for renewable energy developments should be used to help rectify this situation by providing funding to implement appropriate existing conservation plans and recommended recovery actions, and to improve these plans over time via the DRECP Adaptive Management and Monitoring Program.* In addition, The Nature Conservancy, SCWildlands, California Partners in Flight (CalPIF), and other conservation NGOs have been developing science-based maps and plans for conserving desert resources, and although the science advisors have not comprehensively reviewed their work or compared their approaches with our recommendations, we believe such assessments are valuable references for identifying important conservation areas and actions. To be efficient, *DRECP should use such existing conservation assessments and plans to advantage, supplementing and improving on them with peer review, as necessary, and with due consideration of our other recommendations.*

- Consider how energy developments may affect geomorphic systems and processes that sustain ecosystems and *avoid siting developments where they will disrupt essential physical geological processes.* Two important examples are eolian (wind-driven) systems such as active sand dunes, and low-slope alluvial fans that produce sheetwash that sustains downslope desert vegetation through runon. Avoid developments that might affect the production, transport, or settling of wind-blown sands or that could divert, disrupt, or channelize natural sheetflows.

- *Encourage renewable energy developments that maximize energy produced per unit land area.* Land disturbance for project footprints should be minimized to the degree feasible while maximizing energy production.

- *Encourage renewable energy developments that use less water,* such as air-cooled generators, to minimize groundwater overdraft. Groundwater flow paths should be clearly understood within the vicinity of water-cooled generation facilities to avoid impacts on groundwater-fed riparian ecosystems. *Water use from alluvial aquifers, such as those along the Mojave and Amargosa rivers, should be avoided to minimize impacts on riparian resources.*

2 Plan Scope

The scope of a conservation plan includes its biological goals, geographic extent, permit duration, species and communities to be addressed, and actions to be permitted.

2.1 Biological Goals

The delineation of clear objectives with measurable outcomes is central to the success of conservation planning. Objectives should guide the selection of conservation targets or goals, the structure of impact analyses, and the targets and measures selected for monitoring.

The NCCP Act (Sher 2001, California Senate Bill No. 107) states that the purpose of NCCP planning is "to sustain and restore those species and their habitat... that are necessary to maintain the continued viability of those biological communities impacted by human changes to the landscape" and that "it is the policy of the state to conserve, protect, restore, and enhance natural communities." Thus, while one objective of NCCPs and HCPs is to obtain authorizations (or permits) to "take" some habitat or individuals of listed or otherwise sensitive species, the broader goals are to sustain, restore, and enhance biological diversity and ecological functionality in general. The advisors recommend that the plan's overarching goal should be to *contribute to the persistence, distribution, and diversity of the desert biota and all its natural components and processes today and into the future, while accommodating renewable energy development and adapting to climate change.*

To create a plan that meets the goals of the NCCP Act, the advisors recommend that the plan (1) include explicit, hierarchical goals for the maintenance of biological diversity and ecosystem function in addition to goals for listed or sensitive species intended for permit coverage; (2) evaluate the impact of various planning scenarios on those biodiversity and ecosystem function goals, in addition to evaluating impacts on covered species; and (3) choose conservation strategies and policies that best satisfy this suite of biological goals while also meeting renewable energy goals.

2.2 Geographic Extent of Plan Area

The large geographic area addressed by the DRECP (Figure 1) is unprecedented for an NCCP and introduces tremendous complexity to the planning process. The plan area includes parts of the Great Basin, Mojave, and western Sonoran (or Colorado) deserts, as well as ecotones of these desert communities with the adjacent ecosystems in the Sierra Nevada, Tehachapi Mountains, Transverse Ranges (Western Transverse Ranges, San Gabriel, and San Bernardino mountains), and Peninsular Ranges (Baldwin et al. 2002). Three floristic and geographic subdivisions of California are represented: the California Floristic Province, Great Basin Province, and Desert Province. These floristic and geographic subdivisions can be further divided into regions based on climate (precipitation and temperature patterns), floristics, topography, and geology (e.g., Rowlands et al. 1982, 1995; Miles et al. 1998; Hereford et al. 2006; Webb et al. 2009a).

This large size and tremendous biogeographic and climatic diversity will make planning and analysis especially challenging. Species are naturally distributed unevenly across the landscape,

and the spatial scale and resolution need to be fit appropriately to each organism and analysis. In some cases analyses should be done at a subregional or local scale, while other analyses may need to cover the entire planning area. For example, for some species a single habitat suitability or climate-change sensitivity model covering the entire planning area may be less accurate than several subregional models that can account for differences in how a particular species selects habitat or responds physiologically to climate variables in different geographic regions. We therefore recommend dividing the planning area into several regions or planning units that are both ecologically relevant and potentially useful for dealing with the likely clustering of renewable energy developments in different regions. Examples of appropriate subdivisions include the Ecological Sections and Subsections delineated by the USDA and USDI (Miles et al. 1998; http://www.fs.fed.us/r5/projects/ecoregions/toc.htm) or the subdivisions delineated by Webb et al. (2009a) for the Mojave Desert. Figure 2 illustrates the Ecological Subsections of the Mojave Desert as delineated by Miles et al. (1998) (similar Subsection maps exist for the Sonoran and Colorado Desert Sections in California but are not included here). Figure 3 illustrates the Subdivisions of the Mojave Desert as recognized by Webb et al. 2009a). Note that Webb et al. (2009a) only covered the Mojave Desert, so if their system is used, similar subdivisions would need to be delineated for the Sonoran and Colorado deserts to recognize such regions as the Coachella Valley, Borrego Valley-West Mesa, Imperial Valley, and East Mesa-Sand Hills.

It is evident from various maps of proposed energy developments (e.g., BLM Solar Study Areas, Commercial Renewable Energy Zones [CREZ], and solar lease applications) that the developments are likely to be clustered. This suggests that conservation planning, impact analyses, and mitigation requirements should be focused at scales and in areas relevant to the clustered footprints of these likely renewable energy areas. Subdividing should therefore also consider likely clustering patterns, such that individual planning units include one or more of these clusters. This would focus conservation and mitigation actions appropriately within the affected regions.

We understand that the planning area was expanded beyond the deserts proper to include some adjacent mountain watersheds that have high wind-energy potential. The advisors point out that this adds even more complexity to the plan by affecting a wider array of non-desert communities and species. We are also unclear why this expansion into mountainous areas of high wind potential was not done consistently along the planning boundary—in particular why the planning area ends along the eastern boundary of San Diego County rather than including areas of high wind potential in the Peninsular Ranges to the west (NREL 50-m wind resource map; http://www.windpoweringamerica.gov/maps_template.asp?stateab=ca).
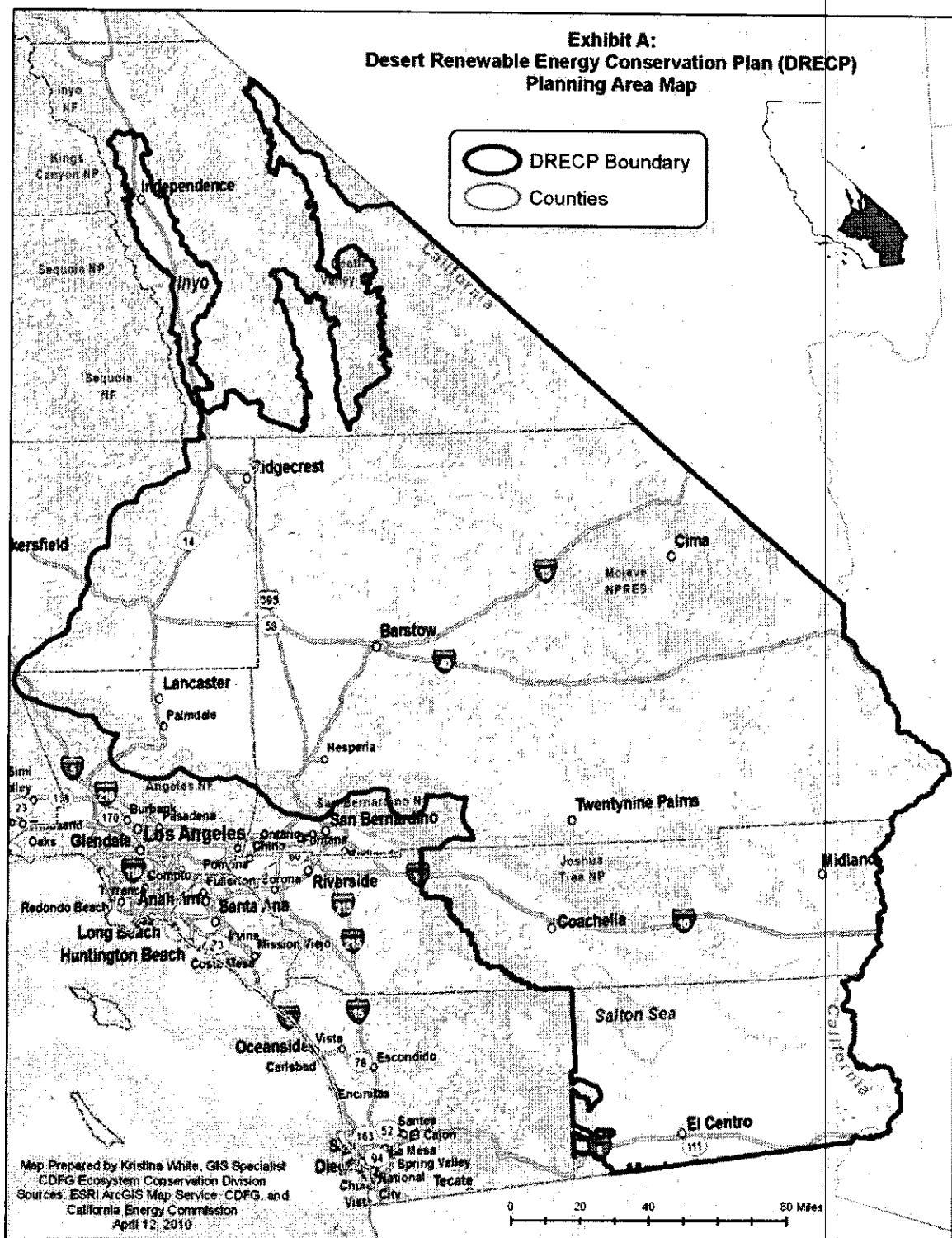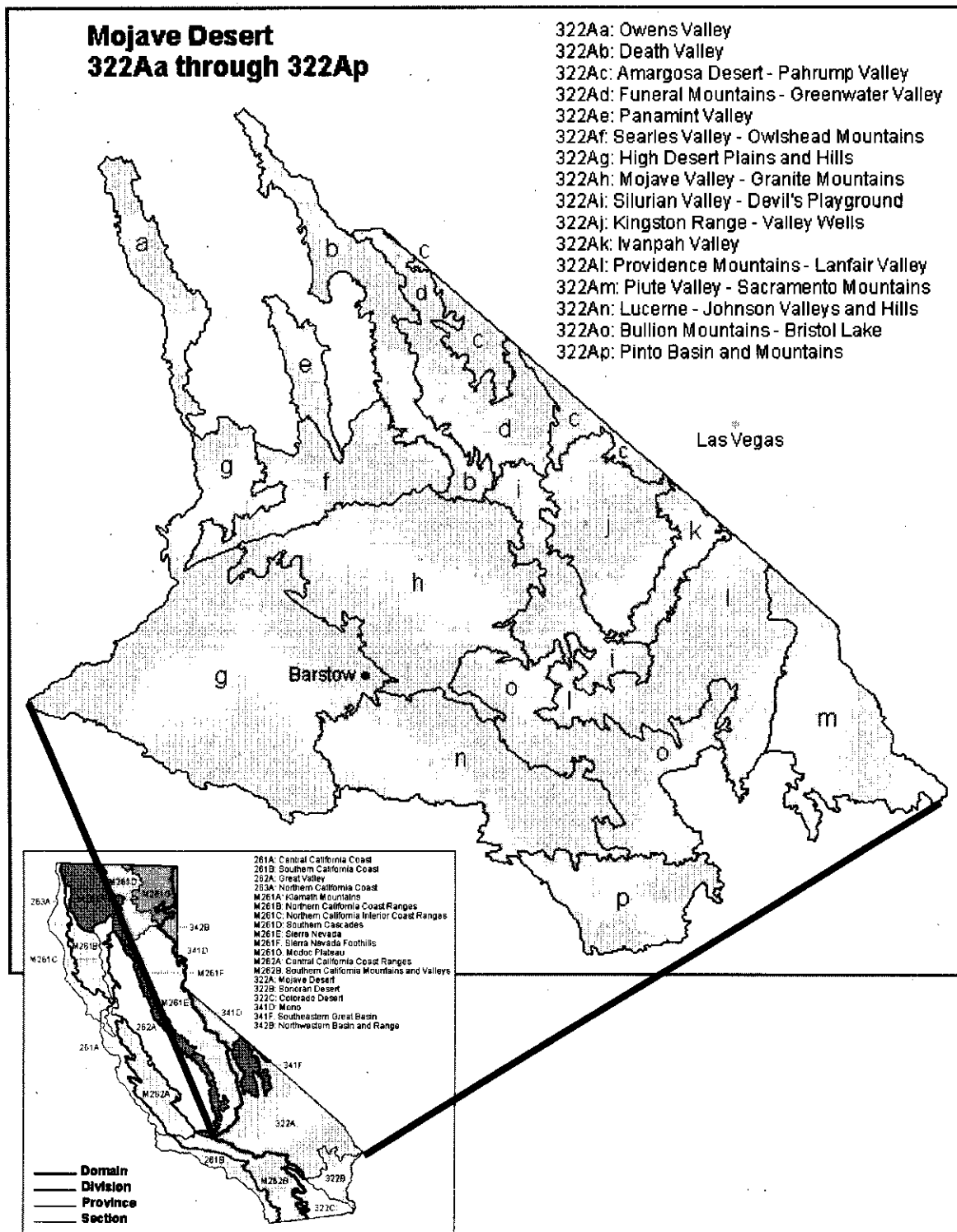
Figure 1. The DRECP Planning Area (Courtesy of CDFG).

Figure 2. Ecological Subsections of the Mojave Desert Section in California as delineated by Miles et al. (1998). The inset shows Ecological Sections in California.
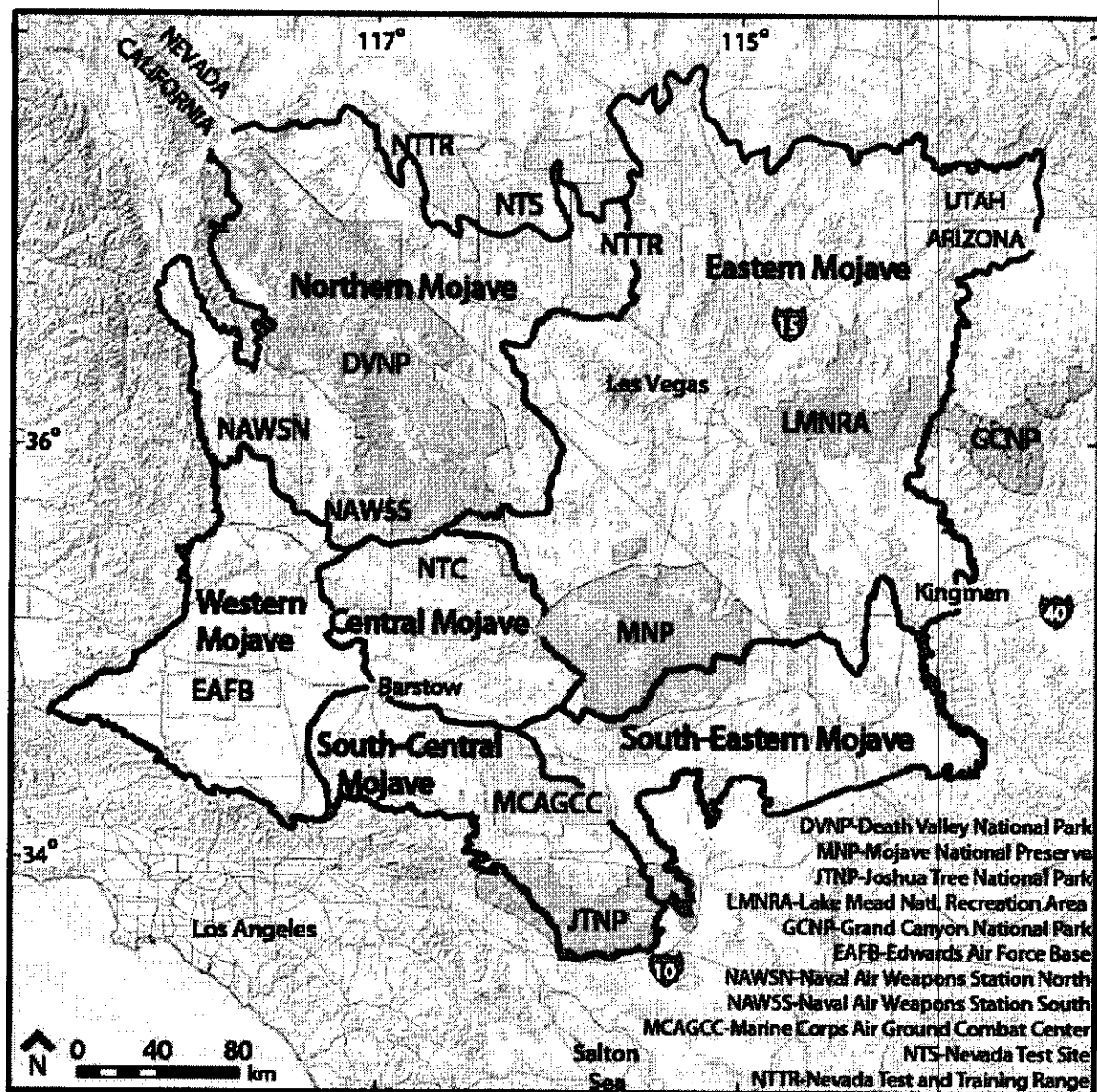
Figure 3. Subdivisions in the Mojave Desert delineated by Webb et al. (2009a).

2.3 Permit Duration

A permit term of 30 or 50 years is common for regional conservation plans (Rahn et al. 2006). *The advisors recommend 30 years as the maximum that is scientifically defensible in light of environmental variability, the pace of climate change, and the likely life of energy developments.* We do *not* support a longer (e.g., 50-year) duration, due to increasing uncertainties about biological effects, climate shifts, and technological changes with longer durations.

Regardless of permit duration, protections offered to biological resources (e.g., reserve areas and their management) are expected to continue in perpetuity. There should be no "walk-off" option, such that these protections are voided at the end of the permit duration. The plan should have built in requirements (such as bond funds) to ensure that remedial actions, such as decommissioning and ecological restoration, are implemented at the end of a development's useful life and that appropriate protections and management actions are continued in perpetuity. However, in recognition of the very long-term effects of surface disturbance in the desert, locations permitted for renewable energy may best be reused for similar purposes in the future (using whatever appropriate or best renewable energy technology is available at that time). If there is no need to reuse previously disturbed sites for new projects in the future, decommissioning and ecological restoration should be done using the best available and scientifically justified methods available at that time, recognizing that our current understanding of desert restoration is rudimentary. Although decommissioning and restoration may benefit DRECP species and communities, however, these future actions cannot be assumed to fully restore the original ecological conditions or full biological value of these sites, and remedial actions at the end of a project's life cannot be considered full mitigation for the project.

We also stress the importance of an effective monitoring and adaptive management program to ensure that plan goals are being met within and beyond any permit duration. Science-informed management intervention will be required to address changing conditions, including climate change, within and beyond the permit horizon. *We recommend that species statuses, species distributions, conservation needs, and other important aspects of the plan be reassessed at least every 10 years in light of changing conditions and accumulating information.*

2.4 Natural Communities

The plan should address the needs of whole, intact, natural communities and mosaics of communities at the landscape scale to accommodate natural ecological processes, including range shifts, rather than focusing just on individual species. The planning area supports hundreds of species—described, undescribed, and as of yet undiscovered—that are endemic to isolated communities or special habitat features, such as wetlands, desert wash woodlands, unique soil types, and active sand dunes. The only way to deal effectively with such species is to deal with entire communities, rather than focusing on the individual needs of every constituent species. Rare or unique desert communities and special features (such as dunes and springs), and the processes that sustain them (e.g., sand transport for dunes, groundwater aquifers for wetlands), should be "covered" by the plan in that they should be avoided to the degree possible by development and they should be foci for conservation actions. The plan should have a goal of

no anthropogenically induced loss of the rare natural communities, special features, and ecological processes described below.

Active sand dunes provide a stark example of the high degree of endemism in isolated and unique desert communities or features. The insular distribution of desert dunes, coupled with challenging habitat conditions, has resulted in isolation, local adaptations, and speciation. The Kelso Dunes alone have 10 described endemic arthropods (eight beetles, a sand-treader cricket, and a Jerusalem cricket); the Algodones Dunes have eight (seven beetles, one sand-treader cricket); and every southern California dune system that has received any level of taxonomic surveys has one or more endemic arthropods (at least 30 or 40 overall).

2.4.1 Vegetation Alliances and Unique Plant Assemblages

We recommend using the list of California Terrestrial Natural Communities and California Vegetation Alliances included as Appendix B (provided by Dr. Todd Keeler-Wolf, California Department of Fish and Game, June 2010) to define natural communities and vegetation alliances by region. These Natural Communities and Vegetation Alliances for the state are based on Grossman et al. (1998), Holland (1986), and Sawyer et al. (2009). Over 150 vegetation alliances occur in the planning area. Those that are composed of native species, are endemic to the state, have limited distributions, and are essential to supporting covered plant and animal species should be given conservation attention.

The advisors recommend that special protective measures be taken to conserve Unique Plant Assemblages (UPAs), Stands, or Vegetation Alliances that are limited in distribution or that support sensitive or endemic species (U.S. Department of the Interior, Bureau of Land Management 1980, California Department of Fish and Game 2009). These include the following:

- Those UPAs listed and shown on maps in the California Desert Conservation Area Plan (CDCA) of 1980 as amended. The categories in the CDCA Plan should serve as a starting point and are repeated here for convenience with a few examples: Great Basin enclaves; coastal California enclaves; montane enclaves (e.g., white fir forests in Clark, New York, and Kingston mountains); enclaves of unknown affinities (e.g. Chuckwalla Bench/Chocolate Mountains Munz cholla); plant assemblages that reach their range limits within the California deserts; unusual psammophytic (sand-dependent) assemblages; plant assemblages associated with springs, seeps, and near-surface waters; plant assemblages with unusually high density or cover of some particular species (e.g., Davies Valley Succulent Scrub Assemblage); and plant assemblages with individual members of which attain great age and/or size. Two additional examples from the CDCA are listed below, the first with a new title from the list of plant alliances:

    o Spinescale Scrub Alliance, dominated by *Atriplex spinifera* [aka Mojave saltbush]
    o Crucifixion Thorn Stands (*Castela emory*), a Special Stand

- Vegetation Alliances and UPAs associated with rivers, marshes, springs, seeps, near-surface waters, washes, ephemeral standing waters (small and large playas), and ephemeral standing waters adjacent to dune systems. A few examples are:

- o Desert willow woodland (*Chilopsis linearis* Alliance)
- o Blue palo verde-Ironwood woodland (*Parkinsonia florida-Olneya tesota* Alliance)
- o Smoke tree woodland (*Psorothamnus spinosus* Alliance)
- o Fremont cottonwood forest (*Populus fremontii* Alliance)
- o Arroyo willow thickets (*Salix lasiolepis* Alliance)
- o Yellow willow thickets *(Salix lutea* Alliance)
- o Mesquite bosque, mesquite thicket (*Prosopis glandulosa* Alliance)
- o Screwbean mesquite bosques (*Prosopis pubescens* Alliance)
- o Mulefat thickets (*Baccharis salicifolia* Alliance)
- o Black-stem rabbitbrush scrub (*Ericameria paniculata* Alliance)
- o Scale-broom scrub (*Lepidospartum squamatum* Alliance)
- o Bladder sage scrub (*Salazaria mexicana* Alliance)
- o Yerba mansa (*Anemopsis californica*) meadows (e.g., in Afton Canyon)
- o Desert panic grass patches (*Panicum urvilleanum*) (e.g., along the Mojave River)
- o California fan palm oasis (*Washingtonia filifera* Alliance)

- Vegetation Alliances associated with rare, threatened, and endangered animals, e.g.:

  - o Creosote bush-white bur sage scrub (*Larrea tridentata-Ambrosia dumosa* Alliance) supporting big galleta (*Pleuraphis rigida*) or a diverse shrub layer
  - o Spinescale Scrub Alliance, dominated by *Atriplex spinifera* [aka Mojave saltbush]
  - o Spiny hop sage scrub (*Grayia spinosa* Alliance)

- Once wide-spread vegetation alliances, now limited and rapidly diminishing because of development, e.g.:

  - o California poppy fields (*Eschscholzia californica*)
  - o Joshua Tree Woodlands alliance (*Yucca brevifolia* alliance)—diminished stands in western Mojave Desert

Current scientific standards are available for classifying the uniqueness of vegetation alliances through NatureServe's Community Heritage Program, which is internationally recognized as the Natural Communities Conservation Ranking system. This system includes global uniqueness ranking (G rankings) and state (S rankings) as well as a threats ranking. It therefore provides recognition of rare and unusual plant assemblages. The ranking is categorized into five distributions. The advisors recommended that vegetation alliances occurring within the following global and state rankings be covered by DRECP:

- G1, S1 – critically imperiled; fewer than 6 viable occurrences worldwide/statewide and/or up to 518 hectares known;
- G2, S2 – imperiled; 6-20 viable occurrences worldwide/statewide and/or more than 518 – 2,950 hectares known;
- G3, S3 – vulnerable; 21-100 viable occurrences worldwide/statewide and/or more than 2,950 – 12,950 hectares known.

These rankings capture not only the rarity of the alliance within the state boundaries but also outside of the state. All of these alliance rankings are considered "rare and threatened"

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throughout the alliance's range (Sawyer et al. 2009). High priority for conservation should be focused on those alliances and associations that have a threat ranking of 0.1 (Very Threatened) and 0.2 (Threatened). Because our knowledge of the distribution of rare and unusual vegetation alliances in the California desert is currently incomplete, it is imperative that additional vegetation mapping be completed throughout the desert regions. The advisors recommend that new data be incorporated into the database for the DRECP, and recognized and incorporated through the adaptive management strategy.

2.5 Covered Species

Typically, NCCP/HCPs identify a list of species[4] to be covered by "take authorizations" using several selection criteria, including their conservation status, occurrence in the plan area, likelihood of being affected by plan actions, and sufficiency of knowledge to determine plan effects: We agree with this general approach, but offer some further guidance concerning these selection criteria:

- **Conservation Status.** Covered species typically include those species, subspecies, or distinct population segments (hereafter, collectively called species) that are listed under state or federal Endangered Species Acts or that are considered likely to be listed during the plan's permit duration. These generally include California "Species of Special Concern" (also known as the Special Animals List) or other taxa that meet one or more criteria for listing as threatened or endangered but that have not been legally protected.

- **Occurrence in Plan Area.** Consideration should be given to all species known or likely to occur in the planning area, *during the plan's permit duration.* Note that it is quite possible that some species not currently known from the planning area could enter the planning area over the next 30 to 50 years due to climate change or other dynamics.

- **Plan Effects.** Species likely to be affected, whether positively or negatively. Often, planners only consider those species that may be adversely affected ("taken") by covered actions. However, some species may benefit from the conservation actions in the plan although they may not be adversely affected by development of renewable energy facilities.

- **Information Adequacy.** Species for which we do not have adequate information to determine how covered actions may affect them, or what conservation actions may benefit them, are often omitted from covered species lists. However, we recommend that the covered species list be kept relatively comprehensive despite such uncertainties. Data gaps that interfere with our ability to assess plan effects can be reduced over time via the adaptive management and monitoring program, ecological research, and advances in predictive modeling (e.g., for species' distributions and responses to plan actions or climate change). However, if little-known species are left off the covered species list due to information gaps, they are less likely to garner the research and monitoring attention needed to close those gaps and ensure their conservation.

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[4] Note that under the Endangered Species Act, species, subspecies, or distinct population segments can be listed as threatened or endangered. Distinct population segments are populations of a species that are distinct, relatively reproductively isolated from other populations of the species, and represent a significant evolutionary lineage of the species. Throughout this document, we use the word species to refer to all three categories (species, subspecies, or distinct population segment).

The advisors reviewed a preliminary list of species of "planning interest" included in Exhibit B of the DRECP Planning Agreement (dated March 2010; Table 1). We noted a variety of errors, including inappropriate inclusion of full species rather than subspecies of conservation concern, inclusion of species not found in the planning area, exclusion of species or subspecies of conservation concern that do occur in the plan area, and apparently a lack of consideration of information from previous conservation and recovery plans. The following sections address these issues in more detail by major taxonomic groupings. They provide *examples* of apparent errors of omission and commission in the current species list and recommendations for assembling a more defensible covered species list. *We recommend that DRECP form a committee or subcommittee of qualified biologists to prepare a proposed covered species list based on the factors described above, and considering information presented in this section.*

We also recommend that any *future lists of species produced for DRECP be organized in traditional taxonomic order using scientific nomenclature*. The current list included as Table 1 is organized alphabetically by common name, with no regard for taxonomic hierarchy or species relations. Some species and subspecies of conservation concern in the planning area do not have common names and can only be identified by scientific name. Because there is no standardized list of common names for most taxa (with the exception of North American birds, for which the American Ornithologists Union establishes standardized list) multiple species may share the same common name, or the same species may have multiple names. Scientific nomenclature exists to avoid such confusion.

Table 1. "Preliminary list of species of planning interest" included as Exhibit B of the DRECP Planning Agreement (March 2010). *This is **not** included here as a recommended covered species list because it contains errors and requires substantial revision (see text).*

Common Name	Scientific Name	CESA	ESA	California Special Concern	BLM Sensitive
ANIMALS					
Arizona myotis	*Myotis occultus*			X	
Arroyo toad	*Anaxyrus californicus*		Endangered		
Arroyo toad	*Bufo californicus*			X	
Bald eagle	*Haliaeetus leucocephalus*	Endangered	Delisted		
Barefoot gecko	*Coleonyx switaki*	Threatened			
Bendire's thrasher	*Toxostoma bendirei*				X
Bewick's wren	*Thryomanes bewickii*			X	
Big free-tailed bat	*Nyctinomops macrotis*			X	
Bighorn sheep	*Ovis canadensis*	Threatened	Endangered		
Burrowing owl	*Athene cunicularia*			X	X
Cactus wren	*Campylorhynchus brunneicapillus*			X	
California black rail	*Laterallus jamaicensis coturniculus*	Threatened			
California condor	*Gymnogyps californianus*	Endangered	Endangered		
California leaf-nosed bat	*Macrotus californicus*			X	X

Common Name	Scientific Name	CESA	ESA	California Special Concern	BLM Sensitive
California pocket mouse	*Chaetodipus californicus*			X	
Cave myotis	*Myotis velifer*			X	X
Coachella Valley fringe-toed lizard	*Uma inornata*	Endangered	Threatened		
Coachwhip	*Masticophis flagellum*			X	
Colorado desert fringe-toed lizard	*Uma notata*			X	X
Common ensatina	*Ensatina eschscholtzii*			X	X
Common yellowthroat	*Geothlypis trichas*			X	
Crissal thrasher	*Toxostoma crissale*			X	
Desert night lizard	*Xantusia vigilis*			X	
Desert tortoise	*Gopherus agassizii*	Threatened	Threatened		
Desert woodrat	*Neotoma lepida*			X	
Ferruginous hawk	*Buteo regalis*				X
Flat-tail horned lizard	*Phrynosoma mcallii*			X	X
Fringed myotis	*Myotis thysanodes*				X
Gila monster	*Heloderma suspectum*			X	X
Gila woodpecker	*Melanerpes uropygialis*	Endangered			
Gilded flicker	*Colaptes chrysoides*	Endangered			
Golden eagle	*Aquila chrysaetos*				X
Gray vireo	*Vireo vicinior*			X	X
Inyo Mountains salamander	*Batrachoseps campi*			X	X
Least Bell's vireo	*Vireo bellii pusillus*	Endangered	Endangered		
Le Conte's thrasher	*Toxostoma lecontei*			X	
Little pocket mouse	*Perognathus longimembris*			X	X
Loggerhead shrike	*Lanius ludovicianus*			X	
Long-eared myotis	*Myotis evotis*				X
Long-eared owl	*Asio otus*			X	
Lucy's warbler	*Vermivora luciae*			X	
Merriam's kangaroo rat	*Dipodomys merriami*			X	
Mojave fringe-toed lizard	*Uma scoparia*			X	X
Mountain plover	*Charadrius montanus*			X	
Nelson's antelope squirrel	*Ammospermophilus nelsoni*	Threatened			
Orange-throated whiptail	*Aspidoscelis hyperytha*			X	
Pallid bat	*Antrozous pallidus*			X	X
Palm Springs round-tailed ground squirrel	*Spermophilus tereticaudus chlorus*		Candidate		
Panamint alligator lizard	*Elgaria panamintina*			X	X
Pocketed free-tailed bat	*Nyctinomops femorosaccus*			X	
Quino checkerspot butterfly	*Euphydryas editha quino*		Endangered		
Rosy boa	*Charina trivirgata*				X
Round-tailed ground squirrel	*Spermophilus tereticaudus*			X	
Rufous-crowned sparrow	*Aimophila ruficeps*			X	

Common Name	Scientific Name	CESA	ESA	California Special Concern	BLM Sensitive
Sage sparrow	*Amphispiza belli*			X	
Snowy plover	*Charadrius alexandrinus*		Threatened	X	
Southern rubber boa	*Charina umbratica*			X	
Spotted bat	*Euderma maculatum*			X	X
Summer tanager	*Piranga rubra*			X	
Swainson's hawk	*Buteo swainsoni*	Threatened			
Tehachapi slender salamander	*Batrachoseps stebbinsi*	Threatened			
Townsend's big-eared bat	*Corynorhinus townsendii*			X	
Vermilion flycatcher	*Pyrocephalus rubinus*			X	
Western mastiff bat	*Eumops perotis*			X	X
Western patchnose snake	*Salvadora hexalepis*			X	
Western pond turtle	*Actinemys marmorata*			X	X
Western red bat	*Lasiurus blossevillii*			X	
Western skink	*Eumeces skiltonianus*			X	X
Western small-footed myotis	*Myotis ciliolabrum*				X
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	Endangered	Candidate		
Willow flycatcher	*Empidonax traillii*	Endangered			
Yellow warbler	*Dendroica petechia*			X	
Yellow-breasted chat	*Icteria virens*			X	
Yuma clapper rail	*Rallus longirostris yumanensis*	Threatened	Endangered		
Yuma myotis	*Myotis yumanensis*				X
PLANTS					
Bird-foot checkerbloom	*Sidalcea pedata*	Endangered	Endangered		
Coachella Valley milk-vetch	*Astragalus lentiginosus* var. *coachellae*		Endangered		
Cushenbury buckwheat	*Eriogonum ovalifolium* var. *vineum*		Endangered		
Cushenbury milk-vetch	*Astragalus albens*		Endangered		
Cushenbury oxytheca	*Acanthoscyphus parishii* var. *goodmaniana*		Endangered		
Cuyamaca larkspur	*Delphinium hesperium* ssp. *cuyamacae*	Rare			
Lane Mountain milk-vetch	*Astragalus jaegerianus*		Endangered		
Mojave tarplant	*Deinandra mohavensis*	Endangered			
Owens Valley checkerbloom	*Sidalcea covillei*	Endangered			
Red Rock tarplant	*Deinandra arida*	Rare			
Santa Ana River woollystar	*Eriastrum densifolium* ssp. *sanctorum*	Endangered	Endangered		
Slender-petaled thelypodiu	*Thelypodium stenopetalum*	Endangered	Endangered		
Southern mountain buckwheat	*Eriogonum kennedyi* var. *austromontanum*		Threatened		
Triple-ribbed milk-vetch	*Astragalus tricarinatus*		Endangered		

2.5.1 Mammals

Table 1 contains significant errors of omission and commission concerning potential covered mammal species. A number of mammal taxa were included in Table 1 on the basis that they are California Mammal Species of Special Concern (MSSC), but without appropriate recognition of subspecific designations and ranges. Note that the MSSC list is currently being revised by a team of mammalogists that are reviewing all available data on the status and distribution of mammals in California (W. Spencer, S. Osborn, et al., In Prep.). The MSSC team has compiled a large database of mammal locality data and is preparing range maps and other information for peer review. A final MSSC list and assessment document is scheduled for completion by May 2011. We recommend finalizing the list of potential covered mammals in late 2010, by which time the draft list of MSSC, along with refined range maps, should be available.

In the meantime, the following species could be *removed* from the potential covered species list due to relatively low level of conservation concern within the planning area, or lack of occurrence in the planning area:

- **California pocket mouse** (*Chaetodipus californicus*). This species of pocket mouse is widespread and common in California, mostly in shrublands outside of desert regions. Although one subspecies, *C.c. femoralis*, is a current California MSSC, it is associated with coastal sage scrub outside the current planning area boundaries.

- **Desert woodrat** (*Neotoma lepida*). This is a very common and widespread species throughout California's desert regions. Although one subspecies (*N.l. intermedia*) is a current MSSC, it is associated with coastal sage scrub outside the current planning area boundaries. Moreover, the taxonomy of the *Neotoma lepida* group was recently revised by Patton et al. (2007), which removed a number of former *N. lepida* subspecies, subsuming some within other species of *Neotoma,* including *N.l. intermedia,* which is now *N. bryanti intermedia.* The status of all species and subspecies in the revised taxonomy is currently under review, but at this point it seems unlikely that any *Neotoma* species or subspecies in the DRECP study area will be considered to be of conservation concern.

- **Merriam's kangaroo rat** (*Dipodomys merriami*). This smallest of the kangaroo rat species is common and widespread throughout the deserts, and it is not of conservation concern throughout most of its range. One subspecies of *D. merriami* is federally Endangered (the San Bernardino kangaroo rat, *D.m. parvus*), but it occurs outside the DRECP area, west of the San Bernardino and San Jacinto Mountains. Similarly, another highly restricted and impacted subspecies (the earthquake kangaroo rat, *D. m collinus*) occurs outside the DRECP area in sandy upland valleys in the Peninsular ranges in San Diego County and southernmost Riverside County. Finally, although *D.m. arenivagus* has a highly restricted range that is partially within the plan area, west of the Salton Sea, it is not currently an MSSC and does not appear likely to be added to the MSSC list.

- **Nelson's antelope squirrel** (*Ammospermophilus nelsoni*). This state Threatened species of ground squirrel is found in the San Joaquin Valley, outside the DRECP plan area.

- **Yuma myotis** (*Myotis yumanensis*). Although considered sensitive by the BLM, the Yuma myotis is widely distributed, roosts in a wide variety of natural and anthropogenic structures, and appears well adapted to survival in close proximity to humans. It is considered low-

medium priority for conservation by the Western Bat Working Group. Its potential for listing over the next 30-50 years is minimal.

The following species can be **retained** on the potential covered species list for DRECP even though, *at the full species level,* they are quite common and widespread. Nevertheless, *several rare or narrowly distributed subspecies of these species are of conservation concern in the planning area. We recommend considering each subspecies individually for inclusion or exclusion from the covered species list,* as detailed here:

- **Little pocket mouse** (*Perognathus longimembris*). This small, silky pocket mouse is associated with fine sandy soils throughout California's deserts and some southern California cismontane (west of the coastal mountains) basins and coastal plains. Although the species as a whole is quite common and widespread, it has a number of rare, endemic subspecies that are of conservation concern, *each of which should be treated separately as a covered species*:

  o *P.l. bangsi* (Palm Springs pocket mouse) is restricted to fine sandy soils in the Coachella Valley and southern portions of Joshua Tree National Park, south along either side of the Imperial Valley to about the Mexican border (Ocotillo). It is a current MSSC and will likely remain on the MSSC list due to its highly restricted range and loss of most of its habitat on the Coachella and Imperial Valley floors (Brylski et al. 1998).

  o *P.l. bombycinus* (no common name) ranges from Baja California, Mexico, into the southern and eastern Colorado Desert in California (Brylski et al. 1998). It is a current MSSC that is likely to remain on the list due to restricted distribution and habitat loss.

  o *P.l. brevinasus* (Los Angeles pocket mouse) is restricted primarily to cismontane basins outside the DRECP plan area; accept where it intergrades with *P.l. bangsi* in the San Gorgonio Pass-Palm Springs area (Brylski et al. 1998). It is a current MSSC and will likely remain on the list due to its highly restricted distribution and loss and fragmentation of populations by urban development.

  o *P.l. internationalis* (Jacumba pocket mouse) is found southwest of the Salton Sea and into Baja California, Mexico. Due to restricted range, there is some potential it will become an MSSC, but it is unclear whether it occurs within current DRECP boundaries.

  o *P.l. salinensis* (no common name) is known only from within Death Valley National Park, so it is unlikely to be affected by plan actions (J. Patton, personal communication).

  o *P.l. tularensis* (no common name) is restricted to the Kern Plateau, probably outside of DRECP boundaries (J. Patton, personal communication).

- **Round-tailed ground squirrel** (*Spermophilus* [now *Xerospermophilus*] *tereticaudus*)[5]. This species is fairly common and widespread in the Colorado and Mojave Deserts south and east of the Mojave River. At the full-species level, it is not of elevated conservation concern.

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[5] A common issue with CNDDB and California's Species of Special Concern lists is that they do not keep up with taxonomic changes. For example, the genus *Spermophilus* was recently split into eight genera based on substantial morphological, genetic, ecological, and behavioral variation (Helgen et al. 2009). Although in this particular case, the change did not affect the conservation status of the taxa in DRECP, in other cases it does, and these differences cannot be ascertained from CNDDB or CWHR data and range maps.

However, the subspecies *S.t. chlorus* (Palm Springs ground squirrel) has a very limited distribution in the Coachella Valley, where much of its sandy habitat has been lost to development. The Palm Springs ground squirrel is an MSSC and a federal Candidate for listing, and is highly likely to remain an MSSC with potential to become listed as Threatened or Endangered. *We therefore recommend retaining X.t. chlorus, but **not** the full species of X. tereticaudus, as a candidate for coverage under DRECP.*

The following species should be ***added*** as potential covered species because they are found in the planning area, are of conservation concern, and could be affected by the plan:

- **Tehachapi pocket mouse** (*Perognathus alticolus inexpectatus*). This MSSC is restricted to a narrow range along the western-most edges of the Mojave Desert and adjacent slopes of the Tehachapi and San Gabriel Mountains. It has only been detected from the vicinity of Tehachapi Pass, west to Mount Pinos, and south to Elizabeth and Quail Lakes, between 1030 and 1830 m elevation. This range corresponds closely with areas of high wind energy potential (NREL wind potential maps).

- **Yellow-eared pocket mouse** (*Perognathus parvus xanthonotus*). Although not currently on the MSSC list[6], this narrow-endemic pocket mouse is BLM sensitive and likely to be added to the MSSC list. It is known from only four localities on the eastern slope of the Tehachapi Mountains at Horse, Sage, Freeman, and Indian Wells canyons, between 1400 and 1615 m elevation. This range coincides with an area of high wind-energy potential.

- **Mohave ground squirrel** (*Spermophilus [Xerospermophilus] mohavensis*). This state-listed Threatened species was clearly an inadvertent omission from the preliminary list of species (Table 1), as it is a key species of concern in areas with high solar development potential in the western Mojave Desert.

- **Mojave River vole** (*Microtus californicus mohavensis*). This subspecies of the California vole is an MSSC. It is restricted to areas along the margins of the Mojave River where water comes to the surface due to shallow water table, in and near Victorville and Oro Grande. Although it is unlikely to be directly impacted by energy developments, any actions that might affect the hydrology of the Mojave River would be detrimental. A *Mictrotus californicus* population also occurs at Harper Lake Marsh about 10-15 miles northwest of Barstow. Although it is unknown whether this is *M.c. mohavensis* or another, less sensitive subspecies, any populations of voles or other species restricted to isolated wetland habitats in the desert may be unique and should be considered sensitive. The advisors recommend avoiding developments that could reduce the water table at Harper Lake or any other desert wetlands.

- **Amargosa River vole** (*Microtus californicus scirpensis*). This subspecies of the California vole is both federally and state-listed as Endangered. It is associated with Olney bulrush (*Scirpus olneyi*) marshes along the Amargosa River, and is found in disjunct populations that may be temporary in nature (Bleich 1998). Although this species is unlikely to be directly

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[6] Although Williams (1986) originally included yellow-eared pocket mouse as an MSSC, Brylski et al. (1998) placed it on an MSSC "Watch List" due to lack of sufficient information.

impacted by energy developments, any actions that may affect hydrology of the Amargosa River would be detrimental.

- **Hoary bat** (*Lasiurus cinereus*). Although this species is widely distributed and unlikely to be listed as threatened or endangered in the near future, hoary bats are the most frequently killed species at wind energy developments in North America (Arnett et al. 2008) and have been recorded as fatalities at wind energy facilities within the DRECP (Chatfield et al. 2009). Given the cumulative impacts of massive expansion of utility-scale wind energy development in the United States, combined with low reproductive rates of bats, there is some potential for hoary bats to be added to one or more special status lists within the next 30-50 years.

- **Western yellow bat** (*Lasiurus xanthinus*). This species is currently on the MSSC list and a large proportion of its distribution in California is within the DRECP area. Fatalities of this species have been recorded within the DRECP area (Chatfield et al. 2009).

2.5.2 Birds

The Draft Covered Species List (Table 1) requires modification to reflect the latest listings by the California Department of Fish and Game and the United States Department of Interior, as well as to apply more accurately to relevant subspecies and other infraspecific categories. In many cases the California Bird Species of Special Concern list (hereafter BSSC; Shuford and Gardali 2008) limits the seasonal or infraspecific application of its listings. United States Fish and Wildlife Service (USFWS) listings also need to be updated, resulting in some additions to the covered species list (see below).

Subspecies taxonomy is in a state of flux for North American birds. The most recent formal treatment of subspecies by the American Ornithologists' Union Committee on Classification and Nomenclature was published in 1957 (AOU 1957); more recent formal checklists (e.g., AOU 1998) do not include subspecies, although well-marked infraspecific groups may be annotated. Current trends recognize the utility and convenience of subspecies (Fitzpatrick 2010) and the need for more quantitative diagnoses of subspecies (e.g. Remsen 2010). Without refinement of subspecies treatments, conservation efforts can be confused or even hampered (Haig and D'Elia 2010).

We recommend that the following species be *removed* from the list of potentially covered species:

- **Bewick's wren** (*Thryomanes bewickii*). No mainland subspecies in western North America have formal conservation status. The widespread cismontane subspecies *charienturus* occurs in the western margins of the Mojave and Colorado deserts, and the Great Basin subspecies *eremophilus* occurs in the higher elevations of the northeastern Mojave Desert; there are no indications of declines of either taxon on the California deserts.

- **Cactus wren** (*Campylorhynchus brunneicapillus*). Although this species needs to be considered in desert conservation planning, populations in the DRECP area have no formal conservation status. The California BSSC designation applies only to the coastal subspecies *sandiegensis* from southern Orange County through coastal San Diego County (Shuford and Gardali 2008), though the remaining coastal populations north to Los Angeles and Ventura

Counties (considered part of the widespread desert subspecies anthonyi) are similarly imperiled. Widespread *anthonyi* of the Mojave and Colorado Deserts has no formal status.

- **Le Conte's thrasher** (*Toxostoma lecontei*). Although this is an important planning species in the California deserts, the nominate subspecies of the Mojave and Colorado Desert has no formal BSSC status (such status applies only to the San Joaquin Valley population; Shuford and Gardali 2008).

- **Common yellowthroat** (*Geothlypis trichas*). Only the San Francisco Bay subspecies *sinuosa* has BSSC status; breeding populations and widespread migrants on the deserts have no formal or informal conservation status.

- **Rufous-crowned sparrow** (*Aimophila ruficeps*). Only the northern Channel Island endemic subspecies *obscura* has BSSC status. Otherwise this species is west of the deserts, except for small, local populations of the interior subspecies *scottii* in the higher portions of the eastern Mojave Desert, which have no formal status but which should be addressed if its limited habitats undergo potential impact.

- **Sage sparrow** (*Amphispiza belli*). Although cismontane nominate *belli* has shown local declines, it is not present in the deserts. Formal status (ESA Threatened and BSSC) applies only to the endemic subspecies of San Clemente Island. The breeding subspecies in the DRECP planning area is *canescens*; it has no formal status but may be an important indicator species of alkali scrub and other desert scrub habitats.

The following species should be *retained* on the list of potentially covered species, although their designations need modification in Table 1:

- **Snowy plover** (*Charadrius alexandrinus*). Delete ESA Threatened designation in Table 1, which only applies to coastal populations (to 50 miles inland, which might border portions of the planning area, e.g. in the Lancaster area); add California BSSC designation (which applies to interior California populations).

- **Willow flycatcher** (*Empidonax traillii*). Add ESA Endangered status, which applies to the subspecies *extimus* ("Southwestern Willow Flycatcher") which breeds along the lower Colorado River and (at least formerly) elsewhere in desert riparian areas.

- **Bendire's thrasher** (*Toxostoma bendirei*). Add California BSSC designation.

- **Yellow warbler** (*Dendroica petechia*). The table should clarify that both the subspecies *sonorana* (lower Colorado River) and *brewsteri* (widely in cismontane California, and locally in desert riparian areas) are listed as California BSSCs and treated in separate accounts in the BSSC publication (Shuford and Gardali 2008).

The following species should be considered for *addition* to the list of covered species by virtue of conservation status:

- **Fulvous whistling-duck** (*Dendrocygna bicolor*). California BSSC; breeds (now very rarely) in freshwater areas along and bordering the southern portion of the Salton Sea, and regular but declining as a post-breeding visitor to that area. All Salton Sea bird species are potentially impacted by geothermal and solar energy development and associated transmission lines.

- **Redhead** (*Aythya americana*). California BSSC; breeds locally in desert wetlands, including Piute Ponds on Edwards AFB, wetlands in eastern Kern County, and the Salton Sea.

- **California brown pelican** (*Pelecanus occidentalis californicus*). Although recently de-listed by ESA and CESA, the California brown pelican remains a California Fully Protected Species, and de-listed species still require conservation monitoring and protection. This species is a regular visitor (mainly in summer and fall) to the Salton Sea and has made breeding attempts there. It occurs only casually elsewhere on the California deserts.

- **Least bittern** (*Ixobrychus exilis*). California BSSC (breeding populations); a local breeder in freshwater wetlands on the deserts; more numerous at the Salton Sea and elsewhere in the Imperial Valley and lower Colorado River.

- **Wood stork** (*Mycteria americana*). California BSC. Regular post-breeding visitor from colonies in Mexico to the southern (mainly southeastern) shoreline of the Salton Sea and nearby freshwater lakes.

- **Northern harrier** (*Circus cyaneus*). California BSSC (breeding populations); local breeder in marshes and (after years of high rainfall?) annual growth in the Imperial Valley and Mojave Desert.

- **Peregrine falcon** (*Falco peregrinus*). Although recently de-listed by ESA and CESA, such de-listed species still require conservation monitoring and protection.

- **Lesser sandhill crane** (*Grus canadensis canadensis*). California BSSC; wintering population in the Imperial Valley and probably lower Colorado River

- **Greater sandhill crane** (*Grus canadensis tabida*). California ESA Threatened; small numbers likely winter population in the Imperial Valley.

- **Van Rossem's gull-billed tern** (*Gelochelidon nilotica vanrossemi*). California BSSC; candidate for ESA Threatened/Endangered species status as of June 2010. Breeds at the Salton Sea (mainly southern end); also uses upland and agricultural areas of Imperial Valley for foraging.

- **Elf owl** (*Micrathene whitneyi*). California ESA Endangered. Highly endangered and nearly extirpated from California, with very local breeding populations (most now eliminated) along the lower Colorado River and west to Corn Spring in the Chuckwalla Mountains.

- **Long-eared owl** (*Asio otus*). California BSSC (breeding populations). Local breeder on the California deserts.

- **Short-eared owl** (*Asio flammeus*). California's BSSC (breeding populations). Very localized breeder on the California deserts.

- **Purple martin** (*Progne subis*). California BSSC (breeding populations). Although this species is not known to breed in the desert planning area, some of the few extant breeding colonies in southern California are near the western edge of the deserts (e.g. Tehachapi Mountains, Cajon Pass area, mountains of San Diego County) and foraging birds may utilize the fringes of the deserts and/or be impacted by transmission corridors coming from the deserts.

- **Bank swallow** (*Riparia riparia*). California ESA Threatened. Migrant through the California deserts, with concentrations regularly noted at wetland areas such as Piute Ponds and the Salton Sea. Nests just north of the planning area in the northern Owens Valley.

- **Inyo California towhee** (*Pipilo crissalis eremophilus*). California ESA Endangered; ESA Threatened. It appears that most or all habitat occupied by this subspecies is outside the planning area, but given the potential for shifting or undiscovered populations and slight seasonal movements this taxon should still receive consideration.

- **Large-billed savannah sparrow** (*Passerculus sandwichensis rostratus*). California BSSC. Regular post-breeding visitor to the shoreline of the Salton Sea, especially at the southern end.

- **Grasshopper sparrow** (*Ammodramus savannarum*). California BSSC. Scarce migrant and possibly local breeder on the California desert margins.

- **Tricolored blackbird** (*Agelaius tricolor*). California BSSC and BLM Sensitive Species; potential ESA listing. Important colonies are located in the western Mojave Desert from the western Antelope Valley east to the Victorville/Newberry Springs area; desert agricultural areas and livestock ranches form important wintering habitat.

- **Yellow-headed blackbird** (*Xanthocephalus xanthocephalus*). California BSSC. Breeds locally on the deserts from the Owens Valley and western Antelope Valley south to the Salton Sea and lower Colorado River.

- **Arizona Bell's vireo** (*Vireo bellii arizonae*). CESA Endangered; populations along the lower Colorado River and in riparian washes west of the river north to Inyo County are relevant to the DRECP.

The following species should receive consideration in desert planning by virtue of being listed as USFWS "Birds of Conservation Concern" within the relevant "Bird Conservation Region" (in the case of the Mojave and Sonoran Deserts, BCR #33). Some of these are already on the list of covered species; for those that are not we provide the scientific name.

- Least bittern
- Bald eagle
- Peregrine falcon
- Prairie falcon (*Falco mexicanus*)
- Black rail
- Snowy plover
- Mountain plover
- Whimbrel (*Numenius phaeopus*)
- Long-billed curlew (*Numenius americanus*)
- Marbled Godwit (*Limosa fedoa*)
- Red knot (*Calidris canutus roselaari*)
- Gull-billed tern
- Black skimmer (*Rynchops niger*)

- Yellow-billed cuckoo
- Elf owl
- Burrowing owl
- Costa's hummingbird (*Calypte costae*)
- Gila woodpecker
- Gilded Flicker
- Least Bell's vireo
- Gray vireo
- Bendire's thrasher
- Le Conte's thrasher (*Toxostoma lecontei*)
- Lucy's warbler
- Sonoran yellow warbler
- Black-chinned sparrow (*Spizella atrogularis*)
- Lawrence's goldfinch (*Spinus lawrencei*)

2.5.3 Reptiles and Amphibians

The following species are recommended for *deletion* from the list as not occurring in the DRECP planning area or unlikely to be affected by plan actions:

- **Common ensatina**
- **Orange-throated whiptail**
- **Rubber boa**
- **Tehachapi Mountains slender salamander**
- **Western skink**
- **Panamint Mountains alligator lizard.** The advisors believe that this species is outside of the DRECP planning boundary within the Panamint, Inyo, and Argus mountain ranges.
- **Inyo Mountains slender salamander.** The advisors believe that this species is outside of the DRECP planning boundaries within the Inyo Mountains.

The following species are recommended to be *retained* on the list because they may occur in the planning area and have restricted distributions, are restricted to special features or other isolated habitats (e.g., sand dunes, wetlands, rock outcrops, riparian zones), or are listed as being of conservation concern. Developments that fragment their habitats, alter ecosystem processes (wind/sand flow to dunes, reduce water infiltration or increase groundwater extraction damaging wetlands), or increase access for collectors will reduce the sustainability of these populations.

- **Western pond turtle.** This species occurs in Afton Canyon and at Camp Cady along the Mojave River and could be adversely affected by any actions affecting the watershed.
- **Arroyo toad.** This species at least formerly occurred in Afton Canyon along the Mojave River. The advisors are unsure whether this population is extant. We recommend surveys or interviews with species experts, and avoiding any actions that could affect the Mojave River watershed.

- **Coachella Valley fringe-toed lizard**
- **Colorado Desert fringe-toed lizard**
- **Mojave fringe-toed lizard**
- **Flat-tailed horned lizard**
- **Desert tortoise**
- **Barefoot gecko**
- **Gila monster**
- **Couch's spadefoot toad**
- **Gilbert's skink**

2.5.4 Fish

A variety of rare, endemic pupfishes (*Cyprinodon* spp.) are found in springs, streams, and swamps in the DRECP plan area. Any activities that affect ground or surface waters may affect these isolated habitats and could adversely affect these unique fishes. We recommend consulting an independent scientific expert on these species (e.g., Don Sada, Desert Research Institute, Reno, Nevada) to determine whether any could be affected by plan actions and should be added as potentially covered species. The plan should thoroughly consider and avoid potential effects of renewable energy projects on surface or ground water hydrology.

2.5.5 Invertebrates

Accounting for and conserving invertebrates, especially arthropods, is difficult but necessary for a successful conservation plan. Although invertebrates comprise more than half the biodiversity in terrestrial ecosystems, most groups of insects and other arthropods are poorly known, with numerous undescribed species (New 1993, 1999, Redak 2000, Wilson 1988). Nevertheless, arthropods provide crucial ecological functions, including pollination, herbivory, and decomposition, that strongly influence the structure and function of natural communities. The advisors noted that arthropods were grossly underrepresented in the proposed list of covered species, with only a single endangered butterfly on the list (Quino checkerspot; *Euphydryas editha quino*)—and that species has not been recorded in the planning area, as it is associated with coastal sage scrub habitat to the west. There are nevertheless many sensitive species of invertebrates in the planning area that should be considered for coverage. For example, Table 2 lists desert insects recently reviewed as candidates for threatened and endangered status (to date USFWS has ruled that there is insufficient evidence to list any of these species). Regardless of their legal status, these species may be at risk and are representative of unique habitats, such as dunes and sand plains. Furthermore, Bunn et al. (2007) listed 28 California-endemic, special status invertebrates in the Mojave Desert and 13 in the Colorado Desert. We recommend a thorough review of available information on the status and distribution of rare and endemic invertebrates in the planning area, including interviews with experts, to assemble a list of invertebrates for consideration as covered species. Appendix C lists individuals having pertinent expertise that should be contacted for input.

Table 2. Desert invertebrates recently considered for threatened and endangered status (Federal Register 71(160) 47765-47771. 2006).

Common Name	Scientific Name	Order
Sand wasp	*Microbembix elegans*	Hymenoptera
Sand wasp	*Stictiella villegasi*	Hymenoptera
Solitary bee	*Perdita algodones*	Hymenoptera
Solitary bee	*Perdita glamis*	Hymenoptera
Vespid wasp	*Euparagian.* sp.	Hymenoptera
Velvet ant	*Dasymutilla nocturna*	Hymenoptera
Velvet ant	*Dasymutilla imperialis*	Hymenoptera
Algodones sand jewel beetle	*Lepismadora algodones*	Coleoptera
Algodones white wax jewel beetle	*Prasinalia imperialis*	Coleoptera
Algodones croton jewel beetle	*Agrilus harenus*	Coleoptera
Hardy's dune beetle	*Anomala hardyorum*	Coleoptera
Scarab beetle	*Cyclocephala wandae*	Coleoptera
Ruth's dune weevil (new subspecies 1)	*Trigonoscuta rothi rothi*	Coleoptera
Ruth's dune weevil (new subspecies 1)	*Trigonoscuta rothi algodones*	Coleoptera
Ruth's dune weevil (new subspecies 1)	*Trigonoscuta rothi imperialis*	Coleoptera
Ruth's dune weevil (new subspecies 1)	*Trigonoscuta rothi punctata*	Coleoptera

After compiling a list of potential invertebrate species of concern, an effort should be made to establish their distributions in the plan area. This could be done once a draft DRECP is developed by holding taxonomic-focused meetings involving individuals listed in Appendix C, and by examining collections and databases from the following museums:

- Entomology Research Museum, University of California, Riverside
- Bohort Entomology Museum, University of California, Davis
- Essig Entomology Museum, University of California, Berkeley
- Natural History Museum of Los Angeles
- California Academy of Sciences
- Natural History Museum of San Diego County

Examination of these collections will likely lead to further examinations of additional private and public collections. The goal should be to establish maps of current and historic distributions of rare invertebrate species. Gaps in distributions should be surveyed. Existing location data for arthropods is biased towards easily accessible roads, such that historical distributions may be misleading.

2.5.6 Plants

Table 1 appears to include only plants protected under the state and federal Endangered Species Acts. A much larger suite of rare plants should be considered as potentially covered species, including all species recognized by the California Native Plant Society's (CNPS) as "1B List" and "List 2" plants (Appendix D–DRECP Recommended Covered Plant Species). The 1B designation identifies plants known to be rare, threatened, or endangered in California and elsewhere. The "List 2" designation identifies plants known to be rare, threatened, or endangered in California but more common elsewhere. Despite List 2's wider distribution, these species are rare in California, and their inclusion as covered species helps to realize the NCCP goal of protecting California's biodiversity. As with the rare vegetation alliances, high priority for conservation should be focused on those rare plants that have a threat ranking of 0.1 (Seriously threatened in California; high degree/immediacy of threat) or 0.2 (Fairly threatened in California; moderate degree/immediacy of threat).

In June 2010, the CNPS Rare Plant Program developed a list of rare, threatened, and endangered desert plants potentially affected by the footprints of wind and solar projects proposed up to that time in the California Desert. This list of high priority "at risk" species includes rare plants with occurrences documented by the California Natural Diversity Data Base that fell within a proposed project footprint and/or within a BLM Solar Energy Study Area (SESA) as of June 2010 (Appendix E). GIS layers used in this analysis include:

- BLM renewable energy project layers
- DFG renewable energy project layers
- RETI renewable energy project layers
- RETI transmission line layers
- RETI substation layer
- BLM SESA layer
- REAT RESA layer

The list of affected species considered at high to moderate risk from renewable energy projects contains 171 taxa, of which 102 are on CNPS List 1B, including 14 federally endangered species, 5 federally threatened species, and 1 federal candidate for listing (also California endangered), and 10 California endangered species. Sixty-nine additional taxa are on CNPS List 2. List 1B plants are considered special-status species by BLM, and both List 1B and List 2 taxa meet the definition of rare under CEQA. Thus, these plants require mitigation under either NEPA and/or CEQA.

Similar to the unusual plant assemblages and rare vegetation alliances, our knowledge of the distribution of rare plants in the California deserts is currently incomplete. For this reason, the advisors recommend that additional season-appropriate surveys conducted throughout the desert regions be incorporated into the database for the DRECP, and recognized and incorporated through the adaptive management strategy.

2.6 Additional Planning Species

The advisors recommend considering whether the list of covered species should be supplemented with additional *planning species* that can assist with meeting plan goals (e.g., because they may serve as easily monitored "indicators" of environmental conditions. Specifically, we propose a method modified from Lambeck (1997), who suggested that conservationists identify groups of species whose vulnerability can be attributed to a common cause, such as loss of habitat area or alteration of a natural disturbance regime. Species in each group can then be ranked in terms of their vulnerability to those threats, and the most vulnerable members may be used as indicators for the group. Often, but not always, such indicator species are listed as threatened or endangered or likely to be listed in the future. This process has been used in California to select focal bird species for seven of the eight habitat-based bird conservation plans, as described by Chase and Geupel (2005). California Partner's in Flight (2009) recently completed a conservation plan for desert birds that should also be consulted.

Lambeck identified four functional categories of focal species. For each group the focal species are those most demanding for the attribute that defines that group and which therefore serve as the "umbrella" species for that group. Together, these species tell us what patterns and processes in the landscape must be sustained in order to sustain biodiversity. Their collective needs define conditions and thresholds—such as patch size, connectivity, fire frequency, etc.—that must be met if the native biota is to be maintained (Lambeck 1997).

- *Area-limited species* have large home ranges, occur at low densities, or otherwise require large areas to maintain viable populations. Examples include large mammals (such as bighorn sheep) and large raptors (such as golden eagle or California condor).

- *Dispersal-limited species* are limited in their dispersal capacity, sensitive to particular movement barriers such as highways or canals, or are vulnerable to mortality when trying to move through human-dominated landscapes. Examples include numerous amphibians and reptiles (e.g., desert tortoise), large-seeded herbaceous plants (Layne locoweed, *Astragalus laynei*), and species sensitive to roadkill (such as desert tortoise).

- *Resource-limited species* require resources that are at least occasionally in critically short supply. Good examples for DRECP include species that rely on wetlands and open water, such as the southern yellow bat (*Lasiurus ega*), which is restricted to unburned palm oases.

- *Process-limited species* are sensitive to details of the disturbance regime (e.g., the frequency, severity, or seasonality of floods or fires) or other manifestations of natural processes, such as hydroperiod, fire-return intervals, or the flow velocity of streams. Examples include species associated with active sand dunes, which relay on wind-transport of sands; perennial plants that require extremely low fire frequency (e.g. blackbrush, *Coleogyne ramosissima*, and Joshua tree; DeFalco et al. 2010); and playa invertebrates, such as fairy shrimp, that require inundation for the completion of their life cycles.

To this list we add one category:

- *Keystone species*, which exert a disproportionately strong influence on community structure or function due to their physical or biological effects on ecosystems and their interactions with other species (Soulé et al. 2003). Examples include top carnivores (like cougar) that may provide top-down regulation of food webs (Soulé and Terborgh 1999). Some keystone species are also known as *ecosystem engineers* because they physically alter the environment to create habitat features used by other species. Examples include burrowing animals (like tortoises, badgers, and kangaroo rats) that provide microhabitats and homes for numerous other species, and harvester ants, which significantly alter soil structure and nutrients, influence desert seed banks, and hence vegetation (DeFalco et al. 2009). Creosote bush (*Larrea tridentata*) can be considered an ecosystem engineer because its long lifespan enables accumulation of eolian sediments around its base, forming coppice mounds that provide habitat for annual plants and serve as substrate for numerous burrowing animals, including desert tortoises and rodents.

We suggest that plan participants review the list of potentially covered species to see whether they adequately represent this range of functional categories for broadly defined natural communities (one approach might be to use vegetation Classes and Subclasses as listed in Appendix B as a basis for defining broad natural communities, but this deserves further consideration and discussion). A table or matrix that categorizes species by functional category and community type could be used for this purpose. For categories or communities not adequately represented by the existing covered species list, consider supplementing the list with additional planning species to ensure that all communities and essential processes are addressed.

Regardless of whether the plan uses this structured approach to adding planning species, we recommend considering the needs of at least the following species in designing the reserve and developing mitigation, management, and monitoring plans, even though these species are not listed or are unlikely to be listed as Threatened or Endangered:

- **American badger** (*Taxidea taxus*). Badgers are uncommon and declining indicators of open habitats in California (Williams 1986, Quinn 2008). They require very large landscapes and are highly sensitive to habitat fragmentation and roadkill (Quinn 2008, Crooks 2002). They are also important keystone species due to their burrowing activities.

- **Golden eagle**. Eagles are protected above and beyond the measures of the Migratory Bird Treaty Act by the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c), enacted in 1940. However, the wide-ranging Golden Eagle is also a key planning species because of the large individual home range, reliance on healthy populations of native vertebrate prey (particularly lagomorphs, especially *Lepus*), high susceptibility to disturbance by humans at nest sites, and vulnerability to collisions with power lines and wind turbines (Kochert et al. 2002).

- **Joshua tree** (*Yucca brevifolia*). The Joshua tree is widespread in the Mojave Desert where it is susceptible to fire associated with invasive grasses (DeFalco et al. 2010) and climate change (Cole et al. In Press). Both living and dead Joshua trees provide nesting platforms for raptors and passerines, including red-tailed hawks (*Buteo jamaicensis*), golden eagles (*Aquila*

chrysaetos), loggerhead shrikes *(Lanius ludovicianus),* Scott's orioles *(Icterus parisorum),* and Cassin's kingbirds *(Tyrannus vociferans).* They also provide the only cavity spaces over large areas for such species as ladder-backed woodpeckers *(Picoides scalaris),* Northern flickers *(Colaptes auratus),* small owls, and brown-crested flycatchers *(Myiarchus tyrannulus).* Such reptiles as the night lizard *(Xantusia vigilis),* desert spiny lizard *(Sceloporus magister),* and night snake *(Hypsiglena torquata)* are also closely associated with live or dead Joshua trees. Invertebrates are famously associated with tree yuccas in the obligate mutualism of the yucca moth *(Tegeticula* spp.), and a host of other species feed on all parts of the Joshua tree. Another recently described association of the Joshua tree is the relationship with desert rodents which cache and eat the seeds (Vander Wall et al. 2006, Waitman 2009). Evidence of the sensitivity of Joshua tree distribution to climate change occurs in the fossil record (Cole et al. In Press).

- **Ironwood** *(Olneya tesota).* The ironwood is a keystone species in the Sonoran Desert due to its influence on soil nutrients and the food and cover it provides for a variety of desert biota (Nabhan and Carr 1994). Ironwood provides nesting platforms and cavities for nesting birds, and its dense canopy is utilized by nearly 150 bird species. The ironwood is the last in a phenological series of desert tree legumes to bloom following mesquite and palo verde. The Ironwood provides sustenance to invertebrates and thereby food for migrating and resident birds. In addition, ironwood is one of the longest-living plants in the Sonoran Desert, with individuals living well over 1000 years, so it serves as an extremely long-term component over centuries of extreme drought in providing a micro-habitat with less direct sunlight, lower surface temperatures, more organic matter, higher water availability, and protection from herbivores. Over the lifetime of one tree, more than 230 plant species have been recorded starting their growth within the protective microclimate under ironwood "nurse plants" (Nabhan and Carr 1994). This also creates an optimum wildflower nursery which is foraged by rabbits, bighorn, and other native species. An extraordinary level of biodiversity is created by ironwoods, including many dozens of species of bees, ant colonies, and other insects.

- **Blackbrush** *(Coleogyne ramosissima).* Near monospecific stands of blackbrush occur in the Mojave Desert on old geomorphic surfaces with substantial calcrete in the underlying soil horizons. These stands, typically at intermediate elevations and occasionally with significant populations of Joshua trees, typically have high levels of non-native annuals, notably red brome *(Bromus madritensis* ssp. *rubens),* which provide the fine-fuel loading for wildfire, and blackbrush itself is highly flammable. As a result, a disproportionate number of fires, and particularly ones covering larger areas, occur in this vegetation alliance (Brooks and Esque 2002, Brooks and Matchett 2003, 2006). Recent work on the Nevada Test Site (Esque and Webb, unpublished data) suggests that a large amount of the area occupied by near-monospecific stands of blackbrush are burning, and previous work has suggested that natural recovery of blackbrush stands may require millennia (Webb et al. 2009b). We believe there is a pressing need to preserve the remaining area of this unique vegetation alliance from human-induced ignition.

- **Spiny hopsage** *(Grayia spinosa).* The presence of this species is thought by some indicative of suitable habitat for Mojave groundsquirrel, although it is uncertain whether the species itself contributes to habitat quality for this animal.

The following bird species were selected by CalPIF (2009) as desert focal species because they use desert vegetation as their primary breeding habitat, they are great enough in abundance to provide adequate sample sizes for statistical comparisons, and they have experienced reductions from their historical breeding range. They should therefore be considered as potential planning species for DRECP.

- **Costa's hummingbird** (*Calypte costae*).

- **Ladder-backed woodpecker** (*Picoides scalaris*).

- **Ash-throated flycatcher** (*Myiarchus cinerascens*). Although this species is common and widespread, it is an obligate cavity nester and therefore can serves as a surrogate for assessing nest site availability for desert cavity-nesting species.

- **Verdin** (*Auriparus flaviceps*).

- **Black-tailed gnatcatcher** (*Polioptila melanura*).

- **Le Conte's thrasher** (*Toxostoma lecontei*).

- **Crissal thrasher** (*Toxostoma crissale*). This species is of interest because it occupies two very different desert woodland types – mesquite and riparian in the lower deserts, and pinyon-juniper woodland in the higher areas of the eastern Mojave Desert.

- **Phainopepla** (*Phainopepla nitens*). Phainopeplas provide important ecological services (dispersal of mistletoe seeds).

- **Black-throated sparrow** (*Amphispiza bilineata*).

- **Scott's oriole** (*Icterus parisorum*). This is a focal species in the analysis of desert woodlands (Joshua tree and pinyon-juniper).

The following bird species may also require attention in conservation planning and project siting analysis for various reasons:

- **Common raven** (*Corvus corax*). In recent years, raven populations have increased enormously in the Mojave Desert due to human activities that provide food and habitat structure (Boarman 1993, Boarman and Berry 1995). As subsidized predators, ravens can do significant harm to populations of sensitive species, including desert tortoise and various lizards and other small vertebrates. CalPIF (2009) designated the common raven as a planning species because it is widespread in desert habitats, is in part a human commensal, thrives in developed and disturbed lands and where nest sites are provided by transmission lines and other human-built structures, and is a known and significant subsidized predator on a variety of sensitive species.

- **Harris's hawk** (*Parabuteo unicinctus*). Very localized resident (though largely extirpated) along the lower Colorado River and occasionally in desert woodlands farther west.

- **Greater roadrunner** (*Geococcyx californianus*). Widespread in the deserts, but of interest because severe declines of cismontane populations indicate a lack of compatibility with large-scale development (in addition to its iconic status as a quintessential desert bird).

- **Brown-crested flycatcher** (*Myiarchus tyrannulus*). Very localized secondary cavity nester in desert riparian habitats (formerly listed as a California BSSC).

- **Scrub jay** (*Aphelocoma californica*). Two subspecies are localized on the California deserts. *A.c. cana* on Eagle Mountain in Riverside County, and *A.c. nevadae* [alternatively called *A.c. woodhousei*, though most authors restrict that name to a more easterly population] in the montane woodlands of the eastern Mojave Desert.

- **Pinyon jay** (*Gymnorhinus gymnorhinus*). A localized pinyon-pine specialist found in some of the higher ranges of the eastern Mojave and along the western fringes of the deserts in the Sierra Nevada, San Bernardino Mountains, and San Jacinto Mountains.

- **Juniper titmouse** (*Baeolophus ridgwayi*). Localized resident of pinyon-juniper woodlands in the eastern Mojave Desert.

- **Northern cardinal** (*Cardinalis cardinalis*). Rare visitor to the lower Colorado River, occasionally breeding. Some or most records elsewhere on the deserts may pertain to escapees.

2.7 Special Features

A wide variety of geological and hydrological features provide habitat attributes essential to numerous desert species and communities. The following features should be mapped to the degree feasible and considered in conservation design and project siting.

- **Desert pavement.** Desert pavement is a dense, continuous cover of pebbles and rock fragments resulting from erosional processes over very long periods. They serve to armor underlying soils from wind erosion (Miller et al. 2009). Breaking of pavements by scraping or other mechanical forces can increase erosion and wind-blown dusts. Development should avoid disturbance to desert pavements. The distribution of desert pavements can be obtained from surficial geologic maps, generally published at 1:100,000 scale and available on the internet (e.g., for near Blythe, California, http://ngmdb.usgs.gov/Prodesc/proddesc_76909.htm).

- **Playas.** Playas are alkaline flats or basins where surface water collects following runoff and either evaporates or infiltrates into the subsurface. The interior portions of playas can develop physical crusts that make their silt and clay soils relatively stable to wind erosion if not mechanically disturbed. Playa margins, in contrast, can be sources for windblown dust, particularly if physical and biological crusts are disrupted. Playa dusts also contain concentrations of toxic substances, such as arsenic and other heavy metals (Chaffee and Berry 2006). Maintenance of crusts and perennial vegetation will reduce dust emissions. Energy projects should avoid use of playa surfaces and only use playa aprons if surface disruption is minimal and vegetation cover is minimally disturbed.

- **Alluvial fans and bajadas.** Alluvial fans are fan-shaped deposits formed where fast-flowing streams exit canyons onto flatter plains. The coalescing of adjacent alluvial fans into a single apron of sloping deposits is called a bajada. Sediments are deposited on alluvial fans by two fluvial processes, streamflow flooding and debris flow. The slowing of floodwaters as they enter and spread over alluvial fans creates gradients of particle sizes, with larger rocks generally deposited near the top of the fan and progressively smaller rocks and soil particles farther down, concluding in fine silts and clays where the fan may terminate in a playa.

Debris flow can transport large particles long distances downslope from mountain fronts onto alluvial fans and create a complex spatial arrangement of particles. Both processes create physical gradients of particles and soils that provide spatially varied habitats for different types of plants and animals. Groundwater recharge is extremely rare in the deserts, and typically only occurs at the top of fans near major mountain fronts or, to a lesser extent, along ephemeral washes that extend downslope through the fans. Disruption of these ephemeral washes, and particularly blockages of washes upslope of mountain fronts, will negatively influence groundwater recharge and should be avoided. Finally, sheetwash, particularly following summer thunderstorms, creates habitat-sustaining runon on low-slope settings, sustaining desert ecosystems that otherwise would be more xeric. Disruption of sheetflow systems using diversion berms or channelization should be avoided.

- **Biological soil crusts.** Biological soil crusts are soil surface communities of mosses, fungi, algae, and bacteria that are particularly well developed where winter rains dominate. They provide armoring of the soil surface, reduce erosion from water and wind, and create a roughened surface where seeds may be caught. They also help with varied biogeochemical cycling, decomposition, and fixation of nitrogen, which can be a limiting nutrient during wet years. Removal or disruption of biological soil crusts can increase dust production. It can also limit primary production, especially of desert annuals, an important food source for many desert animals. Siting of developments should avoid disruption of biological soil crusts, which may require millennia to recover (Webb et al. 2009b).

- **Cliffs.** Vertical cliff environments provide uniquely harsh thermal and hydraulic environments that tend to have reduced but unique vegetation types. Due to their harshness, such sites are difficult to rehabilitate following disturbance. The base of these vertical habitats provide unique run-on habitats that may be particularly species rich, and production can be quite high depending on soil conditions; however, intense recreational use (e.g., rock climbing) can severely damage these areas. Cliffs provides nest sites and perches for raptor, vultures, and passerine birds, and roost sites for multiple species of bats. Siting renewable energy facilities or transmission lines near cliffs may increase risks to these species. The chuckwalla lizard (*Ater obesus*) and the lyre snake (*Trimorphodon bisctatus*) are also found almost exclusively in this and nearby boulder-rich habitats.

- **Caves and mines.** Caves and mines can be important aggregation sites for several species of bats recommended for coverage (e.g., *Antrozous pallidus, Corynorhinus townsendii, Myotis occultus,* and *M. velifer*). Although renewable energy developments are unlikely to directly disturb cave and mine habitat, siting wind turbines near caves or mines may increase mortality risks for these species. In addition, renewable energy components close to caves or mines may disrupt microclimate conditions or entry/exit routes of bats. Due to sensitivities about publicly revealing the locations of bat caves and mines, we recommend consulting the California Bat Conservation Plan (currently in preparation) and experts in desert bat conservation (e.g., Dr. Pat Brown-Berry) for information on how best to map or use information on bat caves and mines,.

- **Gypsum-rich soils.** These soils contain high quantities of the mineral gypsum and tend to be harsh environments for desert plants. Those plants that can survive on these conditions tend to speciate rapidly and thus, gypsum soil types often support rare, endemic plant communities.

- **Riparian channels and washes.** Two types of riparian ecosystems occur in the California deserts. Obligate riparian systems occur along perennial or intermittent streams with shallow groundwater, particularly in alluvial aquifers where a shallow confinement layer or a fault forces water to or near the surface, such as occurs along the Mojave and Amargosa rivers. Xeroriparian systems are more common and occur along large wash systems that have periodic runoff to sustain episodic channel recharge and allow growth of facultative riparian species—notably leguminous trees such as mesquite (*Prosopis glandulosa)*, palo verde *(Parkinsonia sp.)* and smoketree (*Psorothamnus spinosus)*. Both types of riparian systems provide high-value wildlife habitat with more abundant food, cover, and other resources than other desert communities. Riparian ecosystems are also naturally resilient, provide linear habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife—all characteristics that can contribute to ecological adaptation to climate change (Seavy et al. 2009). Disruption of riparian channels and washes should be strictly avoided by renewable energy developments and associated roads, etc.

- **Seeps, springs, and pools.** All surface waters and shallow ground waters are essential resources for innumerable species in the deserts. Water is a limiting resource for nearly all desert species, and DRECP should avoid any actions that can directly or indirectly affect these resources via changes in ground or surface water hydrology.

- **Sand dunes.** Sand dunes are part of the larger eolian systems of the California deserts that may be either fossil (formed during a different climatic regime), stabilized, or active. All eolian systems were created by a wind system that entrains sediments typically deposited by streamflow, winnows out the fine-grained material and transports it long distances as dust, and transports sand-sized particles that accumulate into dunes. Some eolian systems accumulate sediments as a result of a shifting wind field; this is the typical reason for the formation of star dunes such as the Dumont and Eureka dunes in the northeastern Mojave Desert. Other eolian systems respond to a unidirectional but divergent wind field that results in directional eolian transport and deposition of sands in barcan or linear dunefields, such as those in the Coachella Valley. Sand dunes sustain an inordinately large number of rare, endemic species, particularly on their margins. Developments should avoid eolian surfaces and disruption of eolian-transport areas.

2.8 Ecological Processes

2.8.1 Geomorphology and Hydrology

Geomorphology of the California deserts has a controlling influence on local- and watershed-scale hydrology, primary production of desert vegetation, stabilization against wind erosion and blowing dust, and the habitat usage of animals. The characteristics of desert soils and other geomorphic surfaces develop over millennia, and disturbances to these important characteristics can have ecological ramifications that last indefinitely. Moreover, some geomorphic surfaces, particularly those bearing desert pavements, formed in past climatic regimes and cannot recover following disturbances under today's climate.

Geomorphic systems in the California deserts are unique in North America because the Basin and Range in this region is more tectonically active than areas to the north or east, and the basins generally are closed (unlike those to the east which drain to river systems). Rainfall seasonality

and intensity varies with elevation and in both north-south and east-west gradients, with the highest annual precipitation in northern areas at higher elevation and the highest proportion of summer rainfall in the eastern and southeastern areas. Desert pavements are more common in the central and eastern portions of the California deserts than in the western Mojave.

Geomorphic surfaces are mapped according to the characteristics and processes of landforms, whether they are sand dunes, colluvial[7] slopes, alluvial fans, ephemeral channels, or playas, and the deposits are the near-surface materials associated with those landforms (Miller et al. 2009). Alluvial fans cover the largest area of concern to solar installations, while mountains are generally the sites for wind turbines. The hydrology of desert mountains is complicated because thin veneers of colluvium underlain by variously weathered bedrock create a complicated flow system for precipitation, which may infiltrate into surficial materials and reach groundwater systems or runoff into ephemeral channels that exit mountain fronts and reach alluvial fans. Mountain front recharge is thought to be the primary means of replenishing groundwater systems that underlie all valleys in the California deserts.

Soil characteristics as influenced by geomorphic surfaces are critical to understanding ecosystem function in North American deserts (McAuliffe 1994, Smith et al. 1995, Stevenson et al. 2009). Soils provide the foundation for terrestrial ecosystems, and small differences in soil properties can have large effects on water-holding capacity and nutrient availability (Comstock and Ehleringer 1992, McAuliffe 2003) which affects plant communities and, in turn, animals communities. Downslope from mountain fronts, depositional surfaces (alluvial fans and other landforms collectively called piedmonts) accumulate sediment eroded from the mountains over geologic time. Most alluvial systems in the California deserts terminate in closed basins known as playas, and some of these are connected via overflow systems that developed during the Pleistocene or earlier in geologic time. Playa margins can, in certain cases, have marginal depositional areas where most of the sediment transported in ephemeral channels is deposited prior to water entering the playa. Sand dunes, sand sheets, and alluvial fans are associated with alluvial depositional areas, generally wide, low-slope areas that include playas and depositional plains (Griffiths et al. 2002).

Plant community composition and primary production vary on piedmonts with characteristics of geologic deposits in addition to elevation and precipitation. Surficial geologic deposits vary in soil particle-size distribution, bulk density, and horizonation of the soil. The particle-size distribution of soils determines water-holding capacity: coarse-grained soils have low water-holding capacity and high infiltration rates, while finer-grained soils, particularly those ringing playas with higher silt/clay content, have high-water holding capacities, low infiltration rates, and particles that can bind nutrients. The particle-size distribution generally decreases downslope from mountain fronts to playa termination in response to channel incision and alluvial fan slope (Blair and McPherson 1994). A wide range of geomorphic features and distinctly different soil characteristics can therefore co-occur in close proximity (McFadden and Knuepfer 1990) increasing the diversity of plant and animal communities on piedmonts.

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[7] Materials transported by mast wasting processes, such as landslides and rockfalls.

The low rates of weathering and soil formation in deserts is caused by low precipitation, with lower relative importance of parent material and vegetation (Jenny 1941). Pedogenesis, or soil formation processes, creates soil layers formed from a combination of weathering of deposits in place, eolian deposition of sediment, and rainwater transport of various chemicals (Pavich and Chadwick 2003). Soil characteristics depend on the physical and chemical properties of the deposited sediments that have weathered in place as well as the characteristics of incoming dust. Surface roughness, which is affected by numerous factors, including surface age and the presence of physical or biological soil crusts, can affect the capture and retention of dust particles, organic material (including seeds), and nutrient status.

Organisms interact with soils through bioturbation, in which plant root growth and the burrowing activities of animals alter soil layering, organic material, and nutrient availability (Belnap et al. 2008). Coppice mounds beneath *Larrea tridentata* (creosote bush)—mounds of typically fine-grained sediments mostly from eolian deposition—are common sites for rodent burrows (Titus et al. 2002). Mounds associated with harvester ant colonies are a mix of surface and subsurface soil and large amounts of organic matter collected by the ants. Desert tortoises, larger mammals, lizards, and snakes all utilize burrows, affecting soil texture and chemistry. Varying soil properties affect desert fauna, which prefer specific soil depths and textures for their burrows (Hafner 1977, Whitford 2002). For example, tortoises tend not to dig burrows in sandy soils because they easily collapse.

2.8.2   Eolian Processes and Dustfall

Movement of soil particles (sand, silt and clay) by wind is one of the dominant processes in dryland environments (Breshears et al. 2003). Soil movement affects ecosystem function by altering soil texture, depth, and chemistry, which can strongly affect plant and animal communities. Alteration of natural soil movement processes by construction or other human effects can have long-lasting impacts that reach far beyond the footprint of the project—for example by increasing atmospheric dusts or by disrupting eolian processes that maintain sand dune communities.

Although there are some soil surface types that are inherently unstable (e.g., playa margins, dry wash bottoms), contrary to common belief, most desert surfaces are very stable and produce little sediment in the absence of disturbance (Marticorena et al. 1997). Natural armoring of the soil surface is provided by rocks, physical and biological soil crusts, plants, and plant litter (van Donk et al. 2003). Construction that disturbs these features can greatly increase soil movements and deposition of soil particles in other locations. Loss of soil via wind erosion leaves behind a coarser textured soil with lower fertility and water-holding capacity. Fine particles (silt and clay) can move great distances on the wind, even around the globe, and degrade air quality and visibility. Deposition of dusts can alter soil fertility and water-holding capacity and therefore plant community composition (Reynolds et al. 2001) often favoring non-native annual grasses (Miller et al. 2006). Dust accumulation on leaves and stems of desert plants can reduce physiological performance, plant growth and seedling establishment (Sharifi et al. 1997, 1999, D.R. Sandquist, pers. comm.). Fine soil particles can also transport and deposit toxic elements, such as mercury and arsenic, onto plants and watersheds (Chaffee and Berry 2006). Sources of such toxicants include mines, mine waste, roads, and other disturbed areas, as well as playas.

Because sand grains are larger, they tend not to travel so far as the silts and clays that comprise dust. Input of sand onto existing soil surfaces increases water infiltration, dilutes nutrient concentrations, reduces soil surface stability, and restricts the ability of the soils to hold nutrients and water (Breshears et al. 2003). Sand deposition can also bury plants and change which animal species can effectively burrow or live in the area. Wind-blown sands can also break up the physical crusting that stabilizes finer soils and dislodge the fine particles to increase dust flow.

2.8.3   Ecological Range Shifts

It is important that DRECP planners recognize that species' ranges are dynamic and that reliance on static range maps can be misleading. Species' populations naturally fluctuate and shift on the landscape over time due to natural and anthropogenically affected climatic shifts, species interactions, and stochastic population processes. Absence of species occurrences from particular areas or periods should not be considered a permanent condition (except in cases of irreversible habitat conversion), and DRECP should strive for a conservation design that accommodates community and species requirements today and in the future, especially considering likely shifts due to climate change.

In geologic time, North American deserts are relatively young, with their current distributions dating from the late Quaternary (Axelrod 1979). The late Pleistocene through late Holocene warmer-drier climate corresponds with the formation, accumulation and current distribution of sand dunes across western North America (Norris and Norris 1961, Wintle et al. 1994). The species associations that comprise communities and community distributions are therefore recent and likely still in flux. Additionally, species may be expected to experience shifts in their populations due to meta-population dynamics or seasonal changes in their distribution and abundance.

However, these natural fluctuations in the distributions and abundance of desert organisms may be exacerbated by climate change. The southern California deserts are likely to experience a greater shift from current climate means than any North American site south of the Arctic Circle (Kerr 2008). Although changes in precipitation are less certain than those in temperature, there may be increased droughts in the future, and droughts are major forcing functions in desert ecosystems (Hereford et al. 2006). As climate changes there may be areas with "novel climate conditions" that never previously existed within the DRECP. It is difficult to know how desert organisms will respond to such novel climate conditions. Some organisms may shift to track preferred climatic conditions, but others may need to adapt in place to changing conditions—or go extinct—for example for those species that require particular geological substrates or features that will not move. In the future we can expect new associations or communities of species than we see today (Stralberg et al. 2009). Conservation designs based on a concept of ecological stasis, either with respect to species distributions or community associations, are therefore doomed to fail in the long term.

All of this argues strongly for a conservation design that accommodates a changing climatological and ecological landscape by avoiding further fragmentation of the desert landscape, and hence providing maximum potential for species to track their preferred habitat-climate envelopes as conditions change. However, the reality is that our deserts have already

experienced a large amount of fragmentation from roads, cities, canals, military bases, and other developments. Alternative energy development could further contribute to this landscape fragmentation. Maintaining or improving landscape-level linkages that meet the niche requirements of all covered communities and species should be a key focus of DRECP. Section 4.2 of this report provides detailed recommendations for a robust, interconnected reserve system.

2.8.4 Wildlife Movement and Population Connectivity

Sustaining and enhancing habitat connectivity in the face of energy development, urban sprawl, transportation improvements, off-road vehicle use, climate change, and other stressors is a major conservation concern in California's deserts (Spencer et al. 2010). Populations of many of the region's rare and endemic species—such as the desert tortoise, Mohave ground squirrel, and desert bighorn sheep—are becoming increasingly isolated from one another, leading to decreased genetic diversity and risk of extirpations (Hagerty et al. in review, Epps et al. 2007, Hagerty and Tracy 2010). To counter these effects, various analyses have been recently completed or are underway to identify areas in need of conservation and active management to maintain and improve habitat connectivity and wildlife movement potential. The following references should be consulted by DRECP and used to help site renewable energy developments and conservation actions: the California Essential Habitat Connectivity Project (Spencer et al. 2010), the California Desert Connectivity Project (Penrod et al., in preparation), the South Coast Missing Linkages Project (Beier et al. 2006, South Coast Wildlands 2008), and likely bighorn sheep movement corridors (Epps et al. 2007). Section 4.2.8 provides specific recommendations for incorporating results of these projects and ensuring adequate connectivity in the DRECP reserve design process.

2.9 Environmental Gradients

The advisors recommend careful consideration of how environmental gradients can be used in modeling species distributions, understanding important ecological processes, and guiding conservation design. Environmental gradients are graded spatial variations in some aspect of the physical environment, such as changes in temperature and precipitation with elevation or latitude, ground-water depth with distance from a stream or mountain front, or soil particle size and depth with position along an alluvial slope (see Section 2.8). Many organisms naturally distribute themselves in communities relative to such gradients, and preserving broad, intact gradients may help facilitate adaptation to climate change. For example, some species may adjust to a changing climate by shifting upslope to remain within their preferred niches based on temperature and precipitation gradients (Tingley et al. 2009). Because elevation gradients encompass multiple microclimates within a relatively small area or distance, vagile organisms can potentially shift more quickly in steep areas relative to flatter areas (Loarie et al. 2009), and biotic responses to climate change may be mediated by spatial heterogeneity in the landscape (Ackerly et al. 2010). Elevation and other gradients should be preserved with minimal fragmentation to accommodate potential range shifts. Conservation areas on flatter terrain, or on broad, homogeneous landscapes with little variation in conditions, should be connected to more heterogeneous or topographically diverse areas that provide a greater variety of conditions for species to select from under future climate conditions.

2.10 Covered Actions

This section briefly summarizes some potential impacts of renewable energy developments on covered species and communities based on our observations as ecologists. This is not a comprehensive review of all potential impacts, because the science advisors are not experts in the design, construction, or operation of energy facilities. We therefore recommend a more thorough and quantitative review of impacts from alternative energy facilities and appurtenances that builds on our initial overview. This comprehensive review should involve individuals with pertinent scientific and engineering expertise concerning the nature of the various technologies and their specific impacts (e.g., experts at the National Renewable Energy Lab [NREL] or other independent and objective experts).

The primary focus of this overview is the potential ecological impacts of large-scale solar and wind energy projects and associated roads and transmission lines. Our review of geothermal energy impacts is more cursory, and we do not specifically discuss the nature of impacts of RPS biomass projects. Some impacts are likely similar among all technologies (e.g., energy transmission from production sites and disturbance of habitat and wildlife during construction). However, different technologies will differ in the nature, extent, and timing of their impacts and therefore will require different siting criteria and different types of monitoring and mitigation. The plan should address at least the following topics with respect to the different technologies in assessing impacts to covered resources, siting of facilities, and mitigation and best management practices for construction and operations.

- Ground disturbance and associated changes in habitat value, erosion, hydrology, etc., probably represents the single greatest impact of renewable energy development, and the amount and distribution of surface disturbance will vary tremendously between different types of energy development. The plan should consider, for example, the relative effects of a single, large, contiguous footprint versus dispersed small footprints in different contexts. It should also recognize that the impacts of developments on desert ecology and covered species can extend well beyond development footprints due to effects on hydrology, eolian processes, and other factors reviewed in Section 2.8.

- If energy facilities are fenced (e.g., for security purposes) they are likely to become barriers to movement for many species. However, fencing may also protect animals from entrapment in degraded, denuded, or dangerous areas.

- Renewable energy facilities and associated utility roads may expand the influence of cities, towns and settlements and provide additional human access to remote desert areas. Different technologies are likely to vary in the amount and distribution patterns of new roads, which increase habitat fragmentation along with a wide variety of direct and indirect adverse effects to desert ecosystems.

- Construction and operation of facilities may require water for cooling, cleaning of equipment, dust control on roads or during construction, etc. The total amount of water required, and sources of this water, should be thoroughly evaluated for each type of facility, with a goal of strictly minimizing total water use over the life of a project.

- Cables and other linear structures may be buried or above ground. Buried cables will create greater ground disturbance and may disrupt sensitive hydrologies. Aerial cables will disturb the ground for towers, may increase bird fatalities from collisions, introduce perching structures, and increase predation by subsidized predators, such as ravens.

- Renewable energy facilities can have direct effects on wildlife behavior, reproduction, and mortality due to attraction to or avoidance of structures. For example, some species may be attracted to the newly created shade of solar projects, and birds and bats may be attracted to towers or other tall structures. Polarized light reflected from photovoltaic panels creates "ecological traps" for species that mistake the panels for water (Horvath et al. 2010); some birds and insects may be killed by concentrated heat at solar thermal facilities; and many birds and bats are killed by wind turbines (Arnett et al. 2008, Smallwood and Karas 2009).

Table 3 suggests one approach for categorizing differences among technologies in these types of impacts. This approach should be evaluated and completed by DRECP participants, scientists, and engineers having relevant expertise. The following sections elaborate on some of these issues for different types of facilities.

Table 3. A sample approach for categorizing the nature of impacts from alternative development types to guide planning and analysis. This table is tentative and incomplete, and intended only as a sample framework that should be refined and expanded on with input from scientists and engineers more familiar with the impacts of the various technologies.

Criteria	Concentrating Solar	Solar Photovoltaic	Geothermal	Wind
Total Project Area	Low	Low	?	High
Technology Footprint	Contiguous Area	?	?	Highly Dispersed
Surface Disturbance	High	High	?	Low
Road Density	Low	?	?	High
Within-site Transmission Cables	Few	?		Many
Water Use	High	Medium	High	None
Indirect Impacts on Wildlife	Avoidance or Attraction	?	?	Avoidance or Attraction
Direct Impacts on Wildlife	Insects and a few birds killed by heating?	?	?	Collision mortality of bats and birds (insects?)

2.10.1 Roads

Most renewable energy facilities require access roads, which have a wide array of adverse effects on desert resources:

- Increased access by humans may increase disease incidence in wild tortoise populations via more widespread release of captive desert tortoises carrying infectious diseases (e.g., mycoplasmosis, herpesvirus) (Johnson et al. 2006). Captive tortoises are commonly released in the desert (Murphy et al. 2007) and a recent study in the central Mojave Desert found that wild tortoises with mycoplasmosis were more likely to occur near offices, facilities, urbanized areas and paved roads than in remote areas (Berry et al. 2006).

- Some access roads may need to be regularly graded as maintenance. This often produces berms or deeply incised road beds with steep walls that can entrap animals like desert tortoises and cause death by hyperthermia, increased predation, roadkill, or illegal collecting by humans.

- Access roads (especially those associated with transmission lines) provide food and subsidies for avian and mammalian predators. Subsidized predators (e.g., ravens) use the transmission line towers for nesting, perching, and searching for live prey (tortoises, lizards, other birds and their nests). Prey crossing roads are highly visible to predators, and roadkills provide additional food for subsidized predators.

- Access roads provide sources for invasion and establishment of alien plants along and outward from verges and in disturbed areas associated with power towers and transmission lines. One of the more important factors in alien species richness and biomass of *Erodium cicutarium* is density of dirt roads (Brooks and Berry 2006).

- Recreationists and others use utility access roads for numerous types of activities that can negatively affect vegetation and animals living on adjacent lands. For example, trash and illegal dumping occur along roads, attracting subsidized predators.

- Roads alter the surface hydrology (ephemeral stream channels) which alters vegetation species distributions.

Section 4.3 provides guidance for siting, designing, and implementing actions to mitigate the effects of roads and other barriers to wildlife movement

2.10.2 Transmission Lines

Exhibit C of the DRECP Planning Agreement lists the following sorts of covered actions concerning energy transmission: new foundation, delivery, and connector transmission lines required for accessing renewable energy; transmission upgrades; new transmission lines to connect renewable energy projects to the grid; tower or pole replacements; and substations and switchyards. We assume it will also cover new roads, road improvements or other surface disturbances necessary to access new or existing transmission lines and facilities for construction or maintenance.

We emphasize that even though the development footprints of transmission poles and towers are not large, that some desert vegetation can be retained within transmission rights-of-way (ROW), and that some wildlife may live in transmission ROWs, the impacts of transmission lines are not as benign to desert resources as sometimes believed. For example, ravens were once rare in the deserts but have become much more common due, in part, to use of transmission structures for perching, roosting, and nesting. Ravens are attracted to developments, dirt and paved roads, water sources, transmission line structures and human habitations (Boarman 1993, 2003; Boarman and Berry 1995; Knight et al. 1993; Kristan and Boarman 2003). Ravens reduce tortoise populations by preying on young tortoises. Tortoises are also killed by vehicles when crossing the transmission line roads, buried by road graders when utility roads are being maintained, and die from overheating when caught between the berms of transmission line roads (K.H. Berry, personal observations). During 2008-2009, ravens attacked adult tortoises in the Central Mojave Desert (A.P. Woodman, personal communication).

Disturbances from construction of new powerlines may also contribute to the invasion, establishment and dominance of alien plants in the Mojave Desert via soil disturbance and transport of seeds by vehicles (summarized in Brooks and Berry 2006, Brooks and Lair 2009).

2.10.3 Solar Projects

The DRECP is to cover both photovoltaic (PV) and thermal concentrating solar projects, including construction of new facilities and substations, expansions or upgrades to existing facilities, and all project related facilities, including roads, utility connects, transmission, water, and gas lines, etc. The greatest impacts to ecological resources, depending largely on siting, are likely to be the direct removal, degradation, and fragmentation of natural communities and habitat and populations of desert species. Because utility-scale solar developments are very land intensive, direct loss of habitat could potentially be highly significant, unless developments can be sited in already disturbed and degraded lands, such as brownfields, former agricultural lands, or previously graded lands. Nevertheless, as discussed in Section 2.8—and regardless of where they are sited—the ecological effects of projects that disturb desert soils can extend far beyond the areal footprint of the development itself due to downslope effects on hydrology and downwind effects on eolian processes, among other effects. Such offsite effects must be accounted for in the siting, design, construction, mitigation, and monitoring of solar energy developments.

Indirect effects of utility-scale solar may be very significant, but to our knowledge they are poorly studied. Indirect effects may include increased light pollution (which can adversely affect nocturnal species); increased dust and sand generation (and potential for toxic chemical deposition, etc.; see Section 2.8); use of water for dust control, cleaning, cooling, or other operations (potentially depleting ground water sources that sustain scarce and essential wetland and water sources for desert ecosystems) ; and changes to local and downslope hydrology (with associated effects to plant and animal communities).

Solar developments may also have significant direct effects on the behavior, reproduction, and mortality of wildlife species. For example, solar panels create a new source of polarized light pollution that can confuse animals that use polarized light for orientation or behavioral cues. Insects that breed over and deposit eggs in water bodies have been shown to be more attracted to

the strongly polarized light reflections off of solar panels than they are to water. This creates an "ecological trap" for such species, resulting in reproductive failure and direct mortality (Horvath et al. 2010). Birds that are attracted to water sources may also be adversely affected[8]. Moreover, the advisors are concerned that thermal concentrating facilities may kill birds and insects directly via thermal stress.

One peer reviewer of this report raised the issue of elevated local or regional temperatures in the vicinity of large-scale solar developments as a potentially significant adverse effect. The advisors are not aware of any studies of local climate effects of large-scale solar projects, and therefore do not know how significant such impacts might be on desert ecology. We therefore recommend further research on this issue, and certainly monitoring of local climate effects as part of the Adaptive Management and Monitoring Program (Section 6).

2.10.4 Wind Projects

According to the DRECP Planning Agreement, the following types of actions are to be covered: installation of anemometers, new turbine installation, expansion of existing wind projects, upgrades to existing facilities, and project-related facilities like roads, and transmission, water, and gas lines. Although the development footprint of wind towers is relatively small (e.g., compared to solar developments), numerous birds and bats are killed by turbine strikes (Arnett et al. 2008), and wind developments have the potential for significant, regional population effects on some species. Turbine towers can also be used for perching and nesting by raptors and thus may elevate predation levels on nearby prey species.

The California condor is an endangered species that has been reestablished in the Tehachapi Mountains and other California mountain ranges. Populations are expanding in the vicinity of existing wind farms in the Tehachapi Mountains and southern Sierra Nevada. We fear there is a high probability of condor mortalities by turbine collisions during the permit duration.

At least two rare rodents recommended for coverage, the yellow-eared pocket mouse and Tehachapi pocket mouse, have extremely limited ranges that correspond closely with areas of high wind potential on the slopes of the southern Sierra Nevada, Tehachapi, and Transverse Ranges. The rarity of these species suggests that intensive surveys should be performed to identify and avoid occupied or potential habitat areas for direct impacts of wind-farm developments (including roads, etc.). Turbines and other facilities should be designed to eliminate perching by raptors, to avoid elevated predation pressure on these nocturnal rodents, especially by owls.

Bat fatalities have been found at every wind facility in North America that has been specifically monitored for bats. Large fatality events were first documented on forested ridges in the eastern U.S, but more recent studies have documented high fatality rates in plains and agricultural habitats of the Midwest and western Canada (Arnett et al. 2009, Baerwald and Barclay 2009a). Most studies find that migratory species during the migration season account for the greatest

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[8] At least one advisor has observed migratory water birds becoming trapped between stacked pipes at construction sites in desert areas, because the birds apparently mistook the pipes as water bodies and attempted to land on them.

number of mortalities (Arnett et al. 2008). There is little information on bat migration patterns in the desert southwest, but a recent study found that the majority of bat fatalities at a wind energy facility near Palm Springs occurred during presumed periods of migration (Chatfield et al. 2009). This provides hope that fatalities may be somewhat predictable in time and therefore avoidable by managing turbine operations adaptively.

2.10.5 Geothermal Projects

The advisors are not experts in geothermal projects or their impacts on biological resources, and we did not specifically discuss recommendations for such projects. In general, we note that current and proposed geothermal developments occur near the Salton Sea and its various open-water, shoreline, riparian, marsh, and agricultural habitats that support abundant bird life. Associated transmission lines, night-lighting, construction and maintenance activities, and water usage likely have adverse impacts on a number of covered species. It is our observation that impacts of current geothermal development at the Salton Sea have come mainly from their siting (near or even on important wildlife habitat), and some of us have observed mortalities of large birds hitting transmission lines during flight near the Salton Sea. We also note that water consumption of geothermal plants may be a concern (although we understand this varies greatly depending on specific technologies, such as whether and how water is reinjected).

3 Principles for Addressing Information Gaps and Uncertainties

Gaps in available information on biological resources are always among the biggest sources of uncertainty for regional conservation plans. Here we address some approaches for filling these data gaps and dealing with scientific uncertainty.

3.1 Environmental Base Maps

Accurate and reliable maps of ecological, climatic, and geological features and species distributions are essential to good conservation planning and their lack represents a critical information gap.

3.1.1 Vegetation Maps

For DRECP, accurate, up-to-date, and fine-resolution land cover or vegetation maps are a key data gap. Vegetation mapping is not comprehensive across the plan area, and mapping efforts vary in detail, approach, and accuracy in different regions (Appendix F). Currently, there is no detailed vegetation map, nor a special features map, for the western Mojave Desert. The advisors recommend that both an alliance-level vegetation map and a special botanical or vegetation features map be assembled for this area, much like the one that was developed for the central Mojave (Thomas et al. 2004). While the central Mojave special features map may need updating and refinement, it does represent a well-executed initial effort for defining natural communities. New mapping efforts to assemble an alliance-level map should be based on high quality digital imagery and should be delineated and labeled using standard CDFG vegetation protocols (http://www.dfg.ca.gov/biogeodata/vegcamp/pdfs/Final_SB_85_Report.pdf).

Unfortunately, creating a comprehensive, alliance-level vegetation and special features map for the entire western Mojave region would take approximately 18 months once sufficient funding is provided to secure contract mapping, which would augment mapping that could be accomplished through CDFG's Vegcamp efforts during the same time period (T. Keeler-Wolf, personal communications). Given this is not possible under the DRECP schedule or available funding, vegetation alliance and special features mapping should be prioritized within currently unmapped regions most likely to be affected by renewable energy developments, such as renewable energy study areas in the Western Mojave west of Barstow and around Owens Lake.

An option for providing a useable vegetation map on a rapid schedule would be to create an "interim" or mid-level vegetation map that lacks some of the detail, field survey data, and accuracy assessment needed for a final map, but that would nevertheless be an improvement over the current situation. The interim map could be completed in less than 18 months by compiling new and existing vegetation maps with minor reformatting to allow for standardized representation. It could be produced by photo-interpreters familiar with California desert vegetation and supplemented with field reconnaissance. Individually attributed polygons would contain information on alliance or alliance groups (compliant with the National Vegetation Classification System [NVCS] mid-level hierarchy based on ecologically aggregated groups of alliances [FGDC 2008 in Sawyer et al. 2009]), basic structure (cover classes, height classes), and

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stand quality (attributes for degree of "roadedness," invasive exotic cover, and other easily interpreted attributes). An interim map, as described, would lack the detail needed for a final map, as well as a rigorous accuracy assessment and a complete synoptic revision. In addition, it would not be reliable in all attributes or spatial representation. Nonetheless, it would better determine the distribution of vegetation, including unique or rare vegetation types, than existing, broad-scale, maps. It would also represent an improvement over existing low-resolution vegetation maps for purposes of habitat or species distribution models. The interim map would be merged with re-scaled, existing data-driven vegetation maps for the central and eastern Mojave and several of the large state and national parks to create a single vegetation data layer that would provide an improved, baseline map for regional planning.

However, it is important to recognize that such an interim, mid-scale map is a compromise and should not be considered a final product: We believe that a comprehensive, fine-scale, alliance-level vegetation map supported by rigorous field data collection over multiple years and a formal accuracy assessment per CDFG protocols, should be completed as soon as possible, whether it can be finished prior to the draft DRECP, or after the draft plan for use during plan implementation

See Appendix F for a more comprehensive review and recommendations concerning vegetation mapping in the planning area.

3.1.2 Special or Unique Plant Assemblage Mapping

The advisors recommend that a special features map similar to that created for the Central Mojave Vegetation Database (Thomas et al, 2004) be made for the rest of the planning area. It would serve as a template for the development of a database describing rare or localized vegetation types, habitats or plant species. The Significant Natural Area approach for the western Mojave could be used for this map as several species or vegetation occurrences overlap and can be used to identify spatially explicit units for conservation which would otherwise not be shown on the alliance level vegetation map.

The following excerpts from a metadata report for special features coverage for the Central Mojave Vegetation Database specify methodology that could be used as a model for creating a comprehensive special features map for the entire planning area. Refer to the entire metadata report (see Appendix F) for additional detail on the types of entities covered in the special features layer for the Central Mojave Vegetation Database.

The Central Mojave Special Features coverage is composed of point locations representing a rare/special vegetation alliance, unique stand, or a feature with co-occurring or potential vegetation alliances. Each point location was obtained from existing digital map databases, hard copy source maps, literature descriptions, or field work conducted for this project or other Mojave Desert field projects.

Other special features such as wetlands and rare plant occurrences were added to the point coverage. Locations of springs were added to the Central Mojave Special Features map database from USGS Digital Line Graph (DLG) map databases (1:24,000 and 1:100,000) which resulted in 640 spring locations. Riparian and wetland features for portions of Death Valley were

extracted from the National Wetlands Inventory (NWI) map database. Some of those features are known to be devoid of vascular vegetation (e.g. salt flats); however, other features are known to be vegetated. Point locations for crucifixion thorn (*Castela emoryi*) were obtained from map databases developed by the Bureau of Land Management in association with the Northern and Eastern Colorado Desert planning effort.

3.1.3   Other Important Maps

A variety of existing maps and GIS data layers should be consulted during planning and incorporated into a central GIS database for use in spatially explicit models or other purposes, including:

- Surficial geologic maps available from the California Geological Survey (http://www.consrv.ca.gov/cgs/information/geologic_mapping/Pages/index.aspx) and the U.S. Geological Survey (http://ngmdb.usgs.gov/).

- Soil and substrate geospatial data, which can be obtained from a combination of surficial geologic maps and data developed by the National Resource Conservation Service, including the STATSGO and SSURGO databases (http://soils.usda.gov/survey/geography/statsgo/; http://soils.usda.gov/survey/geography/ssurgo/).

- Disturbance maps (recent or historic ORV, military training, homesteads, agriculture, livestock grazing, brownfields, etc., that would affect soil surface and vegetation). If no existing map combines these sorts of disturbances, such a map should be created to identify preferential areas for siting renewable energy projects. The U.S. Bureau of Land Management, California Desert District, Moreno Valley, has such maps.

- Wildlife linkage, movement corridor, and habitat connectivity maps, including at least the following:

  - South Coast Missing Linkage Project Linkage Designs that are at least partly within the DRECP Area (available at http://scwildlands.org/index.aspx).

  - Least-cost corridor models and habitat suitability models for diverse focal species, and draft Linkage Designs to accommodate a broader range of species are currently being prepared by SCWildlands for the California Desert Connectivity Project (Penrod et al., in preparation).

  - Natural Landscape Blocks and Essential Connectivity Areas mapped for the California Essential Habitat Connectivity Project (Spencer et al. 2010). Links to download the report, maps, and GIS data are at www.dfg.ca.gov/habcon/connectivity/.

  - Dispersal and least-cost path models for desert bighorn sheep identified by Epps et al. (2007).

- Fire maps (contact Matt Brooks at USGS for up-to-date maps).

- Nitrogen deposition maps (from Drs. Ellen Bauder and Edith Allen, UC Riverside).

- Fault lines (associated with concentrations of springs, seeps, and hanging gardens). These can be determined from geologic maps.

- Audubon Important Bird Areas.

- Paleo site data.

- BLM maps of permit applications to identify conflicts between proposed projects and potential reserve areas.

- Maps of critical habitat and/or sensitive habitats for rare, threatened, and endangered species from existing documents.

- Maps of existing or proposed Wilderness; designated Research Natural Areas, Natural Areas, and Areas of Critical Environmental Concern.

- Road density map, with indicating differences between paved roads, dirt or gravel roads, graded or ungraded roads, etc.

- Existing utility lines, corridors, fiber optic cables, aqueducts and other linear features, including information on width of rights-of-way and disturbed areas.

- Map of water sources, springs, seeps, rivers, streams; map of primary, secondary, tertiary and other washes.

- Google Earth is a good aerial imagery tool, especially using the "history" option, which can reveal areas subject to historic disturbance.

Note GIS data layers vary in their reliability, accuracy, and recency. All data should be carefully reviewed and assessed for accuracy in the field prior to use in models or for planning.

3.2   General Information Sources

The following information sources about desert ecology and species should be consulted during plan preparation:

- Berry, K.H., and R. Murphy. 2006. Deserts of the World Part I: the Changing Mojave Desert. Journal of Arid Environments 67, Supplement, Special Issue.

- Pavlik, B. 2008. The California Deserts. University of California Press.

- Rundel, P.W., and Gibson, A.C. 1996. Ecological Communities and Processes in a Mojave Desert Ecosystem, Rock Valley, Nevada. Cambridge University Press, 369 p.

- Shuford, W.D., and T. Gardali (eds.). 2008. California Bird Species of Special Concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of western birds, no. 1. Western Field Ornithologists, Camarillo, CA. and California Department of Fish and Game, Sacramento, CA.

- Webb et al. 2009c. The Mojave Desert: Ecosystem Processes and Sustainability. University of Nevada Press, Reno, Nevada.

- Whitford, W. 2002. Ecology of Desert Systems. Academic Press, London.

- Wilshire, H.G., J.E. Nielson, and R.W. Hazlett. 2008. The American West at Risk. Science, Myths, and Politics of Land Abuse and Recovery. Oxford University Press, New York.

3.3 Species Locality Data

In addition to CNDDB and other databases maintained by CDFG in the BIOS program (http://bios.dfg.ca.gov/), there are a variety of sources of species locality data that should be incorporated into BIOS or a central DRECP database and used in species distribution modeling, including at least the following:

- California Mammal Species of Special Concern database (MSSC; Spencer et al. in prep; database expected to be available by late 2010; range maps in 2011).

- PRBO Conservation Science and the California Avian Data Center (www.prbo.org/cadc) which is a node of the Avian Knowledge Network.

- Cornell Laboratory of Ornithology's eBird database (http://ebird.org/content/ebird)

- Local BLM offices conducting biotic inventories.

- Museum records. Digital databases are now available for many museum collections, including ORNIS for avian museum databases (http://ornisnet.org/) and MaNIS (http://manisnet.org/) for mammals[9], HerpNET (http://www.herpnet.org/herpnet/index.html) for amphibians and reptiles, and the Consortium of California Herbaria (http://ucjeps.berkeley.edu/consortium/), and the San Diego Natural History Museum's Plant Atlas (http://www.sdnhm.org/plantatlas/index.html) for plants.

- Site-specific information from EIRs and EISs (compiled into a central database).

3.4 Species Habitat Suitability and Distribution Models

Information on species' distribution and abundance are critical inputs to conservation planning. Range maps are not always available for individual species. Survey data may be used to infer distributional limits or abundance if they are comprehensive and collected broadly across the regions. However, because comprehensive survey coverage is not feasible for most species, we recommend judicious use of habitat suitability models or species distribution models (SDMs). SDMs allow point locality data to be extrapolated to determine probability of occurrence maps which may be used to infer species presence or habitat suitability over broad areas, including areas not previously surveyed. Where data are sufficient, empirical or statistical models based on species locality data (or presence-absence data) are preferred. Where data are not sufficient for empirical models, careful use of "expert-opinion" models may be warranted. Moreover, in cases where available survey data are strongly spatially biased, or for species that may have been extirpated from areas of suitable habitat, habitat distribution models based on expert opinion may be more appropriate than models built using species locality data (Early et al. 2008).

3.4.1 Empirical or Statistical Models

Empirical (statistical) modeling approaches are better than simple GIS overlay or "query" models that are often used in conservation plans as proxies for mapping habitat values or

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[9] Note, however, that MaNIS data have been incorporated into the MSSC database.

predicting species distributions. Although the overlay method is useful as an initial step for exploring which factors, *of those available in the GIS*, seem to be associated with species occurrences (e.g., they are more useful as *exploratory* rather than *forecasting* models; O'Connor 2002), the resulting maps inevitably contain significant errors if used to represent or predict species distributions, at least in part because they cannot account for interactions among variables in affecting habitat suitability. Statistical SDMs have the added benefit of specifically quantifying uncertainties in model predictions.

Species distribution (or occupancy) modeling is a very active and constantly evolving research field with numerous recent advances (Elith et al. 2006, Elith and Leathwick 2009; http://biodiversityinformatics.amnh.org/index.php?section=sdm_guide). SDMs use environmental variables characterizing places where a species does (or does not) occur based on survey data to develop sophisticated correlative models. SDMs may also be extrapolated to project future occurrences in places where the correlated environmental features are projected to be present in the future (Wiens et al. 2009). Care should be taken to select a modeling approach and SDM algorithm that performs well based on recent peer-reviewed literature and which is appropriate for the organism being modeled. It may be prudent to model the data with more than one SDM algorithm and examine overlap among model outputs ("consensus modeling"), as well as the amount of uncertainty among model outputs (see Wiens 2009 for an example of uncertainty analysis).

We emphasize the importance of expertise and rigor in applying these highly technical models. In our collective experience, this expertise is generally lacking at environmental consulting firms that prepare HCPs, NCCPs, and NEPA and CEQA documents. However, there is a growing pool of appropriate expertise at academic research institutions, science-based NGOs, and science-based government agencies, such as USGS. *We urge DRECP to tap appropriate expertise for the application of any scientific models, because learning-while-doing is inefficient and error-ridden.*

To construct a SDM, the following components and steps are needed: acquisition of biotic inventory data, selection of relevant environmental variables, selection of one or more SDM algorithms, selection of spatial scale, evaluation of model results, and interpretation of the resulting output. All of these steps should be well documented and defended when presenting model output results.

- **Biotic inventory data**: Ideally biotic inventory have been collected over the range of geographic and environmental space that one wants to create a model for. Systematic or random sampling designs are ideal, but almost never possible and not essential. Occupancy modeling approaches (MacKenzie et al. 2006) can control for species detectability and can be used to augment or expand simple presence localities.

- **Algorithm selection**: Ideally, species distribution models should be built using empirical, statistical methods, such as generalized additive models (GAM) or hierarchical regression models (see Scott et al. 2002, Guisan and Thuiller 2005, Beissinger et al. 2006, Elith et al.

2006, and Elith and Leathwick 2009 for recent reviews)[10]. Some algorithms are appropriate for presence-only data (e.g., from museum records or CNDDB), while other algorithms incorporate presence and absence inventory. Because new algorithms are constantly being developed, care should be taken to select an algorithm that has been well documented in the recent peer reviewed literature.

- **Selection of environmental variables**: Carefully think through *all* environmental factors most likely to affect each species' distribution, and how these factors may interact (e.g., vegetation, geologic substrate, terrain, hydrology, climate, insolation, other species). Species experts and the literature should be consulted to determine the relevant environmental factors. Avoid combining redundant (highly correlated) factors within a model, and select those variables most likely to explain variations in habitat quality. In doing this, recognize that there are many useful environmental variables that can be derived from existing GIS layers, such as indices of habitat patch size, fragmentation, distance from water, primary productivity, insolation, or road densities.

- **Selection of spatial scale**: The spatial scale should be relevant for the taxa of interest, as well as incorporating the scale of the environmental variables (e.g., some environmental variables are only available at 800m or 1km sized pixels). The grain size selection may affect model results (Guisan et al. 2007). Most SDMs involve averaging variables over a "moving window" of a size relevant to the species in question, based, for example, on the species' average home range size or the scale at which individuals select habitat areas.

- **Evaluation of model results**: The resulting SDM output should be statistically evaluated. There are a variety of approaches for assessing predictive performance and selecting test statistics. If a model performs poorly it should be documented and potentially re-run with alternate environmental data, additional biotic inventory data, or some other considerations based on input from experts on the taxa. Usually, a variety of alternative or "candidate" models are created using different combinations of variables, where each combination of variables represents a reasonable hypothesis about what factors interact to influence habitat suitability. These candidate models are then statistically compared or "competed" (using information-theoretic metrics) to select a single "best" model or a combination of models that may be averaged together (Burnham and Anderson 2002).

- **Interpretation of output**: Most statistical models produce continuous gradients of a species' probability of occurrence, or at least multiple categories of habitat value, which can be more revealing for conservation planning than discrete suitable/unsuitable habitat maps. Ideally an expert on the taxa can review the final model output. It is important to realize that probability of occurrence is just that: species sometimes are found in places with a low probability of occurrence, and may sometimes be absent from those with a high probability— because random events and stochastic processes are common in nature. Maps that represent habitat in a simple suitable-nonsuitable format, or species occurrence as a simple presence or absence format, are generally misleading.

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[10] A number of sophisticated software packages for analyzing species distribution data are now freely available, such as MaxEnt (www.cs.princeton. edu/ ~schapire/maxent).

3.4.2   Expert-opinion Models

Unfortunately, empirical SDM models often require more species location points than are available (especially for rare and endangered species), and they may not be appropriate if there is a great deal of spatial bias in the underlying data or for species that are absent from areas of suitable habitat due to other factors like predation, collecting, or disease, or species with strong metapopulation dynamics that cause populations to appear and disappear in suitable habitat over time (Early et al. 2008). Under such conditions, we endorse cautious use of "expert opinion" habitat distribution models, so long as they adhere to some guidelines to be as reliable as possible.

Base the models as much as possible on peer-reviewed literature, and obtain expert review of models. Use model logic to capture how environmental variables interact to affect habitat value. Most GIS query models use simple Boolean "and" logic (i.e., a species may occur if a site has the right soil AND vegetation AND elevation, etc.). However, other logical interactions (e.g., using Boolean "or" logic) may also apply (i.e., a species may occur in vegetation type A at low elevation, OR type B at higher elevation, etc.). A full review of these concepts is beyond the scope of this report, but we recommend reviewing Scott et al. (2002), Guisan and Thuiller (2005), Beissinger et al. (2006) or other recent reviews of habitat modeling for ideas. Regardless of what model approach and variables are used, uncertainties in model predictions should be clearly articulated and considered in any decisions based on them.

SCWildlands has prepared expert-opinion habitat models for 48 focal species in California deserts for the California Desert Connectivity Project (Penrod et al. in preparation). These models use variable scoring and weighting factors developed by species experts using a variety of available GIS environmental data layers. Data classes relevant to habitat suitability for each species were scored from 1-10, and the scores were combined using weighted arithmetic or geometric means to rank habitat suitability from low to high, using such variables as vegetation type, elevation, terrain ruggedness, distance from water, and road density. The advisors did not have time to comprehensively review the draft SCWildlands models for this report. We recommend that they be subject to peer review to determine their potential utility to DRECP.

3.5   Decision Support Models

Decision support models are increasingly recognized as tools to guide decision making for natural resources and systems in complex landscapes (Llewellyn et al. 1996, Leung 1997, Seavy and Howell 2010). Informed decision making for the addition of renewable energy facilities and their infrastructure to the desert southwest may be greatly facilitated by this process. The benefits of spatially explicit decision support systems include (1) the ability to balance interacting land uses while considering resource values and existing land use agreements, (2) merging data from multiple sources such that potential conflicts, interactions and synergisms can be readily identified and openly discussed among interested parties, (3) analyze landscapes (e.g. this 23,000,000 ac study area) in consideration of realistically complex management situations, and (4) the process is highly documented, repeatable, and can be readily modified to explore alternatives by all interested parties (Heaton et al. 2008).

Within this framework, one important consideration is the nature of the modeling input. Decision support models can be formulated using deterministic and probabilistic data, as well as expert opinion (see Section 3.4). The distinction among these data sources should be explicitly stated within the context of model documentation. Furthermore, any of these data may be available from peer-reviewed documents, gray literature, or expert opinion, and the source of information should also be explicitly stated. The distinction among data sources can have important ramifications for the end product and the integrity of the process. Models based on empirical data and vetted by peer review provide a level of confidence, but availability of such models is limited. In contrast, expert opinion models or models not vetted by the peer-review process are more readily available, but confidence in their outputs is generally lower. Hybrid models based on inputs from all potential data sources may provide the broadest potential for exploring the complex issues related to energy, resources and societal needs and creating realistic scenarios. Therefore hybrid models are a potential construct, but the nature of all inputs should be explained in detail so reviewers understand the limitations and uncertainties.

Acquiring data and ensuring its reliability can be a very challenging aspect of this type of work. To the greatest extent possible, reliable and thoroughly reviewed data sources that are already assembled should be relied on, as data assembly and review is time consuming and expensive. Compatible data sets that are previously assembled and peer reviewed should be acquired and used to the greatest extent possible.

3.5.1   Desert Tortoise Spatial Decision Support Model

An example decision support model with direct applicability to DRECP exists for the desert tortoise. The following information is provided courtesy of Cat Darst of the USFWS Desert Tortoise Recovery Office:

> The Desert Tortoise Recovery Office spatial decision support system identifies and prioritizes actions that are most likely to ameliorate threats to tortoise populations at any geographic extent (>1 square kilometer) within the tortoise's range. To do this, the decision support system utilizes GIS data of the spatial extent of threats (*i.e.*, where threats occur geographically) to calculate how changes in threats contribute to changes in tortoise population numbers.
>
> The decision support system models the relationships between threats, population stresses, and demographic change factors. The relationships within the model are weighted using institutional understanding of the strengths of: (1) inter-threat links, (2) threat to population stress links, and (3) population stress to demographic change links. The GIS data of the spatial extent of threats are then geoprocessed with these weights to calculate how changes in threats contribute to changes in tortoise population numbers and how recovery action implementation is predicted to ameliorate those threats.
>
> Future versions of the decision support system may permit managers to conduct gap analysis on their current/planned recovery actions (*i.e.*, compare ideal to current or planned management actions to identify gaps in management prescriptions for a given area) or to evaluate actions in terms of their near- vs. long-term contribution to recovery. The decision support system may also be used to develop prioritizations that account for economic,

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political, and operational constraints that managers face when implementing recovery. All data and underlying models will be updated and evaluated on a regular basis.

The DRECP independent science advisors recommend considering use of the Desert Tortoise Decision Support Model for assessing and comparing plan alternatives, and considering whether similar systems can and should be developed for other resources of interest. If not already done, the model should be subject to peer review before application. Most important, the current environmental data layers used in the model are known to have errors (C. Darst, personal communications) and require updating and corrections before they can be depended on. Nevertheless, given that the input variables are adequate, such decision-support tools could be used to compare the relative likely effects of alternative development-conservation-mitigation-management scenarios on the species, and thereby select combinations of actions most likely to contribute to the conservation and recovery of the species.

3.5.2   Spatially Explicit Population Models

Spatially explicit population models (SEPM) are more quantitative extensions of the sorts of decision- support models discussed above, and provide a powerful means of comparing alternative conservation strategies for rare or endangered species (Carroll et al. 2003, Carroll 2007, Spencer et al. 2008, Carroll et al. In Press, Spencer et al. In Press). SEPMs track the fates of many simulated individuals through time as they move across a grid of cells in a geographic information system (GIS) environment—and grow, reproduce, disperse, and die. The software package HEXSIM (http://www.epa.gov/wed/pages/models/hexsim/index.htm, which updates an earlier version called PATCH; Schumaker 1998), links the survival and fecundity of individuals or groups of animals to data on mortality risk and habitat productivity at the scale of an individual territory (or a pack territory for social groups). Population vital rates can be weighted based on habitat suitability—for example, with higher mortality rates or lower reproductive weights in suboptimal habitats. The behavior of large numbers of individuals, over a large number of replicate simulations (to account for effects of stochasticity) is then used to determine the range of likely fates for the population under alternative scenarios and to assess uncertainties about the likely outcomes. Hence, SEPMS can be used to make relative comparisons of how a population or metapopulation may fare under alternative future scenarios—such as alternative reserve designs, development scenarios, types of management intervention, or assumptions about future climatic or other conditions (Spencer et al. 2008, Carroll et al. In Press, Spencer et al. In Press).

SEPMs are data hungry, however, and are best used on species for which there is reasonably good information on species' demographic rates and processes (e.g., reproductive rates, mortality rates, dispersal characteristics) and how these may vary with habitat condition. We recommend exploring the use of SEPMs to compare among plan alternatives for a few key covered species for which there may be sufficient data to parameterize models, especially desert tortoise and bighorn sheep. Other species for which the approach may be useful (given adequate demographic data) include Mohave ground squirrel, flat-tailed horned lizard, and leopard lizard.

3.6 Anticipating Climate Change

The world of climate-change modeling, and of predicting the responses of species and ecological communities to climate change, is developing rapidly, but large uncertainties remain (e.g., Oreskes 2004, Hayhoe et al. 2004, Wiens et al. 2009, Stralberg et al. 2009, Beier and Brost 2010). What is certain is that desert climates will change to the detriment of many species, and that some species ranges will shift, creating new and novel ecological communities, and thus new interactions with uncertain effects. And, contrary to popular perception, new studies are suggesting that the pace with which species may need to adapt or shift their ranges in response to climate change may be more dramatic in broad, relatively flat terrain (like deserts, plains, and grasslands) than in more dramatic, mountainous terrain (Loarie et al. 2009, Stralberg et al. 2009).

The following concerns about predicting climate-change effects on species distributions are based on comments submitted by a peer reviewer of this report (Dr. James Patton, Professor Emeritus, UC Berkeley): Most climate-effects distribution models have been based on climate variables alone (typically the Bioclim variables), whereas soil types, geological formations, plant communities and other variables are also important to many species. Plant communities will reflect local climates to some degree, but climate alone cannot predict future plant combinations that will be important to animal species. The data points used for distribution modeling are also important: We know that there have been range shifts over the past century, but we don't know if those shifts have been monotonic with time or if an abrupt distributional shift occurred in a particular focal time-period. Studies like the Grinnell Resurvey Project (http://mvz.berkeley.edu/Grinnell/research/index.html) reveal that not all species have shifted their ranges (about 50%), and for those that have, the shift is not always in the same direction. Hence, distribution modeling for two known points in time (early 20th century and today) does not predict current distribution no matter how good the "fit" is for either of these time periods. As a consequence, projecting to the future from today alone for any particular species is problematic at best.

We recommend that participants continue to track the evolving scientific literature on climate change effects in the planning area, *while planning a reserve network that is as comprehensive and robust as possible to this uncertain future. This means conserving large areas that encompass broad environmental gradients (e.g., a wide range of latitudinal, longitudinal, elevational, climatic, and geological conditions) within an interconnected reserve network (to allow the greatest potential for range shifts), and that it maximize conservation of ground and surface waters, riparian areas, and washes to maximize resiliency in the face of climate change.*

A promising analytical approach to consider using in designing a reserve system that is robust to climate change is the land-facets approach advocated by Beier and Brost (2010). This approach recognizes that species distributions are largely functions of climate—which changes—in concert with physical attributes of the landscape (especially soils, elevation, topographic position, and exposure to sunlight)—which are much more stable over time. Conserving interconnected areas that represent the full spectrum of these physical, landform attributes, may allow species to shift their distributions with climate change while remaining within their favored physical niche.

The plan should also anticipate the need to monitor and respond to changes via the adaptive management and monitoring program, which will entail establishing comprehensive baseline monitoring stations as soon as possible (Section 6.4).

Where sufficient SDMs exist for species (Section 3.4) based on current climate data, future projections should be made to determine how species distributions may shift under climate change. These sophisticated models should be based on the latest peer reviewed methods and climate models (Wiens et al. 2009) and should include measures of uncertainty where possible.

4 Principles for Conservation and Reserve Design

This section provides a review of the [11]REAT "starting points" maps and recommends approaches for designing an ecological reserve network in the planning area to sustain biological diversity, natural ecological communities, and ecosystem functions. It also provides some guidance for siting, configuring, and mitigating developments to minimize adverse effects to desert ecosystems. Section 5 provides further details for selected covered species and communities.

4.1   Review of REAT "Starting Point" Maps

At our April 2010 science advisors' workshop, REAT representatives presented some preliminary maps intended to help guide where conservation actions and renewable energy developments should be sited. The REAT maps can be improved by more careful use of existing data, increased transparency in methods, and more rigorous application of reserve-design principles and models, as detailed below. Among the potential problems with application of the REAT maps were the following:

Inappropriate use of species locality data points to prioritize areas of conservation concern. We recommend that DRECP a*void using species observation locality data (e.g., from the California Natural Diversity Data Base, CNDDB) as a primary foundation for siting development or conservation actions using GIS overlay models.* Because CNDDB (and other locality databases) are compiled largely from incidental observations, rather than systematic surveys or random sampling programs, they are inherently spatially biased—and a*bsence of points from a locale cannot be interpreted as absence of the species.* The advisors were not provided details concerning the ranking methods and criteria used to create the REAT "species sensitivity ranking" maps, but we understand that CNDDB data (along with other unspecified data sources) were weighted based on species conservation sensitivities and then combined using GIS overlay techniques. Because we cannot account for spatial survey biases in this approach, the advisors cannot concur with the interpretation that "the darker the color the higher the sensitivity," or conversely, we have no confidence that areas lighter in color are necessarily of lower biological value.

CNDDB data represent an incomplete and inaccurate means for assessing species of conservation concern in the area (see Section 2.5 for errors of omission and commission from the draft covered species list, apparently resulting from using CNDDB to generate the list). CNDDB prioritizes species that are considered of conservation concern, but such lists change over time and CNDDB does not provide comprehensive coverage. Numerous rare and sensitive taxa are not included in CNDDB or have very few observations in the database—for example, in the case where a species was only recently added to a conservation concern list. In addition, CNDDB data are processed and uploaded at irregular intervals, with emphasis placed on different geographic regions of the state in different years. Perhaps most important, many of the sensitive

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[11] REAT is the Renewable Energy Action Team, with representatives from US Fish and Wildlife Service, California Department of Fish and Game, California Energy Comission, Bureau of Land Management, and the California Natural Resources Agency.

taxa within the DRECP region are *subspecies* rather than full species, and data that do not consistently differentiate subspecies should not be used if one cannot determine whether a species record represents a relatively common or rare subspecies. Finally, great care should be taken in relying on any locality data that are not supported by vouchered specimens residing in a repository (herbarium or museum collection) upon which the identification can be verified. Taxonomy changes and uncertainties in identifications made by different observers vary too substantially to base important decisions on non-vouchered records.

Because of these concerns, CNDDB data, or any similar locality data, are best used as inputs to objective and appropriate modeling algorithms that can be used to project likely species distributions over unsurveyed areas (see Section 3.4), or to help verify or supplement other objective depictions of species distributions, rather than as primary predictors of species distribution and especially of species absence. *In the absence of appropriate, spatially explicit models or maps of species distributions, use "no regrets" approaches that site developments in areas already irreversibly converted by previous disturbance, and site conservation actions in areas already known to be important for sustaining covered species and communities, as detailed below.*

Inappropriate use of species range maps. Use of species range maps from the California Wildlife Habitat Relationships (CWHR) program suffers from similar problems as use of CNDDB data. Although the current protocols for CWHR range map revisions (Hooper et al. 2009, unpublished) are technically sound, most CWHR range maps have not been updated based on these protocols, and many are coarse in resolution and out of date. In many cases they have not been updated to reflect recent taxonomic changes. Moreover, to our knowledge CWHR range maps exist only for full species, not for subspecies. Overlaying species range maps to identify "hotspots" of sensitive species occurrences can therefore be highly misleading. For example, although the round-tailed ground squirrel, little pocket mouse, and Merriam's kangaroo rat are all very widespread species (see Section 2.5), their rare, endemic, and listed subspecies are very narrowly distributed; thus, use of the species range maps provides a distorted picture of areas most important for conserving sensitive taxa. *If GIS overlay methods are to be used to help identify areas of high or low conservation concern, great care should be taken to use range maps that accurately portray the ranges of the taxa of concern.*

Creating a single composite map of multiple environmental data layers without adequate analytical transparency. The advisors reviewed REAT maps showing "conservation opportunity areas" described as supporting "key populations or connections between key populations." The potential value or application of these maps is not clear without differentiating the various species, populations, or connections comprising it, and without explaining the methods used to produce the composite. Moreover, it is impossible to compare differing biological values or constraints on different parts of the map, which is essential to insightful prioritizing or phasing of conservation actions. Future maps should clearly differentiate, for example, existing reserve areas, unconserved areas, modeled habitat connectivity areas, species' ranges, and other important inputs to inform decision-making. If a single summary or composite map is desired for simplicity (e.g., for public outreach), the individual data layers (and how they were derived and treated in the composite) should be made available, and the compositing criteria and methods clearly articulated. *It is critical that all analyses and decision-making processes be as transparent and understandable as possible.*

4.2 Reserve Design Process

Reserves (otherwise known as protected areas, conservation areas, preserves, etc.) have been a cornerstone of conservation for centuries (Grove 1992). There has been a recent shift in perspective toward viewing landscapes as wholes in conservation planning, with increased attention to the contributions to conservation from the landscape matrix (i.e., mixed-use areas), rather than solely from reserves. Nevertheless, areas protected from intensive human use remain fundamental to conservation planning, because many species, communities, and processes are sensitive to human activity (Noss et al. 1999).

Principles for conservation planning and reserve design emerged as empirical generalizations based on case studies such as conservation of the northern spotted owl (Wilcove and Murphy 1991) and the southern California coastal sage scrub (Noss et al. 1997). These principles have been bolstered and refined over time with experience in diverse settings and planning contexts worldwide. The advent of systematic conservation planning and the increased use of sophisticated site-selection algorithms and spatially explicit habitat and population models (Margules and Pressey 2000, Carroll et al. 2003, Moilanen et al. 2009, Spencer et al. In Press) has made conservation planning more rigorous and quantitative, but sometimes at the cost of making conservation plans less comprehendible to land-use planners, decision-makers, and the general public, and often through a protracted process that defeats the original proactive intent.

For the DRECP *we recommend a phased conservation planning process, which takes full advantage of the considerable conservation and recovery plans already available for the region.* This phased approach will allow planners to make immediate "no regrets" decisions on important areas to conserve, areas where renewable energy projects can be sited, and methods for mitigating adverse effects of development—while at the same time performing additional conservation planning analyses to fill gaps in understanding and guide more difficult decisions. These analyses should be performed using a fully transparent process that incorporates empirical design principles and expert guidance. In other words, *the plan should be developed in an incremental, adaptive-management framework (as detailed in Section 6), evolving over time, both before and during implementation, as new information becomes available to fill our knowledge gaps.* Thus, some development and conservation can proceed as the planning process develops, guided at least in part by sophisticated modeling to help verify and refine what is already known. We offer the following principles as guidance for a comprehensive and systematic approach to planning a reserve network for DRECP.

4.2.1 Make Use of Existing Planning Documents

Conservation planning rarely happens in a vacuum, and DRECP has the benefit of numerous existing, science-based plans and analyses to use as a foundation. *We recommend that DRECP implement and improve on conservation actions identified by existing conservation and recovery plans in the planning area, beginning as soon as possible.* Considerable scientific input has already been applied in delineating important conservation areas and designing specific conservation and mitigation actions to preserve and recover sensitive desert species and communities in such documents as the Western Mojave Plan, the Northern and Eastern Colorado Desert Coordinated Management Plan, the Desert Tortoise Recovery Plan, the CalPIF Desert

Bird Conservation Plan, and ecoregional assessments prepared by The Nature Conservancy and other NGOs (see Appendix G for additional documents pertinent to conservation planning in California deserts). However, few of these conservation actions have actually been implemented, in large part due to lack of sufficient funding and staffing at the responsible agencies (Bunn et al. 2007). *Mitigation for renewable energy developments should be used to help rectify this situation by providing funding to implement appropriate conservation and recovery actions identified in existing plans, and to improve these plans over time via the DRECP Adaptive Management and Monitoring Program.*

In addition to plans prepared by government agencies, The Nature Conservancy, SCWildlands, Conservation Biology Institute, PRBO Conservation Science, and other research and planning NGOs have been developing maps and plans for conserving desert resources in recent years, using many of the types of sophisticated GIS models and decision-support tools recommended in this document. Although the science advisors have not comprehensively reviewed this body of work or specifically compared and contrasted their approaches with our recommendations, we believe such assessments are valuable references to build on for identifying DRECP conservation areas and actions. Rather than re-invent wheels, *DRECP should carefully review all such existing conservation assessments and plans and prioritize and phase implementation of the most useful and scientifically justified actions they recommend.* This review should consider our recommendations as general guidance, and should involve adequate scientific oversight and peer review of important documents or decisions.

4.2.2 Subdivide the Planning Area and Scale Each Task Appropriately

As detailed in Section 2.2, *we recommend dividing the planning area into several regions or planning units that are both ecologically relevant and potentially useful for dealing with the likely clustering of renewable energy developments* in different regions. Importantly, however, while planning subdivisions may be convenient and scientifically defensible across numerous planning tasks and analyses, they should not be universally applied to all species, communities, or analyses of interest (i.e., *don't assume "one-size-fits-all"*). Some analyses may need to be done at the scale of the entire DRECP area, others at more local or regional scales. If planning subdivisions are developed, consider whether they are appropriate for each analytical task, or whether combining, merging, or further subdividing the units is justified for any particular map, model, or analysis.

For some species, subregions might be best defined based on the species' demographic and genetic population structure across the planning region. For example, the desert tortoise recovery units, which are based on core tortoise population areas and genetic differences among them, may be most appropriate to use for that species. However, for most DRECP communities and species, subdivisions based on Ecological Sections and Subsections (Miles et al. 1998; http://www.fs.fed.us/r5/projects/ecoregions/toc.htm) or the subdivisions delineated by Webb et al. (2009a) for the Mojave Desert (see section 2.2) should suffice for ensuring adequate representation of biogeographic variability across the planning area.

Representation goals (defined in Section 4.2.3, below) *for each covered species and community should be established for each subregion, as well as for the entire DRECP area, to ensure*

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adequate representation of biogeographic, genetic, and population variability across the plan area. At the community level, for example, a vegetation type might be well distributed throughout the planning area, but with considerable variation in species composition, climate, and habitat structure among subregions. Consequently, protecting examples of a vegetation type in certain subregions but not others will not capture this range of variation and may not allow for adequate adaptation to climate change. At the species level, a species that is distributed throughout much of the planning region, but in separate populations that vary in size or other characteristics, might be most efficiently conserved in a portion of the plan area supporting the largest and most intact population; however, other populations might be genetically distinct, provide insurance against diseases or catastrophes, be important functional components of a regional metapopulation, or turn out to be the most viable populations under changed climatic conditions.

4.2.3 Identify Areas Important to Conservation, and Areas *Not* Important to Conservation

The conventional approach in modern conservation planning is to conduct a top-down analysis of the planning region to identify and prioritize the most important areas to conserve. This approach is often guided by *representation goals*—or proportions of particular resource types (e.g., community types) to be conserved within a reserve network. The approach is intended to assure that all species, communities, and other features of interest are sufficiently represented in reserve areas to assure their viability. The advisors recommend combining this approach (detailed in the next section, 4.2.4) with an additional "bottom-up" approach of quickly identifying those areas that are demonstrably *not* important to achieving conservation goals— i.e., areas that due to previous disturbance are irreversibly converted from potential to support covered species, communities, or important ecological processes (such as wildlife movements). This will allow for the near-term siting of renewable energy developments in areas unlikely to contribute to the conservation of covered species or communities while planning of a more comprehensive, top-down reserve network can proceed. However, we urge diligent application of the Precautionary Principle in identifying such "no-regrets" areas for near-term development. The only areas likely to be unimportant for conservation are areas that have had native vegetation at least partly removed and the soil surface broken (e.g., by grading, grubbing, or tilling) that are also in locations unlikely to contribute to reserve viability or wildlife movement potential. We recommend that the DRECP planners map out areas of current and historical disturbance, verified by field surveys *and compared with existing reserve and linkage maps,* to make this assessment.

4.2.4 Apply Site-Selection Algorithms Wisely

Objective *site-selection algorithms* are useful in the top-down reserve selection process because, when used properly, they assure adequate representation of all features in a cost-efficient manner and because they allow transparent development and application of *a priori* representation goals by plan participants and stakeholders. Marxan (Possingham et al. 2000; http://www.uq.edu.au/marxan/index.html) and Zonation (Moilanen et al. 2005; http://www.helsinki.fi/bioscience/consplan/software/Zonation/index.html) are two algorithms that are widely used and have proven useful in diverse planning contexts. During the run of the Marxan algorithm, an initial portfolio of planning units is selected and the total cost calculated.

Planning units are then added and removed and the total cost re-evaluated through multiple iterations in an attempt to improve the total cost and efficiency of the portfolio for the selected conservation targets. The Zonation algorithm starts from the full landscape, and then iteratively discards locations (grid cells) of lowest value from the edge of the remaining area, thus maintaining a high degree of structural connectivity in the remaining habitat. Zonation works particularly well with grid-based inputs, especially those created by species distribution models. Moreover, instead of outputting the optimal set of sites for achieving targets, Zonation outputs the hierarchy of cell *removal* throughout the landscape and species loss curves, which can be useful in quickly identifying areas *not* important to conservation and therefore available for siting developments (see Section 4.2.3).

The selection of an algorithm and the associated parameter choices should be justified based on recent standards and peer reviewed literature, especially since this field of conservation biology is changing rapidly. We suggest that DRECP planners experiment with different algorithms before choosing one, and that they perform sensitivity analyses with each algorithm– e.g., vary the quantitative representation goals for various biodiversity features, clustering of planning units (i.e., the boundary length modifier in Marxan), etc., and observe the effect in terms of the pattern and overall area of selected sites in the design. Sensitivity analyses may also provide insight into the uncertainly associated with the reserve selection algorithm and output scenario. The specifications of the parameter settings within an algorithm should be well-documented and justified. In general, we suggest that site-selection algorithms are useful for defining the 'skeleton' of a reserve design, to which planners must apply expert opinion to add the 'flesh.' For example, site-selection algorithms often do not adequately account for connectivity between selected reserve sites, and habitat connectivity areas need to be added to the map.

Regardless of the selection algorithm used, usually some additional analysis is needed to prioritize sites for protection. This is often done by combining two criteria: irreplaceability (or biological value) and vulnerability (or threat) (Margules and Pressey 2000). Irreplaceability is a measure of the relative biological value and distinctiveness of a site. Sites supporting endemic species that occur nowhere else are irreplaceable relative to sites that contain only common or widespread species, for example. At the species level, a site with a high population growth rate, which serves as source population in a regional metapopulation, is irreplaceable; a sink population (where deaths exceed births) is generally not. However, when viewed at a broader spatial or temporal scale, sink populations may play important roles in metapopulation persistence, for example by providing connectivity or "stepping stones" between source populations or by increasing overall metapopulation size and genetic diversity. Also, populations that are sinks in most years may occasionally be sources, therefore enhancing the viability of metapopulation (e.g., Murphy 2002).

Vulnerability at the species level can be measured as the predicted decline in demographic value (e.g., population growth rate) over a period of time if development or other habitat degradation occurs (Carroll et al. 2003). Figure 4, from a study of the Greater Yellowstone Ecosystem, shows how sites might be ranked for conservation priority in terms of their irreplaceability and vulnerability. Sites in quadrant 1 are considered of highest priority for immediate action. However, in the long-term, sites in quadrant 2, being equally irreplaceable on average, are just as

important to protect – and are often more intact because they are generally more remote from human population centers (Noss et al. 2002).
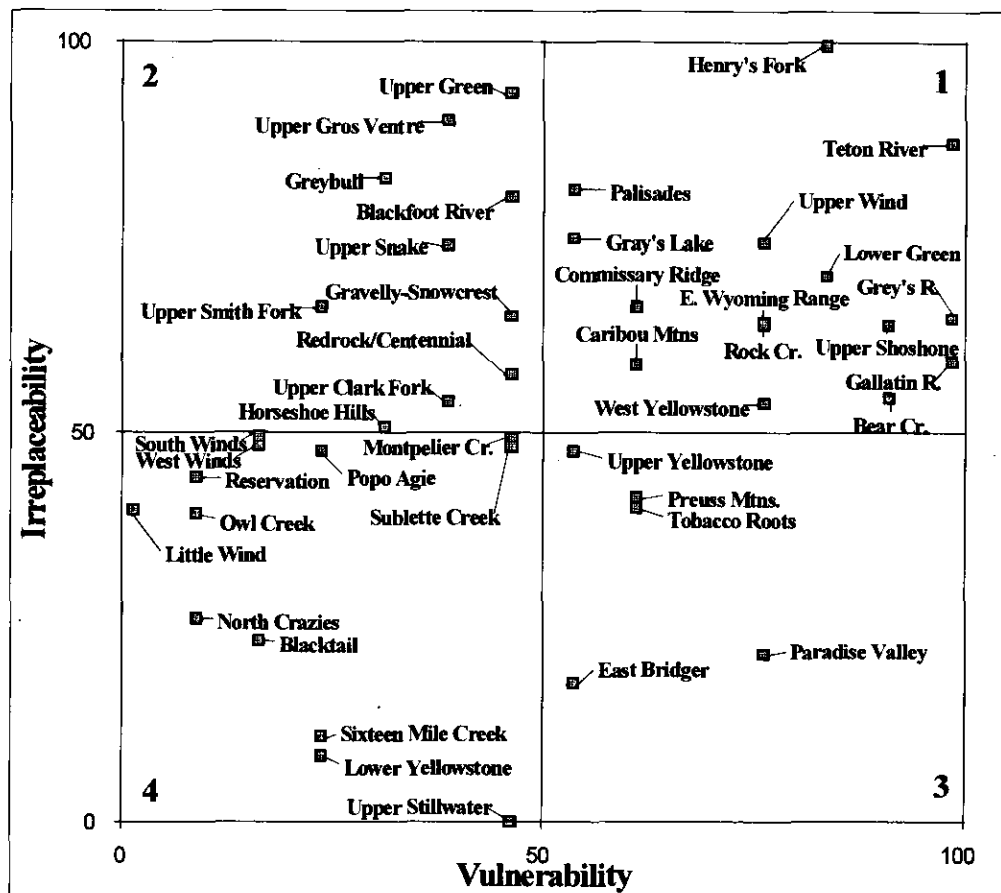
Figure 4. Example of site-specific conservation ranking based on irreplaceability and vulnerability scores. Sites in Quadrant 1 are highest priority for conservation.

Prioritization schemes are most useful in cases where scheduling issues exist – i.e., when it is not possible to protect all important sites at once. In such cases it is urgent to protect the high-value sites that are most threatened. In some conservation plans, including NCCPs, it is possible (at least in principle) to protect most or all biologically valuable sites at once, so such prioritization may not be needed. Nevertheless, if any delays in implementing a plan are anticipated, prioritization should be pursued.

In most conservation plans that apply site-selection algorithms, existing protected areas are "locked into" any conservation solution so that new reserves will add to the existing system rather than replace it. Hence, we recommend that top-down conservation planning for the DRECP start with the existing system of reserves (all categories) and build on it by adding new reserves, buffers, and connectivity. Importantly, the design must be based, to a large extent, on existing distributions of species, communities, and other features. However, it must also be able to accommodate shifts in species distributions with expected climate change. Hence, reserve system should protect a full range of enduring features and physical and ecological gradients

(Section 2.9) within contiguous and interconnected areas. Such a reserve system will provide species maximum opportunities to shift their distributions over time.

We suggest that the following elements are essential conservation targets, for which high representation goals should be established (i.e., approaching 100% in some cases):

- Unique Plant Assemblages as identified in Section 2.4.1.

- Special Features, as identified in Section 2.7.

- Areas of known importance to key covered or planning species, including at least the following:

  o desert tortoise critical habitat

  o bighorn populations and linkages

  o "core populations" and hypothesized linkages for Mohave ground squirrel

  o populations of species that are endemic or near-endemic (e.g., over 75% of total distribution) to the planning region

  o known habitat or populations of other species that are determined to be at high risk of extinction within the planning region

- Linkages between core habitat areas identified by any of the following: the California Desert Connectivity Project (Penrod et al., in preparation), South Coast Missing Linkages Project (Beier et al. 2006, South Coast Wildlands 2008) and California Essential Habitat Connectivity Project (Spencer et al. 2010).

- Habitat predicted to be essential to accommodate distributional shifts, in response to climate change, as predicted based on existing (e.g., Wiens et al. 2009) or future models.

- Areas important to maintaining dynamic geological processes, including eolian sand sources, wind corridors, and settling areas.

- Hydrologically important areas (e.g., washes, groundwater recharge areas, springs, seeps, etc.), including first- through fourth-order washes and washlets.

Regardless of the precise inputs, goals, and algorithms used, site-selection algorithms must be applied in a transparent and easily understandable manner. Use of algorithms must be augmented by attention to reserve design principles, and expert knowledge on species life histories, ecological processes, and other factors that determine viability of species and sustainability of ecosystem functions.

4.2.5 Use Planning Species and Other Key Surrogates to Derive Specific Design Standards

Many conservation planning efforts have applied general rules or principles (e.g., "bigger is better," "connected is better than unconnected," "corridors should be wide rather than narrow") that are difficult to apply in practice because they lack specificity. Only through intelligent consideration of the life histories of particular species, the distribution of physical environmental features, and the operation of key natural processes can conservation plans move beyond simple

generalizations. We recommend the use of focal or planning species (see section 2.6, above) to help derive more realistic and specific reserve design standards. In addition, natural processes, such as wind, hydrology, and fire (in areas with historic fire regimes) can be useful as surrogates for reserve design, with the goal being to maintain a spatial configuration of habitats that allows for natural operation of these processes.

4.2.6 Provide Large, Well Distributed Core Areas, but Don't Ignore Important Small Areas

Arguments in the academic literature about whether it is better to have fewer large reserves or more small reserves have died down with the recognition that the question is a red herring–it depends on the species and other case-specific details, and almost never will a conservation planner have to decide between one or the other (Soulé and Simberloff 1986, Noss and Cooperrider 1994). All else being equal, reserves should be as large as possible, because larger reserves have more resources, higher species richness, and larger populations that are less vulnerable to extinction; larger reserves are also less vulnerable to edge effects and other threats that cross reserve boundaries. However, many natural features (e.g., a spring or isolated dune) are small but nevertheless irreplaceable. They should be buffered, when possible (see below), but certainly not ignored simply because they are small.

An important consideration in determining necessary reserve size is the area requirements of the species of conservation interest that inhabit the area. Different species have different area requirements, with large-bodied carnivores generally requiring the largest areas (Woodroffe and Ginsberg 1998). We recommend that planners for the DRECP identify the most area-limited focal species (see Section 2.6) for each major vegetation type as a guide, the objective being to create reserves large and/or connected enough (see below) to maintain viable populations of all of those species.

4.2.7 Buffer Reserves with Compatible Land Use

The concept of surrounding reserves with buffer zones of appropriate, low-intensity land use goes back at least to the seminal work of ecologist Victor Shelford in the 1920s through 1940s (Croker 1991) and later incorporated into the biosphere model (UNESCO 1974) and adapted to reserve design in diverse landscapes (Harris 1984, Noss and Harris 1986, Noss 1987). Although well accepted by conservation biologists, the buffer zone idea has not always been politically palatable (i.e., it is seen by some as a sneak attempt to enlarge reserves; Noss, pers. obs.), nor have established buffer zones been easy to defend. Nevertheless, the concept remains valid, and establishment of the buffer zones is even more defensible and urgent during the present period of rapid climate change and shifting species distributions. The details of buffer zones (e.g., how wide they need to be, what land uses are permissible, are they considered part of a reserve or a separate, outside zone) are again highly case specific, depending on the particular species and resources that are expected to benefit from buffering, the size and habitat quality of the core area that is being buffered, the nature of the surrounding matrix, land ownership and land use issues, and other factors. There may be no substitute for highly skilled expert opinion in determining buffer zone requirements, although a well-designed adaptive monitoring program (Section 6) should supply empirical data over time to better justify and refine buffer requirements.

4.2.8 Connect Reserve Areas and Provide for Wildlife Movement

Habitat fragmentation and disruption of wildlife movements are great threats to covered species. Connectivity needs are species- and landscape-specific, and approaches based on the requirements of a wide range of focal species are generally most defensible (Beier et al. 2006, 2008; Spencer et al. 2010). Although it is important to select and plan for the needs of those focal species that are most sensitive to habitat fragmentation and movement barriers, it is also important to consider the different movement modes and constraints of diverse taxa. Although large carnivores are often assumed to be ideal focal species for designing corridors, corridors designed for them may not provide adequate connectivity for other wildlife (Beier et al. 2009). Some species that are not particularly wide-ranging (e.g., many reptiles or small mammals) are appropriate focal species for designing linkages, in part because they may be more likely than larger animals to avoid roads or be killed on roads. And, although birds are often neglected in connectivity plans because most can fly over unsuitable areas, some birds are highly susceptible to fragmentation effects and are useful for connectivity planning—such as roadrunners, quail, or other birds that mostly travel on the ground or fly only short distances.

Rigorous tools are now available for designing, assessing, and comparing linkage designs and movement corridors (Beier et al. 2008, McRae and Beier 2007, McRae et al. 2008, Spencer et al. 2010) and for incorporating uncertainty into corridor designs (Beier et al. 2009). However, rather than starting from scratch, *we recommend that DRECP review, incorporate, and build on previous connectivity work in the planning area. Specifically, the following references should be consulted by DRECP, and their results used to help with DRECP reserve design:*

- California Essential Habitat Connectivity Project (CEHC; Spencer et al. 2010),

- California Desert Connectivity Project (Penrod et al., in preparation),

- South Coast Missing Linkages Project (SCML; Beier et al. 2006, South Coast Wildlands 2008),

- Likely bighorn sheep movement corridors (Epps et al. 2007).

The California Desert Connectivity Project (Penrod et al., in preparation) provides the most comprehensive and detailed connectivity analysis available for the DRECP planning area. Results of this project—including least-cost corridor models for diverse focal species and detailed, multi-species linkage designs using the methods described in Beier et al. (2006)— should be incorporated into the DRECP reserve design following peer review and refinement, as needed. The goals of the Desert Connectivity project are to identify the most important areas in need of conservation and management to sustain and improve habitat connectivity and movement potential between large core areas (mostly large habitat areas on public lands) throughout California's deserts. The process included using an expert workshop—attended by numerous scientists, conservationists, and land managers from governmental and nongovernmental organizations—to identify large habitat areas in California's deserts that are most in need of connectivity and to select diverse focal species whose movement and habitat needs should be accommodated by landscape linkages. The experts identified 47 important linkage areas, which were objectively rated using a consensus scoring procedure to rank their biological irreplaceability (value) and the relative degree of threat to their functional connectivity

(see section 4.2.4). This ranking process was used to prioritize 23 linkage areas for detailed modeling and linkage design, based on the habitat and movement needs of 48 focal species (10 reptiles and amphibians, 13 mammals, 11 birds, 9 plants, and 5 invertebrates).

Least-cost corridor models (Beier et al. 2006, 2008) were then developed between habitat and population core areas for each species. These single-species linkages were then composited (using a GIS "union" function), further assessed for their ability to support populations and movements of focal species, and buffered (following methods described by Beier et al. 2006) to develop 23 robust, multi-species linkage designs intended to ensure functional connectivity for all focal species. Detailed management and monitoring recommendations are being developed for each linkage area, which includes identifying specific locations and design criteria for wildlife crossing improvements, such as road-crossing structures (e.g., wildlife underpasses or overpasses), wildlife fencing, and other measures to reduce roadkill and improve population connectivity.

The South Coast Missing Linkages (SCML) project (Beier et al. 2006, South Coast Wildlands (2008) preceded the Desert Connectivity Project (Penrod et al. in preparation), which expanded the geographic area from California's South Coast Ecoregion across California's desert ecoregions. SCML developed several linkage designs that connected portions of the South Coast Ecoregion with the Mojave and Sonoran Desert Ecoregions, and thus several linkage designs prepared for SCML are partly within the DRECP plan area and should be incorporated (see Appendix G for hyperlinks to appropriate SCML linkage reports). The Desert Connectivity Project was designed to be complementary to SCML, using similar analytical tools; *and together all existing linkage designs from these two projects that are in or partly within the DRECP area should be incorporated into the DRECP conservation design.*

The California Essential Habitat Connectivity Project (CEHC; Spencer et al. 2010) was coarser in scale than the Desert Connectivity Project or SCML, and did not use focal species to identify areas needing connection (instead, it used indices of environmental integrity and other biological inputs to identify large "Natural Landscape Blocks" and "Essential Connectivity Areas" throughout California). We do not recommend relying on maps from CEHC as *primary* inputs for site-specific reserve design in DRECP—due to coarse resolution, data constraints, and resulting errors of omission from the Natural Landscape Blocks and Essential Connectivity Areas, *especially in the deserts* (Spencer et al. 2010, page 41). The finer-resolution, focal-species maps produced by Penrod et al. (in preparation) and South Coast Wildlands (2008) are more defensible for DRECP reserve-design purposes. Nevertheless, we recommend considering the Natural Landscape Blocks and Essential Connectivity Areas identified by the CEHC as additional important areas to conserve, particularly where they lie outside of conservation priority areas not already conserved or mapped by other efforts.

More importantly, CEHC is an important source of information and guidance for how to maintain and improve habitat connectivity, wildlife movement, and adaptation to climate change. It provides a comprehensive and stepwise review of how to develop detailed regional and local linkage plans, wildlife crossing structures, and other conservation actions to counter fragmentation and climate change effects on ecological communities and species. It also

addresses methods for incorporating climate change adaptation into linkage designs, such as the land-facets approach of Beier and Brost (2010).

Additional Linkage Planning. Although the existing linkage plans discussed above provide a solid starting point for addressing habitat connectivity in DRECP, we emphasize that *these efforts should not be used uncritically, but should be reviewed, refined, and built upon as needed to meet plan goals.* Additional linkage designs, for additional focal species or areas of concern, may be required to supplement existing designs. Spencer et al. (2010) detail step-by-step processes for preparing such designs. In addition, they stress the importance of *recognizing all riparian areas and washes as important linkage features* (which is especially true in light of climate change: Seavy et al. 2009) regardless of their location inside or outside of natural habitat blocks or reserve areas.

4.3 Siting, Configuring, and Mitigating Renewable Energy Developments

Renewable energy developments may contribute to loss, fragmentation, and deterioration of plant and animal populations and habitats; changes in above and belowground hydrology; and increases in roads, vehicular traffic, subsidized predators, light pollution, dust, and human populations locally and regionally. The extent of the negative impacts depends on the type, location and size of the development, as well as how the energy is transmitted off-site. Some negative impacts from development will spill over onto adjacent lands and may have impacts far beyond the footprint of the developed site. Also, as introduced in Section 2.10, different types of renewable energy development will have different sorts of impacts, and therefore different siting and mitigation guidelines.

4.3.1 General Guidance for All Covered Actions

In general, the advisors recommend adhering to the strict sequencing of "avoid, minimize, and mitigate" for impacts to biological resources and ecosystem processes. Preference should always be given to avoiding impacts to undisturbed habitat areas and siting developments on already disturbed areas, so long as siting a development in a previously disturbed area won't disrupt important ecosystem processes, such as wildlife movements, water flows, or eolian sand transport and dune dynamics. Where strict avoidance of new disturbance is not possible, project siting and design should strive to minimize impacts to native vegetation, undisturbed soils, wildlife movement, or other important resources and processes. Finally, unavoidable impacts should be mitigated by appropriate actions.

The following recommendations apply to all covered actions:

- Site developments to the greatest extent possible on already disturbed lands (where vegetation has been altered and soil surface broken or disturbed), such as fallow agricultural fields, brownfield sites, industrial sites, and scattered private and public lands within and adjacent to cities and towns. Such sites are readily available throughout the Mojave and western Sonoran deserts. We also of course endorse "roof-top" or distributed solar development in urban areas to maximize power production from sites with little or no biological value.

- Site developments as close as possible to and use existing transmission line corridors and rights-of-way as a high priority. "Bundle" or co-locate linear facilities immediately adjacent and parallel to one another to avoid new fragmenting effects. Be aware in some cases that this make an existing partial barrier to wildlife movement even worse, but in most cases this is likely better than creating new fragmentation. Mitigate adverse effects of linear features on wildlife movement by creating safe crossing areas through existing, new, or bundled groups of linear features

- Avoid any developments within critical habitats for federal and state-listed threatened and endangered species; candidate species for federal or state-listing; sensitive habitats, core areas, and important linkages, migration corridors, or habitat connectivity areas (Spencer et al. 2010, South Coast Wildlands 2008, Penrod et al. in preparation, Epps 2007); or in designated Natural Areas, Research Natural Areas, Areas of Critical Environmental Concern, and Wilderness.

- Minimize the impact footprint of a development to the maximum extent possible, recognizing that the impact footprint may be larger than the actual development or construction footprint. For example, wind energy projects are often characterized as having relatively small project footprints, because the turbines themselves disturb small areas of ground. However, in assessing ecological footprints it is important to include all components necessary for a viable project (e.g., access roads and transmission lines). Include offsite effects, such as interruption of sheet flows that support downslope vegetation or interruption of blowing sands that support active dune systems.

- Avoid contributing to habitat fragmentation adjacent to or in the proximity of reserve areas or important habitat areas, including National Parks, ACECs, Wilderness Areas, etc. In many cases, the original boundaries of sensitive environmental areas were based on such factors as land ownership and politics, rather than on principles of reserve design or on maintaining viability of an ecosystem. Siting a renewable energy project with associated transmission lines adjacent to a protected area has high potential for fragmenting the landscape.

- Fence highways and roads providing access to renewable energy sites with appropriate animal-proof fencing to reduce illegal collection and road kills of wildlife, and to reduce food sources of subsidized predators. Special wildlife crossing structures (e.g., underpasses and overpasses that facilitate movements of animals) may be necessary for sites that are not located in or adjacent to towns and cities. The type of wildlife crossing and fence will depend on the focal species of concern. See Boarman (1995) and Boarman et al. (1997) for effectiveness of fences and culverts for protecting desert tortoises along highways, and Spencer et al. (2010) and references therein for general guidance for siting and designing wildlife crossing structures.

- Reduce light pollution by minimizing the number and intensity of lighting units and directing any light away from habitat areas.

- Fence artificial water sources, such as evaporation ponds, and cover them to reduce subsidies to predators (e.g., coyotes and ravens) and to prevent birds, bats, and other animals from becoming entangled, ill, or otherwise harmed by the fluids.

- Minimize dust and sand generated by construction and by travel on dirt roads. Avoid producing deposits and accumulation of eolian sands adjacent to and downwind from the site,

because such surficial materials provide seed beds for alien plants and cause habitat deterioration.

- Restrict temporary construction disturbances, such as lay-downs and access routes, to existing roads and disturbed areas.

- Develop and implement a long-term program to eliminate alien annual plants in and near project sites, access roads, and transmission line corridors and other areas used to transmit power.

- Develop and implement a long-term program to prevent trash and food scraps associated with the facility, contractors, and employees from becoming distributed beyond closed receptacles at the site. Trash must not be allowed to blow out of or away from the site and access roads and become distributed on the landscape. Trash has a negative effect on wildlife and may draw in undesirable species or aggregate species in disproportionate numbers (such as ravens). Collect any trash that blows off-site.

- Evaluate growth-inducing and cumulative impacts as part of environmental analyses, minimization and mitigation measures, and permit requirements.

4.3.2   Linear Infrastructure

- Minimize the total length of new (and temporary) roads, transmission lines, or other linear structures to the degree possible by siting energy projects near existing infrastructure, and avoid bisecting undisturbed desert habitats or crossing preserve areas. "Bundle" or co-locate new roads and transmission lines within existing easements and transmission line corridors, and retrofit existing transmission lines to carry additional electricity, or site new rights-of-way along other existing linear features, such as canals, roads, and aqueducts.

- Site, design, and construct appropriate crossing structures for wildlife across roads, canals, and other linear barriers or filters to wildlife movement. See Spencer et al. (2010, pages 141-146) and references therein (especially Meese et al. 2009, Clevenger and Huijser 2009, and http://www.wildlifeandroads.org/) for detailed reviews of road mitigation measures and recommendations for siting, designing, and implementing crossing structures, fences, and related measures. In addition, see Brooks (1995, 2000), Boarman (1995), and Boarman et al. (1997) for information on the effectiveness of fencing and culverts as mitigation measures for desert reserves and desert tortoises.

- Where new or refurbished transmission lines cross desert habitats, evaluate whether undergrounding can be used to minimize impacts. Undergrounding may not be desirable, because this could alter hydrological or other overland flow processes. Conduct pilot tests with appropriate Before/After-Control/Impact (BACI) sampling designs (see Section 6.4) to compare the relative impacts of different transmission designs (e.g., elevated vs. undergrounded) on biological and geohydrological resources.

- Use deterrent devices to discourage perching by ravens and raptors (Slater and Smith 2010) on transmission lines, towers, or other structures.

4.3.3   Solar Projects

The main impact of solar projects on biological resources is the direct removal, degradation, and fragmentation of habitat areas, although there are also concerns about indirect impacts and potential mortality of birds and insects from thermal concentrating facilities (Section 2.10.3).

- Site solar energy facilities on previously disturbed lands such as old or abandoned agricultural fields, areas scraped or bulldozed for development of tract housing, lands cleared of native vegetation and zoned for light industry, and lands within or on edges of cities, towns, and existing settlements on valley floors.

- Study the possibility of siting solar projects in long, narrow, linear arrays along existing roads (e.g., in interstate medians?), canals, or other linear features that already represent barriers to wildlife movement or major habitat fragmentation features. This will minimize new fragmentation effects. Mitigate the combined effect of any new developments and existing features with wildlife crossing features, including occasional wide gaps in developments, coupled with appropriate wildlife crossing structures (e.g., wildlife overpasses, underpasses, or bridges to accommodate road crossings) and appropriate wildlife fencing to funnel animals to the crossing location.

- If necessary, fence solar facilities with animal-proof exclusion fencing to protect against entrapment and mortalities, but mitigate for disruption of wildlife movement potential by improving wildlife crossing areas elsewhere (e.g., by providing road crossing structures for wildlife in other locations).

- Avoid siting on playas, playa margins, high-slope alluvial fans or bajadas, and old geologic surfaces armored with desert pavement because of the high potential for dust pollution and disruption of hydrological regimes. Site solar energy facilities on low-slope fan aprons out of eolian transport zones and preferably in previously disturbed landscapes.

- Avoid siting near habitats that concentrate birds and other desert wildlife, including all wetlands, major washes, oases, etc.

- Mitigate the confusing effects of polarized light reflections from solar panels on wildlife species that may mistake them for water bodies or that otherwise use polarized light as behavioral cues by experimenting with and applying cell borders or grids that break up the reflections, as described by Horvath et al. (2010).

4.3.4   Wind Projects

Although the direct impact footprint of wind turbines are relatively small, like all projects their ancillary features, including roads, transmission lines, etc., increase both the direct and indirect impacts. Wind turbines also can directly kill numerous birds and bats, which is one of the major concerns.

Fortunately, good guidance already exists for siting turbines and mitigating for and monitoring their effects. New federal guidelines for minimizing adverse effects of wind turbines on wildlife were recently released (too recent for review in this report) by the USFWS Wind Turbine Advisory Committee. In addition, the California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development (CEC and CDFG 2007) provide relevant, science-based

guidance for siting of wind energy developments in California. They provide relevant guidance for pre-construction and operations monitoring of bat and bird activity levels, fatality monitoring during operations, siting recommendations at the facility and turbine level, and approaches to mitigation. The Guidelines were completed following a stakeholder process facilitated by CEC and CDFG and have been vetted by conservationists, developers, and other interested parties to arrive at a set of mutually acceptable standards. Although new information gathered during implementation of wind-energy developments should continue to improve on these guidelines, they provide the best available guidance on monitoring and mitigation and should be used by DRECP.

Especially important is a recommendation in the Guidelines to archive results of pre-construction and operations monitoring efforts in an accessible database. This recommendation applies to all proposed sites within the DRECP planning area, whether they become operational facilities or not. Over time, such a database has the potential to promote adaptive learning regarding the linkage between pre-construction surveys and fatality rates of bats and birds at operational facilities. In addition, it may help to suggest thresholds for what should be considered high levels of activity or sites which pose greatest risk to birds or bats.

As part of pre-construction monitoring for siting new or repowered turbines, study the flight and foraging behavior of condors and other raptors relative to terrain, wind, and other factors. Research has shown, for example that repowering older wind turbines in the Altamont Pass Wind Resource Area (central California) with fewer, taller turbines reduced mortality rates for large raptors like golden eagle and redtailed hawk, although it may have increased bat mortality rates (Smallwood and Karas 2009). Switching to single pole (as opposed to open lattice) tower structures, and sealing all openings that birds can enter or use for nesting, has reduced perching and nesting by birds on the towers, further reducing mortality rates. Avoiding the siting of turbines in ridge saddles or other terrain features that tend to concentrate flight paths can also reduce impacts (Smallwood et al. 2009).

Evaluate temporal avoidance to further minimize potential impacts at both the facility-and turbine-level (CEC and CDFG 2007) by defining when impacts occur, and under what environmental conditions (e.g., time of day, season, wind speed, and temperature). Intensive (e.g., daily) ground searches for bird and bat mortalities during selected periods could provide sufficient data resolution to evaluate these factors. Using this information, it is possible to fine-tune turbine operations to reduce mortalities. For example, recent research demonstrating that bat activity and fatalities were highest on nights with low to moderate wind speeds (Arnett 2005, Arnett et al. 2006, Weller 2008) has led to mitigation experiments where cut-in speeds of turbines have been raised to reduce bat fatalities. These mitigations have led to >50% reductions in bat fatalities with minimal changes to power output (Arnett et al. 2009, Baerwald et al. 2009).

4.3.5 Guidelines for Improving Effectiveness of Mitigation

Numerous mitigation actions to offset adverse development impacts to plants and animals have been tried, but the successes and failures of various approaches are poorly documented and few publications are available concerning the effectiveness of alternative mitigation measures for biological resources in the California deserts. Some information is available on the value of fenced and protected preserves (e.g., Brooks 1995, 2000). Data are also available on

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effectiveness of highway fencing and use of culverts to protect desert tortoises (Boarman 1995, Boarman et al. 1997). However, much more needs to be done within a scientific framework on such topics as control of invasive and established alien plants, recovery of native annual and perennial vegetation after disturbance, and control of subsidized predators.

We recommend that *DRECP encourage and potentially fund a research project by an appropriate academic or research institution to review the history and effectiveness of various mitigation and conservation actions in California.* The objectives of the document should be to identify what works and what has not, to recommend possible solutions, and to advance the state-of-the art in mitigating and off-setting the effects of development, especially with regard to renewable energy projects. The compilers of this document should work with employees in state and federal agencies associated with protection and management of public and private lands, non-profit corporations involved in acquiring and protecting land and implementing mitigation measures, and law enforcement personnel actively engaged in protecting habitat and wildlife. This compilation should focus on what can be done to improve conservation and mitigation efforts. Some individuals may be reluctant to speak about failures. Nevertheless, failures should be identified and used as a means of improving the mitigation and compensation process.

One action that we generally do *not* endorse as mitigation *per se*—except perhaps under certain rare circumstances where scientific evidence suggests it may be warranted—is animal translocations out of proposed development areas into reserve areas. This is often done but rarely effective—a "feel-good" measure that has dubious ecological benefits and potential to do more harm than good. Although carefully designed translocations can be useful under certain circumstances—such as reintroducing a species to former areas of occupancy, given that the reason for their original extirpation has been rectified—simply moving animals from one area to another (likely already occupied) area is not recommended. In all cases, such extraordinary actions as translocations, reintroductions, or predator control should be treated as adaptive management experiments, with appropriate monitoring to ascertain their effectiveness and to maximize information gained from the experiment.

5 Additional Principles for Conserving Select Covered Species

Previous sections of this report provide comprehensive approaches for conserving covered species and communities via avoidance, minimization, and mitigation measures and a broad, landscape-level approach to designing a reserve network for desert biota. This section provides some additional information pertinent to conserving and managing particular species or groups of species, over and above recommendations in earlier sections. This information should be seen as supplemental to a comprehensive, multi-species, multi-community approach to conserving and managing a broad, landscape-level reserve network to sustain desert communities now and into the future.

- **Mohave Ground Squirrel.** We advise following recommendations currently being prepared by the Mohave Ground Squirrel Technical Advisory Group (MGS TAG), a long-standing committee of MGS technical experts from the private sector, academia, and land management and regulatory agencies. The TAG has drafted MGS conservation priorities based on recommendations made by Leitner (2008) and modified based on more recent information and expertise of TAG members. The document is currently in review by TAG members, with a goal of producing a final, consensus document as early as September, 2010 (S. Osborn, CDFG, MGS TAG Chair, personal communications). In the meantime, the DRECP advisors generally endorse the following recommendations from P. Leitner (2008, and personal communications) concerning conservation priorities for Mohave ground squirrel: (1) maintain connections between known population areas and avoid siting developments in known population areas or potential connectivity areas; (2) establish buffer zones of at least 5 miles (8 km) around four identified "core" population boundaries, avoid developments in these buffer zones, and manage them to protect colonizing juveniles; (3) acquire private inholdings within these delineated core populations; (4) restrict off-highway vehicle (OHV) use to designated routes within BLM lands in core areas; (5) conduct additional surveys to identify new population areas and improve understanding of potential connecting habitats. In general, the advisors do *not* recommend translocation or captive breeding as effective mitigation or conservation actions for Mohave ground squirrel (or most covered species). Natural history characteristics of MGS make them particularly poor candidates for translocation or captive breeding, and *in situ* habitat conservation and management is far superior to attempting to move animals to new locations or to bolster existing populations. If translocations are attempted, they must be treated as experiments, with intensive and long-term monitoring of populations to determine their effectiveness and improve scientific understanding of the species.

- **Desert Tortoise** (*Gopherus agassizii*). The advisors recommend that DRECP review and implement appropriate conservation, mitigation, and recovery actions outlined in the Desert Tortoise Recovery Plan. The desert tortoise is a widespread species (Nussear et al. 2009) whose numbers have declined for decades and continue to do so (USFWS 1994) due to a variety of anthropogenic activities (USFWS 1994, Tracy et al. 2004). Tortoise populations are susceptible to losses from disease (Jacobson et al. 1994, Homer et al. 1998, Brown et al.

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1999, Christopher et al. 2003) drought (Berry et al. 2002, Longshore et al. 2003) and predation (Esque et al. *In Press*) and are slow to recover. Little empirical data are available about the dispersal and survival of young desert tortoises, although adult tortoise movements have been observed for decades. Desert tortoise home ranges are known to range from 4 to 40 ha or more, and movements of up to 20 km have been recorded. There is one published record of movements in excess of 30 km from the Sonoran Desert (Edwards et al. 2004). Thus relatively short dispersal distances coupled with long life-spans likely mean that isolation by distance is a primary mechanism for population differentiation (Murphy et al. 2007, Hagerty and Tracy 2010). Based on landscape genetics analyses, connectivity among desert tortoise populations has been primarily affected by mountain ranges and extremely low elevation valleys (Hagerty et al. *In Review*). Disturbances caused by linear features or activities that block landscape pinch points have "likely removed all possible paths among previously connected populations" (Hagerty and Tracy 2010). Connectivity among populations may also be affected by factors causing localized extinctions. As with the Mohave ground squirrel, the advisors do *not* recommend translocation of desert tortoise as effective mitigation or conservation action, in part because translocated tortoises suffer high mortality rates. We do endorse implementing roadside fencing to reduce roadkill and road undercrosses to improve population connectivity, as called for in the Desert Tortoise Recovery Plan.

- **Bats**. Basic conservation needs of bats are met by ensuring that roosts, foraging areas, and free water are maintained within a few km of one another. However species of bats differ in the types of structures used as roosts, types of habitat favored for foraging, and nightly distances travelled to reach foraging and drinking areas. Therefore, conservation and mitigation efforts must take care to ensure that proposed actions are species-specific and maintain viable juxtaposition between important resources. For instance, loss of cave roost habitat in one area cannot be mitigated via protection of rock face or tree roost habitat elsewhere, as it would be unlikely to be used by the affected species. Similarly, loss of roost habitat cannot be offset through provision of foraging habitat. The success even of in-kind (e.g., protection of foraging habitat to offset loss elsewhere) habitat substitution should be verified through an adaptive management process before it is widely implemented as a mitigation tool.

In addition, bats must be able to move freely between seasonal habitats to reach mating and birthing areas. Evidence to date suggests that bats are most vulnerable to collision mortality with wind turbines during these seasonal movements (Arnett et al. 2008). These conclusions were based largely on impacts to tree roosting bats at latitudes further north than the DRECP planning area. However recent monitoring results at a wind energy facility within the DRECP planning area suggest that timing of impacts may be similar (e.g., during spring and fall migration periods) even if the species involved differ (Chatfield et al. 2009). Effective conservation of bats that migrate seasonally should ensure that steps are taken to minimize collision mortality at wind energy facilities.

6 Principles for Adaptive Management and Monitoring

Adaptive management is a systematic process of using advances in scientific knowledge to continually improve management practices by learning from outcomes of previous actions. An Adaptive Management and Monitoring Program is a mandatory component of an NCCP/HCP, and a carefully designed management and monitoring program is essential to success of any conservation plan. Often, however, this crucial component is addressed near the end of the planning process, almost as an afterthought once the conservation design and mitigation measures are established. We recommend an alternative strategy of developing key aspects of the Adaptive Management and Monitoring Program up front. In essence, *DRECP should be treated as a huge environmental experiment that should be developed and implemented incrementally in an adaptive management framework—with continuous monitoring and scientific evaluation to reduce uncertainties and improve plan actions over time.*

The advisors strongly recommend the following Principles to guide the statutorily required Adaptive Management and Monitoring Program (AMP), which we expand on in following sections:

- **Timing:** *Begin monitoring studies, and implementing adaptive management actions, immediately—during planning—to reduce uncertainties about plan outcomes and inform future plan decisions.*

- **Institutional structure:** *Develop a formal institutional structure that ensures strong, effective feedback from monitoring and research studies to plan decisions, and use this structure to continually improve all aspects of the plan over time, during both plan development and implementation.*

- **Hypothesis-based monitoring:** *Use conceptual and quantitative models that formalize understanding of the systems of interest to guide development and testing of hypotheses with monitoring studies.*

- **Appropriate monitoring design.** *Use robust statistical sampling designs for monitoring programs to maximize reliability of resulting data, including (1) Before/After-Control/Impact designs for new energy developments and (2) systematic surveys across the plan area to better establish landscape-scale baseline conditions.*

- **Focused research studies.** *Implement focused research studies to address uncertainties about how to sustain covered species and communities, such as landscape genetics and demographic studies to determine where conservation actions are most needed to sustain populations in the face of habitat fragmentation and climate change.*

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6.1 Implement Monitoring and Adaptive Management Immediately

Typically, adaptive management and monitoring plans have been developed as final steps in NCCP and HCP planning, with monitoring recommendations developed almost as an afterthought once the conservation plan is drafted, or even after an implementing agreement has been signed (personal observations of advisors). Given uncertainties about the impacts of diverse renewable energy developments and associated infrastructure on covered species and communities, DRECP should reverse this typical approach by *immediately developing and implementing monitoring protocols and securing access to lands proposed for renewable energy development.* Researchers from governmental and nongovernmental research institutions *must have access to lands proposed for development before, during, and after construction and operation of energy developments and appurtenance structures.* Access prior to construction is necessary to characterize ecological baseline conditions in and near proposed developments and thus allow Before/After—Control/Impact (BACI) sampling designs (Green 1979). BACI designs allow for much stronger inference about impacts of developments on biological resources than the "after-the-fact" monitoring typically implemented by conservation plans. Results of these studies should be used to evaluate impacts during and after construction, and use the results to inform future developments. Moreover, the plan should initiate some systematic, landscape-scale sampling across the study area to better characterize baseline environmental conditions prior to implementation of large-scale energy developments and further climate change. These recommendations are expanded on in Section 6.4.

The advisors recommend obtaining additional scientific input as soon as possible to assess monitoring priorities, metrics, sampling designs, and related matters to implement at renewable energy projects permitted during within the coming months or year. Solid baseline sampling should occur as soon as possible, prior to any construction. Monitoring designs and protocols can be modified over time, but it is essential that initial sampling is robust to any likely changes to ensure comparable data over time. Detailed monitoring recommendations were beyond the scope of this science advisory report, given available time.

6.2 Framework and Institutional Structure

In concept, adaptive management is a strong and scientifically sound approach for improving plan actions by "learning as you implement." Unfortunately, however, it is almost never successfully applied due to weak institutional structures that fail to ensure that accumulating scientific information—whether data collected within the plan from monitoring studies, or information from outside the plan from research studies—is actually applied to refine actions and make the plan truly adaptive. Lack of clearly defined and enforced institutional processes, and a failure to assign, fund, and empower the necessary personnel, are typical. Independent Science Advisors for the Sacramento-San Joaquin Bay Delta Conservation Plan (BDCP) tackled this problem for that plan based on their collective experience with both failed and successful AMPs for other large, complex conservation and restoration plans around the world (Dahm et al. 2009). We urge DRECP to develop an institutional structure similar to that recommended by Dahm et al. (2009) as illustrated in Figure 5. This structure, along with more detailed guidance provided by Dahm et al. (2009) represents a vast improvement over the often vague and weak structure s that generally doom AMPs to fail. It should be adapted and refined as necessary to fit the
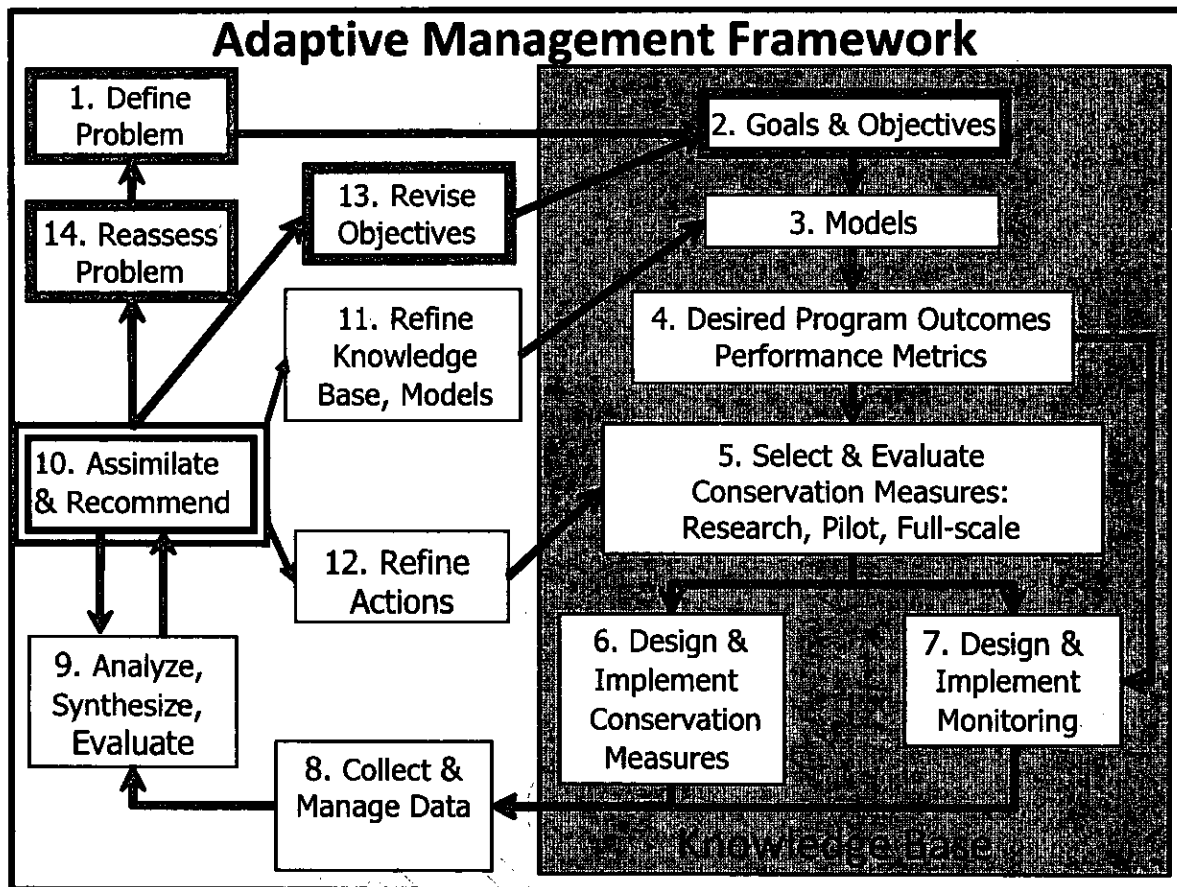
Figure 5. *A recommended AMP framework showing the flow of information and responsibilities of different entities.* The large shaded box underlying the right side of the figure represents the knowledge base for defining goals and objectives, designing predictive models, predicting outcomes, identifying performance metrics, and designing and implementing conservation measures and monitoring actions. Boxes framed with thin lines represent tasks performed by technical staff, such as scientists, land and water managers, and other analysts. Boxes framed with bold lines represent tasks performed by senior decision makers (i.e., policy makers and program managers who control program objectives and funding). The box framed with double lines (Box 10) represents a key step that is missing from most AMPs: Assimilate and Recommend. This task requires a body of skillful "polymaths" who understand both the technical and policy implications of the information passed along by technical staff (who analyze, synthesize, and evaluate monitoring and other data; Boxes 8 and 9). The task represented by Box 10 is to assimilate this diverse information, understand its consequences, and formulate recommendations to both the senior decision makers and the technical staff, such as revising plan objectives or conservation measures (Dahm et al. 2009).

particular needs of DRECP. For example, there should be a well-defined and enforced process for amending existing land-use and preserve management plans in California's deserts based on the DRECP conservation design and mitigation actions and the DRECP adaptive management and monitoring program. Likewise, there should be a clear and enforceable process for amending pre-existing permits for renewable energy developments based on new and emerging information concerning effective mitigation measures, new threats, and so on.

A key component of this recommended structure is represented by Box 10—assimilate information and formulate recommendations—which is where AMPs typically fail to adequately feed scientific information back into management and policy decisions. This function requires both policy and technical expertise, and is fundamental to the successful integration of accumulating knowledge and information into plan policies, such as revising goals and objectives, refining analytical models, or allocating funding. The link between the technical step of "Analyze, Synthesize, Evaluate" and the decision-making step of "Assimilate and Recommend" requires regular interaction and exchange of information between technical staff and decision makers.

Box 10 highlights the need for some highly skilled agent (person, team, office) to be assigned the responsibility for continually assimilating scientific information generated by investigations *both within and external to the adaptive management program* and transforming it into knowledge of the kind required for management actions. Boxes 11 through 14 indicate that such actions may include (1) refining a particular conservation measure, (2) refining the knowledge base and models of system behavior that are extracted from the knowledge base, (3) revising objectives of an entire conservation measure, and (4) reassessing whether the original target problem is solved, transformed, or still a problem. This last action may also be affected by external events such as changing societal preferences, newly recognized environmental threats, changes in available technology, or other changed or unforeseen circumstances. If new information suggests that conservation and mitigation actions codified in existing permits are ineffective, there should be a formal process for amending permits to rectify the situation.

The actions of the agent represented by Box 10 need to be carried out continually but on a range of time scales. For example, individual components of the knowledge base might be refined gradually and annually, whereas particular conservation measures might be refined only after a few years of project implementation. The entire problem might be re-assessed or re-visited once in a decade. The key principle, however, is that *the process of transferring and transforming the results of technical analyses into knowledge to support decisions cannot be taken for granted in the hope that it will occur in the absence of a body specifically charged with making it happen.* This function requires remarkably skillful people, who are truly inter-disciplinary ("polymaths"). Whatever their training, these individuals (or team of individuals) need to be comfortable with a wide range of technical information, as well as understand the functioning of government, law, economics, and the management of large projects.

## 6.3   Hypothesis-based Monitoring and Adaptive Management

Adaptive management is an active process in which new knowledge is gained and applied to managing natural resources (Holling 1978, Walters 1986). An overarching goal of adaptive management is to maintain optimally functioning ecosystems, with all their components (Noss

and Cooperrider 1994). This necessitates understanding the dynamics of populations, communities, and the resources they need (Landres et al. 1999). Hypotheses about processes and interactions that characterize sustainable populations, as well as proximate and ultimate stressors that affect them, need to be identified. When monitoring efforts determine those stressors are evident, management experiments are used to test various means of reducing the stressor's impact. These management experiments are coupled with focused monitoring to evaluate success (Morrison et al. 2001).

Traditional monitoring approaches that focus on quantifying population size, despite increasingly high levels of statistical rigor, have generally failed to address critical questions regarding factors that affect species and community dynamics (Barrows et al. 2005, Barrows and Allen 2007). Consequently, traditional monitoring often fails to provide clear direction to management. We propose a monitoring framework that is explicitly hypothesis-based, with species monitoring performed within a context of community, landscape, and ecosystem scales. This framework approach has been published (Atkinson et al. 2004, Barrows et al. 2005) and is being adopted as a guiding philosophy for many HCPs and NCCPs throughout California. The authors of the 1994 Desert Tortoise Recovery Plan also explicitly recommended hypothesis-based research and monitoring.

This approach builds on existing published research and employs primary data collection to build conceptual and quantitative models that link species population trajectories with community or ecosystem processes and conditions (conceptual model examples: Figures 6-7). The conceptual models are essentially a collection of hypotheses regarding the drivers and stressors of a species' or communities' temporal and spatial dynamics. It is an iterative process of designing a monitoring approach and collecting data to statistically evaluate models and hypothesis by partitioning large-scale models into discrete units. This breaks down the inherent complexity of ecological systems into manageable questions. A conceptual model leads to questions that can be answered with monitoring and addressed with adaptive management. Unless the model possesses that heuristic character it is of little value.

Figure 6 illustrates a conceptual model for desert tortoise. Monitoring long-lived species like desert tortoises is often problematic, because tortoise populations can remain stable for years even with little or no reproduction, so it may take many years to detect effects of stressors on tortoise populations. However, by examining the conceptual model we can develop a monitoring design that compares different metrics, such as the incidence of diseased adults or raven predation on hatchlings, with respect to road density or other measures of habitat fragmentation. If the numbers of predated hatchlings or diseased adults exceed that of unfragmented sites, management actions should strive to mitigate fragmentation effects. Similarly, invasive species such as Sahara mustard, *Brassica tournefortii*, are thought to be a source of stress for tortoises. A monitoring strategy to address this question might test such alternative hypotheses as: (1) is the mustard density associated with fragmentation or with loss of food?; or (2) are tortoises negatively impacted by the mustard, and if so how? This latter question could be addresses by comparing tortoise condition (perhaps by a morphometric-adjusted measure of the tortoises' weight, or incidence of disease) in mustard-infested versus mustard-free landscapes. If the tortoises' condition in the mustard areas is poorer than that on the native control sites, then adaptive management strategies to control the mustard should become a priority.

Desert Tortoise Conceptual Threats Model
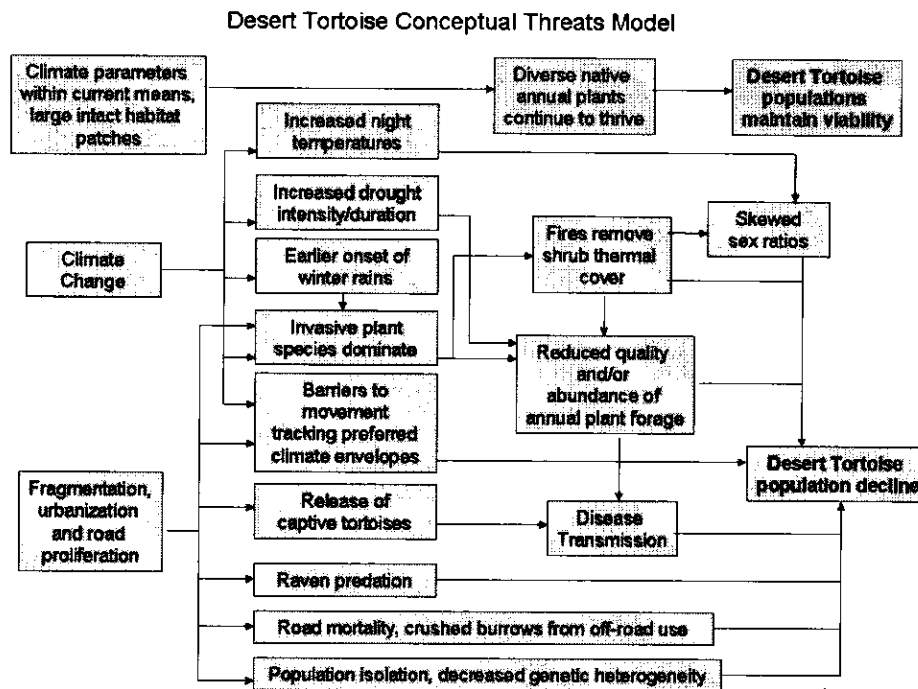
Figure 6. Desert tortoise conceptual model.

Using the Mojave fringe-toed lizard as an example of a shorter-lived species with more volatile population dynamics (Figure 7) again suggests questions about the impacts of invasive species such as Sahara mustard. Here, rather than looking at adult condition, a more straight forward approach would be to compare lizard abundances in areas with mustard and those without mustard. However to get at more proximate drivers the monitoring could also measure sand compaction and insect prey abundance with respect to the mustard as well. By measuring the mustard with respect to lizard abundance along with sand compaction and prey abundance we can evaluate whether mustard is compromising the lizards' population, and if it is, determine what pathway is driving the effect. This increases our understanding, focuses adaptive management responses, and identifies metrics for evaluating the success of mustard control measures.

Through time this hypothesis-driven process increases our understanding of how populations and communities change with respect to a range of environmental conditions. The conceptual models can be modified with new information, and ideally will evolve into quantitative, predictive models. They allow us to learn about the complex interrelationships that typify natural systems, the factors that stress natural systems, and what management tools are best used to address those stressors.

Mojave fringe-toed Lizard - Desert Sand Dune Conceptual Threats Model
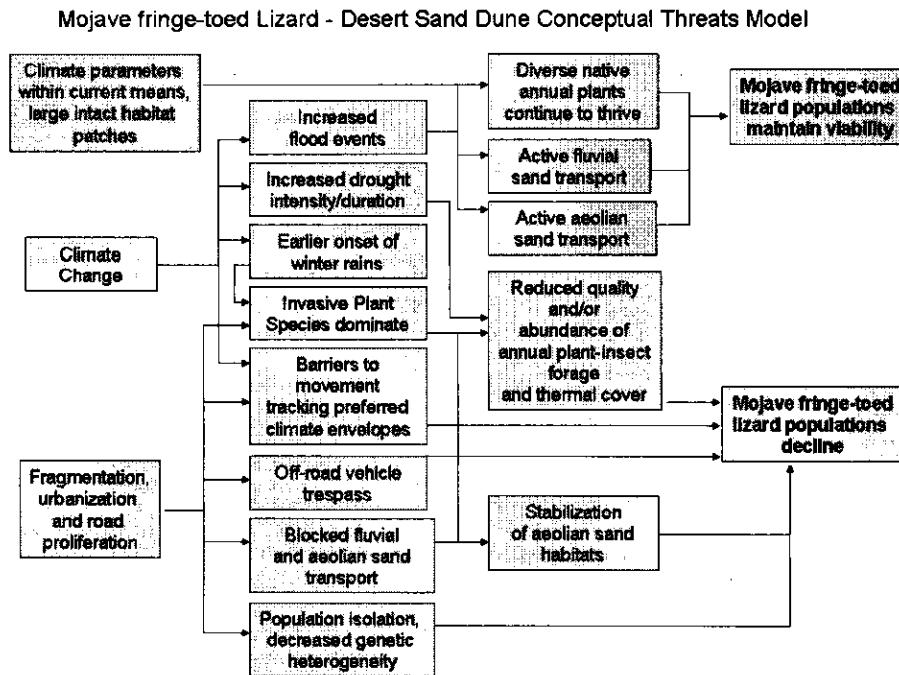
Figure 7. Mojave fringe-toed lizard conceptual model.

6.4 Monitoring Design and Research Recommendations

Renewable energy development will have impacts on species, communities, and processes that are largely unknown at this time. Mitigation for such impacts should occur via an integrated process of siting decisions, reserve establishment, and habitat management and restoration. The challenge then is to monitor both net losses and gains at various scales across the landscape. This requires systematic monitoring at impact sites, mitigation sites, and control sites (areas with no impacts or mitigation actions).

We recommend developing statistically robust monitoring designs to (1) clearly establish the effects of new developments and mitigation actions on covered species and communities, (2) better understand population distribution and dynamics of key covered or planning species, and (3) establish baseline conditions across the planning area to better understand and respond to future changes, due, for example, to climate shifts. We also endorse (4) additional research on genetic and demographic connectivity of select species' populations across the study region to better delineate important landscape connectivity areas for conservation and adaptation to climate change.

6.4.1 BACI Design for Renewable Energy Developments

Before/after - control/impact (BACI) sampling designs can be a powerful tool for understanding the impacts of anthropogenic changes on biological resources, if they are carefully designed with adequate replication and sufficient temporal sampling (Green 1979, Underwood 1994, DeLucas et al. 2005). The basic idea is to establish impact sites (e.g., areas to be developed) and control

sites (those with no development) and to sample them before the impacts occur (to establish comparable baseline conditions in the two types of sites) and after the impacts occur (for sufficient duration to observe an environmental response to the impacts). Only with this sort of design can one differentiate spatial and temporal influences to better understand potential cause-effect relationships between the development and the environmental responses. A full review of potential BACI studies and their design is beyond the scope of this report, but we recommend that the plan carefully consider the range of species, ecological conditions, and impacts that could be studied with appropriate BACI designs. *A critical issue is that access to researchers must be established in potential renewable energy development areas before, during, and after development.* DRECP should establish requirements for research and monitoring access as a condition on renewable energy permits, and should use results of BACI studies to refine siting, mitigation, and other requirements for future permits.

6.4.2 Systematic Surveys for Baseline Conditions

We recommend that a comprehensive monitoring plan be designed, at the earliest stages of plan implementation, for each covered species, community, and process of interest. Monitoring sites should be established throughout the planning area; in addition to areas with expected impacts (either positive or negative). Sites should be selected from a statistical framework (e.g., random or systematic sampling, stratified appropriately based on natural communities) at an appropriate spatial scale for the entity to be monitored. Monitoring efficiencies can be generated by co-locating sample locations for multiple species or processes of concern (Manley et al. 2004).

Results of initial monitoring should be used as "baseline" data for adaptive monitoring processes, as well as for detecting and responding to changing climatic conditions. It should be expected that design and implementation of a robust program to characterize population status, distribution, or habitat associations for some covered species will take multiple years depending on status of existing information. For instance, varying levels of precipitation altered the set of habitat variables that explained occupancy patterns of Palm Springs ground squirrel (Ball et al. 2010). Time and cost required are often cited as reasons for not establishing statistically-robust, systematic monitoring programs. However, we contend that given the presumed 30-year duration of the DRECP and our strong recommendations for an adaptive approach to conservation/mitigation/restoration, investment in a systematic, multiple-species monitoring program is a vital investment in its success.

6.4.3 Population Monitoring

Accurate estimates of covered species populations are often difficult, expensive, and unnecessary. A more reasonable approach for monitoring regional populations for most species is to use presence-absence patterns and modern site occupancy estimation measures (Scott et al. 2002, Manley et al. 2004, MacKenzie et al. 2006). These approaches are able to account for surveys where probability of detection is <1, a situation which is common for many covered species. An example of such an approach has already been implemented for the Palm Springs ground squirrel within the DRECP Planning area (Ball et al. 2010). The robustness of such approaches improves when monitoring locations are selected from a probability-based sampling method across the area of interest. Efficiencies accrue from co-locating sampling locations for multiple taxonomic groups. We recommend that such an approach be considered for monitoring

population status of the large number of Covered Species for which detailed population information is not available.

6.4.4 Focused Research Studies and Surveys

We recommend some focused research studies and surveys for select covered species be developed to clarify how best to conserve and manage these species. Below are some examples, but others will arise during planning:

- **Mohave Ground Squirrel Surveys.** We recommend more comprehensive surveys, using appropriate systematic or random sampling designs, to better establish the distribution, abundance, and connectivity of the Mohave ground squirrel metapopulation in the western Mojave Desert. There are large gaps in existing survey efforts, and there could additional core population areas or important connectivity areas between cores than those that have been hypothesized based on existing data (Leitner 2008). Renewable energy developments should be sited so as to avoid occupied habitats or important connecting habitats, and conservation actions should strive to secure, buffer, and connect occupied and potential habitat areas.

- **Genetic and Demographic Connectivity Studies.** We endorse proposals to use population genetic data and habitat suitability modeling to provide spatially explicit inferences about important demographic connectivity areas and movement corridors. Results could be used to refine our understanding of habitat connectivity for such key species as desert tortoise and Mohave ground squirrel to inform where to focus conservation and mitigation actions to sustain or improve population connectivity to ensure species persistence in light of habitat fragmentation and climate change. However, we also endorse genetic connectivity studies across a broader range of species, including more common or unlisted species, to better understand broader, ecological implications of fragmentation and climate change on desert ecosystems.

- **Mortality monitoring.** Guidelines for producing credible mortality estimates of bats and birds at wind energy facilities in California already exist (CEC and CDFG 2007). Importantly, mortality estimates must account for biases associated with carcass removal and searcher efficiency. The existing Guidelines (CEC and CDFG 2007) should be modified for implementation at other types of renewable energy developments (e.g., solar) and associated infrastructure within the DRECP.

6.4.5 Other Environmental Monitoring

In addition to monitoring biotic conditions and processes, we recommend that at least the following physical conditions and processes should be systematically monitored using BACI designs for new developments and to establish baseline conditions and changes throughout the planning area:

- Ground water levels and impacts—e.g., to determine whether water use or hydrological effects of developments are adversely affecting water tables and dependent resources.

- Local climate levels and impacts—e.g., to determine whether large solar arrays may affect local or regional climate conditions and hence ecological conditions.

- Erosion and deposition effects—e.g., to determine whether developments are altering soil erosion/deposition processes, eolian transport and dune maintenance processes, or levels of toxins in the atmosphere or on desert vegetation and watersheds (see Section 2.8).

6.5 Land Management Recommendations

6.5.1 Invasive Species Management

We recommend that management of exotic plants be considered as part of the energy development process and as a strategy for partly mitigating direct native habitat destruction due to energy development. It is likely that activities associated with energy development will contribute to the establishment and spread of invasive, exotic plant species. Movement of mechanized equipment can distribute seeds, construction of linear corridors (e.g., transmission lines, roads) can harbor exotics and facilitate their spread, and disturbance promotes exotic species (Lodge et al. 2006). While mitigating for direct habitat destruction by managing other lands does not fully compensate for the destroyed habitat, we suggest that managing exotics on lands adjacent to energy installations (to limit any spread of exotics due to the disturbance) and in conservation areas be considered as part of plans for partly mitigating habitat loss.

Bossard et al. (2000) summarize troublesome exotic plants of the California desert. Some species are more harmful than others. Exotic alien annuals such as Arab grass and bromes (*Schismus* sp., *Bromus rubens, B. tectorum*) now occupy over 60% of the biomass in the western, central, and southern Mojave Desert regions (Brooks and Berry 2006). The exotic annuals are highly successful, competitive, and have negative effects on native animals that rely on and prefer specific species of native food plants (e.g., desert tortoise, see Jennings 2002). Exotic annual grasses such as red brome (*Bromus rubens*) are currently of great concern to resource managers because these species are highly invasive and linked to wildfires by providing continuous fuel loads. Fires are not thought to have been prevalent historically in the Mojave Desert owing to discontinuous fuel loads, but have increased in extent in recent decades concurrently with expanding populations of exotic plants (Zouhar et al. 2008). These fires devastate native communities dominated by long-lived perennials such as blackbrush (*Coleogyne ramosissima*), which are not considered fire-adapted due to the absence of fire in the evolutionary history of the desert (Abella 2010). We suggest that an analysis of fire potential (based on fuel loads and ignition probabilities) be used as a tool for prioritizing exotic species management treatments, in conjunction with locations of sensitive species or communities with high conservation priority, and corridors where transport of exotic plants might be greatest. We recommend that equal attention be paid to high- and medium-fire potential areas. High-potential areas require treatment because of high risk; medium-potential areas can benefit from treatment to avoid becoming at risk.

Little funding for research has been dedicated to developing treatment strategies for exotic plants in southwestern hot deserts such as the Mojave. However, studies such as Allen et al. (2005) suggest that there is potential for testing different herbicides and other treatments for reducing the prevalence of red brome and other exotic plants. Key factors that should be considered in

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evaluations of herbicide and other treatment strategies include whether the herbicide acts as a pre- or post-emergent, the timing and duration required for effective treatment, and effects on the non-target native community. Additionally, consideration should be given to post-treatment management, as often establishing a competitive native vegetation type can reduce probabilities of resurgence of the exotic species. Since exotic species management strategies are not well tested in desert areas, these projects could take the form of applied projects that are conducted at an operational scale but within a planned study design that includes untreated controls. This can enable conclusions to be drawn about the effectiveness of candidate treatments and allow development of strategies that may be feasible to implement over the broad scales necessary to make a difference ecologically.

6.5.2   Restoration and Improvement of Habitat

We do not recommend considering habitat creation or ecological restoration as full mitigation for new habitat disturbances, although some habitat improvements and revegetation actions should be considered, in some cases, as partial mitigation for habitat destruction. Such actions might include revegetating disturbed areas (including by wildfires) with native plants within conservation reserves. Revegetation in arid lands is expensive and prone to failure due to unpredictable rainfall, and it is difficult to reestablish all features and processes of functional ecosystems. However, a recent review of revegetation practices in the Mojave Desert found that there are some examples of successful revegetation projects (Abella and Newton 2009).

Seeding and planting of greenhouse-grown or salvaged plants are the most common methods of revegetation. There are advantages and disadvantages to both methods; for example, larger areas can be revegetated through seeding than through planting. Associated treatments, including protecting seeds and plants from being eaten, can make the difference between successful and failed projects. Abella and Newton (2009) compiled a list of the performance of an array of native species in revegetation projects as well as the effectiveness of treatments. In addition, restoration activities such as reestablishing native riparian vegetation and hydrological patterns along springs and water courses could greatly improve habitat value and provide an adaptation strategy if the climate changes (Seavy et al. 2009). This is especially appropriate for renewable energy facilities that require significant amounts of water and may further stress groundwater supplies. Restoration efforts should not focus solely on "cosmetic" areas such as campgrounds or visitor centers, but should include meaningful areas for habitat conservation improvement purposes.

To the degree feasible, we suggest considering maintaining natural vegetation within renewable energy installations to maintain some habitat value, but carefully monitoring how this affects ecological communities and covered species. The current paradigm is to bulldoze the soil and vegetation to establish energy sites. Assessing alternative strategies that include retaining as much vegetation as possible would be a large improvement over clearing all vegetation. It is possible that that some vegetation can coexist with energy installations to provide some habitat as well as to sequester carbon. An initiative to incorporate vegetation within energy installations should include balancing any conflicts of retaining vegetation with fire hazard, maintenance and performance of the energy structures, and the ability of the vegetation to grow within the energy sites. If vegetation can co-exist within arrays, the best strategy would likely be to leave mature plants (i.e., not bulldoze them in the first place), as opposed to trying to revegetate after the fact.

However, it is uncertain what type of native plant species are best adapted to co-exist with energy sites, so species that can thrive with shade cast by solar structures and other aspects of the sites may need to be identified and promoted. In addition, where energy installations are sited by leasing private agricultural land or private or public abandoned agricultural land, it may be possible to grow crops (or restore native desert vegetation) in concert with energy structures. Using agricultural land for energy installations has many advantages (e.g., the land is already relatively level) and is a strategy we recommend.

Monitoring should also consider whether maintaining some habitat value within renewable energy developments may do more harm than good, for example by attracting species into areas with high mortality rates. In this case, habitats within energy developments may be "sink habitats" where mortality exceeds reproduction. If this effect is strong, it has potential to reduce regional populations of covered species. Answers to such questions should be answered early if possible, by carefully designed BACI monitoring studies at developments that are permitted in the near future.

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EXHIBIT 464

CAN MODELING IMPROVE ESTIMATION OF DESERT TORTOISE POPULATION DENSITIES?

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Abstract. The federally listed desert tortoise (*Gopherus agassizii*) is currently monitored using distance sampling to estimate population densities. Distance sampling, as with many other techniques for estimating population density, assumes that it is possible to quantify the proportion of animals available to be counted in any census. Because desert tortoises spend much of their life in burrows, and the proportion of tortoises in burrows at any time can be extremely variable, this assumption is difficult to meet. This proportion of animals available to be counted is used as a correction factor (g_0) in distance sampling and has been estimated from daily censuses of small populations of tortoises (6–12 individuals). These censuses are costly and produce imprecise estimates of g_0 due to small sample sizes. We used data on tortoise activity from a large ($N = 150$) experimental population to model activity as a function of the biophysical attributes of the environment, but these models did not improve the precision of estimates from the focal populations. Thus, to evaluate how much of the variance in tortoise activity is apparently not predictable, we assessed whether activity on any particular day can predict activity on subsequent days with essentially identical environmental conditions. Tortoise activity was only weakly correlated on consecutive days, indicating that behavior was not repeatable or consistent among days with similar physical environments.

Key words: activity modeling; detectability; distance sampling; Gopherus agassizii; *monitoring; neural network modeling; power analysis.*

INTRODUCTION

In 1991, desert tortoise (*Gopherus agassizii*) populations distributed north and west of the Colorado River were listed as "threatened" under the Endangered Species Act of 1973 (U.S. Fish and Wildlife Service 1990). The recovery plan for this species recommended monitoring the effectiveness of management actions by assessing population sizes for one tortoise generation (25 years). One criterion to delist this species is to demonstrate a statistically significant upward or stable trend in population size over a 25-year time period (U.S. Fish and Wildlife Service 1994).

Range-wide monitoring of population densities of desert tortoises was initiated in 1996, using stratified random transects in all 14 Desert Wildlife Management Areas (DWMAs) contained within the six Recovery Units (Appendix; U.S. Fish and Wildlife Service 1994, Anderson et al. 2001). Population densities within DWMAs have been calculated using "distance sampling" calculations (Anderson et al. 2001, Buckland et al. 2001) as

$$D = \frac{n}{l \times w} \times \frac{1}{P_a \times g_0} \qquad (1)$$

where D is the estimated density of animals, n is the

number of animals observed on transects, l is the total length of the transect walked, and w is the width of the transect. In addition, this equation uses two functions to estimate how many animals are missed during the sampling as a function of (1) their distance from the transect (detectability, P_a; see Plate 1), and (2) their availability to be encountered by an observer (g_0). Tortoises are frequently unavailable to be sampled because tortoises are cryptic and make extensive use of underground shelters.

Desert tortoises spend much of the year in burrows even during the active season (Woodbury and Hardy 1948, Nagy and Medica 1986, Bulova 1994), and usually only the proportion of the tortoise population that is above ground is sampled. This can lead to a violation of a critical assumption of the distance sampling technique, namely, that all animals on the line are found (Anderson et al. 2001, Buckland et al. 2001). Aboveground availability (g_0) is currently estimated by monitoring the proportion of radiotelemetered animals ($N = 6$–12) that are visible to observers at several sites within the desert tortoise recovery units (Anderson et al. 2001).

The goals of this study were: to identify the level of precision necessary to statistically detect trends in tortoise populations; to explore the error in density estimates that could be induced by estimating g_0 from observing small focal populations; and to explore the extent to which modeling g_0 using a suite of environmental conditions could improve estimates of g_0.

MATERIALS AND METHODS

Power analysis

To get an estimate of the precision necessary to satisfy the first U.S. Fish and Wildlife Service delisting criterion we conducted a power analysis to estimate the statistical power to detect growth in populations at different growth rates and with different degrees of error in the density estimates over a 25-year period. The power analysis used computer simulations (Link and Hatfield 1990) of population growth for populations with a constant average growth rate. Simulated growth rates ranged from 1% to 5% annual growth in increments of 1% (Hatfield et al. 1996), and coefficients of variation for the density estimates ranged from 5% to 100% in increments of 5% for each subsequent analysis.

Populations were simulated to grow at a specified average growth rate starting with 1000 individuals, and a population size was generated for each time step that was randomly modified according to a specified coefficient of variation. Thus, a population of N_{t+1} at time $(t + 1)$ was calculated as a product of the population one year prior (N_t) multiplied by the discrete population growth rate (λ). Variation was then added to the resulting population estimate (N_i) by drawing a number from a random-normal distribution with a mean of N and a specified coefficient of variation (CV):

$$N_{t+1} = N_t \times f(\lambda, \text{CV}). \tag{2}$$

We simulated population size over 25 years and then regressed the resulting annual population sizes against time. Statistical power was determined from the proportions of 1000 simulations of population growth with each set of population parameters (λ and CV) that were significant with an alpha of 0.05 (Hatfield et al. 1996).

Source of data for calculating g_0

Approximately 150 adult desert tortoises were tracked weekly at one site near Las Vegas, Nevada, USA (Appendix). The tortoises were located approximately between 04:00 and 16:00, which generally bounded the daily activity times of tortoises. These animals were monitored over a three-year period (1997–1999) using hand-held radiotelemetry receivers (e.g., Telonics TR-2, Mesa, Arizona, USA). Radio transmitters (AVM models G3, SB2, or SB2-RL) were attached to tortoises in a manner similar to that described in Boarman et al. (1998). The body of the transmitter was attached (with epoxy) to the first costal scute, usually on the left side of the animal, to provide the best positioning of the antenna. The antenna was then affixed (with epoxy) to the center of each costal scute from front to rear, wrapping around the back of the animal and continuing forward on the opposite side. Silicone caulk was used to secure the antenna in the scute margins while allowing for growth of the animals (Boarman et al. 1998). All tortoises were numbered with a paper tag covered with clear epoxy, and the carapaces were notched on the marginal scutes by creating a small groove using a triangular file (Cagle 1939).

When tortoises were located, the date, time, and the microhabitat of the animals were recorded. We categorized the microhabitats into four general categories: in the open, under vegetation, in a pallet (a shallow shelter that does not completely cover the tortoise, Bulova 1994), or in a burrow. To approximate availability we further categorized each microhabitat as above ground (i.e., under vegetation or in the open), or below ground (i.e., in a burrow or a pallet) and calculated the proportion of animals above ground.

Environment

A weather station recorded environmental and operative temperatures (T_e; Bakken et al. 1985) at a central location at the study site. Operative temperatures represent an estimated potential body temperature if the animals were to achieve a steady state under current environmental conditions (Tracy 1982, Bakken et al. 1985, O'Connor et al. 2000). Operative temperatures were measured using painted cast aluminum models of both juvenile (carapace length [CL] = 80 mm), and adult-sized (CL = 240 mm) tortoises placed in full sun and in shaded microhabitats (Zimmerman et al. 1994). The amount of solar radiation was measured using a pyranometer (model number LI-200SA, LI-COR, Lincoln, Nebraska, USA). Wind speed was measured at a height of 1 m from the surface with a cup anemometer (model number 03101, Campbell Scientific, Logan, Utah, USA). Air temperatures were measured at 10, 20, and 40 cm above the ground with shielded thermocouples (Christian and Tracy 1985). Soil temperatures were measured at the substratum surface, and at 10, 20, and 70 cm below the surface. All thermocouples were 24-gauge type k (Omega Engineering, Stamford, Connecticut, USA). Data were recorded using a CR-10X datalogger with an AM416 multiplexer (Campbell Scientific, Logan, Utah, USA).

Average and variance of g_0 with sample size

We wanted to determine the possible error in the estimates of the proportion of tortoises above ground and available to be censused as a function of sample size. To do this we used the microhabitat locations that we categorized as above or below ground for 376 observations of ~120 tortoises from 24 May 1999 to 18 June 1999. Animals that were found either in the open or under vegetation were classified as above ground, and animals that were in a burrow or a pallet were classified as below ground. Samples of these 376 observations ranging from 3 to 150 observations were drawn randomly, and the average and standard deviation of the locations were calculated. This was repeated with 100 random draws (with replacement) of observations at each sample size.

TABLE 1. Sensitivity analyses of the input variables to the results of the Artificial Neural Network model.

Inputs to model	Influence on g_0
Maximum of large T_e in shade	0.027
Maximum of surface temp. in shade	0.020
Average of large T_e in sun	0.021
Average of T_{air} (20 cm) in shade	0.017
Maximum of small T_e model in sun	0.016
Average of small T_e model in sun	0.014
Average soil temp. (-30 cm) in sun	0.013
Minimum of small T_e model in shade	0.013
Average of large T_e model in shade	0.009
Average of soil temp. (-10 cm) in sun	0.007
Average of small T_e model in shade	0.006
Average soil temp. (-70 cm) in sun	0.005
Minimum of small T_e model in sun	0.005
Maximum of large T_e model in sun	0.003
Maximum of surface temp. in sun	0.002
Average of T_{air} (40 cm) in sun	0.002
Average of wind speed (m/s)	0.001
Average of T_{air} (40 cm) in shade	0.001

Notes: Air and soil temperatures are expressed in centimeters above or below the surface. The sensitivity analysis was performed by running the model with each input value set at one standard deviation above and below its mean, and measuring how much the output varied. The influence on the predicted proportion of animals active (g_0) is the standard deviation of each output divided by the standard deviation of each input. Operative temperature is represented by T_e, and air temperature is represented by T_{air}.

We fitted a power function to the curve created by the standard deviations of the measurements ($y = 0.5479x^{-0.5678}$), and the first derivative of the fitted function ($dy/dx = -0.3111x^{-1.5678}$) indicated the number of samples at which relatively little change occurred in the reduction of the standard deviation as sample sizes increased.

Model of g_0

We used an Artificial Neural Network (ANN) to model daily tortoise activity (g_0) as a function of 18 site-specific environmental variables recorded by the weather station. The environmental variables that we used as inputs included: daily values of maximum solar radiation, rainfall, average wind speed, and minimum, maximum, and average temperatures of air, soil, and operative temperature (T_e) models (Bakken et al. 1985). The model was constructed from 334 days of input using 65% of the data for training, 25% for cross-validation, and 10% for testing the network. Specifically, the neural network was a back-propagating network consisting of one hidden layer of four processing elements and one hidden layer, using Tan-h transfer functions, with a momentum-learning-rate of 0.7 per epoch (Principe et al. 2000). We used weight decay to allow model inputs to drop out of the model when they did not contribute to the prediction of g_0. The network was constructed using NeuroSolutions for Excel (Version 4.2, Neuro Dimension, Gainesville, Florida, USA). This software normalized inputs prior to running the model.

The relative influence of different inputs to the model was quantified by sensitivity analyses of each variable on the predicted outcome (Table 1). The sensitivity analysis consisted of running the model with each normalized input value set at one standard deviation above and below its mean, and measuring how much the output varied. The standard deviation of each output was then divided by the standard deviation of each input.

Repeatability of g_0

To assess the repeatability of tortoise activity across time, we chose consecutive pairs of days from three years of observations with the criterion that the difference between the maximum operative temperature of the first and second day was not $>5°C$. The proportions of tortoises active on the first and second days were then regressed against one another to indicate the repeatability of percentage activity for the tortoise population on similar days.

RESULTS

Power analysis

Coefficients of variation of $>12\%$ around a growth rate of 1% per year would not allow enough statistical power (i.e., 0.8) to detect the trend over a 25-year period (Fig. 1). To achieve similar power for 2%, 3%, 4%, and 5% annual growth rates the coefficients of variation of the population estimate would need to be less than or equal to $\sim 25\%$, 35%, 45%, and 55%, respectively.

Microhabitat use

The proportions of animals that were found in underground microhabitats (pallets and burrows) during the part of the day when tortoises are active over the three-year study period ranged from 60% to 75% (Fig. 2). In addition, the numbers of animals found in different microhabitats differed among years ($\chi^2 = 324.3$, df = 6, $P < 0.0001$). Tortoises used burrows much more than the other three microhabitats (Fig. 2).
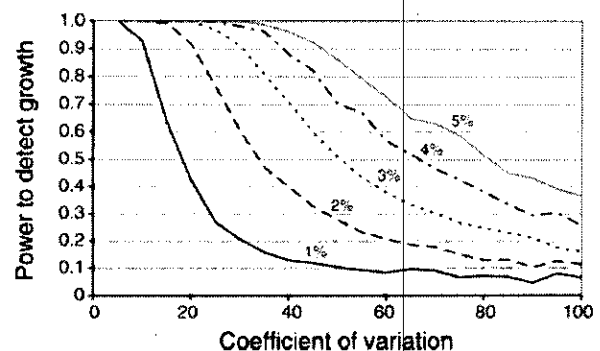

FIG. 1. Power to detect different growth trends in annualized population growth rates as a function of the coefficient of variation of the density estimates. Curves represent the power to detect different population growth rates from 1% to 5% growth.

The proportion of animals active varied annually, seasonally, weekly, and daily (Fig. 3). For example, high levels of spring activity in April and May of 1998 were not as great in either 1997 or 1999. The period of activity in the fall of 1997 (roughly October), was qualitatively higher than that seen in either of the other two years. The variation in daily activity was not consistent throughout the season, or among years. For example, the variation in the proportion of animals active during spring in 1997 was greater than that for 1998. In all years, tortoises were generally more active during the morning hours.

Average and variance of g_0 with sample size

Sample size had a large influence on the precision of the estimates of g_0. With a sample size of 100, the proportion of animals active was very similar to the average of the population of 150 tortoises. However, as would be expected, the variance of the estimates was greater for smaller sample sizes. The reduction in the variance of the estimates of activity was not linearly related to the number of samples. A power function was fitted to the curve created by the standard deviations of the means with an explained variance of 97%. The rate of change of standard deviation (where the first derivative of the power function fit to the standard deviations approached 0) indicates that with at least 20–30 animals the variance in the estimate of g_0 became nearly a constant at a low value. The sample size required to achieve a coefficient of variation in the estimate of g_0 (let alone other sources of variation implicit in the sampling technique) of <12% (see previous power analysis) was ~95 animals. This implies that focal populations may never be of sufficient size to estimate g_0 precisely.

Neural network model

The neural network model of tortoise activity yielded a significantly correlated estimate of modeled g_0 and measured g_0 ($F_{1,82} = 58.3$, $P < 0.0001$), but explained only 42% of the variance in g_0. This level of explained variance corresponded to a CV of ~57% (by taking the RMSE/mean of the response variable), which would occlude trends in growth rates of >5% per year. The input variables to the model to which the outputs were most responsive included the maximum daily temperature of the large T_e model, the surface temperature in a shaded microhabitat, and the daily average of the large T_e model in the sunny microhabitat (Table 1).

Repeatability

Activity of tortoises on consecutive days with similar climate was significantly correlated. However, this correlation explained only 29% of the variance ($r = 0.54$) indicating that behavior may not be repeatable at the population level.

DISCUSSION

The foremost criterion for desert tortoise populations to be delisted requires that there be a statistically
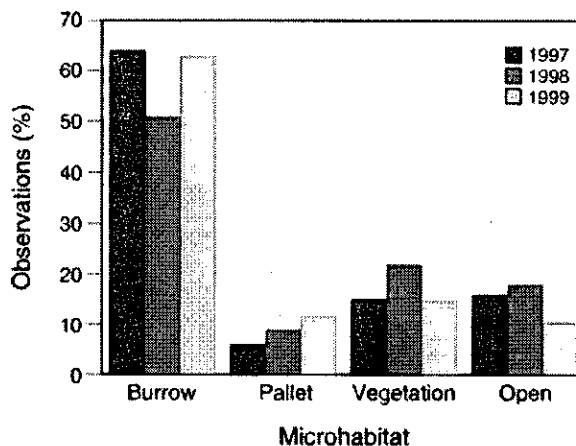

FIG. 2. Percentage of observations of ~150 free-ranging desert tortoises in three field seasons during the daytime hours at Bird Spring Valley, in southern Nevada. Tortoises were categorized as (1) in a burrow, (2) in a pallet, (3) under vegetation, or (4) in the open.

significant upward or level trend in population size over a 25-year period (U.S. Fish and Wildlife Service 1994). The maximum reasonable population growth rate for tortoise populations has been estimated to be ~1% per year under ideal reproductive conditions (U.S. Fish and Wildlife Service 1994), albeit population declines can occur at rates up to 30% in a single year (Longshore et al. 2003). Our power analysis indicated that to detect a trend over a 25-year time period with a 1% annual growth rate, the coefficient of variation about the density estimates would have to be 12% or less.

Current estimates of population density from range-wide transect sampling for desert tortoises for the years 2001 through 2005 have coefficients of variation that range from 9.5% to 56.2%, depending on the year and area sampled (U.S. Fish and Wildlife Service 2006). With this magnitude of variation, tortoise populations would have to increase at rates of at least 4% per year to detect an upward trend in a 25-year period with sufficient power (Cohen 1988). With such low potential growth rates and the high variance in population density estimates reported from the range-wide monitoring program, this criterion may be intractable.

Another important result from this analysis is that it applies not only to the detection of increasing trends, but also decreasing ones. Thus, tortoise populations could decline at a rate of up to 4% per year, and that trend would still not be distinguishable from populations with no statistical trend at all. Clearly more precise density estimates are necessary to make sound decisions regarding the recovery and conservation of this species, as the error present in the current sampling method is exceedingly high (Gerrodette 1987, Taylor and Gerrodette 1993, Freilich et al. 2005).

The difficulties of sampling desert tortoises for population densities largely result from the fossorial habits of the species (Freilich et al. 2000). Tortoises
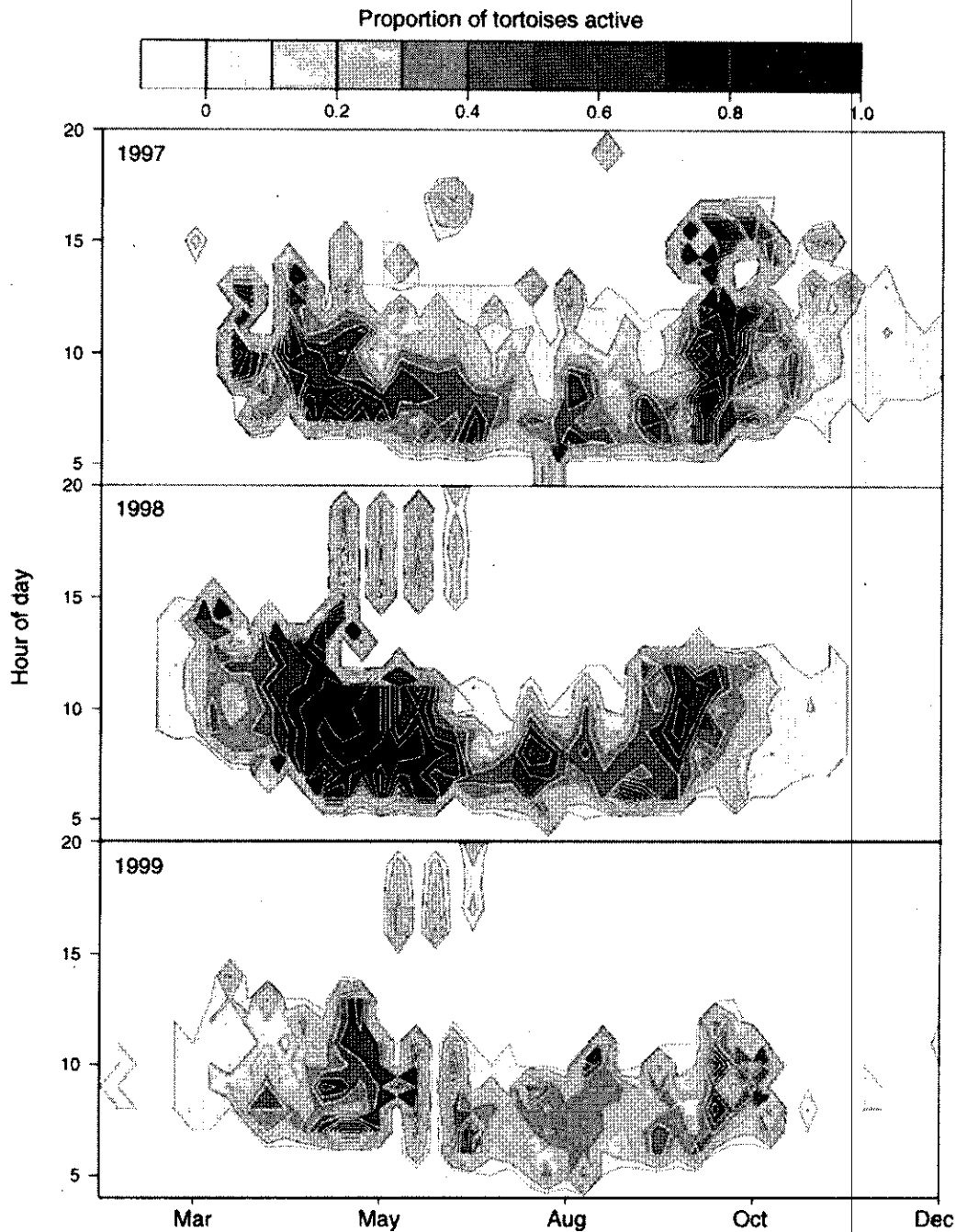
Proportion of tortoises active

FIG. 3.   The proportion of animals active for each hour of the day calculated from daily tracking of 150 tortoises at Bird Spring Valley, Nevada. The proportion of tortoises active is denoted by the darkness of the color, where gray colors indicate low levels of activity, and black denotes high levels of activity. The white background indicates times when animals were not sampled by radiotelemetry.

spend much of the year in underground burrows (Figs. 1 and 3; Woodbury and Hardy 1948, Nagy and Medica 1986, Bulova 1994), and the patterns of tortoise activity vary annually, seasonally, and daily (Fig. 3; Duda et al. 1999, Freilich et al. 2000, Anderson et al. 2001), yet none of this variance is accounted for in estimates of g_0 for population density estimates of tortoises. This is critically important because an improperly calculated g_0 will impart significant error to density estimates. Both of the modifiers to the density estimation equation (P_a and g_0) are influenced by tortoise activity and the mechanisms determining patterns of activity (Eq. 1). The precision of the detectability estimate (P_a) calculated by distance sampling is largely influenced by the

PLATE 1. A desert tortoise that covered itself with sand seeking shade under a shrub. Photo credit: K. Nussear.

numbers of animals encountered on transects. A sample must include at least 60–80 animals to estimate P_a with adequate precision using distance sampling (Buckland et al. 2001). To achieve sample sizes of 60–80 desert tortoises the established monitoring protocols have included animals found on the surface, as well as those in burrows. However, the animals in burrows are currently treated in the same way statistically as animals on the surface. Specifically, the probability of detecting burrows as a function of distance from the line, and the detectability of tortoises in those burrows have not been evaluated, but are assumed to be the same as detecting an animal on the surface. Additionally, estimates of the proportion of animals above ground (which should equal g_0 in the strictest sense) are influenced by the sample size of focal populations, and by the times of year that tortoises are sampled (Fig. 3).

In some years there may be so few tortoises active that the number of animals encountered on transects will be low, and thus the precision of the estimate of P_a will be low (e.g., Fig. 3, 1999). In other years, there may be high variability in the proportion of animals active as a function of the week of the year or time of day during the sampling period (e.g., Fig. 3, spring of 1997). These mechanisms create an inherent lack of precision in the estimation of the availability of animals to be sampled, and this error will be incorporated into the estimates of tortoise density in unknown magnitudes.

Focal observations of 8–10 tortoises per site have been used to infer g_0 during the sampling period. If focal populations are used, the number of animals included in the sample is important to the precision and accuracy of the g_0 estimate. Monte Carlo simulations of g_0 measured from a population tracked by radiotelemetry of ~150 animals indicate that the sampling error associated with samples of 8–12 animals (the number of focal animals used in many of the focal sites) may lead to errors in the estimation of g_0 as high as 50%. Additionally, even if the focal populations are increased to 20 or 30 animals, the variance in the estimates of g_0 resulting from "snapshot" monitoring of focal animals remains as high as 25% (in this analysis). Indeed, a population of ~100 tortoises would be required to achieve a coefficient of variation for g_0 alone that was 12%. Thus, precise estimates of g_0 may require large focal groups that would be prohibitively costly, and may not reduce the error in the estimation of g_0 sufficiently to increase the precision of annual density estimates to acceptable levels.

We modeled the proportions of animals active on a given day as a function of several environmental variables related to the biophysical environment of desert tortoises using an Artificial Neural Network as one possible approach to create a more cost effective and precise means of estimating g_0. Several other factors, such as forage availability, are likely to be important to quantifying tortoise activity; however the biophysical parameters that we included are likely to

define the thermal environment, which has been demonstrated to influence activity strongly (Zimmerman et al. 1994, Hillard 1996). This model had a high level of variance around the mean predictions. In fact, the amount of variation explained by our model is roughly equivalent to that expected using small focal populations to estimate g_0. Thus, our initial model does not create an improvement over using focal animals to estimate g_0.

To test the precision with which it is possible to model g_0, we examined the repeatability of population level activity estimates, under similar environmental conditions by analyzing the proportion of tortoises that were active on consecutive days. Despite similar environmental conditions, the proportion of tortoises active on consecutive days was only weakly correlated. This indicates that the behavior of tortoises is not especially predictable based upon environmental variables alone. This may place limitations on our ability ever to model tortoise activity at the population level.

While our example highlights an approach to modeling activity as a surrogate for availability of desert tortoises, there are many animals that frequently have a reduced availability or observability (i.e., $g(0) < 1$) to sampling efforts. Examples in the literature include those from a variety of species, including cetaceans (Skaug et al. 2004), birds (Hone and Short 1988), large herding herbivores (Jachmann 2002), kangaroos (Pople et al. 1998), sea turtles (Gómez de Segura et al. 2006), lizards, and snakes (Rodda and Campbell 2002). For animals typically censused using areal surveys this is an especially relevant topic. Frequently, efforts to estimate availability/visibility involve modeling aspects of the animal's behavior; such as surfacing intervals in whales and sea turtles (Skaug et al. 2004, Gómez de Segura et al. 2006); differences in coloration of individuals, or herd behavior due to daily or seasonal differences in temperature, and detectability in large mammals (Bayliss and Giles 1985, Hill et al. 1985, Jachmann 2002). Our approach stems from examining the behavior of the population as a function of key environmental drivers of behavior (Zimmerman et al. 1994).

We think the need for modeling approaches extends beyond studies using transect methods to survey for an organism. For example, prior to 1999, survey efforts for desert tortoises consisted of a score of permanent study plots located throughout the Mojave that were surveyed, and densities were estimated using mark–recapture techniques. These surveys took place using a 30-day marking phase, and a 30-day recapture phase (Berry 1986). Over a 60-day time period, tortoise behavior, and the resulting availability of these animals is likely to change. Seasonal changes in behavior will influence the precision of the density estimates as a smaller proportion of the population is available for sampling (Williams et al. 2001), and could also violate the equal catchability assumptions of capture–recapture analysis if there are seasonal differences in activity among different members of the population (e.g., genders or size classes).

We think that understanding the effects that behavior and the resulting observability of an animal is important to the methods that we use to estimate their population sizes or densities. This is an important factor to consider when designing and implementing survey studies, and this importance extends beyond studies that use distance to estimate population parameters.

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APPENDIX

A map of transects surveyed during the 2001 season and the field site for behavioral observations (*Ecological Archives* A017-021-A1).

EXHIBIT 465

STATE OF CALIFORNIA

**Energy Resources Conservation
and Development Commission**

In the Matter of:

The Application for Certification for the
CALICO SOLAR PROJECT

Docket No. 08-AFC-13

**ADDITIONAL REBUTTAL TESTIMONY OF
DAVID S. WHITLEY ON BEHALF OF
THE CALIFORNIA UNIONS FOR RELIABLE ENERGY
ON CULTURAL RESOURCES FOR THE CALICO SOLAR PROJECT**

· September 17, 2010

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I.   Introduction

I am a professional archaeologist. I received a Ph.D. in Anthropology, with a specialization in Archaeology, from the University of California, Los Angeles, in 1982. I have been previously employed as Chief Archaeologist at UCLA; have served as US Representative and on the Council of Directors for the International Council of Monuments and Sites (ICOMOS); and was appointed as Prehistoric Archaeologist to the State of California, Historical Resources Commission (1986-7). In 2001 I received the Thomas F. King Award for Excellence in Cultural Resource Management from the Society for California Archaeology. I have provided cultural resources consulting services for CEQA and NEPA applications for over 30 years. My professional publications include over 100 articles and book chapters, and seventeen books and monographs, and I fully meet the Secretary of the Interior's Standards and Guidelines for Professional Qualifications as a Principal Investigator for archaeological projects (see 36 CFR Part 61). I am also an Adjunct Professor at the School of Geographical Sciences at Arizona State University, Tempe, where I serve on doctoral dissertation committees for geomorphology students.

The California Unions for Reliable Energy (CURE) retained my firm, ASM Affiliates, Inc., to review Scenario 6 (docketed on 8 September 2010) and Scenario 5.5 (docketed on 8 and 10 September 2010), pursuant to the Committee's September 3, 2010 Order, for the Calico Solar Project (Calico or Project), and to prepare expert testimony regarding the potential adverse impacts to cultural resources that will result from Project development of these alternatives.

In the following, I demonstrate that both proposed Scenarios 5.5 and 6 have the potential to adversely impact over 100 archaeological sites, the significance of which has not yet been determined; that the CEC Staff and Applicant have continued to fail to consider whether Unique cultural resources are present within the Project, despite this requirement in CEQA; that the CEC Staff and Applicant have failed to consider the possibility that Native American sacred sites may be present within either Project scenario; and that the CEC's proposed Conditions of Certification do not conform to standard archaeological practice, defy archaeological logic, and fail to comply with CEQA.

II.   Neither Scenario 5.5 or 6 Will Significantly Reduce Impacts to Cultural Resources

According to the declaration of Rachael Nixon, Senior Archaeological Project Manager on behalf of Calico Solar, dated 13 September 2010, the changes resulting from either Scenario 5.5, or Scenario 6 will result in the avoidance of only four archaeological sites (p. 2). In both cases, over 100 archeological sites will still fall within the Project Area of Potential Effects (APE). That is, proposed Scenarios 5.5 and 6 each represent an insignificant reduction in the adverse impacts to cultural resources that will accrue as a result of the Project.

In my previous testimony (Exhibit 441), I demonstrated that the Applicant: (1) failed to identify the potential adverse impacts to cultural resources that will result from the Project; (2) failed to follow standard archaeological practice for CEQA compliance and implementation; and (3) failed to consider "Unique" cultural resources, as defined in CEQA (see PRC 21083.2; see below). I note further that the July 2010 CEC Staff Assessment of Cultural Resources and Native American Values (Exhibit 309) ("Staff Assessment") concurred with my first two points. For example, Staff stated that:

> "the data on which the applicant's and the BLM's conclusions are based are not adequate to definitively draw conclusions regarding resource eligibility" (p. C.2-1).

Staff further observed that "additional investigation is warranted in order to more definitively draw conclusions regarding archaeological site significance" (p. C.2-91).

The California State Historic Preservation Officer (SHPO) confirmed these two conclusions, stating that:

> "it has not been fully demonstrated that the sites in question do not include a subsurface archaeological component which might change [the Applicant's and BLM's] eligibility determinations" (25 August 2010 letter from M. Wayne Donaldson, SHPO, to Roxie C. Trost, BLM, Exhibit 311).

Proposed Scenarios 5.5 and 6 will result in the potential destruction of over 100 archaeological sites whose significance has not yet been established, despite the fact that, as CEC Staff have observed, "The lack of site testing, as in this case, is an exception to this common practice" (Staff Assessment, p. C.2-96). It is my professional opinion that the CEC Staff have not conducted the analysis necessary to determine the significance of impacts to cultural resources that will be impacted by Project development. Moreover, it is inconsistent with current archeological practice to defer this analysis until after Project approval. The proposals of scenarios 5.5 and 6 do nothing to change that fact.

III. Failure to Consider Unique Cultural Resources

It is necessary to re-iterate that the Staff Assessment and the Applicant's Technical Report (R.A. Nixon, 2010, Class III Cultural Resources Technical Report for the Calico Solar Project, San Bernardino County, California, pp. 5-45-159, 5-383-95) ("Technical Report") have failed to consider the potential impact of the Project on Unique cultural resources, as required by CEQA (PRC 21083.2). This failure is particularly grievous, in light of the probability that such Unique resources are

present within the Project APE, regardless of the recently proposed new development Scenarios.

With respect to adverse impacts to cultural resources, the CEQA Guidelines state clearly that:

> "If an archaeological site does not meet the criteria defined in subdivision (a) [i.e., CRHR eligibility], but does meet the definition of a unique archeological resource in Section 21083.2 of the Public Resources Code, the site shall be treated in accordance with the provisions of section 21083.2. The time and cost limitations described in Public Resources Code Section 21083.2 (c-f) do not apply to surveys and site evaluation activities intended to determine whether the project location contains unique archaeological resources" (CEQA Guidelines 15064.5 (c) (3)).

As demonstrated in my 16 August 2010 rebuttal testimony (Exhibit 441), there is substantial and credible evidence that Unique cultural resources may be present within the Project APE. Unique resources are defined in CEQA as those that, beyond just contributing to general archaeological knowledge, have special and particular qualities, such as being the oldest of a particular site type, or that contain information that is needed to answer important scientific questions that are demonstrably of widespread public interest. Perhaps the most important such question, that is of fundamental archaeological concern and widespread popular interest, is the first peopling of the Americas: when did humans first arrive in North America? This question is directly relevant to the potential significance of the archaeological sites within the Calico Project, because the archaeological record of this immediate area, including the kinds of sites identified within the Project APE—regardless of development Scenario—have figured importantly in the research and debate about this problem.

In light of the failure of the CEC Staff Assessment and Applicant Technical Report to comply with CEQA and consider whether Unique cultural resources are present within the Project, included in the latest proposed Conditions of Certification, I am obliged to re-iterate and expand upon my earlier statements that there is evidence to suggest that the Calico Project as redesigned in Scenario 5.5 and 6 has the potential to adversely impact Unique resources; specifically, sites relevant to the first peopling of the Americas problem. Close to a century of Mojave Desert research has been conducted to address this question, which remains unanswered, heavily debated, and sometimes very controversial—signaling the fact that this is a topic requiring additional study. Importantly, surface archaeological sites like those within the Project APE have provided an important source of data for this research. The history of archaeological investigations on this topic is large (although effectively ignored in the site significance recommendations made in both the Applicant's Technical Report and the CEC Staff Assessment). A brief list of some of

the studies that have been conducted on Mojave Desert surface archaeological sites includes:

- E.W.C. Campbell, et al., 1937, The Archaeology of Pleistocene Lake Mohave. *Southwest Museum Papers 11*. Los Angeles, California: Southwest Museum.
- E.L. Davis, et al., 1969, *The Western Lithic Co-Tradition*. San Diego Museum Papers 6, San Diego.
- P.J. Wilke and A. B. Schroth, 1989, Lithic Raw Material Prospects in the Mojave Desert, California, *Journal of California and Great Basin Anthropology* 11:146-174.
- D.B. Bamforth, 1990, Settlement, Raw Material, and Lithic Procurement in the Central Mojave Desert, *Journal of Anthropological Archaeology*, vol. 9, pp. 70–104.
- D.B. Bamforth, 1992, Quarries in Context: A Regional Perspective on Lithic Procurement, in *Stone Tool Procurement, Production and Distribution in California Prehistory*, pp. 131–150. J. E. Arnold, ed. Perspectives in California Archaeology, No. 2. University of California, Los Angeles: Institute of Archaeology.

Research on Mojave Desert surface archaeological sites has been aided by recent technical advances in the scientific dating of surface artifacts and rock features, making the study of surface sites all the more scientifically important. These again were effectively overlooked or ignored in the Applicant's Technical Report and the CEC Staff Assessment. Some of these latest relevant advances, and demonstrations of their international applicability and utility, have been published in the following scientific papers:

- T. Liu and R.I. Dorn, 1996, Understanding the Spatial Variability of Environmental Change in Drylands with Rock Varnish Microlaminations. *Annals of the Association of American Geographers* 86:187-212.
- M. Cremaschi, 1996, The rock varnish in the Messak Sattafet (Fezzan, Libyan Sahara): age, archaeological context, and paleoenvironmental implication. *Geoarchaeology* 11:393-421.
- R.I. Dorn, 1998, *Rock Coatings*. Amsterdam, Elsevier.
- B. Zhou, et al., 2000, Rock varnish microlaminations from northern Tianshan, Xinjiang and their paleoclimatic implications. *Chinese Science Bulletin* 45:372-376.
- T. Liu, 2003, Blind testing of rock varnish microstratigraphy as a chronometric indicator: results on late Quaternary lava flows in the Mojave Desert, California. *Geology* 53:209-234.
- R.I. Dorn, 2007, Rock varnish. In *Geochemical Sediments and Landscapes*, edited by D.J. Nash and S.J. McLaren, pp. 246-297. London, Blackwell.

- T. Liu, 2008, Rock varnish microlamination dating of late Quaternary features in the drylands of western USA. *Geomorphology* 93: 501-523.
- T. Liu, 2008, Rock varnish evidence for latest Pleistocene millennial-scale wet events in the drylands of western United States. *Geology* 36: 403-406.
- A. Zerboni, 2008, Holocene rock varnish on the Messak plateau (Libyan Sahara): Chronology of weathering processes. *Geomorphology* (2008), doi: 10.1016/geomorph.2008.06.010.
- R.I. Dorn, 2009, Desert rock coatings. In *Geomorphology of Desert Environments 2nd Edition*, ed. A.J. Parsons and A.D. Abrahams, Springer, chapter 7, pages 153-186.

As this partial list demonstrates, a large body of international research has been completed that provides the means for scientifically dating surface sites, artifacts, petroglyphs, and rock features. Some of the archaeological papers that have applied these technical advances in the Mojave Desert, in order to address the question of the first peopling of the Americas, include the following:

- R.I. Dorn, et al., 1986, Cation-Ratio and Accelerator Radiocarbon Dating of Rock Varnish on Mojave Artifacts and Landforms, *Science* 231:830-833.
- D.B. Bamforth and R.I. Dorn, 1988, On the Nature and Antiquity of the Manix Lake Lithic Industry, *Journal of California and Great Basin Anthropology* 10:209-226.
- R.I. Dorn et al., 1992, New Approach to the Radiocarbon Dating of Rock Varnish, with Examples from Drylands, *Annals of the Association of American Geographers* 82:136-151.
- D.S. Whitley and R.I. Dorn, 1993, New Perspectives on the Clovis vs. Pre-Clovis Controversy, *American Antiquity* 58:626-647.
- N. Cerveny, et al., 2006, A New Strategy for Analyzing the Chronometry of Constructed Rock Features in Deserts, *Geoarchaeology* 21(3):281-303.
- D.S. Whitley, et al., 2007, High-Stand Shoreline Survey of the Christmas Canyon Sub-Basin of Searles Lake, Inyo County, California. In *A Festschrift Honoring the Contributions of California Archaeologist Jay von Werlhof*, ed. R.L. Kaldenberg, pp. 209-224. Ridgecrest: Maturango Museum Publication 20.
- D.S. Whitley and R.I. Dorn, 2010, The Coso Petroglyph Chronology, *Pacific Coast Archaeological Society Quarterly* 43:135-157.

It is important to emphasize that these publications include articles in major international refereed journals, such as *Science* and *American Antiquity*. The fact that studies of Mojave Desert surface sites, artifacts and rock features have been published in major international journals demonstrates the potential scientific importance of surface sites. The fact that these same sites have been studied to address the first peopling of the Americas problem illustrates the point that

equivalent sites within the Project APE likely represent Unique cultural resources, as defined by CEQA.

Neither Scenario 5.5 nor 6 complies with the CEQA requirement to consider Unique cultural resources. Adoption of either of these Scenarios will still result in a project that fails to comply with CEQA.

IV.   Failure to Consider Potential Native American Sacred Sites

The Applicant and CEC Staff apparently only considered the possibility that sites within the Project APE might be eligible under a single CRHP criterion, #4, or research importance (equivalent to NHPA criterion D). But the cultural resources technical report describes the presence of two resources, CA-SBR-13093/H and -1908/H, which may be Native American sacred sites (see R.A. Nixon, 2010, Class III Cultural Resources Technical Report for the Calico Solar Project, San Bernardino County, California, pp. 5-45-159, 5-383-95).

The four sites that will fall outside of the Project APE under proposed Scenarios 5.5 and 6 have not been publicly identified. It is not yet clear, accordingly, whether CA-SBR-13093/H and/or -1908/H will or will not be included within the Project under either scenario. We assume, in the following, that one or both are still within the proposed APE, regardless of development scenario. The information provided below describes the data supporting the conclusion that these two sites likely represent Native American ritual locales, and that the proposed treatment of these sites is inappropriate. This represents evidence that was overlooked or ignored in the Applicant Technical Report and CEC Staff Assessment, and further emphasizes their failure to adequately identify and evaluate the potential adverse impacts of the Project to cultural resources.

Both sites CA-SBR-13093/H and -1908/H contain large quantities of archaeological features described as 'rock clusters.' Features of this type are relatively rare in the Mojave Desert archaeological record, and are especially rare in the numbers present within the Project area (almost 500 at CA-SBR-1908/H alone). The Applicant has recommended that the rock features at these two sites are CRHP eligible, apparently due to their research value, but that the associated surface artifacts— that is, the stone artifacts found in and around these features—are recommended as not eligible (R.A. Nixon, 2010, Class III Cultural Resources Technical Report for the Calico Solar Project, San Bernardino County, California, p. 7-12). The apparent basis for these conclusions are the inferences that the associated artifacts are believed to have resulted from stone tool manufacturing activities, whereas the rock cluster features are assumed to have been the product of some other, as yet unidentified, activity. Regardless of assumptions, the Applicant's conclusion is that no adverse impacts to cultural resources will occur if the rock features are preserved, even if the artifacts associated with them are destroyed by grading and construction.

The Applicant's opinion that archaeological features on a site are significant whereas their associated artifacts have no scientific value is an extreme, if not unprecedented, position that contradicts the central importance of archaeological context and site integrity—for both research and cultural resource management concerns. As stated in the *Handbook of Archaeological Methods* (edited by H.D.G. Maschner and C. Chippindale, 2005, AltaMira Press, Lanham, MD), reflecting near-universal professional opinion and practice, for example:

> "The central point here is that an artifact or feature excavated has meaning partly in relation to other finds from the same or related contexts" (p. 648).

The Applicant's position that a site's artifacts can be ignored and destroyed, because they putatively have no research value, whereas the same site's features can be preserved, and that such a treatment will not result in significant adverse impacts to cultural resources, defies the most fundamental archaeological principles.

But there are additional problems with the proposal that the features on these sites will be preserved whereas the associated artifacts may be destroyed. This position, first, reflects an additional failure to adequately evaluate the sites within the Project APE. As the Secretary of the Interior's *Standards and Guidelines for Archeology and Historic Preservation* (48 FR 44716, 1983) state clearly:

> "Decisions about the identification, evaluation, registration and treatment of historic properties are most reliably made when the relationship of individual properties to other similar properties is understood. Information about historic properties representing aspects of history, architecture, archeology, engineering and culture must be collected and organized to define these relationships. This organizational framework is called a "historic context."...The development of historic contexts is the foundation for decisions about identification, evaluation, registration and treatment of historic properties."

No such historical context was developed in order to adequately evaluate the two archaeological sites in question, for example by comparing the sites to the other known examples of similar sites in the Mojave Desert, or to the existing literature on the origin and meaning of the kinds of features that these sites contain.

The result is that data supporting the likelihood that these sites are Native American sacred places, second, was overlooked or ignored by the Applicant and the CEC Staff. Recent ethnographic and archaeological research throughout the far western United States, in fact, has shown that rock features of the type found on these two Project sites were sometimes created during ritual activities. For example, documentation of the religious origin of stone piles and alignments in northern California and the Columbia Plateau, similar to the features at the two

sites within the Project, has been provided in numerous ethnographic and archaeological studies, including:

- W.W. Caldwell and R.L. Carlson, 1954, Further documentation of "Stone Piling" during the Plateau Vision Quest. *American Anthropologist* 56, 441-442.
- J. Miller, 1983, Basin Religion and Theology: A Comparative Study of Power (*Puha*). *Journal of California and Great Basin Anthropology* 5:66-86.
- J.L. Chartkoff, 1983, A Rock Feature Complex from Northwestern California. *American Antiquity* 48, 745-760.
- T. Buckley, 1986, Lexical Transcription and Archaeological Interpretation: "A Rock Feature Complex from Northwestern California." *American Antiquity* 51, 617-618.

Ethnographic documentation of the ritual creation and use of cairns, alignments and rock circles has also been provided in the following studies for Numic-speaking peoples—which include Southern Paiute-speakers who were one of the Native American tribal groups that used the Project area:

- R.W. Stoffle, et al., 2004, *Puha Flows From It: The Cultural Landscape Study of the Spring Mountains*. University of Arizona, BARA report.
- M. Buttram, 2006, Puha Path: Tippipah Spring to Scrugham Peak. Paper presented at the Great Basin Anthropological Conference, Las Vegas.
- M.N. Zedeño, et al., 2006, *From Red Springs to Cane Springs: Landscapes of Movement Along the Great Belted Range*. University of Arizona, BARA report.
- K.J Carroll, 2007, *Place, Performance and Social Memory in the 1890s Ghost Dance*. Ph.D. Dissertation, Department of Anthropology, University of Arizona, Tucson.
- K. La Pierre, 2010, A Preliminary Report of a Rock Feature Complex on the East Side of Searles Lake (CA-SBR-12134/H), Western Mojave Desert, San Bernardino County, California. *Pacific Coast Archaeological Society Quarterly* 43:84-100.

Furthermore, ethnographic studies have documented the fact that, within the context of sacred sites, seemingly mundane stone tools (including lithic debitage, the by-product of tool manufacture), were left as ritual offerings. Again considering only Paiute and Shoshone-speaking tribes, these studies include:

- C.R. Brooks, et al., 1979 *A Land Use History of Coso Hot Springs, Inyo County, California*. NWC Administrative Publication 200, China Lake Naval Air Weapons Station, Ridgecrest.

- L. Loendorf, 1993, Rock Art and Water Ghost Woman on the Wind River, Wyoming. Paper delivered at International Shamanism and Rock Art Conference, Witt Museum, San Antonio, Texas.
- R.W. Stoffle, et al. 2005, *Yanawant: Paiute Places and Landscapes in the Arizona Strip.* University of Arizona, BARA report.

The BLM 8110 Manual, *Identifying and Evaluating Cultural Resources* (December 2004), explicitly acknowledges this circumstance, stating that seemingly mundane artifacts instead may have had sacred uses, and requiring that such a possibility be considered during the eligibility evaluation process:

> "Properties used for traditional religious purposes by Native Americans may be found eligible for the National Register. The eligibility exclusion pertaining to religious properties is not intended to exclude traditional cultural properties merely because they have religious uses, as <u>traditional cultures often do not distinguish between what is secular and what is sacred</u>" (8110.32F1; emphasis added).

As this archaeological guidance indicates, the inference that mundane economic activities (such as tool production) and its resulting artifacts can always be distinguished or separated from ritual activities is often incorrect with respect to traditional, non-western cultures, where sacred and secular activities overlap.

Perhaps most importantly, recent Mojave Desert archaeological studies—again, overlooked by the Applicant Technical Report and CEC Staff Assessment—have documented, dated and analyzed the kinds of rock features found on these two Project sites. These studies include:

- N. Cerveny, et al., 2006, A New Strategy for Analyzing the Chronometry of Constructed Rock Features in Deserts, *Geoarchaeology* 21(3):281-303.
- D.S. Whitley, et al., 2007, High-Stand Shoreline Survey of the Christmas Canyon Sub-Basin of Searles Lake, Inyo County, California. In *A Festschrift Honoring the Contributions of California Archaeologist Jay von Werlhof*, ed. R.L. Kaldenberg, pp. 209-224. Ridgecrest: Maturango Museum Publication 20.
- K. La Pierre, 2010, A Preliminary Report of a Rock Feature Complex on the East Side of Searles Lake (CA-SBR-12134/H), Western Mojave Desert, San Bernardino County, California. *Pacific Coast Archaeological Society Quarterly* 43:84-100.
- K. La Pierre, 2010, Rock Alignments, Cairns, and Artifact Caches at the Mirror Point Site (CA-SBR-12134/H), East Searles Lake in the Western Mojave Desert, San Bernardino County, California. Paper presented at the Society for California Archaeology meetings, Riverside.

The last author has conducted detailed studies of the rock features at site CA-SBR-12134/H which, like the two sites within the Project APE, contains a concentration of rock features. These features include a mix of historic and prehistoric artifacts, demonstrating recent as well as longer-term use of the site; in some cases artifacts were embedded within the rock features and required excavation to expose; the site's artifacts included stone tools that, in other contexts, would be considered secular rather than religious in origin; and obsidian originating from as far away as Utah was found in one of the stone features. The artifacts found in association with these rock features, which La Pierre carefully documented, are primary elements in her analysis. The study concludes that the rock features were created for ritual purposes, and used in religious contexts.

Substantial ethnographic evidence demonstrates that rock features of the type found at two sites within the Project potentially were (and perhaps continue to be) made by Native Americans as part of ritual activities. Archaeological evidence suggests that this practice may extend back earlier in time, and techniques have been developed that allow the scientific dating of these kinds of features. The ethnography further shows that seemingly mundane artifacts at sites of this nature, including "lithic debitage," in certain cases were left as ritual offerings. All of this evidence and these circumstances suggest that sites CA-SBR-13093/H and -1908/H may in fact be Native American sacred sites. Further, they have the potential, through possible continued use, to be designated NRHP Traditional Cultural Properties. Assuming that all or portions of either site are included within the boundaries of Scenario 5.5 or 6, the proposed Project has the potential to adversely impact sites which the Applicant has already conceded are significant cultural resources, and that may be Native American sacred sites.

The California Public Resources Code states that:

> "No public agency, and no private party using or occupying public property, or operating on public property, under a public license, permit, grant, lease, or contract made on or after July 1, 1977, shall in any manner whatsoever interfere with the free expression or exercise of Native American religion as provided in the United States Constitution and the California Constitution; nor shall any such agency or party cause severe or irreparable damage to any Native American sanctified cemetery, place of worship, religious or ceremonial site, or sacred shrine located on public property, except on a clear and convincing showing that the public interest and necessity so require" (PRC 5097.9).

V. Conditions of Certification Fail to Comply with CEQA and Standard Archaeological Practice

The CEC Staff has proposed Conditions of Certification that fail to comply with CEQA, and that do not follow widely accepted and standard archaeological practice. These Conditions will apply regardless of proposed or adopted development Scenario.

CUL-4 states in part that:

> "The project owner shall prepare and submit...separate protocols for the CRHR evaluation of each archaeological site type or site type group in the CPM-approved, final archaeological resource taxonomy and for each archaeological district, landscape, or other large-scale archaeological resource in the subject taxonomy. A field methodology will be included in each protocol which outlines a representative sample of 20% of each of the site types which would be selected for further evaluation."

That is, CUL-4 will require the testing, evaluation and determination of significance of only 20% of the individual archaeological sites within each pre-determined site type or category.

The problems with this Condition are obvious and straightforward:

- As the CEC Staff Assessment repeatedly notes, the archaeological data on the over 100 sites within the Project APE, regardless of development Scenario, are currently inadequate for evaluative purposes. CUL-4, contradicting Staff's observation, pre-supposes that site types can be satisfactorily and accurately determined with the data at hand, before site testing has occurred. Yet as the Staff Assessment further notes:

  > "it is common professional practice in cultural resource management to conduct at least some degree of subsurface sampling of archaeological sites that may be directly and permanently affected by a proposed project (even for sparse lithic scatters), particularly considering the broad expanse of land and degree of surface manifestations of archaeological remains reported by the applicant in the project area. The lack of site testing, as in this case, is an exception to this common practice" (p. C.2-96).

  Whereas much of the language in the Staff Assessment limits itself to the question of eligibility and resource significance, it is an archaeological fact that the same data, and testing procedures, are

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commonly required to make either eligibility determinations or site type identifications.

To cite the obvious example of this fact, the Staff Assessment in the quote above identifies the requirement to conduct some degree of testing "even for sparse lithic scatters." This site type is defined in the California Office of Historic Preservation's "California Archaeological Resource Identification and Data Acquisition Program: Sparse Lithic Scatters" protocol ("CARIDAP," T. Jackson et al. 1988). The defining characteristics of this class of site include: (1) a low surface density of artifacts; (2) a restricted range of types of artifacts present; and (3) the absence of a subsurface archaeological deposit.

Absent subsurface excavations and testing, it is impossible to determine whether a site has or lacks a subsurface deposit, except in the most extraordinary of circumstances (e.g., artifacts found on the surface of solid bedrock.) That is, it is impossible to identify "even...sparse lithic scatters" without subsurface testing.

- CUL-4 fails to consider the CEQA requirement to identify and properly treat Unique cultural resources. It assumes instead that over 100 archaeological sites within the Project APE, regardless of development Scenario, will be sufficiently similar to all fall within a few site type categories. CUL-4 assumes this finding without supporting evidence or data, contrary to Staff's own acknowledgment that subsurface testing is standard and required to assess and accurately define archaeological sites.

CUL-4 presupposes the existence of the kind of data that result from site testing, prior to testing, in order to establish a taxonomy of site types, intended to guide the testing procedure. This Condition contradicts standard archaeological practice. Worse, it defies logic. Given its failure to accommodate the potential for Unique cultural resources, it further fails to comply with CEQA.

In summary, proposed Scenarios 5.5 and 6 will continue to result in potentially significant adverse impacts to over 100 archaeological sites. The CEC Staff Assessment and Applicant Technical Report have failed to consider the potential for Unique cultural resources within any of the potential development scenarios, despite the requirement to do so in CEQA. They have also failed to consider the possibility that Native American sacred sites may be adversely impacted by the Project, despite the evidence that such sites are likely present within the proposed APEs. Finally, the proposed cultural Conditions for Certification also fail to comply with CEQA, and they have been written in such a manner that they contradict standard archaeological principles, and defy logic.

DECLARATION

I, David Whitley, declare as follows:

I have reviewed the above testimony regarding the Calico Solar Energy Project. To the best of my knowledge, all of the facts in my testimony are true and correct. To the extent that this testimony contains opinion, such opinion is my own.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct to the best of my knowledge and belief. This declaration is signed at _Tehacupi_, California.

Dated: *17 Sept. 2010* Signed: *David S. Whitley*

Calico Solar – 08-AFC-13
DECLARATION OF SERVICE

I, David Weber, declare that on September 17, 2010, I served and filed copies of the attached CALIFORNIA UNIONS FOR RELIABLE ENERGY'S EXHIBITS 461 - 465, dated September 17, 2010. The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at www.energy.ca.gov/sitingcases/calicosolar/CalicoSolar_POS.pdf. The document has been sent to both the other parties in this proceeding as shown on the Proof of Service list and to the Commission's Docket Unit electronically to all email addresses on the Proof of Service list; and by depositing in the U.S. mail at South San Francisco, CA, with first-class postage thereon fully prepaid and addressed as provided on the Proof of Service list to those addresses NOT marked "email preferred."

AND

By sending an original paper copy and one electronic copy, mailed and emailed respectively to:

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 08-AFC-13
1516 Ninth Street, MS 4
Sacramento, CA 95814-5512
docket@energy.state.us.ca.

I declare under penalty of perjury that the foregoing is true and correct. Executed at South San Francisco, CA, on September 17, 2010.

_____/s/_____
David Weber

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