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Lange's Metalmark Butterfly Threat Assessment and Ranking of Potential Management Alternatives: FINAL REPORT

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SUMMARY

U.S. Fish and Wildlife Service staff and other interested scientists and parties held a workshop on April 11 and 12, 2013, to evaluate threats and rank potential management strategies for the federally endangered Lange's metalmark butterfly (*Apodemia mormo langei*; hereafter "LMB"), a highly imperiled butterfly that persists in the wild only at Antioch Dunes National Wildlife Refuge (NWR) in Antioch, California.

During the workshop, 16 workshop participants scored 17 threats (Table 1) identified as having the potential to negatively impact LMB populations and life-history attributes. The 7 most significant threats, in order of declining importance, were: (1) invasive grasses and forbs; (2) demographic stochasticity; (3) altered substrate (i.e., reduced open sand areas); (4) nitrogen deposition; (5) wildfire; (6) climate change; and (7) altered disturbance regime.

The participants identified 19 potential management alternatives to address threats to LMB and selected 7 that would be further analyzed with respect to the top-ranked threats (Table 2). Two management alternatives, captive breeding–augmentation and captive breeding–reintroduction, were not analyzed because they were deemed to be integral to all other strategies and will be continued.

The participants predicted the effectiveness of the 7 selected management alternatives in addressing the top 7 threats to LMB. The management alternatives, in order of decreasing expected performance across the top 7 threats, were: (1) sand dune construction; (2) mechanical scraping; (3) manual vegetation control; (4) herbicides; (5) grazing; (6) mowing; and (7) public access/human disturbance.

Management activities could themselves be threats to LMB or to two federally endangered plants that occur on the refuge, Antioch Dunes evening primrose (*Oenothera deltoides spp. howellii*) and Contra Costa wallflower (*Erysimum capitatum spp. angustatum*), hereafter "endangered plants." Therefore, participants were asked to estimate the probability that each management alternative could result in a net negative outcome. The alternatives with the greatest expected risk of having a net negative effect on LMB were: (1) public access/human disturbance; (2) grazing; (3) herbicides; and (4) mowing. The management alternatives with the greatest expected risk of having a net negative effect on the two federally endangered plants were: (1) grazing; (2) mechanical scraping; (3) herbicides; and (4) public access/human disturbance.

The workshop was designed to provide a structured process for assessing threats, not for providing decisions. As such, the results provide plausible working hypotheses about threats to target species and an initial basis for ranking alternative management actions according to their expected performance in addressing threats. All results are contingent on the expertise and experience of the workshop participants.

INTRODUCTION

The LMB population at Antioch Dunes NWR has significantly decreased since 1999 without any indication of stability or recovery, putting the species in danger of imminent extinction (Sacramento Fish and Wildlife Field Office 2013). A large number of potential threats may have contributed to this decline, and there are limited conservation resources to address them. The goal of the workshop was to assist managers in identifying optimal management alternatives that are most likely to address or ameliorate the most important threats. The workshop and follow-up meetings consisted of a review and ranking of threats to the species, identification of potential management alternatives, prediction of the relative performance of alternatives in addressing threats, and assessing the risk associated with each management alternative to LMB and to the two endangered plants.

METHODS

Expert Elicitation Procedures

Prior to the workshop, Ecological Services field office and refuge staff compiled a preliminary list of threats to LMB with definitions. The term "threat" is defined as any of the effects on LMB life history attributes that may result in the species not being sustainable in the geographic area being assessed (Antioch Dunes National Wildlife Refuge).

The first day of the workshop consisted of a field visit to the refuge and a discussion of threats to LMB. The second day of the workshop consisted of an expert elicitation panel facilitated by Travis Longcore, Science Director of The Urban Wildlands Group, and Orien Richmond, Wildlife Biologist with the Fish and Wildlife Service Inventory and Monitoring Program. Workshop participants (Table 3) consisted of LMB, geographic and subject-area experts. Expert elicitation is a growing field of study with an expanding body of methods for eliciting and combining judgments from experts (Conroy and Peterson 2013). Eleven participants (not including the moderators) were present at the meeting on April 12, while 5 participants (Don Brubaker, Ivette Loredo, Laura Shaskey, Rachel Tertes and Susan Euing) were separately interviewed later (Table 3).

On the second day of the workshop, participants reviewed and refined the preliminary list of threats as a group to arrive at 17 threats that would be ranked (Table 1). Longcore and Richmond moderated the panel to evaluate and rank the 17 selected threats. First, the participants were asked to silently allocate 100 points among the 17 threats based on the degree to which each threat is currently negatively affecting LMB numbers and/or preventing its recovery. Next, the panel engaged in a moderated disclosure of their threat scores. This allowed participants to articulate reasons for their scoring, to hear how and why others scored as they did, and to briefly ask each other clarifying questions.

After the threats were ranked, Longcore and Richmond moderated a general discussion to arrive at management objectives for LMB. The main objective agreed on by all participants was to maximize the abundance of the wild population.

Next, Longcore and Richmond moderated an open-ended brainstorm of potential management actions that could be undertaken to address the threats. This resulted in a list of 19 potential management actions (Table 2). The group then narrowed this list down to 7 actions by selecting those that were most relevant to the top 7 threats identified in the threat evaluation (“Selected Alternatives” in Table 2).

The assessment of management alternatives requires making predictions about their expected performance in terms of the stated objective—maximizing the abundance of the wild LMB population. In the absence of empirical information or quantitative models relating management alternatives to LMB population size, Longcore and Richmond used expert elicitation to predict the expected performance of the selected management alternatives in addressing the highest-ranked threats, which entailed the following steps. In the first step, the participants were asked to consider a matrix of the top 7 threats and the 7 management alternatives. For each alternative and threat combination in the matrix, participants were instructed to silently assign a performance score as in the following example:

“If Threat A (e.g., wildfire) were the ONLY significant threat affecting LMB (i.e., the only threat negatively affecting the population and/or preventing recovery), what would the performance of management Alternative 1 be (e.g., grazing) if it were the primary alternative employed over the next 5 years?” Performance was scored on a scale of 0–100, with 0 corresponding to extinction, 5 corresponding to the current state of the population in 2013 (status quo) and 100 corresponding to the peak population from the 1990’s (~2,300 butterflies on a “peak count”).

In the second step, the panel engaged in a moderated disclosure of their first-round performance scores. This allowed participants to articulate reasons for their scoring, to hear how and why others scored as they did, and to briefly ask each other clarifying questions.

Finally, the panel assessed the risks of the management actions themselves harming LMB and the two endangered plants on the refuge (e.g., overgrazing or herbicides resulting in increased mortality of egg, larvae, or adults). Participants were told to assume that management alternatives would be implemented with reasonable precautions so as to minimize potential harm to the target species. Participants were asked to assign a score for each management alternative representing the probability of a management action resulting in a net negative effect on LMB or the endangered plants. A net negative effect would indicate that the management action would cause more harm to the butterfly or the endangered plants than good. For example, “A grazing program that is implemented with reasonable precautions has a 10% chance of doing more harm than good to LMB on the refuge.”

Data Analysis

We entered individual panelists' threat scores into a spreadsheet and calculated average scores, which were interpreted as the central tendencies of the panel as a whole.

We entered individual panelists' performance scores for each management alternative and threat combination into a spreadsheet and calculated the average score across panelists. For each management alternative, we summarized the performance scores by taking a weighted average across the top 7 threats; the weights were the average threat scores from the threat evaluation step. Thus, management alternatives that had high expected performance with respect to highly-ranked threats scored higher than alternatives that had low expected performance with respect to lower-ranked threats.

Finally, we entered the individual panelists' scores for the probability of each management alternative having a net negative effect on LMB and the two endangered plants into a spreadsheet and calculated average scores across panelists.

RESULTS

Threat Ranking

Based on average threat scores, the threats, in order of declining importance, were: (1) invasive grasses and forbs; (2) demographic stochasticity; (3) altered substrate (i.e., reduced open sand areas); (4) nitrogen deposition; (5) wildfire; (6) climate change; (7) altered disturbance regime; (8) loss of nectar plants; (9) increased woody vegetation; (10) vector control; (11) dispersal limitation; (12) development; (13) floristic diversity; (14) host plant disease; (15) predation/parasites; (16) gypsum; and (17) butterfly disease.

Management Alternative Ranking

Based on average performance scores, the management alternatives with the highest expected performance across the top 7 threats, in order of declining performance, were: (1) sand dune construction; (2) mechanical scraping; (3) manual vegetation control; (4) herbicides; (5) grazing; (6) mowing; and (7) public access/human disturbance.

Risks of Management Alternatives

Management alternatives, in order of decreasing probability of having a potentially net negative effect on LMB, were: (1) public access/human disturbance; (2) grazing; (3) herbicides; (4) mowing; (5) mechanical scraping; (6) sand dune construction; and (7) manual vegetation control.

Management alternatives, in order of decreasing probability of having a net negative on the two endangered plants, were: (1) grazing; (2) mechanical scraping; (3) herbicides; (4) public access/human disturbance; (5) mowing; (6) sand dune construction; and (7) manual vegetation control.

DISCUSSION AND INTERPRETATION

The results of the workshop revealed a consensus that habitat-related threats are currently considered to be the most important threats to LMB. Highly ranked habitat-related threats included invasive grasses and forbs, altered substrate, nitrogen deposition (contributing to invasion by nonnative grasses and forbs) and altered disturbance regime. Small population size (demographic stochasticity) and wildfire were also highly ranked threats; wildfire can directly kill all life stages of LMB and also affect negatively impact LMB habitat by contributing nutrients to the substrate, which contributes to invasion by nonnative grasses and forbs.

Given the apparent importance of habitat-related threats, the assessment of potential management alternatives focused on habitat-related management alternatives. Among the management alternatives that were considered, sand dune construction, mechanical scraping and manual vegetation control had the highest predicted performance across the threats that were considered in the analysis.

The results of this process should be interpreted as a survey of informed expert judgment based on the knowledge of the specific panelists who were able to attend the workshop. Several other highly experienced lepidopterists/insect ecologists were invited to participate but were unable to do so. Many of the panelists became informed about LMB by working as managers or biologists at Antioch Dunes National Wildlife Refuge, studying journal articles and reports on butterfly ecology, biology, and conservation; by listening to presentations by expert researchers; and, for some panelists, by having conducted surveys or research on LMB directly.

The ranking of threats and the potential performance of alternative management activities are not derived from direct empirical field data. Workshop outcomes would likely have differed with an alternate group of workshop participants, or more specifically with an altered composition of panelists from different biological specialties. Thus, results stemming from this exercise should be interpreted with caution. The outcomes represent potentially testable working hypotheses and provide a basis for implementing adaptive management, whereby additional knowledge about the system can be gained through repeated decision making, monitoring, and data analysis.

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Table 1. Definitions of threats used in the LMB threat assessment.

Short Threat Name	Direct Threat	Indirect Threat(s) or Driver(s)	Stress on LMB	Notes and potential solutions
Climate	Climate change and severe weather; e.g., habitat shifting and alteration, droughts, temperature extremes, storms and flooding	Burning of fossil fuels.	-Loss of habitat -Altered temperature and moisture regimes causing direct mortality and/or impaired reproduction OR indirect mortality and/or impaired reproduction via phonological mismatches with host and/or nectar plants	We do not know how LMB is affected by warmer temperatures. It is apparent that this species can survive in harsh conditions and may not be as adversely affected as other species. Maybe consider reintroductions into different suitable locales. Climate change is thought to have resulted in earlier first spring flights for butterflies in California (Forister and Shapiro 2003).
Demographic stochasticity	Increased demographic stochasticity and negative genetic effects resulting from small population size	Loss of dune habitat and all other threats contribute to small population size	-Increased risk of local population extinction -Loss of heterozygosity -Inbreeding depression	The captive rearing project does not provide insurance against extinction because of difficulties getting LMB to mate and lay eggs in captivity (Johnson et al. 2011).
Development	Residential and commercial development off of the refuge; e.g., housing and urban areas, commercial and industrial areas	Policies of City of Antioch; management practices of local landowners	-Loss of habitat	Current management of lands adjacent to the refuge is not optimized for LMB. Acquiring new lands that could be restored to dune habitat would be beneficial. Habitat loss at low elevations in California is thought to be a major driver of declines in butterfly species richness (Forister et al. 2010).
Dispersal limitation	Dispersal limitation due to large dispersal distances between habitat patches (habitat fragmentation) and potentially unsuitable matrix land cover between patches (e.g., coyote bush and oaks at the Sardis Unit)	Habitat loss and all other threats have contributed to a very restricted distribution; encroaching woody vegetation has reduced dispersal corridors	-Reduced colonization rates of suitable habitat patches	Improve vegetation cover between habitat patches to encourage dispersal (e.g., remove tall woody vegetation); restore habitat on the refuge and surrounding lands.
Disturbance regime	Natural system modifications; e.g., reduced sand deposition at Antioch Dunes as a result of water management/use (dams, levies, etc.) in the Sacramento/San Joaquin River Delta system	Agriculture and urban water uses in the Central Valley and Delta	-Loss of habitat	Adding new sand to the refuge and periodically promoting disturbance to reset succession would address this threat. Unclear if this has to be piling up loose sand, or could it also just be removing vegetation. Removal of non-native vegetation by cattle improved conditions for the bay checkerspot butterfly in grasslands (Weiss 1999). However, use of cattle is probably not appropriate for low-nutrient dune systems.

Short Threat Name	Direct Threat	Indirect Threat(s) or Driver(s)	Stress on LMB	Notes and potential solutions
Floristic diversity	Decreased native floristic diversity	Invasive grasses and forbs; encroaching woody vegetation	-Loss of habitat -Increased mortality	Invasive plants outcompete native plants that provide resting sites and camouflage. Dick Arnold remarked on the lack of lotus plants that can provide camouflage during mating. Control of invasive plants is needed.
Gypsum	Pollution, industrial: gypsum dust from adjacent gypsum plant	Policies of City of Antioch	-Increased mortality -Reduced reproduction	The concern is that gypsum dust could damage LMB larvae by having a sandpaper effect on internal (midgut) components and the exoskeleton. Jana Johnson conducted tests of gypsum dusting on larvae of Behr's MB. The study was halted when the threat of a local fire caused relocation of the project temporarily. More research is needed.
Host plant disease	Increased buckwheat disease/parasites	Invasive grasses and forbs contribute to a more moist microclimate that may favor disease	-Increased mortality -Reduced reproduction	This remains a possible threat. The 5 year review notes that some of the ADEP was subject to infestation by true bugs in the family Miridae. Preventative measures are not currently in place but need to be addressed. Refuge biologists have observed aphid infestation, but this was limited. No pandemic infestation has been observed.
Invasive plants	Invasive non-native/alien species	Nitrogen deposition from industry and urbanization; lack of disturbance (moving sand) and low deposition of new sand; City of Antioch yard waste disposal site adjacent to refuge is a seed source	-Loss of habitat -Increased mortality -Reduced reproduction	Invasive grasses and forbs reduce open sand areas, outcompete host and native nectar plants, change the microclimate and alter the structure of host plants. May increase disease incidence due to altered microclimate. Large amounts of vetch and grasses are constantly being removed by cutting and by scraping (both hand and mechanical removal). Removal of invasive plants is an immense challenge.
LMB disease	Increased incidence of LMB disease	Invasive grasses and forbs contribute to a more moist microclimate that may favor disease	-Increased mortality	No specific diseases have been detected in LMB to date. Possible that a fungus could cause infection. Vetch cover, for example, could enhance fungal growth as it covers buckwheat plants. There is a need to review known lepidopteran-specific diseases and their causes and extrapolate to LMB scenario if possible. Several different types of diseases may be relevant: bacteria, fungi, viruses, Wolbachia
Nectar plants	Decreased nectar plants	Invasive grasses and forbs; encroaching woody vegetation.	-Increased mortality -Decreased longevity -Decreased fecundity	Control of invasive plants is needed to address this threat.

Short Threat Name	Direct Threat	Indirect Threat(s) or Driver(s)	Stress on LMB	Notes and potential solutions
Nitrogen deposition	Pollution: atmospheric nitrogen deposition	Industrial activity; car exhaust. These effects can come from miles away from the refuge	-Loss of habitat -Increased mortality -Reduced reproduction	Atmospheric nitrogen deposition favors invasive plants that outcompete native host and nectar plants. Nitrogen deposition can be addressed by periodically adding new, low-nutrient substrate to the site, flipping the existing substrate and/or reducing emissions from nearby anthropogenic nitrogen sources (e.g., power plant factories and cars).
Predators/parasites	Invasive non-native/alien predators and/or overabundant native predators and/or parasites	Sale of predatory insects (e.g., mantids) for garden use; altered insect/parasitoid community due to invasive plants	-Increased mortality	A survey of animals (birds, invertebrates, etc.) at the refuge could reveal possible predators. For example, Susan has seen larvae of another butterfly species being predated upon by a member of the Asilidae family (robber fly). Field cages may help for head starting larvae but need to be evaluated first.
Substrate	Altered substrate (i.e., reduced open sand areas)	Sand mining; wind; lack of sand deposition due to altered hydrology and sediment load in the Delta and the rivers feeding it	-Increased mortality -Decreased reproduction	Loss of original open sand substrate may have a direct or indirect effect on LMB that we have not detected. This question is being addressed by a study at UC Davis by Allison.
Vector control	Pollution: air-borne pollution from vector control efforts	Policies to prevent disease (Mosquito Abatement District); wetland management policies	-Increased mortality	The Mosquito Abatement District allows for spraying of insecticides to reduce the incidence of West NileVirus at a wetland adjacent to the Stamm Unit. The spray could drift on to the refuge and affect LMB. Refuge staff have worked with county mosquito control staff to ensure insecticide isn't applied on the Stamm side of the road nor in breezy conditions. Improved flows to the wetland would reduce mosquito incidence.
Wildfire	Natural system modifications: increased wildfire frequency/intensity	Adjacent railroad and human trespassers are ignition sources; increased abundance of flashy fine fuels is caused by non-native/invasive plants	-Increased mortality	Wildfire is uncommon in dune ecosystems; fire incidence and frequency have increased due to the buildup of fuels (non-native/invasive plants). Large drops in LMB counts have been observed immediately following previous wildfires on the refuge. Fire prevention measures are in place. Wildfires have been minimized in the last few years. However, buildup of flashy fine fuels continues. Appropriate fencing along the railroad tracks and increased law enforcement presence could reduce the risk of wildfire.

Short Threat Name	Direct Threat	Indirect Threat(s) or Driver(s)	Stress on LMB	Notes and potential solutions
Woody vegetation	Overabundant native species: encroaching woody vegetation (lupine, coyote bush and coast live oak)	Lack of disturbance (moving sand) and deposition of new sand; nitrogen deposition from industry and urbanization	-Loss of habitat -Reduced reproduction	Encroaching woody vegetation reduces open sand areas and shades out host and nectar plants. Refuge staff are planning to remove coyote bush and coast live oaks from parts of the Sardis Unit. Some areas of Stamm have dense lupine stands that could be thinned. Shrubs and trees may provide some beneficial shelter from wind.

Table 2. Potential and selected management alternatives to address threats to LMB.

Potential management alternatives	**Selected management alternatives**	**Description**	**Threats expected to be ameliorated by the strategy**	**Assumptions**
Bank stabilization		Building up levees along the San Joaquin River by adding sediment; this would decrease use of the refuge by boaters.	-Wildfire	
Buckwheat planting/seeding		Planting or seeding buckwheat to increase the coverage of host plants.	-Dispersal limitation -Host plant disease -Invasive plants	Will be incorporated into other habitat management alternatives.
Captive breeding - augmentation		Augmenting the existing LMB population at the Sardis Unit from the captive population.	-Demographic stochasticity	Will continue to be implemented.
Captive breeding - reintroduction		Reintroducing LMB at the Stamm Unit from the captive population.	-Demographic stochasticity	Will continue to be implemented.
Corridor construction		Targeted restoration of dune plants and open areas in corridors to connect existing high-quality habitat patches. Particularly needed at the Sardis Unit.	-Dispersal limitation -Invasive plants	
Fire breaks		Controlling vegetation and/or addition of flashing along the railway. Particularly needed at Stamm Unit.	-Wildfire -Invasive plants	
Further regulation of mosquito control		Putting in place additional policies to reduce impacts of vector control on LMB; e.g., stricter limits on timing and duration of air-borne application of chemicals.	-Vector control	
Grazing	X	Implementing a grazing program to control/reduce invasive plants and create more open dune areas. Note that grazing may also exacerbate nitrogen deposition and could result in direct LMB mortality.	-Disturbance regime -Invasive plants -Substrate	Grazing is implemented at appropriate levels to control invasive plants and to minimize direct and indirect negative impacts to LMB and endangered plants. Host plants will be planted following grazing.

Potential management alternatives	Selected management alternatives	Description	Threats expected to be ameliorated by the strategy	Assumptions
Herbicides	X	Applying herbicides in a targeted fashion to control/reduce invasive plants and create more open dune areas. Note that triclopyr, sethoxydim, and imazapyr are known to reduce the number of adults that emerge from pupation in a close relative of LMB (Stark et al. 2012).	-Disturbance regime -Invasive plants -Substrate -Woody vegetation	Herbicides are applied at appropriate levels to minimize direct impacts to LMB and endangered plants. Host plants will be planted following herbicide application. Plant biomass is not removed following treatment.
Manual vegetation control	X	Manually removing annual plants and woody vegetation to control/reduce invasive plants and create more open dune areas. Manual removal has been used effectively in the restoration of coastal dunes in northern California (Pickart 2013).	-Disturbance regime -Invasive plants -Substrate -Woody vegetation	Manual removal of annuals is implemented while minimizing impacts to buckwheat and endangered plants. Host plants will be planted following removal. Plant biomass is removed following management.
Mechanical scraping	X	Mechanically scraping annual plants and woody vegetation and/or horizon flipping to control/reduce invasive plants and create more open dune areas.	-Disturbance regime -Invasive plants -Substrate -Woody vegetation	Mechanical scraping is implemented while minimizing impacts to buckwheat and endangered plants. Host plants will be planted following scraping. Plant biomass is removed following management.
Mowing	X	Mowing annual plants to control/reduce invasive plants and create more open dune areas.	-Disturbance regime -Invasive plants -Substrate	Mowing is implemented while minimizing impacts to LMB and endangered plants Host plants will be planted following mowing. Plant biomass is removed following management.
Nectar source planting/seeding		Planting and seeding native plants that are nectar sources for LMB.	-Nectar plants	
Other native planting/seeding		Planting and seeding other native plants such as early-successional dune species; e.g., Lotus, deerweed	-Floristic diversity	

Potential management alternatives	**Selected management alternatives**	**Description**	**Threats expected to be ameliorated by the strategy**	**Assumptions**
Prescribed fire		Using prescribed fire to control/reduce invasive plants and create more open dune areas. Note that prescribed fire may exacerbate nitrogen deposition and could result in direct LMB mortality.	-Disturbance regime -Invasive plants -Substrate -Woody vegetation	Prescribed fire would increase soil nutrient levels.
Reduce mosquito habitat		Removing water hyacinth from adjacent slough to reduce mosquito abundance	-Vector control	
Public access/human disturbance	X	Reopening the refuge for public access (e.g., fishing, mountain biking) or other human disturbance (e.g., ATV training). Strong concerns that there could be an increase in vandalism, fires and increased adverse impacts to the LMB and plants.	-Disturbance regime -Substrate	Opening the refuge for more public access would increase the risk of fire.
Sand dune construction	X	Sand dune construction on 10-acre area on the Stamm Unit using dredge sediment.	-Disturbance regime -Invasive plants -Substrate -Woody vegetation	Dredged sediment is low in nutrients and is not a source of invasive plant species. Host plants will be planted following dune construction. Additional flipping of the sand will be carried out if invasive plants become prevalent.
Land acquisition		Secure new lands under conservation management with potentially suitable LMB habitat. Need a study to determine if new lands have potential habitat and/or the listed species present.	-Development	

Table 3. Workshop participants, experience and affiliations.

Name	Experience	Organization	Email
Anne Morkill	Wildlife biologist – 12 years Refuge management – 15 years including 6 years with active butterfly recovery activities in Florida	U.S. Fish & Wildlife Service	anne_morkill@fws.gov
Cay Goude	Endangered species biologist – 30 years Ecologist – 8 years	U.S. Fish & Wildlife Service	cay_goude@fws.gov
Chris Nagano	Endangered species biologist – 24 years Entomologist (specialized in butterfly ecology)	U.S. Fish & Wildlife Service	chris_nagano@fws.gov
David Kelly	Wildlife biologist – 11 years	U.S. Fish & Wildlife Service	david_kelly@fws.gov
Don Brubaker	Antioch Dunes NWR manager – 5 years	U.S. Fish & Wildlife Service	don_brubaker@fws.gov
Ivette Loredo	Antioch Dunes NWR biologist – 3 years (1999-2002) USFWS biologist/wildlife refuge specialist – 17 years	U.S. Fish & Wildlife Service	ivette_loredo@fws.gov
Jana Johnson	MS Biology (specializing in Wildlife Management) PhD Biology (specializing Ecology & Evolutionary Biology) Rearing/researching endangered Lepidoptera – 10 years	The Urban Wildlands Group	janamaxandsam@yahoo.com
Josh Hull	Conservation ecologist – 10 years Endangered species recovery – 5 years	U.S. Fish & Wildlife Service	josh_hull@fws.gov
Joy Albertson	Wildlife biologist – 26 years	U.S. Fish & Wildlife Service	joy_albertson@fws.gov
Ken Osborne	BS and MS Entomology Specializing in Lepidoptera – 50 years Wildlife biologist – 17 years	Osborne Biological Consulting	euproserpinus@msn.com
Laura Shaskey	Antioch Dunes NWR biologist – 1 year Wildlife ecologist – 9 years	U.S. Fish & Wildlife Service	laura_shaskey@fws.gov
Louis Terrazas	Antioch Dunes Wildife Refuge Specialist – 8 years	U.S. Fish & Wildlife Service	louis_terrazas@fws.gov
Orien Richmond**	Wildlife ecologist – 13 years	U.S. Fish & Wildlife Service	orien_richmond@fws.gov
Rachel Tertes	Antioch Dunes NWR biologist – 4 years USFWS wildlife biologist – 12 years	U.S. Fish & Wildlife Service	rachel_tertes@fws.gov
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Susan Euing	Antioch Dunes NWR biologist – 9 years	U.S. Fish & Wildlife Service	susan_euing@fws.gov
Travis Longcore*	Conservation biologist – 17 years	The Urban Wildlands Group	longcore@urbanwildlands.org
Winnie Chan	Refuge/natural resource planning – 12 years	U.S. Fish & Wildlife Service	winnie_chan@fws.gov

* Panel moderator

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