Connectivity Strategic Plan for Western San Diego County Science Session

Workshop Materials

Workshop materials include:

Connectivity Strategic Plan for Western San Diego County Science Session

Agenda

Date: Tuesday, July 1, 2014
Time: 8:30 am – 4:30 pm
Location: USGS Conference Room 103, 4165 Spruance Rd, San Diego, CA 92101

Meeting Organizers: Yvonne C. Moore, Coordinator (evemoore99@gmail.com)
Ron Rempel, Administrator (rrempel2@msn.com)
Dr. Kris Preston, Ecologist (kpreston@usgs.gov)
Emily Perkins, GIS Manager (eperkins@usgs.gov)

Invitees & Group Assignments:

Group	Last Name	First Name	Affiliation
Large Animals	Bohonak	Andrew	SDSU
Large Animals	Crooks	Kevin	CSU
Large Animals	Garrison	Jennifer	CDFW
Large Animals	Jennings	Megan	USFS/SDSU
Large Animals	Martin	Barry	WTI
Large Animals	Perkins	Emily	SDMMP
Large Animals	Rempel	Ron	SDMMP
Large Animals	Rochester	Carlton	USGS
Large Animals	Smith	Trish	TNC
Large Animals	Stallcup	Jerre	CBI
Large Animals	Vickers	Winston	UCD - WHC
Large Animals	Wynn	Susan	USFWS
Pollinators	Dodero	Mark	RECON
Pollinators	Greer	Keith	SANDAG
Pollinators	Hung	James	UCSD
Pollinators	Marschalek	Dan	SDSU
Pollinators	Preston	Kris	SDMMP
Pollinators	Rebman	John	SDMNH
Pollinators	Vandergast	Amy	USGS
Pollinators	Wall	Michael	SDNHM
Pollinators	Wood	Dustin	USGS

Group	Last Name	First Name	Affiliation
Small Animals	Brehme	Cheryl	USGS
Small Animals	Brown	Chris	USGS
Small Animals	Dillingham	Tim	CDFW
Small Animals	Humphrey	Rosanne	ESA
Small Animals	Longcore	Travis	UWC
Small Animals	McCutcheon	Sarah	SANDAG
Small Animals	Miner	Karen	CDFW
Small Animals	Mitrovich	Milan	NROC
Small Animals	Moore	Yvonne	SDMMP
Small Animals	Richmond	Jonathan	USGS
Small Animals	Tracey	Jeff	USGS
Small Animals	Tremor	Scott	SDMNH
Not attending	Botta	Randy	CDFW
Not attending	Brown	Sally	USFWS
Not attending	Clark	Rulon	SDSU
Not attending	Fisher	Robert	USGS
Not attending	Holway	David	UCSD
Not attending	Johnson	Brenda	CDFW
Not attending	Smith	Kim	Caltrans
Not attending	Spencer	Wayne	CBI

Background:

A strategic plan for connectivity (CSP) of preserve lands in western San Diego County was developed for the San Diego Association of Government's Environmental Mitigation Program Working Group (EMPWG) in 2011. It was prepared by the SDMMP utilizing the input from a science workshop held in 2010. Many of the high priority items in the CSP have been completed and the data collected over the past several years are being utilized to inform management decisions. It is time to update and refocus our connectivity strategies and priorities for implementation.

Purpose and Format:

The purpose of the meeting is to gather input for the updated plan. We will be following a similar format to the connectivity workshop that was held in 2010. It will be a one-day, all day meeting, with a review of completed and in process projects, followed by breakout groups, and then coming back together for a integration of ideas and recap session. The breakout groups are: (1) Large Animals and Landscape Connectivity; (2) Small Animals; and (3) Pollinators. The meeting will focus on:

1. Identifying species to focus questions on connectivity;
2. Identifying questions and objectives to be considered for connectivity for species, and
3. Identifying available methodologies for addressing the questions and objectives

With input from the meeting, the SDMMP will draft the 2014 edition of the CSP and provide it to participants for review and comment. After incorporating needed revisions, the SDMMP will present it to the EMPWG and interested stakeholders for their input. The current CSP and appendices can be accessed on our reports and products webpage on the SDMMP website: http://sdmmp.com/reports_and_products/Reports_Products_MainPage.aspx (scroll down to Strategic Plans).

Connectivity Strategic Plan for Western San Diego County
Science Session – July 1, 2014
AGENDA

8:30am – 8:45am	Introductions, Logistics, Format, Purpose and Goal of Meeting
8:45am – 9:15am	Connectivity Strategic Plan Background & Status of Connectivity Projects
9:15am – 9:30am	Conserved Lands and Remaining Open Space Patches
9:30am – 10:15am	Connectivity Project Presentations (8 min) • Mountain Lion Movement Study – Winston Vickers • Bobcat Movement Study – Megan Jennings • American Badger Study – Cheryl Brehme • Underpass/Linkage Study – Carlton Rochester
10:15am – 10:30am	**BREAK**
10:30am – 11:45am	Connectivity Project Presentations (8 min) • Deer Genetics - Andy Bohonak • Fairy Shrimp Genetics – Andy Bohonak • Small Animal Underpass Improvement Study – Jeff Tracey • Southwestern Pond Turtle Genetics – Chris Brown • City of Carlsbad Connectivity Study – Rosanne Humphrey • Native Bee Study – James Hung
11:45am – 12:00pm	Instructions for Break-out Group Meetings
12:00pm – 12:30pm	Get Your Lunch and Find Your Room (Rm 103, 201, 270)
12:30pm – 2:30pm	Working Lunch and Break-Out Group Meetings • Large Animals and Landscape Connectivity • Small Animals • Pollinators
2:30pm – 2:45pm	**BREAK** (& Re-group in Room 103)
2:45pm – 4:00pm	Group Presentations (20min ea.) & Discussion
4:00pm – 4:30pm	Closing Remarks & Action Items

Connectivity Strategic Plan for Western San Diego County Science Session

Project Summaries

These project summaries document expert findings regarding connectivity on at-risk resources.

Connectivity Project Summary of At Risk Resource – Mountain Lion

Assessor: Winston Vickers

Agency/Institution: UC Davis Wildlife Health Center

Resource being assessed: Mountain lion (puma (*Puma concolor*)) connectivity

Sampling technique: Trail cameras, puma capture and GPS-collaring

General location: Western San Diego County west of the Cuyamaca Mountains, and extending from the US-Mexico border in the south to the area just north of Ramona.

Specific preserves (if applicable):

Time series: May 2012 – June 2014

Finding regarding connectivity and resource: Connectivity for pumas between certain San Diego County conserved lands is very limited, and mortality rates from roads are high, though other risks to pumas such as being killed after issuance of a depredation permit (4 pumas in the last year), are also quite significant. Highways and associated development, even rural development, appear to be the primary limiters of connectivity between conserved lands. Highways in the study area that are implicated as partial barriers to movement or containing sections that are higher risk for pumas include Interstate 15, Valley Center Rd (S6), SR 67, SR 78, Wildcat Canyon / Barona Road, Interstate 8, Interstate 15, and SR 94. In many sections noted as having limited puma crossings or collisions with vehicles, conserved lands existed adjacent to or near both sides of the highway. No puma use was documented on conserved lands west of I-15, and very minimal use of conserved lands was noted west of SR 67 south of Ramona. The one crossing of a GPS-collared puma onto conserved lands west of SR 67 was a one-time brief crossing from east to west followed by the puma involved (M107) being killed by a vehicle collision when trying to cross back to the east. Crossing of Wildcat Canyon / Barona Road was limited almost entirely to one short section north of the Barona Casino, despite the presence of conserved lands on both sides of the road over a much more substantial distance. It is apparent that in order for pumas to occupy normally sized territories (over 100 square miles in some cases) in this landscape, regular crossings of busy highways are required of essentially all individuals, and this fact should be taken into account in highway / development and conservation planning. In order for highway crossings by pumas to safely occur consistently, adequately sized crossing structures as well as fencing that is adequate to funnel animals to safe crossings is often required. It appears that numerous sections of the named highways and other roads and development in the study area likely pose a hazard for pumas, and are at least partial barriers to connectivity between blocks of conserved habitat.

The UCD team believes that data to date suggests that conservation prioritization should be given to protection and expansion of the natural travel corridors between conserved lands that

have been shown to be utilized or potentially utilized by pumas in this study and our previous work.

Additional preservation of corridors is especially critical between the conserved lands in the Ramona area and those to the north and northwest (Palomar and Santa Ana Mountain ranges) due to recent findings of severe genetic restriction of pumas in the Santa Ana range (inclusive of the San Diego County portion of the range), and clear genetic separation between those pumas and the populations east of I-15.

We urge conservation of additional lands near roads where puma approaches to road crossings have been documented, and expansion of the size of currently conserved lands wherever possible. We urge joint effort between San Diego, Riverside, and Orange Counties to improve connectivity for mt lions specifically across I-15 between Temecula and Escondido. The few remaining locations where viable crossings could be created or improved exist in that section of I-15, and are rapidly being degraded further.

We feel that it is also important to assure not only that adequate numbers of safe crossing structures are present in all of the travel corridors that we have documented, but also appropriate fencing (for this species) should be utilized to funnel animals to safe structures and prevent vehicle-related mortalities. It is important to note that the remaining connections between conserved lands in this study area are currently often fragmented, and present elevated risks to pumas from other human interactions that are independent of risks posed by the highway crossings.

Hypothesized mechanism for impacts: Fragmentation of habitat by roads and human development (barrier effects, mortality from vehicles, higher risks overall in areas adjacent to human activity), and relatively small size of conserved habitat patches and corridors (relative to mt lion home range sizes), are both responsible for negative impacts on puma use of conserved lands. These factors are exerting especially negative effects on puma population stability and genetics in the northwest portion of the county west of I-15, and the contiguous counties to the north.
These negative mechanisms can be expected to further erode connectivity and possibly impact puma population demographic and genetic stability elsewhere in western San Diego County if the amount of conserved lands and the connections between them are not improved.

Information needs for future adaptive management:
Additional camera monitoring, acquisition of additional puma movement and genetic data, updated modeling of habitat and potential movement corridors (based on both habitat use data and genetic data) in the northern portion of the county.
Current and future information developed by study of puma can provide important guidance for prioritization of conservation purchases in the future, especially in the central- and north-western portions of the county.

References:
See attached sheet

Connectivity Project Summary of At Risk Resource - Bobcat

Assessor: Megan Jennings and Rebecca Lewison with Erin Boydston and Lisa Lyren

Agency/Institution: Institute for Ecological Monitoring and Management at SDSU and USGS

Resource being assessed: Connectivity for large animals using bobcats as a model species

Sampling technique: Remote cameras, GPS telemetry, road kill collection, genetic analysis, habitat/connectivity modeling, occupancy modeling

General location: San Diego MSCP Area

Specific preserves (if applicable): Los Penasquitos Canyon, Black Mountain, Boden Canyon, San Dieguito River lands, Ramona Grasslands, Boulder Oaks, Iron Mountain, Sycamore Canyon/Goodan Ranch, Rattlesnake Canyon, Mt. Woodson, Cleveland National Forest

Time series: 2009-2012

Finding regarding connectivity and resource (see attached map):

- Overall, there is evidence of connectivity in the inland and coastal areas of the MSCP network that we sampled.
- Genetic analysis showed some degree of genetic differentiation between coastal bobcats west of I-15 and inland animals to the east, but did not indicate subpopulation differentiation has occurred. This supports the assertion that the coastal and inland areas have some level of connectivity.
- Movement analyses (camera and telemetry) showed direct use of five of seven linkages that were monitored. Detected movement was highest in Linkage 6-7, Linkage 8-10, and Linkage 5-6.
- For linkages not directly monitored, results from landscape models suggest that at least five other areas identified as putative linkages may have limited to no current connectivity, and another nine may only function partially. These limitations will likely increase under future, projected land use.
- Our analyses suggest that connectivity of large animals is more likely to be affected by project changes in land use patterns than projected changes in habitat related to climate change.

Hypothesized mechanism for impacts:

- Habitat alteration and recreation, in addition to other ecological variables, are currently affecting wildlife occupancy. These effects may increase under projected land use shifts.
- Heavily traveled secondary roads with traffic moving at high rates of speed may pose the largest threat to medium-wide ranging wildlife species attempting to move between core

conserved areas, especially from coastal to inland areas. Roadkill mortality appears to increase with seasonal increases in animal movement.

- For species sensitive to habitat fragmentation, increasing fire frequency may be leading to impaired landscape connectivity. Failure to account for fire return interval departures can result in overestimation of landscape connectivity.
- Projected habitat shifts resulting from climate change did not lead to substantial changes in habitat suitability or effective distance between preserves. However, future land use plans that lead to increased areas of altered use categories are likely to reduce habitat suitability in and around inland preserves.

Information needs for future adaptive management:

For large animals (not to be interpreted as a prioritized list):

- Additional genetic data and analyses
- Region-wide analysis of genetic data (Los Angeles, Orange County, and San Diego County)
- Further occupancy analysis of remote camera data, including an analysis of the patterns of species co-occurrence in conserved cores, at pinch points, and in linkages
- Comparison of CBI connectivity assessment remote camera data from early 2000s to present day
- Additional roadkill collection and data mining to conduct hotspot analysis
- Ensemble analysis of connectivity using species distribution modeling and connectivity assessment programs such as Circuitscape, MaxEnt, Linkage Mapper, and ModEco
- Continue to map actual movement corridors between conserved cores using above data to improve monitoring and management
- Testing and refinement of individual-based models developed from Orange County bobcat data (Tracey et al.) with San Diego bobcat data

For all currently monitored indicator species:

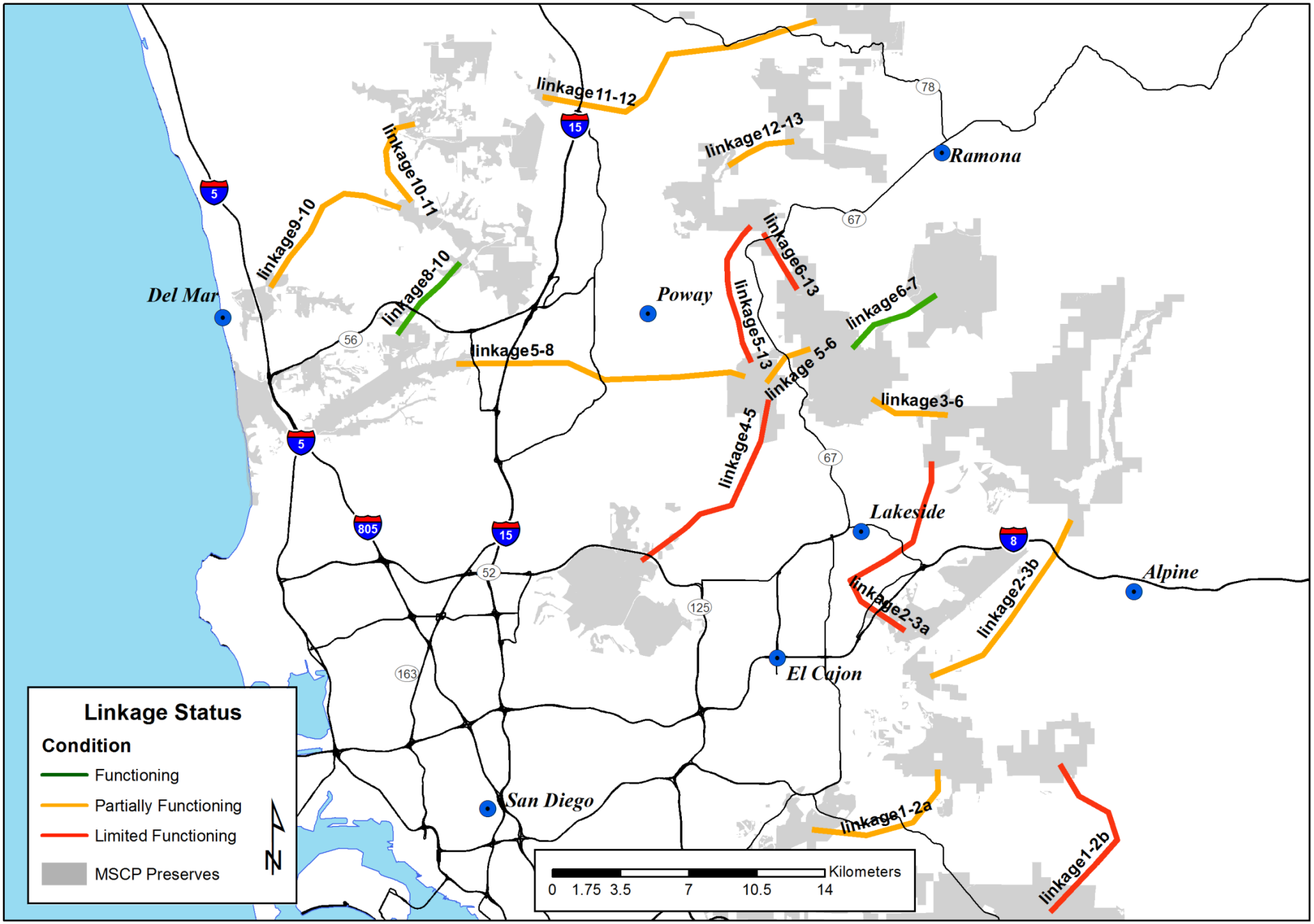
- Synoptic assessment of connectivity data from all focal species across projects conducted in the County, including analysis of connectivity under climate change and shifting land use patterns. This comprehensive assessment can also take an ensemble analysis approach. This approach is needed to ensure return on investment for all the individual connectivity that have been funded and to ensure that the results from these different studies can be integrated into a common connectivity assessment for the MSCP.

References:

Conservation Biology Institute. 2002. Wildlife corridor monitoring study for the MSCP. Prepared for City of Poway, City of San Diego, and CA Dept of Fish and Game.

Conservation Biology Institute. 2003 a. Review of regional habitat linkage monitoring locations, MSCP. Prepared for the CA Dept of Fish and Game. NCCP Local Assistance Grant #P0050009, Task A.

Jennings, M & R Lewison. 2013. Planning for connectivity under climate change: Using bobcat movement to assess landscape connectivity across San Diego County's open spaces. *Technical Report*.


linkage11-12
linkage12-13
linkage10-11
linkage9-10
linkage8-10
linkage5-8
linkage6-13
linkage5-13
linkage6-7
linkage 5-6
linkage3-6
linkage4-5
linkage2-3a
linkage2-3b
linkage1-2a
linkage1-2b
Ramona
Del Mar
Poway
Lakeside
Alpine
El Cajon
San Diego
5
15
78
67
56
805
52
125
163
8
Linkage Status
Condition
Functioning
Partially Functioning
Limited Functioning
MSCP Preserves
N
Kilometers
0 1.75 3.5 7 10.5 14

Connectivity Project Summary of At Risk Resource – American Badger

Assessor: Cheryl Brehme

Agency/Institution: USGS

Resource being assessed: American Badger

Sampling technique: Sign surveys, canine scent detection of scat, genetic testing of scat, hair snags and cameras.

General location: Western San Diego County (on or near Conserved Lands in MSPA)

Specific preserves (if applicable): NA- see below

Time series: 2011, 2014

Finding regarding connectivity and resource: Badgers are present but likely in low densities in areas of western San Diego County. Activity was confirmed in 2011 in Marine Corps Base Camp Pendleton, Fallbrook Naval Weapons Station, Daley Ranch in Escondido, Ramona Grasslands, Warner Springs Ranch, Whelan Lake, Crestridge Ecological Reserve, Santa Ysabel Ecological Reserve, Hollenbeck Canyon Wildlife Area (HCWA), and Marron Valley. In 2014, we could not confirm recent badger activity in the MSPA and adjacent focal areas of Ramona Grasslands, HCWA, Marron Valley, or Santa Ysabel ER, but have confirmed recent badger activity at Volcan Mountain ER, upper San Diego River, and Barnett Ranch. Study is ongoing with results and conclusions still pending.

Hypothesized mechanism for impacts: Badgers have large home ranges and are thus vulnerable to effects of habitat fragmentation. Road kill has been shown to be a primary cause of mortality in other parts of their range. Historic and current sighting records in San Diego are primarily from road kill records. Rodenticide exposure is a major concern due to their widespread use in suburban and rural areas and because the badgers' primary prey items (squirrels and other small mammals) are often considered rodent pests. Take of badgers for depredation, predator control, and fur-trapping are legal and could also be a significant contributor to their decline.

Information needs for future adaptive management: Identify areas within San Diego County with stable badger populations or recurring annual activity, characterize home range patterns within occupied habitat and document dispersal into adjacent conserved lands in the MSPA. Use these data to identify important movement corridors, foraging areas, primary threats, and causes of mortality.

Key References:

Adams, I.T. and T.A. Kinley. 2004. Badger (Taxidea taxus jeffersonii). Accounts and Measures for Managing Identified Wildlife; Coast Forest Region. British Columbia Ministry of Water, Land and Air Protection.

Brehme, C.S., C. Rochester, S.A. Hathaway, B.H. Smith, and R.N. Fisher 2012. Rapid Assessment of the Distribution of American Badgers within Western San Diego County. Data Summary prepared for California Department of Fish and Game. 42pp.

California Department of Fish & Game Trapping License Examination Reference Guide http://dfg.ca.gov/wildlife/hunting/uplandgame/docs/CADFGTrappingGuideJan2009.pdf

Quinn, J. 2008. The ecology of the American badger (Taxidea taxus) in California: assessing conservation status on multiple scales. Ph.D. Dissertation. The University of California Davis, Davis, CA. 200pp.

Other references available upon request

Connectivity Project Summary of At Risk Resource – Small Vertebrates

Assessor: Jeff A Tracey, Cheryl S. Brehme, Carlton Rochester, Denise Clark, and Robert N. Fisher

Agency/Institution: USGS

Resource being assessed: Small Vertebrate Use of Wildlife Underpasses

Sampling technique: Specialized infrared motion detection cameras in underpasses, BACI design to investigate the effectiveness of adding structures to underpasses to enhance small vertebrate use.

General location: Large underpasses in coastal San Diego County that had no roads or water courses passing through them

Specific preserves (if applicable): Valley Center, Carmel County, Sorrento Valley Road, Scripps Poway Pkwy, Highway 52

Time series: 2012 - 2014

Finding regarding connectivity and resource:
This is the first study, to our knowledge, to show the use of underpasses by a community of small vertebrates. Previous studies have lacked the sensitivity to document mice, lizards and snakes. We have shown that these members of the community can be studied successfully using these passive methods.

The results of modeling gave evidence to support the short-term effectiveness of the added structure treatments on small vertebrate use and suggested that these rates changed on the specific side the treatment was applied rather than the entire underpass. There were also larger numbers of images per day containing of small mammals on ledges, where they exist, compared to ground level interior and exterior cameras. Many pictures of rodent species using the ledges appeared to show that they were using the ledges as a vantage point to prey upon invertebrate species below.

The community composition appeared to differ within the underpasses in comparison to outside the underpasses. In particular, initial results indicate that small mammals, rabbits, bobcats, and roadrunners may tend to use underpasses less than the surrounding habitat, while reptiles (snakes and lizards), squirrels, medium sized mammals and deer use underpasses more than the surrounding habitat. Future modeling of these data will help us to better discern these effects.

Our initial correlation analysis does not suggest a strong association between mean daily small vertebrate use and use by bobcats, foxes and coyotes, deer, or roadrunners. These species are often used in the region as indicators of functional landscape connectivity or “umbrella species”.

However, if there is no evidence to support the association between use or connectivity for these species and small vertebrates, then small vertebrates must be studied and monitored separately.

Hypothesized mechanism for impacts:
Roads of different sizes, substrates, and traffic volumes have been shown to inhibit the movement of large mammals, small mammals and herpetofauna. If a road creates an impermeable barrier to animal movement, populations can become isolated or fragmented. Fragmented populations are more vulnerable to local extinctions and other negative effects from demographic and environmental stochasticity, as well as from increased inbreeding and genetic drift (see reviews by Trombulak and Frissel 2000, Foreman et al. 2003, Fahrig and Rytwinski 2009, Taylor and Goldingay. 2010).

Information needs for future adaptive management:
Our recommendations include additional monitoring in 2017, five years after addition of structure, to reassess the effect of structure on the use of underpasses by small and large vertebrates. This will allow sufficient time for most species to have acclimated to the structures and for us to adequately make a conclusion on their long term effectiveness. Because of the very large data set, many potential research questions, and many underpass covariates for the analyses, we recommend further analyses that will be valuable for evaluating the effectiveness of wildlife structures and differential responses of species and species groups based upon life history characteristics.

Finally, additional field experiments, such as addition of ledges to underpasses and relocation experiments will provide further information to allow for informed and successful decision making for maximizing wildlife connectivity under roadways that would otherwise be barriers for movement or mortality sinks.

References:

Tracey, J. A., C. S. Brehme, Rochester, C., Clark D., and R. N. Fisher. 2014. A Field Study of Small Vertebrate Use of Wildlife Underpasses in San Diego County, 2014. U.S. Geological DRAFT Data Summary prepared for California Department of Fish and Wildlife. 74 pp.

Connectivity Project Summary of At Risk Resource – Wildlife Linkages

Assessor: Carlton Rochester

Agency/Institution: U.S. Geological Survey – Western Research Center: San Diego Field Station

Resource being assessed: Wildlife linkages evaluation

Sampling technique: GIS, satellite imagery, land use data

General location: San Diego MSCP

Specific preserves (if applicable): core conserved areas within the MSCP as identified in the Connectivity Monitoring Strategic Plan for the San Diego Preserve System (CMSP)

Time series: 2011 through 2014

Finding regarding connectivity and resource: Of the 16 linkages identified in the CMSP, eight are estimated to be functional, having a high likelihood to provide suitable habitat and movement routes to allow wildlife to effectively move back and forth between the conserved areas. These linkages typically have low levels of development between the core conserved areas and infrastructure to allow wildlife movement past potential barriers. Eight linkages were estimated as non-functional, having significant barriers to wildlife movement, so much so that it seems very unlikely that none but the most disturbance tolerant species will be able to move from one area to the next.

Functional:

1. CA-1 to CA-2B: Otay Mountain/RJER to SDNWR/Crestridge (Eastern linkage through Rancho Jamul/Hollenbeck Canyon)
2. CA-3 to CA-6: El Capitan Reservoir to Iron Mountain/San Vicente Reservoir
3. CA-4 to CA-5: Mission Trails Regional Park to Gooden Ranch/Sycamore Canyon
4. CA-6 to CA-7: Iron Mountain/San Vicente Reservoir to Barnett Ranch/Monte Vista Ranch
5. CA-8 to CA-10: Los Peñasquitos Canyon to Black Mountain
6. CA-10 to CA-11: Black Mountain to Lake Hodges/Del Dios
7. CA-11 to CA-12: Lake Hodges/Del Dios to Ramona Grasslands/Boden Canyon (during low water level)
8. CA-12 to CA-13: Ramona Grasslands/Boden Canyon to Mt. Woodson/Blue Sky ER

Non-functional:

1. CA-1 to CA-2A: Otay Mountain/RJER to SDNWR/Crestridge (north of SR-94 at Las Montañas)
2. CA-2 to CA-3A: McGinty Mountain/Crestridge to Harbison Canyon/El Capitan Reservoir (Lakeside Archipelago)

3. CA-2 to CA-3B: McGinty Mountain/Crestridge to Harbison Canyon/El Capitan Reservoir (Peutz Valley Road and I-8)
4. CA-5 to CA-6: Goodan Ranch/Sycamore Canyon to Iron Mountain/San Vicente Reservoir
5. CA-5 to CA-8: Sycamore Canyon/Goodan Ranch to Torrey Pines/Del Mar Mesa/Los Peñasquitos Canyon
6. CA-5 to CA-13: Sycamore Canyon/Goodan Ranch to Mt. Woodson
7. CA-6 to CA-13: Iron Mountain/San Vicente Reservoir to Mt. Woodson/Blue Sky ER
8. CA-9 to CA-10: Del Mar Lagoon to Black Mountain

Hypothesized mechanism for impacts: habitat fragmentation associated with housing and other development, lack of suitable structures supporting wildlife movement

Information needs for future adaptive management: For all linkages, whether estimated to be functional or non-functional, monitoring critical points along the linkage should continue to help confirm or refute the linkage rating. Additional monitoring and wildlife use data will better inform species models and future management decisions.

References:

San Diego Management and Monitoring Program. 2011. Connectivity monitoring strategic plan for the San Diego Preserve System. Prepared for the San Diego Environmental Mitigation Program Working Group.

Connectivity Project Summary of At Risk Resource – Mule Deer

Assessor: Andrew Bohonak[1] and Anna Mitelberg[2]

Agency/Institution: San Diego State University[1] and San Diego Zoo Institute for Conservation Research[2]

Resource being assessed: Southern mule deer shrimp *Odocoileus hemionus fuliginatus* (MSCP focal species)

Sampling technique: Genetic analysis of scat samples

General location: Coastal San Diego County, particularly in the suburbs north of Miramar, and with particular attention to open spaces and wildlife corridors.

Specific preserves (if applicable): Torrey Pines State Reserve, Sorrento Valley, Penasquitos Canyon, Penasquitos Creek, Carrol Canyon, Miramar, Mission Trails Regional Park, Tierrasanta, Beeler Canyon, Sycamore Canyon, Calavera Preserve, Rancho La Costa HCA, Wild Animal Park, Cuyamaca Reserve, Cleveland National Forest, Julian, Lake Jennings, Hollenbeck Canyon, Rancho Jamul ER, San Miguel Mountain Open Space, South Crest, Sycuan Peak

Time series: Field collections from 2006-2007, and 2012-2013

Finding regarding connectivity and resource:

1. Southern mule deer have less overall genetic diversity than subspecies elsewhere in the state.
2. There is statistical justification for dividing coastal San Diego County into numerous management units. In the western part of our study area where sampling was the most dense (Torrey Pines east to Sycamore Canyon), populations generally correspond to existing reserves and canyons.
3. As in prior studies, the isolating effects of I-5 north of the I-5/805 merge are apparent, as well as the isolating effects of I-805 south of the merge.

Hypothesized mechanism for impacts:

4. Southern mule deer are relatively sedentary/territorial over many years. Offspring are often found very close to one or both parents. Females in close proximity tend to be more closely related than males in close proximity.
5. Low genetic diversity is consistent with an effective population size that is less than 200 individuals for the region we studied (up to 500 km^2), and perhaps less than 100. It is unclear how extreme and recent any past population bottleneck may have been. For example, it is possible that this subspecies has always had relatively small population sizes -- even prior to modern urbanization.
6. Major freeways correlate with population boundaries, at least in some areas.

Information needs for future adaptive management:

7. Prevent regional declines in genetic diversity
    a. We recommend that further urban encroachment be minimized, and that connectivity and local population sizes be maintained at least at their current levels, or increased where feasible.
8. Define multiple management units for southern mule deer
    a. We recommend that southern mule deer in an area that includes Torrey Pines, Sorrento Valley, Penasquitos Canyon, Penasquitos Creek, Carrol Canyon, MCAS Miramar and Mission Trails be considered as a separate management unit from those elsewhere in the subspecies range. This corresponds to the "Western gene pool" from this study.
    b. We recommend that management units more spatially restricted than these two gene pools also be considered.
    c. We recommend that genetic analyses be conducted in other areas of the species range under threat of habitat conversion, comparable in spatial and temporal coverage to this study.
    d. We recommend that the existing literature be combined with new demographic studies to provide accurate estimates of population size (both Ne and census size), and generation time. These estimates will improve interpretations of current and future genetic data.
9. Maintain high levels of connectivity
    a. We recommend that existing levels of habitat connectivity in western San Diego County be maintained, in light of limited lifetime movement that appears to be typical of southern mule deer.
    b. We recommend that additional non-genetic studies be conducted to quantify mule deer movement between SV and CC.
    c. We recommend that additional genetic studies of mule deer be conducted on MCAS Miramar, to clarify its role in regional conservation of this species.
10. Future studies
    a. DNA of sufficient quality for reliable, high resolution genetic analyses can be obtained from mule deer scat for future studies. The microsatellites we have optimized provide a very accurate individual DNA fingerprint. Even for full siblings (same mother and same father), the probability of an identical fingerprint is only 5×10^{-5}. Gender, parent-offspring relationships, within-generation movement and cross-generation movement can be inferred.
    b. Fine-scale inferences about movement patterns could be made elsewhere in the species range with new field samples that have spatial and temporal coverage comparable to our completed study. The goals for future genetic studies must be defined before sampling, and should link to specific parameters that inform management directly.

c. Low-cost (or volunteer) field assistants could annually archive scat or tissue samples in a permanent genetic resource bank, even if funds for another genetic study are not immediately available. The supply costs to extract, preserve and archive DNA for future studies would be relatively low.

References:

Bohonak, A. J., and A. Mitelberg. 2014. Social structure and genetic connectivity in the southern mule deer: Implications for management. Final Report. San Diego State University. Contract from California Department of Fish and Wildlife. April 16, 2014.

Mitelberg, A. 2010. Social structure and genetic connectivity in the San Diego southern mule deer. Master's thesis, Department of Biology, San Diego State University. San Diego, California.

Connectivity Project Summary of At Risk Resource – S. W. Pond Turtle

Assessor: Chris Brown, Robert Fisher

Agency/Institution: U.S. Geological Survey, Western Ecological Research Center

Resource being assessed: Southern western pond turtle

Sampling technique: Single nucleotide polymorphism/Visual encounter & trapping surveys

General location: Coastal San Diego, Orange, Los Angeles and Riverside counties

Time series: 2002-2013

Finding regarding connectivity and resource: The SNP loci data had enough resolution to identify "natural" breaks in the species (where populations became genetically distinct from adjacent populations), so that management units for conservation could be developed. In assessing genetic bottlenecks, we determined that only the most remote and undisturbed sites appear to genetically retain high diversity and a full complement of haplotypes. In our sampling for tissue collection we found similar numbers of native and nonnative turtles in the wild. We also detected evidence of pond turtles being moved into the area from the north, as released or escaped pets, human mediated movement of pond turtles being more of a problem than we knew.

Hypothesized mechanism for impacts: Interactions between altered hydrologic regimes (water diversion/impoundment), nonnative aquatic species (crayfish, bullfrogs, and predatory fish), and public access impact the species. Nonnative aquatic species effect recruitment through both predation and competition. Distance to road, nearest public access and type of public access increase the potential for individual turtles to be removed from the site (either picked up as pets or through road mortality) and increase the potential for nonnatives to be released at the site.

Information needs for future adaptive management: There are watersheds where we know little about turtle populations and/or their genetics which are regional gaps in knowledge that could help in making decisions for management and recovery of the species.

References:

Fisher, R.N., Wood, D.A., Brown, C.W., Spinks, P.Q., and A.G. Vandergast. 2014. Phylogenetic and population genetic analyses of the western pond turtle (*Emys marmorata*), in southern California. Prepared for the California Department of Fish and Wildlife, January 2014. U.S. Geological Survey, San Diego, CA, 59 pp.

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the San Diego MSCP and surrounding areas. Report to County of San Diego and CDFW, San Diego, California. 190 pp.
Spinks, P.Q., R.C. Thomson, and H. B. Shaffer. The advantages of going large: genome-wide SNPs clarify the complex population history and systematics of the threatened western pond turtle. Molecular Ecology. 23(9): 2228-2241.

Connectivity Project Summary of At Risk Resource – Native Bees

Assessors: Keng-Lou James Hung and Dr. David A. Holway

Agency/Institution: University of California, San Diego

Resource being assessed: Native bees (Hymenoptera: Anthophila)

Sampling technique: Aerial netting, fluorescently painted bowl traps, visual plant surveys

General location: Greater San Diego Region

Specific preserves (if applicable): Mission Trails RP, Scripps Coastal Reserve (UCNRS), Elliott Chaparral Reserve (UCNRS), Otay-Sweetwater Unit (SDNWR), Tijuana River National Estuarine Research Reserve (SDNWR), Chollas Creek Park, Pasatiempo Open Space, Juniper Canyon.

Time series: 2011-2012

Finding regarding connectivity and resource: In fragments of scrub habitat <40 ha in size (e.g. open space parks embedded in urban matrix), native bee species richness and genus richness were roughly 35% lower than those in large, intact patches of scrub habitat >400 ha in size (e.g. Mission Trails Regional Park), despite similar richness and density of blooming native plant species in the two types of habitats. Bee assemblages in fragments also included a higher proportion of floral generalist species. Certain bee taxa that occur in large numbers in intact habitats but are mostly absent from fragment (e.g. *Eucera* spp.) may serve as indicators of habitat connectivity / quality.

Hypothesized mechanism for impacts: Certain specialist bee species (and genera) may disappear from fragments when their host plants fail to occur at high enough densities (or are extirpated altogether). Certain bee species may also require special nesting substrates that are absent from fragments. Also, given their isolation fragments may also lose species when they fail to receive recolonization following natural processes of local metapopulation extinctions. Generalists are more abundant in fragments likely because of their ability to thrive on invasive flowering plants, which tend to be more abundant in fragments.

Information needs for future adaptive management: What is the rate of bee species recolonization to isolated fragments? How do different bee species move among discrete patches of urban habitat through non-green urban matrices? What constitutes a “corridor” from the point of view of native insect pollinators? What are the levels of pollinator diversity required for indefinite persistence of our native insect-pollinated flora?

References:

Bommarco, R., J.C. Biesmeijer, B. Meyer et al. 2010. Dispersal capacity and diet breadth modify the response of wild bees to habitat loss. *Proc. R. Soc. Lond. B Biol. Sci*., 277, 2075–2082.

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Winfree, R., R. Aguilar, D.P. Vázquez, et al. 2009. A meta-analysis of bees' responses to anthropogenic disturbance. *Ecology* 90:2068–2076.

Connectivity Project Summary of At Risk Resource – S.D. Fairy Shrimp

Assessor: Andrew Bohonak[1] and Marie Simovich[2]

Agency/Institution: San Diego State University[1] and University of San Diego[2]

Resource being assessed: San Diego fairy shrimp Branchinecta sandiegonensis (federally endangered)

Sampling technique: Genetic analysis of samples from pools across the species range

General location: Coastal San Diego County.

Specific preserves (if applicable): Most populations are on property owned by MCAS Miramar, MCB Camp Pendleton, or the City of San Diego. Some are found in other protected lands.

Time series: Field collections primarily from 2002-2005; time series not explicitly analyzed

Finding regarding connectivity and resource:

Genetic divergence among vernal pools and pool complexes

11. Genetic differentiation among vernal pools is statistically significant and relatively strong, even over relatively small distances. These patterns hold for two types of genetic markers (mtDNA sequences and microsatellites). Genetic differentiation generally increases as geographic distance increases. Pool connectivity is greater within complexes than between complexes. This implies limited connectivity among pool complexes, and throughout San Diego County.
12. Previous research identified two highly divergent mtDNA lineages within the species that have specific geographic distributions. With the newer data, these mtDNA lineages are more divergent for microsatellite markers *on average* than one would expect. However, the degree of microsatellite divergence between these lineages is far less than for the mtDNA.
13. Preliminary sampling of MCAS Miramar shows that the A4 complex is unusually divergent in terms of microsatellite markers, but not mtDNA. We interpret this to mean that the biological isolation of this area is relatively recent (compared to evolutionary time scales). Additional sampling form Miramar is needed.
14. In the microsatellite data set, Mira Mesa and Del Mar Mesa pools show somewhat higher divergence than one would expect. The southern border of this group is largely coincident with a small portion of the Rose Canyon fault zone, with the exception of Nobel Drive pools just north of the canyon, and Sander pools just south. Fine scale genetic patterns in this area would benefit from additional sampling.

Hybridization

15. Versatile fairy shrimp (B. lindahli) are found in disturbed pools within the costal range of B. sandiegonensis. Hybridization between these species is recognized as a threat to the San Diego fairy shrimp. These two species can hybridize in the lab, consultants have previously speculated about hybrids in field populations, and we have published a paper demonstrating that hybrids are present in several disturbed pools in coastal San Diego County.

Hypothesized mechanism for impacts:

Genetic divergence among vernal pools and pool complexes

16. Significant loss of vernal pool habitat has already occurred. The integrity of remaining pool complexes should be maintained at the broadest possible spatial scale (pool complex, preferably the micro-watershed for the complex).
17. Our overall assessment is significant biotic connectivity is normally restricted to pools within complexes, and pools within 5 km of one another. These patterns are assumed to correlate with local adaptation in traits that matter for individual fitness.
18. After several studies study, we can still find no single environmental factor such as soil type, latitude or elevation that is an obvious causal factor for overall genetic divergence within San Diego fairy shrimp
19. Human activities often homogenize these naturally distinct populations, rather than isolate them.

Hybridization

20. Preliminary data suggest that hybrids are primarily found in severely disturbed pools. Although their "background" presence in undisturbed landscapes has not yet been documented, they are clearly more prevalent in road ruts and other highly disturbed basins than in undisturbed pools.

Information needs for future adaptive management:

21. Movement of cysts among pools should be minimized, and especially outside of pool complexes. The genetic data suggest that biotic connectivity is very localized. (A common assumption in conservation genetics is that restricted gene flow for microsatellites correlates with local adaptation for traits that affect survival and reproduction. However, we acknowledge that this assumption must be validated with actual studies of individual fitness.)
22. It follows that newly created pools should be stocked from a single pool complex as close as possible. Stocking single new pools from a single source pool (rather than a multi-pool mixture) is recommended unless logistical or endangered species impacts preclude this.
23. Beyond low levels of connectivity among pool complexes, there may be an even more significant amount of divergence between the pools of {Mira Mesa, Del Mar Mesa} and the remainder of the species range. Additional care should be taken to minimize

homogenization of these sites with Miramar and populations south, with Ramona to the east, and with Pendleton to the distant north.

24. We have published a method for identifying hybrids from mature fairy shrimp females. We are attempting to develop a genetic hybrid index at this time.
25. Quantifying the extent of hybridization and its correlates is our current goal.

References:

Andrews, J. M. 2013. Conservation genetics of the endangered San Diego fairy shrimp (Branchinecta sandiegonensis). Thesis, Biology, M.S. San Diego, CA.

Andrews, J. M., A. J. Bohonak, and M. A. Simovich. 2014. Isolation and characterization of polymorphic microsatellite loci in the endangered San Diego fairy shrimp (Branchinecta sandiegonensis). Conservation Genetics Resources 6: 401-403.

Bohonak, A. J. 2005. Genetic testing of the endangered fairy shrimp species Branchinecta sandiegonensis. Final report to City of San Diego and US Fish and Wildlife Service. (Appendix to the City of San Diego's Vernal Pool Inventory). August 12, 2005.

Bohonak, A. J., and M. A. Simovich. 2013. Human impact to vernal pool complexes in Southern California. Final Report. San Diego State University. Contract from SANDAG. July 31, 2013.

Simovich, M. A., K. A. Davis, and A. J. Bohonak. 2013. Landscape homogenization threatens the genetic integrity of the endangered San Diego fairy shrimp Branchinecta sandiegonensis (Branchiopoda: Anostraca). Journal of Crustacean Biology 33: 730-740.

U.S. Fish and Wildlife Service. 2008. San Diego fairy shrimp (Branchinecta sandiegonensis) 5-year review: Summary and evaluation. Carlsbad, California. September 2008.

Connectivity Project Summary of At Risk Resource - Lizards

Assessor: Tara Luckau

Agency/Institution: San Diego State University

Resource being assessed: population genetics of lizards (*Aspidoscelis hyperythra* [a CA species of special concern] and *Sceloporus occidentalis*)

Sampling technique: tissue taken from animals in USGS pitfall trap arrays; microsatellite genetic analysis

General location: San Diego County

Specific preserves: Rancho Jamul Ecological Reserve, Hollenbeck Canyon Wildlife Area, Torrey Pines State Park, Cabrillo National Monument, Santa Ysabel Preserve, Marine Corps Base Camp Pendleton

Time series: 2010-2013

Finding regarding connectivity and resource:
On a county-wide scale, there is evidence to support population structure (genetic differentiation) for both species of lizards, based on F-statistics as well as Bayesian clustering. However, since sampling sites were widely separated by urbanization, much greater than the lizard species' dispersal distances, this result is expected.
On the other hand, analysis conducted at the scale of each sampling site shows little population structure, based on Bayesian clustering. Further fine-scale landscape analysis indicates some influence of landscape features on genetic patterns, but this pattern largely varies with sampling site rather than lizard species or particular landscape features. At nearly all sampling sites, the presence of roads does not correlate with genetic patterns for either species of lizard, indicating these linear anthropogenic structures do not present a barrier to dispersal for these lizards. For those sampling sites that did have landscape features that correlated with genetic patterns, vegetation and slope correlated most consistently, though not at all sites for either species of lizard. Soil type does not correlate with genetic patterns at nearly all sampling sites. Interestingly, the Torrey Pines sampling site showed no significant correlations between landscape features and genetic patterns.

Hypothesized mechanism for impacts:
Though population differentiation exists on a county-wide scale, lizards seem to be robust to fine-scale features of the landscape. Anthropogenic structures seem to impact these lizards only at a large scale; there is no genetic evidence to suggest that roads bisecting lizard habitat impede sufficient gene flow to maintain population connectivity. Estimations of population size have not yet been conducted using this genetic dataset, but the populations of these lizards may be large enough to resist population differentiation at the scales and sites included in this assessment.

Information needs for future adaptive management:
Future monitoring of habitat connectivity may be the only concern for *Aspidoscelis hyperythra*

and *Sceloporus occidentalis*. Vegetation and slope were the habitat features that correlated strongest and most frequently for this dataset, so maintenance of native habitats like coastal sage scrub and chaparral should be considered. A more uniform sampling design, where lizard tissues are collected across the landscape, rather than at particular trap sites, may be able to better capture potential gene flow barriers not considered in this assessment.

References:

Connectivity Strategic Plan for Western San Diego County Science Session

CSP Objectives and Brief Project Information

Connectivity Strategic Plan Priority Actions to Achieve Objectives for Large Animals (LA1, LA2), Small Animals (SA1), and Birds (B1, B2) and Project Status, if any

CSP Obj.	Actions to Achieve Objectives	Resource Assessed	Assessor / Affiliation	General Location	Time Series	Sampling Techn.	Connected?	Main Conclusions	Recommended Future Studies
LA1	Conduct GPS telemetry studies of mountain lions utilizing core areas generally east of I-15 and SR 125 to determine extent and specific location of lion movement between core areas. Include collection and analysis of genetic material to determine gene flow among core areas and relatedness of individuals and population size.	Mountain Lion	Winston Vickers / UC Davis Wildlife Health Center	Western San Diego County west of the Cuyamaca Mountains, and extending from the US-Mexico border in the south to the area just north of Ramona	May 2012 – June 2014	Trail cameras, puma capture and GPS-collaring	Not really	Connectivity for pumas between certain San Diego County conserved lands is very limited, and mortality rates from roads are high…	Additional camera monitoring, acquisition of additional puma movement and genetic data, updated modeling of habitat and potential movement corridors (based on both habitat use data and genetic data) in the northern portion of the county.
LA1	Conduct initial surveys of habitat potentially occupied by badgers and assess the potential (both feasibility and cost) of conducting GPS telemetry studies to identify specific locations important to badger movement in habitats fragmented by roads. Include collection of genetic material to determine gene flow within and between occupied core areas.	American Badger	Cheryl Brehme / USGS	Western San Diego County (on or near Conserved Lands in MSPA)	2011, 2014	Sign surveys, canine scent detection of scat, genetic testing of scat, hair snags and cameras.	Too few to determine	Badgers are present but likely in low densities in areas of western San Diego County.	Identify areas within San Diego County with stable badger populations or recurring annual activity, characterize home range patterns within occupied habitat and document dispersal into adjacent conserved lands in the MSPA. Use these data to identify important movement corridors, foraging areas, primary threats, and causes of mortality.
LA1	Monitor large animal chokepoints identified by CBI (2002) and compare monitoring methodologies (cameras, tracks, etc.) as part of a long-term monitoring strategy for chokepoints.	Linkages	Carlton Rochester / USGS	San Diego MSCP	2011 through 2014	GIS, satellite imagery, land use data	Some yes, some no	Of the 16 linkages identified in the CMSP, eight are estimated to be functional, having a high likelihood to provide suitable habitat and movement routes to allow wildlife to effectively move back and forth between the conserved areas. Eight linkages were estimated as non-functional, having significant barriers to wildlife movement, so much so that it seems very unlikely that none but the most disturbance tolerant species will be able to move from one area to the next.	...monitoring critical points along the linkage should continue to help confirm or refute the linkage rating. Additional monitoring and wildlife use data will better inform species models and future management decisions.

Connectivity Strategic Plan Priority Actions to Achieve Objectives for Large Animals (LA1, LA2), Small Animals (SA1), and Birds (B1, B2) and Project Status, if any

CSP Obj.	Actions to Achieve Objectives	Resource Assessed	Assessor / Affiliation	General Location	Time Series	Sampling Techn.	Connected?	Main Conclusions	Recommended Future Studies
LA2	Analyze existing genetic data from deer fecal analysis and utilize the data to evaluate core area connectivity for deer.	Deer	Andrew J. Bohonak & Anna Mitelberg / SDSU & ICR	Coastal San Diego County, particularly in the suburbs north of Miramar	2012 - 2013 and 2006-2007	Scat samples, DNA extraction and amplification of microsatellite markers	Yes & No	• Southern mule deer have less overall genetic diversity than subspecies elsewhere in the state. This is consistent with an effective population size that is less than 200 individuals for the region we studied (up to 500 km2), and perhaps less than 100. • Southern mule deer are relatively sedentary/territorial over many years. Offspring are often found very close to one or both parents. • Females in close proximity tend to be more closely related than males in close proximity. • There is statistical justification for dividing the area covered by this study into 2-9 management units. In the western part of our study area, where sampling was the most dense, populations generally correspond to existing reserves and canyons. • As in prior studies, the isolating effects of I-5 north of the I-5/805 merge are apparent, as well as the isolating effects of I-805 south of the merge.	• We recommend that existing levels of habitat connectivity in western San Diego County be maintained, in light of limited lifetime movement that appears to be typical of southern mule deer. • We recommend that additional non-genetic studies be conducted to quantify mule deer movement between SV and CC. • We recommend that additional genetic studies of mule deer be conducted on MCAS Miramar, to clarify its role in regional conservation of this species.
LA2	Analyze San Diego Tracking Team (SDTT) data collected subsequent to the data analyzed by Markovchick-Nicholls et al. (2008) to determine if SDTT data can be used to determine occupancy of habitat patches and infer connectivity for bobcats over time.	Multiple Species							

Connectivity Strategic Plan Priority Actions to Achieve Objectives for Large Animals (LA1, LA2), Small Animals (SA1), and Birds (B1, B2) and Project Status, if any

CSP Obj.	Actions to Achieve Objectives	Resource Assessed	Assessor / Affiliation	General Location	Time Series	Sampling Techn.	Connected?	Main Conclusions	Recommended Future Studies
LA2	Obtain bobcat genetic material for core areas and utilize it to assess current connectivity for bobcats. Further evaluate multiple long-term monitoring strategies (e.g. genetic monitoring in a manner similar to that proposed by Vandergast et. al (2009) "Building better roads for wildlife: assessing the effects of roads on animal dispersal and genetic connectivity" or using camera traps as recommended by USGS for a preserve in Orange County or other or combination of methodologies).	Bobcat							
LA2	Utilize radio telemetry to determine where bobcats frequently cross roads.	Bobcat	Megan Jennings & Rebecca Lewison / SDSU & Erin Boydsten & Lisa Lyren / USGS	San Diego MSCP Area - Los Penasquitos Canyon, Black Mountain, Boden Canyon, San Dieguito River lands, Ramona Grasslands, Boulder Oaks, Iron Mountain, Sycamore Canyon/Goodan Ranch, Rattlesnake Canyon, Mt. Woodson, Cleveland National Forest	2009-2012	Remote cameras, GPS telemetry, road kill collection, genetic analysis, habitat/connectivity modeling, occupancy modeling	Yes	• Overall, there is evidence of connectivity in the inland and coastal areas of the MSCP network that we sampled. • Genetic analysis showed some degree of genetic differentiation between coastal bobcats west of I-15 and inland animals to the east, but did not indicate subpopulation differentiation has occurred. This supports the assertion that the coastal and inland areas have some level of connectivity.	• Additional genetic data and analyses; • Region-wide analysis of genetic data; • Further occupancy analysis of remote camera data, including an analysis of the patterns of species co-occurrence in conserved cores, at pinch points, and in linkages; • Comparison of CBI connectivity assessment remote camera data from early 2000s to present day; • Additional roadkill collection and data mining to conduct hotspot analysis; • Ensemble analysis of connectivity using species distribution modeling and connectivity assessment programs such as Circuitscape, MaxEnt, Linkage Mapper, and ModEco; • Continue to map actual movement corridors between conserved cores using above data to improve monitoring and management • Testing and refinement of individual-based models developed from Orange County bobcat data (Tracey et al.) with San Diego bobcat data
LA2	Conduct review of roadrunner literature and identify potential connectivity monitoring considerations and costs.	Roadrunner							

Connectivity Strategic Plan Priority Actions to Achieve Objectives for Large Animals (LA1, LA2), Small Animals (SA1), and Birds (B1, B2) and Project Status, if any

CSP Obj.	Actions to Achieve Objectives	Resource Assessed	Assessor / Affiliation	General Location	Time Series	Sampling Techn.	Connected?	Main Conclusions	Recommended Future Studies
SA1	Determine which small animal species are most sensitive to habitat fragmentation including fragmentation due to wildfire.	Multiple Species							
SA1	Determine (1) what type of genetic analysis (mitochondrial, micro satellite, single nucleotide polymorphisms (SNPs) would provide the meaningful data regarding connectivity and (2) which species have appropriate genetic markers already identified.	Multiple Species							
SA1	Using existing information and the new vegetation map (in prep), identify what portions of selected core areas and linkages are occupied by a suite of small animal species sensitive to habitat fragmentation and already have key genetics issues resolved.	Multiple Species							
SA1	Analyze genetic material previously collected (or evaluate existing analyzed data) to help inform decisions on appropriate approaches (sampling design, species, etc.) to genetic monitoring of connectivity for small animals.	Multiple Species							
SA1	Analyze post-fire monitoring data to identify small animal species that are slow to recolonize burned areas, identify potential re-colonization points and methodologies to evaluate potential re-colonization routes/mechanism.	Multiple Species							
SA1	Identify adaptive management actions that could improve inter- and intra-core area connectivity for the identified species.	Multiple Species							
SA1	Evaluate monitoring methods that are available, tested, feasible and cost-effective to determine which species will be selected for connectivity monitoring.	Multiple Species							

Connectivity Strategic Plan Priority Actions to Achieve Objectives for Large Animals (LA1, LA2), Small Animals (SA1), and Birds (B1, B2) and Project Status, if any

CSP Obj.	Actions to Achieve Objectives	Resource Assessed	Assessor / Affiliation	General Location	Time Series	Sampling Techn.	Connected?	Main Conclusions	Recommended Future Studies
B1	Obtain and analyze cactus wren genetic samples from San Diego County.	Cactus Wren	Amy Vandergast & Barbara Kus / USGS	Southern California Range: (Ventura, Los Angeles, San Bernardino, Riverside, Orange and San Diego Counties)	2010-2011	Individual blood samples, DNA extraction and amplification of microsatellite markers	No	We detected 20 populations across the study area, a strong pattern of genetic isolation by distance, and pairwise FST values ranging from 0.033 to 0.182. Bayesian clustering methods detected 12 geographically-relevant genetic clusters. Genetic structure largely mirrors fragmentation patterns caused by urbanization, agriculture, and habitat conversion by wildfire, and many populations are in complete isolation.	• Does habitat restoration between aggregations = increased gene flow? • Translocations success rates adults vs. eggs • Does translocation = increased genetic diversity • Relationships between survival, fitness and genetic diversity
B1	Conduct banding studies to track dispersal of young cactus wrens to determine what habitats/corridors they utilize for dispersal and their dispersal distances.	Cactus Wren	Barbara Kus / USGS	Southern California Range: (Ventura, Los Angeles, San Bernardino, Riverside, Orange and San Diego Counties)					
B1	Obtain and analyze gnatcatcher genetic samples from San Diego County.	CA Gnatcatcher	Amy Vandergast & Barbara Kus / USGS	Southern California Range: (Ventura, Los Angeles, San Bernardino, Riverside, Orange and San Diego Counties)	2011-2012	Individual blood & feather samples, DNA extraction and amplification of microsatellite markers	Yes	We detected a single genetic cluster encompassing the study area using Bayesian clustering methods. Genetic differentiation among aggregations increased with increasing genetic distance indicating a stepping stone gene flow pattern among aggregations. We found no correlation between urban fragmentation and genetic differentiation among aggregations.	• Occupancy and abundance trends over time. • Future genetic monitoring every 5 generation or triggered by changes in occupancy or abundance
B1	Conduct banding studies to track dispersal of gnatcatchers to determine what habitats/corridors they utilize for dispersal and their dispersal distances.	CA Gnatcatcher	Barbara Kus / USGS	Southern California Range: (Ventura, Los Angeles, San Bernardino, Riverside, Orange and San Diego Counties)					

Connectivity Strategic Plan Priority Actions to Achieve Objectives for Large Animals (LA1, LA2), Small Animals (SA1), and Birds (B1, B2) and Project Status, if any

CSP Obj.	Actions to Achieve Objectives	Resource Assessed	Assessor / Affiliation	General Location	Time Series	Sampling Techn.	Connected?	Main Conclusions	Recommended Future Studies
B2	Analyze collected least Bell's vireo genetic samples to determine current degree of connectivity and evaluate the need for further study of factors limiting connectivity.	Least Bell's Vireo							
B2	Evaluate the results of existing genetic analyses for southwestern willow flycatcher populations and assess the need for sampling for additional populations and evaluate the need for further study of factors limiting connectivity.	SW Willow Flycatcher							
NA	Not included in the CSP but was an existing project assessesing connectivity.	South-western Pond Turtle	Chris Brown & Robert Fisher / USGS	Coastal San Diego, Orange, Los Angeles and Riverside counties	2002-2013	Single nucleotide polymorphism / Visual encounter & trapping surveys	Yes within drainages, no across range	The SNP loci data had enough resolution to identify "natural" breaks in the species (where populations became genetically distinct from adjacent populations), so that management units for conservation could be developed. In assessing genetic bottlenecks, we determined that only the most remote and undisturbed sites appear to genetically retain high diversity and a full complement of haplotypes.	There are watersheds where we know little about turtle populations and/or their genetics which are regional gaps in knowledge that could help in making decisions for management and recovery of the species.
NA	Not included in the CSP but was an existing project assessesing connectivity.	Native bees (Hymen---optera: Anthophila)	Keng-Lou James Hung & Dr. David A. Holway / UCSD	Greater San Diego Region	2011-2012	Aerial netting, fluorescently painted bowl traps, visual plant surveys	No	In fragments of scrub habitat <40 ha in size (e.g. open space parks embedded in urban matrix), native bee species richness and genus richness were roughly 35% lower than those in large, intact patches of scrub habitat >400 ha in size (e.g. Mission Trails Regional Park), despite similar richness and density of blooming native plant species in the two types of habitats.	What is the rate of bee species recolonization to isolated fragments? How do different bee species move among discrete patches of urban habitat through non-green urban matrices? What constitutes a "corridor" from the point of view of native insect pollinators? What are the levels of pollinator diversity required for indefinite persistence of our native insect-pollinated flora?

Connectivity Strategic Plan Priority Actions to Achieve Objectives for Large Animals (LA1, LA2), Small Animals (SA1), and Birds (B1, B2) and Project Status, if any

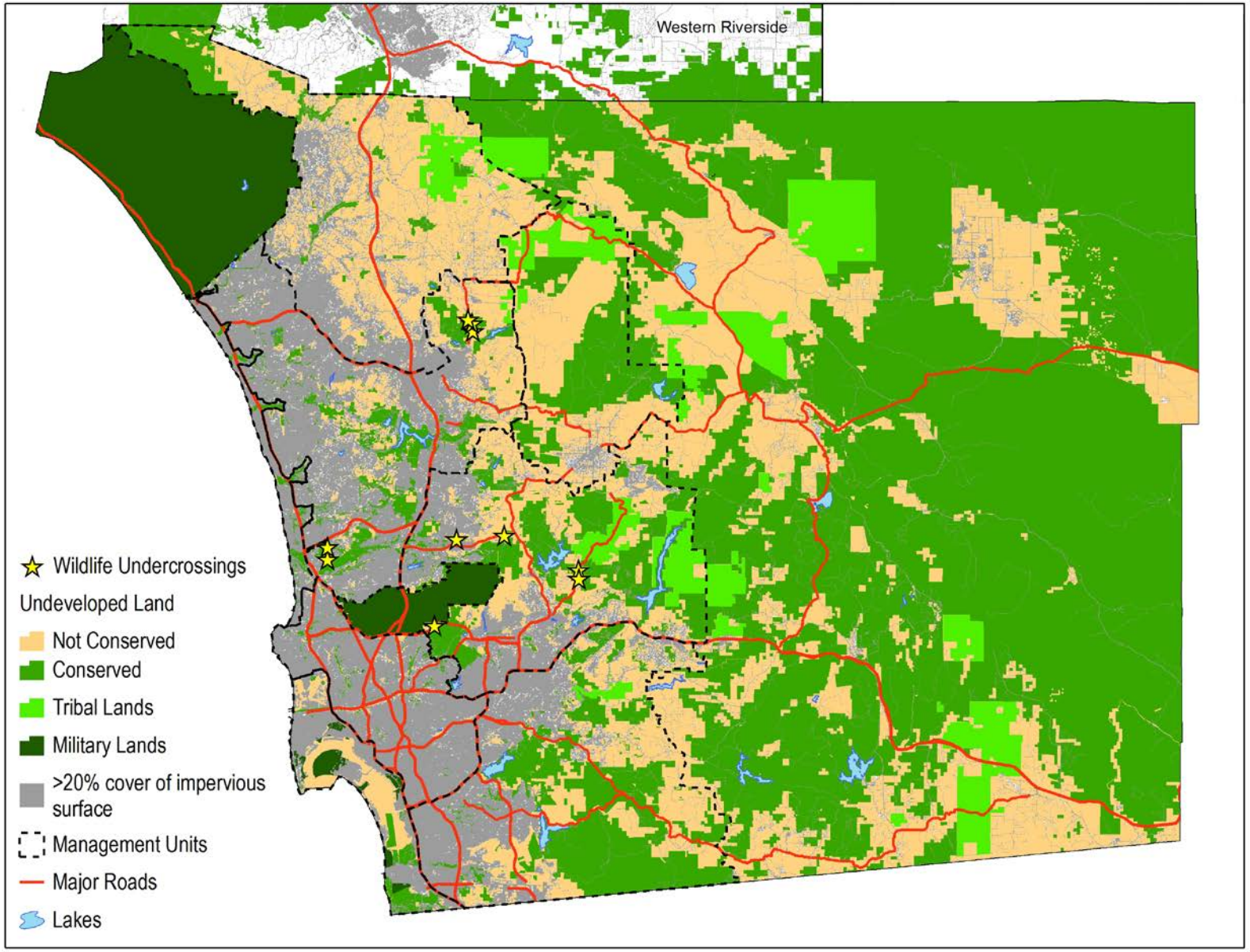
CSP Obj.	Actions to Achieve Objectives	Resource Assessed	Assessor / Affiliation	General Location	Time Series	Sampling Techn.	Connected?	Main Conclusions	Recommended Future Studies
NA	Not included in the CSP but was an existing project assessesing connectivity.	Small Vertebrates	Jeff A Tracey, Cheryl S. Brehme, Carlton Rochester, Denise Clark, and Robert N. Fisher / USGS	Large underpasses in coastal San Diego County that had no roads or water courses passing through them	2012-2014	Specialized infrared motion detection cameras in underpasses, BACI design to investigate the effectiveness of adding structures to underpasses to enhance small vertebrate use.	Can be with added structures in underpasses	The results of modeling gave evidence to support the short-term effectiveness of the added structure treatments on small vertebrate use and suggested that these rates changed on the specific side the treatment was applied rather than the entire underpass. The community composition appeared to differ within the underpasses in comparison to outside the underpasses. In particular, initial results indicate that small mammals, rabbits, bobcats, and roadrunners may tend to use underpasses less than the surrounding habitat, while reptiles (snakes and lizards), squirrels, medium sized mammals and deer use underpasses more than the surrounding habitat. Future modeling of these data will help us to better discern these effects.	...additional monitoring in 2017, five years after addition of structure, to reassess the effect of structure on the use of underpasses by small and large vertebrates.... additional field experiments, such as addition of ledges to underpasses and relocation experiments will provide further information to allow for informed and successful decision making for maximizing wildlife connectivity under roadways that would otherwise be barriers for movement or mortality sinks.

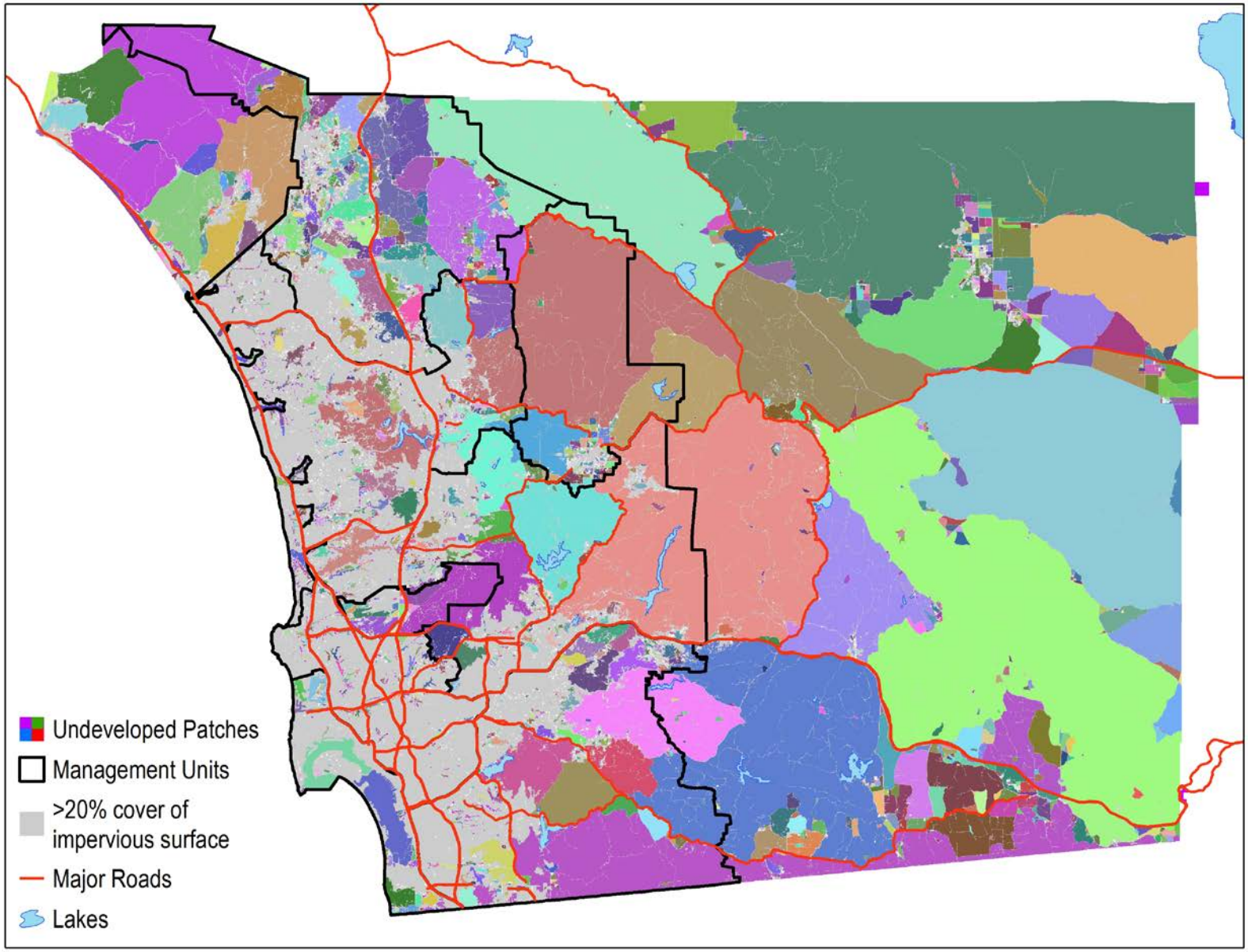
Connectivity Strategic Plan Priority Actions to Achieve Objectives for Large Animals (LA1, LA2), Small Animals (SA1), and Birds (B1, B2) and Project Status, if any

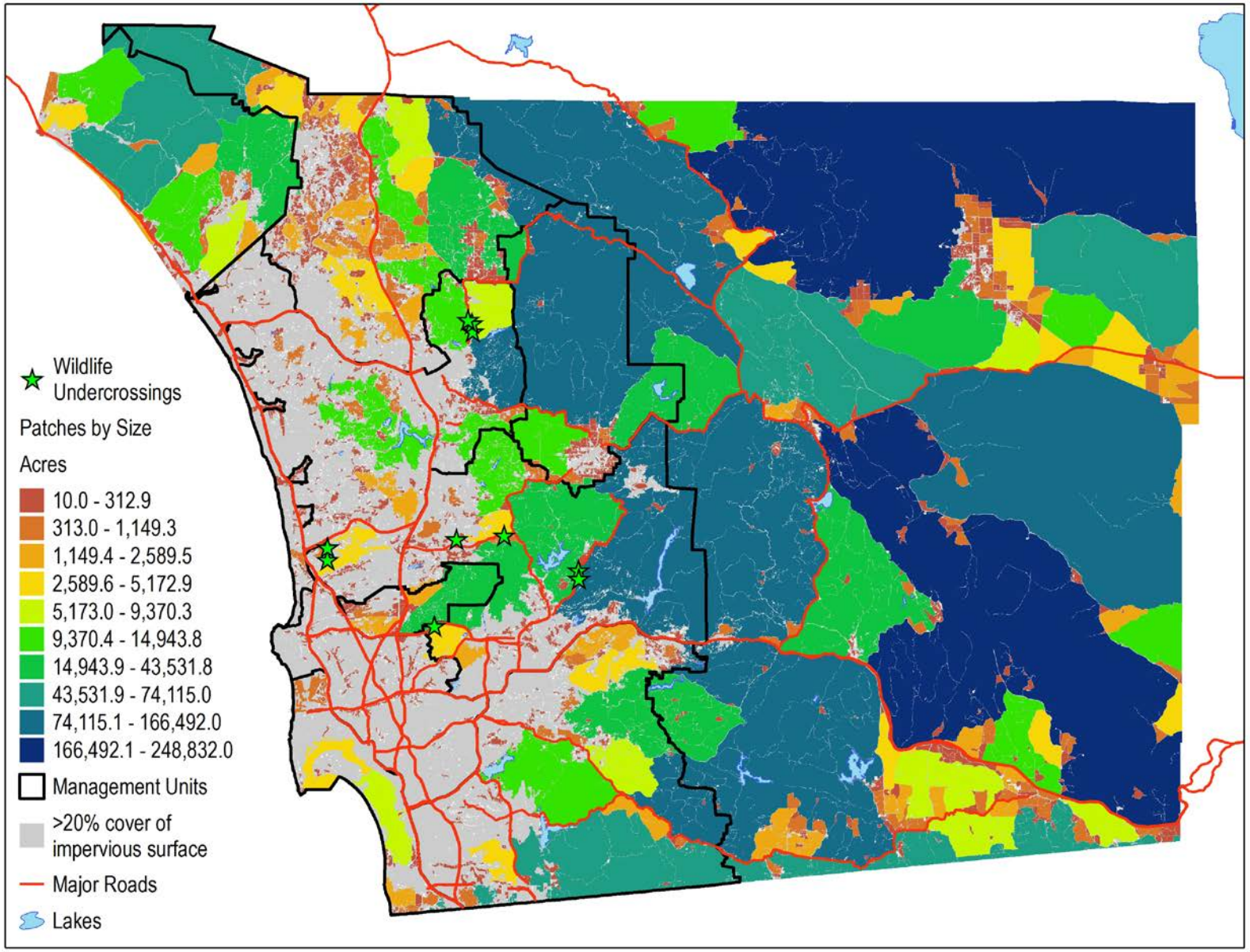
CSP Obj.	Actions to Achieve Objectives	Resource Assessed	Assessor / Affiliation	General Location	Time Series	Sampling Techn.	Connected?	Main Conclusions	Recommended Future Studies
NA	Not included in the CSP but was an existing project assessesing connectivity.	San Diego Fairy Shrimp	Andrew Bohonak & Marie Simovich / SDSU	Coastal San Diego County	Field collections primarily from 2002-2005; time series not explicitly analyzed	Genetic analysis of samples from pools across the species range	No	1. Genetic differentiation among vernal pools is statistically significant and relatively strong, even over relatively small distances. 2. … these mtDNA lineages are more divergent for microsatellite markers on average than one would expect. 3. Preliminary sampling of MCAS Miramar shows that the A4 complex is unusually divergent in terms of microsatellite markers, but not mtDNA. 4. In the microsatellite data set, Mira Mesa and Del Mar Mesa pools show somewhat higher divergence than one would expect. 5. ...These two species can hybridize in the lab, consultants have previously speculated about hybrids in field populations, and we have published a paper demonstrating that hybrids are present in several disturbed pools in coastal San Diego County.	11. Movement of cysts among pools should be minimized, and especially outside of pool complexes....12. It follows that newly created pools should be stocked from a single pool complex as close as possible. Stocking single new pools from a single source pool (rather than a multi-pool mixture) is recommended unless logistical or endangered species impacts preclude this. 13. Beyond low levels of connectivity among pool complexes, there may be an even more significant amount of divergence between the pools of {Mira Mesa, Del Mar Mesa} and the remainder of the species range. Additional care should be taken to minimize homogenization of these sites with Miramar and populations south, with Ramona to the east, and with Pendleton to the distant north. 14. We have published a method for identifying hybrids from mature fairy shrimp females. We are attempting to develop a genetic hybrid index at this time. 15. Quantifying the extent of hybridization and its correlates is our current goal

Connectivity Strategic Plan for Western San Diego County
Science Session

Workshop Map Handouts


Western Riverside
Wildlife Undercrossings
Undeveloped Land
Not Conserved
Conserved
Tribal Lands
Military Lands
>20% cover of impervious surface
Management Units
Major Roads
Lakes


Undeveloped Patches
Management Units
>20% cover of impervious surface
Major Roads
Lakes


Wildlife Undercrossings
Patches by Size
Acres
10.0 - 312.9
313.0 - 1,149.3
1,149.4 - 2,589.5
2,589.6 - 5,172.9
5,173.0 - 9,370.3
9,370.4 - 14,943.8
14,943.9 - 43,531.8
43,531.9 - 74,115.0
74,115.1 - 166,492.0
166,492.1 - 248,832.0
Management Units
>20% cover of impervious surface
Major Roads
Lakes

Connectivity Strategic Plan for Western San Diego County
Science Session

Breakout Groups- Background and Guiding Questions
Large Animals
Small Animals
Pollinators

Large animals- Roads and other barriers and habitat patch size

What do we know about connectivity for large animal species in San Diego?
Where are the large patches of conserved land and which species do we think they support and why?

- Deer*- habitat present
- Mtn. lion*- deer and topographic features appropriate vegetation community present in large patches
- Badger*- grasslands and open shrub lands (positive) and urban edge (negative)
- Bobcat- habitat present
- Coyote- habitat present
- Gray fox- habitat present (positive) and urban edge (negative)

* MSP species

Is there a minimum effective patch size needed for a territorial individual or population?
Is the species sensitivity to fragmentation/road mortality?
Do males and females have different requirements/sensitivity?
What about the future- natural land patch size vs. conserved land patch size?
Are the adjacent matrix lands important and what is the expected future condition of them?

Roads as barriers- what are the important characteristics?

- Width
- Matrix of lands on either side
- Traffic volume
- Vehicle frequency
- Speed
- Fencing and barriers (k rails/jersey barriers)

Which roads currently may define functional patch size?

- SR 67
- SR 94
- I-15
- I-5
- I-8
- 805
- 905
- SR 56
- SR 67
- SR 78
- SR 79
- SR 125
- Valley Center Road
- Wildcat Canyon/Barona Road
- Scripps-Poway Parkway
- Poway Road
- Otay Lakes Road
- Proctor Valley Road
- Honey Springs Road
- others

Other potential barriers

- Lower Otay Lake
- El Capitan
- San Vicente
- Lake Hodges

Should we prioritize the potential functionality of each road segment where it bisects conserved patches of habitat to inform research and management decisions

- Low functionality = one or more of the following
    - High likelihood of mortality if crossed and/or current high mortality rate – ecological sink
    - Gene flow probably blocked
    - Barrier to movement exists- fencing, center divider, etc. – no large animal w/l infrastructure
    - Little to no opportunity for rescue effect
    - Other
- Some functionality =
    - moderate mortality = some gene flow and some opportunity for rescue effect
    - Other
- Functional –
    - Gene flow
    - Low mortality
    - Single population spans the road area
    - Other

Other questions and Regional connectivity issues

- Role of San Diego mtn. lion population (genetic flow) in sustaining Orange and western Riverside mtn. lion population- where is the population in SD County that would potentially provide dispersing individuals to Orange and western Riverside County?
- Where did the male mtn. lion that entered the Orange County population come from?
- Is the population of mtn. lions in San Diego connected to the lion population in the San Jacinto, Santa Rosa and San Gorgonio Mtns? What about to Baja?
- Is the area west of SR 67 (San Diego River to Mt. Woodsen- Sycamore-Gooden to Mission Trails/Miramar) sustainable as mtn. lion habitat?

Large Animal Connectivity/Research needs/priorities?

- How are mtn. lions moving across the fragmented landscape – north County
- Mtn. lion- what is the relationships of individuals to each other and would knowing it inform connectivity actions with Riverside and Orange counties.
- Where are the badger movement areas within and between MUs and which roads are most problematic
- Do we need to know more about deer genetic connectivity across SR 67, other roads?
- Is there currently deer population rescue potential across I-5, 1-15, SR 67, other roads?
- Is connectivity and road mortality a problem for conservation of badgers within he MSPA-?
- Is the reduction in gray fox detections a connectivity issue of importance?
- Is it important to evaluate the genetic connectivity of roadrunner populations?

SMALL ANIMAL GROUP

Initial species list (from CSP 2011): Orange-throated whiptail, San Diego horned lizard, Dulzura kangaroo rat, California ground squirrel, **San Diego black-tailed jackrabbit, western spadefoot toad**, coastal whiptail, deer mouse, big-eared wood rat, desert woodrat, cactus mouse, **San Diego pocket mouse**, California swollenstinger scorpion, Jerusalem cricket and others [**bold = MSP species**]

Rationale for monitoring (from CSP 2011):

- Small animal species typically have small home ranges and maintaining viable populations may be achieved in smaller geographic areas.
- Some small animal species may occupy restricted niches (e.g. salamanders, toads, scorpions, etc.) within a larger conserved landscape.
- Intra-core connectivity may be as important as inter-core connectivity for some small animal species.
- In large diverse linkages, some small animal species may utilize the linkages as "live in" or even core habitat and their presence across a linkage may be an indicator that connectivity goals are being partially achieved.
- Research has demonstrated that some small animals may avoid habitat adjacent to roads and other structures.
- Habitat fragmentation and alteration of micro-habitat areas by fire and other activities may profoundly affect maintenance and recovery of small animal biodiversity of core areas.

Approach First Priority Small Animal (SA1) Connectivity Objectives

1. Determine current connectivity for a suite of small animal species sensitive to both inter- and intra-core area habitat fragmentation.

Actions to Achieve Small Animal Priority One Objectives

- Determine which small animal species are most sensitive to habitat fragmentation including fragmentation due to wildfire.
- Determine (1) what type of genetic analysis (mitochondrial, micro satellite, single nucleotide polymorphisms (SNPs) would provide the meaningful data regarding connectivity and (2) which species have appropriate genetic markers already identified.
- Using existing information and the new vegetation map (in prep), identify what portions of selected core areas and linkages are occupied by a suite of small animal species sensitive to habitat fragmentation and already have key genetics issues resolved.
- Analyze genetic material previously collected (or evaluate existing analyzed data) to help inform decisions on appropriate approaches (sampling design, species, etc.) to genetic monitoring of connectivity for small animals.
- Analyze post-fire monitoring data to identify small animal species that are slow to recolonize burned areas, identify potential re-colonization points and methodologies to evaluate potential re-colonization routes/mechanism.
- Identify adaptive management actions that could improve inter- and intra-core area connectivity for the identified species.

- Evaluate monitoring methods that are available, tested, feasible and cost-effective to determine which species will be selected for connectivity monitoring.

Questions for Today 07/01/2014:

1. Are the objectives and actions from CSP 2011 still valid? [no funding previously applied to implement]
2. What species should be the focus of studies? [above list partially based on using past and future pitfall traps to collect animals and genetic samples along a transect that runs from one core, through a linkage, to another core] Other species and questions to consider:
    a. Arroyo toad - how genetically diverse are populations? Are there problem areas?
    b. SD horned lizard at TNERR – reported to be last remaining coastal pop - is it viable or too isolated? Is this a connectivity problem or a native ant problem?
    c. SD black-tailed jackrabbit – is there a patch size issue? Is there a difference genetically between coastal and inland preserves?
    d. Burrowing owl (moved from birds to SA) – are pops in San Diego connected to pops in Mexico and Imperial Co?
    e. Bats – what pops and caves are connected?
    f. Burned areas – how will these areas be recolonized, will some areas/species need assisted re-colonization? Will soil-remediation be needed?
3. Potential Location for studies
    a. Are **big cores** (RJER/SDNWR/Otay Mtn) really connected or do internal roads constitute a barrier for smaller animals?
    b. How important are small fragmented areas [**NoCo coastal, urban canyons**] Is there a minimum patch size needed to maintain pops?
    c. Roads – different sizes and pavement types, what are impacts? Where do small animals cross the **I-15, I-8, SR94, SR67, SR56, Proctor Valley Rd**? How much roadkill is there? What species are getting across successfully? Do roads act as a filter? What are the important characteristics?
        i. Width
        ii. Matrix of lands on either side
        iii. Traffic volume
        iv. Vehicle frequency
        v. Speed
        vi. Fencing and barriers (k rails/jersey barriers)
4. Potential Methods
    a. Genetic studies - considered most important for determining connectedness. What species do we have in the freezer already? Can we detect genetic drift on short timescale? Which species are most sensitive to decrease in connectivity?
    b. Pitfall traps - where are all existing pitfall traps? If examining impact of roads, add traps to either side of roads?
    c. Camera stations? See USGS small animal underpass study.
    d. VES foot surveys

MSP Small Animals with Species-Specific Objectives (=may not want to focus connectivity efforts since likely already included in MSP, but confirm approach with group if time permits)

- Arroyo toad – genetic material to be collected in 2015, should genetic analysis be done similar to SW pond turtle?
- SW pond turtle – should first priority getting new populations established and then work on connectivity up and down watersheds?
- Townsend's Big-Eared Bat
- Pallid Bat
- Burrowing owl - ICR has been collecting genetic samples, should analysis be done to see if a larger effort is justified?

Pollinators Group

The CSP points out that population connectivity is important for demographic exchange, gene flow, species movement among core areas & patches & shifts in geographic range in response to environmental changes such as wildfire & climate change.

MSP Butterfly Species Connectivity

- MSP butterfly species include Quino checkerspot, Thorne's hairstreak, Harbison's dunskipper, Hermes copper & wandering skipper.
- Is there a potential loss of population connectivity for any of these species? What are the factors affecting connectivity for each species? Rank each species for its risk of loss of connectivity.
- Develop specific questions & objectives to address connectivity issues for those species at highest risk for loss of connectivity.
- What approach & methods could we take to address connectivity issues for butterflies? How would our methods vary depending on species?

MSP Rare Plant Connectivity – Small & Isolated Populations

- Use the rare plant – pollinator spreadsheet to evaluate the SL, SO & SS plant species & rank each species for risk for loss of connectivity between populations.
- For those species at high risk for loss of connectivity, identify those factors that contribute to this risk. Is there a potential pollinator connectivity concern or are other factors more important?
- Genetic studies are planned for several MSP rare plant species to assess genetic population structure. If there are species where it is determined to be important to enhance gene flow among populations, how could we determine if this is a pollinator connectivity issue? What would be the best approach & methods to address questions about pollinator connectivity in rare plant populations?

Rare Plant Connectivity – Community Level Concerns with Maintaining Ecological Function

- Identify important pollinator groups that provide pollination services to native shrubland, grassland, forbland & vernal pool plant communities in western San Diego County. Identify & rank threats to important pollinator groups. Characterize the plant species & habitat attributes that are required to maintain diverse, abundant & resilient pollinator communities.
- Use the rare plant – pollinator spreadsheet to assess different vegetation categories for risk of loss of pollinator services as a result of loss of connectivity. Consider the general extent & configuration of patches of vegetation within the landscape matrix of urban development, Conserved Lands, & undeveloped but unprotected lands. Review the distribution & abundance of rare plants within each vegetation category. Develop criteria & then prioritize each vegetation community for risk of loss of pollinator connectivity. This prioritization should include an assessment of the risk of losing pollinator connectivity to rare plants. What questions need to be addressed for those vegetation

categories prioritized to be at highest risk of loss of pollinator connectivity? What approaches & methodologies could be used to address these questions?

Connectivity Strategic Plan for Western San Diego County
Science Session

Breakout Groups- Notes from Group Sessions
Large Animals
Small Animals
Pollinators

Notes from Large Animal Break-Out Meeting

a. Goals for discussion
   i. Needs for future studies of large animal connectivity
   ii. Which roads are significant problems
   iii. Data needs for road impacts
   iv. Discuss and rationalize whether one or more species may act as umbrella species for conservation
   v. What does it mean to say that a corridor is "functional"?

b. Discuss and rationalize whether one or more species may act as umbrella species for conservation
   i. For *connectivity,* do deer have more difficulty crossing roads? Depends on the landscape, may not be able to generalize. Deer do not go through smaller diameter underpasses, but may be more likely to get killed crossing roads.

c. What does it mean to say that a corridor is "functional"?
   i. Potential criteria: a functional corridor contributes in a significant way to the persistence of a local population.
   ii. Alternatives: a functional corridor maintains movement for a predefined proportion of individuals (say 75%), compared to historical conditions without the road (or other barrier).
   iii. Discussion of relatively high costs that might be needed to make particular corridors or choke points functional for particular species.
   iv. Questions about what the optimization goals are. For example, maximum # species in each core area. Or maximum range for every species in the region. Or maximum population size for every covered species. …
   v. Current goals for MSCP may differ for one or more species from the goals at the time the original plan was conceived.
   vi. Mountain lions: is 67 a significant impact because it is presumed to prevent colonization to the west? Perhaps, but there may only be habitat for < 1 more lion in that area.
   vii. Ron's point: if lions were not getting hit on the 67, some of them would eventually make their way north. Goal is maximizing gene flow over a very large area, to include San Diego, Orange, Riverside Counties …. (Perhaps also maximizing the potential for ecological rescue effect in local areas.) Implicit assumption is that long-term persistence locally requires management over the much larger area.
   viii. Discussion of whether fencing for mountain lions can effectively funnel them into underpasses, and away from roads.
   ix. Discussion of particular areas in which there are land acquisition opportunities (or not) …

x. Reiteration of best expert opinion that mountain lions constitute a good umbrella species because of their large spatial requirement.

xi. Common quantitative framework to evaluate future research and land acquisitions for mountain lions?

xii. Modeling study (PVA) to quantify the marginal benefits of new functional corridors in a variety of places to mountain lion persistence in a variety of local and regional spatial perspectives. e.g., connectivity under the 67 for long-term mountain lion persistence 1) east of 67, and 2) for long-term mountain lion persistence in Orange County and other regions to the north. (In comparison with the current state).

xiii. Ecological and demographic studies in support of the model, as needed.

xiv. **** … but perhaps there is enough consensus from best expert opinion that this study is irrelevant … ?

xv. Modeling study of where exactly the crossing(s) should be. But Ron argues that there are relatively few opportunities for building such underpasses, so that kind of study may be irrelevant.

xvi. Similar studies for deer and other species, but for smaller, more relevant spatial scales.

xvii. Need predictions for connectivity for a variety of species through underpasses of varying sizes.

xviii. Discussion of Megan Jennings study beginning on underpasses…

xix. Do we need studies of ringtail?

xx. Was a kit fox caught in (… some particular area …)

d. <u>Which roads are significant problems</u>

i. Some similarities noted in maps from different species this morning. e.g., roadkill data.

e. <u>Consensus / Needs for future studies of large animal connectivity</u>

i. Mountain lions are a relatively good umbrella species for regional connectivity (where the region is larger than SD County)

ii. Data gap: mountain lion movement in north county

iii. Data gap: deer movement/genetic data north and east of current data set.

iv. A common quantitative definition for "functional" corridor would be extremely helpful, as well as data integration across species and studies.

Connectivity Strategic Plan for Western San Diego County

Science Session, July 1-2014

Small Animal Break-Out Group - Notes

Break-Out Group Participants:
Yvonne Moore (Facilitator) - San Diego Management and Monitoring Program
Cheryl Brehme – US Geological Survey
Chris Brown – US Geological Survey
Tim Dillingham – California Department of Fish and Wildlife
Rosanne Humphrey – Environmental Science Associates Inc
Sarah McCutcheon – San Diego Association of Governments
Karen Miner - California Department of Fish and Wildlife

The group discussed the existing goals and objectives for small animals and decided to keep them with some slight modifications.

Small Animal Objectives:
Goal: Maintain connectivity of small animals in the preserve system
S = specific to small animals sensitive to fragmentation and that we have existing genetic material
M = measurable - genetic connectivity as defined by current criteria, need temporal samples that cover two 10-year time periods
A = Achievable? Yes
R = Relevant to CSP and MSP
T= Time - Obj. are for next five year period.
Obj1. Evaluate genetic connectivity for a suite of small animal species sensitive to inter-core area fragmentation.

Actions: Inventory existing genetic samples
Create database
Map
Model
Meta-analysis of genetic studies already conducted

Pick different groups of species based on movement (wider ranging vs. smaller movement habitat specialist)

Obj.2. Evaluate genetic connectivity for a suite of small animal species sensitive to intra-core area fragmentation.
Obj.3. Evaluate threats to small animals that might cause genetic drift/population fragmentation

A) Current projects – SR94, SR76, SR67
B) Based on results of genetic analysis for locations and species

Connectivity Strategic Plan for Western San Diego County

Science Session, July 1-2014

Plants and Pollinator Break-Out Group - Notes

Break-Out Group Participants:

Facilitator: Kristine Preston - San Diego Management and Monitoring Program (SDMMP)
Amy Vandergast - US Geological Survey; Dan Marschalek - San Diego State University(SDSU); James Hung – University of California San Diego(UCSD); Sharon Coe - SDMMP

Management Strategic Plan (MSP) Butterfly Species Connectivity

MSP butterfly topics for the group to address:

- Is there a special loss of population connectivity for any of the five MSP butterfly species?
- Rank each species for its risk of loss of connectivity.
- Develop specific questions and objectives to address connectivity for those species at highest risk for loss of connectivity.
- What approaches and methods could be taken to address connectivity issues for butterflies? How would methods vary depending on species?

The group discussed what is known about distributions, ecology, and connectivity of five MSP butterfly species. Species were then prioritized for potential risk due to loss of connectivity. The species are ranked from highest risk to lowest risk:

1. Hermes Copper — Found only in San Diego County and northern Baja California. No current information on Mexican populations, a few locations in Baja from the 1980s. Limited range in San Diego County, surveys have been conducted since 2003 in US portion of range. Most butterfly occurrences are in central to south part of San Diego County. Fifteen locations prior to large wildfires in 2003 and 2007. One to two sites have been

recolonized post-fire (Cleveland National Forest). Hermes copper specializes on spiny redberry as host plant. Adults need flat-topped buckwheat flowers for nectar. Work undertaken on assisted translocation by Dan Marschalek from SDSU.

Hermes copper ranks highest for loss of connectivity as it appears most sensitive to fragmentation with a reduction in occupancy from 15 to 2 sites following fire.

2. Harbisons Dunskipper – Range is thought to be from central Orange County (Silverado Canyon) south into Baja California. Several locations in San Diego County, historical records around Poway but can't find there in recent surveys. Harbison's dun skipper relies on San Diego Sedge (Carex spissa) as host plant, which is found only oak riparian. Fly up and down the riparian areas, may be connected within but not between watersheds. May be missing from middle part of range in Poway (where most extensive patch of host plant exists). Hard to detect this year, likely because of drought. Habitat was hit by 2003 and 2007 large wildfires. Sightings in San Pasqual Valley.

Second highest ranked species for risk of loss of connectivity, due to fragmented nature of habitat and to recent lack of butterflies in the center of their range.

3. Quino Checkerspot Butterfly – Once a common southern California butterfly, now extirpated from Orange and LA Counties, from along the coast and now found only in San Diego and Riverside Counties. Listed as federally endangered species. Often uses *Plantago erecta* as host plant, though can use a few other species as well. Timing and amount of precipitation and temperature are important determinants of success of butterfly life cycle through influences on larval development and plant senescence. Butterfly populations appear to have boom vs. bust cycles and metapopulation dynamics, with local population extinctions and recolonizations. Habitat fragmentation, habitat degradation, and drought are reducing population abundance, and Quino checkerspot is not coming back after bust years. Fire has caused habitat degradation over large areas by increasing the distribution and abundance of invasive plant species. Larvae are hard to find. Some are being raised at the zoo. SDMMP and partners will be working on a management implementation for this

plan that includes connectivity modeling to determine where to survey, particularly for source populations.

The Quino checkerspot is thought to be at risk of loss of connectivity in fragmented habitat due to low population abundance, the importance of metapopulation dynamics in maintaining local populations, and lack of any large source populations in San Diego County.

4. Wandering Skipper - Found in coastal lagoons from Santa Barbara County south into Baja California, Mexico. Coastal development has led to loss of estuaries. There may be some connection of populations through the coastal bluffs. Wandering skipper at Bataquitos and Los Penasquitos lagoons show little genetic differentiation based on preliminary analysis of a small number of samples. The host plant is salt grass (*Distichlis spicata),* although this species may use some other plants as well.

Wandering skipper is of moderate concern for loss of connectivity. There is less habitat than historically, so distribution is more fragmented now. However, preliminary genetics indicate similarity among populations and butterflies may be able to move across bluffs.

5. Thorne's Hairstreak - Restricted to Tecate cypress on Otay Mountain in San Diego County. Tecate cypress is larval host plant. Persisted in refugia on the mountain following the 2007 fire and now they have spread back out over the mountain. Tecate cypress may be declining on the mountain. Needs a 35 year fire return interval (study by Regan et al and Nature Reserve of Orange County 2010 Tecate Cypress Management Plan). Fire is important for germination. Tecate cypress is found on 3 other peaks in southern California, but there are no Thorne's hairstreak at these locations. Risk is not from a connectivity issue, rather it is a habitat issue. If habitat expands, then maybe the butterfly could expand? This species seem to be connected on Otay Mountain as it is dispersing and spreading out.

At this time Thorne's hairstreak is considered at the lowest risk from loss of connectivity.

Issues of connectivity could be addressed through mark-recapture studies, genetic analysis (would need closely related species for comparison), and recolonization work. Because of time constraints, the group did not develop specific connectivity questions or further discuss approaches and methods to use in addressing butterfly connectivity issues.

MSP Rare Plant Connectivity – Small and Isolated Populations

MSP rare plant connectivity questions for the group to address:

- Using the rare plant – pollinator spreadsheet, evaluate the SL, SO & SS plant species & rank each species for risk for loss of connectivity between populations.
- For those species at high risk for loss of connectivity, identify those factors that contribute to this risk. Is there a potential pollinator connectivity concern or are other factors more important?
- Genetic studies are planned for several MSP rare plant species to assess genetic population structure. If there are species where it is determined to be important to enhance gene flow among populations, how could we determine if this is a pollinator connectivity issue? What would be the best approach & methods to address questions about pollinator connectivity in rare plant populations?

There was insufficient time to go through each species in the spreadsheet and rank them for potential risk from loss of connectivity. Instead, the group compared two similar species, Blochman's dudleya and short-leaved dudleya. Blochman's dudleya is a very small plant and has only a few widely separated populations in the MSP Area, and there is a loss of connectivity with no potential to establish pollinator connectivity within the MSP Area. In contrast, short-leaved dudleya, also a very small plant, has a very limited geographic range and there may be potential to maintain pollinator connectivity between some populations. So we need to look at whether pollinator connectivity is even feasible or whether some other management action will be needed to retain gene flow.

Rather than look at each species separately, the group came up with some criteria for ranking SL, SO and SS rare plant species for risk of loss of connectivity. Based upon these

criteria, it was decided that at a later date, Kris would rank each plant in the spreadsheet, provide a rationale, and then send the spreadsheet and rankings to the group to review.

Criteria for ranking MSP rare plant species for risk of loss of pollinator connectivity:

1. *Identify pollination mechanism*. Remove from ranking any wind pollinated rare plant species and retain insect pollinated plant species. None of MSP rare plant species is known to be pollinated only by hummingbirds, so ignore hummingbirds for now. The focus is on insect pollinators as bees, flies and beetles are the most important pollinators in San Diego County. Very little is known about beetle pollination. Moths can be more important pollinators compared with butterflies.

2*. Determine whether pollinator connectivity is even feasible.* If there is only one population or only a few populations spread far apart, then the problem is not a pollinator connectivity issue. If there are multiple populations with the potential for a single pollinator to travel between any two of these populations or for pollinator connectivity to be established through creation of an intermediary plant population, then these species should be evaluated for risk of loss of pollinator connectivity.

3. *Characterize the plant specie's self-pollinating capability and reproductive strategy*. Are the plants self-compatible or incompatible and is the reproductive mode primarily through selfing? If plants are self-incompatible or don't self-pollinate, then they are more at risk from loss of connectivity.

4. *Identify or estimate the typical body size of pollinators*. Larger bodied pollinators travel farther and plants with large pollinators likely have a lower risk of loss of pollinator connectivity than plants with small pollinators. There may be little information on pollinators for most of the MSP rare plant species, so size, morphology and color of floral characters may be needed to estimate pollinator type and body size. Plants that have small flowers tend to be pollinated by smaller insects. If plant populations are ≥10 km apart, then probably won't get pollen transfer by insects. The largest bumble bees and honey bees can

forage up to 5 km from their nest. Therefore, populations to be pollinated by these species should be < 5 km apart. An unlikely scenario is that there could be a bumblebee nest situated in a patch of habitat mid-way between two populations. Theoretically, this could extend the pollinator range between rare plant populations to 10 km. This assumes the bumblebee visits the nest at the halfway point in between successive foraging bouts at the two populations and retains the pollen to exchange it.

5. *Determine the relative dispersion and density of rare plants*. Plants that are sparsely distributed, and have lower local densities within a site may be less likely to attract pollinators.

It is important to note that there is a difference between plant visitors versus pollinators. Many insects that visit a plant do not end up leaving pollen at another plant of the same species.

To determine if there is a pollinator connectivity issue, we need to design field studies that can assess how much pollination is occurring and the identity of pollinators versus visitors. Could start with number of visitors going to plant and correlate with population of plants. To identify pollinators could conduct studies that bag flowers, count insect visits, identify pollen and record the density of insects.

MSP Plant Connectivity – Community Level Concerns with Maintaining Ecological Function

- Identify important pollinator groups that provide pollination services to native shrubland (coastal sage scrub and chaparral), grassland, forbland & vernal pool plant communities in western San Diego County. Identify & rank threats to important pollinator groups. Characterize the plant species & habitat attributes that are required to maintain diverse, abundant & resilient pollinator communities.
- Use the rare plant – pollinator spreadsheet to assess different vegetation categories for risk of loss of pollinator services as a result of loss of connectivity. Consider the

general extent & configuration of patches of vegetation within the landscape matrix of urban development, Conserved Lands, & undeveloped but unprotected lands. Review the distribution & abundance of rare plants within each vegetation category. Develop criteria & then prioritize each vegetation community for risk of loss of pollinator connectivity. This prioritization should include an assessment of the risk of losing pollinator connectivity to rare plants. What questions need to be addressed for those vegetation categories prioritized to be at highest risk of loss of pollinator connectivity? What approaches & methodologies could be used to address these questions?

Need to go through the spreadsheet first to see what community types rank highest and then look at this. There is insufficient time to do this now, so Kris will compile the vegetation information and send out to the group to review at a later date.

Examples of a few plant species that could be studied for pollinator connectivity: Del Mar manzanita (probably specialist pollinators); *Ceanothus* (lots of honeybee visitation); *Eriogonum* (generalist pollinators); cactus (specialist pollinators)

General Threats Analysis

Insect communities may be affected by poisons/insecticide/herbicide use, Argentine ants, invasive plant species, fire, habitat fragmentation, and climate change.

Barrel cactus – could be a good example of bringing things together with genetics on the plants, multiple generational analysis and analysis of the large cactus bees. Barrel cactus could have a pre- and post-fragmentation genetic structure. Argentine ants have been shown to reduce visits of cactus bees (flight range is several hundred m) and to cause reductions in fitness. Could do experiments with barrel cactus plantings????