IV. KEY LANDSCAPE PROCESSES

[**Figure IV.1** SAND DUNES, LITTLEROCK CREEK WASH.]

IV. KEY LANDSCAPE PROCESSES

Landscapes in the study area have changed dramatically in the last decades, but the rapidity with which they are currently changing is unprecedented, and their ability to provide ecosystem services is strained. Identification of key landscape processes shaping the future is a first step in determining opportunities for intervention. A synthesis of inventory, literature review, field observation, and expert interviews resulted in identification of the following key processes:

1/ Water cycle,

2/ Provision of ecosystem services,

3/ Agricultural production,

4/ Urban development; and

5/ Energy production.

These key landscape processes are summarized in the following pages. These processes are not classic landscape processes based solely in the biophysical realm. The rate and quality of change resulting from these processes are closely linked to human activity in the cultural, economic, and social realms.

In the Anthropocene, these landscape processes are driven by land cover change. Land cover change is the direct result of demographic, cultural, and economic forces acting upon human management of ecosystems. In this way, land cover change is a key driver of terrestrial ecosystem change (Reyers et al., 2009). In the Land Cover Change Analysis (**Section V.3**), land cover types that drive these key landscape processes are modeled as Agents of Change.

Identification of key landscape processes shaping the future of the study area is a first step in determining opportunities for intervention.

In the Anthropocene, three watersheds define the future of the study area.

The first two are the Antelope and Fremont Valley watersheds, whose springs and creeks supplied the earliest human civilizations in the study area. Recharge for these groundwater basins occurs where the San Gabriels and Tehachapis meet the flat part of the valley (**Figure III.1.10**).

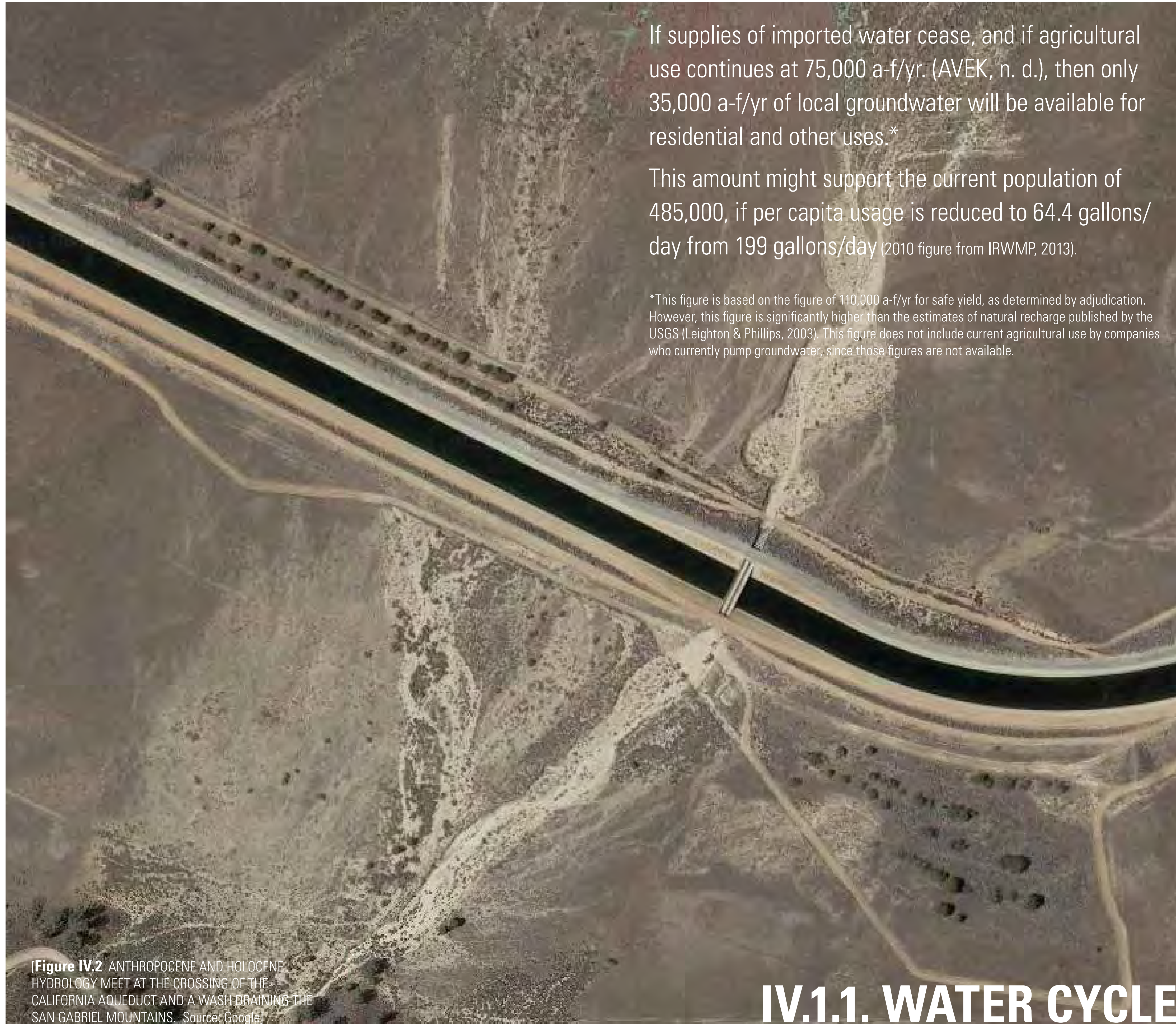
A third watershed has contributed to the dramatic population growth experienced since the 1970s: the Sacramento San Joaquin River watershed. These waters are conveyed over the Tehachapis at great energy cost (NRDC, 2004) to the study area and to Los Angeles.

The current drought challenges water managers to reconsider how limited water resources can be optimized in a future where climate patterns may be shifting. In 2014, in response to a severe multi-year drought, the Department of Water Resources cut supplies of imported water to 5% of the region's original allocation. This sudden drastic restriction may only be a taste of things to come. Given anticipated reductions in Sierra snowpack and increasing pressure to conserve wetland habitat in the Sacramento San Joaquin Delta, the California Aqueduct is unlikely to be a reliable a source of water in the future.

The Antelope-Fremont Valleys groundwater basins, will play an increasingly critical role in the region's future. In 2011, a court determined that 110,000 acre-feet per year would be considered safe yield for the Antelope Valley groundwater basin (Los Angeles County Waterworks Districts, 2011). Historical variability in precipitation levels, however, complicates the issue of determining safe yield. A 2003 report on the Antelope Valley groundwater basin estimated local recharge to be only 30,300-81,400 acre-feet per year (Leighton & Phillips, 2003). Withdrawing more than safe yield could contribute to loss of water storage capacity through further compaction of the aquifer.

If population growth continues and imported water supplies stop, then per capita water consumption will need to drop in order avoid overdrawing the aquifer.

Limiting withdrawals from the aquifer, recycling water, and optimizing recharge of the study area's groundwater basins are ways to increase the stability of the region's water supply. Reducing the use of water for ornamental landscapes and reducing the footprint of irrigated landscapes are strategies to limit water use. Using vegetation to slow the movement of runoff upstream of infitration zones is a strategy to enhance infiltration that will also have biodiversity and flood control benefits.



If supplies of imported water cease, and if agricultural use continues at 75,000 a-f/yr. (AVEK, n. d.), then only 35,000 a-f/yr of local groundwater will be available for residential and other uses.*

This amount might support the current population of 485,000, if per capita usage is reduced to 64.4 gallons/day from 199 gallons/day (2010 figure from IRWMP, 2013).

*This figure is based on the figure of 110,000 a-f/yr for safe yield, as determined by adjudication. However, this figure is significantly higher than the estimates of natural recharge published by the USGS (Leighton & Phillips, 2003). This figure does not include current agricultural use by companies who currently pump groundwater, since those figures are not available.

[**Figure IV.2** ANTHROPOCENE AND HOLOCENE HYDROLOGY MEET AT THE CROSSING OF THE CALIFORNIA AQUEDUCT AND A WASH DRAINING THE SAN GABRIEL MOUNTAINS. Source: Google]

IV.1.1. WATER CYCLE

Human impacts on the ecological infrastructure of the Mojave have altered the landscape's ability to provide ecosystem services. When biotic systems are damaged or lost, the functions they once provided are often replaced by human-engineered solutions, which require larger maintenance inputs and financial investment.

The economic value of the erosion control services provided by Mojave vegetation has been made especially clear in the last several decades, as multiyear droughts led to conditions that exacerbate the problem of fugitive dust (Farber, 2014). Windborne dust is a public safety issue due to its direct impacts (e. g. traffic accidents and property damage) and indirect impacts (e. g. growing incidence of valley fever).

Land use patterns are a key contributor to the increase in windborne dust. Approximately 35,000 square acres of land that previously used to be devoted to agriculture are no longer farmed [**Figure II.5**]. These expanses of disturbed and devegetated land dominate the southern and central portions of the study area. Wind attains higher speeds as it travels long distances across denuded land (MacConnell, 2013). Because wind-borne sand blasts soil crusts that are not protected by vegetation, a downwind domino effect of erosion is created through 'sand blasting' (Farber et al., 2014).

Windborne sand collects in dunes that move across the desert landscape, altering delicate native ecosystems. Plans are being made to ship excess sand to the coast to use in beach replenishment (Farber, 2014).

The solar farms that continue to proliferate in the study area have been accused of contributing to the dust problem.

If climate change brings warmer weather and longer drought cycles, dust storms may become more frequent and severe unless factors that contribute to dust storms are reduced.

Strategies to reduce windborne dust include disallowing temporary land uses that result in removal of perennial desert vegetation, mowing to preserve root systems (instead of uprooting and clearing) when temporary land uses such as construction occur, and incentivizing revegetation with native perennial shrubs after temporary land uses such as agriculture. Establishment of windbreaks may promote the settling of windborne dust and prevent the downwind domino effect of erosion. Maintaining groundwater levels and surface water flow also play a role in limiting dust production (IRWMP, 2013).

Since Mojave plant communities have evolved to provide erosion control and other services under harsh climate conditions, the conservation of local genetic diversity among these plant communities can be considered an ecosystem service.

[**Figure IV.3** ARTHUR B. RIPLEY DESERT WOODLAND STATE PARK.] This island of Joshua tree woodland is protected by State Park status.

IV.1.2. ECOSYSTEM SERVICES

High evapotranspiration rates in desert agricultural regions mean water used per acreage of crop is the highest among all of California's agricultural regions.

Agricultural acreage in the study area peaked in the 1960s, but the resulting overdraft of the aquifer lowered groundwater levels, making the cost of pumping prohibitive. Half a century later, large expanses of abandoned fields continue to lie fallow, contributing to windborne dust. Overgrazing contributes further to erosion, even though County regulations exist to limit grazing (NRCS, 2014). The Mojave's low plant biomass per acre means large expanses of land are necessary to sustain even a couple head of livestock (**Figure III.2.16**) (Pavlik, 2008).

The disparity between supply and demand for groundwater came to a head starting in 1999, when two industrial-scale baby carrot producers challenged municipal water suppliers for the use of limited groundwater supplies. These initial lawsuits soon ballooned into the adjudication of the entire Antelope Valley groundwater basin. Until adjudication is resolved and/or more precipitation fills the state's reservoirs, uncertainty surrounds the future availability and cost of water for agriculture.

While irrigated agriculture is under fire for its consumption of limited water supplies, agricultural landscapes have become recognized as important habitat for numerous rare bird species whose original wetland and grasslands habitats are almost entirely altered (Audubon, n. d.; Garrett, 2014; Hartman & Kyle, 2010). Alfalfa, the state's largest consumer of agricultural water (UC Davis, 2011), has especially high wildlife value because this perennial crop provides year-round habitat.

Given the unsustainability of many current agricultural practices, models of agricultural production that are integrated with water supply management, flood control, biodiversity management, and the cultural and esthetic needs of study area residents promise to increase the sustainability of local agriculture.

[**Figure IV.4** IRRIGATED AGRICULTURE IN THE STUDY AREA.]

IV.1.3. AGRICULTURAL PRODUCTION

An eight-fold increase in the study area population from the early 1980s to 2010 was accompanied by an equally dramatic proliferation of tract housing. Antelope Valley's rapid transformation from an agricultural valley into a sprawling suburb makes it a favorite illustration of the ills of sprawl (Eberhard Architects, 2009; Granola Shotgun, 2014) (**Figure IV.5**).

The driver of sprawl in the study area has been the juxtaposition of vast expanses of undeveloped land with economic pressures from the Los Angeles metropolitan region. Lancaster and Palmdale are bedroom communities for Los Angeles— about half of the workforce in both cities commute to employment in Los Angeles (GAVEA, 2013).

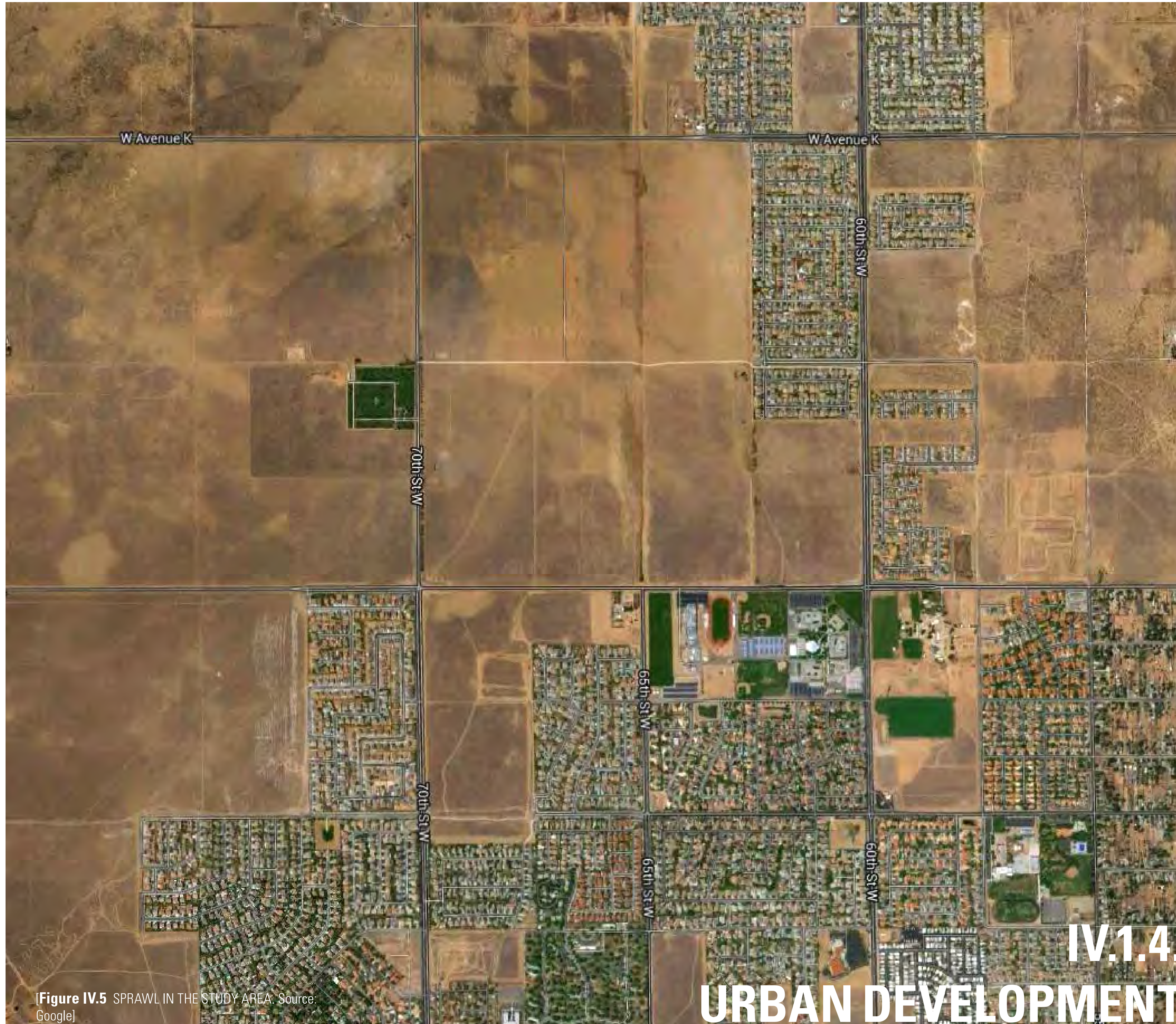
Sprawl replaces habitat and farmland with roads, houses, and infrastructure. Not only does sprawl make residents car-dependent, but it lengthens the distances they need to drive. Longer driving distances contribute to increased air pollution and greenhouse gas emissions. The long commutes that go hand in hand with sprawl are made possible by the availability of cheap gas. As the cost of gas has increased, moderate-income commuters have watched the cost of driving skyrocket to more than 25% of their income (Dewan, 2013).

Sprawl impacts water quality when pollutants accumulate on roadways and are flushed by precipitation into stormdrains and water bodies. In the study area's closed basins, pollutants accumulate in the soil and aquifer. Impermeable surfaces that drain stormwater away from built structures also prevent rainwater from soaking into the ground, where it could be cleansed by soil biota, replenish groundwater supplies, or provide flood control.

Besides such environmental impacts, sprawl is associated with decreased quality of life, social dysfunction, and loss of community (Eberhard, 2009). For planners, however, it has been noted that sprawl is inherently prohibitively inefficient (Eberhard, 2009). As Dewan (2013, n. p.) notes, "low-density developments fail to pay for their own infrastructure."

Currently, a younger generation of homeowners is creating a market for dense, walkable urban centers (Brown, 2014; Dewan, 2013; Logan, 2014). Cities who are revitalizing their downtown areas are growing (Khouri, 2013). Increased density in Los Angeles' urban core is attracting younger residents and empty nesters (Logan, 2014). Elements of smart growth are part of the General Plans of the City of Lancaster and County of Los Angeles. Mixed use, transit-oriented development, and infill development concentrates development where infrastructure already exists, and frees up land for open space.

Cultivating a variety of live, work, and play opportunities in the urban core can encourage increase density as well as quality of life. Lancaster's 'BLVD' revitalization project (completed in 2009), illustrates how well planned walkable districts can stimulate both economic and cultural activity.



[**Figure IV.5** SPRAWL IN THE STUDY AREA. Source: Google]

IV.1.4. URBAN DEVELOPMENT

Large swathes of the study area are devoted to single use utility infrastructure: utility corridors, wind farms, and solar farms, which supply the Los Angeles metropolitan area, home of three percent of the United States population, with electricity and water.

The Los Angeles Aqueduct has conveyed water from the eastern Sierra, through the study area, and toward Los Angeles for more than a century.

In the 1970s, the California Aqueduct was built along the northern slope of the San Gabriels. The aqueduct's open channel attracts waterfowl and provides surface water for common ravens (*Corvus corax*), a native species whose population has exploded in response to the proliferation of water, food, and nesting sites provided by development.

On the north-facing side of the San Gabriels just upslope of the California Aqueduct, high voltage power lines dominate the landscape. The many towers supporting these lines offer ample nesting sites for ravens and hawks, which harass and predate on other birds.

The solar and wind farms which dominate the western portion of the study area have appeared within the last five years. Other alternative energy farms are in the process of being constructed, and even more are planned (**Figure III.2.20**).

Residents find that the quiet landscapes that attracted them to the region are now being replaced by industrial landscapes, with blinking lights and humming turbines. Solar farms are surrounded by fences with exotic trees planted as windbreaks. These additions to the landscape contrast dramatically with native desert landscapes.

The impact of energy and water infrastructure on the study area's habitat connectivity, ecosystem function, and scenic qualities has been larger than its actual footprint. Not only does the patchwork nature of scattered development facilitate edge effects, but utility corridors enable the spread of predator and generalist species (**Section II.3.8**). Yet, it is possible that one day, some utility easements may be managed differently to contribute to conservation goals. As surrounding landscapes become more densely developed, these strips may become part of a larger network of connected habitat.

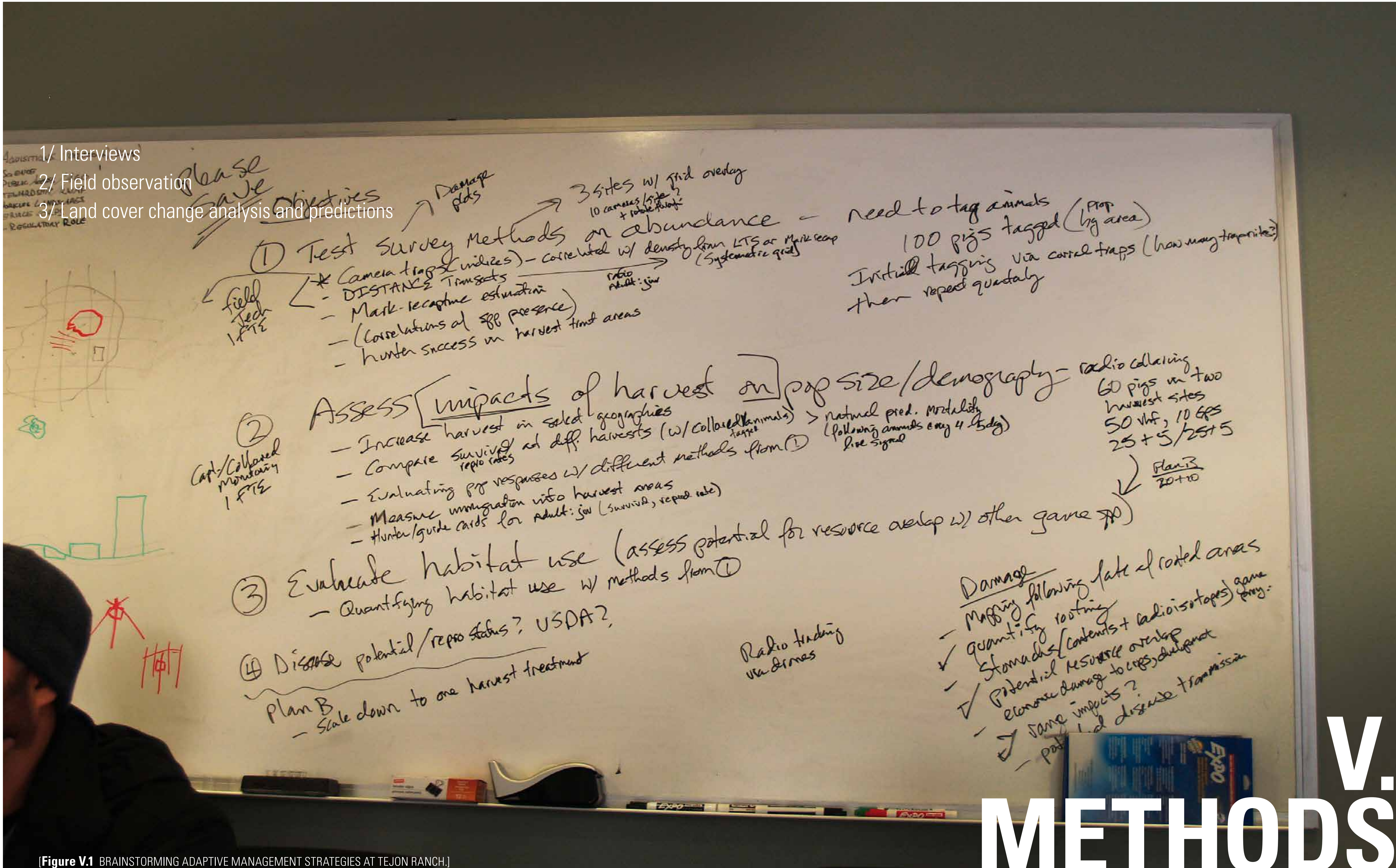
The California Aqueduct also provides opportunities for recreation and connectivity between human communities.

[**Figure IV.6** THE LOS ANGELES AQUEDUCT.]

IV.1.5 ENERGY PRODUCTION

V. METHODS

1/ Interviews
2/ Field observation
3/ Land cover change analysis and predictions



[**Figure V.1** BRAINSTORMING ADAPTIVE MANAGEMENT STRATEGIES AT TEJON RANCH.]

V. METHODS

Data collection strategies were selected based on their value to identifying and prioritizing issues and opportunities within the framework of the goals of this study.

INTERVIEWS with experts in relevant fields helped the team apply the issues uncovered in literature reviews to the specific observed conditions in the study area, and to understand these issues in the broader context of their fields. In several cases, interviews were also opportunities for field observations.

Design involves integrating cultural and physical experiences with landscape and ecosystem processes. *FIELD OBSERVATION* was key to understanding the spatial relationships between various land use types in the study area, and identifying underutilized landscape-based opportunities among them. The team visited major land use types: recent wind and solar development, utility infrastructure, suburban sprawl, agriculture, ecotourism, historical sites, State Parks, recreation, suburban and urban development, rural towns, and major vegetation communities. The journey between these land use types revealed the diversity of lifestyles and values among communities, the fragility of ecological relationships, the rapid pace of change, and the urgent need for integrated planning approaches.

Third, *LAND COVER CHANGE ANALYSIS AND PREDICTION* was conducted to reveal a more objective understanding of the extent and nature of past land use change. The analysis also applied past patterns to project trends into the future.

The team's use of these research methods was iterative and non-linear. In many cases, examination of key issues through literature, interviews, observations, data mining, and exploration of the same issues in additional interviews led to the final analysis.

V.1. Interviews

Subject matter experts were sought in fields related to the key issues. These include: ecology, urban development, conservation development, water and air quality, and dynamic landscape processes (biodiversity, ecology, geomorphology, erosion). The team also sought an understanding of approaches to managing key biodiversity resources of the study area: Edwards Air Force Base, Tejon Ranch, and California State Parks. Tejon Ranch and Edwards Air Force Base are among the largest properties in the study area.

Expert interviewees represent private, federal, and state agencies, and a range of perspectives ranging from applied to academic.

Interviewees were asked to share their experience in their field, reflect on current issues in the study area, suggest opportunities and challenges for design and planning, and identify the key agents of change in the study area.

Some interviews were conducted live. A few were conducted via correspondence. Questions were customized to the expertise of each participant, and thus differed between interviews.

Interviews helped the team synthesize information gathered from literature reviews and field observation, assess its significance for the project, and identify opportunities for planning and design.

The results of each interview are organized into four topic areas: 1/ Setting the context, 2/ Opportunities for land management, 3/ Challenges for land management, and 4/ Recommendations.

Table V.1 summarizes the highlights of the interviews. **Table V.2** organizes highlights of individual interviews according to topic area. A full transcript of each interview is included in **Appendix XI** (DVD).

SETTING THE CONTEXT	OPPORTUNITIES FOR LAND MANAGEMENT	CHALLENGES FOR LAND MANAGEMENT	RECOMMENDATIONS
1/ Habitat fragmentation due to energy development and sprawl. 2/ Quality of life impacts due to recent energy development and sprawl. 3/ Strategies to cultivate stewardship. 4/ The role of climate change.	1/ Ecosystem services provided by desert biota and soils. 2/ The rich biodiversity resources of the study area. 3/ The tenuous status of the study area's biodiversity. 4/ Alternative means of siting alternative energy production, such as on existing infrastructure or in urban settings.	1/ Alternative energy development's disturbance of native vegetation and wildlife habitat. 2/ The challenge posed by restoration given the low ecological recoverability of desert ecosystems from disturbance. 3/ Climate change. 4/ Lack of resources. 5/ Cultural, political, and economic barriers to integrated management of biological resources.	1/ Integrating alternative energy production into existing developed areas. 2/ Limiting sprawl. 3/ Protecting habitat for desert biota that need large, undisturbed expanses. 4/ Considering the habitat needs of migrating birds, butterflies, and native insects. 5/ Creating prototype design ideas for planners and decision makers. 6/ Creating a handbook of critical considerations for study area decision makers. 7/ Increasing stewardship and awareness of ecosystem services provided by local landscapes.

[**Table V.1** OVERVIEW OF INTERVIEW RESULTS.]

INTERVIEWS OVERVIEW

INTERVIEWEE	SUMMARY	SETTING THE CONTEXT	OPPORTUNITIES	CHALLENGES	RECOMMENDATIONS
CHRIS CLARKE Environmental writer Covers desert, alternative energy, and biodiversity issues for KCET. Currently writing a book about Joshua trees.	The desert provides ecosystem services: erosion control, carbon sequestration, and pollination. Threats include loss of wildlife habitat to alternative energy development, and a lack of support for land owners who want to do the right thing.	A. Habitat loss caused by sprawl and energy development. B. Land conservation. C. Depleting biological diversity. D. Losing ecosystem services provided by the desert biota. E. A changing climate. F. The study area is distinguished from the rest of the Mojave by its lower elevation, wetter and deeper soils, and milder summers and winters caused by proximity to the ocean. The local species of Joshua Tree (*Yucca brevifolia* forma *herbertii*) in the study area propagates through ramets.	A. Desert pavements intercept and hold particulates from dust. B. Soils act as a carbon sink. C. AFV is a convenient location to harness electricity from solar and wind energy. D. Native *Asclepias* species benefit migrating monarch butterflies.	A. Disturbed soils release carbon and increase risk of Valley Fever. B. Development of alternative energies disturbs desert biota. C. From a biological point of view, most of the Mojave is still terra incognita. Further study will inform future decisions. D. Lack of land for mitigation will not stop development, only decrease mitigation measures. E. The biota may change with climate change, a shift to more fire prone grasses and fewer trees.	A. Cash for Grass is a program for turning lawn into native landscapes which can include wildflowers. B. Consider alfalfa fields (and other land that is already disturbed) as sites for alternative energy production . C. Preserving land by setting up agricultural/conservation trusts that may be written into the will of property owners. D. Allow species to migrate with climate change by ensuring connectivity and protecting large habitat patches. E. Use of technology to encourage stewardship of the land should be used with caution. F. It is hard to find work in desert towns. People will appreciate the jobs brought by any dollars for revitalization.
JONATHAN FEENSTRA Freelance Biological Consultant Conducts biological monitoring for energy companies in the study area, consulted on the formation of Audubon IBAs.	Habitat loss and fragmentation is a major concern. There needs to be a concerted effort for consolidation of development.	A. Habitat loss and fragmentation. B. Importance of habitat for migratory birds. C. Generalist species such as urban birds and ravens dominate landscapes with built structures. D. Certain species require large expanses of relatively low diversity land. These species are forgotten when high diversity habitat is privileged for protection.	A. Even “disturbed land” is still valuable habitat by virtue of not having human activity on it. B. The great spectacle of spring and fall migration are best witnessed at open water sources in the desert.	A. Fragmentation of habitat due to development. B. Solar is being constructed on viable habitat. C. Local conservationists are relatively few in number, and are not well funded. D. Generalist species such as ravens thrive on edge habitat and any built structures, and harass other birds.	A. Consolidate development around the 14 freeway. B. Protect habitat for species requiring extensive expanses away from “edge habitat,” i.e. roadrunners, Le Conte’s thrasher. C. Allow solar development only on disturbed land.
JOHN GAGLIONE Owner, Fairmont Market A longterm resident of the study area, and owner of a general store adjacent to the the Antelope Valley California Poppy Reserve.	Alternative energy development and climate change are causing devegetation as well as shifts in ranges of species. There have been other shifts in local culture and patterns of farming in the study area.	A. Developers and speculators are buying up land. Alternative energy development is changing the character of the landscape, its habitat quality, and quality of life. B. Adjacent lands are small holdings and residential agriculture.	A. Many people in the Valley do not take the desert for granted because they come from other places. B. The desert is attractive to families who want to raise their kids in an agricultural setting.	A. Solar developments increase temperature and land disturbance. Solar development causes 100% destruction of the land/habitat. B. Burglary has increased due to influence of meth and an influx of renters. C. Changes in zoning and the closer involvement of LA County in enforcement is making it hard for desert residents to maintain the lifestyle.	A. Re-introduce grazing on the State Poppy Reserve to enhance wildflower displays. Sheep benefit flower displays by eating the seeds and excreting them, and by aerating soil.
KIMBALL GARRETT Ornithology Collections Manager, Los Angeles County Natural History Museum Co-author of Birds of Southern California, with Jon Dunn and Brian Small.	Protecting and preserving habitat and native biodiversity is an urgent issue. All intact desert scrub and desert woodland and some agricultural land should be protected.	A. Climate change will have a huge impact, but habitat loss caused by land use patterns is an even more urgent issue. B. Agricultural landscapes have become important wildlife habitat. C. Some Federal actions and listings have been quite effective, but in other cases management of listed species has been much less effective, and many deserving species never get listed at all. D. Using computer modelling to predict species distribution may result in range maps that stray far from observed distribution patterns. Good, comprehensive real data on distribution is available.	A. Agricultural land (fields, grazing areas, windbreaks, surface water sources) provides habitat for numerous bird species of high conservation concern. B. Much wildlife data is collected during biological monitoring during construction, but this data is proprietary and not available to the public.	A. Habitat loss due to alternative energy development. B. Habitat loss due to the decline of agricultural acreage since the mid 1900s (due to development as well as limited supply of water). C. Reduction of air quality due to disturbance of desert soils.	A. Intact desert scrub and woodland must absolutely be protected from development and human activity. B. Limit urban development to its current footprint. C. Design for listed species as well as open country species, desert scrub and desert woodland species, and raptors (including owls). D. Preserve the largest possible tracts of native habitat and ensure their connectivity. E. Site new energy development only on degraded land such as abandoned agricultural fields. F. Limit disturbance to desert soils.

[**Table V.2** INTERVIEWS OVERVIEW.] A full transcript of each interview is included in **Appendix XI** (DVD).

INTERVIEWS OVERVIEW (CONT'D)

INTERVIEWEE	SUMMARY	SETTING THE CONTEXT	OPPORTUNITIES	CHALLENGES	RECOMMENDATIONS
TOM MALONEY Executive Director, Tejon Ranch Conservancy MIKE WHITE Science Director, Tejon Ranch Conservancy	Development planning needs to take into consideration wildlife and habitat. It is possible to create a multifunctional development if a high level of management is involved.	A. Connectivity between habitat patches. B. Sprawl in Antelope Valley. C. Habitat use by migrating birds and bats. D. Citizen science. E. Collaboration between ranchers and farmers and planners. F. Impact of grazing and agriculture on habitat.	A. Newer wind farms are equipped with technology to shut down when condors get within a certain range. B. Citizen science can be useful for certain applications when conservation departments are limited in staff. C. Grazing animals can be managed to selectively eat non-native annual grasses to control weeds and thatch. D. Hunting and conservation can go hand in hand (controlling population of introduced pigs).	A. Poorly planned development is the biggest stressor. The LA General Plan encourages sprawl. B. Conversion of land into agriculture. C. Recovery of land from past agriculture. D. Grazing by sheep. E. Barriers between large patches of native habitat contributes to fragmentation. F. Habitat restoration at a large scale is challenging. G. Local people are not interested in wildlife or stewardship. H. Connectivity for what? Land along the 138 is so fragmented. I. There has not been research on management of grazing on grasslands on the Antelope Valley side.	A. Promote Tejon-style conservation and land use agreements that deliberately assess resource values. B. To reduce bird mortality, wind farms can be encouraged to shut down several weeks per year during bird migration season.
JEFF MARSHALL Geomorphologist, Cal Poly Pomona	The Antelope Valley is the new frontier for development for Los Angeles.	A. Urbanization in Antelope Valley due to proximity to Los Angeles. B. Public perception of the desert (Is it a wild place?, a place for off roading and alternative energy development?, not a place that is planned?)	A. Small faults in the study area may affect the flow of local groundwater.	A. The future will bring greater extremes in climate. B. How accurate are climate prediction models?	A. The Antelope Valley is the natural frontier for Los Angeles' growth northward, so careful planning is especially important.
KEN PELLMAN Public Information Officer, County of Los Angeles Agriculture	Farming is impacted by availability of water from rainfall, groundwater, and the aqueduct. Other concerns are pests, invasives and the harsh climate.	A. Main crops are deciduous fruits, alfalfa, forage hay, bulb onions, carrots, potatos, grapes. Onions and carrots are shipped internationally. Potatoes are processed, then shipped nationally. Alfalfa and hay feed Southern California pleasure and race horses. B. Very few sheep grazing operations still exist, but permits are required to graze in wild lands. Do permits exist to limit grazing on cultivated land?	A. Climate and soils are well suited for decidous fruit. B. Dryland agriculture (barley and alfalfa) still occurs but is limited by rainfall.	A. Groundwater and reclamation are the main sources of water for agriculture. The aqueduct is as well, but it supplies less than in the past. Adjudication could result in diminished production or result in some farms ceasing production. B. Harsh weather conditions such as heat, freeze, wind. C. Disease, pests and invasives.	
ERIN QUESTAD Plant ecologist, Cal Poly Pomona	There is potential to propose science-based approaches to land management that provide ecosystem services but also economic services.	A. Climate change. B. Promoting pollination.	A. Wildflowers provide pollination services especially if timed to bloom when crops would benefit. B. The connectivity maps by Penrod et al. (2012) illustrate conservation's role in the Anthropocene.	A. Assisted migration introduces species into habitats with which they have not evolved. This creates the potential for unforeseen interactions.	A. Modeling programs can add artificial complexity to species range maps. B. It can be useful to identify holes in data which planners should take into consideration.

[**Table V.2** INTERVIEWS OVERVIEW.] A full transcript of each interview is included in **Appendix XI** (DVD).

INTERVIEWS OVERVIEW (CONT'D)

INTERVIEWEE	SUMMARY	SETTING THE CONTEXT	OPPORTUNITIES	CHALLENGES	RECOMMENDATIONS
DANNY REINKE NEPA Manager/Principal Scientist Edwards Air Force Base Environmental Management	EAFB has more resources for research, conservation and documentation than other public lands. However, becoming an "island of biodiversity" is not a desirable outcome in that it will lead to increased regulation of the department's activity.	A. Habitat loss due to alternative energy development. B. Landscape scale is the only way to manage conservation, and to work on this scale, interagency cooperation is important. C. Public lands are undermanaged because of insufficient resources. Rare species are more likely to be documented on DOD lands where more resources exist for research. This does not mean they do not exist on other land. It could simply mean surveying has not been done on other land.	A. There is not enough land to create mitigation habitat for all the acreage that speculators plan to develop. B. EAFB has good inventories of biota, including a herbarium, and several decades worth of records. This is in contrast to BLM land and most other study area land. F. It is in the interests of EAFB to have a large buffer for military activities. This is beneficial for conservation as well. Funds exist to buy land as a buffer.	A. Dust storms could happen more often with climate change and with an increase in solar industry development. B. OHV use is undermanaged because of lack of resources for enforcement and lack of education. C. Buying land for a conservation buffer is a challenge because properties have been bought by alternative energy speculators. D. "This part of the Mojave is transitional. It doesn't have the characteristics of the typical Mojave."	A. It is possible that PV solar farms can be designed and managed to be more compatible with ecosystems (such as the Oro Verde development). B. Education is very important for improving public stewardship. "People become protective of the desert tortoise if they know about it and understand it." G. ORV use should be restricted to disturbed habitat and should involve weed monitoring.
ALLISON TOKUNAGA Environmental Scientist, California State Parks	Though there is anecdotal information about the recent history of the Antelope Valley California Poppy Reserve, there does not appear to have been scientific documentation of patterns of wildflower display or changes in invasive species composition/dominance.	A. Poppy displays and weed production fluctuate due to variable precipitation patterns and other factors. B. Limited resources exist for management of the State Parks. C. Limited data exists to inform management of wildflower displays. D. Management of invasives in the Antelope Valley California Poppy Reserve is a major concern.	A. Some think grazing can enhance wildflower blooms. Some visitors have reported that since grazing was removed, invasive exotics have increased in dominance. (It is possible that the reserve may have once been desert scrub that became flower fields only after grazing.) However, this has not been documented or studied. B. Though anecdotal evidence suggests burns enhance wildflower display, controlled burns would be impractical due to the area's windy conditions.	A. Efforts to revegetate surrounding lands would be hindered by lack of resources. B. Efforts to revegetate surrounding lands would also be hindered by competition from invasive exotics.	
RICK ZIMMER Department of Urban Planning, Cal Poly Pomona	Planners could use a handbook that includes prototype designs and mitigation strategies.	A. Traditional zoning, by definition, separates out single land use. B. More analysis is needed to study the possible outcomes of solar development. C. In planning, the vision must come out of the community. We cannot plan a vision, but we can educate about possibilities and alternative outcome.	A. Alternative energy companies invest in towns so their employees have a place to live. B. Zoning is always market-driven in some way. Planners are responding to developers. Designing a general plan means doing market analysis.	A. Conservation from mitigation could perceivably be satisfied outside of the Antelope Valley by developers.	A. It would be helpful to have a list of considerations for planners and governments as development evolves in the next 50 years, for example: flooding, climate change, pollination. B. Aim for prototype designs rather than specific designs. Show drawings of how different considerations will potentially play out. C. Do not plan things that will quickly go out of date. Markets and technology change.
OTHER LOCAL RESIDENTS Librarian, Rosamond David Eyre, Boron Sport hunters, Fairmont DWP watchman, Three Points	Quality of life is impacted by changes in viewsheds caused by alternative energy development (Librarian). Some express a deep connection with the land and rural lifestyle (Sport hunters, Eyre).	A. Alternative energy development has changed the visual character of the landscape. Humming and blinking lights detract from the desert landscape (Librarian). B. Stewardship and having a connection with the local landscape is important (Sport hunters, Eyre). C. Many people are now selling their land to alternative energy speculators (Sport hunters).	A. The rural setting is desirable for children (Sport hunters) and provides an alternative to city life. B. "What is so special about the land? It's like the taste of ketchup. It just IS." (Eyre)	A. "It's safe in the daytime-- but watch out for the tweekers..." (DWP Watchman, Three Points). B. "In ten years, this area will all be a huge wind farm. Private companies are paying a lot for land. People who want the money are happy for it." (Sport hunters)	A. Build solar panels on all freeways and parking lots to save energy from air conditioning (Eyre).

[**Table V.2** INTERVIEWS OVERVIEW.] A full transcript of each interview is included in **Appendix XI** (DVD).

V.2. Field observations

Field observations provided a first-hand view of land use changes, ecological and landscape processes, urban development processes, possibilities for land stewardship, and impacts from population growth. Major land use types were observed: recent wind and solar development, utility infrastructure, suburban sprawl, agriculture, ecotourism, historical sites, State Parks, recreation, suburban and urban development, rural towns, and major vegetation communities. The journey among these land use types gave the team a sense of the heterogeneity of lifestyles, values, and economic circumstances among the study area communities, as well as an opportunity to interact with residents.

In addition, field observations gave a glimpse into unintended effects on ecosystems and lifestyles caused by the rapid pace of recent land use change. During these trips, landscape phenomena were observed that were better understood over repeat visits, interviews, and research. For example, vast expanses of disturbed land were later revealed by research to be former agricultural fields and grazed lands.

Field observations were key to understanding the spatial relationships of various land use types, and identifying underrecognized landscape-based opportunities among them. This section summarizes highlights from the field observations.

THREE POINTS / Three Points is where the Los Angeles and California Aqueducts cross. It also happens to be situated along the Pacific Crest Trail. Alternative energy infrastructure is conspicuous north of this point. Because of the flat landscape, infrastructure has a visual impact far greater than its actual footprint: it can be seen from great distances away, especially when it is raised in the foothills.

Currently, the design and management of alternative energy sites has clear impacts on existing ecosystems. To discourage raptors from hunting near wind turbines, 150 feet diameter circles around the base of each turbine are cleared of vegetation and regraded to remove crevices that attract prey for the raptors.

The team assessed opportunities for using aqueducts and energy easements for alternative uses. The California Aqueduct creates barriers to movement for terrestrial animals, but has potential as a recreational resource.

Over multiple visits, rapid development of alternative energy forms was observed, as construction appeared to always be in progress on multiple sites.

Disturbance to local plant communities is evident throughout the study area. Plants are slow to grow back from former agricultural areas and corridors of development. Typically, solar developments are completely graded and devegetated, but wind farms are only partially so. Plants were observed growing under the panels of one photovoltaic farm.

ANTELOPE VALLEY CALIFORNIA POPPY STATE NATURAL RESERVE / Poppies are one of the iconic plants of the study area, attracting seasonal day tourism as well as providing the theme of an annual festival. The team visited the Antelope Valley California Poppy State Natural Reserve during the off season, and looked for signs of a perennial poppy type described by Curtis Clark.

Though the reserve is the center of wildflower tourism for casual tourists, the areas with the most profuse blooms are often off the reserve. Spectacular and relatively diverse wildflower blooms occurred in vast swathes of the study area during spring, 2014. These locations are less well known to casual tourists, are relatively unpredictable in abundance and quality during any given year, and do not have the interpretive framework provided at the State Reserve.

LANCASTER AND PALMDALE / Pedestrian activity in the BLVD development and toward the rail stations contrasted with the vast car-oriented expanses of the majority of study area development.

Aerospace memorabilia was displayed with pride throughout downtown Lancaster.

Dust was observed on rooftops of urban housing developments along Amargosa Creek.

TEJON RANCH / Two visits to Tejon Ranch offered first-hand views of the Tehachapi foothills and canyons, as well as areas indicated as infiltration zones by Leighton and Phillips (2003). These zones are currently vast expanses of closely grazed land. Waterways are clearly degraded. Except in some instances, streambanks lack the dense riparian vegetation that slows water and protects water quality. Erosion is accelerated. These are signs that infiltration in these areas is not being optimized.

The canyons were rich with wildflowers and bird life. On one visit, hundreds of thousands of painted lady butterflies were seen in migration.

BIRDING WITH JON FEENSTRA / During the height of spring migration, patches of open water attract a diversity of birds. Piute Ponds, a nearby sewage treatment plant, an organic alfalfa field flood-irrigated with recycled water, and the ponds at Apollo Park are among these locations. Even relatively poor quality habitat, such as Apollo Park, is a magnet for birds. A brief but unsuccessful search for Le Conte's thrasher (*Toxostoma lecontei*) was conducted in an area of known habitat just recently surrounded on four sides with new development.

FLOODING / The study area was observed during a spring rainstorm. Flooding was widespread in the vicinity of the 138. At the Fairmont store, customers stopped by to trade information on the location of road closures.

ECOSYSTEMS / Arthur B. Ripley Desert Woodland State Park, Antelope Valley California Poppy Reserve, Saddleback Butte State Park, Antelope Valley Native American Museum, and Red Rock Canyon State Park are all protected areas whose landscapes illustrate the important services provided by native desert biota. Field observations revealed a sense of the cultural need for and ecological value of these reserves, but also of their relative isolation.

AGRICULTURE / Over the course of multiple site visits, a wide range of agricultural practices and crops were observed, ranging from backyard orchards to industrial farming.

JAWBONE / The team observed some of the impacts of Off Highway Vehicle (OHV) use in multiple sites in the study area, such as in the Jawbone Canyon OHV area, and in numerous other areas not currently designated for OHV use. The persistence of tracks over time illustrates the low ecological recoverability of arid ecosystems. They also illustrate the demand for a diversity of recreational activities in the study area.

SAN GABRIEL FOOTHILLS / The canyons leading down to the valley from the San Gabriels are partially developed, and crisscrossed with utility lines.

ROSAMOND, MOJAVE, BORON / Communities in the northern portion of the study area are more rural and isolated in character. An influx of money for revitalization provided by incremental property tax growth from alternative energy investment may dramatically impact these communities (**Section III.2.5**).

DUSTBUSTERS DUST MITIGATION SITES / Dustbusters studies the factors that contribute to dust storms. The team toured a variety of Dustbusters dust mitigation sites, and learned about the successes and challenges of restoration and dust mitigation in the study area.

V. METHODS

V.3. Land cover change analysis and prediction

1. Introduction to land cover change

Human modification of the natural land cover (LC) constitutes a major source of environmental change (Schneider & Pontius, 2001). Human activities, such as generating energy, producing food, and building urban and transportation infrastructure, are changing land cover at unprecedented rates (Lambin et al., 2001).

This is certainly true in the Antelope-Fremont Valleys, where anthropogenic impact on natural systems is the most important source of change. But natural factors, such as slope, elevation, climate, and plant communities, among others, are also important drivers of change.

Modeling LC change in any area is a complex problem. Change is driven by a number of factors, including both anthropogenic and natural variables. Each variable plays an important role in guiding change, and the greater their number, the greater the complexity of the model.

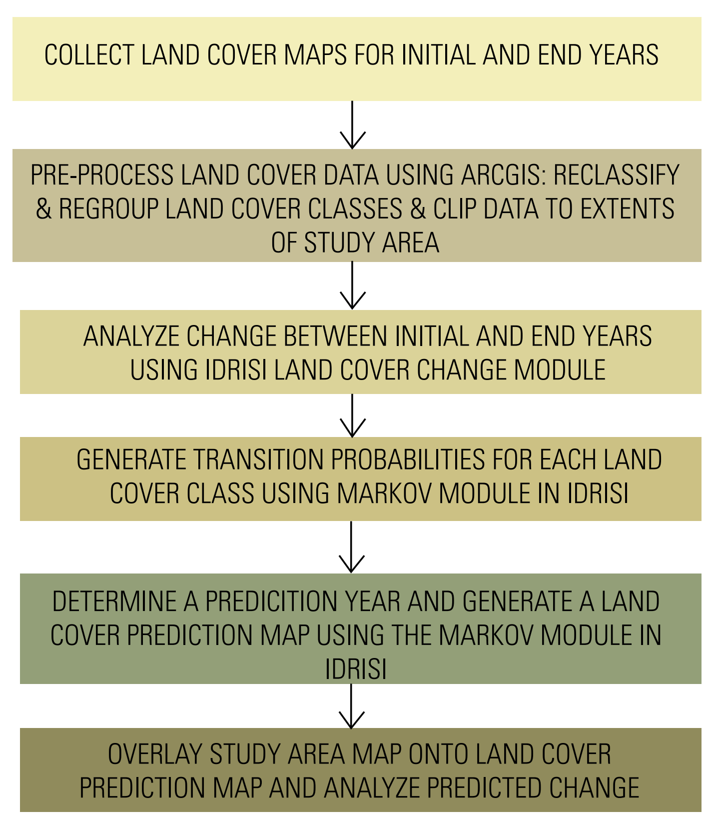
LC change analysis and prediction are powerful tools for understanding change in the landscape (Lambin et al., 1999). These modeling tools are useful for describing three key pieces of information: the variables affecting land cover change, the exact location where change is occurring, and the rate at which it is occurring (Schneider & Pontius, 2001). This information can then be used to predict where change is likely to occur next.

The purpose of this analysis is to better understand the forces of change impacting the large scale natural and human systems of the Antelope and Fremont Valleys. This mathematical model can supplement the study of the anthropogenic and natural forces at play in order to better understand what is changing, as well as where the change is occurring. It is possible to hold a discussion about potential scenarios for the future, and identify some in which there may be a more sustainable management of the land. An overview of the modeling process is shown in **Figure V.3.1**.

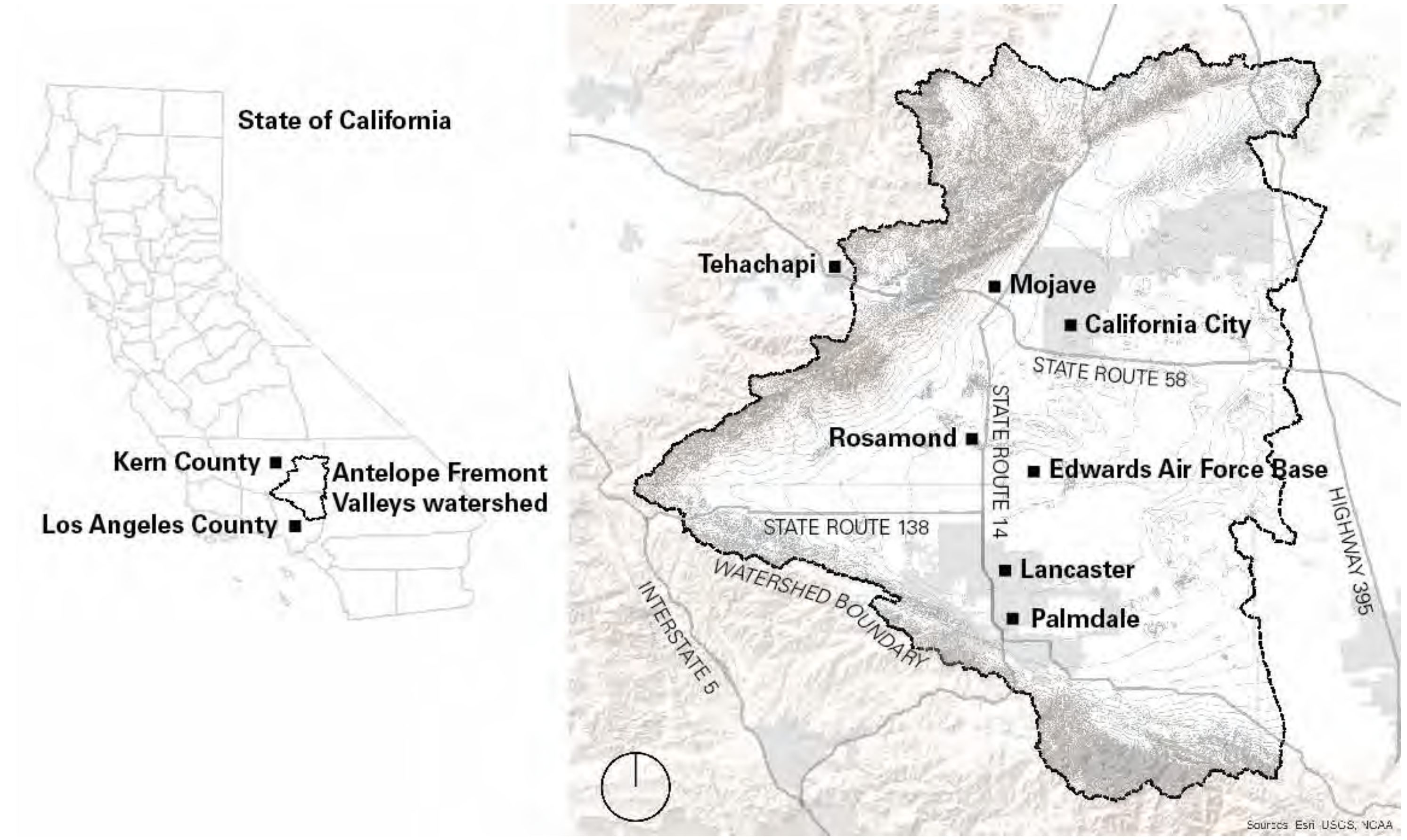
2. Study area and data sets

2.1 Location of study area

The study area analyzed in this model is the full extent of the Antelope and Fremont Valleys watersheds (**Figure V.3.2**). These watersheds are adjacent to and north of the Los Angeles River watershed. The study area covers the westernmost tip of the Mojave Desert ecosystem. It is bordered by the San Gabriel Mountains along the south and southwest, the Tehachapi Mountains along the north and northwest, and its eastern border closely follows the San Bernardino County line.



[**Figure V.3.1** DIAGRAM OF MODELING PROCESS.]



[**Figure V.3.2** LOCATION OF STUDY AREA.] On the left, Antelope Fremont Valleys watershed (bold), straddling Kern County and Los Angeles Counties in the State of California. On the right, main roads and cities within the watershed.

2.2 Determination of agents of change

Section IV described the five key landscape processes in the study area: the water cycle, provision of ecosystem services, agricultural production, urban development, and energy production. In order to model process-based change, it is essential to determine the drivers of change behind each of the key landscape processes. However, determining and incorporating drivers of change into a model is often challenging because of the lack of spatially explicit data linking social and natural processes (Veldkamp & Lambin, 2001).

Available data for the drivers of change in the landscape has been grouped into categories which correspond to land cover classes. These are: habitat, urban development, agriculture, fallow fields (former agriculture), and open water. These agents inform the model and increase its accuracy by taking into account individual behavior of certain types of land use, such as decision making, economic and social pressures, and adaptation over time.

In this section, the change analysis modeling process is described, the interaction of the five agents is studied in the present, and future changes are predicted.

2.3 Data sources

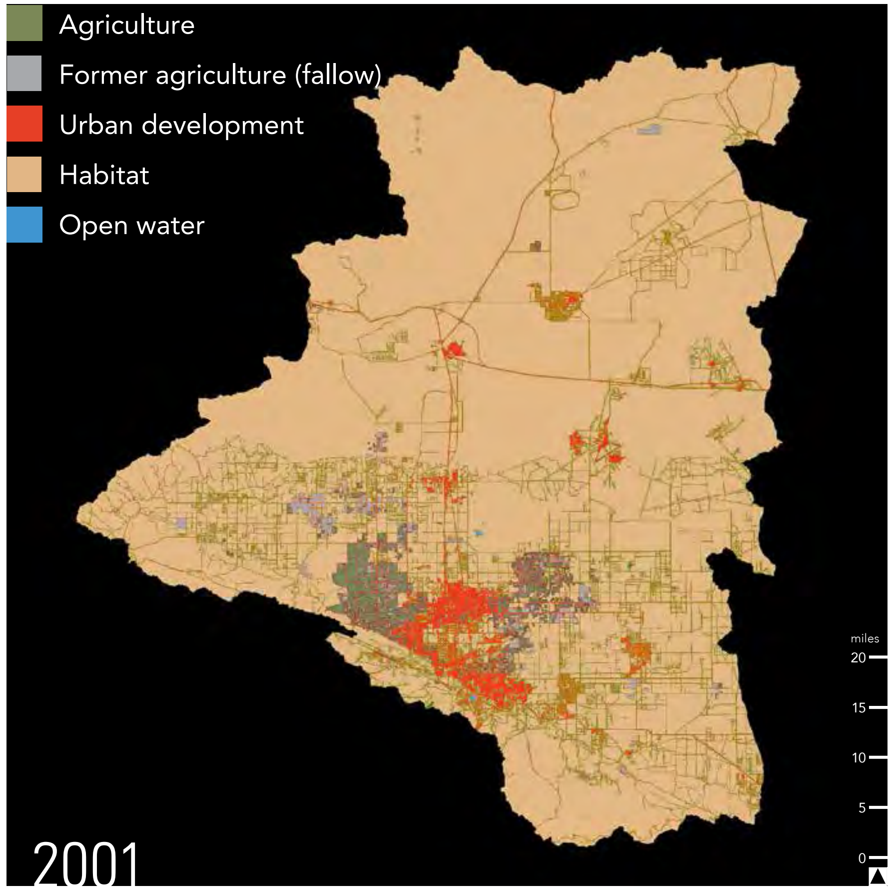
This model analyses two LC images of the Antelope and Fremont Valleys watersheds from 2001 and 2011, obtained from the United States Geological Survey's (USGS) National Land Cover Database (NLCD).

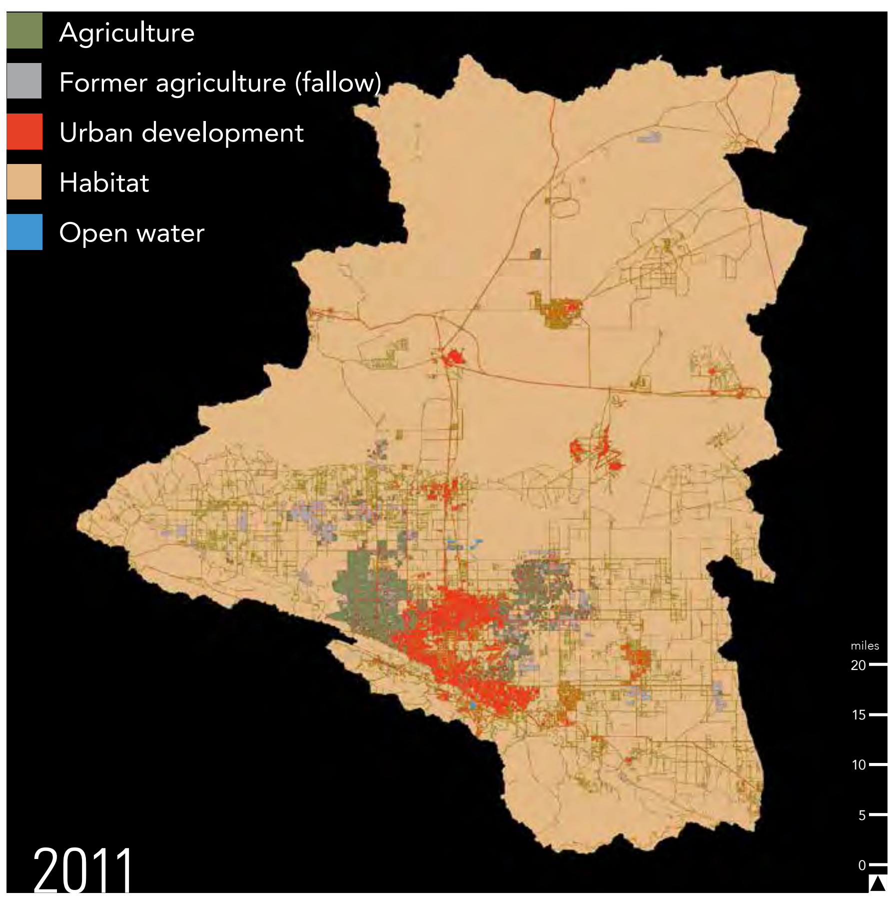
LC images are also available for the years 1992 and 2006 from USGS. However, 1992 uses a different LC classification system which is incompatible with the other years available for the purposes of change analysis. Therefore, 2001 and 2011 were selected because this pair of images represents the longest interval of time available from the USGS.

3. Modeling Methods

In order to analyze change in the landscape, software applications require the input of earlier and later LC states. Depending on the application used, this state can be in the form of raster or vector data.

The software application used in this analysis, IDRISI Selva (version 17.0), uses raster data. The earlier and later states of the landscape consist of land cover data maps from two different time periods.





Land-cover change has been highlighted as one of the most important drivers of terrestrial ecosystem change

(Vitousek et al., 1997; Millenium Ecosystem Assessment, 2005, as cited by Reyers et al., 2009).

[**Figure V.3.3** EARLIER AND LATER LAND COVER STATES.] Land cover for 2001 was used as the initial state, and 2011 as the end state.

LAND COVER CLASSES	KEY LANDSCAPE PROCESSES
AGRICULTURE	Agricultural production
FORMER AGRICULTURE	Fallow fields, cease of agricultural production
DEVELOPMENT	Urban development, energy production, infrastructure
HABITAT	Natural habitat
OPEN WATER	Water bodies, open reservoirs/conveyance

[**Table V.3.1** LANDSCAPE PROCESSES REPRESENTED BY EACH OF THE LAND COVER CLASSES.]

IDRISI analyzes changes to the raster data by looking at the earlier and later state of each cell in the image. In this study, each cell represents a 30 meter by 30 meter (99.425 feet by 99.425 feet) area of land cover.

After identifying all the cells which changed, as well as the LC class they changed to and from, the application is able to output an enormous amount of information about the analysis. Net change, gains and losses per LC class, types of transition, contributions to change, and transition probability can be mapped or graphed to illustrate the analysis.

In addition, the application takes this information along with supplemental information, such as suitability and constraints for future growth, and it can project the trend into the future. This leads to a predicted state of the landscape in any determined year.

3.1 Stochastic systems and change prediction

A stochastic system, as opposed to a determined one, is a numerical system of change in which random change plays a role in determining the outcome of each step in the process. For instance, a mathematical formula will arrive at a determined solution once it is solved, and this solution is always the same. In a random process, each time problem is solved, or change occurs, it is not known what the outcome will be.

Two types of stochastic systems have been studied for the development of the change prediction model for this study. The first one is a Markov Chain and the second is Cellular Automata.

In a Markov Chain process, change is determined during each step by the cell's transition probability, and it is only based on the immediately preceding step. In other words, the process is memory-less. For example, the land cover class of a pixel in each step is determined by the pixel's probabilities of transitioning into another class. This occurs in each step and only affects the next step. Thus, it does not matter what the land cover was three or four steps in the past, the only thing affecting the next step into the future is the current pixel's probabilities.

On the other hand, Cellular Automata is a process in which change is determined during each step by the behavior of individual units called automatons. Each pixel becomes one automaton, whose behavior is governed by a set of pre-established rules. For example, a rule can raise the probabilities of change of an automaton to a particular land cover class, if that class is present near the automaton. Thus, in each step, the automaton analyses its surrounding automata, and changes or not depending on the result of following its rules.

3.2 Hardware and software used

The hardware used for this analysis was a DELL XPS L511Z model laptop computer with 6.00 GB installed memory (RAM), 683GB total disk capacity, and 64-bit Windows 7 Home Premium operating system.

Software applications used for the data preparation and land cover change analysis and prediction included: ESRI ArcGIS 10.2, IDRISI 17.0 Selva edition, Microsoft Excel, and Global Mapper version 15.2.

In addition, some of the output from these programs was redrawn using Adobe Illustrator CS5.1.

3.3 Data preparation

A pair of LC images (earlier and later states) from 2001 and 2011 were obtained from the USGS Land Cover Institute. The study area was clipped from these images, and the rasters were reprojected using ArcMap 10.2. The preprocessed images are shown in **Figure V.3.3**.

3.4 Markov model for change analysis and hybrid cellular automata/Markov model for change prediction

A Markov model was used to analyze past change in the study area. This model is incorporated as a module of IDRISI 17.0 Selva edition software.

In addition, a second module was used for the change prediction. This hybrid cellular automata/Markov model, also included in IDRISI 17.0, can be used for predicting land cover change. The reason for using a hybrid cellular automata model for the future prediction is that it "adds into Markov model not only spatial contiguity but also the probable spatial transitions occurring in a particular area over time" (Subedi et al., 2013). In other words, change in the state of each pixel is affected by that of neighboring pixels. This is important because it simulates how, in the real world, land cover may be strongly influenced by its surroundings and their changes. The hybrid model can be represented mathematically as:

$$L_{(t+1)} = P_{ij} * L_{(t)}$$

and

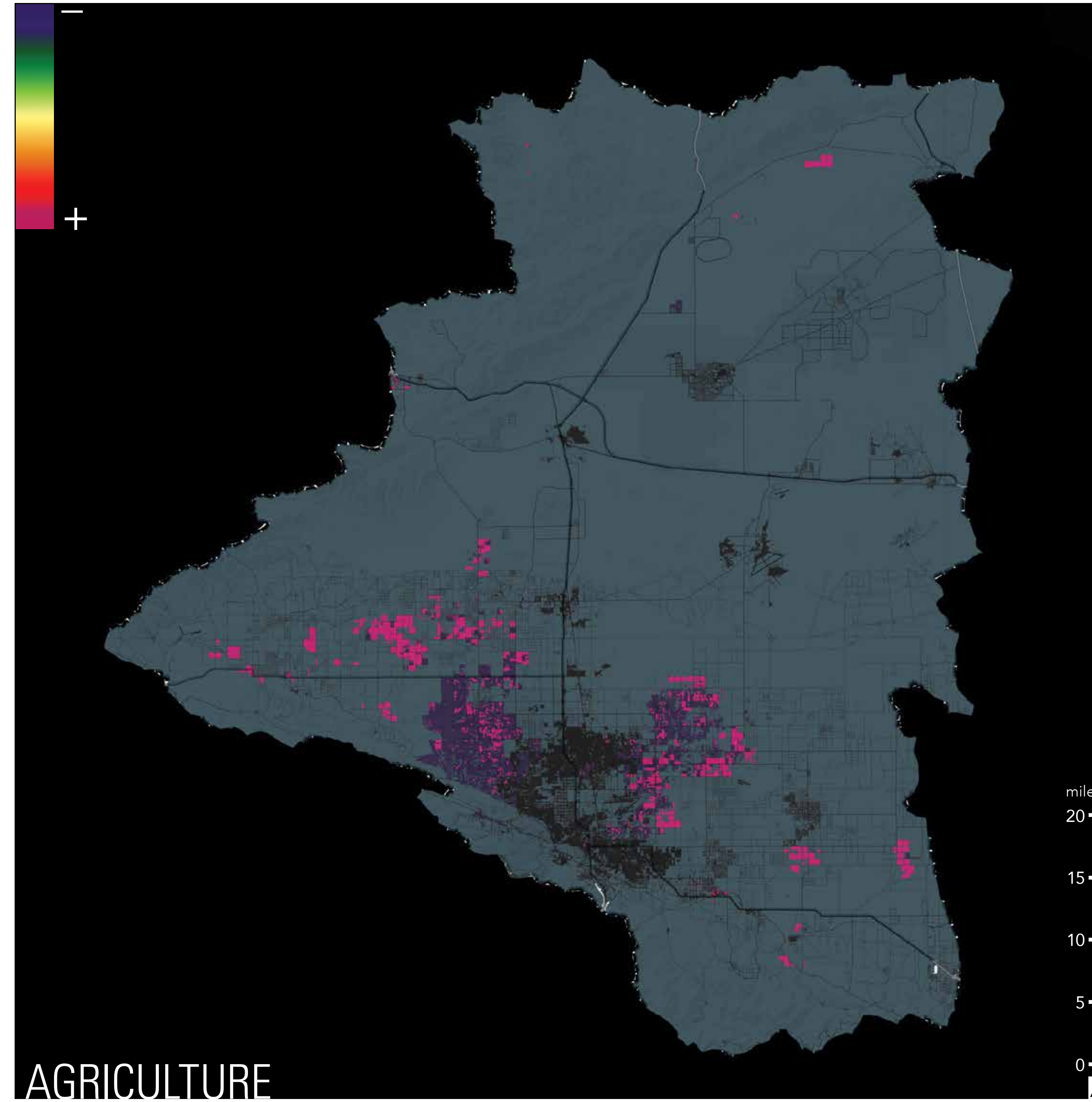
$$Pij = \begin{matrix} P_{11} & P_{12} & \cdots & P_{1m} \\ P_{21} & P_{22} & \cdots & P_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ P_{m1} & P_{m2} & \cdots & P_{mm} \end{matrix}$$

L stands for land-use status, t stands for time, and P stands for transition probability. $L_{(t+1)}$ and $L_{(t)}$ are the land-use status at time t+1 and t respectively. ($0 \le P_{ij} < 1$ and $\sum_{j=1^m} P_{ij}=1$, (i, j = 1,2,…,m)) is the mathematical expression that describes the transition probability matrix in a given state (Subedi et al., 2013).

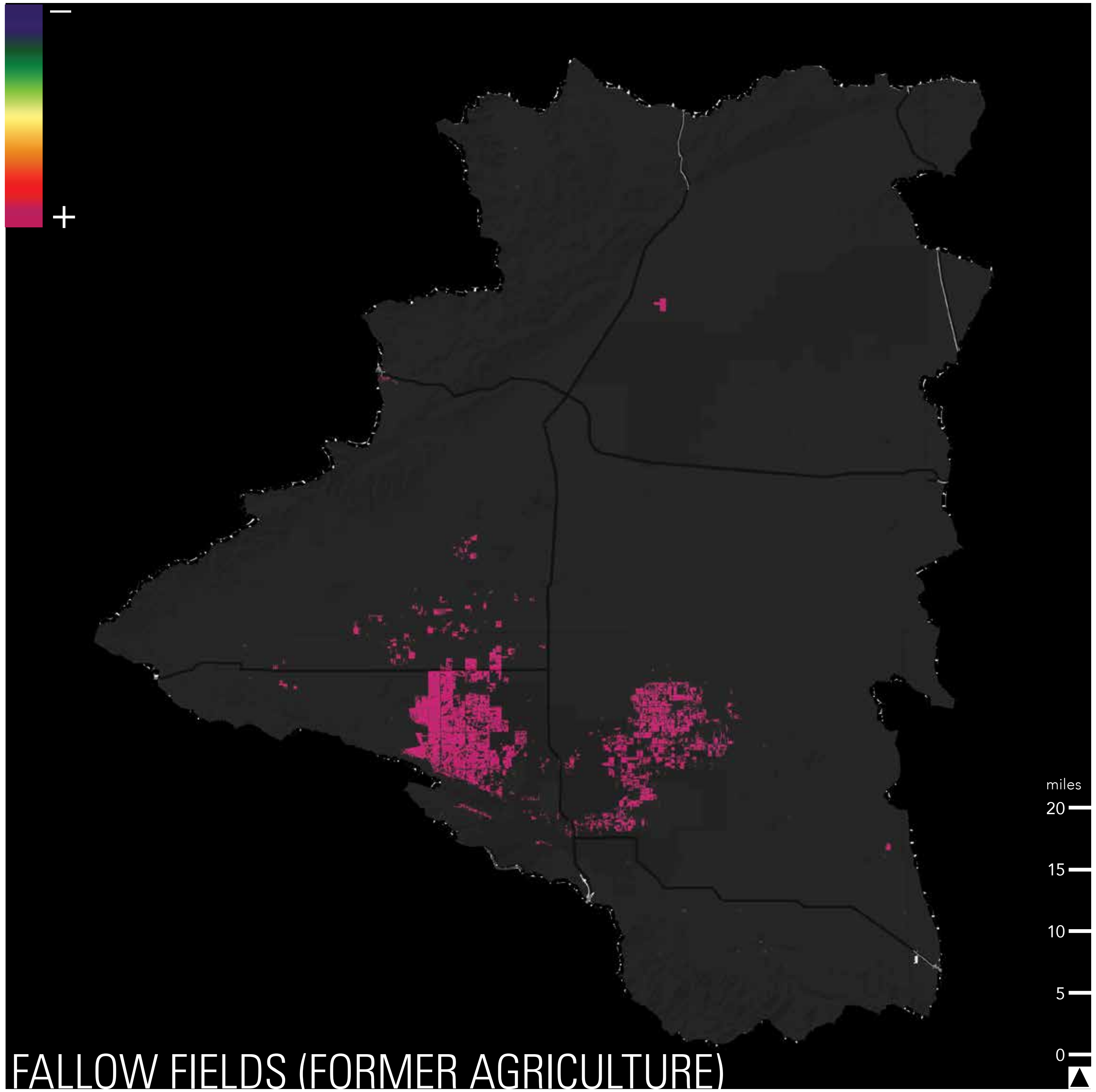
For this analysis, the number of iterations for the projected land cover map was 10. The number of iterations can be any number. The greater the number, the greater the complexity of the prediction, but also the greater processing time and memory (RAM) required. Given the limitations of the hardware, 10 was selected in order to get two iterations for each of the decades in the 50 year prediction. This number could be increased to match the number of years between the initial date and the projected date, in this case 50. However, greater numbers of iterations drastically increase the time and computer resources required for processing, and do not necessarily improve the accuracy of the

LAND COVER CLASSES	Agriculture	Former agriculture	Development	Habitat	Open water
Agriculture	0.7628	0.0006	0.1202	0.1146	0.0018
Former agriculture	0.0149	0.7230	0.2409	0.0212	0.0000
Development	0.0010	0.0000	0.8497	0.1492	0.0001
Habitat	0.0875	0.0014	0.0798	0.8235	0.0079
Open water	0.0028	0.0000	0.0292	0.4051	0.7628

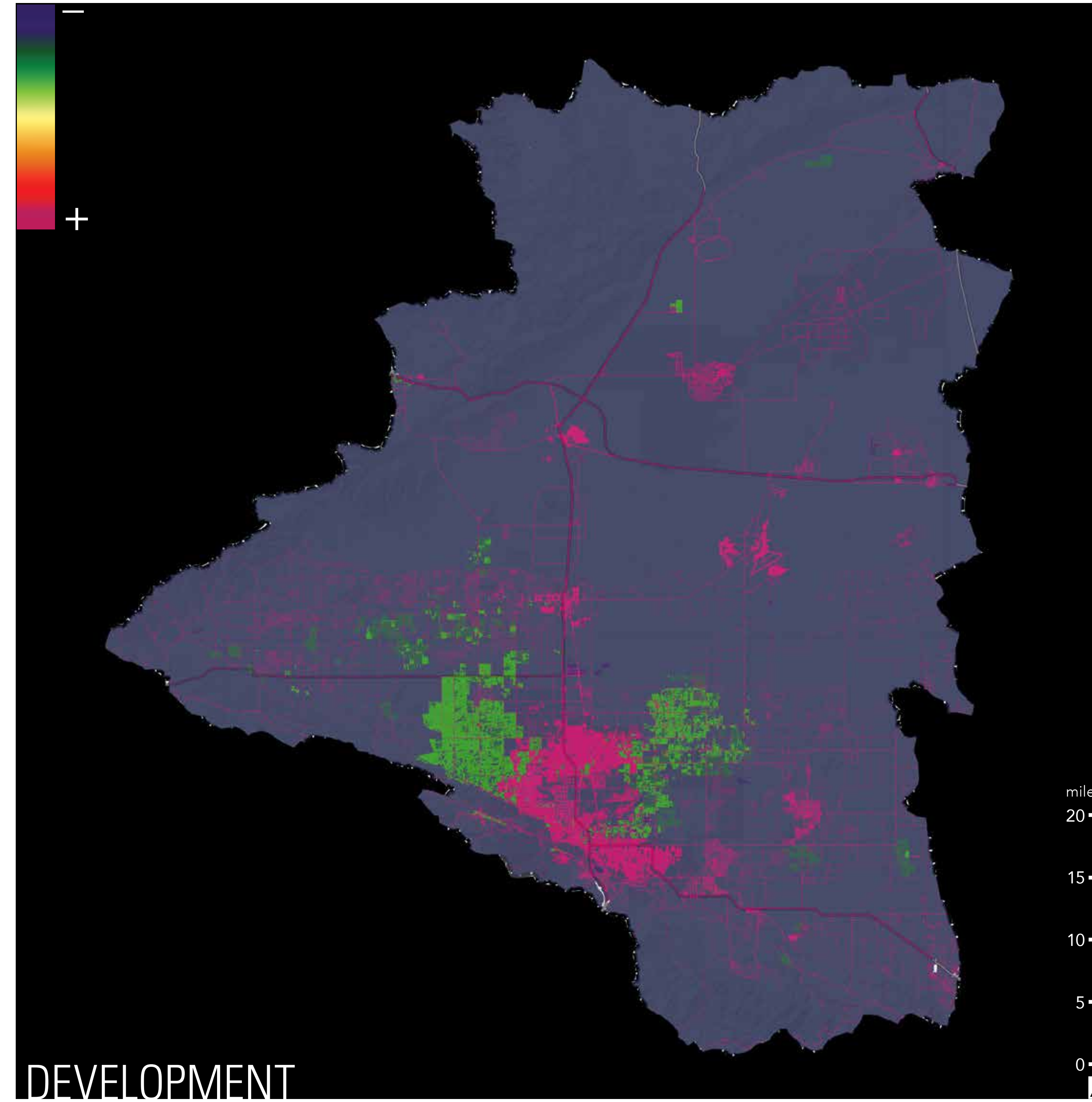
[**Table V.3.2** TRANSITION PROBABILITIES BETWEEN 2001 AND 2011] Percentage probability expressed in decimal numbers, of each land cover class transitioning into another.



[**Figure V.3.4a** MARKOVIAN CONDITIONAL PROBABILITY MAP SERIES: AGRICULTURE.] The color gradient in each of these maps graphically shows the probabilities land cover has to become each of the five land cover classes: map 1, agriculture; map 2, former agriculture; map 3, development; map 4, habitat; and map 5, open water. Note that map 5 shows the minuscule probabilities open water has of becoming anything other than open water.

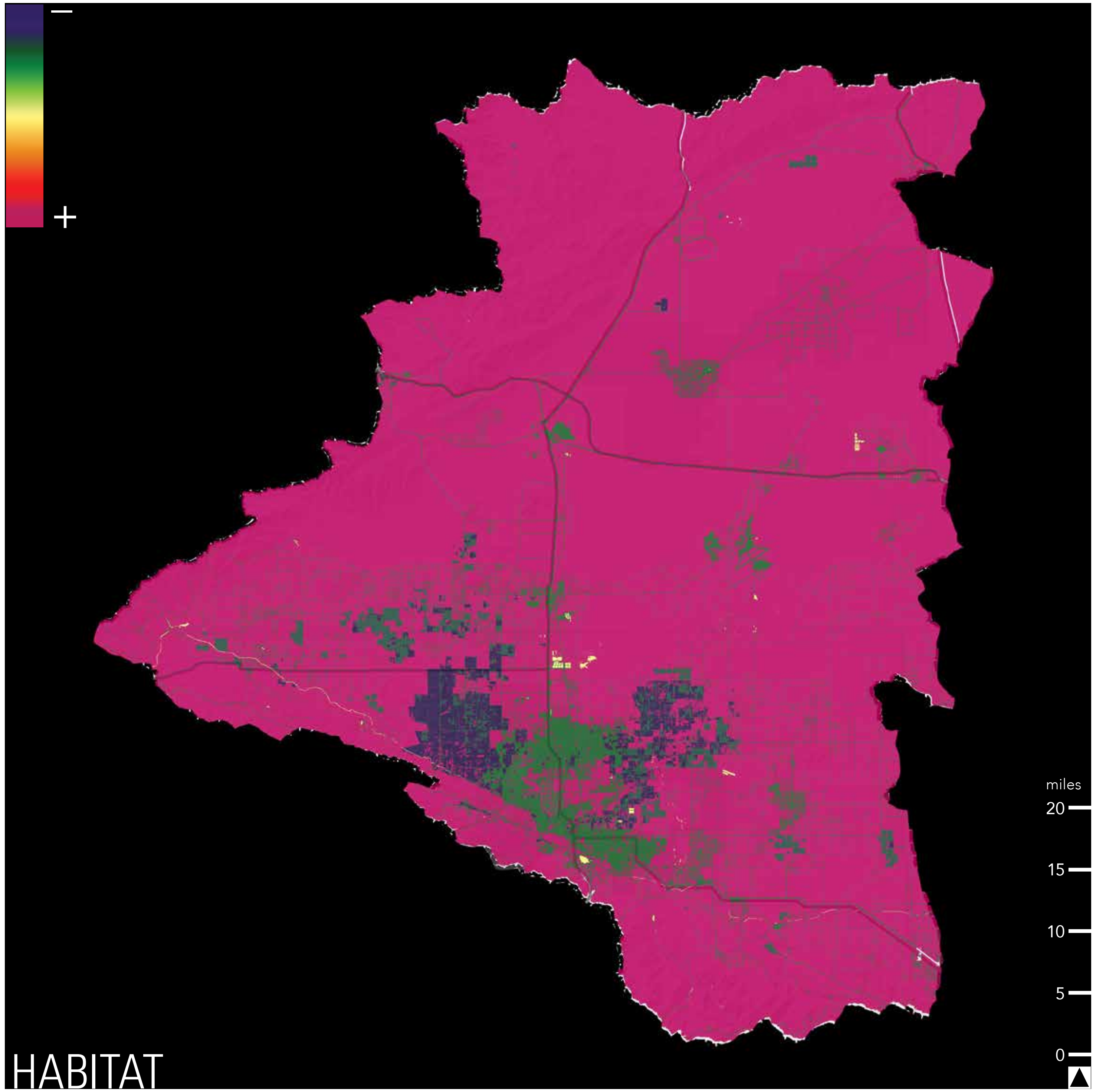


[**Figure V.3.4b** MARKOVIAN CONDITIONAL PROBABILITY MAP SERIES: FORMER AGRICULTURE.] The color gradient in each of these maps graphically shows the probabilities land cover has to become each of the five land cover classes: map 1, agriculture; map 2, former agriculture; map 3, development; map 4, habitat; and map 5, open water. Note that map 5 shows the minuscule probabilities open water has of becoming anything other than open water.

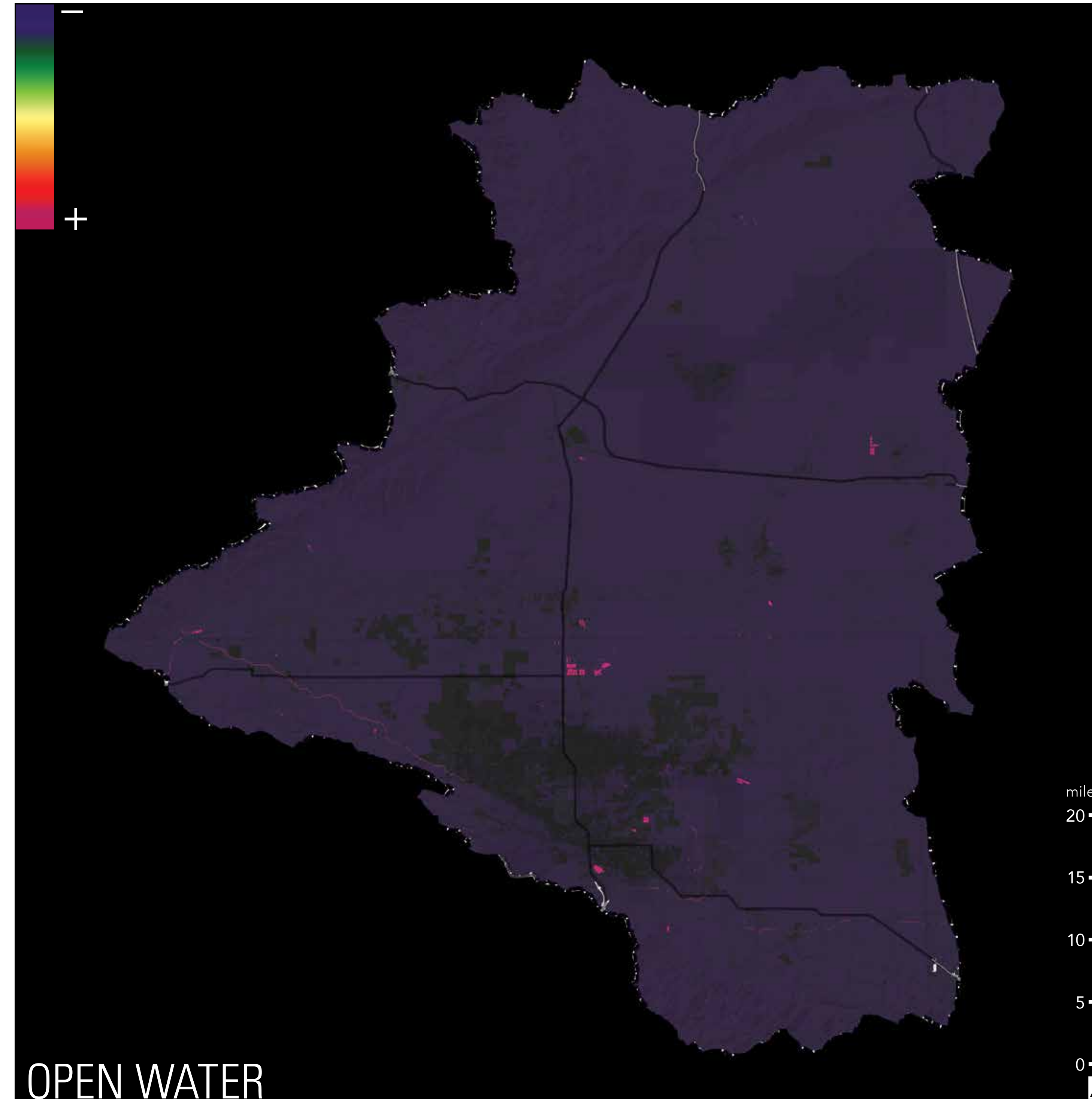


[**Figure V.3.4c** MARKOVIAN CONDITIONAL PROBABILITY MAP SERIES: DEVELOPMENT.] The color gradient in each of these maps graphically shows the probabilities land cover has to become each of the five land cover classes: map 1, agriculture; map 2, former agriculture; map 3, development; map 4, habitat; and map 5, open water. Note that map 5 shows the minuscule probabilities open water has of becoming anything other than open water.

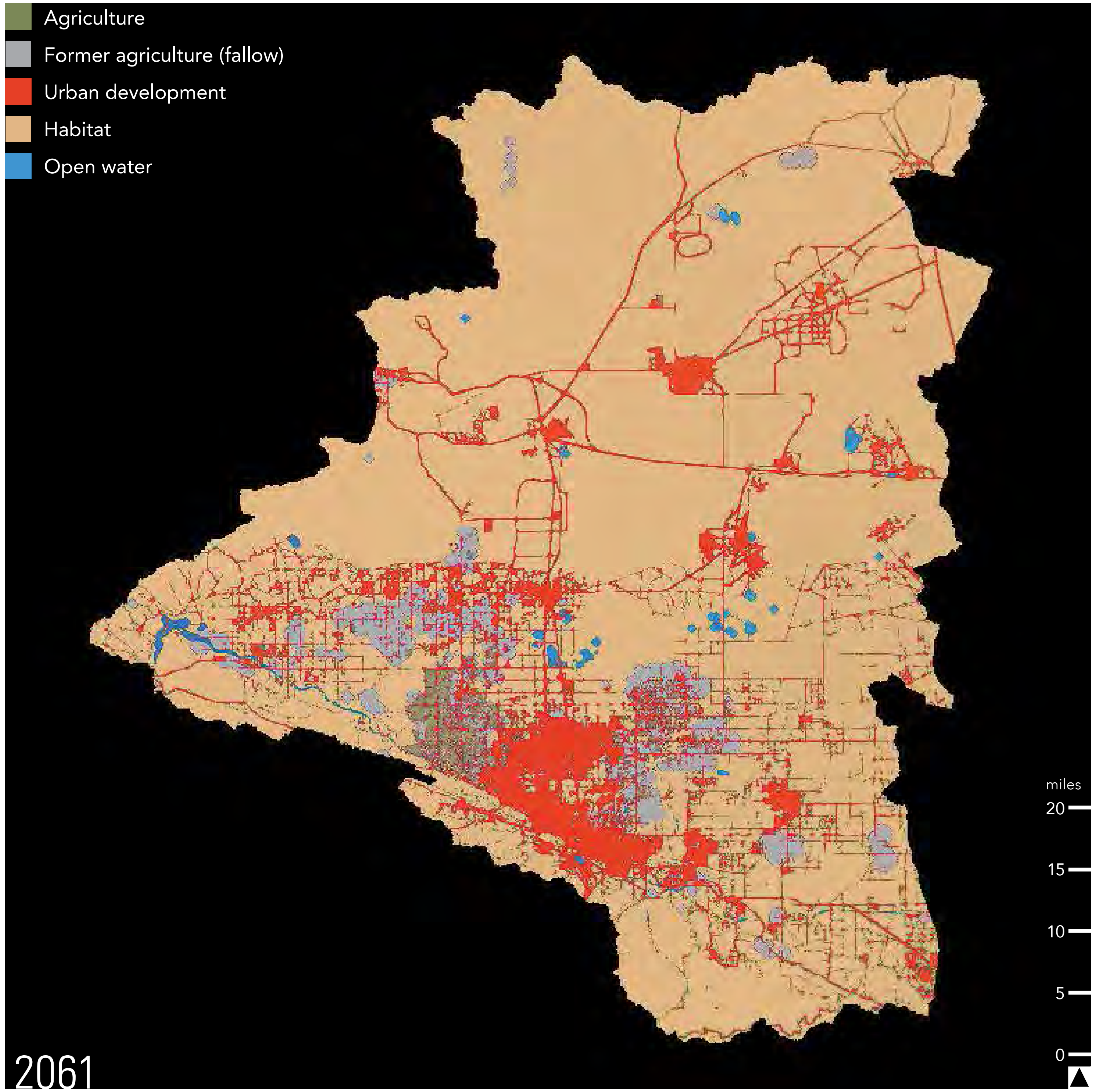
With no changes to current patterns, what will the landscape of the study area look like in fifty years?



[**Figure V.3.4d** MARKOVIAN CONDITIONAL PROBABILITY MAP SERIES: HABITAT.] The color gradient in each of these maps graphically shows the probabilities land cover has to become each of the five land cover classes: map 1, agriculture; map 2, former agriculture; map 3, development; map 4, habitat; and map 5, open water. Note that map 5 shows the minuscule probabilities open water has of becoming anything other than open water.



[**Figure V.3.4e** MARKOVIAN CONDITIONAL PROBABILITY MAP SERIES: OPEN WATER.] The color gradient in each of these maps graphically shows the probabilities land cover has to become each of the five land cover classes: map 1, agriculture; map 2, former agriculture; map 3, development; map 4, habitat; and map 5, open water. Note that map 5 shows the minuscule probabilities open water has of becoming anything other than open water.



[**Figure V.3.5** LAND COVER PREDICTION MAP OF 2061.] This 50 year prediction map is the output produced after 10 iterations (5 years each) by the hybrid Markov/cellular automata model.

The map shows a significant decrease in natural undeveloped land (habitat class), which dropped from 89% to 75%. This drop represents the most significant impact expected to occur in the next 50 years, if change in the study area follows past trends.

prediction. Small glitches in the data can be also be carried over and multiplied with each iteration, thus creation errors in the prediction.

The default 5x5 cellular automata filter type was used, which has the following kernel:

0	0	1	0	0
0	1	1	1	0
1	1	1	1	1
0	1	1	1	0
0	0	1	0	0

The filter is integral to the action of the Cellular Automata component. Its purpose is to down-weight the suitabilities of pixels that are distant from existing instances of the land cover type under consideration. The net effect is that to be a likely choice for land cover conversion, the pixel must be both inherently suitable and near to existing areas of that class (IDRISI Selva, n. p.).

4. Results

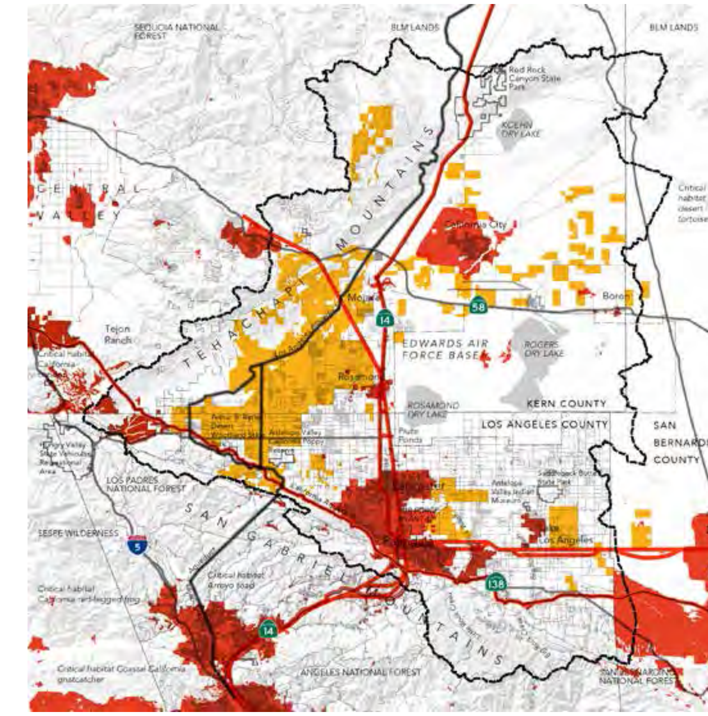
The Markov module of IDRISI produces a transition probabilities table (**Table V.3.2**). Those values represent the likelihood each cell in the raster has to transition to a different LC class, or to remain the same class.

In addition to a table, the module also presents transition probabilities in the form of maps. It creates one Markovian conditional probability map for each of the five land cover classes, as shown in **Figures V.3.4a**-**V.3.4e**.

The resulting projected LC map for 2061 in **Figure V.3.5** shows the distribution of land cover classes following 50 years of growth in the Antelope-Fremont Valleys watersheds. This growth is assumed to follow the same trends it did between the years 2001 and 2011.

5. Discussion

Following those trends, the map shows a significant decrease in natural undeveloped land (habitat class), which dropped from 89.74% to 75.19% (**Figure V.3.7**). This drop represents the most significant change expected over the next 50 years, if past trends continue. It is reasonable to expect a substantial loss of wildlife habitat and a decrease of ecosystem services. Impacts to remaining species are likely to be nonlinear, as patchwork development tends to



Urban 2050 (projected)

Solar and Wind development (current and anticipated)

Transportation or water infrastructure, not permeable to wildlife

Transportation or water infrastructure, possibly permeable to some wildlife

[**Figure V.3.6** PLANNED AND PROPOSED DEVELOPMENT WITH PROJECTED URBAN AREAS. SOURCE: DRECP, California Atlas, Google]

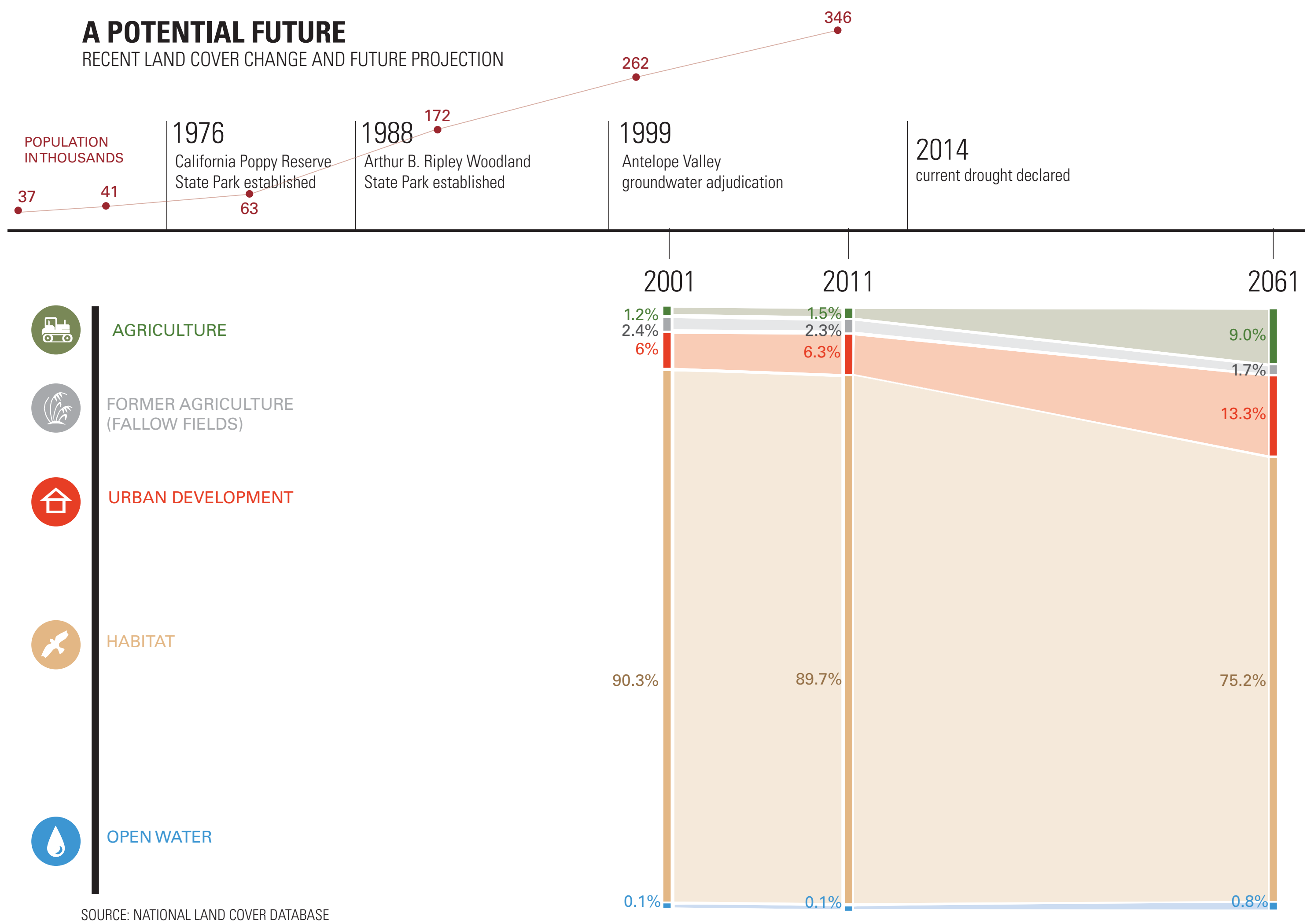
have edge effects that extend beyond developments' actual footprint.

Another important trend is the increase in land used for agriculture, although it is known that due to constraints in water availability, this change is not likely to occur. More likely, agriculture will remain near actual levels or decrease in area, rather than increase.

For that same reason, former agriculture is also expected to increase, despite what the projected land cover map shows. However, it is reasonable to assume that an important part of former agriculture land will transition to developed land. In other words, abandoned farms will be built upon.

This assumption is based in part on the projection for the developed land class, which more than doubles in 2061. The projection map shows developed land growth occurring within close proximity to 2011 developed areas, mainly near cities and along roads.

In addition to the magnitude of change, this prediction map also is useful for identifying where change is most likely to occur. Areas in close proximity to the cities of Lancaster,



[**Figure V.3.7** RECENT LAND COVER CHANGE AND PREDICTION BY CLASS. Source: National Land Cover Database]

LAND COVER CLASSES	Actual area (mi) 2011	Percent of total area 2011	Projected area (mi) 2061	Percent of total area 2061
Agriculture	548	1.5%	3,277	9%
Former agriculture	829	2.3%	620	1.7%
Development	2,294	6.3%	4,811	13.3%
Habitat	32,525	89.7%	27,256	75.2%
Open water	48	0.1%	283	0.8%
TOTAL	36,243	100%	36,248	100%

[**Table V.3.3** AREA (MILES) AND PERCENT TOTAL AREA IN 2014, AND PROJECTED AREA AND PERCENT TOTAL AREA IN 2061 PREDICTION.]

Palmdale, Mojave, Tehachapi, Rosamond, as well as in close proximity to farms and along roads are expected to be impacted the most. The impact of this change could have many implications for ecological services, access to open space, viewsheds, and health issues related to airborne dust for residents.

6. Limitations

There are numerous ways in which the accuracy of this model could be improved.

This model does not take into account socio-economic variables such as demographics, water use per capita, land management practices, and changing attitudes toward stewardship. **Figure V.3.6** shows a buildout scenario of proposed Tejon Ranch Company development, fast-tracked areas for alternative energy development in the study area, as well as projected urban areas. This map shows that other factors besides trends visible between 2001-2011 are expected to have a large impact on land use in the study area. Moreover, inclusion of areas outside the study area boundaries will affect the future of land cover in the study area, since rapid growth is projected in both Tehachapi and Victorville, both right on the boundary of the study area.

The predictions are based on data from 2001-2011 and thus amplify trends specific to this period in time in a linear manner. For example, a slight increase in open water land cover between 2001 and 2011, would predict an increase of eight times by 2061, which is unlikely.

Another trend specific to this period in time is the new influence of carrot production. This change is a response to market innovation and market demand.

Additionally, at the very tail end of the time period, land cover changes began to occur in the study due to the incentivization of alternative energy development. This is also a nonlinear change. Though in the near future, areas designated as 'disturbed' by the DRECP (**Figure III.2.20**) may be expected to become available for fast-tracked alternative energy development, the future of subsidies for alternative energy development is uncertain (**Section II.3.7**), and the speed at which these developments occur may not follow past trends in a linear manner.

Other changes may occur in the future that are not linear extensions of patterns from 2001 to 2011. It is expected that the current water crisis, which has prompted reexamination of California's water system, could prompt a revision of regulation and incentive systems related to water management and agriculture. Such changes would impact agriculture and urban water use, and may even impact the

> With no changes in land use policies, and with increased variability in the severity of cycles of drought and heavy precipitation; amplification of wind erosion, water erosion, fire, or flooding may impact the study area in unpredictable ways.

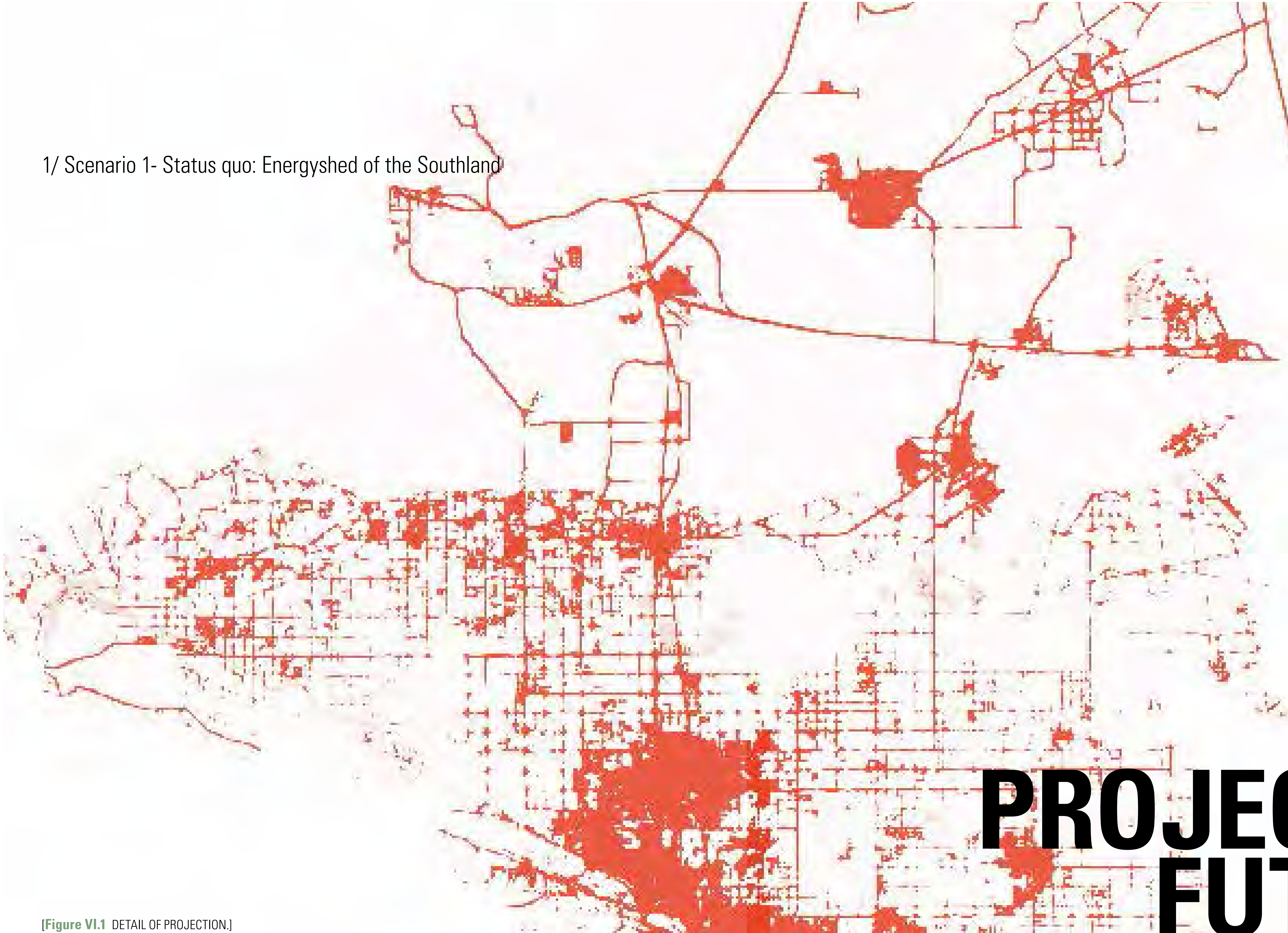
attractiveness of the area to new residents.

With no changes in land use policies around devegetation and grazing, and with increased variability in the severity of cycles of drought and heavy precipitation; amplification of wind erosion, water erosion, fire, or flooding may impact the study area in unpredictable ways. Such changes may also affect the desirability of the study area for new residents, causing changes to population growth that are also nonlinear.

As in the example of the sudden impact of carrot production, innovation and market demand are also nonlinear factors that could shift patterns of land use in the study area in ways that do not conform to past patterns.

Despite these limitations, when supplemented with in-depth research on the human and natural systems, land cover change analysis is a useful tool for clarifying the patterns of change in a study area.

Policy recommendations are listed in **Section VII**.



[**Figure VI.1** DETAIL OF PROJECTION.]

VI. PROJECTED FUTURE

VI. PROJECTED FUTURE

VI.1. Scenario 1- Status quo: Energyshed of the Southland

This projected future combines the development build out map and 2061 projection of the change prediction model, with some adjustments. In this scenario, it is assumed there is no major land use policy change in the Antelope Valley in the next 50 years. Development continues at the same pace as it occurred between 2001 and 2011. Agriculture will be limited due to fluctuating precipitation levels, the groundwater adjudication process, and the cessation of imported supplies from the State Water Project. As more farms are abandoned, some fields remain barren and others are purchased by energy companies or housing development companies, two industries which will likely continue to grow. Other natural undeveloped land is cleared for agricultural purposes, but soon resold to housing development or alternative energy companies. Adding to urban sprawl, individual private landowners continue to build in the suburbs, attracted by the open space and the views.

Various government incentives continue to provide resources for centralized alternative energy farms. The Antelope Valley, with its extensive solar and wind farms, becomes a key energyshed for Southern California.

Airborne dust from wind erosion continues or increases due to drought, but residents of Los Angeles continue to be attracted to the area by relatively low real estate costs.

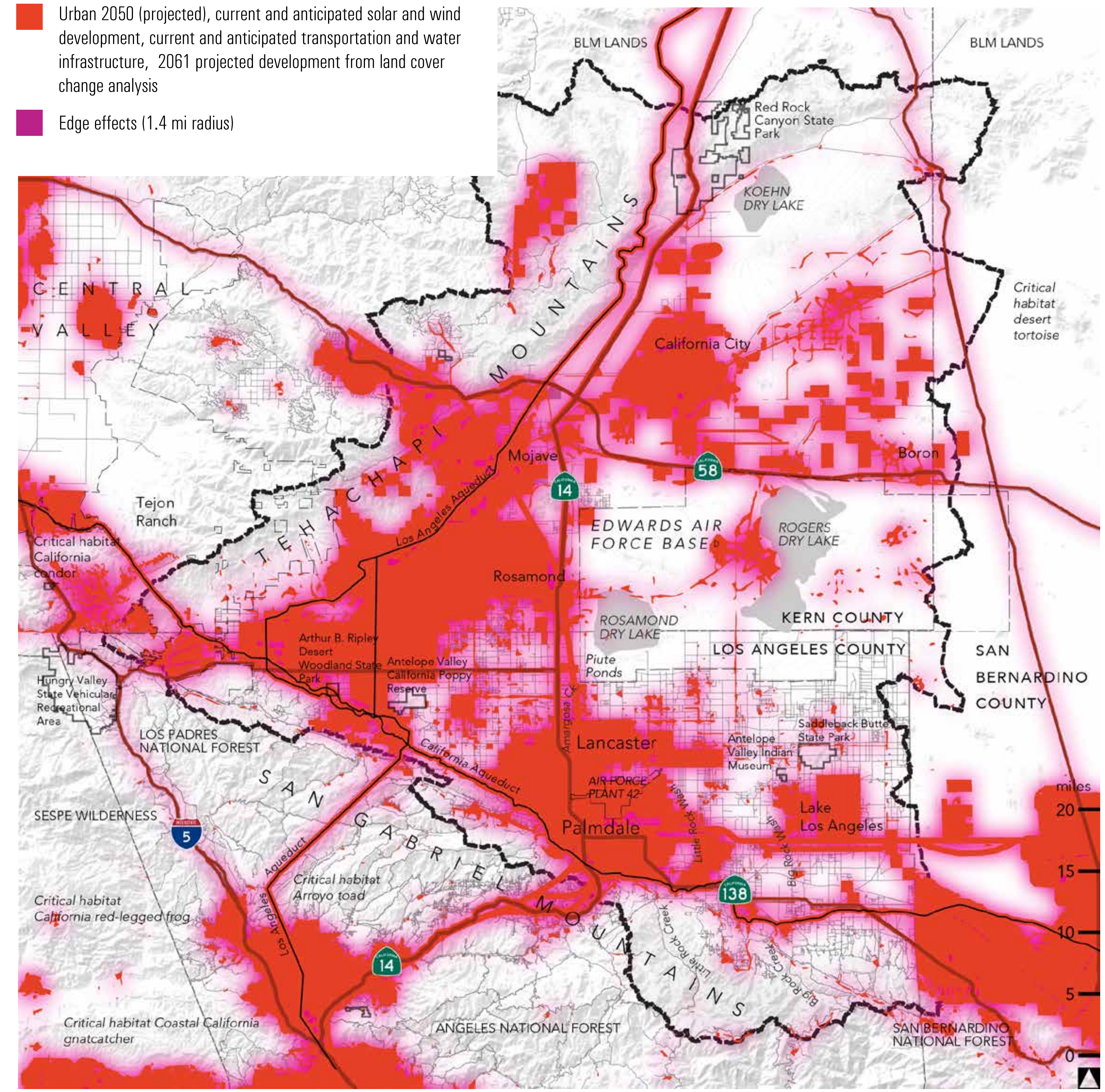
Increased disturbance of the land from urban as well as alternative energy development leads to continued habitat degradation and displacement. Virtually all remaining habitat for LeConte's thrasher (*Toxostoma lecontei*), Mojave ground squirrel (*Xerospermophilus mohavensis*), and desert tortoise (*Gopherus agassizii*) is reduced in area and fragmented.

Figure VI.2 shows all planned and proposed development built out. This includes existing and planned major transportation corridors, projected urban areas, and proposed alternative energy and residential development. In this scenario, much of the valley that is not EAFB will become developed or fragmented by solar thermal development.

Edge effects are depicted with an approximately 1.4 mile. radius, a distance within which ravens are more likely to be found (Coates et al., 2014). Ravens are used as an example because of the large impact they have on study area animal communities (**Section III.1.8**). The addition of edge effects to planned and projected development show how the impact of fragmented development on ecosystems is much larger than its actual footprint.

It is important to note that in this map, disturbed land for energy development is shown as a solid block, even though DRECP anticipates that only a small percentage of this land would actually become developed. Additionally, many planned developments may not actually be built. However, utility corridors and transmission lines, whose edge effects were the basis for the study by Coates (2014), are not shown on this map.

This map shows a visualization of one possible scenario.



[**Figure VI.2** PLANNED AND PROPOSED DEVELOPMENT, PROJECTION OF URBAN AREAS FOR 2050, PROJECTED DEVELOPMENT TO 2061 FROM RASTER ANALYSIS WITH 1.4 MI. EDGE EFFECTS (COATES ET AL., 2014) ADDED.]

The addition of edge effects to planned and projected development show how the impact of fragmented development on ecosystems is much larger than its actual footprint.

1/ Scenario 2- Alternative future: Stewardship
2/ Program guidelines
3/ Design precedent studies
4/ Opportunities analysis

[**Figure VII.1** DETAIL OF PROJECTION.]

VII. ALTERNATIVE FUTURES

VII. ALTERNATIVE FUTURES

1. Scenario 2- Alternative future: Stewardship

In this scenario, alternative energy farms continue to be built, but now are situated exclusively on existing infrastructure, such as paved roads, parking lots, and rooftops. Photovoltaics provide shade and wind protection to urban residents.

Undeveloped land has been granted a greater degree of protection. Joshua tree woodland has been protected from development. Ecological services provided by the desert are recognized, valued and protected.

The main infiltration areas in the watershed are preserved as open space and habitat. With grazing now restricted but managed for biodiversity in the upper watershed, waterways are now full of lush riparian vegetation. The foothills attract wildflower enthusiasts each spring. Thick scrub and native trees are starting to more densely cover the foothills, which slows down the amount of sediment blowing into washes (the source of dust storms).

Soil is protected from erosion, land owners have economic motivation to revegetate disturbed land, and no additional undeveloped land may be cleared for agriculture, as groundwater pumping is limited, and the State Water Project no longer supplies water to the study area.

Urban areas continue to grow by increasing their density.

Urban farming becomes an important source of food, and a larger variety of foods are now locally produced for local markets. The growth of urban farming at multiple scales provides employment and management opportunities for residents of varying education and skill levels. Experimentation with arid lands agriculture becomes a challenge for young horticulturalists.

Residents of the rural parts of the watershed push for protection of viewsheds, support dark skies policies, and manage their land to contribute to regional conservation goals.

Program and design typologies illustrating the Stewardship Scenario are shown in **Figure VII.2** and detailed in **Section VIII**.

[**Figure VII.2** PHOTO COLLAGE OF STEWARDSHIP FUTURE.]

VII.2.1.

ECOSYSTEM SERVICES

- Manage landscape systems to maximize ecosystem services in a sustainable manner.
- Create and maintain ecological infrastructure: a network of undeveloped land with no roads or regular human activity to provide ecosystem services.

[**Figure VII.3** DESERT ANNUALS DRIVE THE DESERT FOOD WEB.]

Regional policy recommendations

- Invest in the designation and maintenance of ecological infrastructure in the same way one would a utility.
- Protect the landscape processes that maintain biodiversity (**Figure VII.3**). Identify and protect existing wildlife corridors and native plant communities. Create buffers and networks among existing reserves.
- Manage genetic diversity as a key component of ecosystem services and biodiversity heritage of the study area. In restoration, use of genotypes of native species which have adapted to the study area may result in greater ecological benefits.
- Public agencies may set an example in the use of natives and Mojave-friendly plant material.
- Waterways and flood plains are opportunities to enhance wildlife habitat and recreational opportunities, while maximizing infiltration.
- Implement financial incentives to promote results-oriented provision of ecosystem services on all land uses, even abandoned agricultural land. Disincentivize uses of land that result in devegetation and loss of ecosystem services (infiltration, flood control, erosion control).

VII.2.2.

AGRICULTURE PRODUCTION

- Organize agriculture to optimize other landscape functions: wildlife habitat, recreation, erosion control, pollinator habitat.
- Incentivize the integration of biodiversity management with crop management.
- Incentivize practices that are sustainable in an arid lands context.

[**Figure VII.4** BLACKBIRDS IN AN ORGANIC ALFALFA FIELD FLOOD IRRIGATED WITH RECYCLED WATER.]

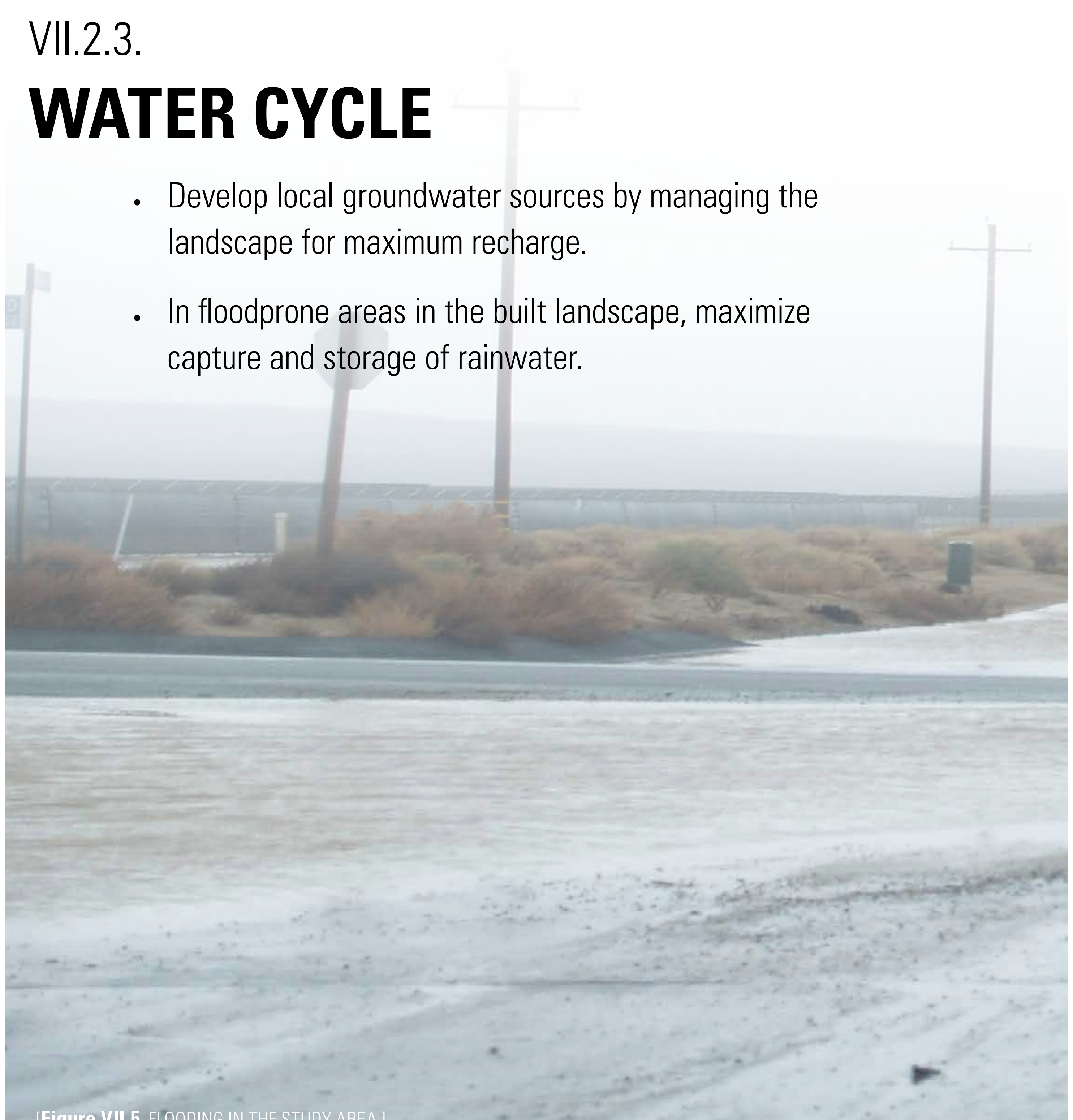
Regional policy recommendations

- Create financial incentives to revegetate land with desert perennial cover after temporary land uses, and on fallow land.
- Incentivize the establishment of windbreaks to mitigate the domino effect of wind erosion.
- Manage windbreaks and fallow land to optimize their value as pollinator habitat.
- Promote drylands agriculture, use of recycled water for agriculture, and crops with low water usage.
- Implement incentives to manage alfalfa fields as wildlife habitat (**Figure VII.4**).
- Zoning and codes should allow for agriculture to occur in the urban areas. Irrigated suburban, public, and interstitial landscapes can incorporate forage and food crops.
- To reduce edge effects, use agricultural belts as a buffer between urban development and native habitat.

VII.2.3.

WATER CYCLE

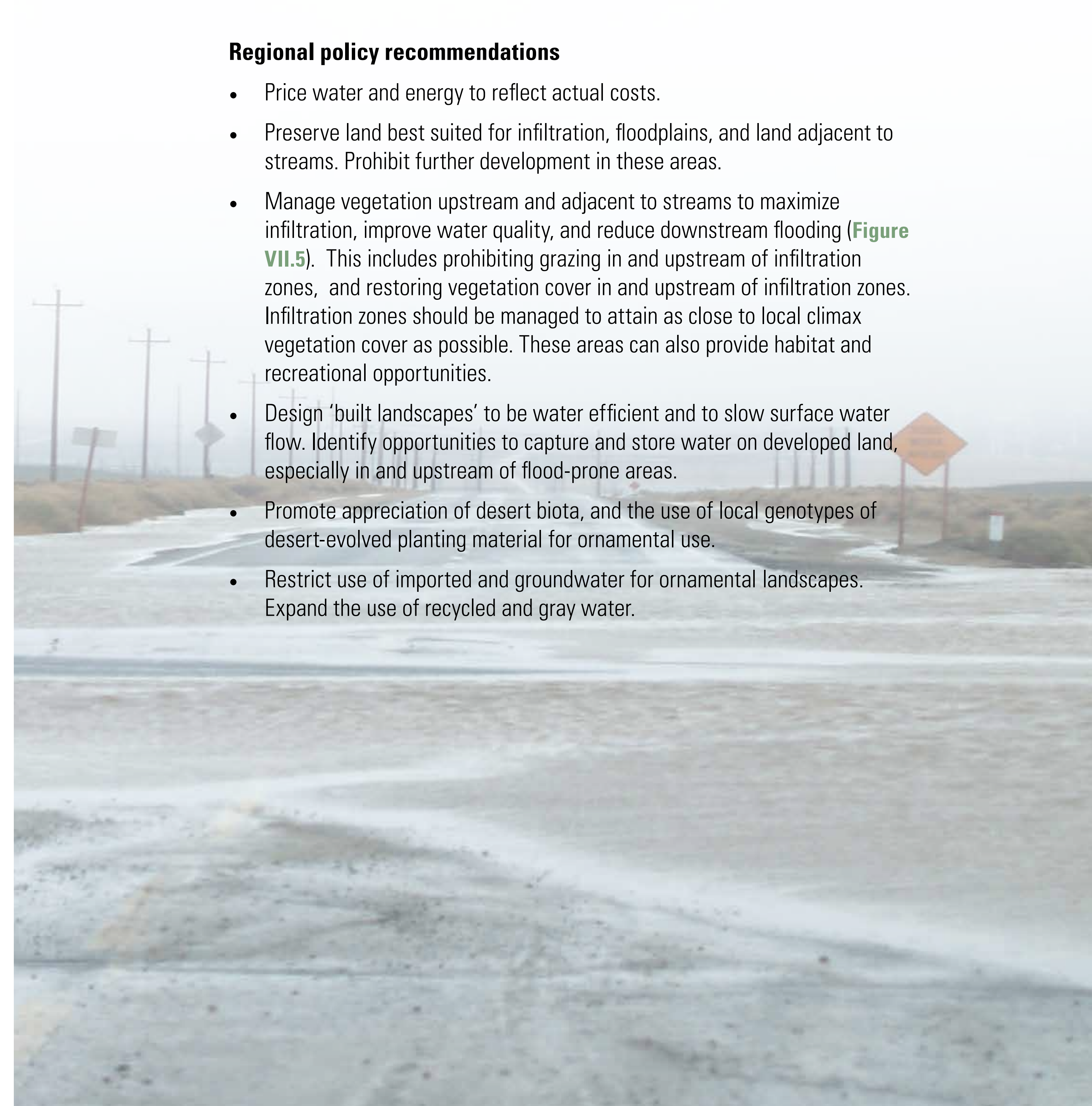
- Develop local groundwater sources by managing the landscape for maximum recharge.
- In floodprone areas in the built landscape, maximize capture and storage of rainwater.



[**Figure VII.5** FLOODING IN THE STUDY AREA.]

Regional policy recommendations

- Price water and energy to reflect actual costs.
- Preserve land best suited for infiltration, floodplains, and land adjacent to streams. Prohibit further development in these areas.
- Manage vegetation upstream and adjacent to streams to maximize infiltration, improve water quality, and reduce downstream flooding (**Figure VII.5**). This includes prohibiting grazing in and upstream of infiltration zones, and restoring vegetation cover in and upstream of infiltration zones. Infiltration zones should be managed to attain as close to local climax vegetation cover as possible. These areas can also provide habitat and recreational opportunities.
- Design 'built landscapes' to be water efficient and to slow surface water flow. Identify opportunities to capture and store water on developed land, especially in and upstream of flood-prone areas.
- Promote appreciation of desert biota, and the use of local genotypes of desert-evolved planting material for ornamental use.
- Restrict use of imported and groundwater for ornamental landscapes. Expand the use of recycled and gray water.



VII.2.4.

URBAN DEVELOPMENT

- Develop first on infill.
- To limit sprawl (**Figure VII.6**), create boundaries for development.
- Design urban spaces to celebrate surrounding natural landscapes.
- Design urban spaces to facilitate opportunities for community interaction.

[**Figure VII.6** JOSHUA TREES SURROUNDED BY SUBURBAN DEVELOPMENT IN LANCASTER.]

Regional policy recommendations

- Implement incentives for increasing density of development.
- Promote public and alternative transportation.
- Identify and promote the unique natural and cultural characteristics of the study area. Use local native plants in low water residential landscaping.
- Create venues/forums through which people can exercise stewardship.
- Develop frameworks for community organization and collaboration.

VII.2.5.

ENERGY PRODUCTION

- Incorporate alternative energy production (**Figure VII.7**) in urban and suburban areas. Use red fields, rooftops, parking lots, highways, and public infrastructure as opportunities for generating alternative energy.
- Design and site energy infrastructure to enhance sense of place in the built environment.

[**Figure VII.7** POPPIES VOLUNTEER UNDER SOLAR PANELS.]

Regional policy recommendations

- Increase alternative energy production on urban infrastructure. Use red fields, rooftops, parking lots, highways, and public infrastructure as opportunities for generating alternative energy.
- Design solar energy production into the urban environment in a way that enhances quality of life and sense of place.
- Establish profit-sharing agreements for the production of energy on public infrastructure (such as roads and parking lots, and the California Aqueduct).
- Allow residents to use and store their own energy without mediation by utilities.
- Identify key views to preserve from development.

VII.3. Design precedent studies

Design precedents relating to the program described in the previous pages are detailed on the following pages.

Goal 1: Envision multifunctional landscape networks that sustain both human and ecological systems.

Wildlife crossings

Wildlife bridges and undercrossings (**Figure VII.8-9**) may partially mitigate habitat fragmentation caused by existing and proposed major roads that cross large habitat patchs.

Animal bridges can benefit large mammals down to insects and reptiles. Numerous guidelines exist for designing crossings based on target species. Analysis of the landscape and habitats must be performed in order to choose the most suitable placement of the bridge or undercrossing.

The design of these structures must blend into landscape features as perceived by target species.

The impact of animal crossings can be assessed for effectiveness after implementation.

Though well planned crossings can mitigate fragmentation, they should not be seen as a solution to the habitat degradation caused by development. Noise, pollution, alterations to drainage and vegetation, and facilitation of the movement of invasives are impacts of roads that affect animal behavior.

Wildlife crossing signs along roads serve more than the practical purpose of warning drivers to watch for wildlife. They also may serve in developing stewardship attitudes by reminding drivers of the dynamic and fragile biological resources of the landscape (**Figure VII.10**).

[**Figure VII.8** ANIMAL BRIDGE PROTOTYPE. Source: Inhabitant.com]

[**Figure VII.9** WILDLIFE CROSSING. Source: wolvesonceroamed.com]

[**Figure VII.10** ANIMAL CROSSING SIGNS. Source: dreamtime.com]

Multitasking energy infrastructure

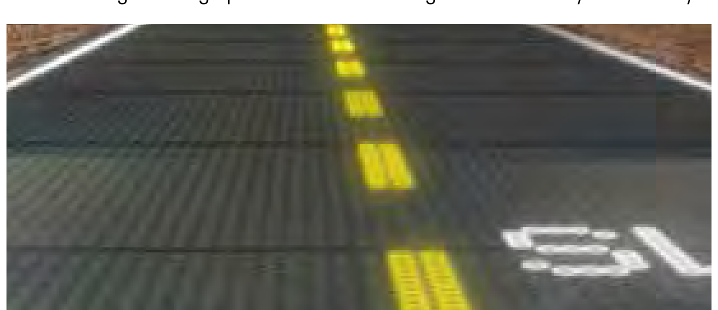
Numerous interviewees suggested that alternative energy infrastructure be incorporated into urban environments to preserve open space, scenic views, and habitat.

There are many examples of the use of photovoltaics in urban environments that serve shading, cooling, and esthetic functions. Such solutions can be as simple as incorporating solar into parking lot structures or on top of already developed urban buildings.

The parking lot at Desert Springs Reserve is esthetically pleasing, and provides needed shade while allowing ventilation (**Figure VII.11**).

In the study area, solar panels can be used as architectural features that frame social gathering spaces. Shade and refuge from strong winds, as provided by solar panels, can create comfortable outdoor gathering and event spaces. With some artistic imagination, such features can serve as placemaking devices as well.

[**Figure VII.11** DESERT SPRINGS PRESERVE PARKING LOT, LAS VEGAS.] Solar need not go on open land. It can serve shading functions and create gathering spaces and wind refuges in the windy desert city.



[**Figure VII.13** SOLAR ROADWAYS. Source: solarroadways.com]

Covered roads with wildlife under- or overcrossings would reduce roadkill, a food source enabling the spread of ravens into remote areas.

Roads are an opportunity for photovoltaic installations (**Figure VII.12**). Covered roads with wildlife under- or overcrossings would reduce roadkill, which is a food source enabling the spread of ravens into remote areas.

Solar Roadways has designed a prototype for a road that is created from photovoltaic panels (**Figure VII.13**). The company proposes to replace highways, driveways, parking lots, and even sidewalks with solar panels. Signals and lane dividers are built in by using LEDs.

[**Figure VII.12** SOLAR SERPENT PROPOSAL, SANTA MONICA. Source: Mans Tham] Besides microclimate control, solar can serve esthetic and placemaking functions. Covered roads with wildlife under- or overcrossings would reduce roadkill, which is a food sources enabling the spread of ravens into remote areas.

[**Figure VII.14** BLADELESS WIND ENERGY GENERATION. Source: Designboom.com]

[**Figure VII.15** BLADELESS WIND ENERGY GENERATION. Source: Inhabitant.com]

[**Figure VII.16** DISTRIBUTED WIND ENERGY GENERATION. Source: energy-green.net]

Bladeless and distributed wind generation

Bladeless wind generation (**Figures VII.14-15**) promises to be less harmful to wildlife than current designs.

Variations in sizes of turbines and alternative configurations are being developed for greater efficiency and reduced impacts to wildlife.

Distributed wind power using numerous smaller turbines in the urban environment (**Figure VII.16**) would create energy closer to where it is needed and used, and reduce pressure to clear open lands for energy production. In the urban environment, any wildlife impacts would be limited to urban generalist species.

Another alternative is mounting wind turbines on already existing transmissions lines or other infrastructure, making the transmissions lines serve more than a single purpose, and concentrating the impacts of development on a smaller footprint.

Goal 2: Promote stewardship and education about landscape services

Promoting place

A community's character can been seen as a narrative of that particular place (American Planning Association, 2011). Aerospace, wildflowers, alternative energies, and Joshua trees are images that study area communities have used to represent themselves. Incorporating community values into planning will increase the success of planning efforts and help the community articulate its own identity (**Figure VII.17**). Records of community meetings described in **Section III.2.5** are a resource in this regard.

Citizen science

Citizen science is the harnessing of volunteers by scientists to aid in scientific investigation. Citizen science may involve crowdsourcing data collection, data entry, transcription, and even analysis. Data collection and data entry is typically organized and structured by scientists and researchers, with data collection and entry facilitated by websites, smart phones, and apps.

Citizen science enables data collection on a broad scale that might be prohibitively expensive if dependent on paid researchers.

Project Budburst (**Figure VII.18**) enlists citizen scientists to collect information on phenology (the timing of life cycle events) of widespread plant species to document and analyze how climate change may affect plant life cycles.

eBird is a website where bird watchers enter data on bird sitings. New data is vetted by regional experts. Data is used to create range maps, to visualize the probability of seeing particular bird species in a given season, and to map bird migration patterns. Data is available for viewing or download to anyone on the web for fun, research, or analysis.

In the Antelope-Fremont Valleys, possible citizen science projects could include: identifying and geolocating rare species, collecting data on pollinators, collecting data on the distribution of native wildflowers and their relationship to various agricultural land management practices, and obtaining more detailed information on the range of key wildlife, such as the Mojave ground squirrel (*Xerospermophilus mohavensis*).

Participation in citizen science data collection programs usually does not require any specialized background. Citizen science and crowdsourced data collection may even be designed for the participation of non-literate volunteers. Some training to assure standardization in data collection is typically required. Thus, participation in citizen science programs often involves 'informal' education in data collection methods.

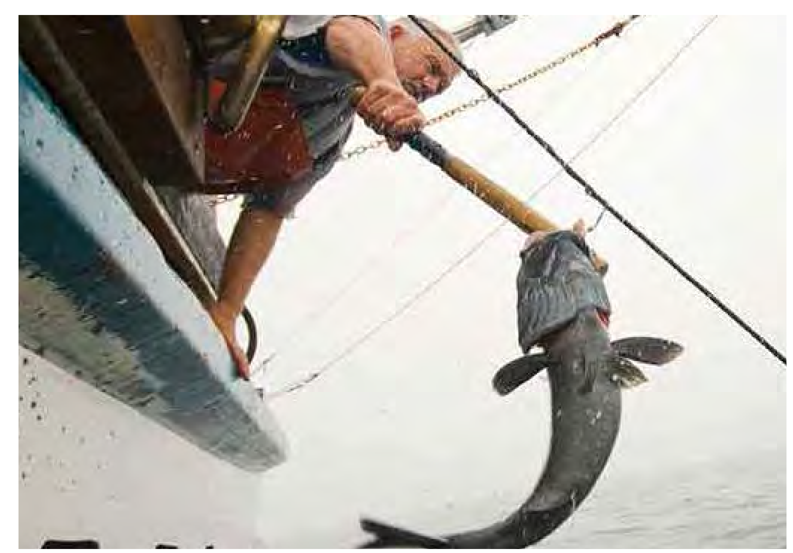
Crowdsourced data collection projects may also cultivate community engagement and stewardship. The Nature Conservancy worked with fishermen in Morro Bay to implement the eCatch program. Using iPads for data collection, fishermen collaborate to develop strategies that lead to more sustainable harvesting practices (**Figure VII.19**). In this program, the link between sustainable harvest and economic viability is clear to participating fishermen, who become sustainability managers in the course of earning a living.

In the context of the study area, similar crowdsourcing approaches could be used to manage grazing more sustainably, or to document grazing's impact on vegetation cover and the spring wildflower bloom.

Crowdsourcing ideas and analysis are can also have applications in the sphere of design and community engagement. Crowdsourcing is increasingly used by urban planners to gather community ideas and feedback. In the study area, planners can use crowdsourced data to articulate the sentiments and preferences of local residents, and to prioritize locations for improvement.

[**Figure VII.17** COMMUNITY CHOSEN ICONS OF PLACE.]

[**Figure VII.18** CITIZEN SCIENCE. Source: Carlye Calvin, Project Bud Burst]



[**Figure VII.19** ECONOMIC VIABILITY MEETS CITIZEN SCIENCE. Source: Bridget Bedaw, Nature Conservancy] Using eCatch, fishermen enter and analyze data, self-organizing to harvest sustainably and ensure profitability.

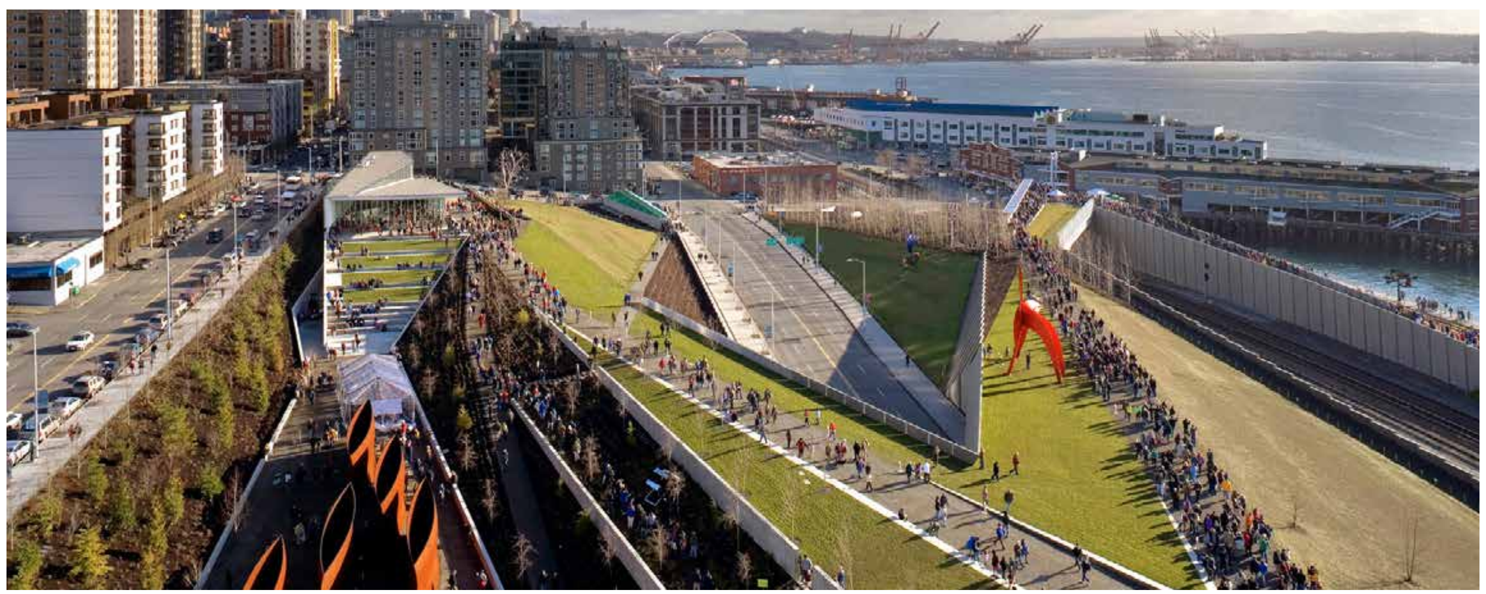
Using eCatch, fishermen enter and analyze data, self-organizing to harvest sustainably and ensure profitability.

Goal 3: Enhance the well-being of the local community

Biodiversity in urban areas

Retaining elements of nature in urban areas is important for the health of urban residents. Numerous studies underscore the physiological, psychological, and health benefits of exposure to nature. Other studies document social benefits, such as reduced crime and reduced domestic violence.

Some suggest that during an era when most of the world's decision makers live in cities, some exposure to nature will enable future leaders to make decisions with an appreciation for ecological and environmental processes.



[**Figure VII.20** OLYMPIC SCULPTURE PARK BY WEISS MANFREDI. Source: weissmanfredi]

Some suggest that during an era when most of the world's decision makers live in cities, some exposure to nature will enable future leaders to make decisions with an appreciation for ecological and environmental processes.

Opportunities to bring nature into the urban environment can be merged with opportunities to provide diverse recreational facilities, passive recreation, and flexible spaces which communities can adapt to their own needs.

River washes and infiltration zones have relatively high biodiversity, and run through highly urbanized areas. These areas present opportunities to merge infiltration, biodiversity, urban connectivity, biking, walking, and passive recreation in an easily accessible environment.

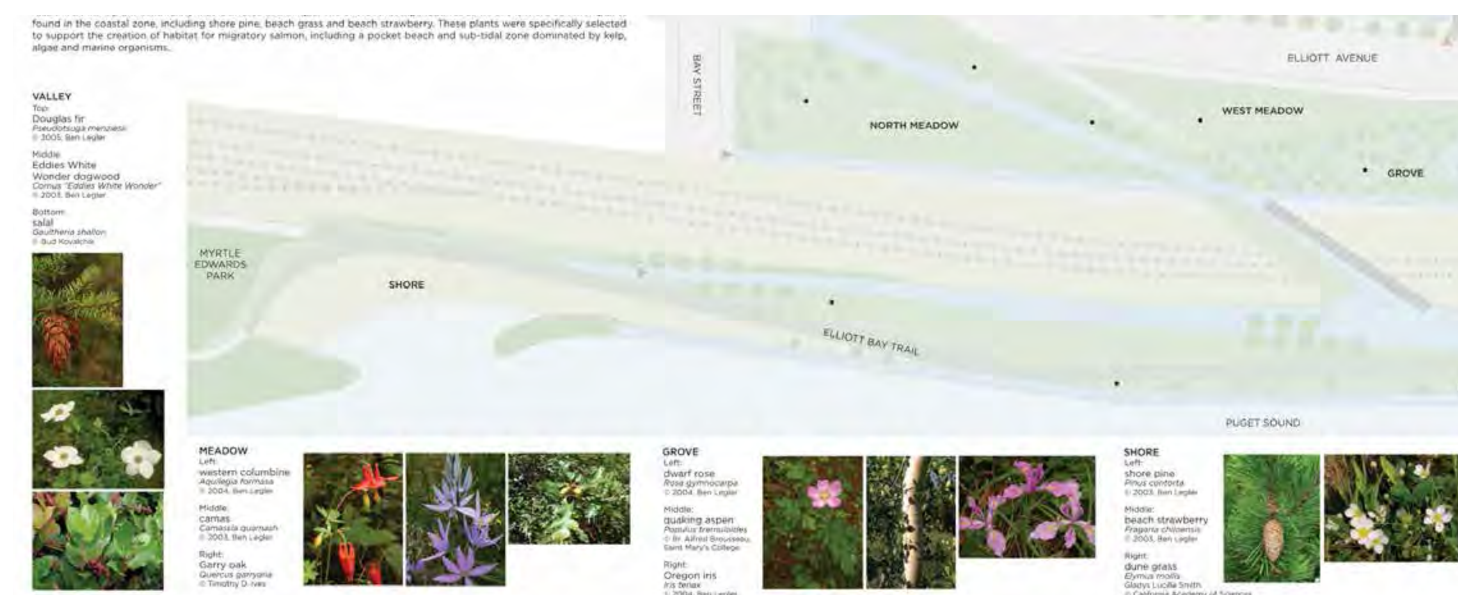
Habitat sculpture parks

The Olympic Sculpture Park in Seattle, Washington is a great example of how a park can be integrated into an urban setting while still providing habitat for native species (**Figure VII.20**). Two elements of the park design are particularly relevant to the study area: the integration of temporary and permanent artwork, and a diversity of habitat types. Many of the sculptures can interact with the surroundings and provide novel opportunities for visitors to appreciate environmental processes. The habitat-friendly design incorporates native plants that have potential to attract native wildlife (**Figure VII.21**). Such natural habitat within an urban area can be an element in a larger connectivity network, such as along a riparian or wash corridor.

Such a park could integrate gathering spaces to provide a venue for a diversity of community-organized cultural events. Sculptures which double as play structures appeal to a variety of ages (**Figure VII.22**). Solar panels can provide energy generation as well as shade and protection from strong winds.

Aqueduct recreation

Several European countries have allowed local aqueducts to support recreational and transportational uses (**Figure VII.23**). Magdeburg Water Bridge in Germany and the



[**Figure VII.21** OLYMPIC SCULPTURE PARK HABITAT MAP. Source: nytimes.com]

[**Figure VII.22** DESERT BIOTA SCULPTURE PLAYGROUND.]

Pontcysyllte Aqueduct in Britain are examples of aqueducts providing recreational functions.

The California Aqueduct runs along the north face of the San Gabriel foothills along the southern portion of the study area. The aqueduct is an open concrete channel that has water flowing in it year round. Transforming the aqueduct into a route for kayaks and canoes would offer a unique recreational attraction. Boaters could experience the nature of the site with intermittent 'highlights' along the way. Along the route, boaters could view animal crossings while learning about large mammals that use the desert. Boaters could be shaded by sculptural solar installations, while they learn about the engineering of the California Aqueduct. Such an approach could develop stewardship among users.

[**Figure VII.23** KAYAKING ON PONTCYSYLLTE AQUEDUCT, GREAT BRITAIN. Source: amusingplanet.net]

These precedent pollination initiatives have in common:

1) the involvement of a broad base of stakeholders in implementing a larger vision,

2) the belief that small and large interventions cumulatively have potential to create a significant impact, and

3) integration of education and appreciation of native ecology.

Pollination network plans

A factor in the decline of pollinator populations is habitat loss. The decline of pollinator populations can diminish agricultural production, as well as impact food webs that depend on flowering plants.

Numerous initatives in Europe and the United States enlist homeowners in creating gardens that provide habitat for pollinators. The intended effect of such gardens is to contribute to pollination networks at a regional scale. Some of these initiatives, such as The Pollinator Pathway® by Sarah Bergmann in Seattle, are integrated into artworks.

In Wales, 'Action Plan for Pollinators' brings together public and private sectors to create guidelines to reverse the decline of pollinator populations. The document identifies areas for action including promoting diverse and connected native flowering habitats across farmland, cities, and developed areas. The plan proposes distributing pollinator packs in schools, farm crop diversification, and the reduction of pesticides by promoting integrated pest management.

Wildflowering L.A. is an artwork by Fritz Haeg that recruited participants throughout Los Angeles to transform city landscapes into fields of native wildflowers. Participants were given native wildflower seed, and attended workshops to learn about wildflower horticulture. A Wildflowering L.A. site hosted by artist Leigh Adams at the Los Angeles County Arboretum included pollinator attractor structures created by Leigh Adams and Matt Geldin (**Figure VII.24a-b**).

These pollinator initiatives all have in common: 1) the involvement of a broad base of stakeholders in implementing a larger vision, 2) the premise that small interventions cumulatively have potential to create a significant impact, and 3) integration of education about native ecology.

The Pollinator Pathway® and the Wales Action Plan follow an evidence-based adaptive management approach to maximize the value of landscape interventions to pollinators. Science-based evaluation is important to ensure that efforts have the intended benefits for the native pollinators.

[**Figure VII.24a** ONE OF THE 50 WILDFLOWERING L. A. SITES. Source: Los Angeles County Arboretum] This installation of Fritz Haeg's Wildflowering L. A. at the Los Angeles County Arboretum included pollinator attractor structures created by Leigh Adams and Matt Geldin.

[**Figure VII.24b** ONE OF THE 50 WILDFLOWERING L. A. SITES. Source: Los Angeles County Arboretum]

VII. ALTERNATIVE FUTURES

VII.4. Opportunities analysis

The previous sections detailed key landscape processes in the study area, and modelled the behavior of the land cover types that drive those processes.

The following analysis is conducted with the goal of seeking opportunities for intervention in these processes. Status quo models for land use and design are the foundation of the buildout scenario. Integrative analysis of issues and alternative typologies may offer options that can help the study area move toward a stewardship scenario.

With increasing pressure for the landscape to accomplish more, it is important to find opportunities for synergy among environmental, economic, and sociocultural infrastructures. The following analysis identifies areas where landscape networks might facilitate ecosystem services and protect the processes that sustain biodiversity, while also fulfilling some of the cultural needs of residents.

This analysis focusses specifically on three processes that are in crisis in the study area. The ecosystem services provided by these processes are:

- Wind erosion control
- Biodiversity
- Water cycle

With increasing pressure for the landscape to accomplish more, it is important to find opportunities for synergy among environmental, economic, and sociocultural infrastructures.

VII.4.1 WIND EROSION

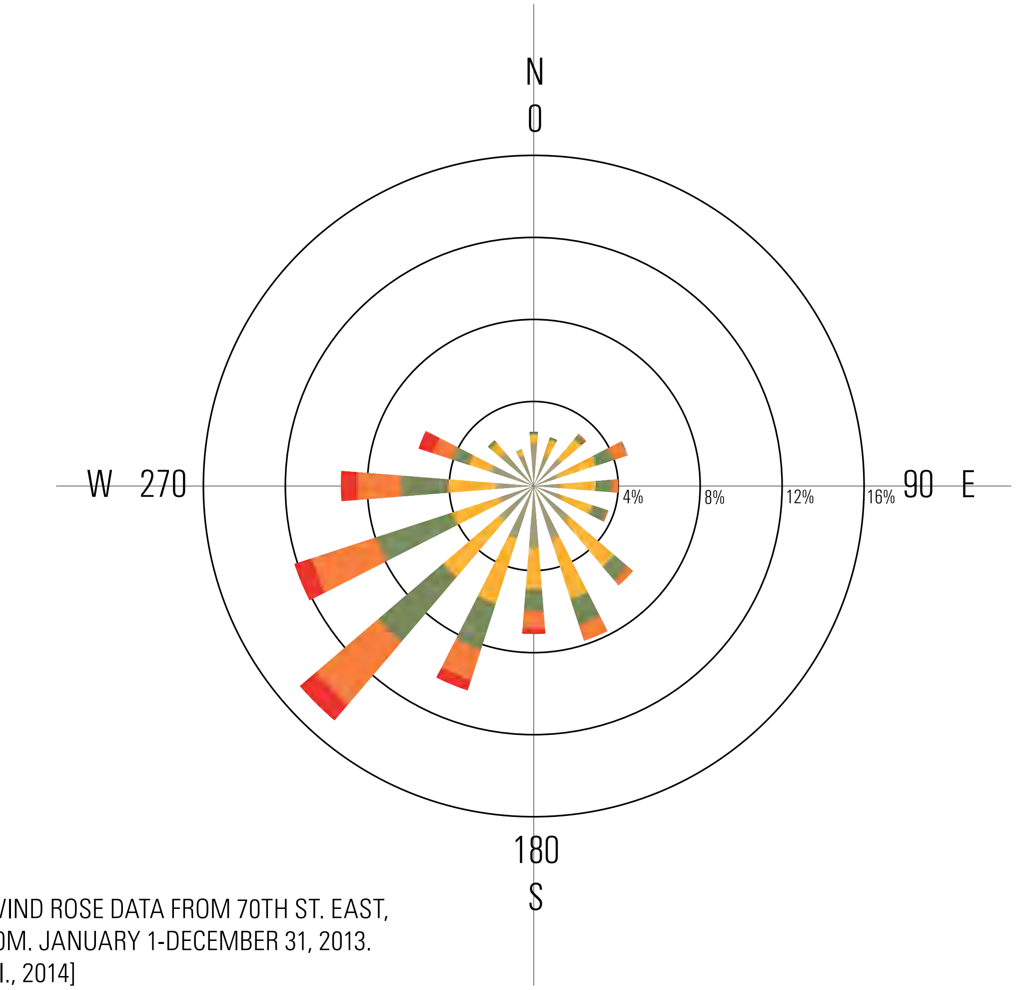
Existing wind patterns

Analysis of wind patterns and the spatial extent of high erodibility areas suggest zones where different strategies to prevent erosion and devegetation can be considered.

The coincidence of some areas of solar and wind energy development with areas of soil with especially high erodibility (**Figure II.6**) was described in **Section II**.

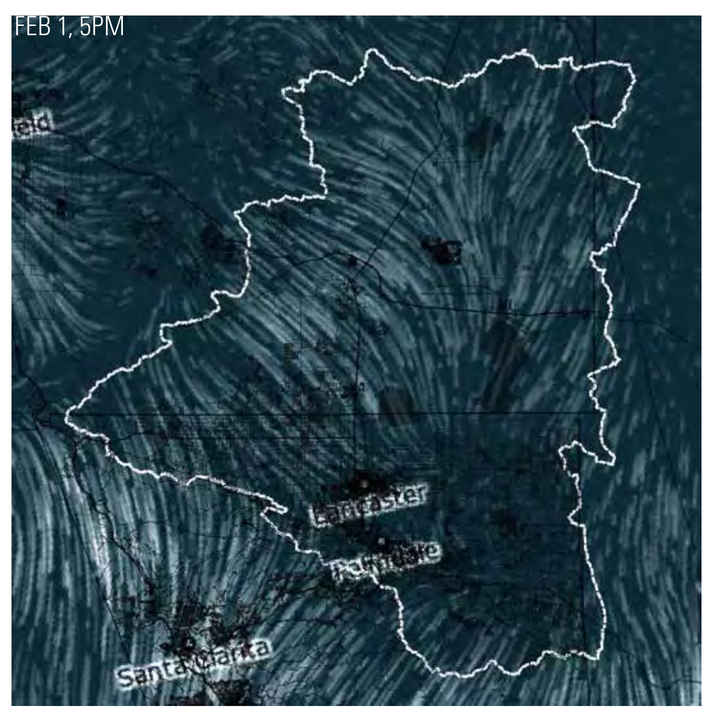
Real time wind maps (**Figure VII.25a-b**) show a sampling of wind patterns in spring, the windiest season, and summer. The strongest winds in the study area are northwesterly winds that come down from the Tehachapis. Because the height of the Tehachapis allows for greater downslope acceleration, these winds can be stronger than the southwesterly winds that come down from the San Gabriels (Farber et al., 2014). The winds lose speed as they move over the desert floor (Farber et al., 2014). However, severe saltation can take place in all seasons. Though the greatest saltation occurs during spring, there are "many days and many hours each day" where the conditions that lead to large scale dust storms may occur.

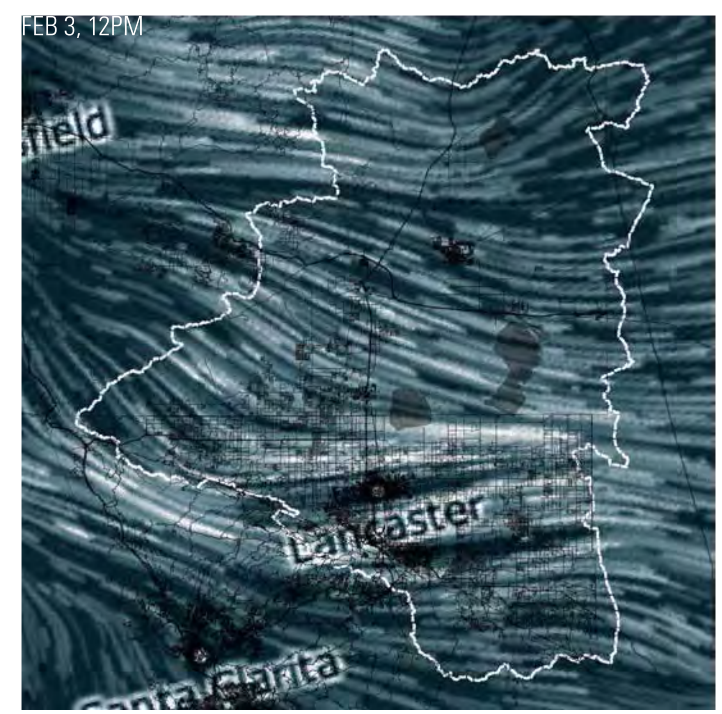
A Lancaster wind rose shows that the predominant winds are from the southwest and come off the San Gabriels (**Figure VII.26**).



> .5 - 5 mph
> 5 - 9 mph
> 9 - 14 mph
> 14 - 20 mph
> 20 mph

[**Figure VII.26** WIND ROSE DATA FROM 70TH ST. EAST, LANCASTER, AT 10M. JANUARY 1-DECEMBER 31, 2013. Source: Farber et al., 2014]

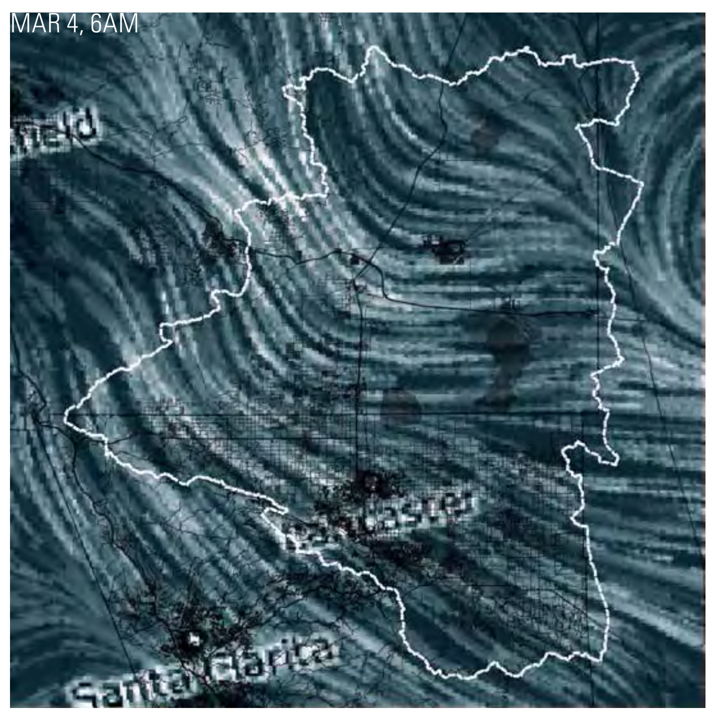




1 mph
3 mph
5 mph
10 mph
15 mph
30 mph

[**Figure VII.25a** A SAMPLING OF WIND PATTERNS IN THE STUDY AREA SPANNING SPRING AND SUMMER 2014. Source: Hint FM]

[**Figure VII.29** TYPE OF VEGETATION COVER AFFECTS EROSION CONTROL.]



1 mph
3 mph
5 mph
10 mph
15 mph
30 mph

[**Figure VII.25b** A SAMPLING OF WIND PATTERNS IN THE STUDY AREA SPANNING SPRING AND SUMMER 2014. Source: Hint FM]

Soil erodibility and zones of disturbance

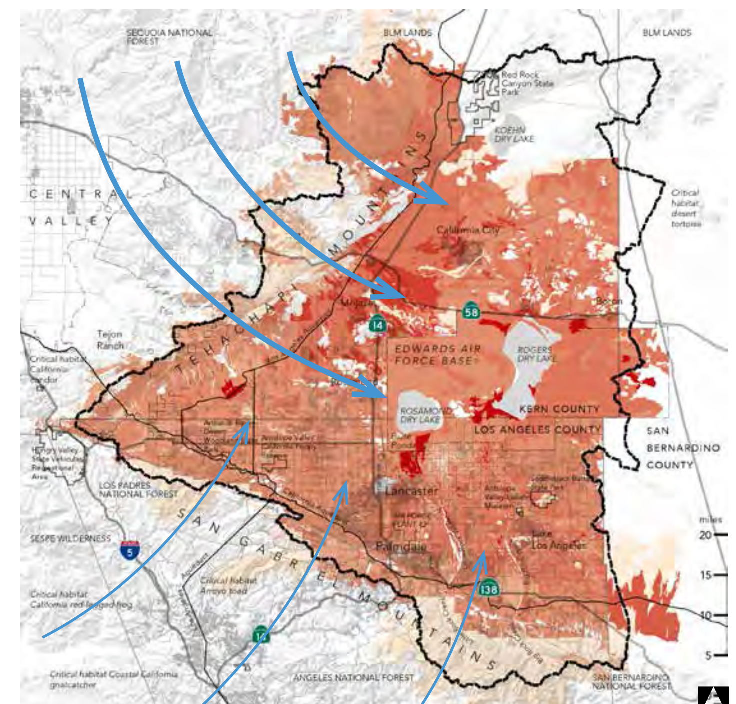
Regional-scale land uses that result in soil disturbance are mapped to compare spatial relationships to wind patterns in **Figure VI.27**. Most disturbed soils are on the western portion of the study area. Since the strongest winds originate from either northwest (Tehachapis) or southwest (San Gabriels), disturbance to soil surfaces in the west are likely to impact much of the study area.

The portion of the study area against the western foothills have the highest wind speeds. These areas have already been heavily disturbed by agriculture and grazing in the last century, and are currently disturbed by new alternative energy development.

The degree of wind erodibility of soil (**Figure VI.27**) can be compared to areas of past, present, and anticipated soil disturbance (**Figure VII.28**).

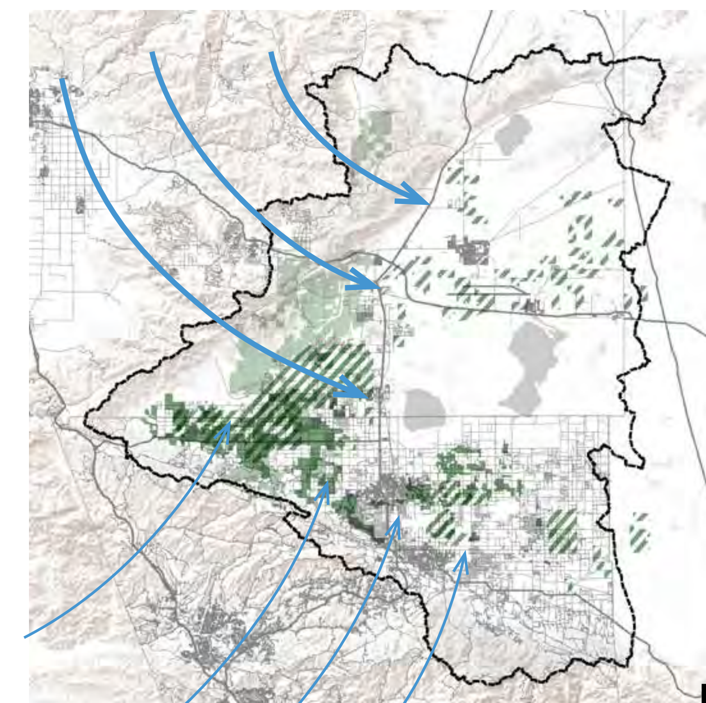
Figure VII.29 shows different levels of vegetation cover which have different degrees of 'roughness,' a factor affecting surface wind speeds.

Figure VI.30 synthesizes this information to suggest three zones of strategy for curbing wind erosion: preventing erosion at the source, addressing processes of disturbance, and managing land that has been previously disturbed.



0
38
48
56
86
134
160
180
220
250 tons/acres/year

[**Figure VII.27** SOIL RATED BY WIND ERODIBILITY. Source: SSURGO]
Soil rated by wind erodibility in tons/acre/year. Darker colors indicate soil types more susceptible to windborne erosion. Inset denotes area shown in aerial views of Lancaster.



Past disturbance- recovering farmland
Recent disturbance- solar and wind development
Expected disturbance- designated 'Disturbed' and 'Solar Thermal' sites, and Projected urban areas, 2050

[**Figure VII.28** WIND DIRECTIONS AND LAND USE CATEGORIES RELATED TO SOIL DISTURBANCE. Source: NREL, RETI]

Opportunities for mitigating wind erosion

Opportunities for addressing wind erosion issues are shown in **Figure VII.30**.

1

ZONE WHERE WIND EROSION STARTS

Slow erosion where it starts. Winds that come off the Tehachapis and San Gabriels are at their maximum speed. Maintaining native vegetation in hills where sand accumulation begins will slow movement of sand into washes, where it is transported into the valley and picked up by the wind. Native vegetative cover helps reduce the speed of surface drainage over the landscape, the speed of wind, and the uplift of particles that cause downwind sand blasting. Junipers, chaparral, and desert scrub provide stable cover that can weather drought.

Grazing and development are land uses that contribute to devegetation in the foothills. Stricter management of both, as well as active revegetation of land may contribute to restoration of vegetation cover.

2

ZONE OF HIGH WIND AND HIGH DISTURBANCE

Slow erosion where it continues. Past and recent soil disturbance has occurred due to agriculture and recent alternative energy development.

Restoring native desert scrub in this zone will have the added benefits of improved biodiversity, habitat, and flood control. Revegetation with plants propagated from local genotypes is recommended.

Because of this area's sensitivity, temporary land uses should be restricted. Financial incentives for maintaining perennial native vegetation can be used to motivate restoration by absentee landowners and landowners who rent fields for temporary agricultural uses.

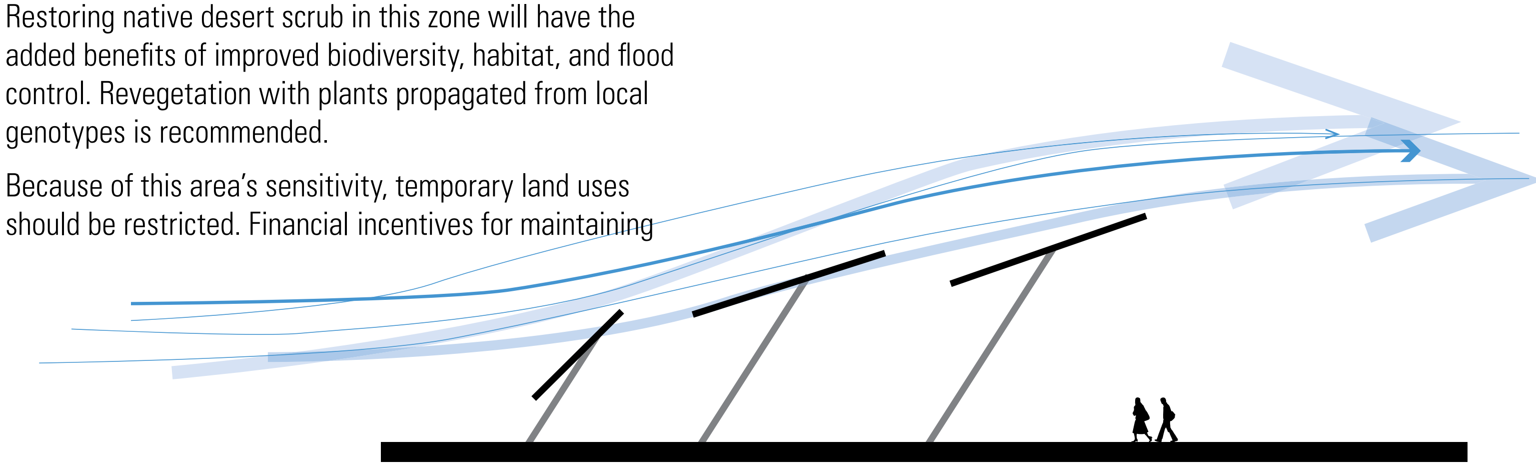
3

ZONE OF IMPENDING DEVELOPMENT

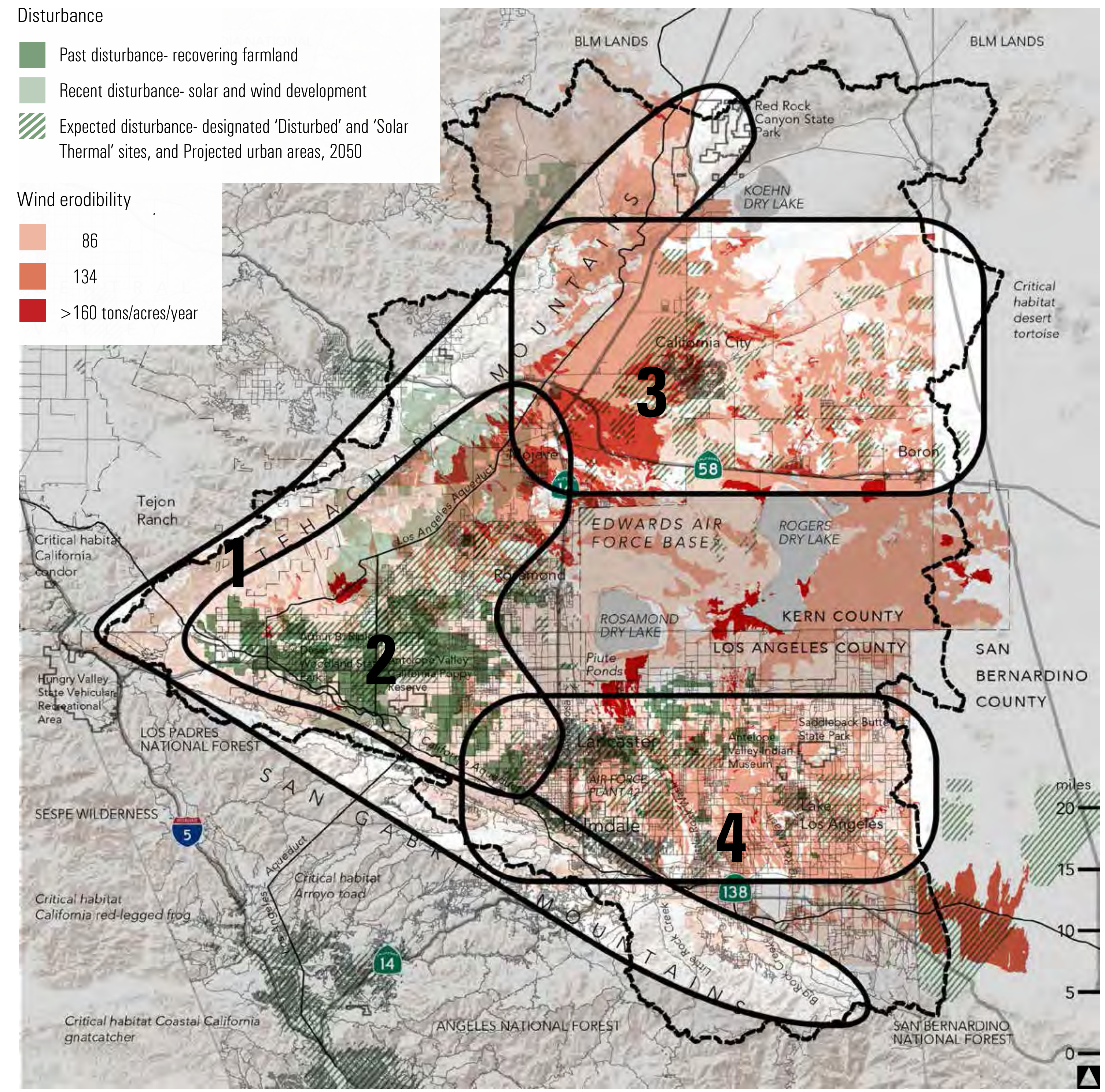
In this very arid area where soils have high wind erodibility, numerous solar thermal plants are planned, and substantial urban development is expected to occur. Construction can be expected to contribute to wind erosion that impacts downwind regions.

Because of this area's aridity, revegetation after soil disturbance is expected to be especially challenging. Strict policies to limit soil disturbance can protect the ecosystem services provided by intact soil and vegetation cover.

NRCS Lancaster suggests that mowing shrubs, rather than wholesale removal, will allow for revegetation from established root systems after construction. In the study area's harsh environmental conditions, this strategy is likely to be more successful than a full scale restoration.



[**Figure VII.31** IN URBAN AREAS DURING PERIODS OF STRONG WIND, SOLAR GENERATING PANELS ADJUST TO PROVIDE SHELTER FROM WIND.]



[**Figure VII.30** OPPORTUNITIES FOR ADDRESSING WIND EROSION: AREAS OF PAST AND FUTURE LAND DISTURBANCE AND WIND ERODIBILITY. Source: SSURGO, NREL, LA 606 Team]

4

ZONE OF EXISTING DEVELOPMENT

Parts of this zone are densely developed. Buildings, landscapes, and solar panels can be designed and sited to maximize roughness to slow wind speeds, and create shelters from the wind.

In 'roughness zones' within suburban development, solar panels may be sited and oriented to create respite from the wind and sun (**Figure VII.31**). Such sheltered spaces may become outdoor recreational and cultural venues in suburban communities that otherwise have little public or community space. Esthetic use of solar panels as architectural elements can contribute to a sense of place.

By slowing the wind, rough zones will allow deposition of sand. Not only will this facilitate removal of sand, but due to the removal of particles from the air, areas downwind will be less vulnerable to sandblasting.

VII.4.2 BIODIVERSITY

Preliminary notes on biodiversity infrastructure

There are many possible approaches to preserving biodiversity in the study area. Because of this projects's focus on design typologies that serve multiple functions, this section considers how opportunities to protect vegetation communities and sensitive plant and animal species might intersect with other planning opportunities in the study area. These opportunities include groundwater infiltration, flood control, erosion control, recreation, and cultural needs.

Protecting and promoting vegetation cover

As described in **Section II**, the provision of ecosystem services such as flood and erosion control are closely linked to the presence of vegetation cover.

Creosote bush scrub may appear common. Yet it provides critical ecosystem services, and its longevity among desert shrubs means it can provide vegetative cover as fluctuations in precipitation levels become more extreme. **Figure III.1.35** shows the extent of Creosote bush in the study area.

Long lived Mojave scrub species have evolved over millennia to provide ecosystem services in spite of prolonged years of drought. They grow and reproduce during years of high precipitation. A revegetation strategy can manage succession for perennial cover by locally adapted genotypes.

Protecting genetic diversity

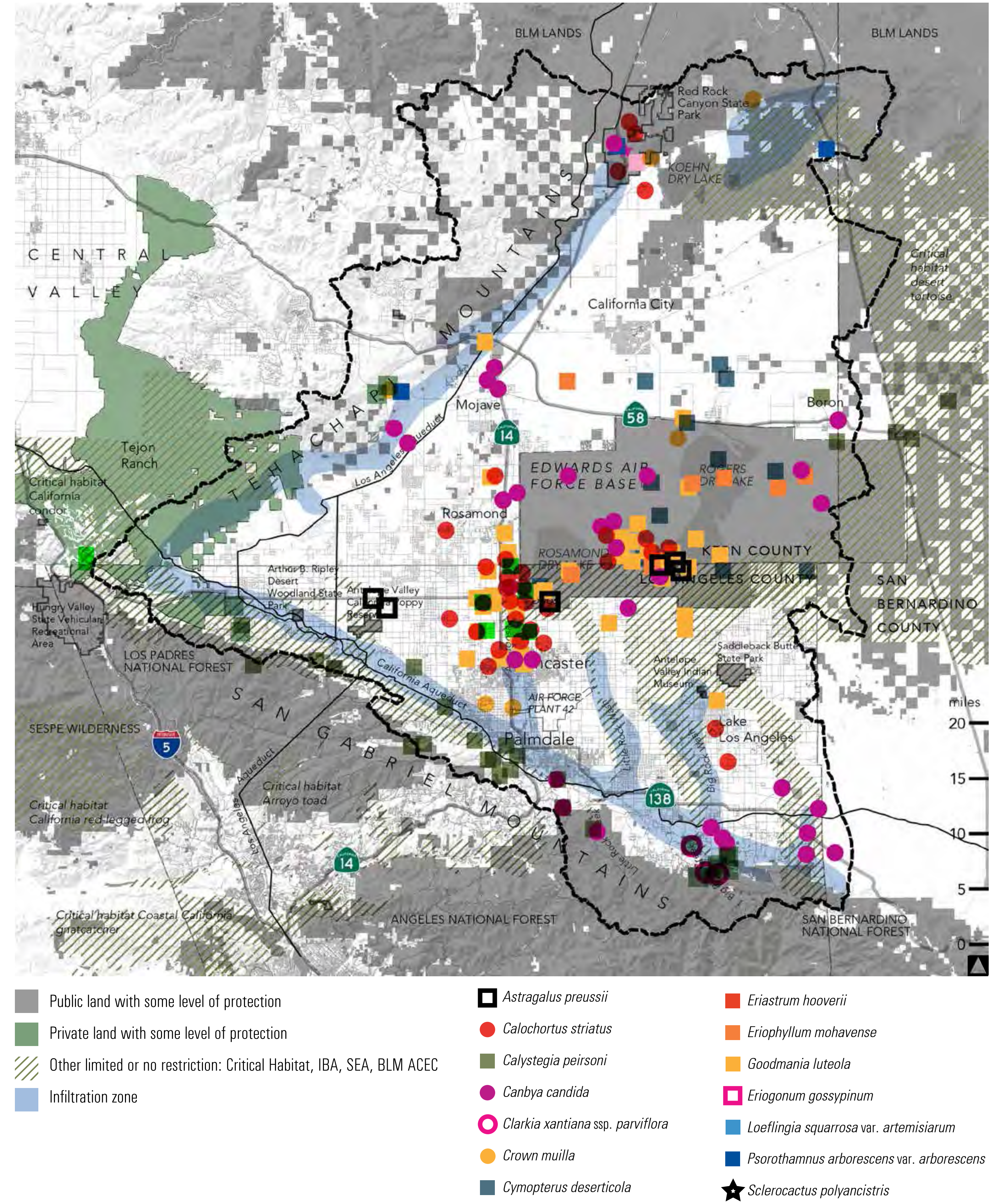
The future resilience of study area ecosystems may draw on the repository of genetic diversity in the study area. The study area houses the westernmost population of Joshua tree and a distinct form of the species, *Yucca brevifolia* forma *herbertii*, the westernmost populations of desert tortoise (*Gopherus agassizii*), Mojave ground squirrel (*Xerospermophilus mohavensis*), Le Conte's thrasher (*Toxostoma lecontei*), Inca dove (*Columbina inca*), and ladder-backed woodpecker (*Picoides scalaris*). The recent discovery of genetic subpopulations of the federally listed desert tortoise (Hagerty, 2011) suggests that there may still be much to be discovered.

Since gene flow is one of the processes that maintains biodiversity, connectivity is essential to biodiversity.

Preserving large, unbroken expanses of habitat

Because habitat loss due to land use is a major threat to numerous species in the study area, protection of remaining habitat from further loss is recommended.

Desert scrub and woodland are key remaining habitats (Garrett, 2014). The extent of Joshua tree woodland is shown in **Figure III.1.35**. Juniper woodlands occur predominantly on private, unprotected land.



[**Figure VII.32** COMPARISON OF OCCURRENCE OF RARE PLANT SPECIES WITH LEVEL OF CONSERVATION PROTECTION AND INFILTRATION ZONES. Source: CalFlora]

Valley lands and grasslands are at high risk of loss to development (Mouat, 2004) and are under-represented in existing wildlife conservation plans (CEHC, 2010; Penrod, 2012). Many grasslands were developed for agriculture early on because of their gentle topography and high soil fertility. The extent of valley grasslands is shown in **Figure III.1.30.**

However, preserving small and isolated areas of each vegetation cover type is not enough. Connectivity is important, as well as preservation of large unbroken expanses of habitat away from human activity and 'edge' (Feenstra, 2014). Large unbroken expanses of habitat are recommended to ensure desert tortoise protection from raven predation (Kristan, 2001), since ravens are more numerous in edge environments.

As a charismatic species that is symbolic of the study area, Joshua tree woodland can be adopted, revegetated, and monitored by clubs and schools in citizen science projects.

Wetland habitats occur at Amargosa Creek and Piute Ponds. Other open bodies of water in the study area, including numerous small lakes, may also attract wildlife.

Finding synergy with rare plant occurrences

Occurrences of rare plants as shown in CalFlora are compared to the position of infiltration zones in **Figure VII.32**. Infiltration zones represent an opportunity to merge protection of vegetation with protection of rare plants.

With the exception of Edwards Air Force Base and Red Rock Canyon State Park, many rare plants are on private, unprotected land (**Figure VII.32**). A cluster of rare plants occurrences is situated in the approximate vicinity of Amargosa Creek in Lancaster, which runs parallel to the 14 Freeway. These plants are on privately owned land which appears to be at risk for increasingly dense development due to proximity to the freeway and other development.

Clusters of sensitive plant occurrences also occur around Piute Ponds and the open water portion of Amargosa Creek.

Opportunities for ecological infrastructure

Opportunities to address biodiversity preservation are shown in **Figure VII.34**. For readability, outlines are only approximated and may not indicate the full extent of the opportunity area.

1

STRENGTHEN PROTECTIONS OF JOSHUA TREE WOODLAND, DESERT SCRUB, JUNIPER WOODLAND, AND GRASSLANDS

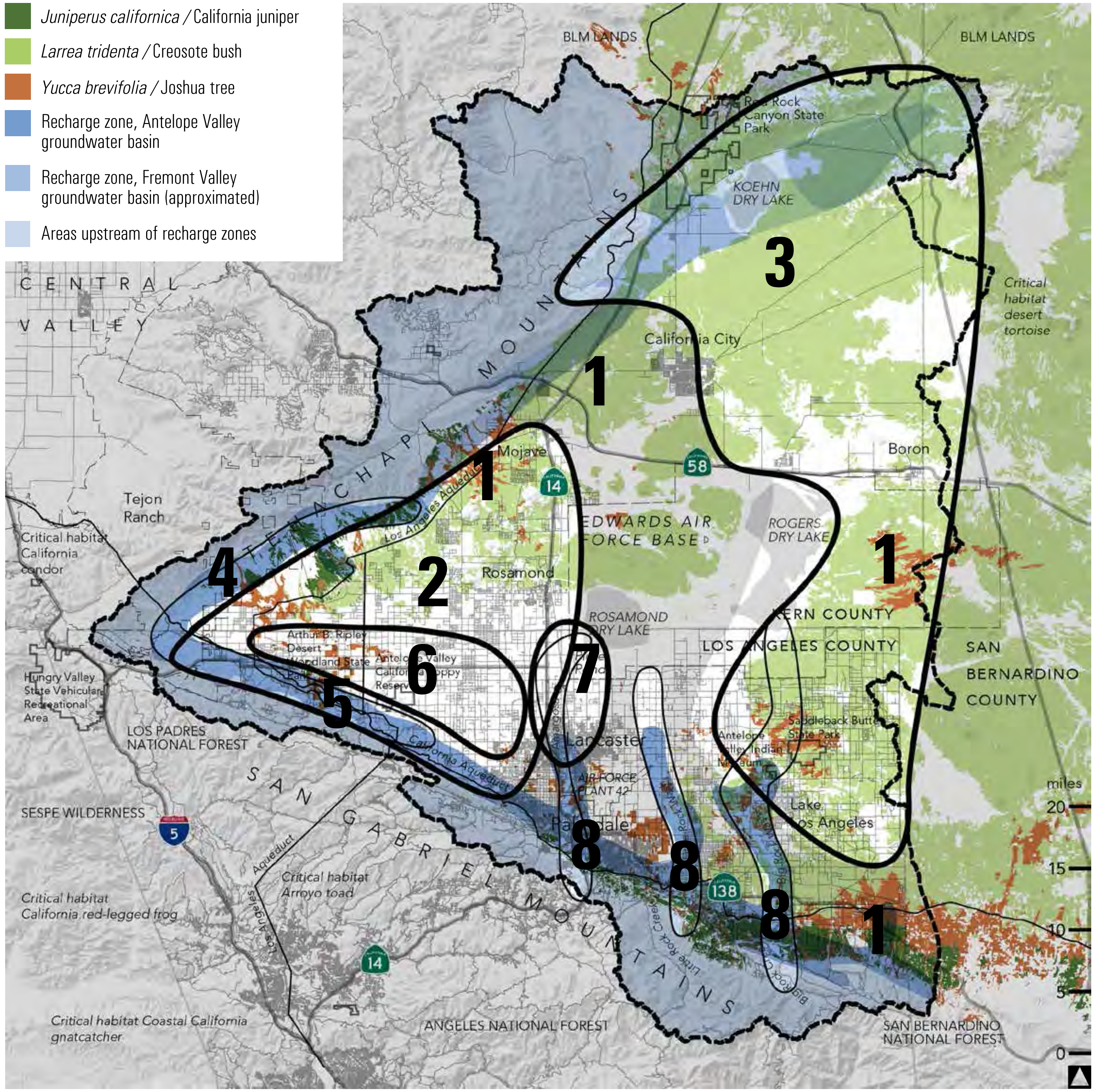
Protect these dwindling habitats that provide multiple ecosystem services, especially erosion control and wildlife habitat. Prevent and mitigate fragmentation of remaining habitat, which, combined with proximity to roads, is associated with high likelihood of common raven use (Coates et al., 2014, **Section II.3.8**).

2

CONSOLIDATE PATCHWORKED LAND USES TO FREE UP LARGE UNBROKEN EXPANSES OF DESERT HABITAT

This area is currently a fragmented patchwork of residential, agricultural, fallow land, and alternative energy farms. Such spatial fragmentation of land uses maximizes edge habitat. By consolidating and 'defragmenting' human uses, the habitat value of fallow land is maximized. Mechanisms for consolidating uses include trade and incentive programs.

[**Figure VII.33** ECOLOGY IN ACTION: STUDYING INTERACTIONS BETWEEN RAVENS AND OTHER BIRD SPECIES AT AMARGOSA CREEK.]



[**Figure VII.34** OPPORTUNITIES FOR ADDRESSING BIODIVERSITY.]

3

PRESERVE LARGE UNBROKEN EXPANSES OF DESERT SCRUB

The northeastern portion of the study area, in the vicinity of California City, is a critical area of potential conflict between biodiversity resources and anticipated growth. Here, large expanses of unprotected land are home to two protected species: Mojave ground squirrel (*Xerospermophilus mohavensis*) and desert tortoise (*Gopherus agassizii*).

Specialist bird species that use these large expanses of suitable habitat include Le Conte's thrasher (*Toxostoma lecontei*) and cactus wren (*Campylorhynchus brunneicapillus*).

Yet, this area has a relatively high rate of population growth (**Figure III.2.25**) and is expected to increase its urban development footprint significantly by 2050 (**Figure III.2.14c**). Additionally, numerous solar thermal sites are proposed (**Figure III.2.15**).

Since this area is especially dry (< 10" rain/year) and its soils have moderate wind erodibility. It would be expected that desert ecosystems in this area would be especially slow to recover from disturbance from construction and development.

Limits to development and the spread of edge effects can protect remaining habitat.

4

MANAGE GRASSLANDS FOR BIODIVERSITY

Promote scientific research on the relationships between grazing and native plant biodiversity on grasslands in the valley. Do the economic benefits of grazing outweigh the costs to the environment in terms of erosion, loss of flood control, and biodiversity?

5

MANAGE PRIVATE LAND AROUND SMALL RESERVES TO MITIGATE THE ISOLATION OF THE RESERVES

Isolated reserves include Antelope Valley California Poppy Reserve, Arthur B. Ripley Desert Woodland State Park, Antelope Valley Indian Museum, Saddleback Butte State Park, and Phacelia Reserve. Incentivize land use practices on private land around these reserves to optimize wildflower display, biodiversity, and habitat value. Harness local citizen scientists to gather data on factors affecting declining species such as burrowing owls (*Athene cunicularia*) or tricolored blackbirds (*Agelaius tricolor*), etc.

6

MANAGE AGRICULTURAL LAND TO MAXIMIZE HABITAT FOR DECLINING GRASSLANDS AND WETLANDS SPECIES

Promote organic agriculture, integrated pest management, pollinator habitat, and crops that have high habitat value.

Numerous bird species that once depended on grassland and wetlands habitats are increasingly dependent on agricultural landscapes for habitat. Though this study recommends restoring wetlands, grasslands, and hydrological functioning in the study area, additional biodiversity gains may be attained by managing agricultural landscapes to benefit wetland and grassland species.

Comparison of a conventionally harvested alfalfa crop with an organic field flood-irrigated with recycled water shows

But aren't all seeds the same?: Protecting local genetic biodiversity

Vast fields of wildflowers which attract throngs of visitors in spring are a unique biological resource. Study area wildflowers have evolved over millennia to survive in the desert: it is important to avoid contamination of native genotypes of wildflowers with strains of native wildflowers from different locations.

> Plants living in an environment over many generations become adapted to the specific environment—those plants that have features that suit them to the habitat are more likely to survive than those that don't, and these plants are the parents of subsequent generations. Where California poppies grow naturally, they are "fine-tuned" to their environment. (Clark, n. d.)

In the Mojave, annuals have evolved a strategy of "bet hedging" where different seeds from the same plant may germinate over a period of years. The important role seed dormancy plays in the survival of desert wildflower species is discussed in detail in **Section III.1.5.b**. In contrast, commercially produced 'native' wildflower seed is selected for traits that perform well in gardens. Not only is commercially produced seed likely to germinate easily and all at once (unlike their wild relatives) but they are also likely to be physiologically uniform in other respects (USDA, n. d.).

When poppies from commercially produced seed genetically mix with locally evolved poppies, genetic contamination of native poppies with nursery-bred strains of poppies can result in the loss of local biodiversity—even if both are technically the same species, '*Eschscholzia californica*.' Genetic contamination can lead to loss of adaptations to the local environment, and can contribute to the decline of locally adapted wildflower species (Clark, n. d.).

Any campaign to promote restoration or native gardening should also involve education about the importance of preserving native genetic diversity by using seed that originates from locally occurring plant populations.

[**Figure VII.35a-b** ORGANIC FIELD FLOOD-IRRIGATED WITH RECYCLED WATER VERSUS CONVENTIONALLY HARVESTED ALFALFA CROP.] Diverse wildlife was seen on the organic flood-irrigated field. No wildlife was seen in the conventional field. Management techniques can affect the value of agricultural fields for wildlife.]

the importance of management techniques in affecting biodiversity (**Figure VII.35a-b**).

Though agricultural landscapes have become important surrogate habitat for bird life (Garrett, 2014), agricultural landscapes may not provide the full range of nutrients of functioning wetlands (Garone, 2011). Additionally, functioning wetlands and grasslands do not pit harvest against nesting birds, as occurs in agricultural fields, where harvests must be timed to avoid conflict with bird life cycles. Thus, agricultural habitat is only meant to supplement restoration of true wetland habitats.

7

AN OPPORTUNITY FOR A BIODIVERSITY PARK

The proximity of several hotspots of bird life (Amargosa Creek, Piute Ponds, and Apollo Community Regional Park) suggest the potential for a linkage opportunity that would double as a wildlife habitat park (**Figure VII.37**). The confluence of bird life at these centers is an opportunity to celebrate the phenomenon of seasonal migration, wetland habitat, and numerous rare plant species that exist in close proximity to an urbanizing area (**Figure VII.32**).

An existing open section of Amargosa Creek (**Figure VII.36**) would provide recreational opportunities for nearby communities. In previous years, Least Bell's vireo (*Vireo bellii pusillus*) has been seen in this location. Management for biodiversity could increase the chances of this species' return.

Nearby Apollo Community Regional Park is a popular place for family picnics (**Figure VII.39**). Though the birding community knows of its value as stopover habitat for migrants (**Figure VI.40a-b**), attention to improving habitat in the park with the involvement of the public could enhance its recreational, esthetic, and biodiversity value.

Piute Ponds, managed by Ducks Unlimited, is not currently publicly accessible. This wetland is a favorite of birders. (**Figure VII.38**).

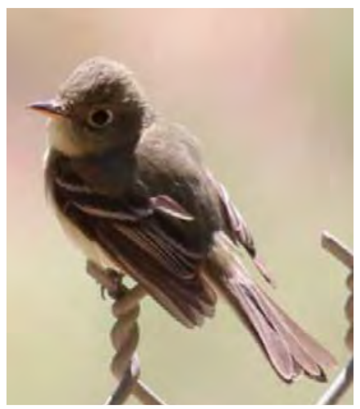
Other public parks currently managed as infiltration basins may also be managed for habitat value.

Genetic contamination of native poppies with nursery-bred strains of 'native' poppies can result in the loss of local biodiversity—even if both are technically the same species, *'Eschscholzia californica'* (Clark, n. d.).

[**Figure VII.36** OPEN SECTION OF AMARGOSA CREEK.]

[**Figure VII.37** CONNECTING URBAN WILDLIFE PARKS.] Proposed park outline, encompassing prime birding locations and locations of rare plants

[**Figure VII.38** WETLANDS SUPPLEMENTED BY RECYCLED WATER AT PIUTE PONDS.]



[**Figure VII.40a** HERMIT WARBLER, ONE OF THE MANY MIGRATING BIRDS MAKING USE OF APOLLO PARK. Source: Jon Feenstra]

[**Figure VII.40b** PACIFIC-SLOPE FLYCATCHER, ONE OF THE MANY MIGRATING BIRDS MAKING USE OF APOLLO PARK. Source: Jon Feenstra]

[**Figure VII.39** APOLLO COMMUNITY REGIONAL PARK.]

8

MANAGE SEASONAL WATERWAYS AS LINKAGE CORRIDORS

Moving the linkage proposed by Penrod (2012) (**Figure II.20**) slightly west to coincide with natural washes will enable it to be combined with other functions such as maximizing infiltration, recreational opportunities, and urban connectivity.

Big Creek drainage may provide a connectivity opportunity for Saddleback Butte State Park, which is otherwise isolated.

Because of its year-round flow and its linkage of the San Gabriels with Rosamond and Rogers Dry Lakes, Amargosa Creek has high potential to improve wildlife connectivity. However, the creek runs along the 14 Freeway in the most developed part of Lancaster and Palmdale. Portions of the creek were recently encased in a pipe for flood control purposes. The conversion of Amargosa Creek into an effective wildlife corridor poses logistical and design challenges, but could have dramatic quality of life benefits for local communities. Numerous river restorations throughout the world show the value to urban cultural life of linear river parks.

The restoration of wildlife connectivity to parts of Amargosa Creek that are currently underground is an exciting design challenge.

"Many scientists concerned with the complex problems of sustainable development have highlighted that if our final objectives are to foster informed decision making; transform attitudes, behavior, and institutions; and develop appropriate capacity, competencies, and ownership, then the way we conduct our science needs to change"

(Reyers, 2009, p. 38).

9

ENGAGE THE COMMUNITY IN BIODIVERSITY MANAGEMENT

Incorporate opportunities to involve local communities in biodiversity management through employment, education, celebration, and citizen science.

Incentivize land management practices that promote biodiversity on private lands: maintain native land cover, provide native pollinator habitat, and managing agriculture for biodiversity.

[**Figure VII.41** UNDERSTANDING THE MYSTERIES OF WILDFLOWER BLOOM.]

10

OPTIMIZE ECOSYSTEM SERVICES

To preserve genetic diversity and resilience, use only native genotypes in revegetation efforts.

USING CITIZEN SCIENCE TO UNDERSTAND THE MYSTERIES OF WILDFLOWERS

Some locals, such as Milt Stark, believe that limited sheep grazing may enhance local wildflower bloom (Breault, 2003). Stark points out that grazed areas adjacent to the reserve may be more floriferous than the reserve itself, where grazing is prohibited. He suggests further study to determine the effects of grazing (whether disturbance by sheep hooves may enhance infiltration or germination, or fertilization by sheep scat may improve soil quality). Though Clark and Charest (1992) published two studies on factors affecting species distribution at the reserve, there do not appear to have been studies of grazing in relation to blooms, or flower displays outside the reserve.

Citizen science can provide opportunities to gather information useful in biodiversity management. Training and participation of lay enthusiasts can build stewardship of local natural resources. Like in eBird, where participants input point data that clarifies large scale trends (Garrett, 2014), data collected by citizen scientists is structured and vetted by professional ecologists.

[**Figure VII.42** ENTERING DATA ON LOCAL PHENOLOGY IN LAKE LOS ANGELES. Source: Citizen scientists by Garth Cripps adapted to Lake Los Angeles setting]

[**Figure VII.43** ECOLOGY IN ACTION: VARIETAL HONEYS FROM LOCALLY DOMINANT FLOWER SPECIES. Source: Adapted from Beverly's Bees]

ECOLOGY IN ACTION

Engaging communities in celebrating natural resources can go beyond informational panels in nature parks. Here are just some ideas:

- Engage Citizen Science to map behavior and distribution of charismatic local species that have conservation value (**Figure VII.42**).
- Create a guidebooks and events that celebrate the study area as a unique part of the Mojave: birds, butterflies, plants, animals, history.
- Celebrate the migratory season. Though birders from the Los Angeles metropolitan region travel to enjoy this phenomenon the study area, it remains obscure to locals.
- Create maps and events to celebrate the unique floral composition associated with each town in the study area: Fairmont, Lake Los Angeles, Rosamond, etc. (**Figure VII.41**)
- Cultivate local industries that celebrate biodiversity, such as varietal honey (**Figure VII.43**).

VII.4.3 WATER CYCLE

Making more water at the source

With the future of imported water supplies in question, local groundwater sources are likely to be an increasingly important source of local water supply. Recharge is discussed in detail in **Section III.1.3.b**. Mountain front recharge zones as indicated by Leighton and Phillips (2003) are shown in **Figure III.1.10**.

Recharge of the Antelope Valley groundwater basin is primarily provided by Big Rock and Little Rock Creeks, which drain from the San Gabriels (USGS Bulletin 118, n. d.) and supply a volume of water an order of magnitude above the total recharge provided by the numerous smaller creeks in the San Gabriels and Tehachapis (Duell, 1987). Infiltration zones for the Antelope Valley groundwater basin occur on private land, with a significant portion in the grazed grasslands of Tejon Ranch.

Given fixed slope and soil characteristics, conditions that enhance infiltration are vegetation cover, the presence of a topsoil layer whose porosity has been enhanced by insects and burrowing animals, and the absence of activities that lead to soil compaction (Fetter, 1980). In otherwise identical landscapes with sandy loam and rolling hills, a wooded landscape would absorb far more precipitation before surface runoff occurs than a cultivated landscape. The latter would be expected to produce up to four times the amount of runoff as a wooded landscape (Marsh, 2010). This runoff is water that would otherwise be stored in the ground, recharging aquifers, and serving plant communities and streams.

Basic measures to enhance the infiltration capacity of recharge zones in the study area include 1/ maximize native vegetative cover, 2/ allow the development of topsoil to support soil biota and wildlife, and 3/ avoid land uses that cause soil compaction. These measures can occur within the recharge zones as well as upslope of these zones.

Current land uses in study area infiltration zones, however, do not maximize the landscape's infiltration capacity.

Little Rock Creek, along with Big Rock Creek, is one of two key suppliers of groundwater recharge to the Antelope Valley

[**Figure VII.44** HILLS OF TEJON RANCH THAT FEED INTO STUDY AREA INFILTRATION ZONES.]

Ecosystem services provided by vegetative cover also include facilitation of infiltration of precipitation into the ground, to eventually replenish the groundwater table.

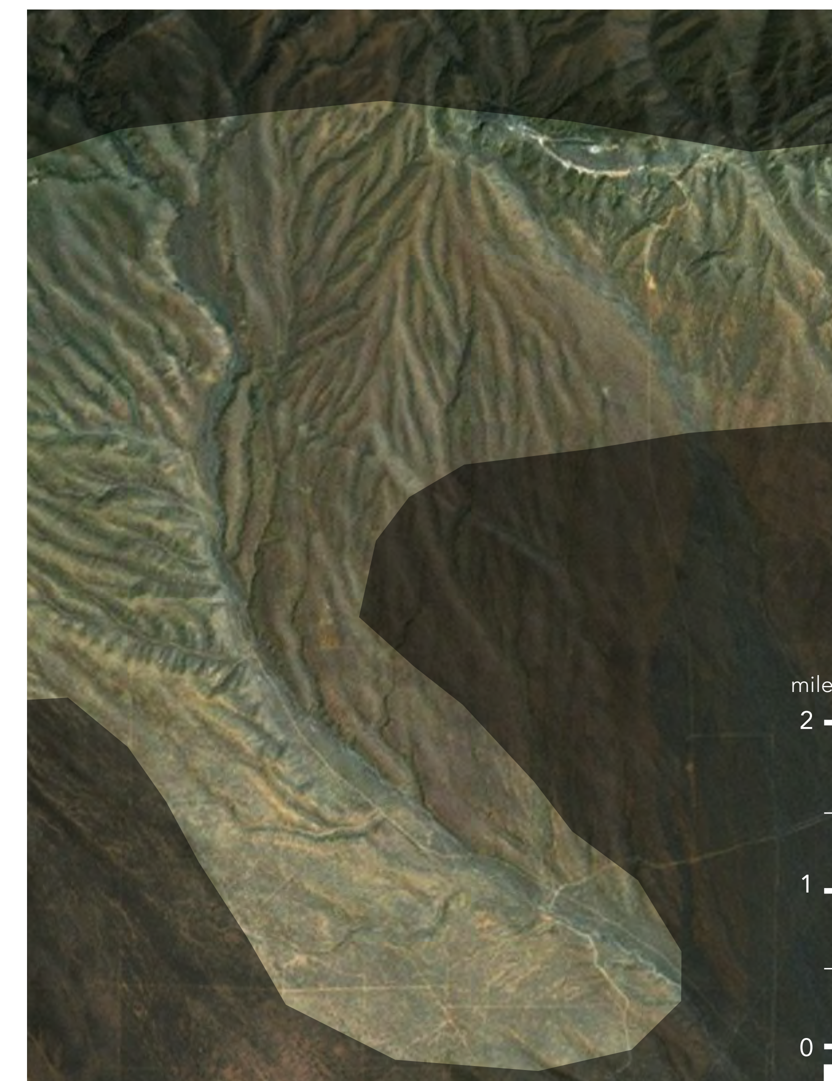
groundwater basin, but is largely in land uses that reduce or remove vegetation cover. A substantial portion is covered with impermeable surfaces (**Figure VII.45**). Maximizing native vegetation, soil development, and reducing the amount of impermeable surfaces in this recharge zone would be expected to increase infiltration into the groundwater basin, while reducing the extent of flooding in the valley (**III.1.17**).

The canyons on the Tehachapi mountains are sparsely developed compared to those in the San Gabriels. A visit

[**Figure VII.45** DENSE DEVELOPMENT WITHIN THE INFILTRATION ZONES OF LITTLE CREEK, RIGHT, AND ADJACENT CREEK.]

[**Figure VII.46** DENUDED WATER WAY AT TEJON RANCH.]

[**Figure VII.47** GULLYING AT BRONCO CANYON, TEJON RANCH.]

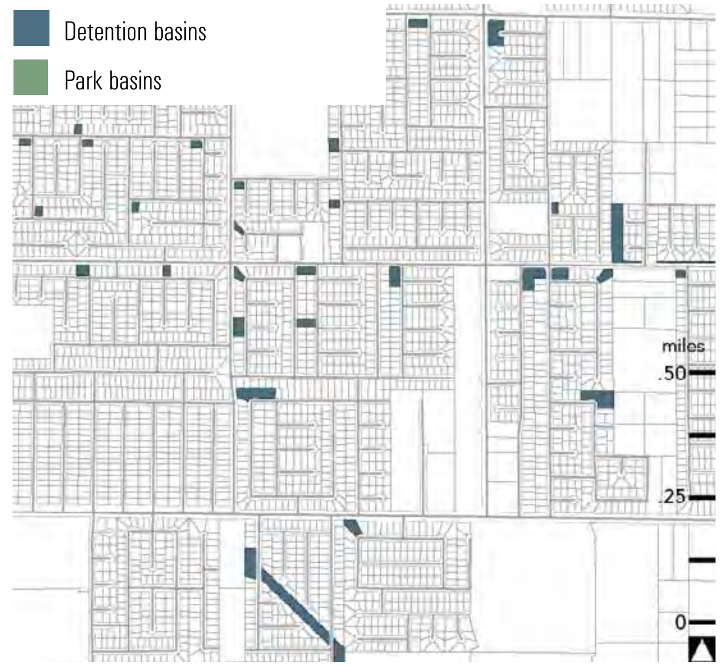


[**Figure VII.48** EROSION IN THE INFILTRATION ZONE AT COTTONWOOD CREEK. Source: Infiltration zone from Leighton & Phillips] to Bronco Canyon on Tejon Ranch, however, revealed the extent of heavy grazing on the infiltration zones on the Tehachapi side (**Figure VI.44**). Because of the near absence of vegetative cover besides exotic annuals and wildflowers, the ability of vegetation to enhance infiltration and slow overland flow is reduced. Except for isolated instances, riparian vegetation is grazed down or absent. Erosion-slowing riparian vegetation is nearly absent in most drainage areas (**Figures VII.46**), and and gullying is evident (**Figure VII.47**). Aerial views of the Tehachapi foothills show a lack of vegetation (**Figure VII.48**).

Since these hills are significant pathways for water that infiltrate into groundwater basins, management of these zones to maximize infiltration can help increase study area's local groundwater supplies while reducing flooding in the valley. It is conceivable that increasing vegetation in these zones may also reduce the amount of sediment washing into streams, thus the supply of windborne dust.

Infiltration basins in developed areas

Because of the limited infiltration capacity of the valley, detention basins are scattered throughout Lancaster and Palmdale (**Figure VII.49**). In many instances, parks are built to serve flood control functions (**Figure VII.50**), where excess water may be conveyed to regional basins, or be allowed to evaporate. Generally, detention basins are cleared of vegetation to maximize capacity.



[**Figure VII.49** DETENTION BASINS IN PALMDALE, SOME DOUBLING AS PARKS. Source: City of Palmdale]

Recycled water

Recycled water is currently used for some agriculture (**Figure VII.35a**) and in Piute Ponds (**VII.38**). Generally, the use of recycled water in the study area is still low compared to the amount of water used from other sources (**Figure III.1.14**).

[**Figure VII.50** TWO DETENTION BASINS IN PALMDALE, INCLUDING QUINONES PARK. Source: Google]

Opportunities for managing the water cycle

Opportunities for addressing the water cycle are shown in **Figure VII.52**.

1

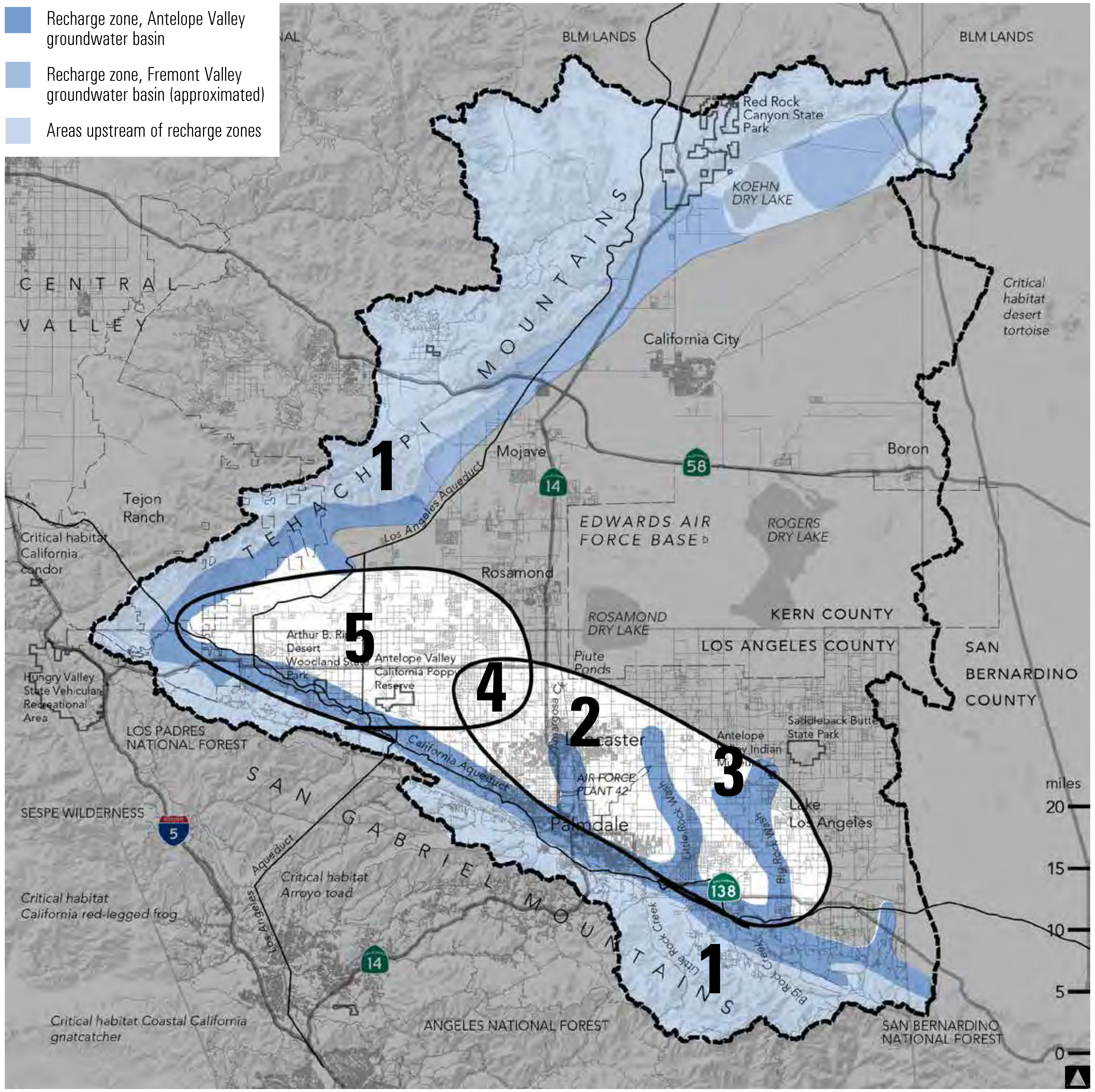
MANAGE INFILTRATION ZONES AND UPLAND AREAS FOR MAXIMUM INFILTRATION (IMPROVED HABITAT VALUE IS AN ADDED BONUS)

The recharge of groundwater supplies via groundwater basins can be maximized by ceasing additional development in and upslope of infiltration zones. Planting native vegetation propagated from local genotypes of plant material in any devegetated or sparsely vegetated areas will slow surface runoff and erosion, while enhancing infiltration. These zones, among the most biodiverse in the study area, can also be managed for habitat value.

Much of the grassland in the western portion of the study area has been overgrazed (**Figure VII.51**). In these areas, revegetation and restoration of waterways cannot occur without limits to grazing. In some watershed restorations, fencing around riparian areas allows continued grazing while providing some measure of protection to waterways and infiltration capacity.

Arthur B. Ripley Desert Woodland State Park and Antelope Valley California Poppy Reserve are adjacent to infiltration zones. Restoration of vegetative cover in those zones, along with stricter limits on grazing, may enhance the ecological connectivity of those isolated reserves.

[**Figure VII.51** GIVEN IDENTICAL SOIL AND SLOPE CONDITIONS, WELL VEGETATED HILLS WILL ALLOW MORE WATER TO INFILTRATE THAN CULTIVATED LANDSCAPES.]



[**Figure VII.52** WATER MANAGEMENT OPPORTUNITIES.]

Promote the production of crops that have low water needs. It has been said that "nothing is grown in the Antelope Valley that could not be grown cheaper elsewhere; the fact that farming continues merely reflects its initial foothold in the local economy"

(Eberhard Architects, 2009, n. p.).

2

EXPAND THE USE OF RECYCLED AND GRAYWATER

Expanded use of recycled and gray water would ease pressure on groundwater and imported water supplies.

Recycled water is produced at an industrial scale at wastewater treatment plants. Graywater systems may be designed on a household scale or on a larger commercial scale.

3

MAKE A LITTLE WATER GO A LONG WAY

Evapotranspiration in the desert region is high, which means overhead irrigation also ends up cooling the air through evaporation. The effectiveness of irrigation for cooling outdoor spaces can be maximized in spaces sheltered from the wind. In this context, the judicious use of irrigation can help create comfortable outdoor spaces that broaden the range of social, cultural, and recreational opportunities for study area residents.

4

CONSOLIDATE AND MERGE LANDSCAPE USES THAT REQUIRE IRRIGATION

Ornamental landscapes require irrigation but produce only visual value. The production of certain agricultural crops and forage in a residential setting would reduce water lost to evapotranspiration, reduce the amount of irrigated landscape over all, and bring agriculture and food production closer to urban centers, where employment opportunities are needed.

5

REASSESS LAND USES THAT REQUIRE LARGE AMOUNTS OF WATER

Some agricultural crops require larger amounts of water and have less wildlife value or higher environmental cost.

Promote the production of crops that have low water needs.

It has been said that "nothing is grown in the Antelope Valley that could not be grown cheaper elsewhere; the fact that farming continues merely reflects its initial foothold in the local economy" (Eberhard Architects, 2009, n. p.).

Consider the economic value of grazing and livestock production in light of the loss of erosion control, infiltration services, and biodiversity caused by overgrazing.

6

IMPLEMENT MEASURES THAT PROTECT GROUNDWATER QUALITY

Because the study area is a closed basin where contaminants accumulate in the soil and groundwater table, the use of pesticides should be limited. Promote the production of crops that can be grown using only biological pest controls.