Large-scale solar energy project development on alluvial fans

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ESA PWA

Agenda

- Scale of renewable energy projects in the desert southwest
- Effects of disrupting ephemeral channels on desert ecology
- Alluvial fans as sediment sources for dune-based ecosystems

Acknowledgements:

California Energy Commission
California Public Utilities Commission
Aspen Environmental

ESA PWA

Overview of Solar Energy Development in Southern California

- In 2007 12% of California's retail electricity was from renewable sources (excluding large hydro)
  - ("renewables" = solar, wind, geothermal, small hydro)
- California's Renewable Portfolio Standard has the goal of generating 33% of retail electricity from renewable sources by 2020
- Scale – 11 large solar projects currently proposed, with approx 5-10 sq miles of direct impact per project, plus indirect impacts
- 20-30 more projects in the pipeline
- 20 projects = 1 x Sacramento

Proposed solar plants >50MW

U.S. Approves California Solar-Thermal Plant, World's Largest

By Jim Efstathiou Jr. - Oct 25, 2010 1:48 PM PT

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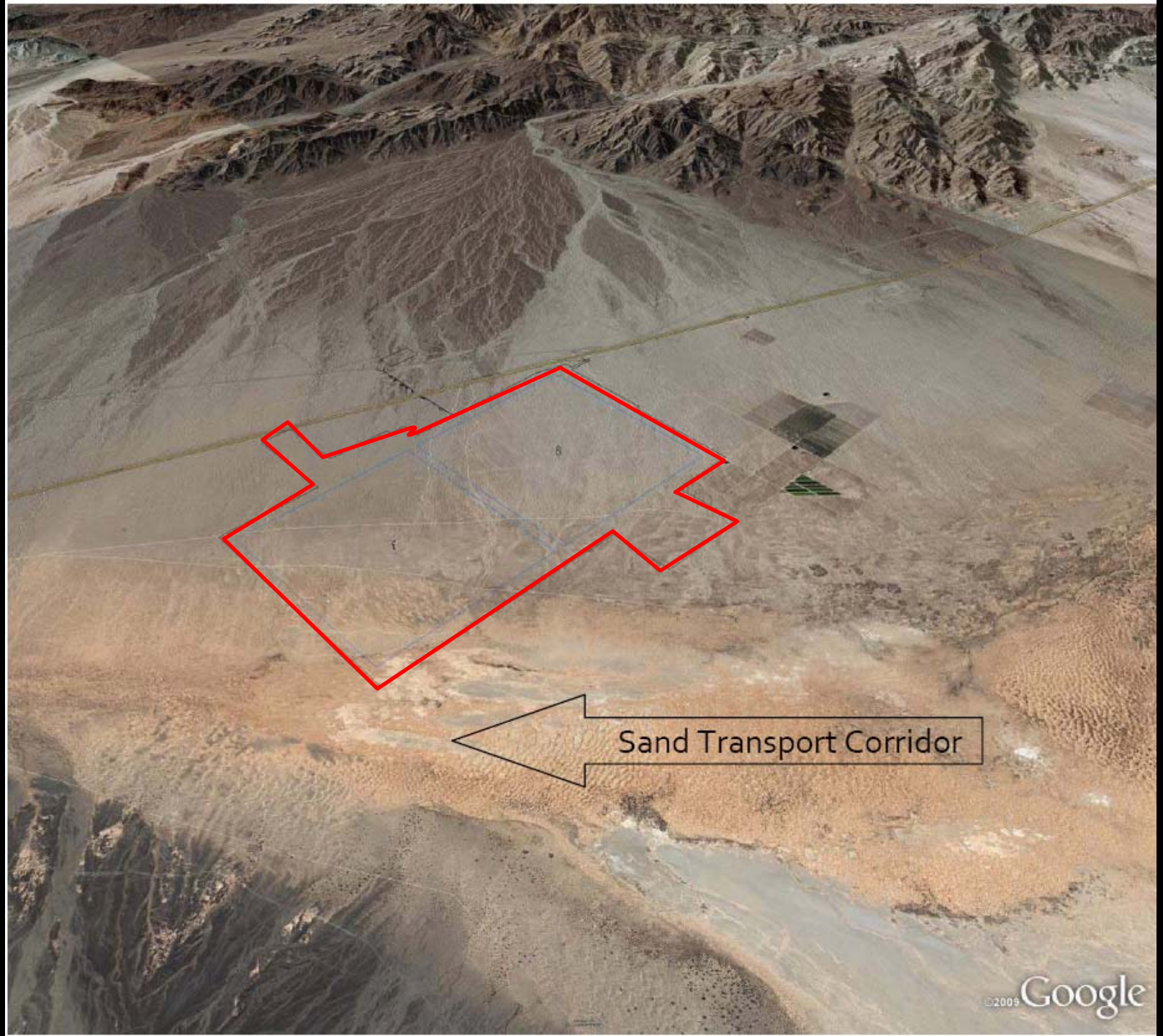
An artist rendering of the Blythe Solar Power Project. Source: Solar Trust of America, LLC

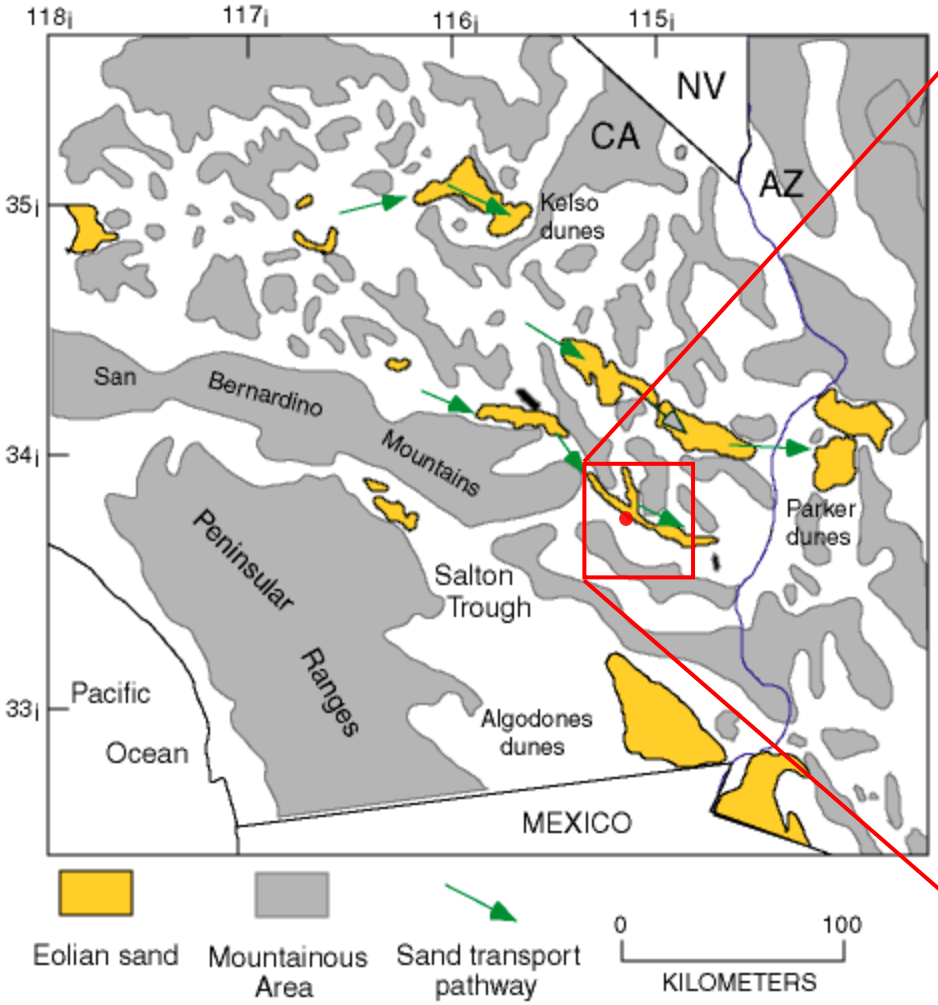
The world's largest power plant using heat from the sun to generate electricity, a planned $6 billion project in California, won approval from U.S. Interior Secretary Ken Salazar.

Solar Millennium LLC of Oakland, California, agreed to fund conservation measures protecting the desert tortoise and Mojave fringe-toed lizard in return for permission to build the Blythe Solar Power Project on public land, the Interior Department said today. Blythe will use mirrors to concentrate the sun's energy rather than solar panels that convert light directly into electricity.

"It's one of those marquee projects that I'm very proud of," Salazar said in an interview before announcing the sixth and largest solar project for U.S. land this month. "We'll demonstrate to the world that we can have large-scale solar projects here in the United States and that they are very much a real part of the


Sand Transport Corridor
©2009 Google

Ephemeral channels and aeolian corridors are the link between headwater sediment sources and downwind dune habitats



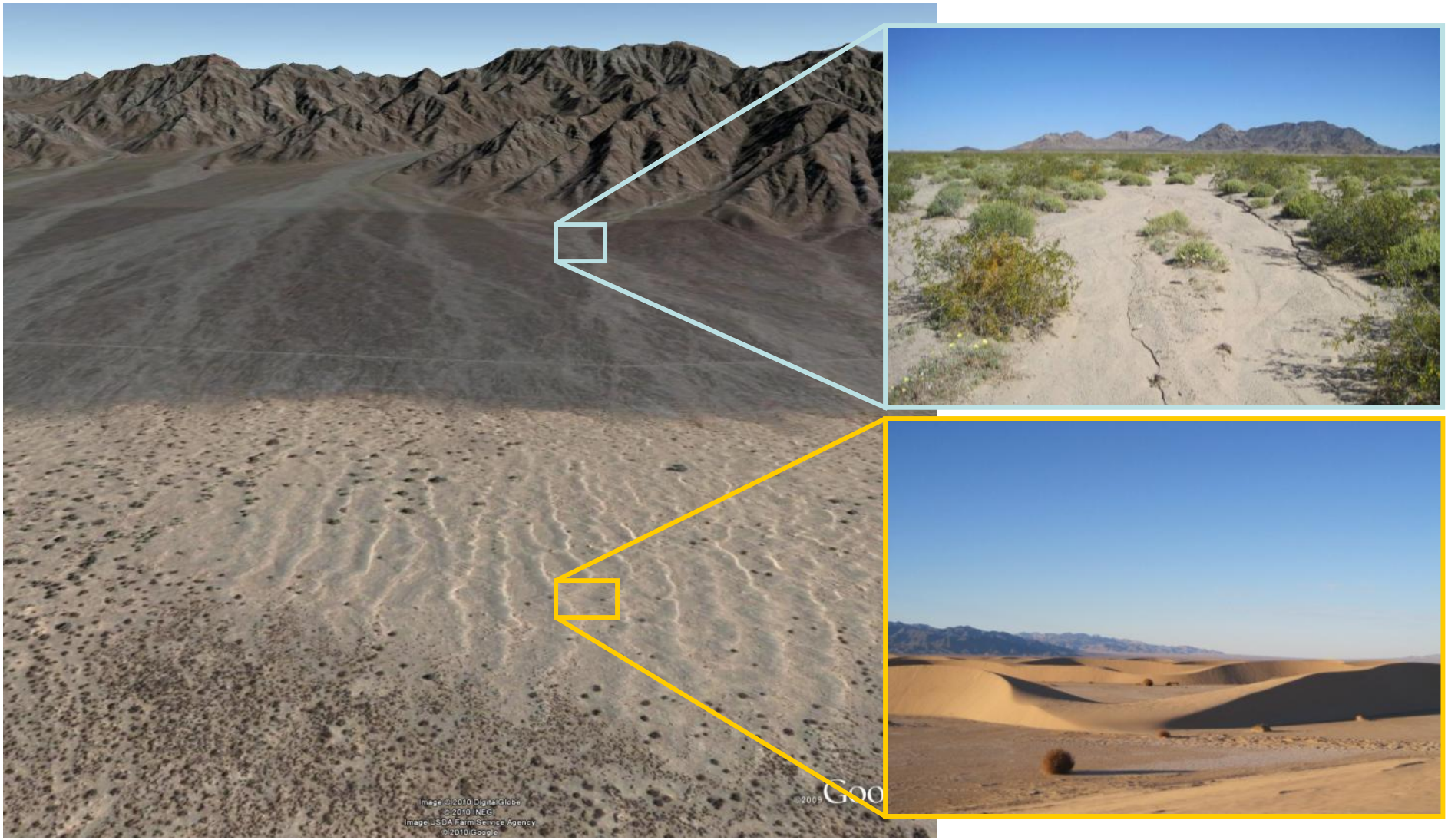
Muhs et. al. 2003

Impacts of solar development on alluvial fan environments

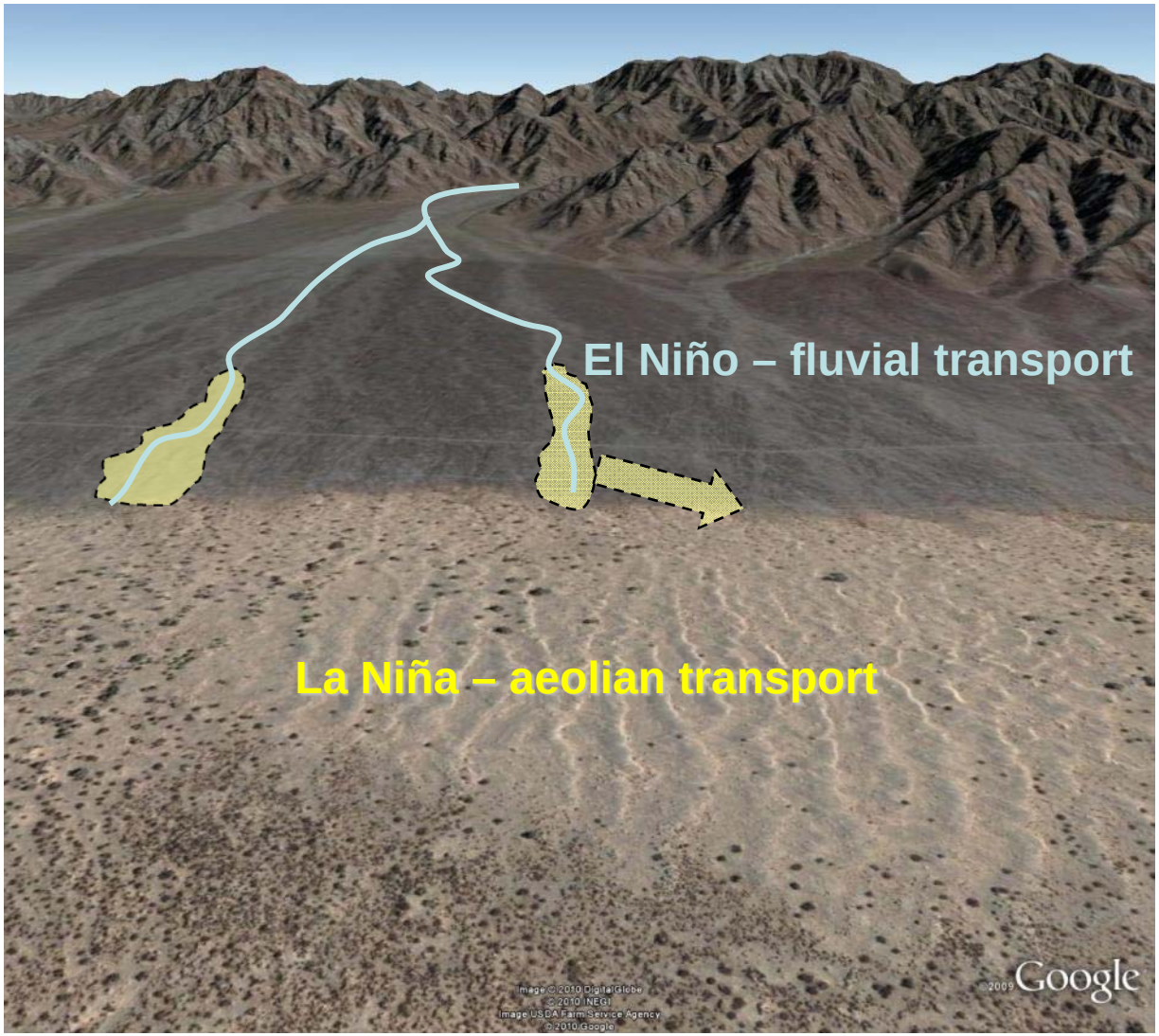
- Direct impacts from size of project footprint (~5 sq miles each)
- Habitat connectivity barriers
- Bird impacts (dazzle and frazzle)

- Disruption to drainage network
- Disruption to dunes by blocking aeolian transport

Sediment transport in the alluvial fan environment



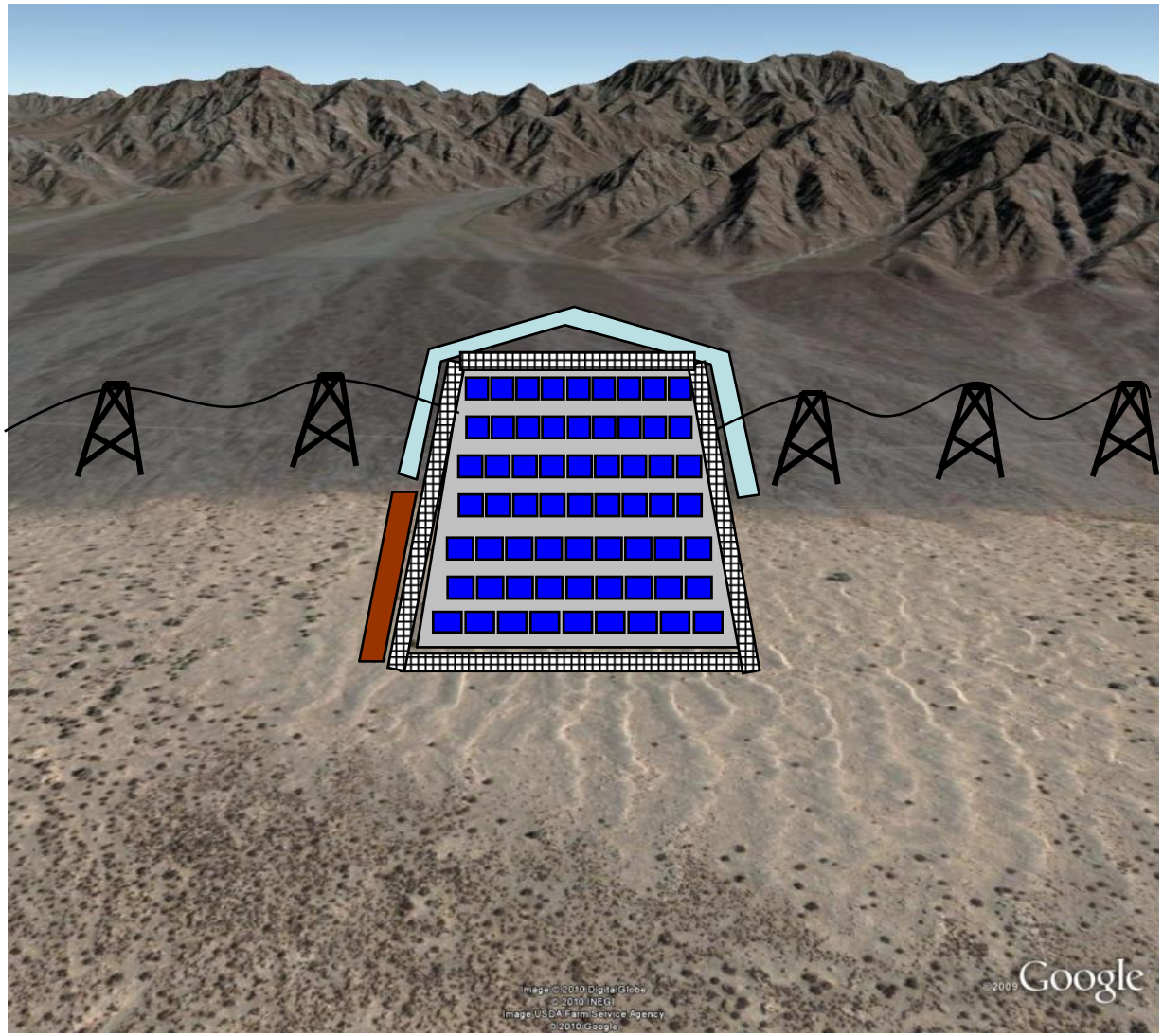
Sediment transport in the alluvial fan environment



El Niño
- wetter winters
- sediment production in ranges and delivery to alluvial fans
- vegetation stabilizes sediment

La Niña
- drier winters
-sparse vegetation
- sediment entrained from fans into dunes

Sediment transport in the alluvial fan environment



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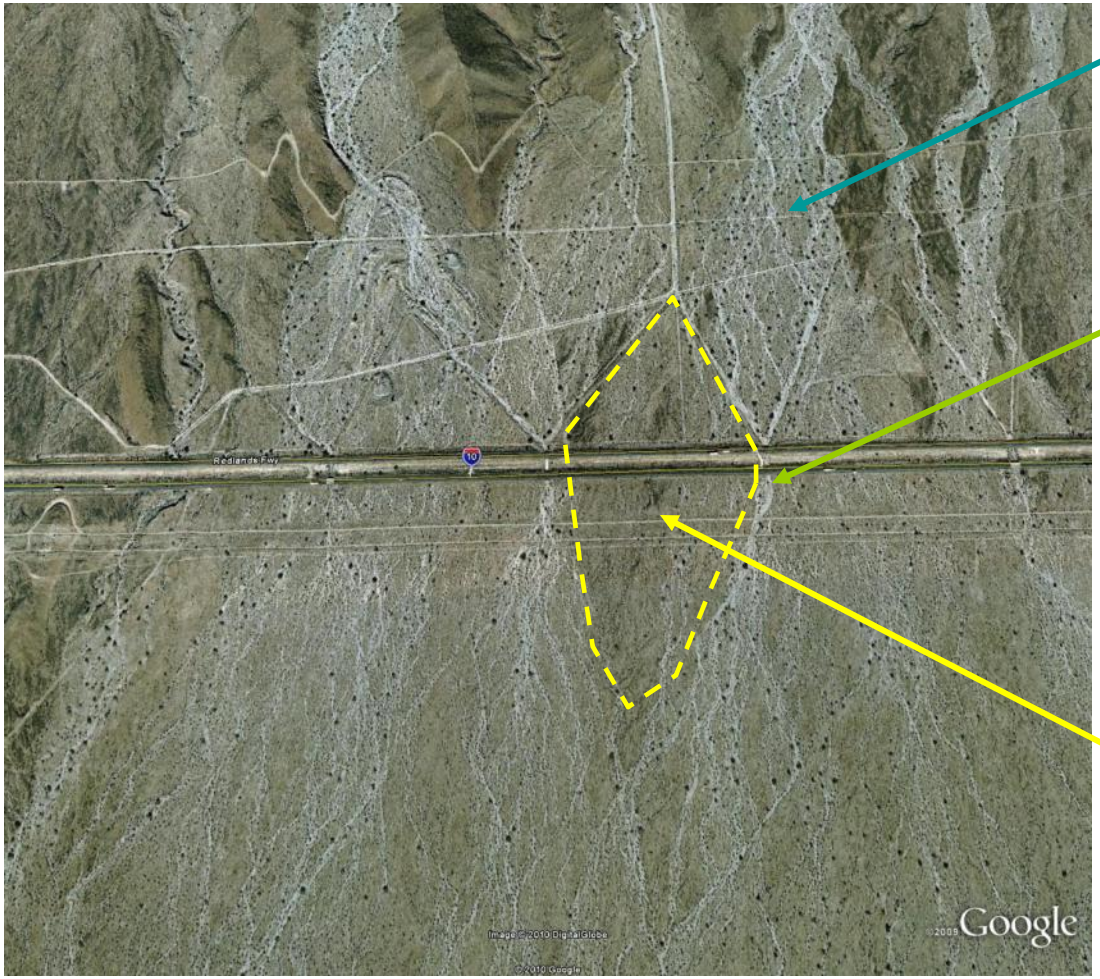
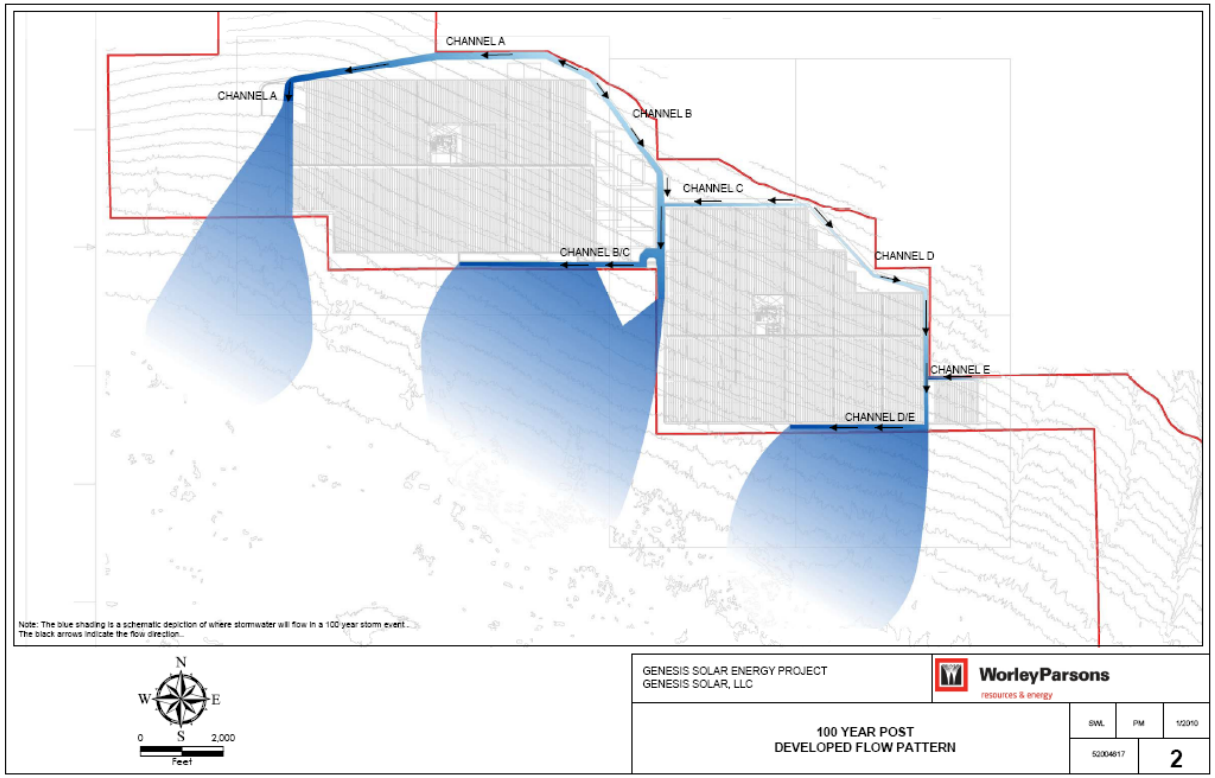
Effects on vegetation and sediment transport



Schlesinger, W. H., and C. S. Jones (1984). The comparative importance of overland runoff and mean annual rainfall to shrub communities of the Mojave Desert, Botanical Gazette, 145, 116-124.

Potential mitigation – flow dispersion

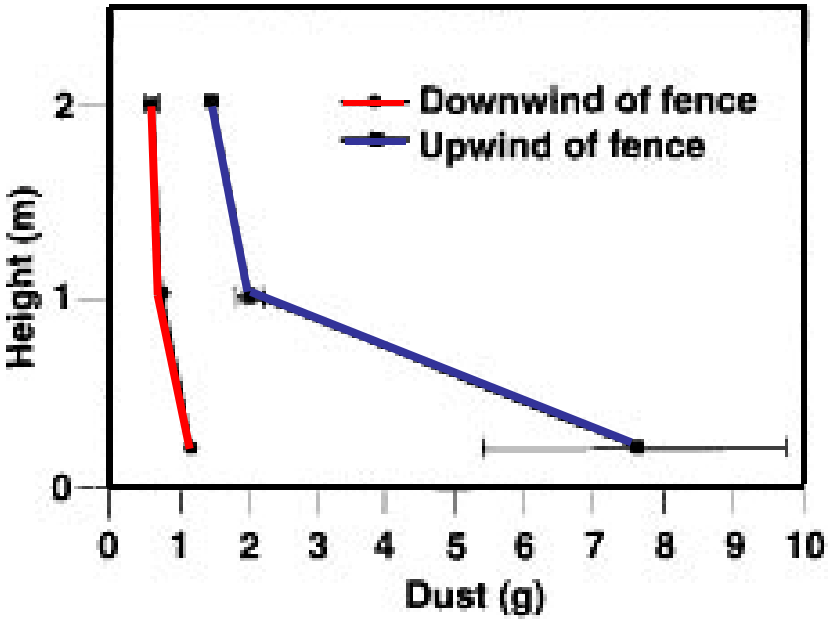


How effective are water dispersal systems likely to be during events that move sediment?

Fences and other obstructions trap wind blown sand, depleting areas downwind to create a ‘sand shadow’

Wind fences provided effective control of blowing fugitive dust in areas with over-blown sand that resisted revegetation efforts.

Grantz et. al 1998



Wind fences in Antelope Valley, Western Mojave Desert, reduced dust transport by 80% close to the ground level. Note that due to its greater mass, sand is more effectively trapped by obstructions than dust.

When upwind sand supply is disrupted sand dunes rapidly erode and lose habitat value

Long-Term Sand Supply to Coachella Valley Fringe-Toed Lizard (*Uma inornata*) Habitat in the Northern Coachella Valley, California

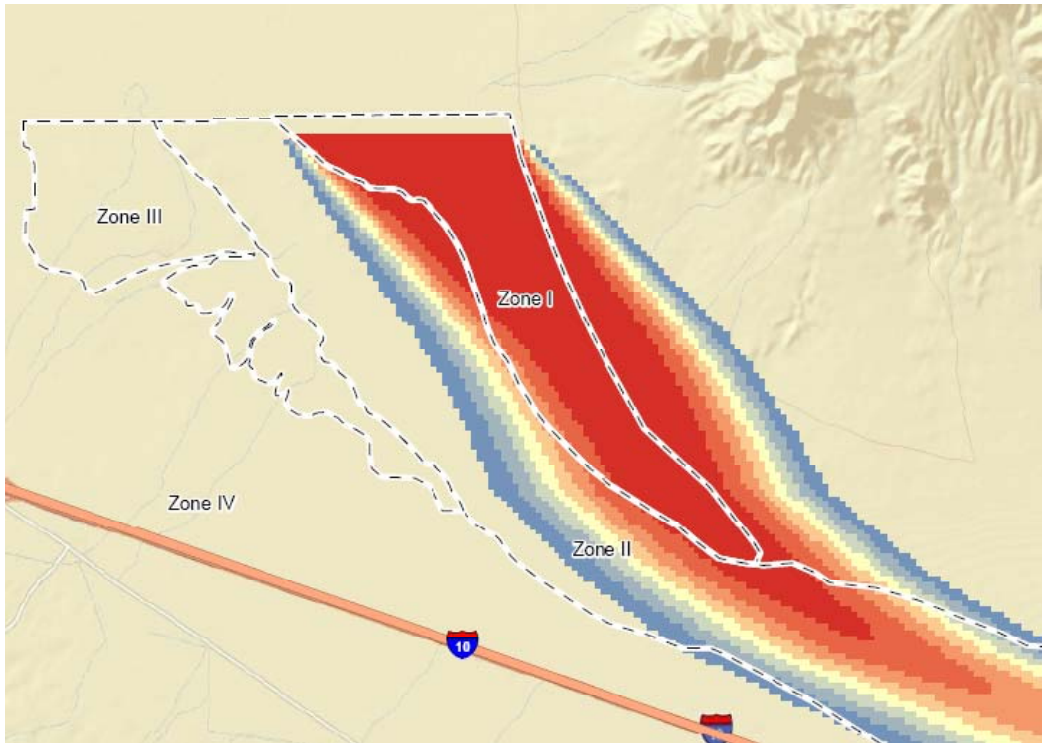
By Peter G. Griffiths, Robert H. Webb, Nicholas Lancaster, Charles A. Kaehler, and Scott C. Lundstrom

It is also likely that the eolian-transport rates are less than used in this analysis, because they are reduced by the presence of vegetation in the transport corridors. As a result, the depletion times in table 16 should be regarded as minimum values. In general, however, the eolian removal of expected annual sediment yields in approximately one year – both before and after development – is consistent with the presence of persistent sand dunes in the Coachella Valley.

Table 16. Eolian depletion rates of fluvial sediment deposited in depositional areas upwind of the Coachella Valley reserves.

Depositional area	MONTHS TO REMOVE ALL SAND		MONTHS TO REMOVE "UMA SAND"	
	Renard (1972) equation	Flood-frequency method	Renard (1972) equation	Flood-frequency method
		Historic record		
San Gorgonio/ Whitewater	12.9	25.3	2.5	4.9
Mission/Morongo	8.0	17.6	1.7	3.8
Long Canyon	3.6	7.4	0.8	1.7
		Modern record		
San Gorgonio/ Whitewater	15.7	30.3	4.1	8.1
Mission/Morongo	8.0	17.6	1.7	3.8
Long Canyon	7.8	17.3	2.0	4.4

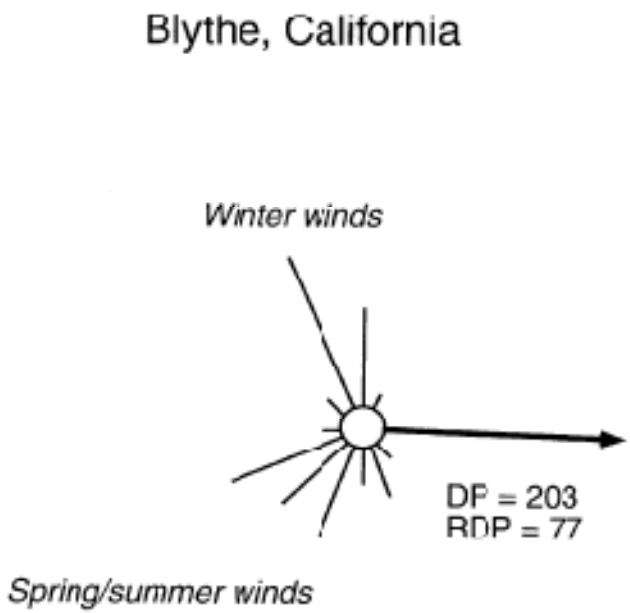
Calculating the area of indirect impact due to sand transport obstruction

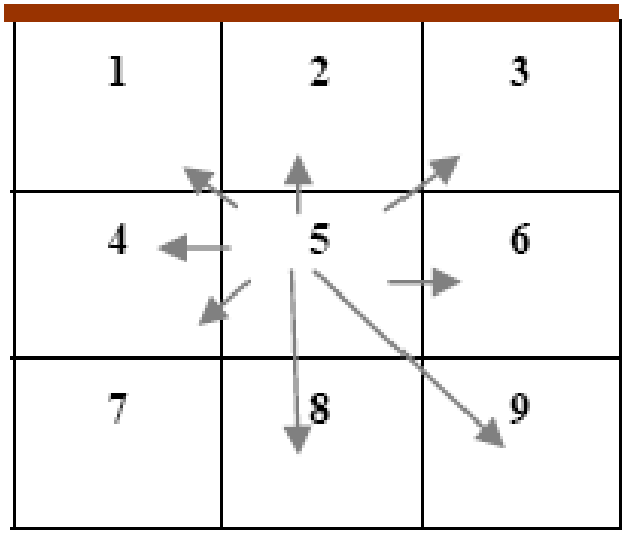


A model of wind transport for sand based on prevailing sand transport direction and wind distribution data

Prevailing sand transport direction is based on sand dunes mapped in field

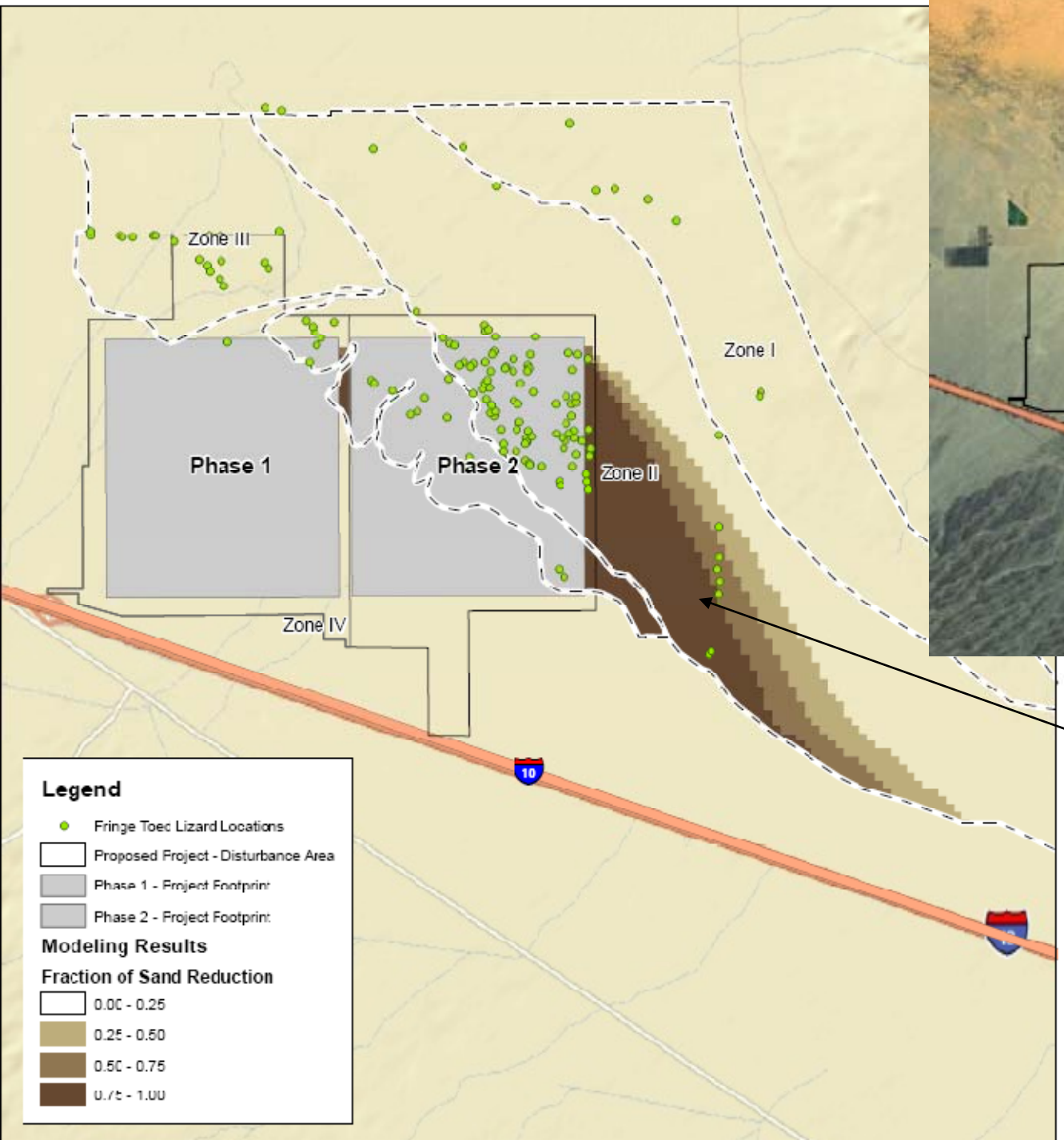
A model of wind transport for sand based on prevailing sand transport direction and wind distribution data



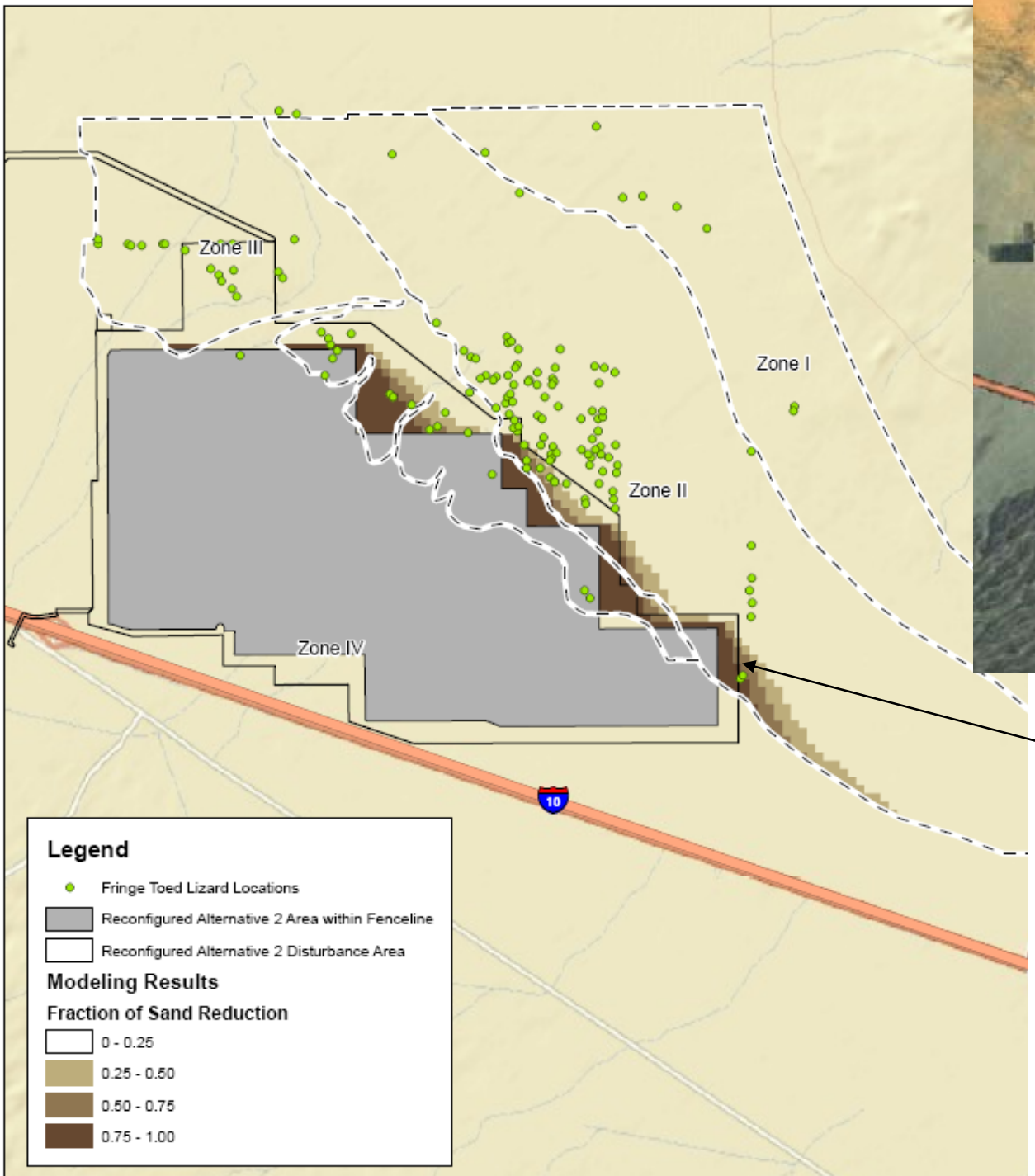


5%	5%	5%
5%	0%	10%
5%	16%	49%

Distribution around prevailing direction is based on Blythe airport wind record

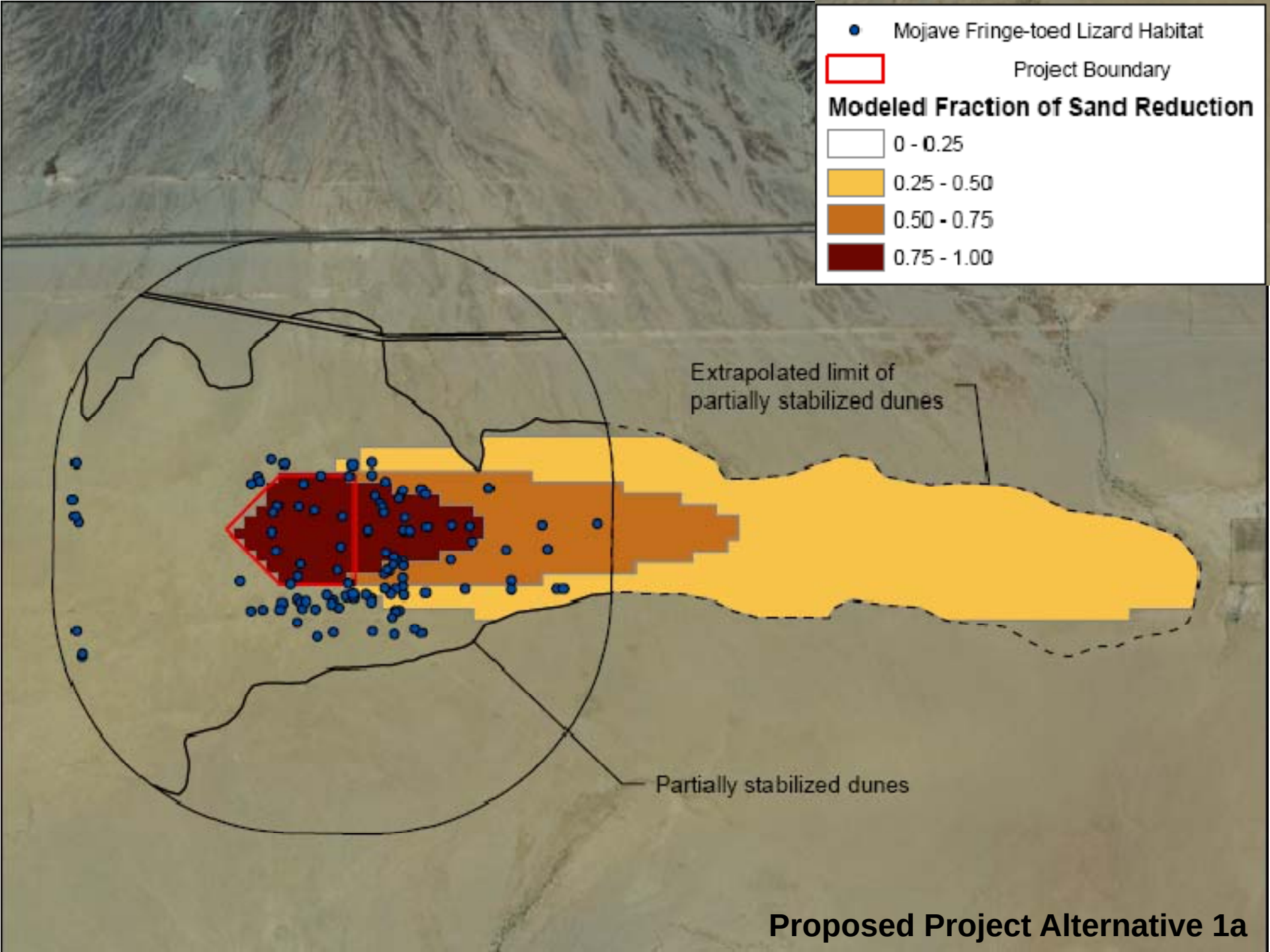


1,113 acres of indirect impact

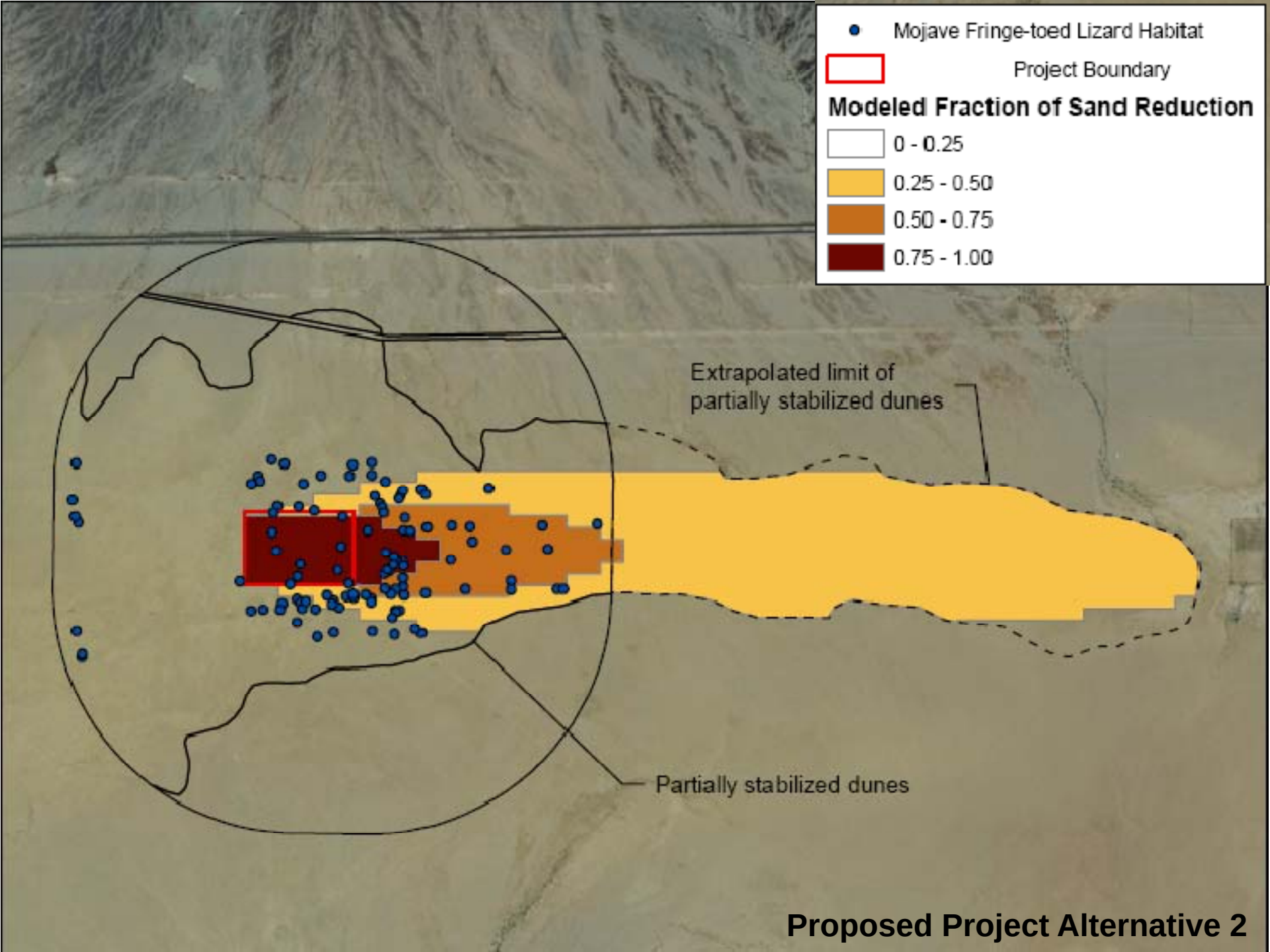


144 acres of indirect impact

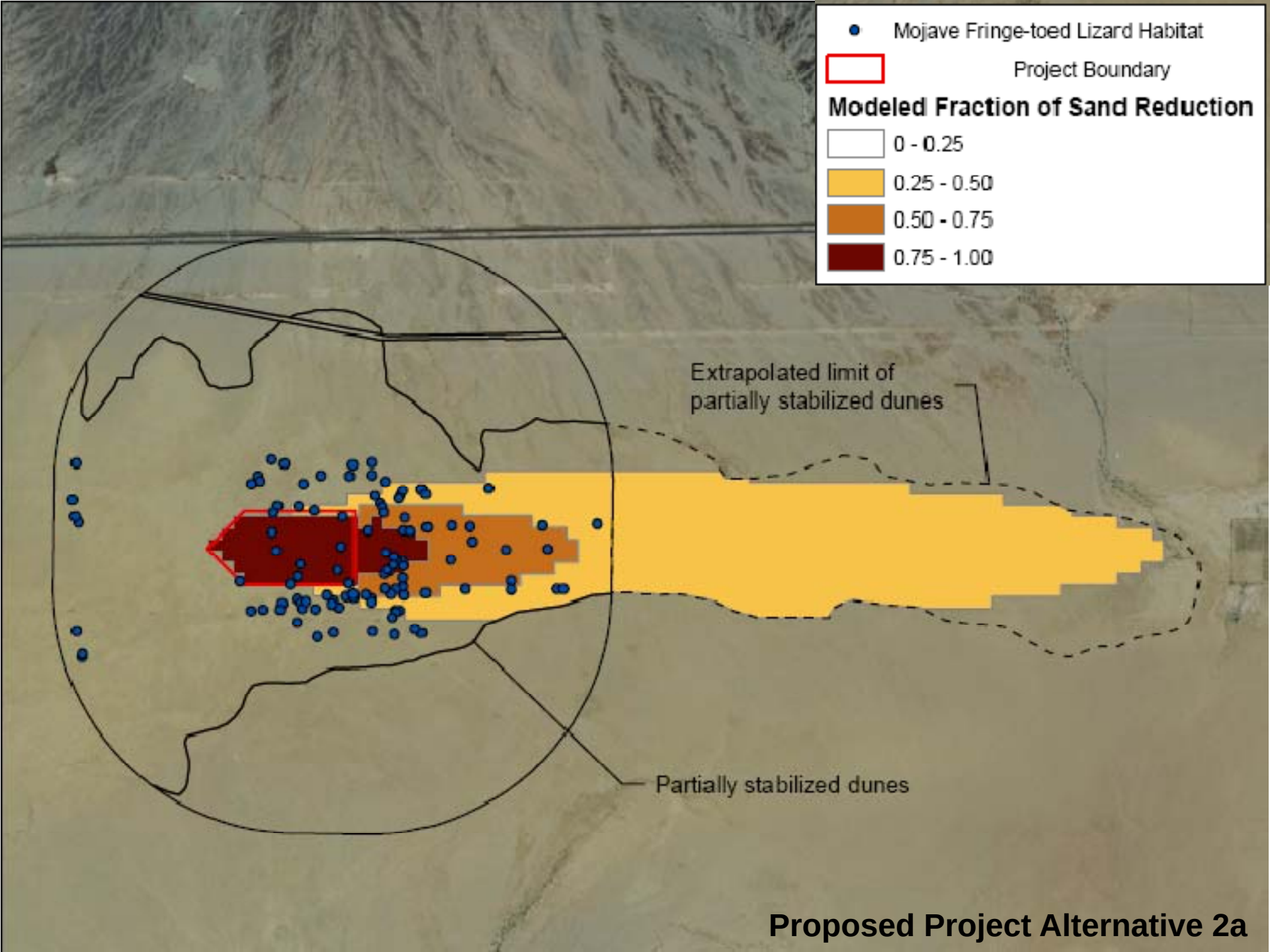
Proposed Project Alternative 1



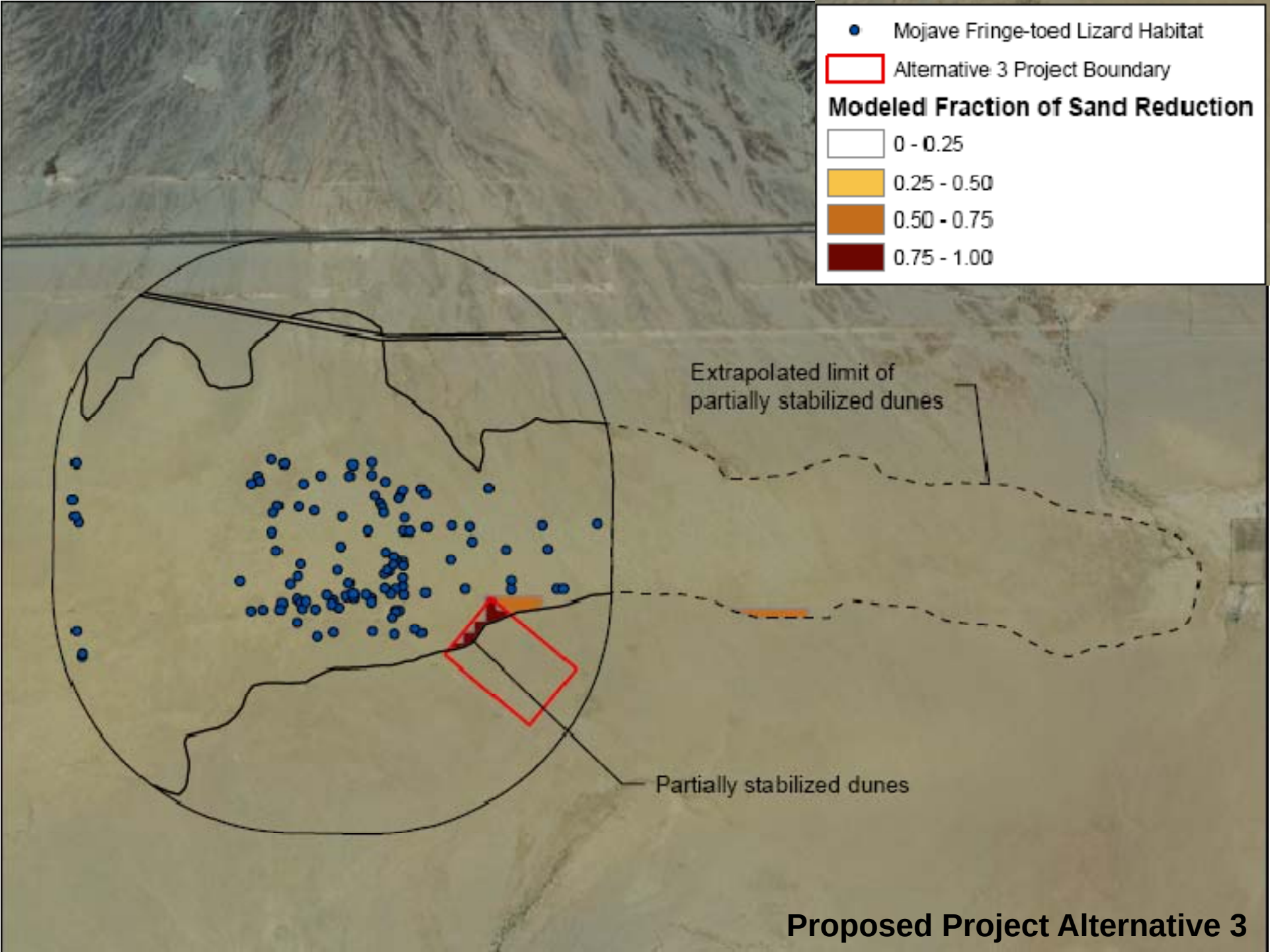
Proposed Project Alternative 1a



Proposed Project Alternative 2



Proposed Project Alternative 2a



Proposed Project Alternative 3

Conclusions

- Ephemeral channels are important pathways for sediment from headwaters to dune habitat
- Water is not the only sediment transporting fluid!
- Maintain sediment continuity where possible – think of sediment as an ecological resource
- Analogous to "Low impact development" principal – sediment dispersal is better than concentration
- If disruption to sediment transport is unavoidable need to either design solutions or be prepared to mitigate heavily (1,000s of acres)
- Monitoring needs to scale to frequency of disturbance (i.e. more than 3 years)

Questions?

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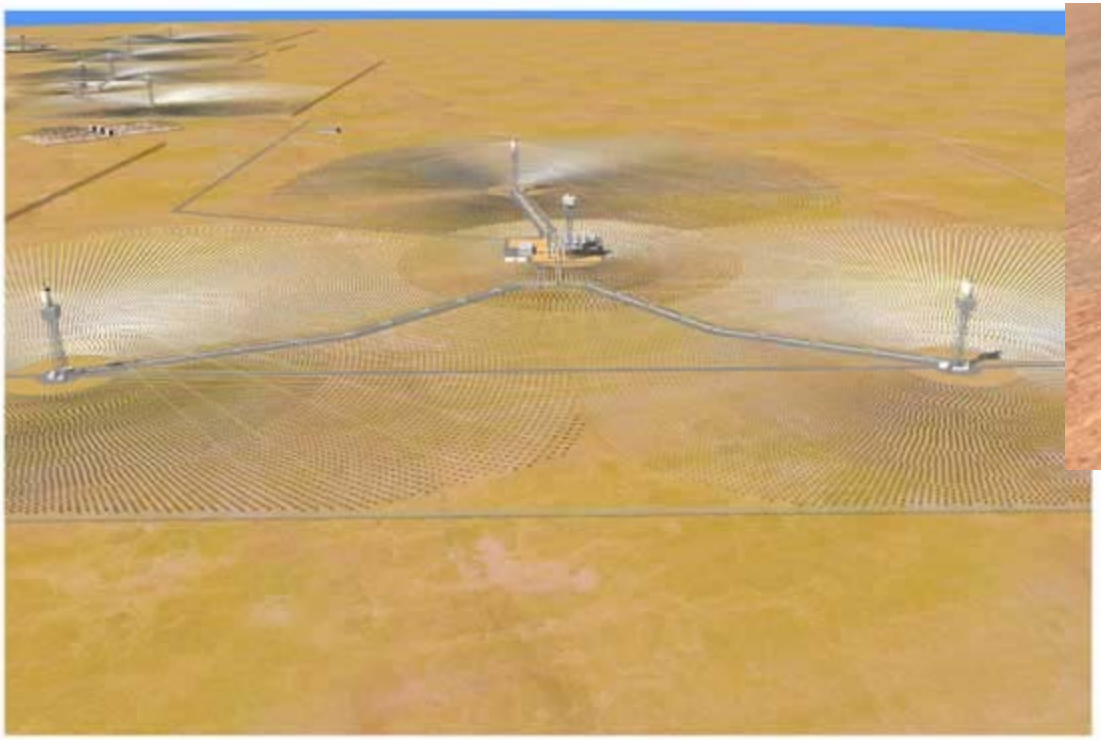
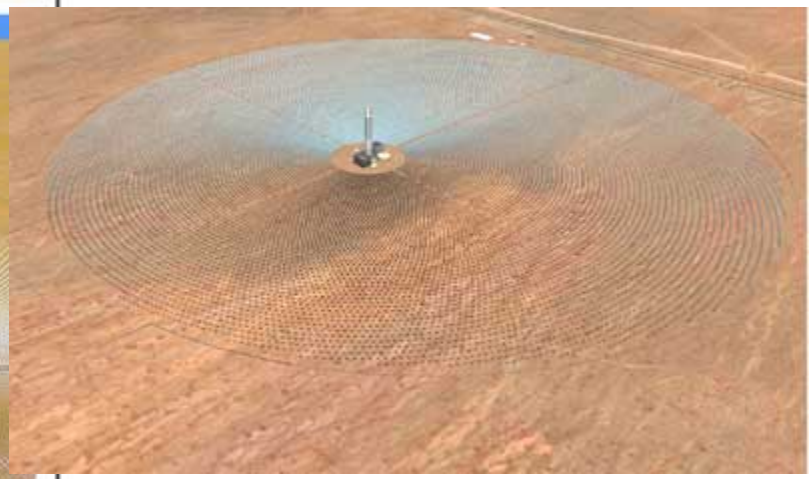


FIGURE 1.3-4
CLOSE-UP OF IVANPAH 1
IVANPAH SOLAR ELECTRIC GENERATING SYS

CH2MHIL



Parabolic trough solar thermal technology

Copeia, 1984(2), pp. 370–378

Effects of Reduction in Windblown Sand on the Abundance of the Fringe-Toed Lizard (*Uma inornata*) in the Coachella Valley, California

Frederick B. Turner, Donald C. Weaver and James C. Rorabaugh

"Data from the six experimental plots show that obstructions to sand flow and ensuing sand depletion and surface stabilization definitely affect the occurrence of Uma inornata. The three plots down- wind of obstructions (2, 4, 6) have been subjected to these processes for 7, 12 and 17 years, respectively. In all three situations changes in aeolian sand characteristics, and possibly in related biological variables, have rendered the areas unsuitable as Uma habitat. The continuing reception of new sand appears, then, to be an indispensable ecological process insofar as the survival of fringe-toed lizards is concerned. The importance of rates of sand passage is less clear. The three plots exhibiting highest densities of Uma (3, 5 and 9) sustain, respectively, passages of 15, 50 and 2.5 m3 per meter-wide path per year. These observations suggest that some active passage of sand is necessary, with the rate of sand transport less important."

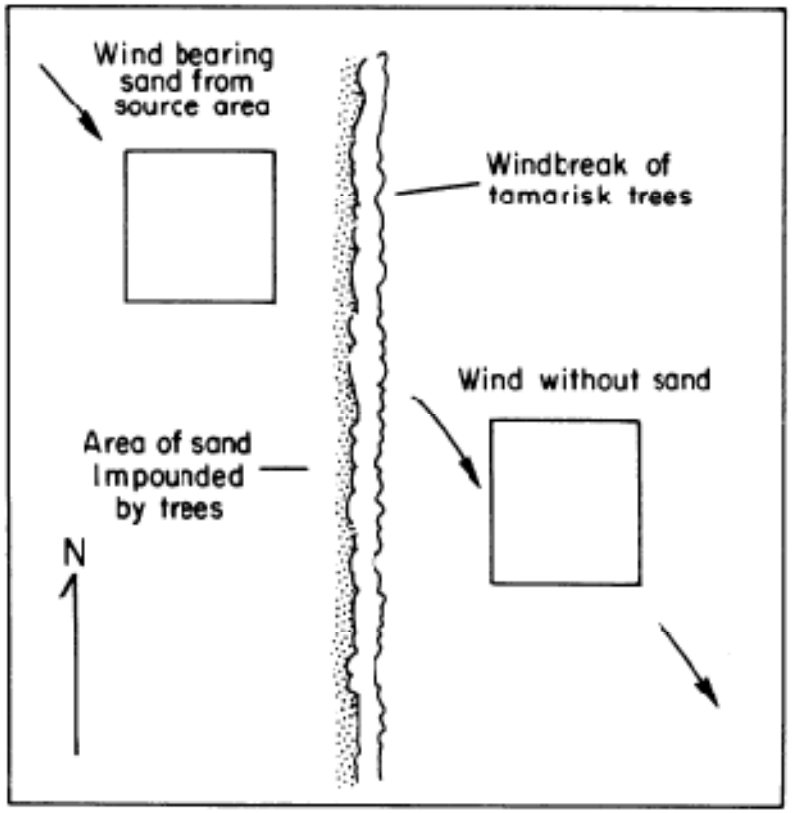


Fig. 1. Generalized plan for disposition of paired sampling sites. Plot in upper left is exposed to normal flow of wind bearing sand particles from source area. Plot in lower right is shielded by windbreak and receives little or no windblown sand.

Drainage capture and concentration