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... ali collaboratively develops innovative methods to produce real change on the ground ... both for the benefit of local communities and the landscapes upon which they rely ...

intermittent system function: a key driver for restoring socio-ecological watershed resiliency in the Southwestern United States

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[2]school of architecture + planning, community & regional planning department, university of new mexico, albuquerque, us

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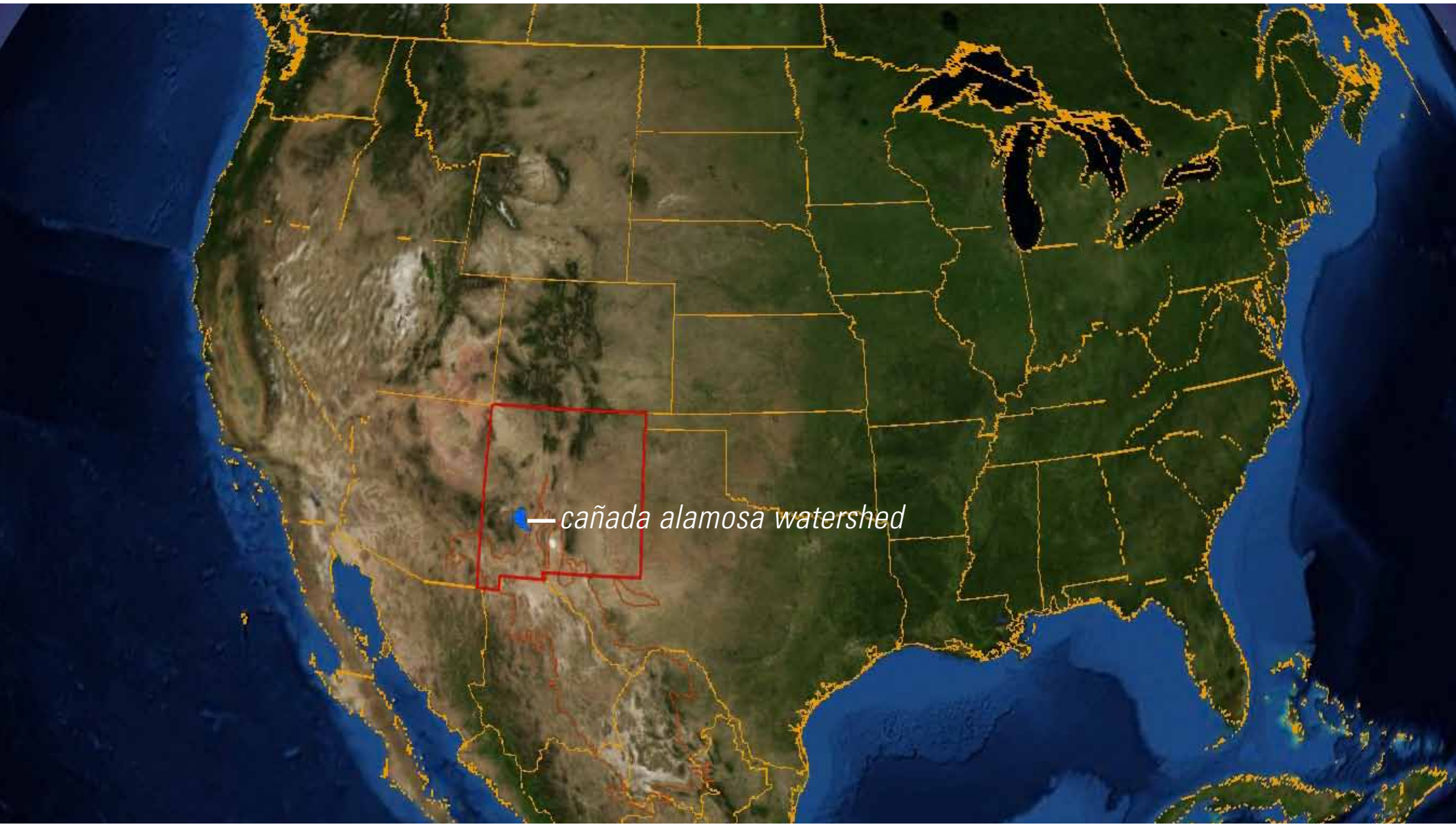


southwestern united states | alamosa LAND INSTITUTE

natural drivers - disturbances - floods, erosion, and aridity

land of extremes | alamosa LAND INSTITUTE

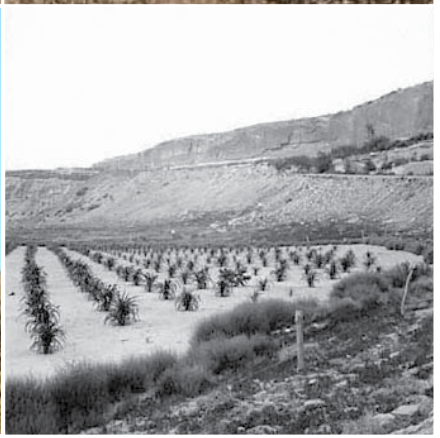
rural working landscapes | alamosa LAND INSTITUTE


geronimo


victorio


lozen


victorio peak



warm spring apache in 1913: "The whole country, once so fertile and green, was now entirely barren. Gravel had washed down, covering all the nice valleys and pastures, even filling up the Warm Springs, which had completely vanished. The reservation was entirely ruined" (Betzinez, 1959).

settlement of west - massive resource withdrawal

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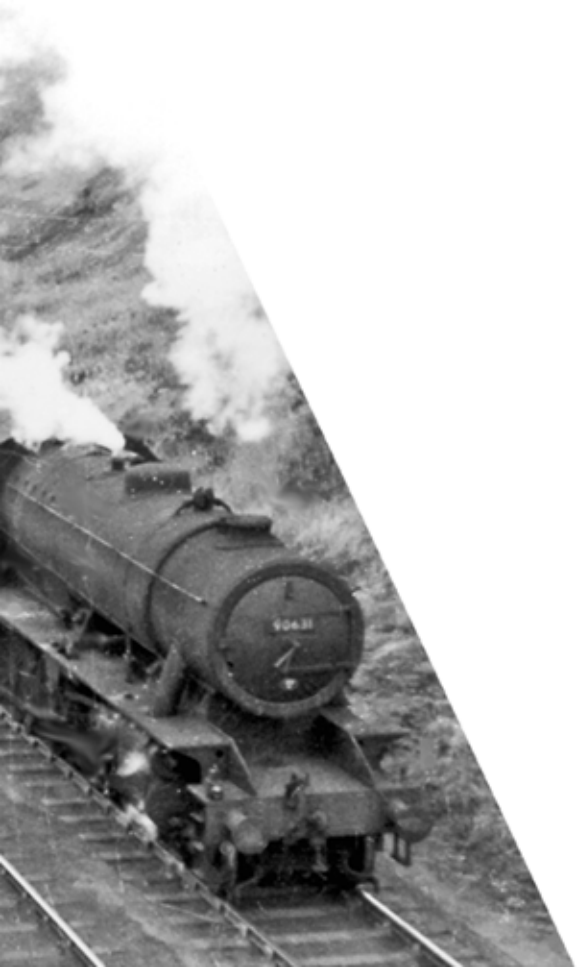

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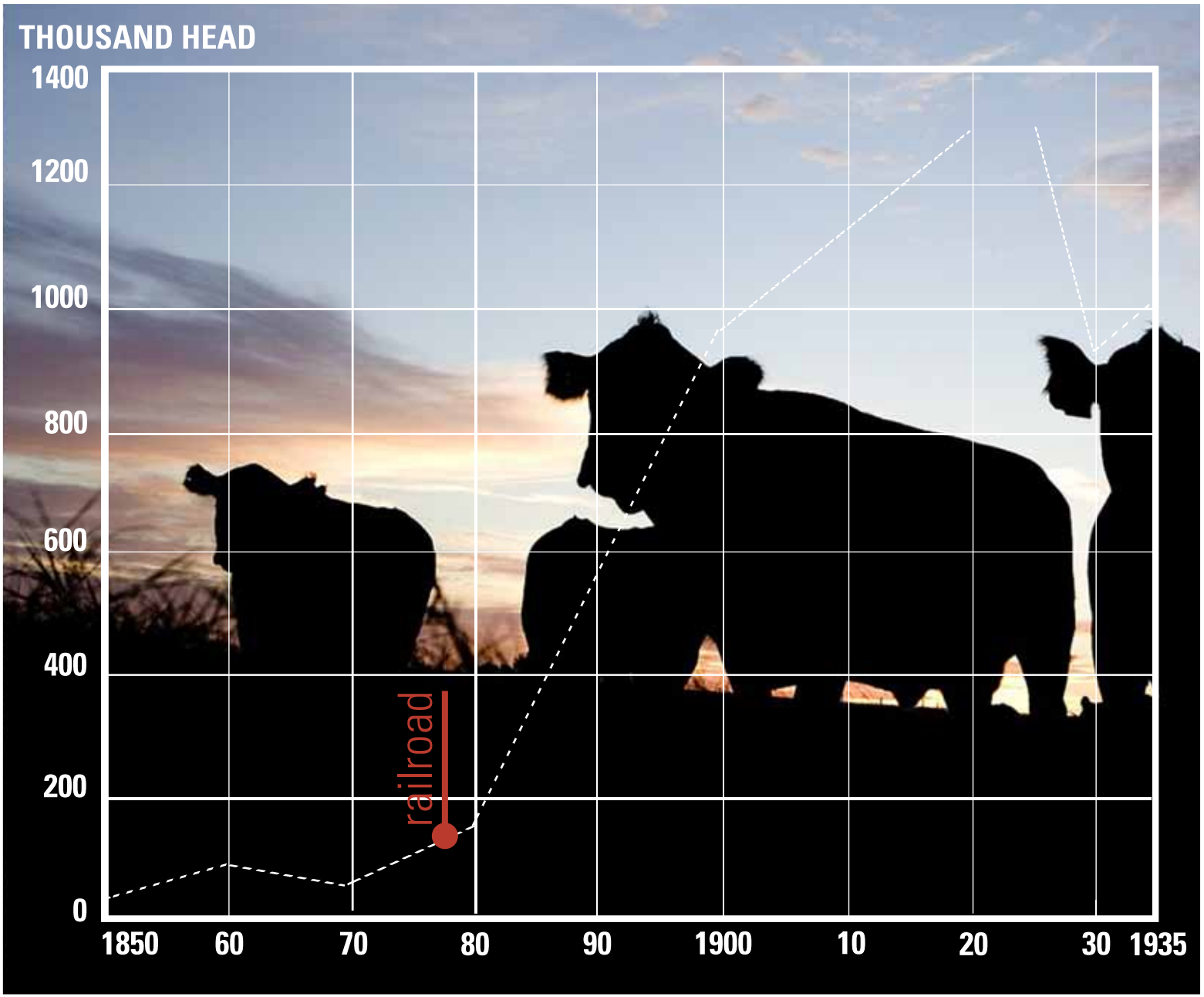

CATTLE IN NEW MEXICO, 1850-1935

opened markets for cattle | alamosa LAND INSTITUTE

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1880's known as the "great barbecue"

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this drought ended traditional flood-water farming in the main valleys throughout present-day New Mexico (Bryan, 1929).

conciding with climate conditions

led to erosion

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catastrophic flooding damage | alamosa LAND INSTITUTE

loss of biodiversity

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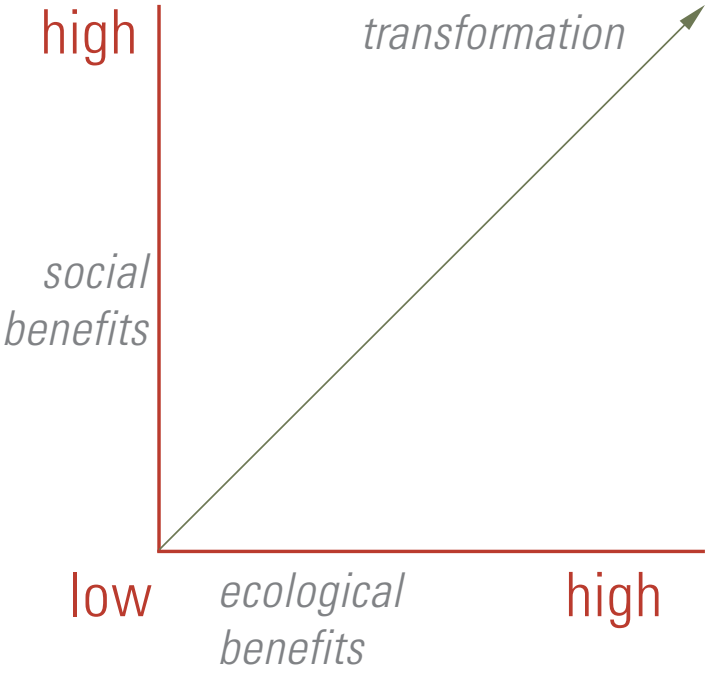
...constraining rivers with levees and dams ... has increased vulnerability to natural disasters by degrading the buffering capacity of the natural system
(eg. Mustafa 2007, Farber and Costanza et al. 1987, Haeuber & Michener 1998).

...today, approx. 90% of AZ and NM's original riparian ecosystems have disappeared
(NMDGF 2006, Krzysik 1990, Ohmart & Anderson 1986, Brinson et al. 1981)



a resilient system remains within critical thresholds of functions,
as well as structural states (Palmer & Febria 2012, Okin et al. 2015)



social functions - significant driver

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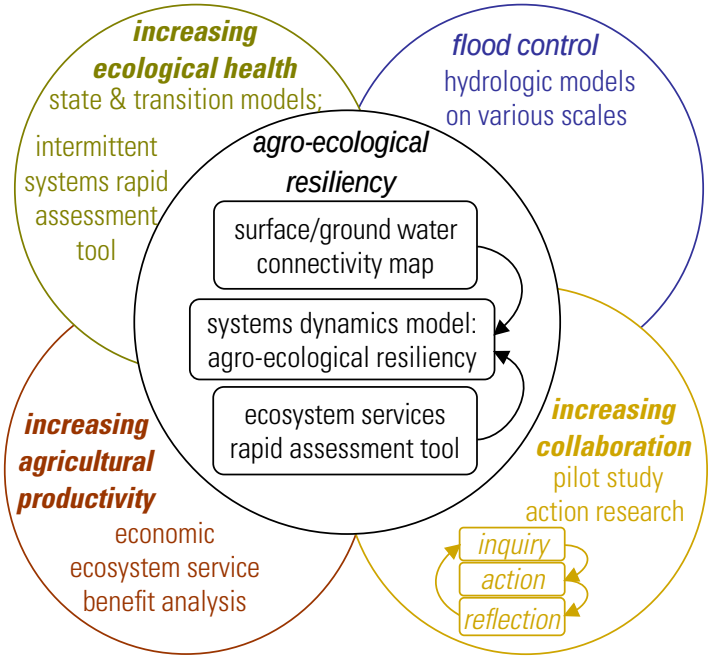

collaborative experimentation on actual land owner goals to fit practices to local conditions
(Ostrom 1990, Tschakert and Dietrich 2010; Lebel et al. 2006)

essential component of adaptation -> experimentation increases social capacity for innovation
(Berkes & Ross 2013)

action-based research

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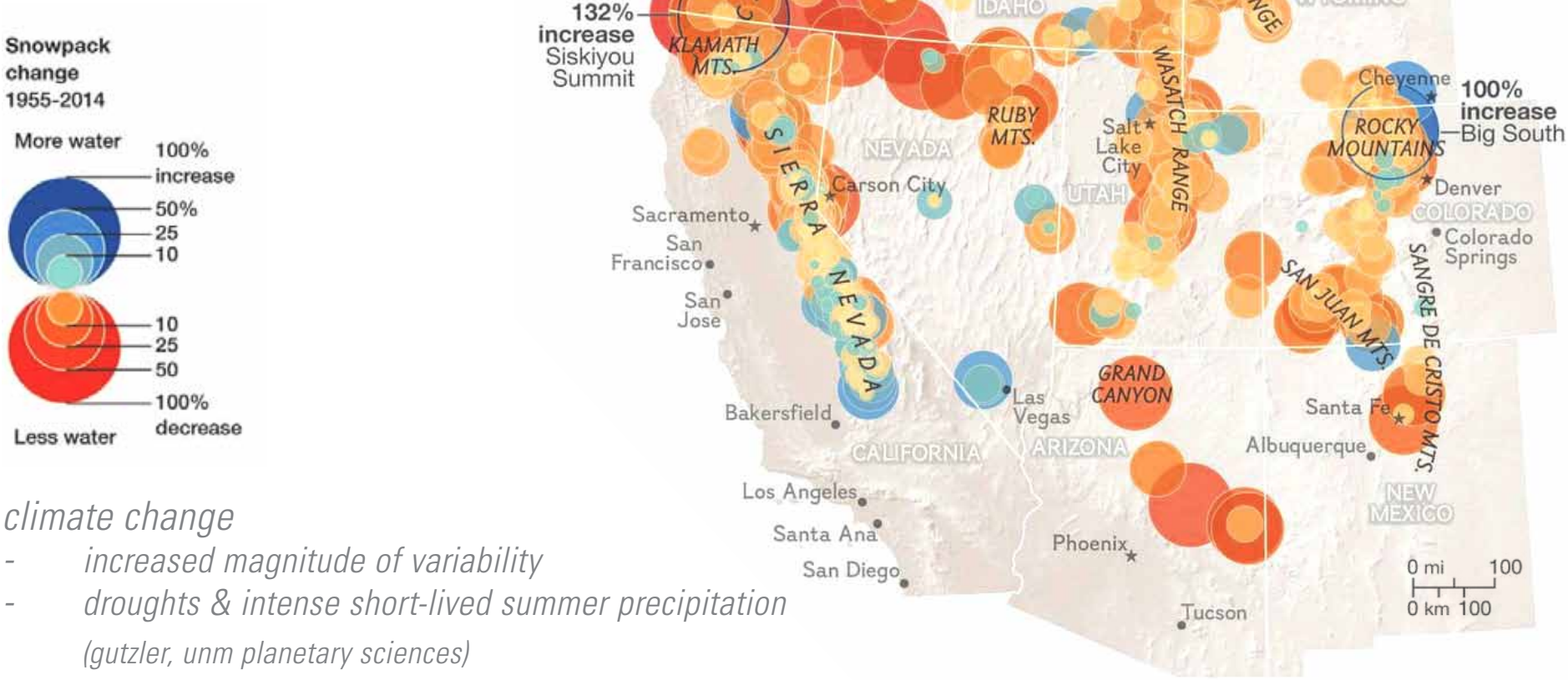


climate change

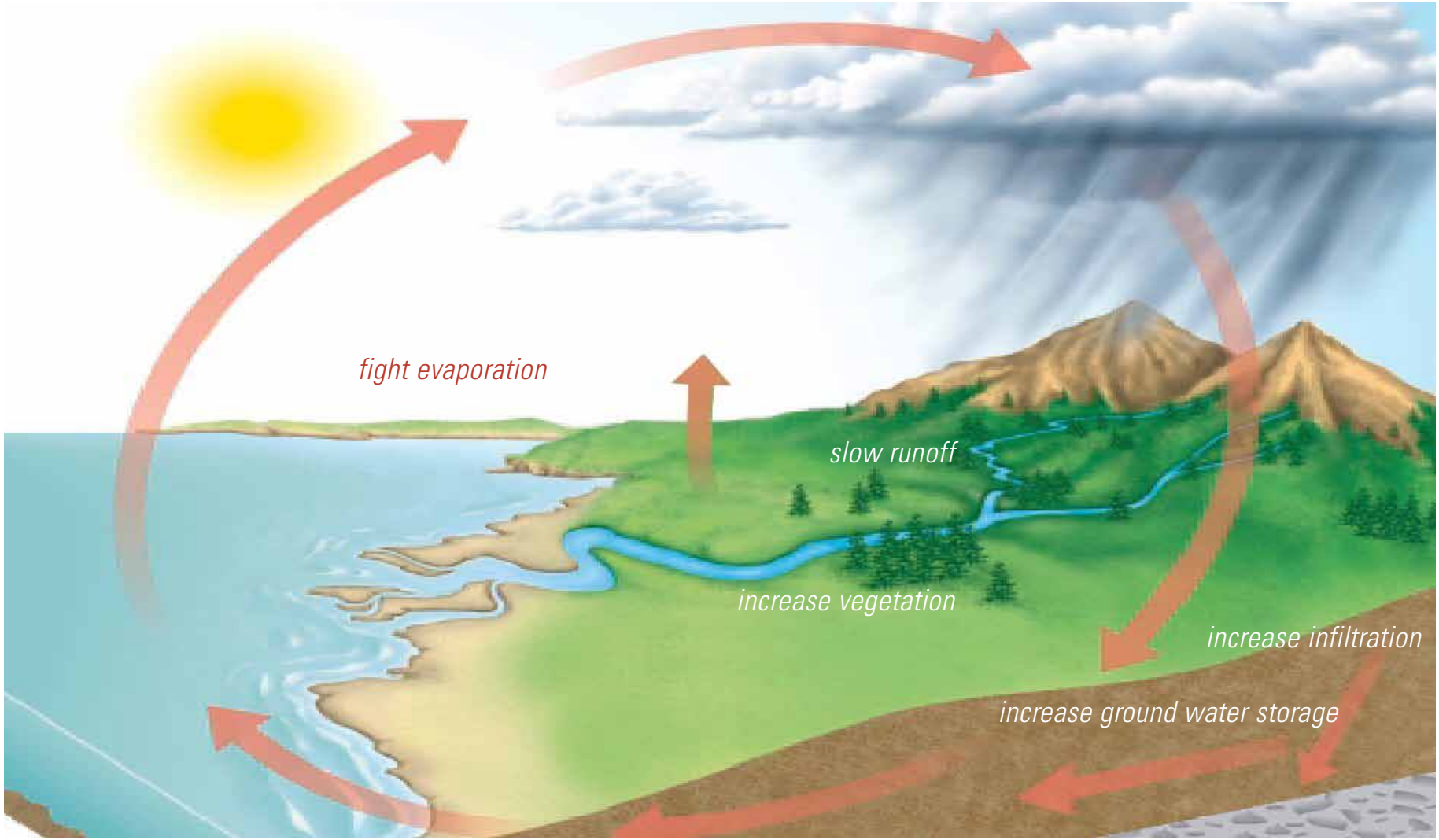
- *increased magnitude of variability*
- *droughts & intense short-lived summer precipitation*

(gutzler, unm planetary sciences)

fewer winter storms are building less snowpack

VIRGINIA W. MASON AND KELSEY NOWAKOWSKI, NGM STAFF
SOURCES: NATURAL RESOURCES CONSERVATION SERVICE; CALIFORNIA DEPARTMENT OF WATER RESOURCES; DARRIN SHARP AND PHILIP MOTE, OREGON STATE UNIVERSITY

major SW water challenge - storage | alamosa LAND INSTITUTE



... reconnect channels and allow floodplains to perform the natural function of storing and conveying floodwaters ... (eg. Opperman et al. 2009; Junk et al. 1989)

need to increase ground water storage | alamosa LAND INSTITUTE

elephante butte reservoir annually evaporated avg. 150,000 afpy in the past sixty years (230,000 afpy full)

approx. 3x what albuquerque citizens consume

who is the biggest water user

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... now throughout the world, "more water evaporates from reservoirs than is consumed by humans" (unep 2008)

... result - evaporation is the biggest consumptive water user in the middle rio grande basin (mrgwa, 1999)

cover more bare soil

slows water delivery to reservoirs

- *increase infiltration through vegetation*
- *compared to bare soil, 37% vegetation cover increased infiltration rates by 6x (Leopold 1951)*

keep water on the watershed | alamosa LAND INSTITUTE

Transpiration is intrinsic to the development of the phytomass	*- Evaporation is not*
Transpiration is a result of life on the planet	*- Evaporation proceeds in the absence of life*
Transpiration enhances soil formation	*- Evaporation does not*
Transpiration results in the production of food and other biomass useful to animals	*- Evaporation does not*
Transpiration directly sustains life	*- Evaporation does not*

victor miguel ponce

cañada alamosa reference areas

transfer evaporative consumptive use to transpiration

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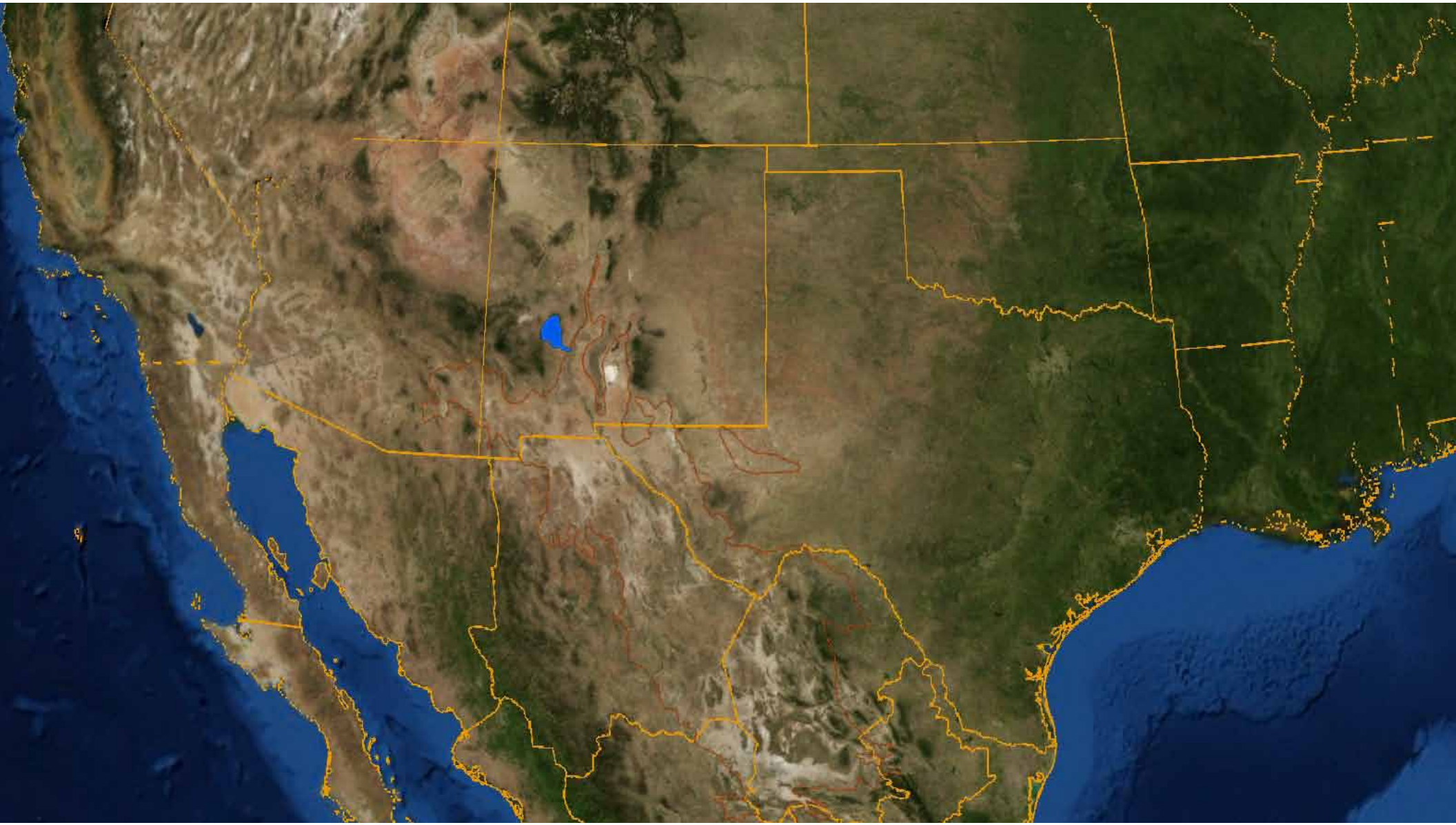
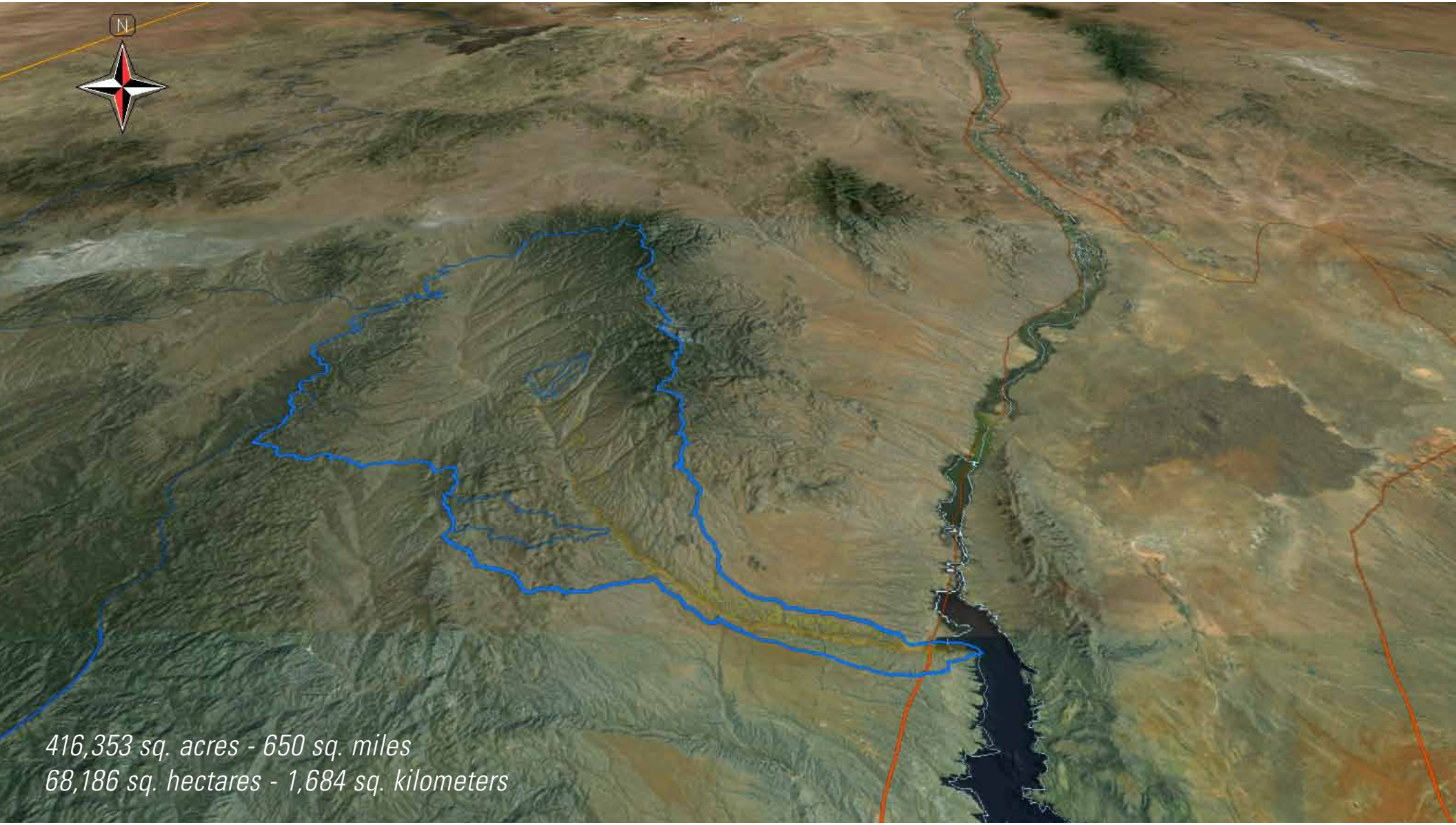
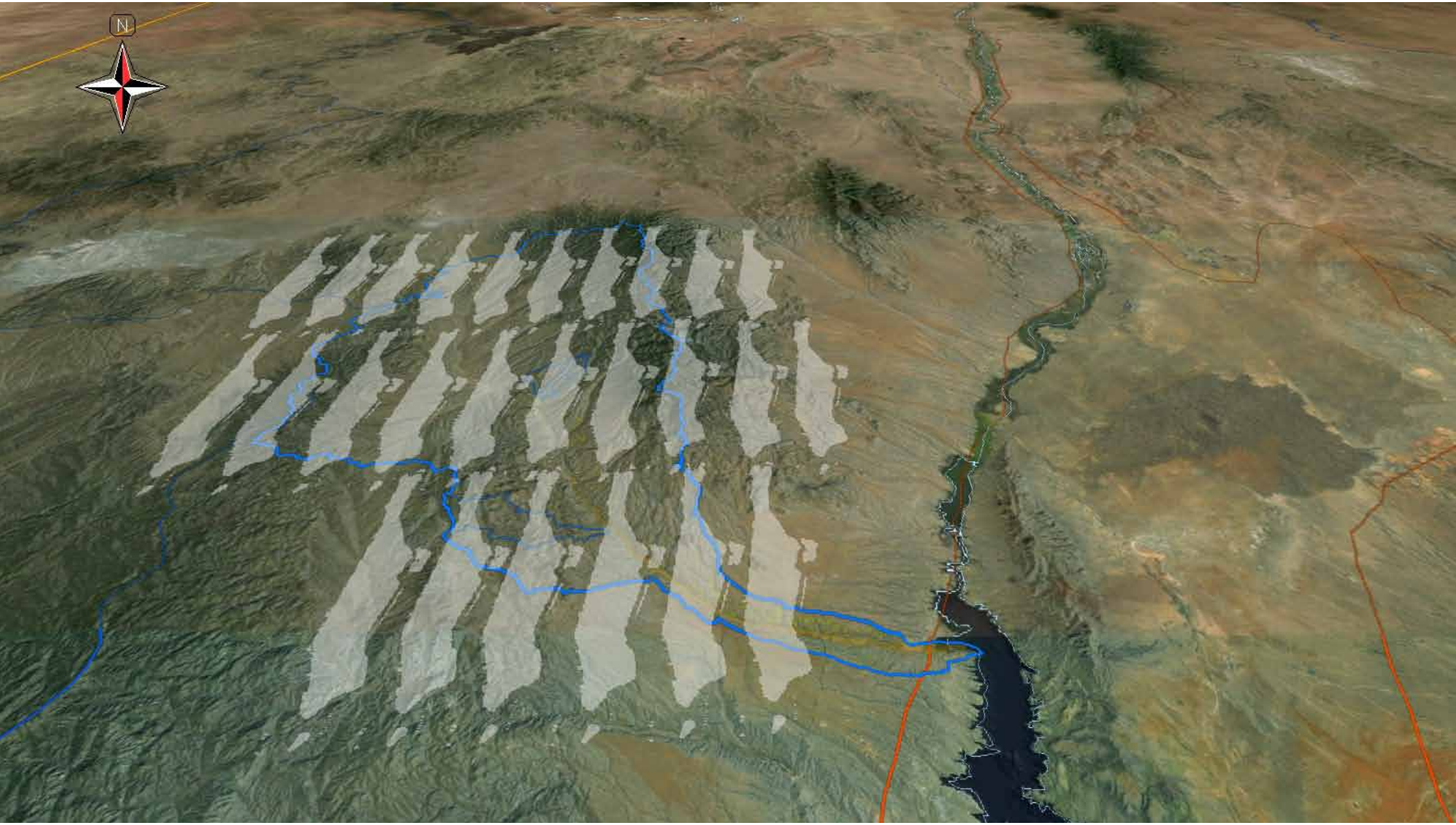


cañada alamosa watershed | alamosa LAND INSTITUTE

rio grande basin | alamosa LAND INSTITUTE



cañada alamosa - 650 sq. miles | alamosa LAND INSTITUTE



fit 26 manhattan islands

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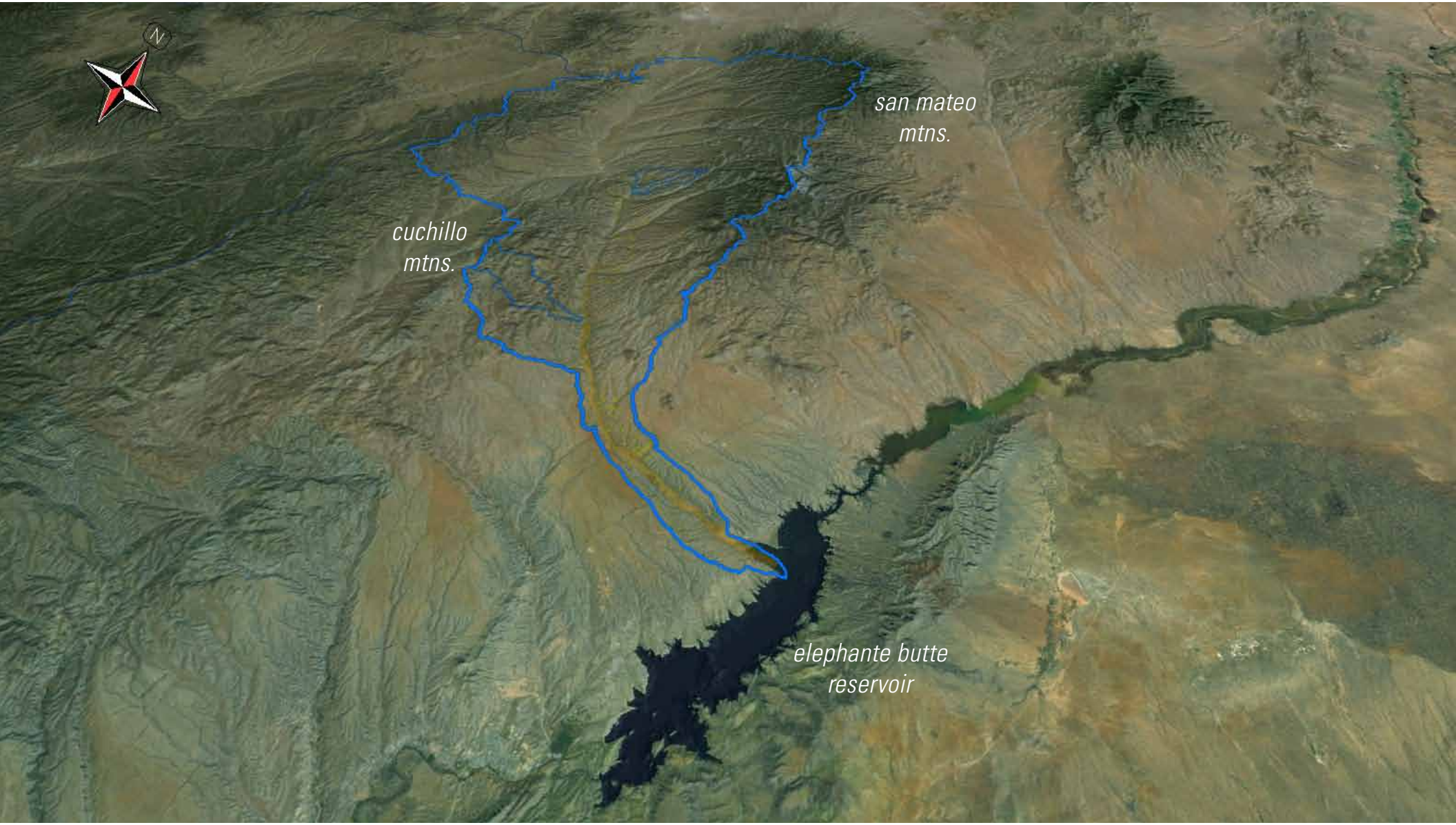

nestled between mountains - drains into reservoir

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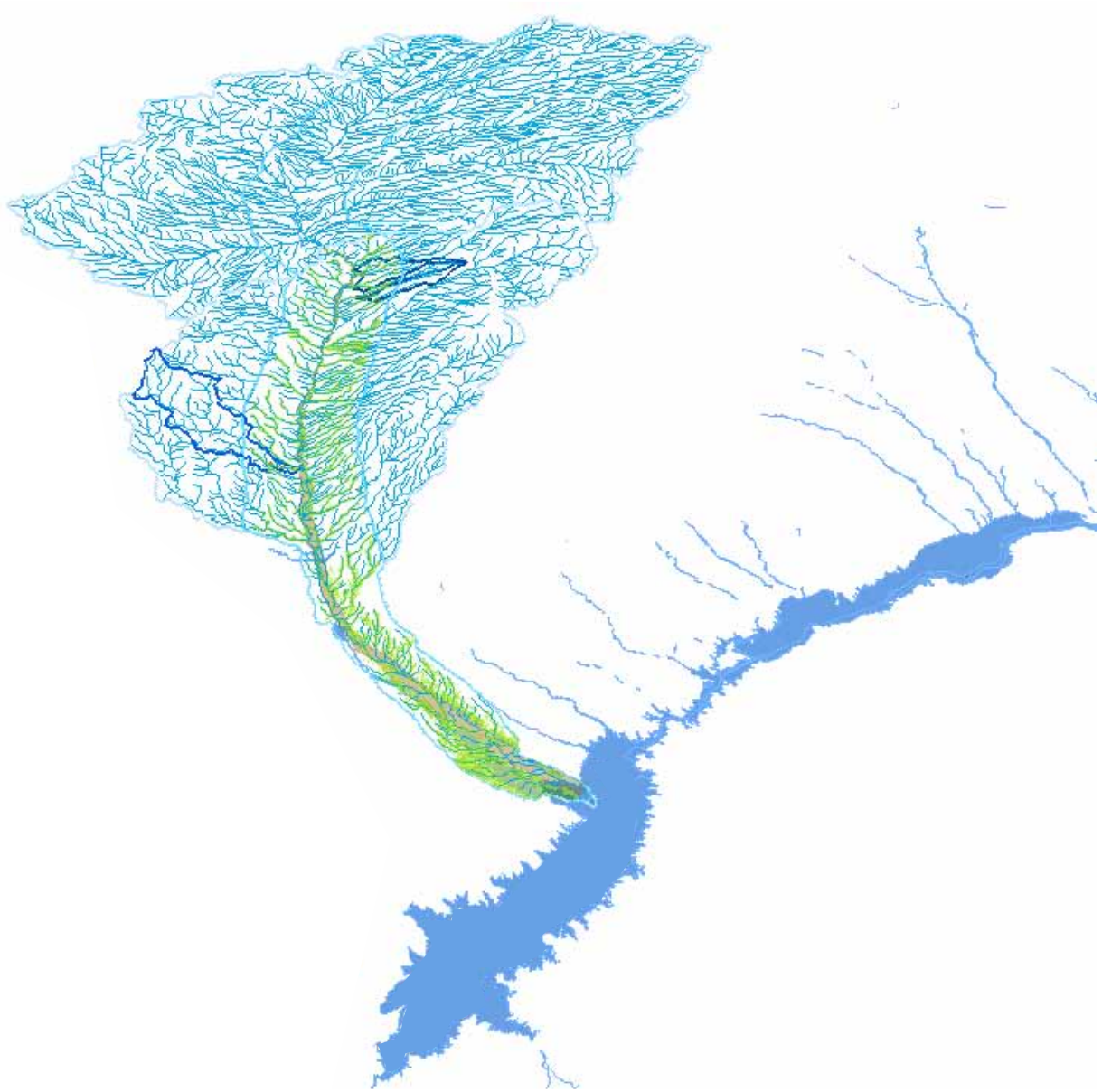


high flood energy | alamosa LAND INSTITUTE

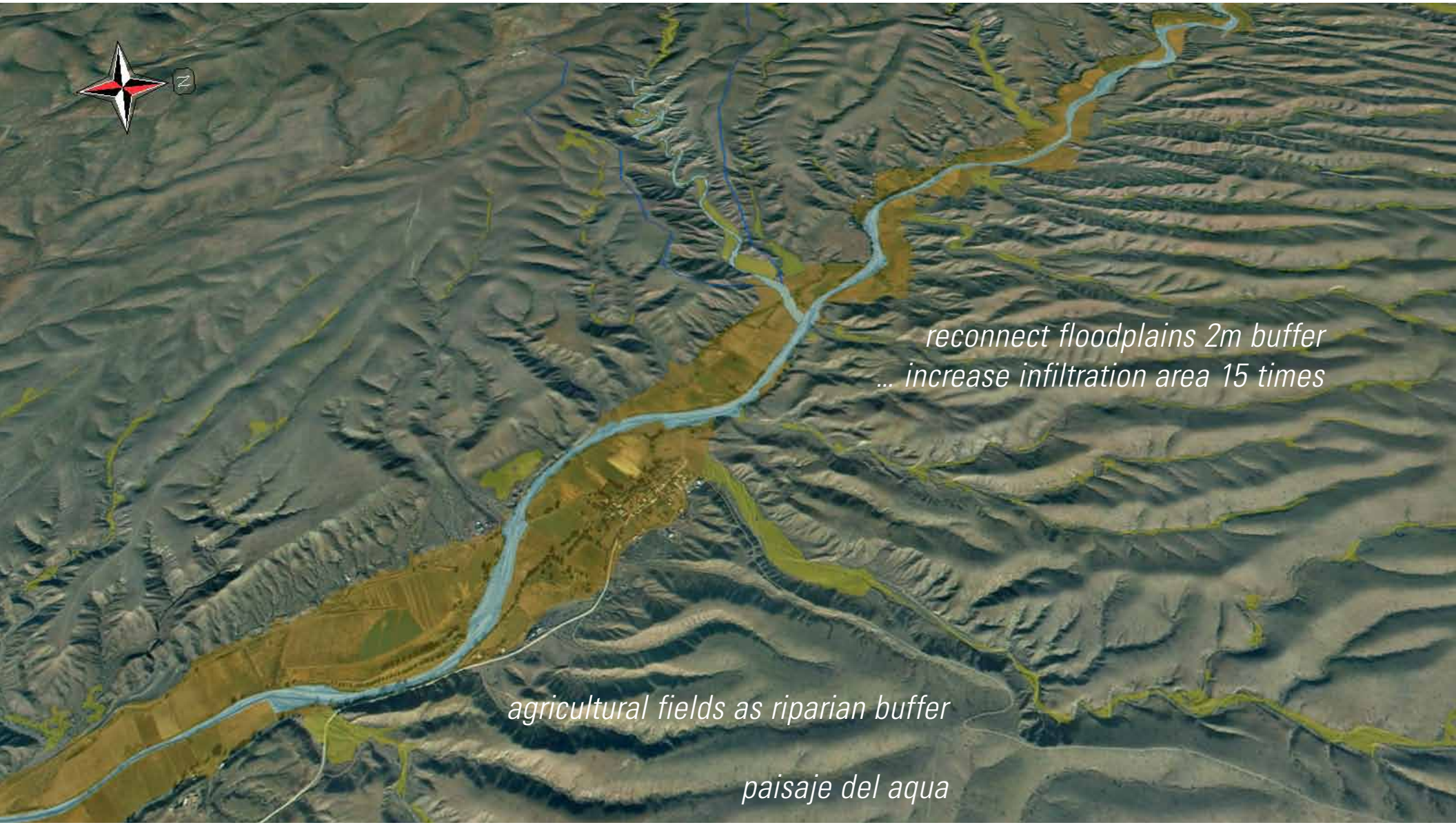
rio grande flow in mid-NM (albuquerque)
4,000 cfs

cañada alamosa
10-year flood
6,000 cfs

Prepared by Matthew Heberger (2013).*

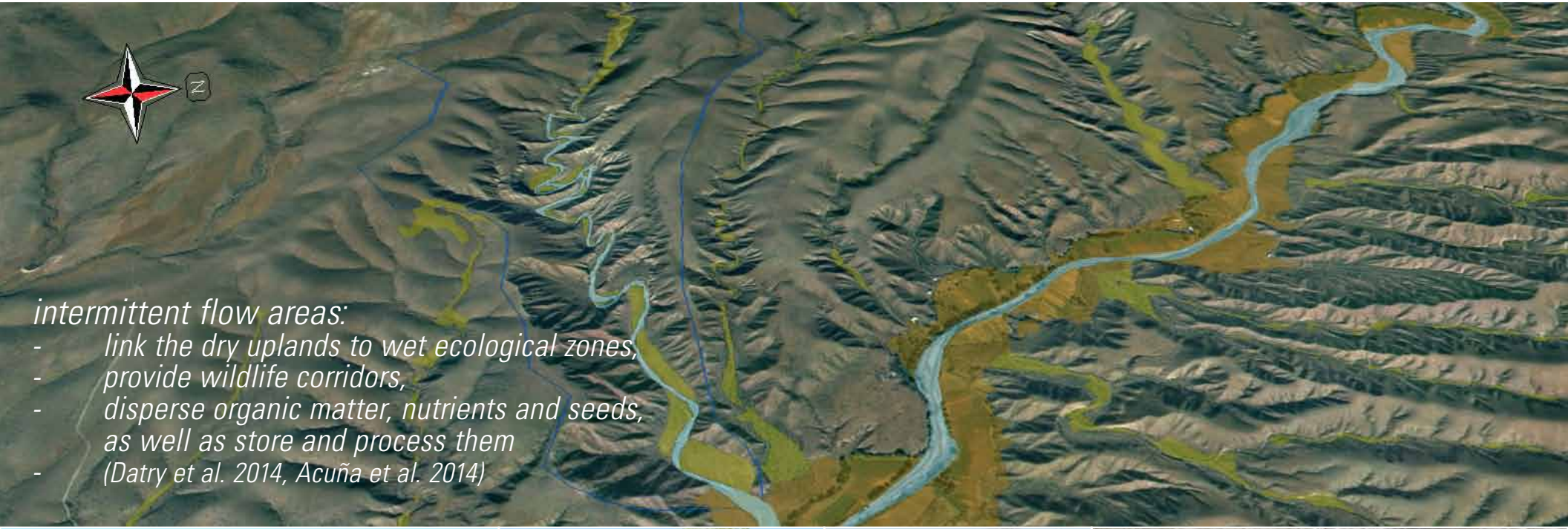
high flood energy | alamosa LAND INSTITUTE

constrained flows | alamosa LAND INSTITUTE



working landscape | alamosa LAND INSTITUTE


N
highest levels of plant diversity -
on intermittent floodplains close to perennial
(Burchsted et al. 2013, Stromberg et al. 2009)



intermittent flow areas:

- *link the dry uplands to wet ecological zones,*
- *provide wildlife corridors,*
- *disperse organic matter, nutrients and seeds, as well as store and process them*
- *(Datry et al. 2014, Acuña et al. 2014)*

.... vegetation loss can see the rate of run-off and erosion accelerate over time and cross the threshold of recovery without intervention
(Wilcox et al. 2003)

surface roughness - dryland infiltration driver

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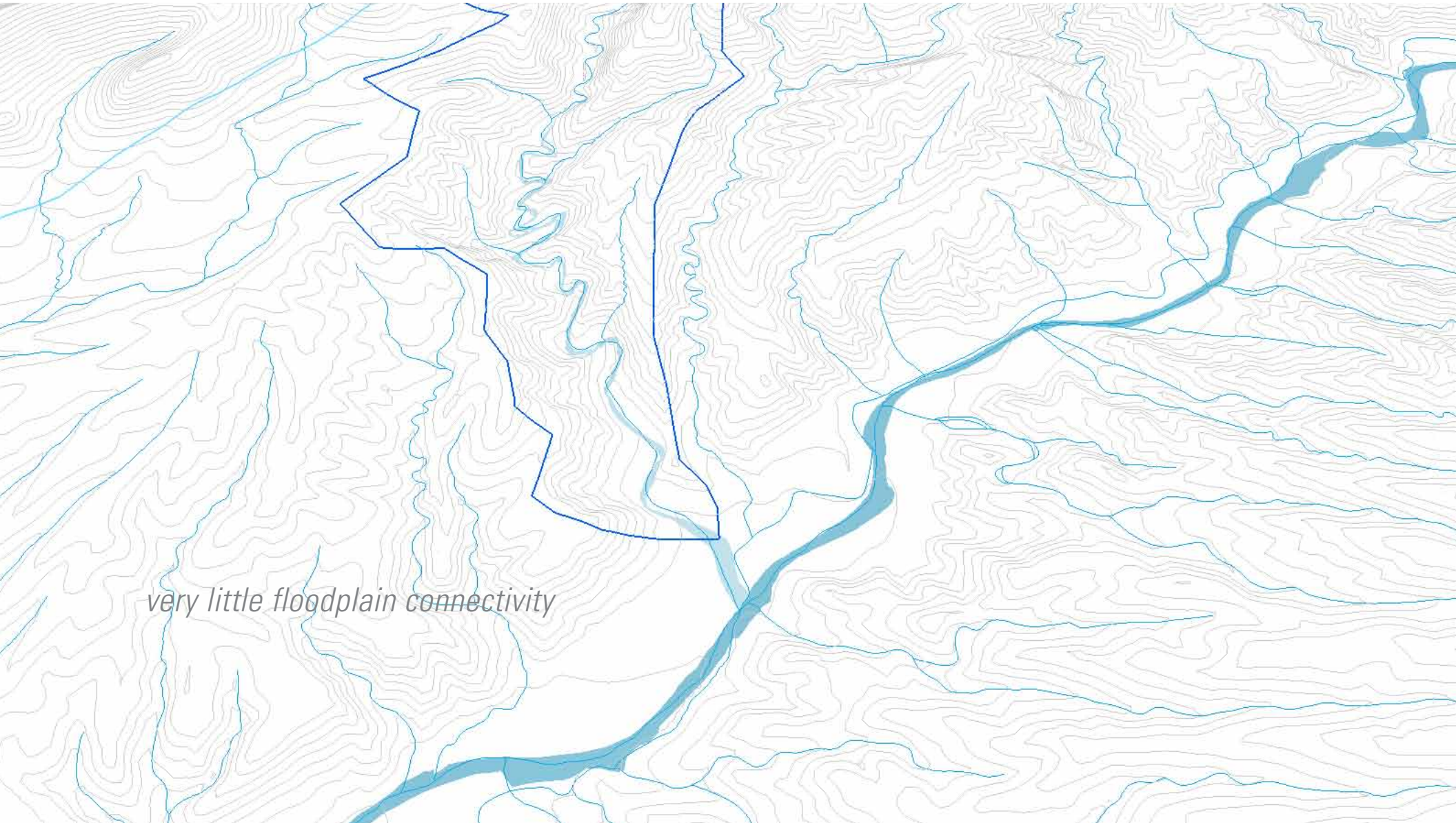

flood flows today

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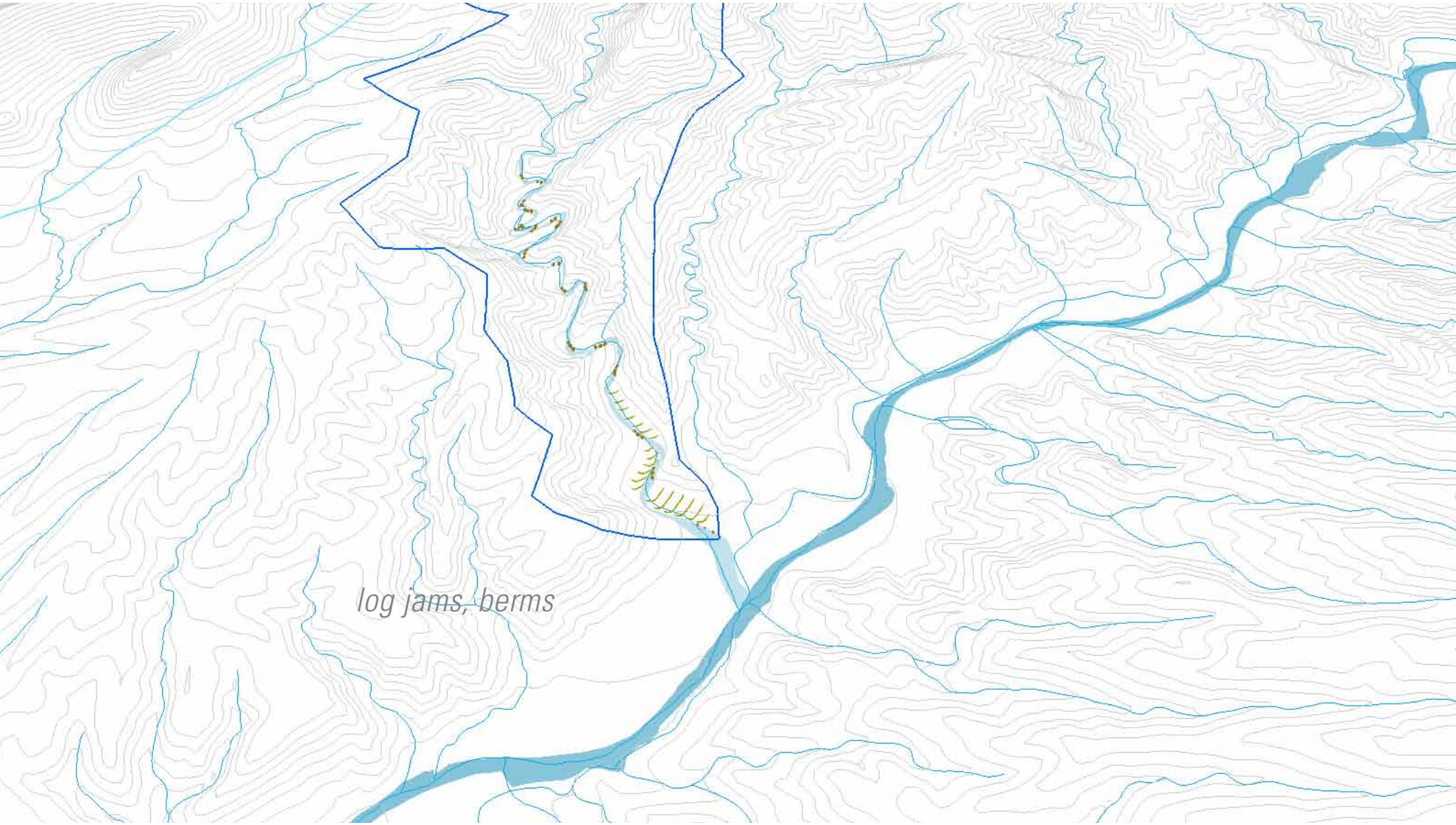

intervention - add surface roughness

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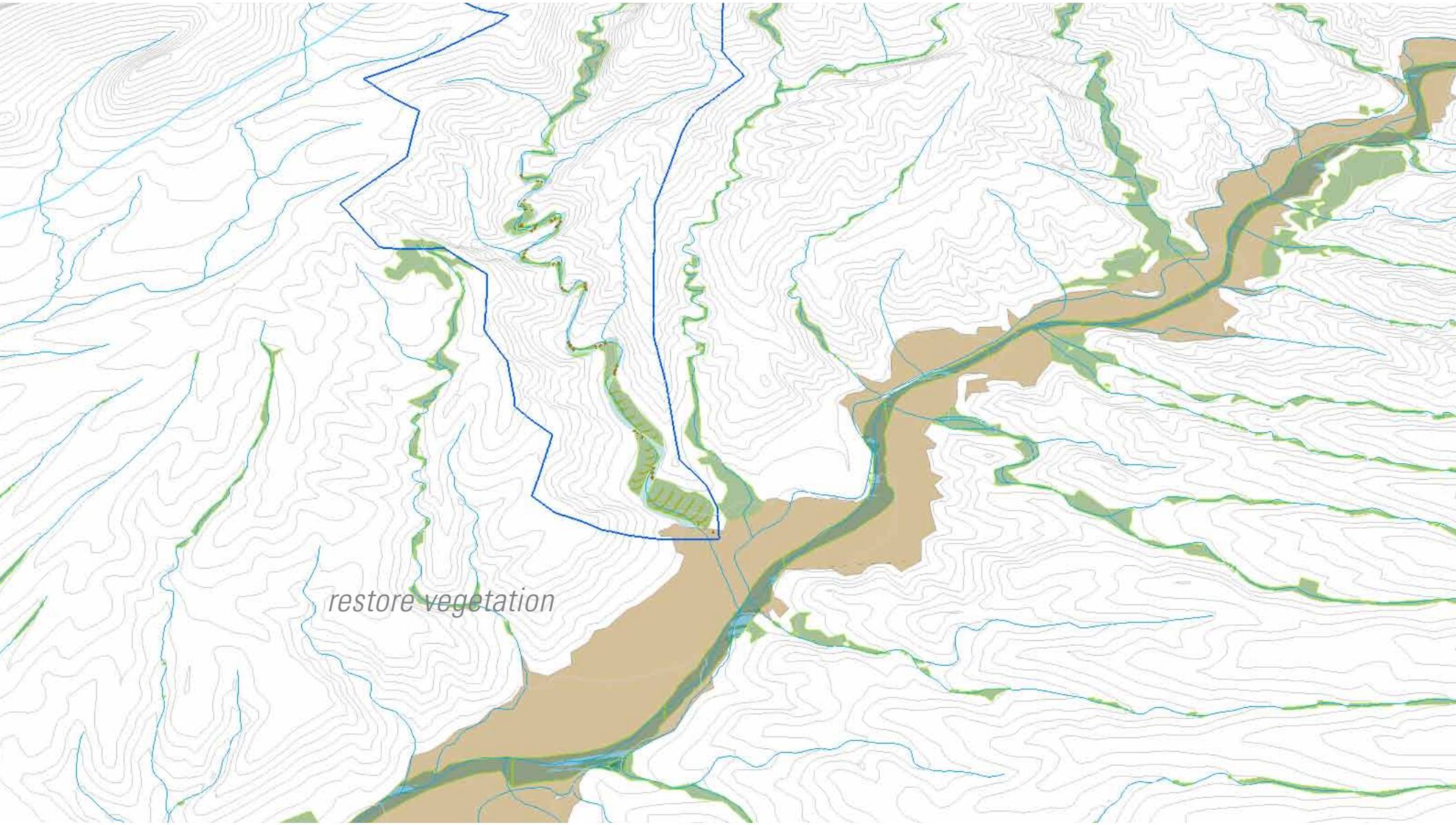

reconnect floodplains

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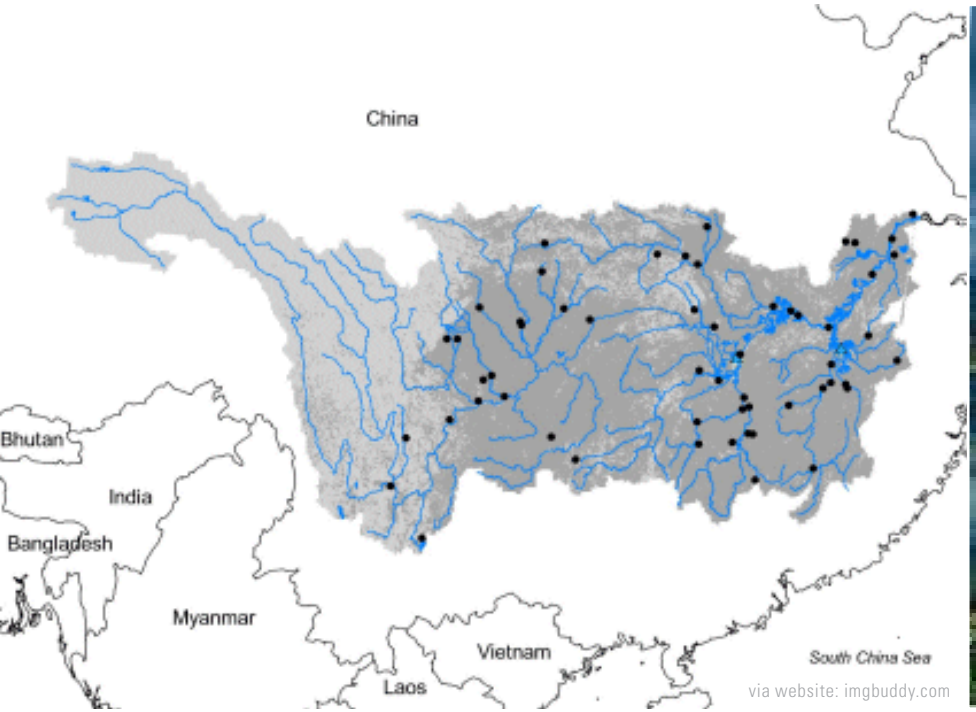
... though not yet widely practiced ... floodplain reconnection has gained global recognition mainly for its ability to control floods, but also increase ecological health, and increase goods and services (Opperman et al. 2009, Molles et al. 1998)

California learned this lesson in the 1930's, and constructed a 60,000-acre bypass to mainly agricultural fields in the Sacramento Valley (Opperman et al. 2009). In 1986 the bypass was able to convey approximately 10 million acre feet of flood water, "more than three times the total floodcontrol storage volume in all Sacramento basin reservoirs."

In 1998, a flood in China's Yangtze River Basin, an area that holds a third of China's population and produces 40% of its GDP, killed more than four thousand people and inflicted economic losses of $25 billion US ...



via website: imgbuddy.com


via website: photo.chinahighlights.com

... this prompted the Chinese government to change its response from raising levees, some already up to 120 feet high, to reconnecting floodplains and restoring vegetation on the uplands (Pittock et al. 2010).

introduce wood debris using beaver methods

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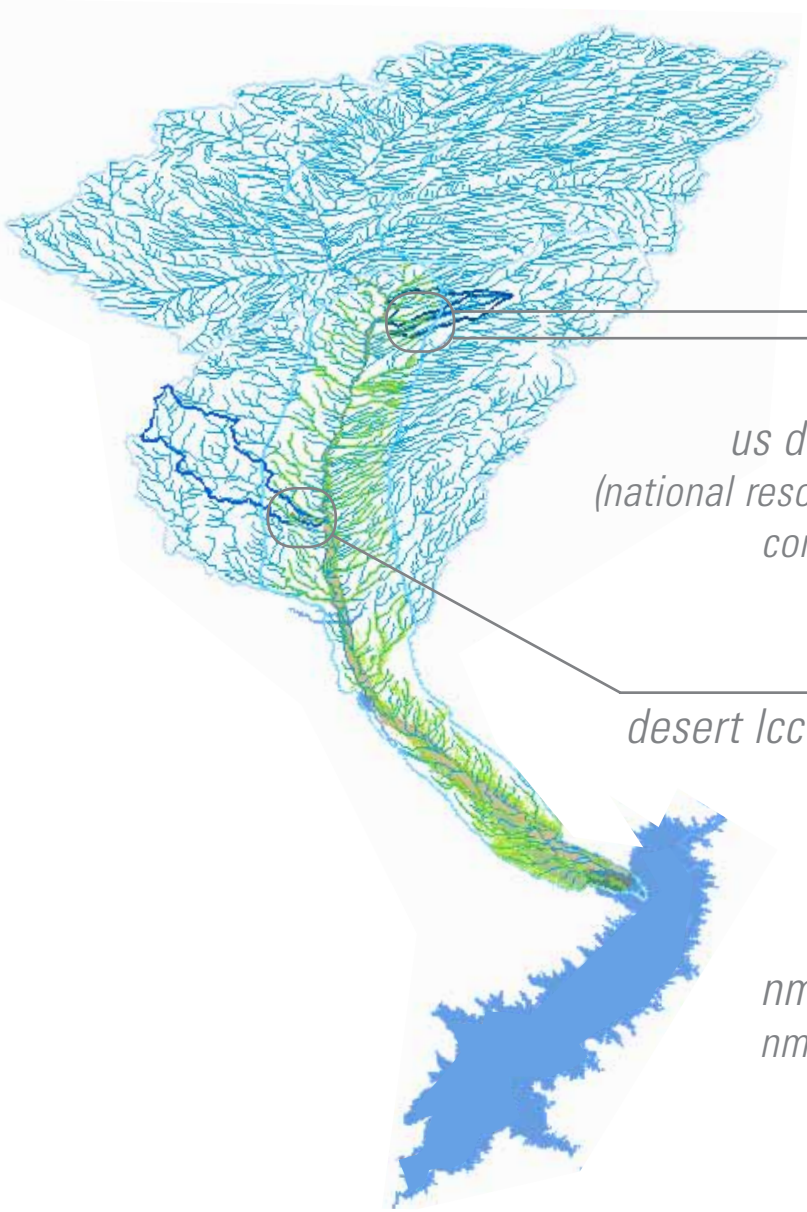
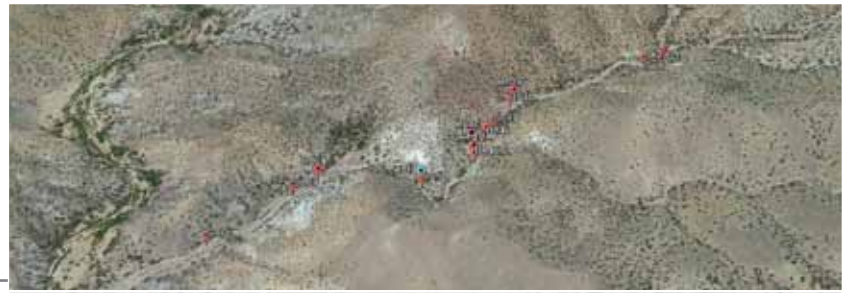


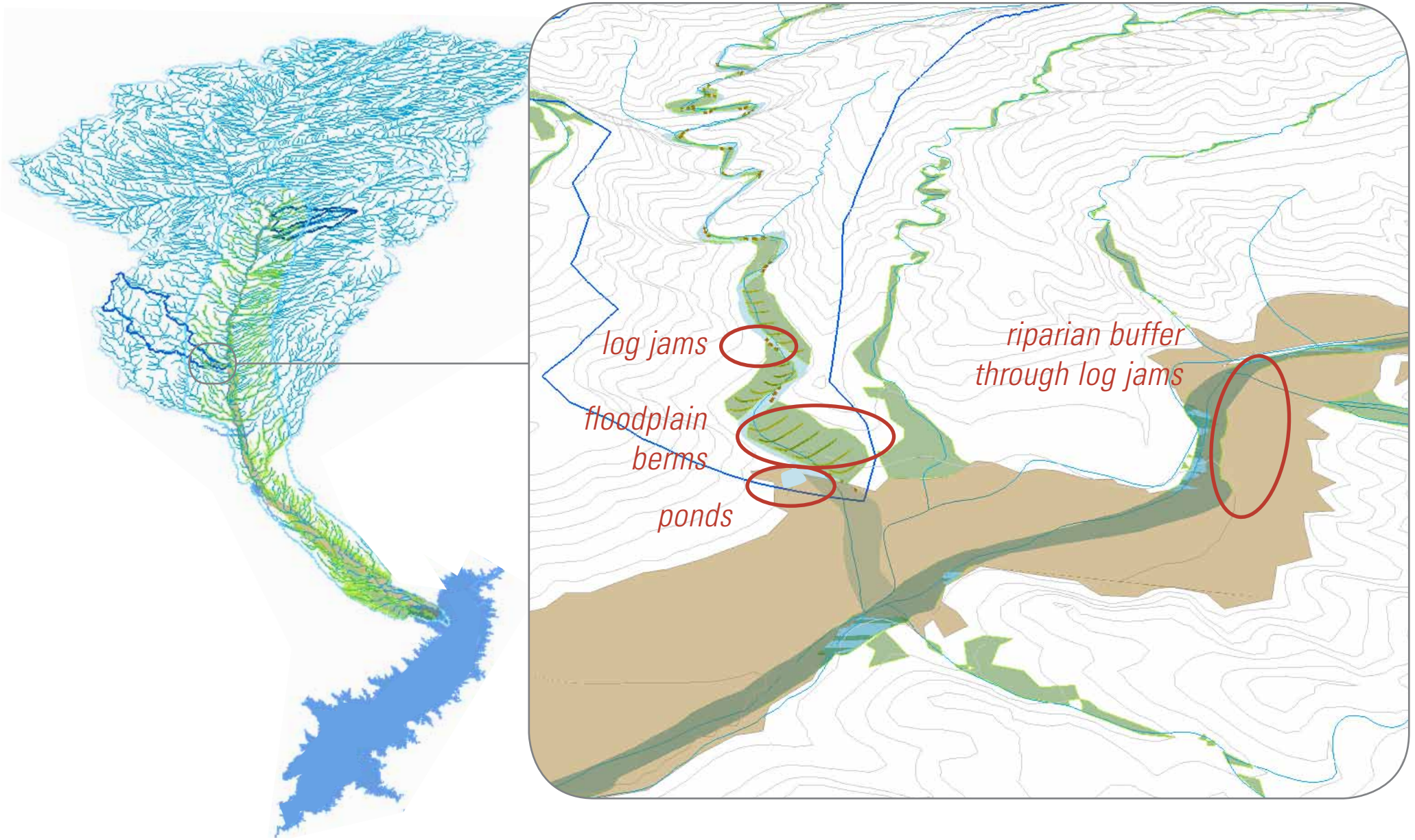
us fish & wildlife service:
partners program to restore wildlife habitat



us dept. of agriculture - nrcs
(national resource conservation service):
conservation innovation grant

desert lcc - bureau of reclamation
us dept. of interior:
(desert landscape conservation cooperative)
partnered with
nm community foundation:
nm river protection fund grant

three cañada alamosa pilot studies | alamosa LAND INSTITUTE



collaboratively developed four practice methods

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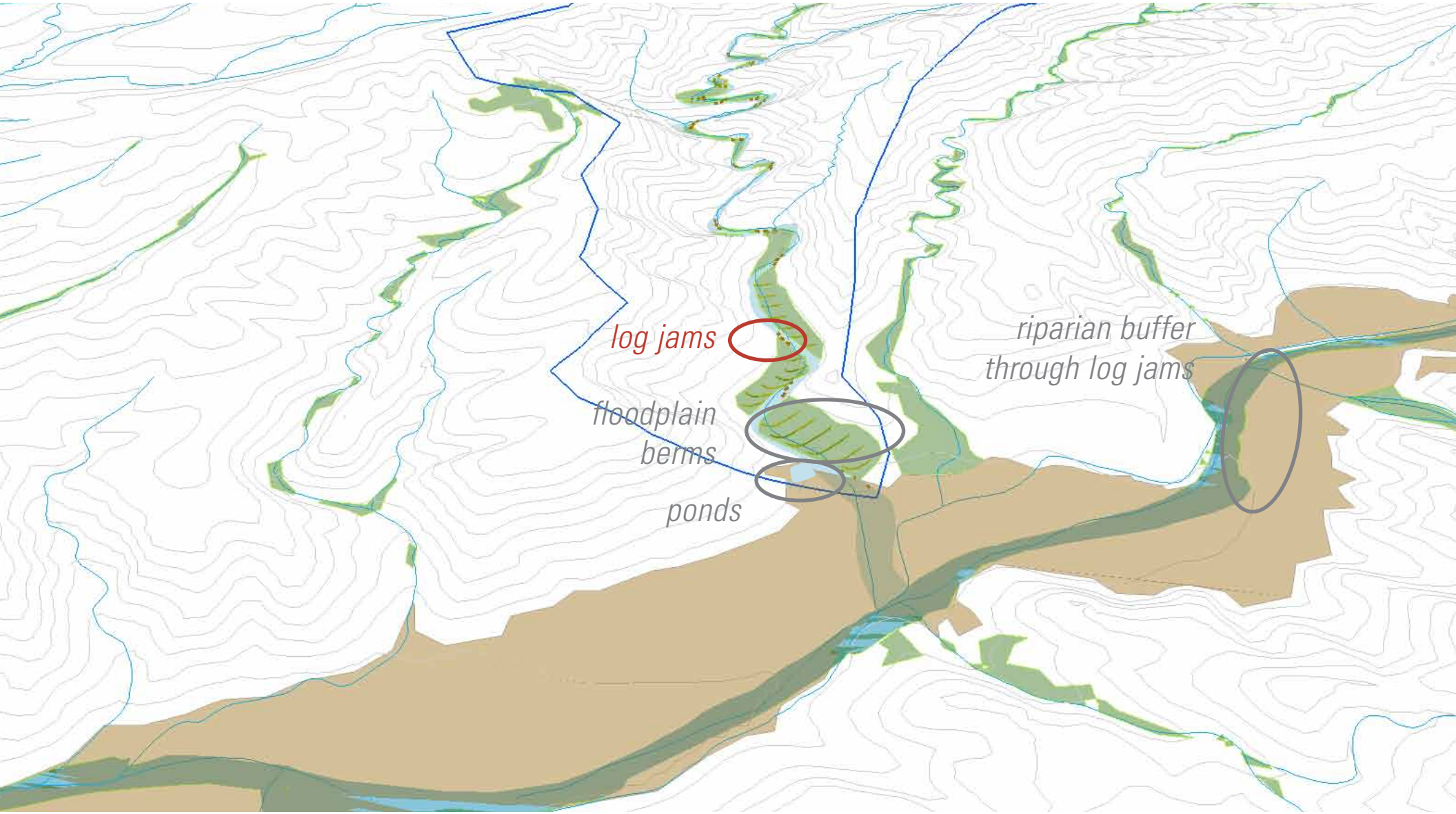
log jams
floodplain
berms
ponds
riparian buffer
through log jams

large wood log jams

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create surface roughness - capture debris

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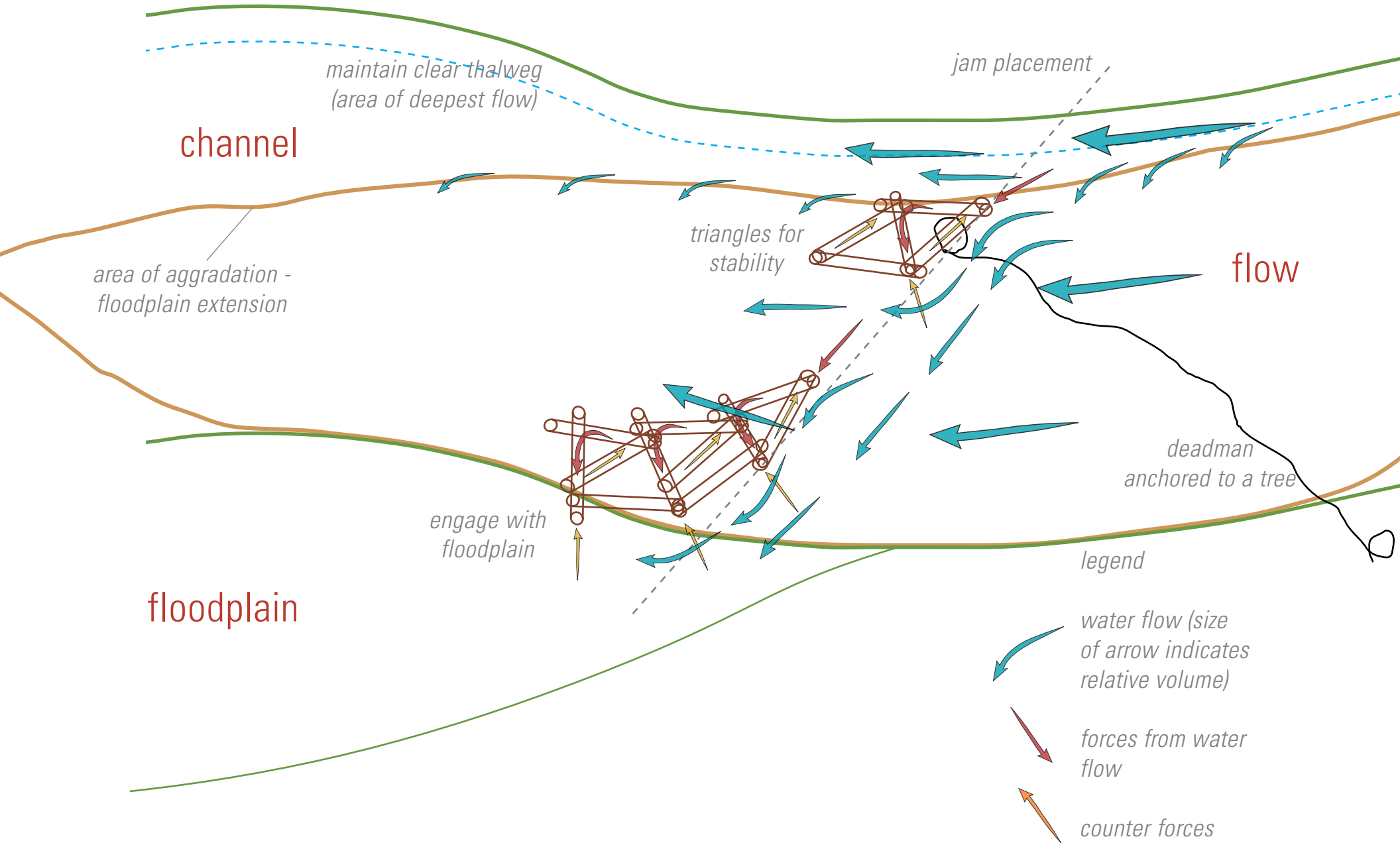

"soft" engineering approach

(eg. Gleick, 2003, Bisson et al., 2003)

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significant aggradation | alamosa LAND INSTITUTE

- *increased sediment, nutrient and organic matter deposition*
- *increased vegetation cover and habitat recruitment*
- *resulting in increased infiltration*

results - slowed flow energy by increased roughness

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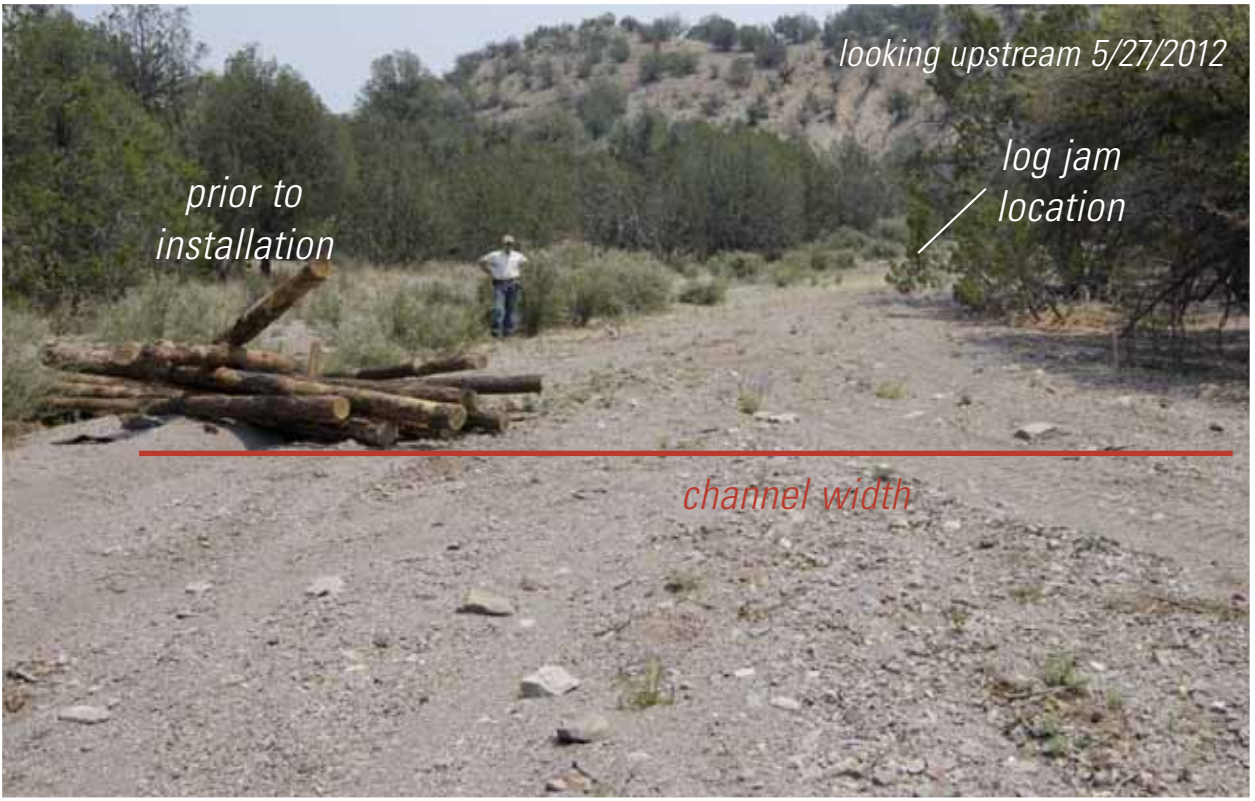

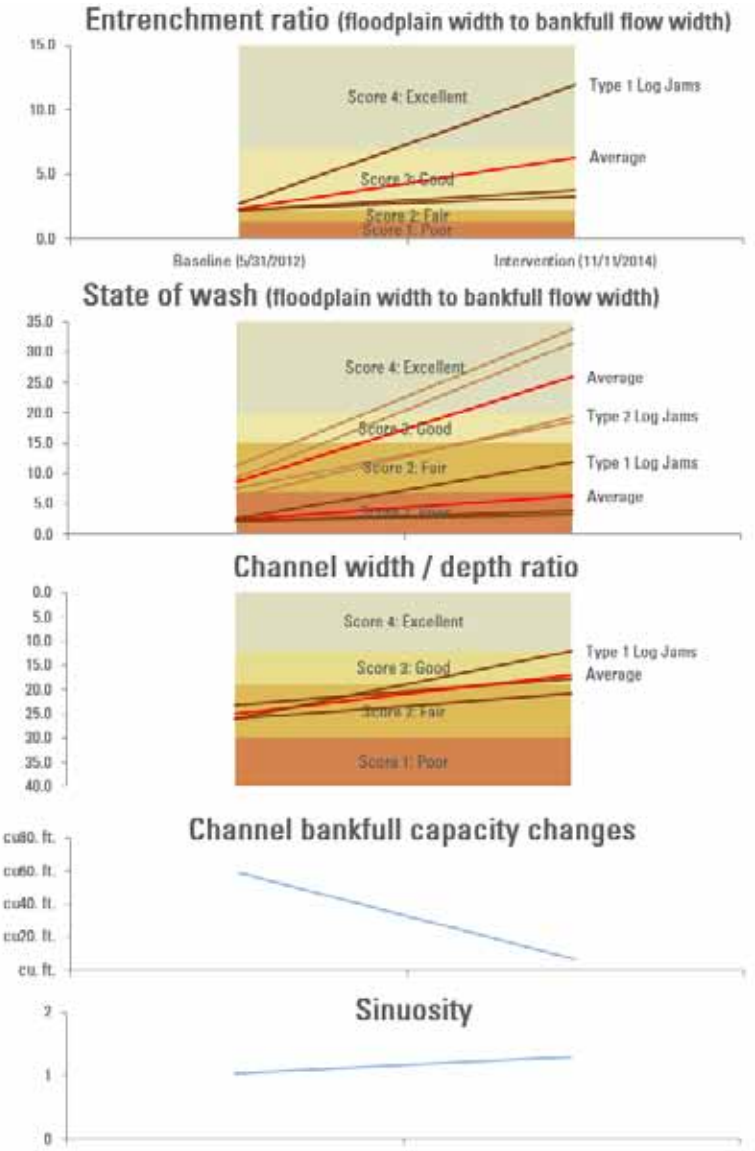

results - improved the channel geomorphology

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threshold indicator - vegetation density @ channel

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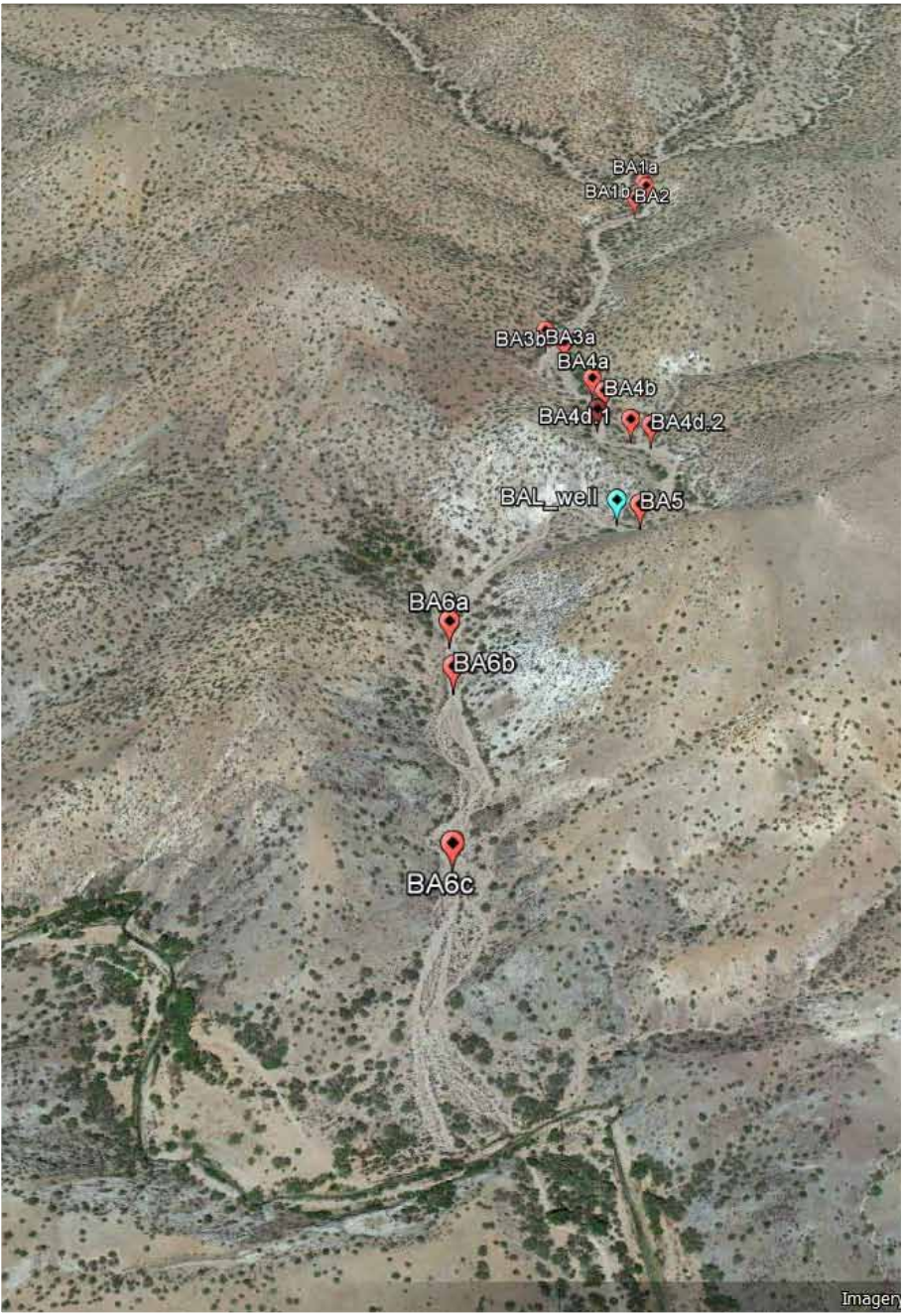
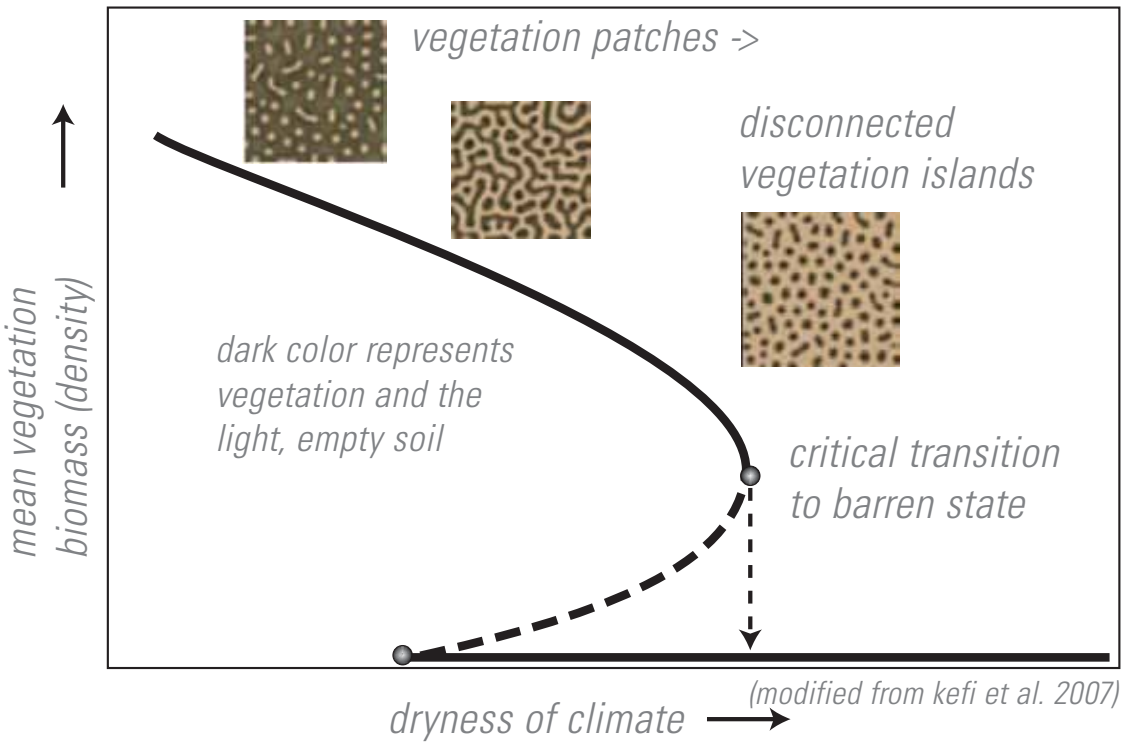
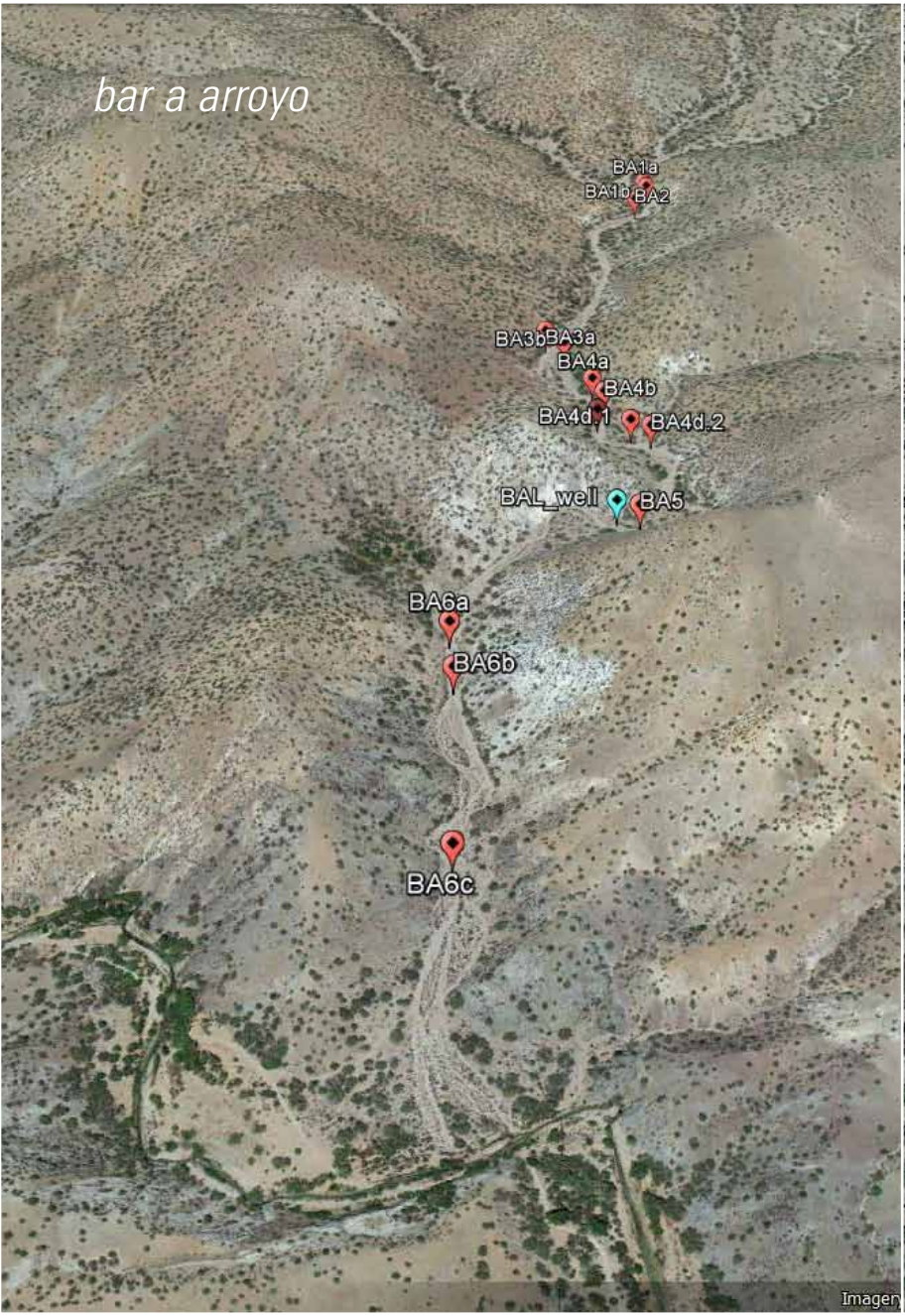
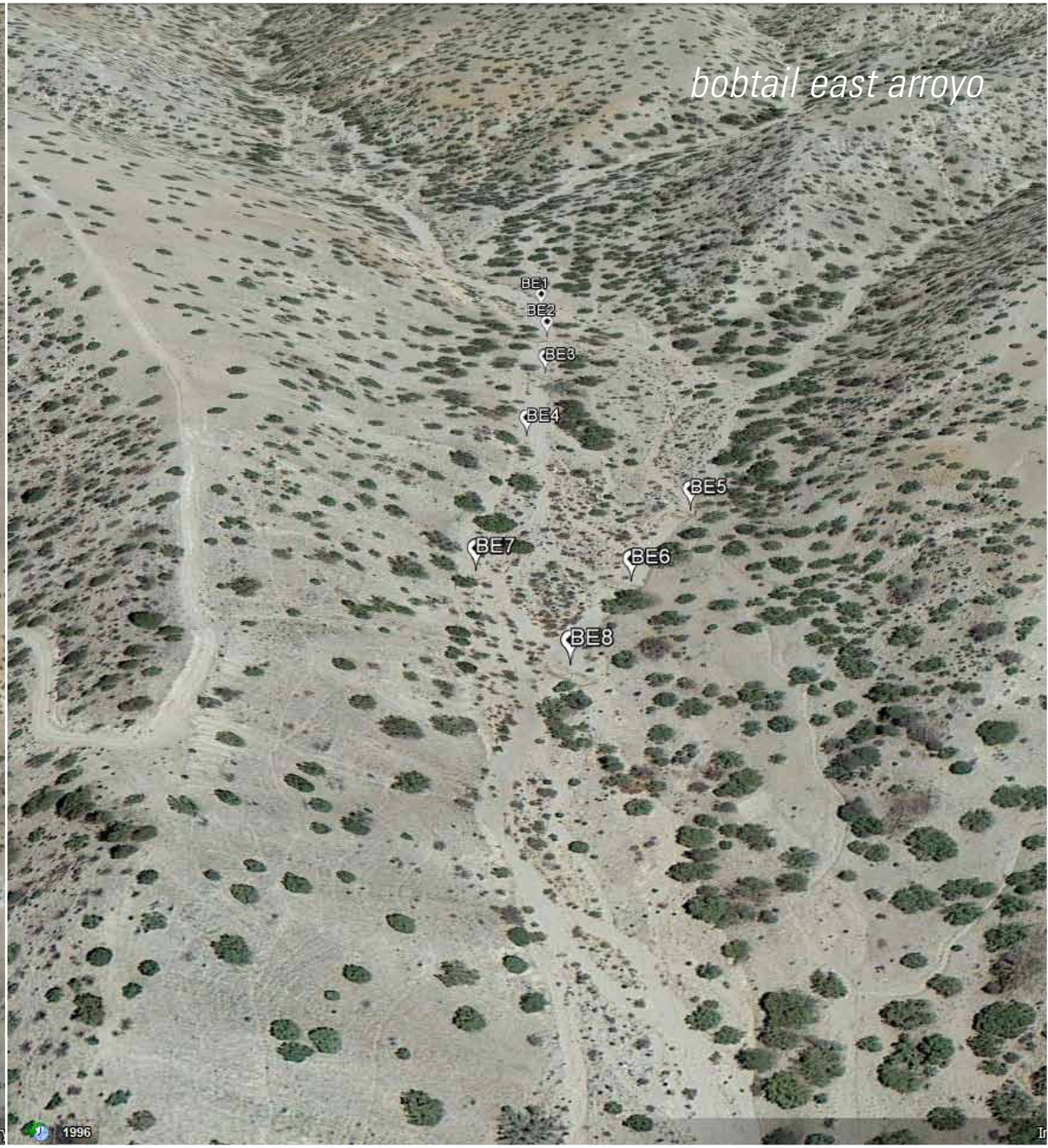




floodplain vegetation density | alamosa LAND INSTITUTE





arroyo pilot studies | alamosa LAND INSTITUTE

reference / restoration state (stable)

at risk state (threshold of stability)

degraded state (unstable)

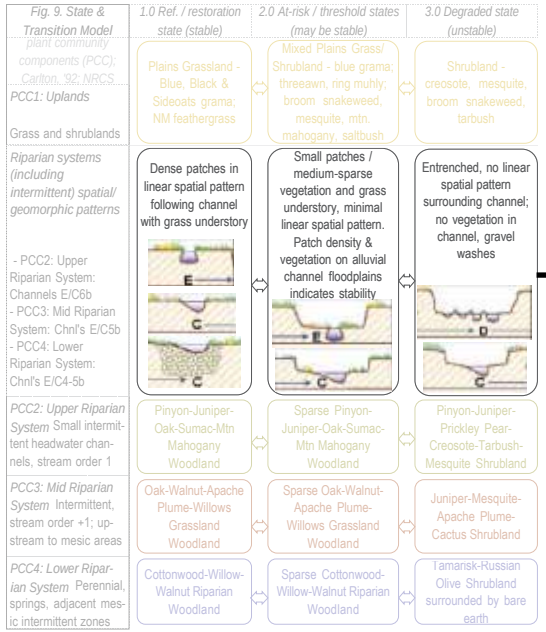
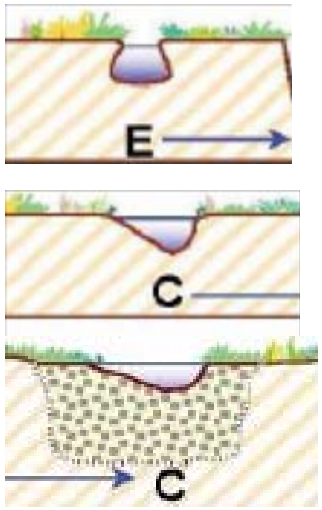
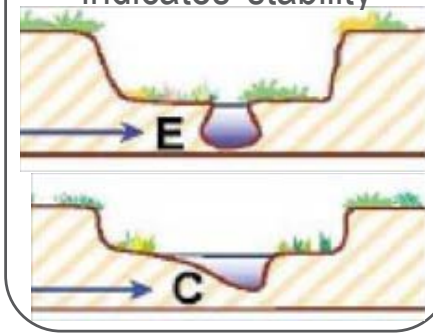


Fig. 9. State & Transition Model	*1.0 Ref. / restoration state (stable)*	*2.0 At-risk / threshold states (may be stable)*	*3.0 Degraded state (unstable)*
plant community components (PCC); Carlton, '92; NRCS			
PCC1: Uplands Grass and shrublands	Plains Grassland - Blue, Black & Sideoats grama; NM feathergrass	Mixed Plains Grass/ Shrubland - blue grama; threeawn, ring muhly; broom snakeweed, mesquite, mtn. mahogany, saltbush	Shrubland - creosote, mesquite, broom snakeweed, tarbush
Riparian systems (including intermittent) spatial/ geomorphic patterns - PCC2: Upper Riparian System: Channels E/C6b - PCC3: Mid Riparian System: Chnl's E/C5b - PCC4: Lower Riparian System: Chnl's E/C4-5b	Dense patches in linear spatial pattern following channel with grass understory	Small patches / medium-sparse vegetation and grass understory, minimal linear spatial pattern. Patch density & vegetation on alluvial channel floodplains indicates stability	Entrenched, no linear spatial pattern surrounding channel; no vegetation in channel, gravel washes
PCC2: Upper Riparian System Small intermittent headwater channels, stream order 1	Pinyon-Juniper-Oak-Sumac-Mtn Mahogany Woodland	Sparse Pinyon-Juniper-Oak-Sumac-Mtn Mahogany Woodland	Pinyon-Juniper-Prickley Pear-Creosote-Tarbush-Mesquite Shrubland
PCC3: Mid Riparian System Intermittent, stream order +1; upstream to mesic areas	Oak-Walnut-Apache Plume-Willows Grassland Woodland	Sparse Oak-Walnut-Apache Plume-Willows Grassland Woodland	Juniper-Mesquite-Apache Plume-Cactus Shrubland
PCC4: Lower Riparian System Perennial, springs, adjacent mesic intermittent zones	Cottonwood-Willow-Walnut Riparian Woodland	Sparse Cottonwood-Willow-Walnut Riparian Woodland	Tamarisk-Russian Olive Shrubland surrounded by bare earth

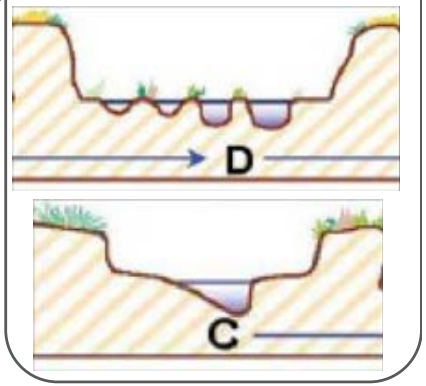
Dense patches in linear spatial pattern following channel with grass understory



Small patches / medium-sparse vegetation and grass understory, minimal linear spatial pattern. Patch density & vegetation on alluvial channel floodplains indicates stability



Entrenched, no linear spatial pattern surrounding channel; no vegetation in channel, gravel washes



state & transition model - floodplain vegetation density

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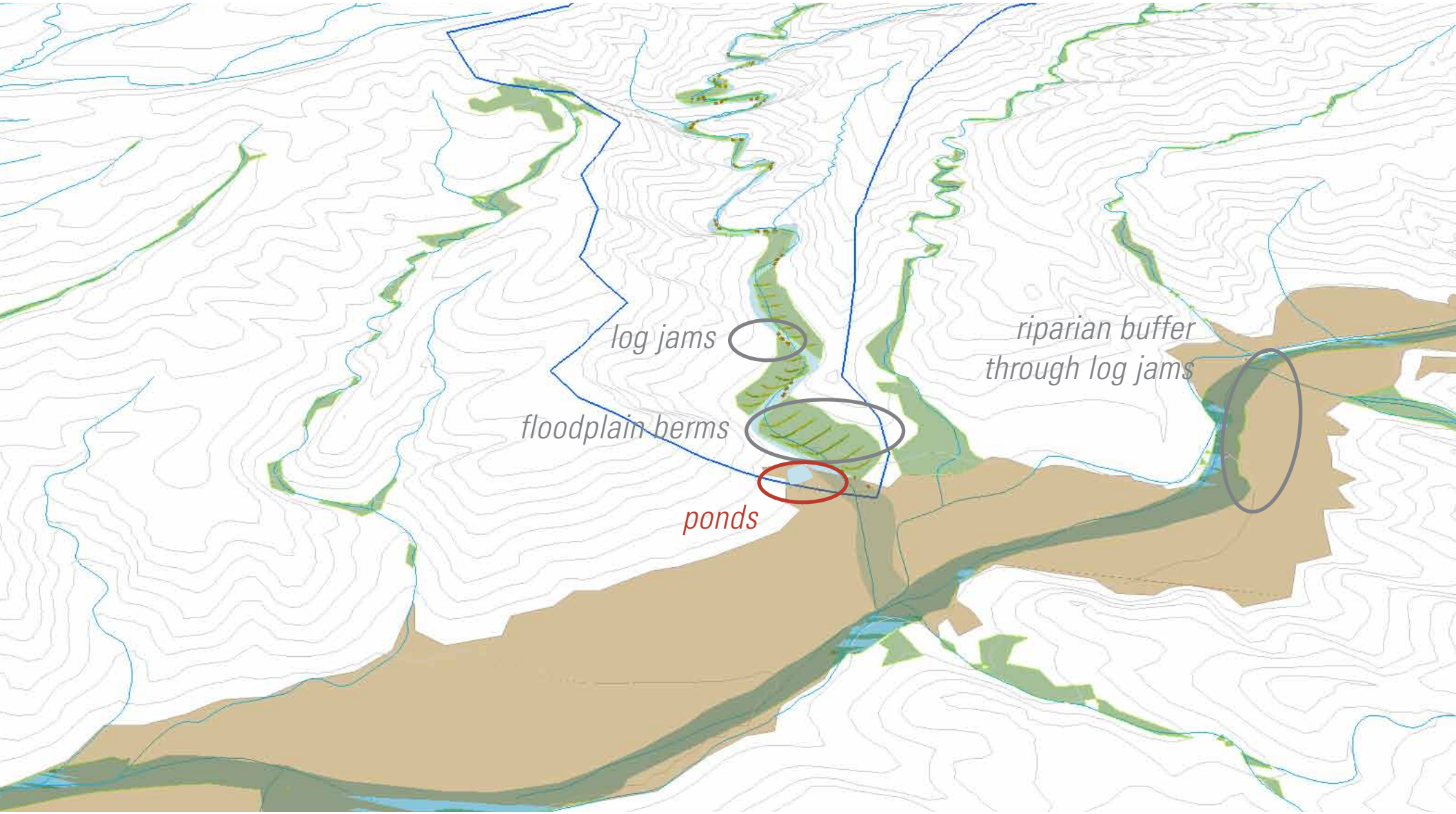
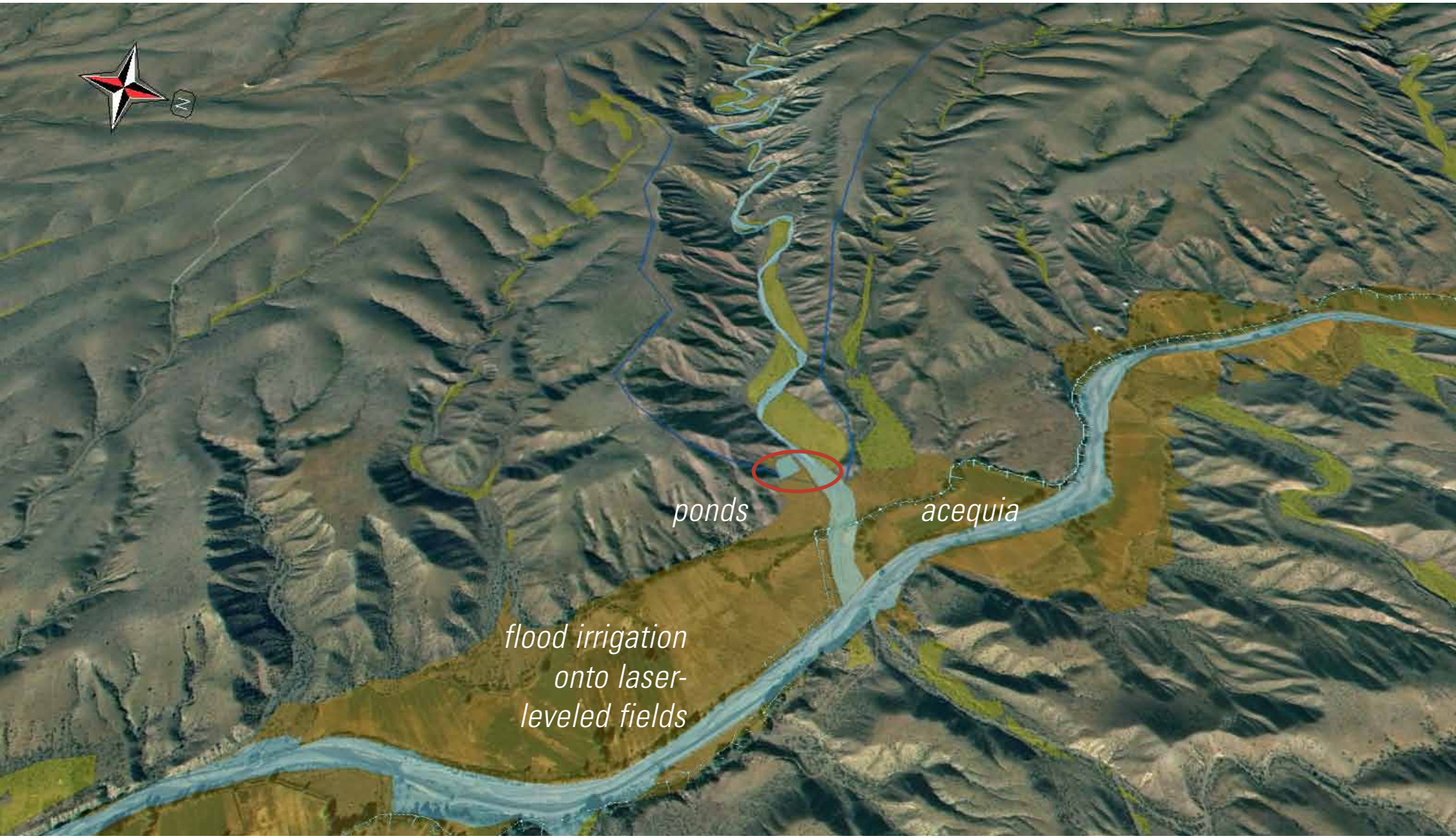


ponds | alamosa LAND INSTITUTE



... traditional acequia practice - flood irrigation ...

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... 1st pond holds up to 1 million gallons ...
... pond sealed within two fills ...

reconnect floodplain - remove berm

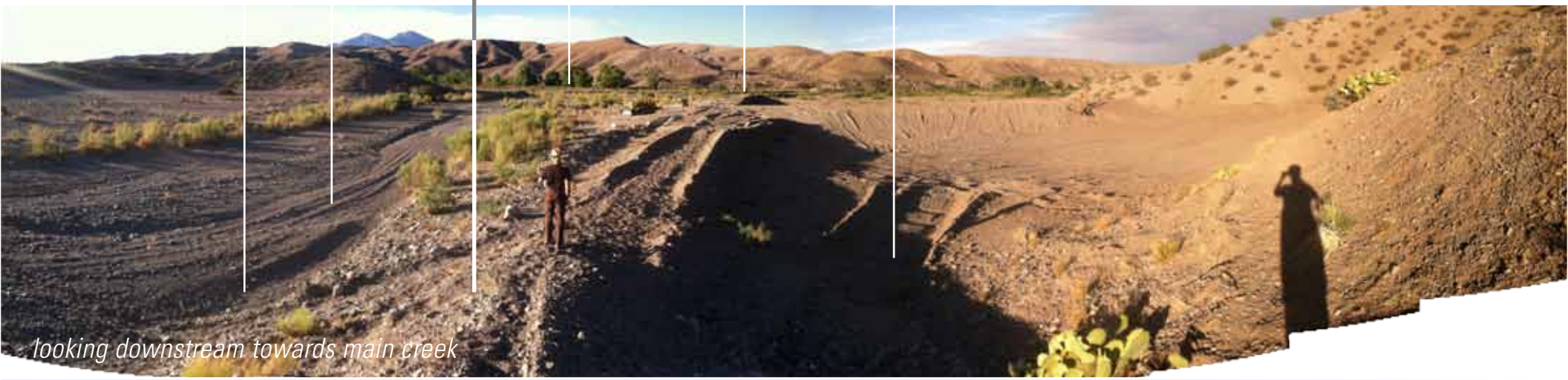
log jam location

arroyo water source

alamosa creek

fields beyond

pond



looking downstream towards main creek

looking towards arroyo

inlet location

arroyo water source

valve

pipe to ditch

future ponds

alamosa creek

construction images

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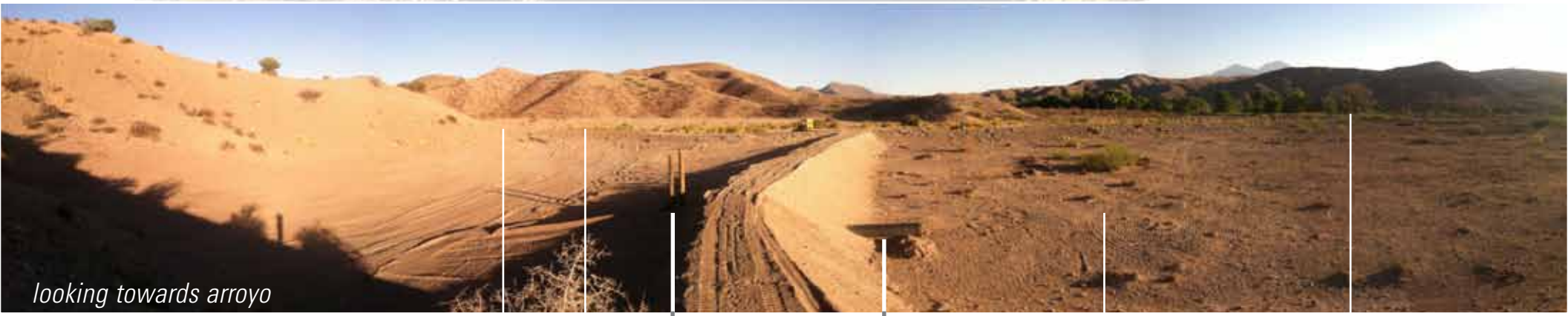

construction images

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3 types of trees, 4 types of shrubs, and 15 types of grasses
such a harsh area, our goal was anything surviving

all tree and 3 of 4 shrub types survived, with between 16 & 56% of grasses surviving first year

species	qty
trees	**73**
fremont cottonwood	21
goodding's willow	22
salix exigua, coyote willow	15
shrubs	**80**
foresteria neomexicana, nm olive	15
rhus trilobata, three leaf sumac/skunkbush	14
amorpha fruiticosa, false indigo bush	16
anemopsis californica, yerba manza	50

grasses	**1385**
carex emoryi, emory's sedge	100
carex hystricina, porcupine sedge	100
disticlis stricta, saltgrass	100
eleocharis parishii, desert spikerush	100
eleocharis palustris, creeping spike rush	100
juncus balticus, baltic rush	100
muhlenbergia asperifolia, scratchgrass	100
puccinellia nuttalliana, nuttall's alkali grass	100

ranunculus cymbalara, marsh buttercup	25
scirpus acutus, hardstem bulrush	100
scirpus maritimus, saltmarsh bulrush	100
scirpus pungens, three square rush	100
scirpus validus, softstem bulrush	100
sporobolus airoides, alkali sacaton	80
sporobolus wrightii, giant sacaton	80
Total	**1535**

planting - seasonal wetland

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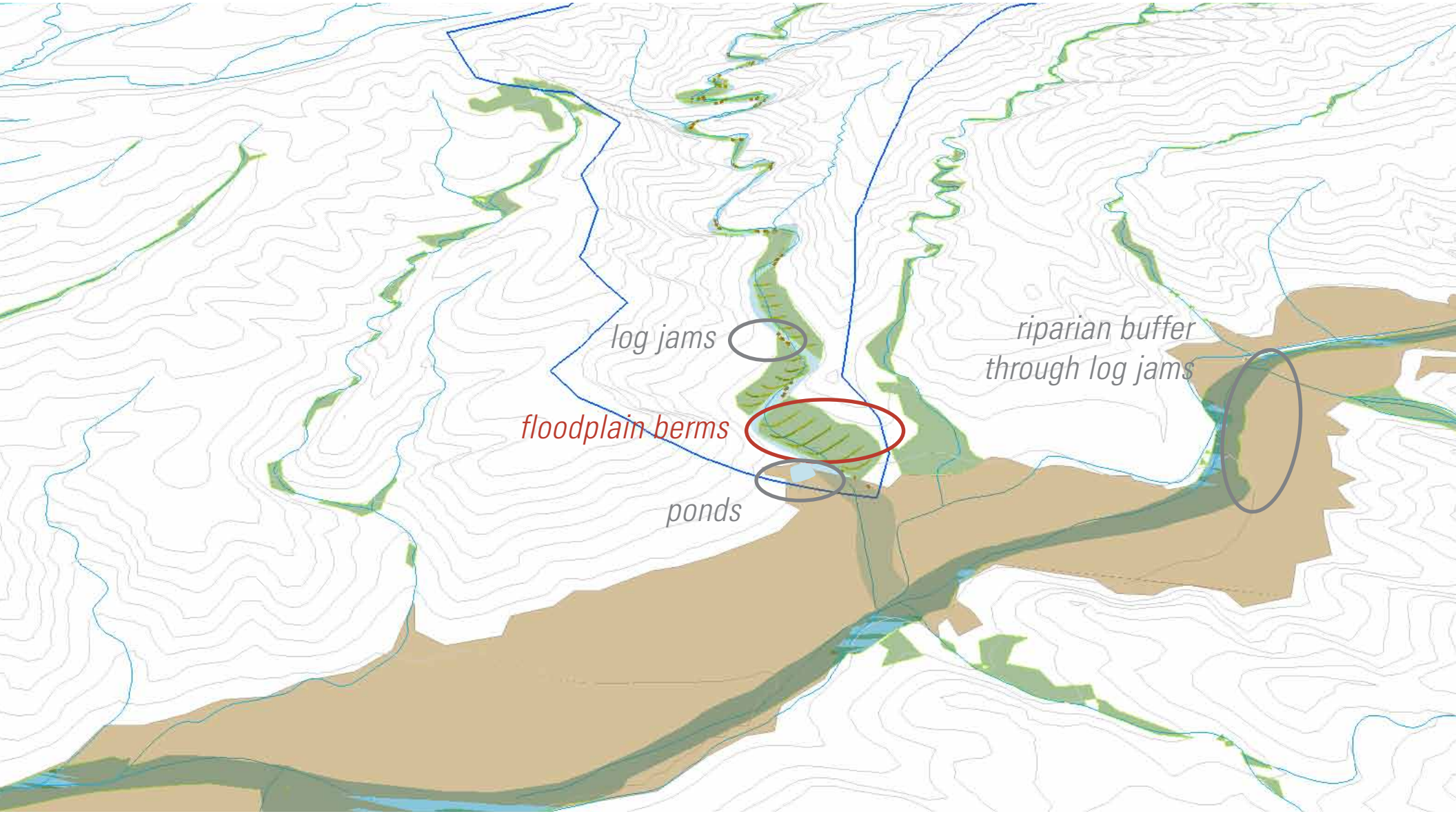

floodplain berms | alamosa LAND INSTITUTE

floodplain flow tends to create channels

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channels can deepen with more flow

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reconnected larger floodplains - add berms

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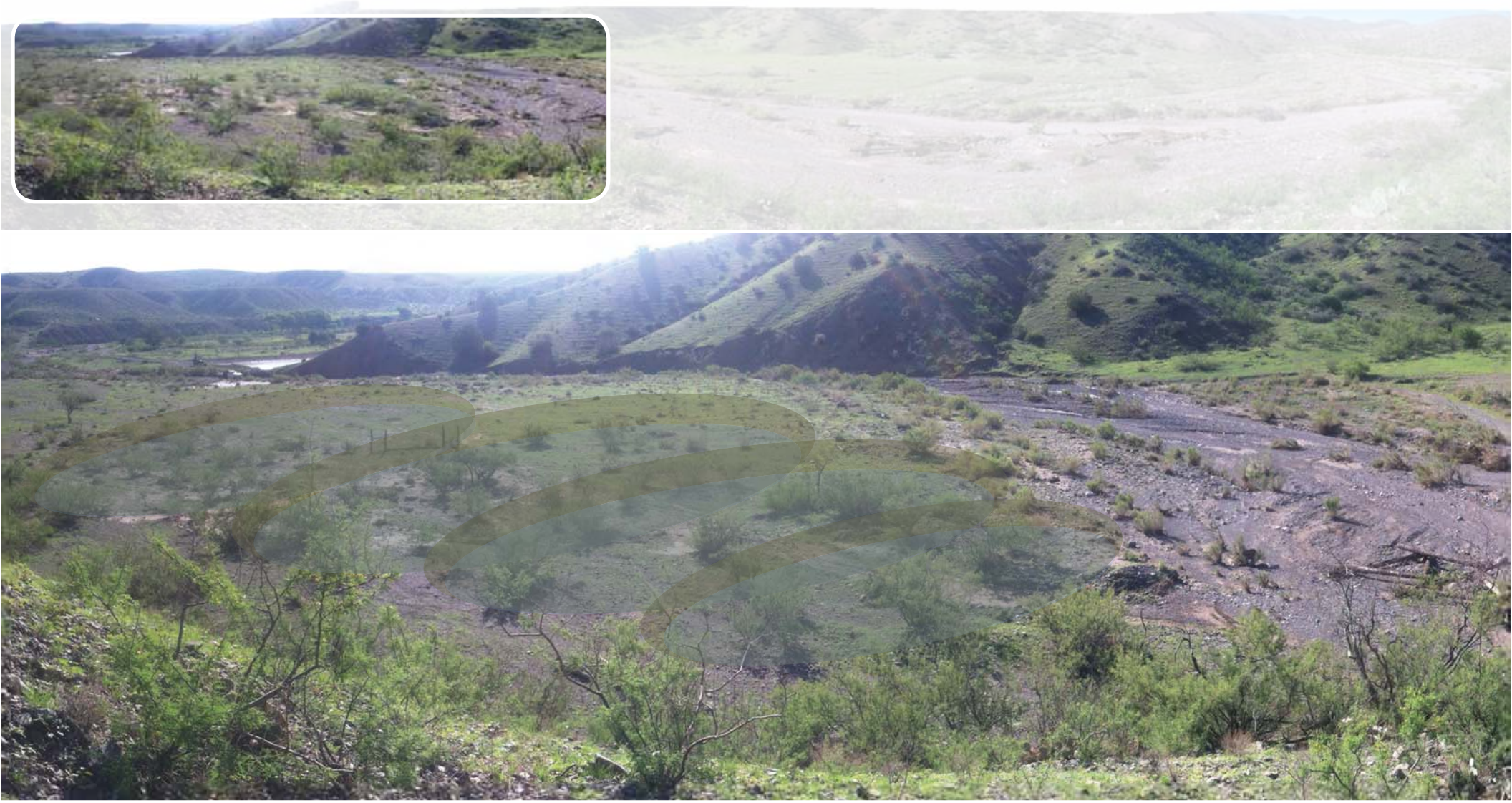
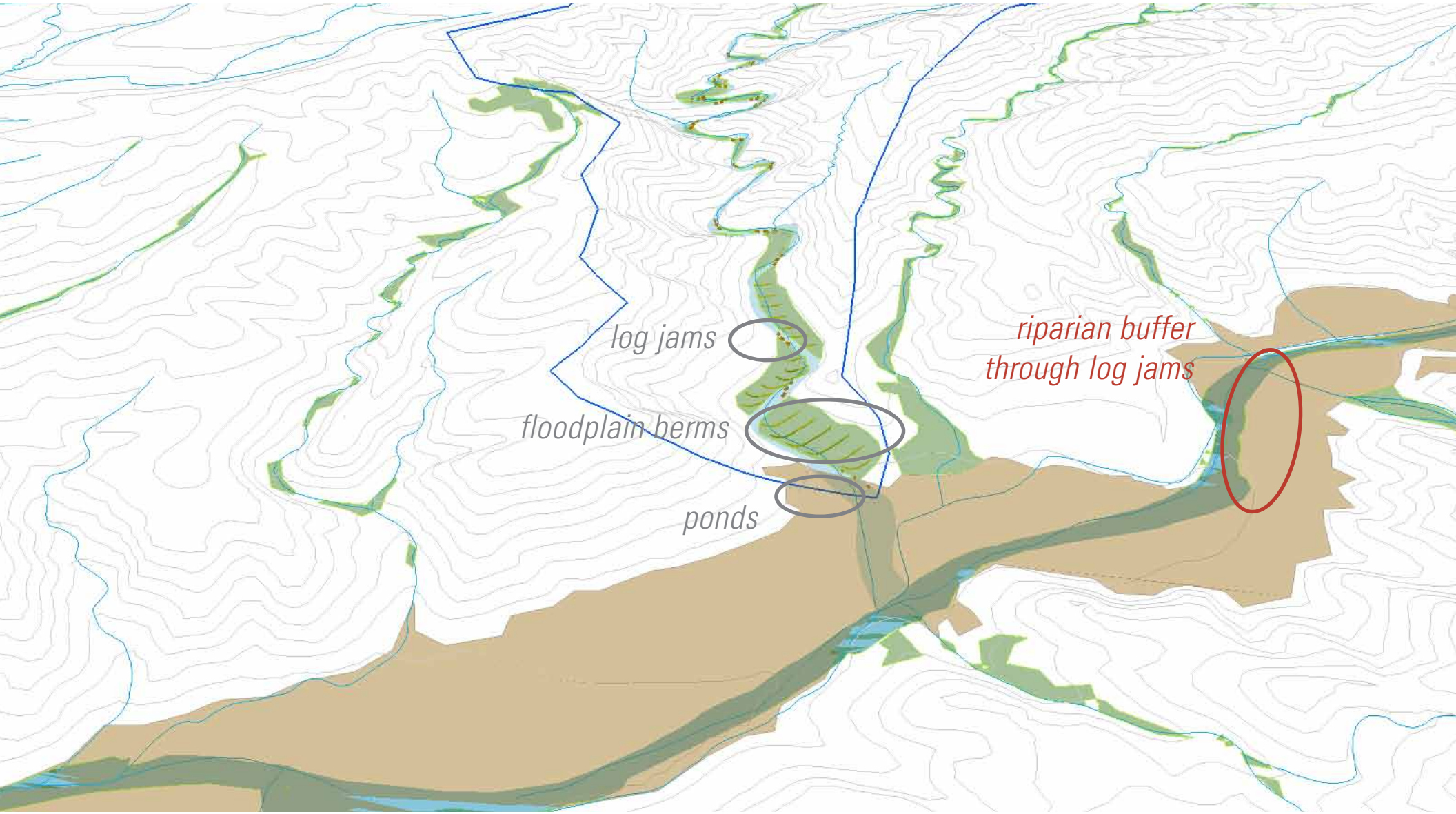


floodplain berms | alamosa LAND INSTITUTE


log jams
floodplain berms
ponds
riparian buffer
through log jams

riparian buffer restoration

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riparian buffer restoration | alamosa LAND INSTITUTE

riparian buffer / bank stabilization

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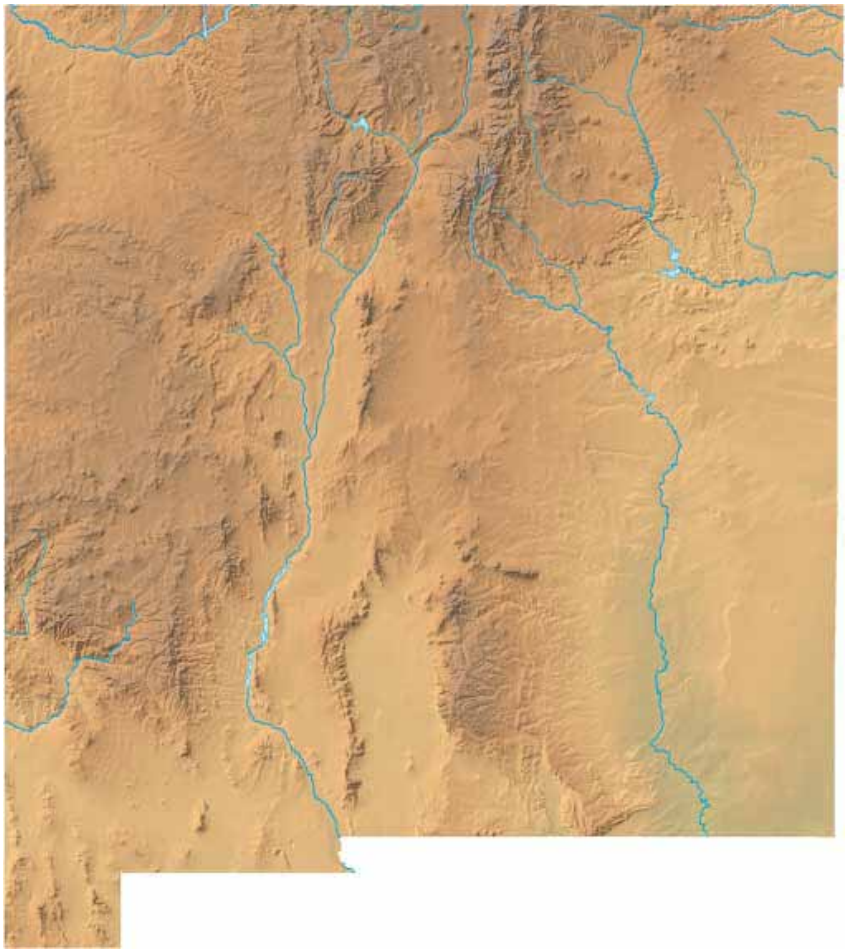

over 94 million acre-feet of rain fall upon nm annually

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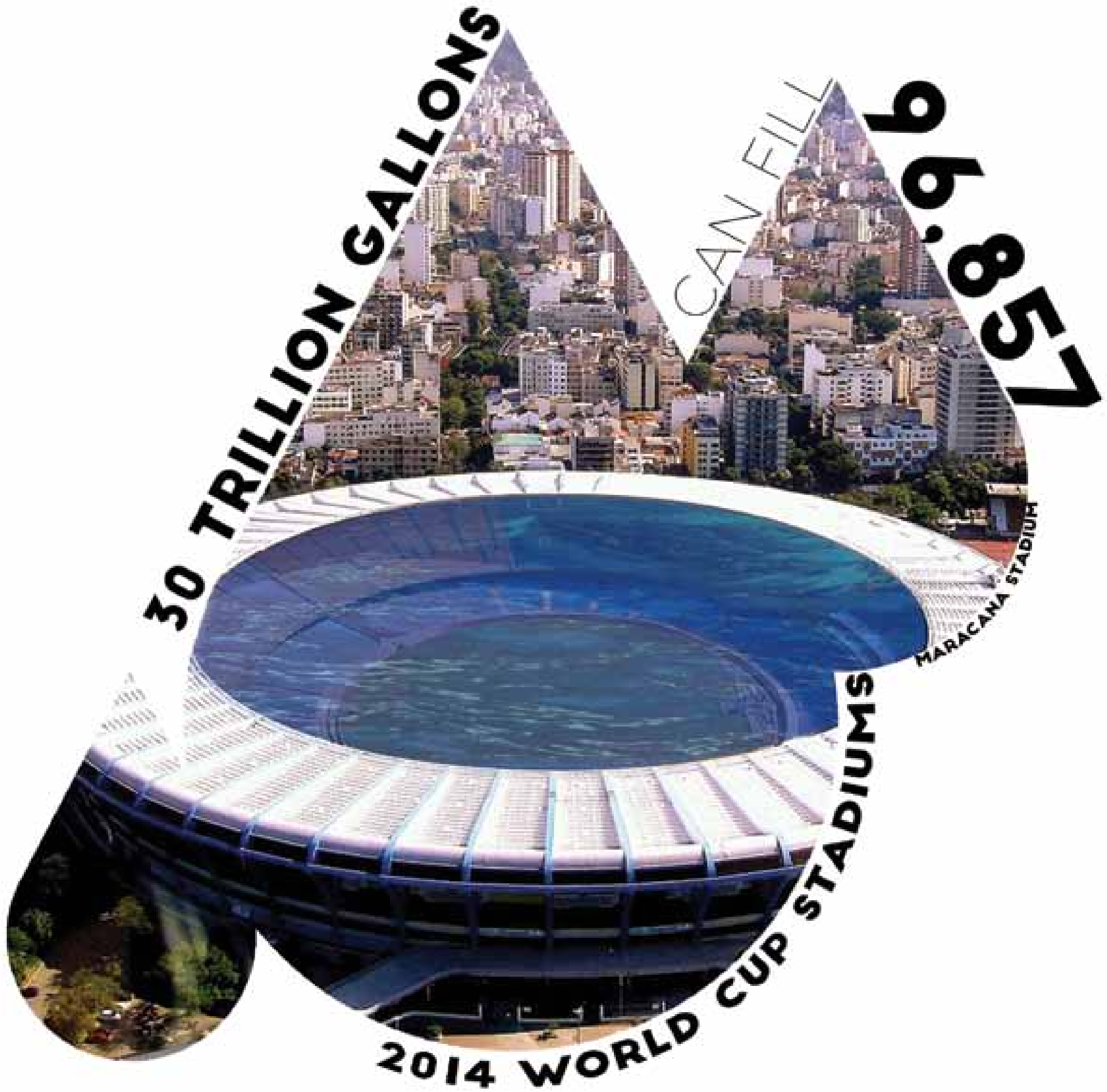
30 TRILLION GALLONS
CAN FILL
99,857
MARACANA STADIUM
2014 WORLD CUP STADIUMS

catastrophic flooding - social issue

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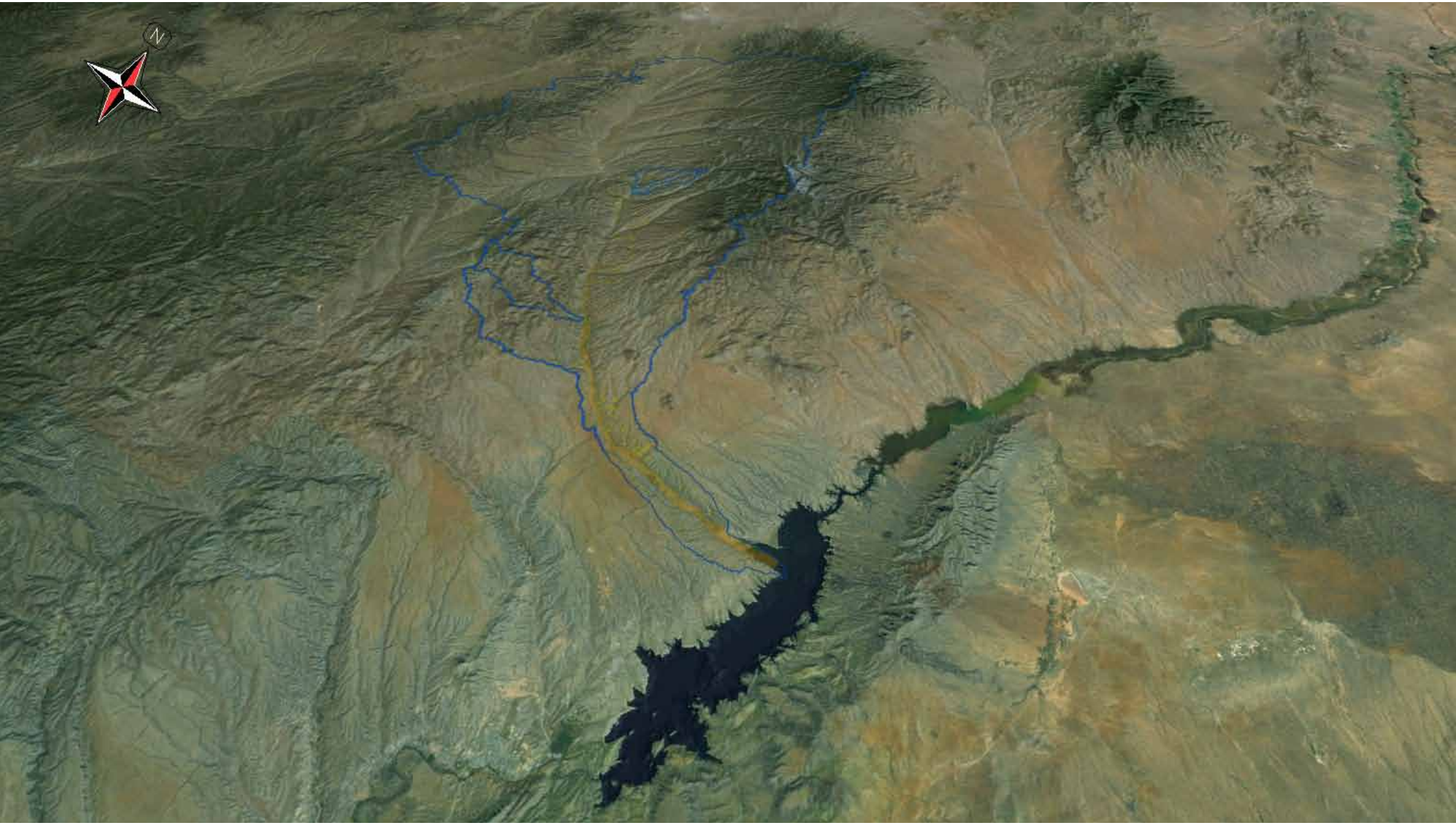
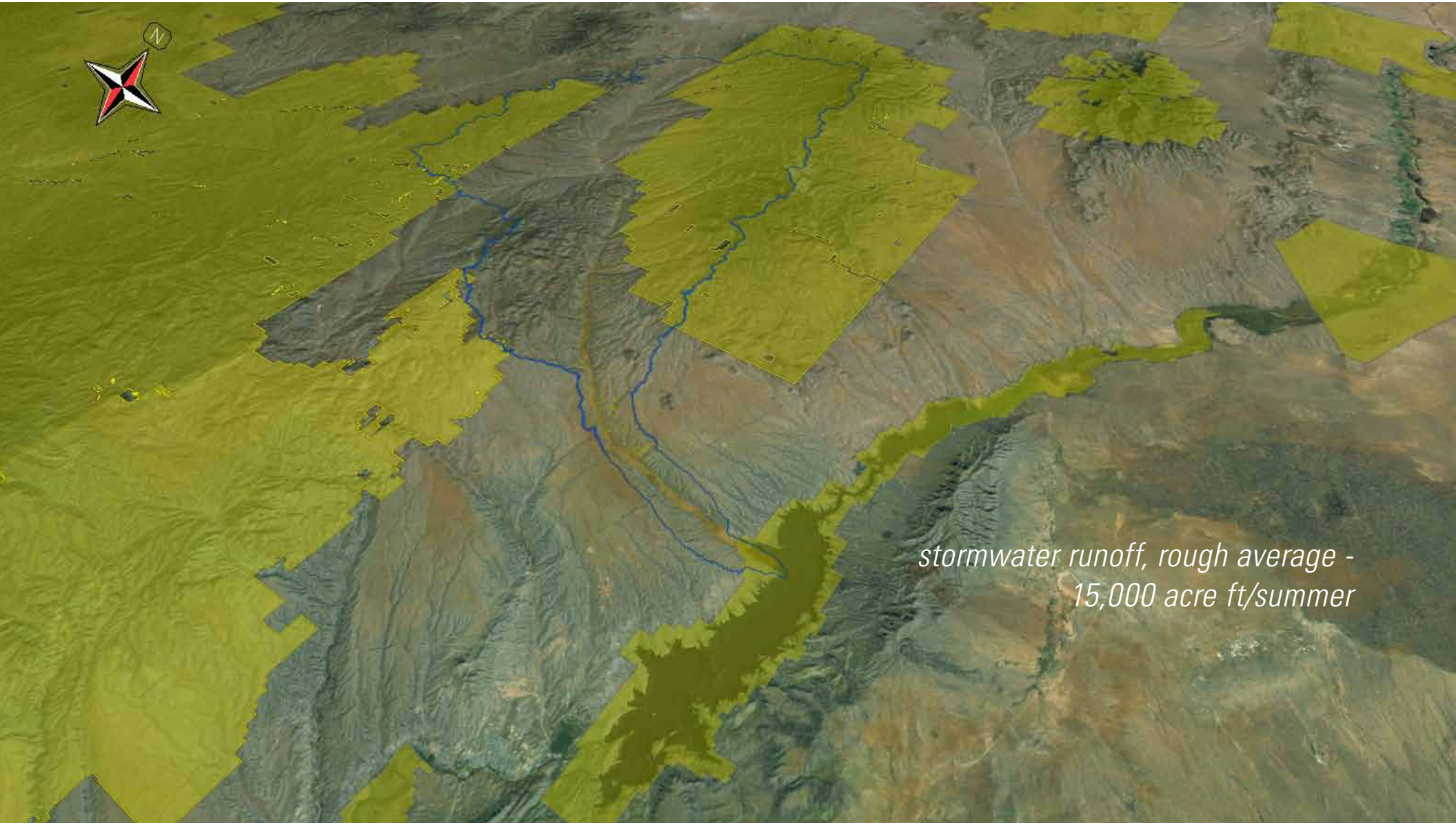


action research experiments | alamosa LAND INSTITUTE



increase infiltration & create connectivity

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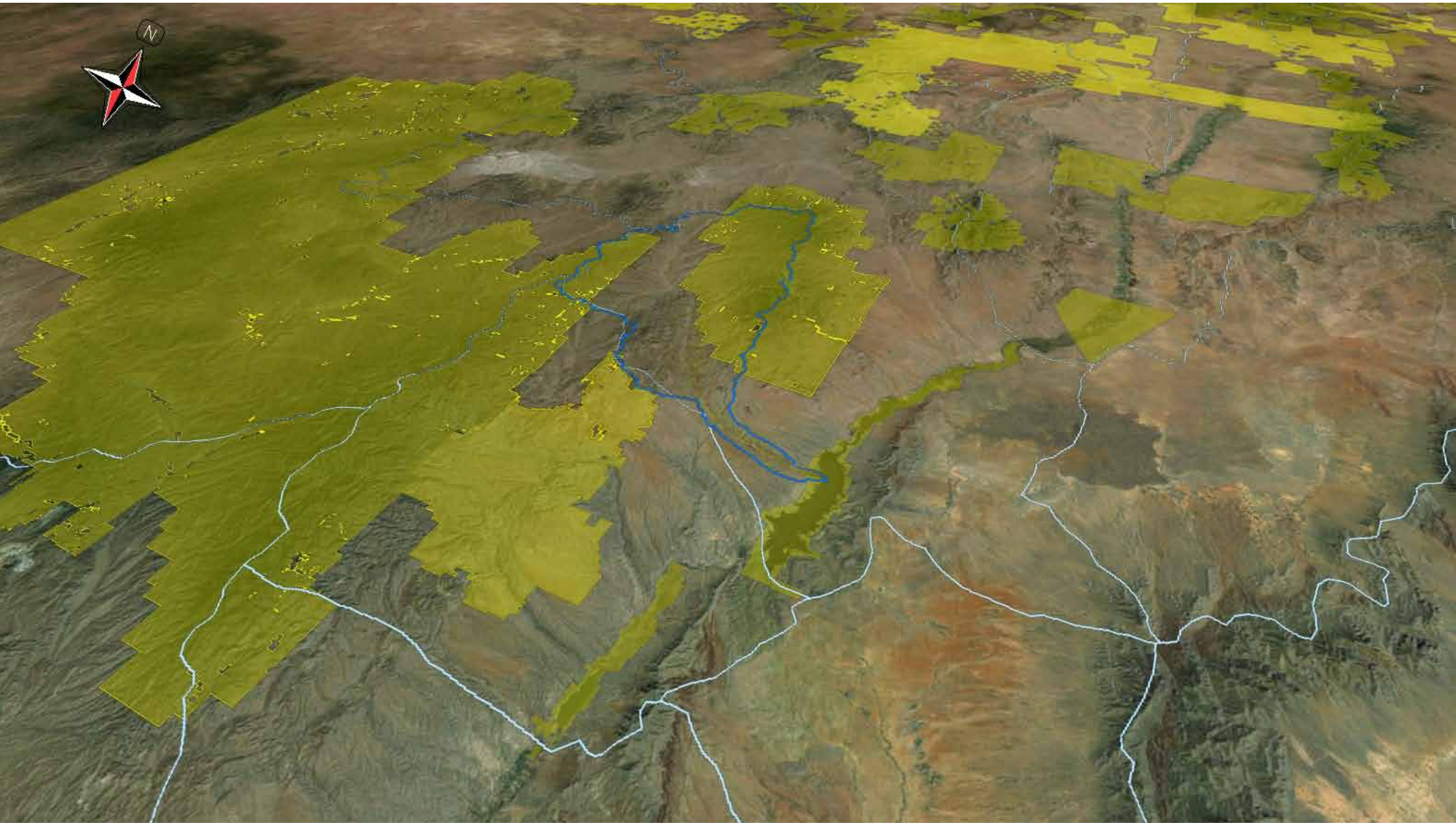
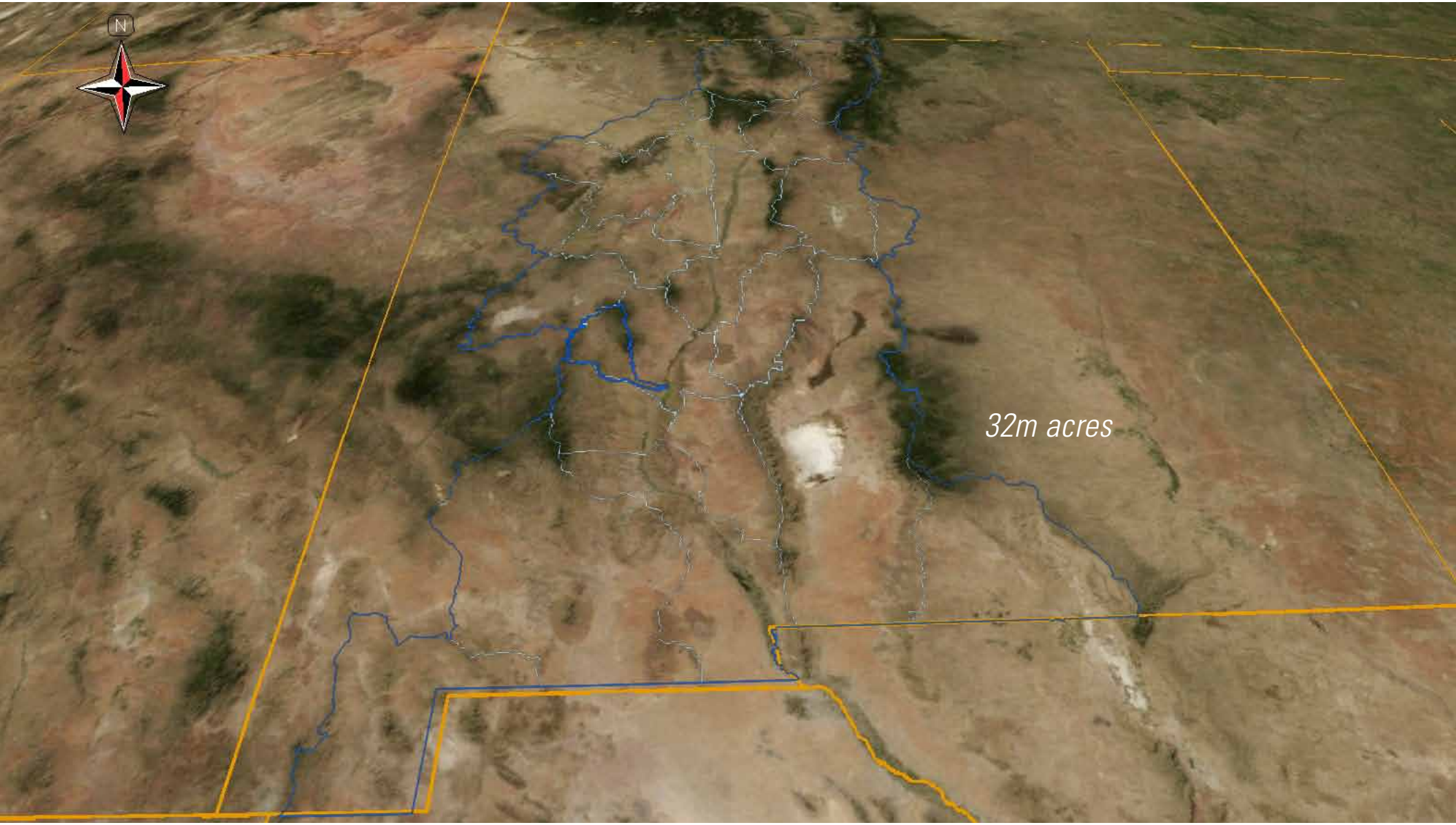
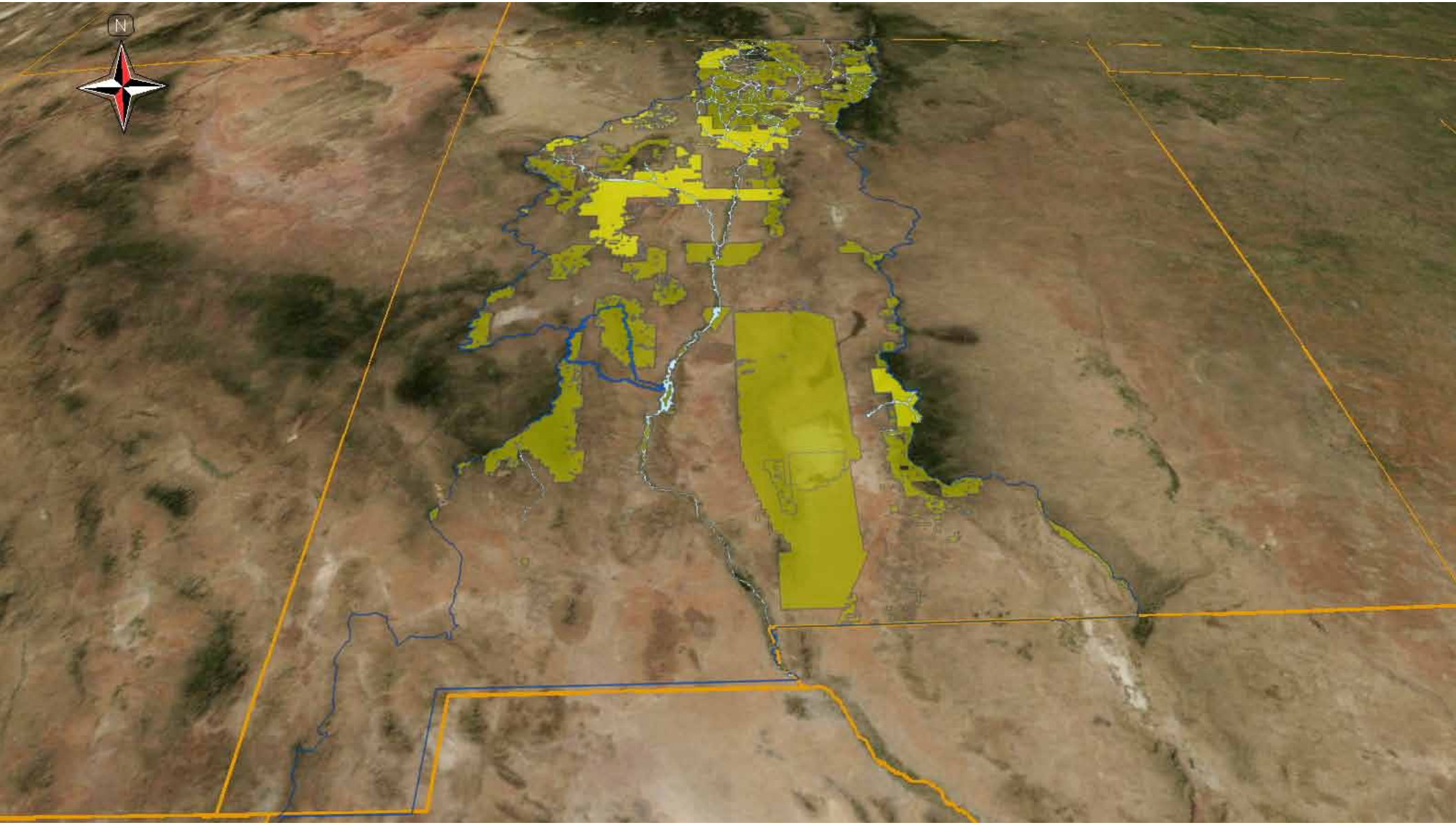


neighboring watersheds | alamosa LAND INSTITUTE



restoration of the rio grande valley | alamosa LAND INSTITUTE

support traditional acequia farmers | alamosa LAND INSTITUTE



1/3 area - 11m acres - protected areas

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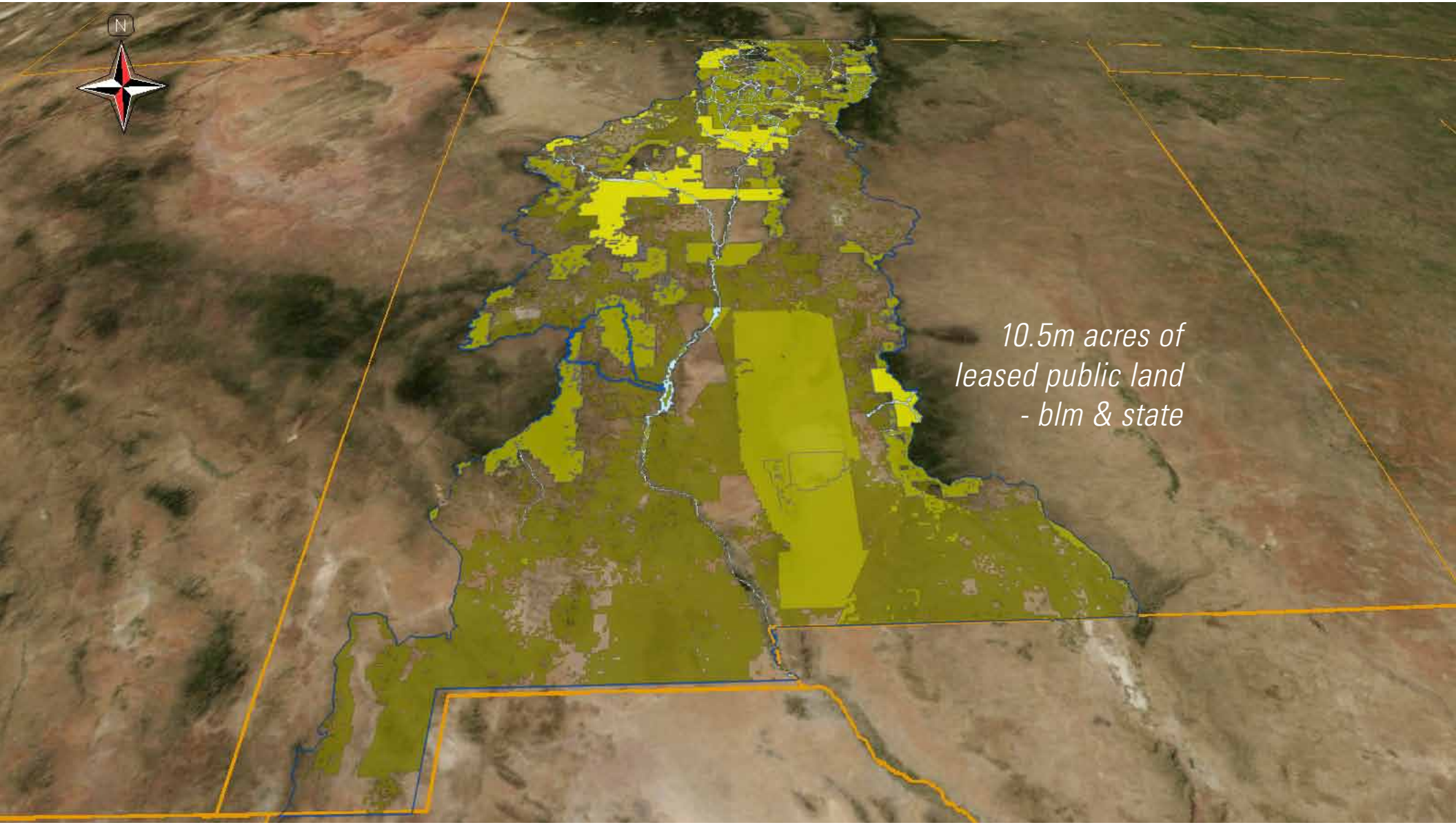

2/3 under protection or regulation

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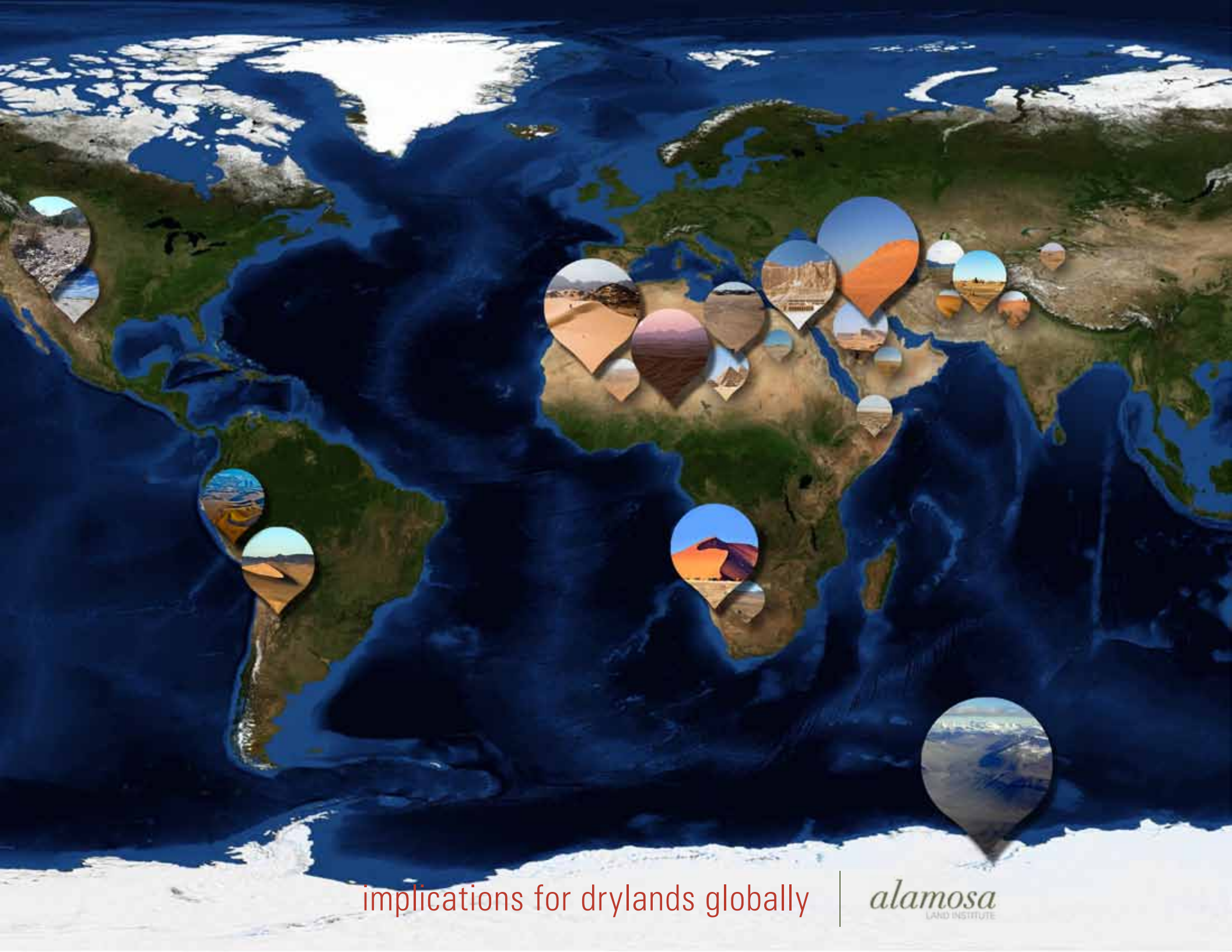

implications for drylands globally

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