RiversEdge West Riparian Restoration Conference
5 February 2019

Use of remote sensing to assess vegetation structure and model riparian wildlife habitat suitability: examples from the Santa Clara River, California

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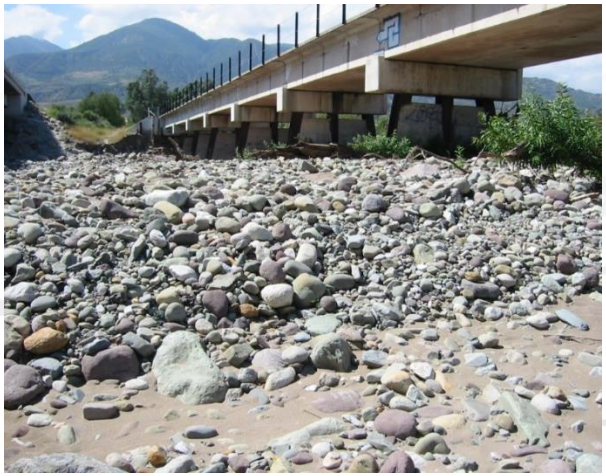
In partnership with USFWS and CDFW

Stillwater Sciences

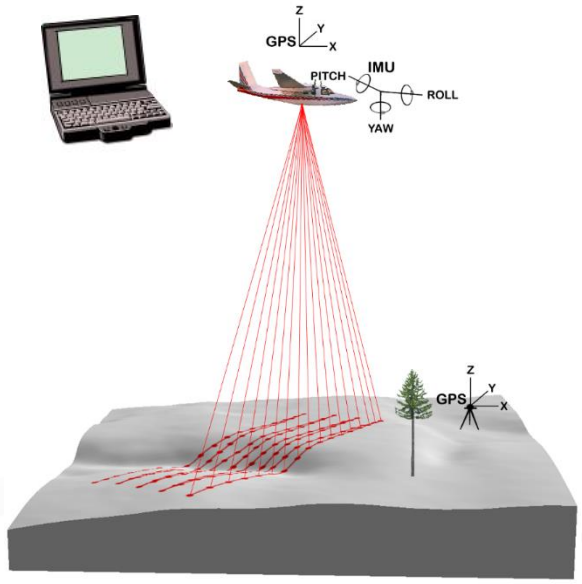
Overview

- LIDAR basics
- Background on the Santa Clara River
- Riparian birds and satellite models for habitat suitability
- LIDAR: topography and relative elevation
- Vegetation structure
  - Canopy height
  - Vertical structure (ground surface to top of canopy)
- Next steps



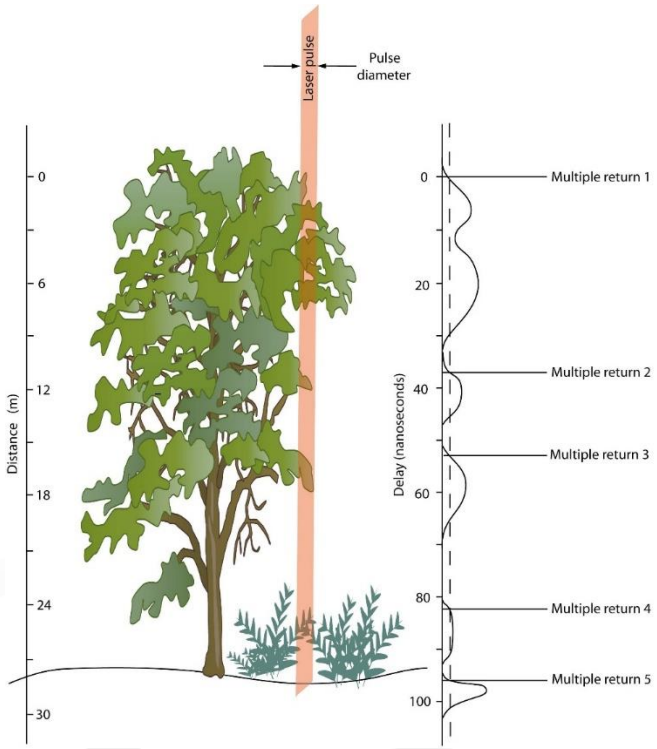
Airborne Laser Scanning (LIDAR) System Components

- Active sensor emits 40,000 – 150,000 infrared laser pulses per second
- Differentially-corrected GPS
- Inertial measurement unit (IMU)
- Computer to control the system monitor mission progress
- Interesting targets

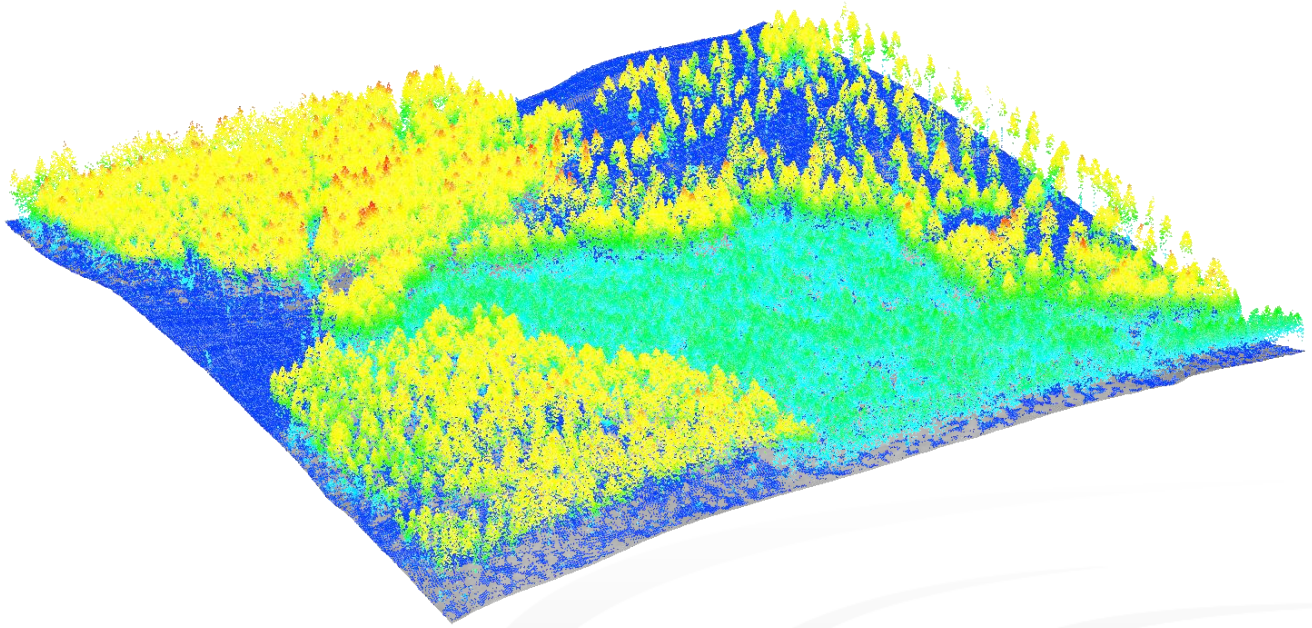


Airborne Laser Scanning (LIDAR) Technology

- Acquires 1-5 reflections (returns) per pulse
- Typically 1 -10 measurements per m^2 or 4,000 – 40,000 measurements per acre
- Data delivered as XYZ points in a "data cloud"
- **Direct measurement of 3-D structure**
  - Terrain
  - Forest vegetation
  - Infrastructure



LIDAR-derived Bare-Earth Surface Model



Santa Clara River Case Study
Regional Overview – Southern California Coastal Watersheds

Santa Clara River and tributaries are a biodiversity hotspot:

- Still in predominantly natural state
- Home to many disappearing animals and plants
- Some of the last major riparian wetlands in Southern California
- Home to 18 Threatened & Endangered Species

FLOOD DYNAMICS

- Vegetation infilling (encroachment) during drier periods between major floods

pre-high flow

FLOOD DYNAMICS

- Vegetation scour and reset after large floods, particularly in El Niño years

high flow

FEB 2005

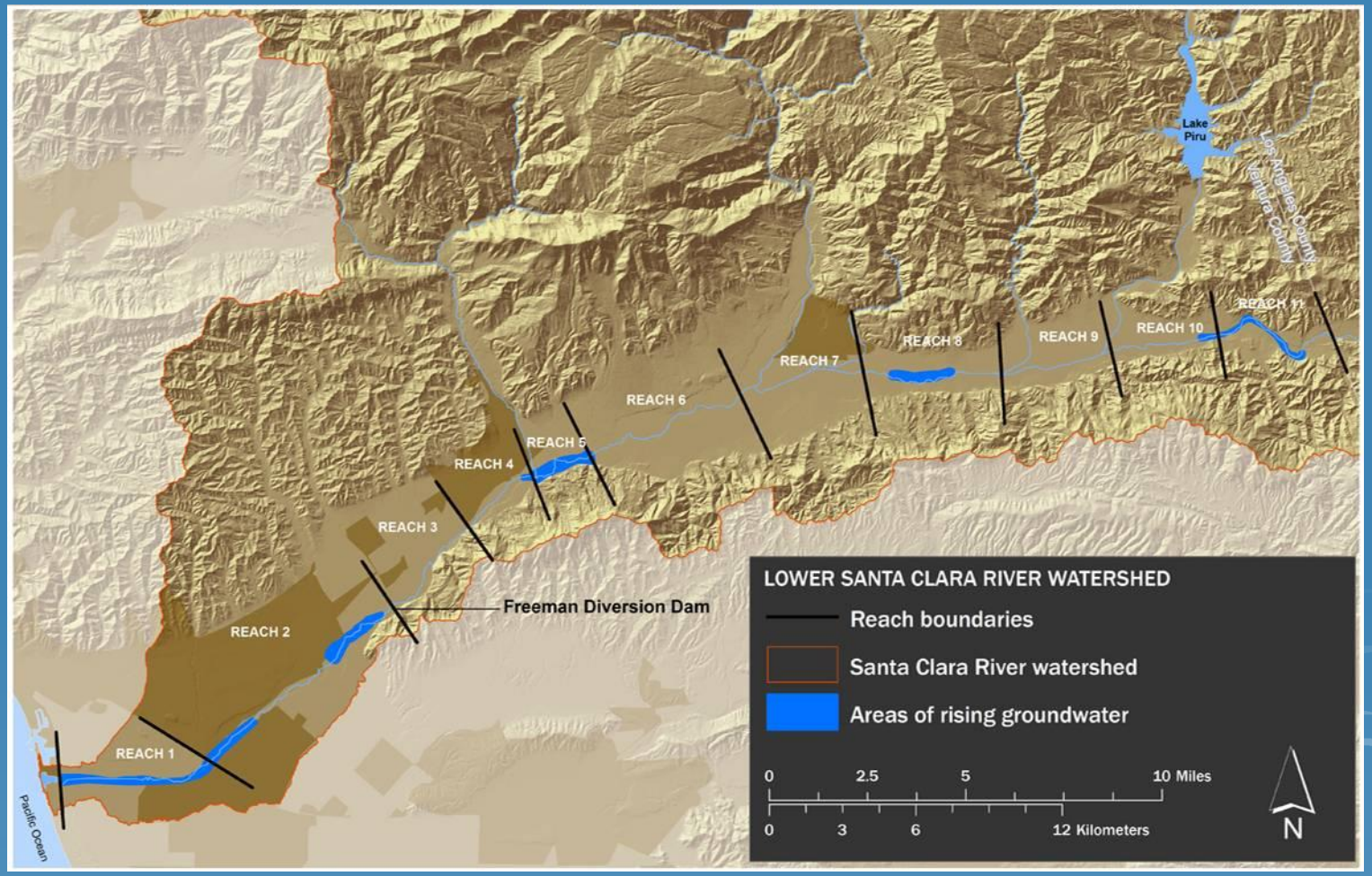
FLOOD DYNAMICS

- Rapid vegetation response after large resetting floods

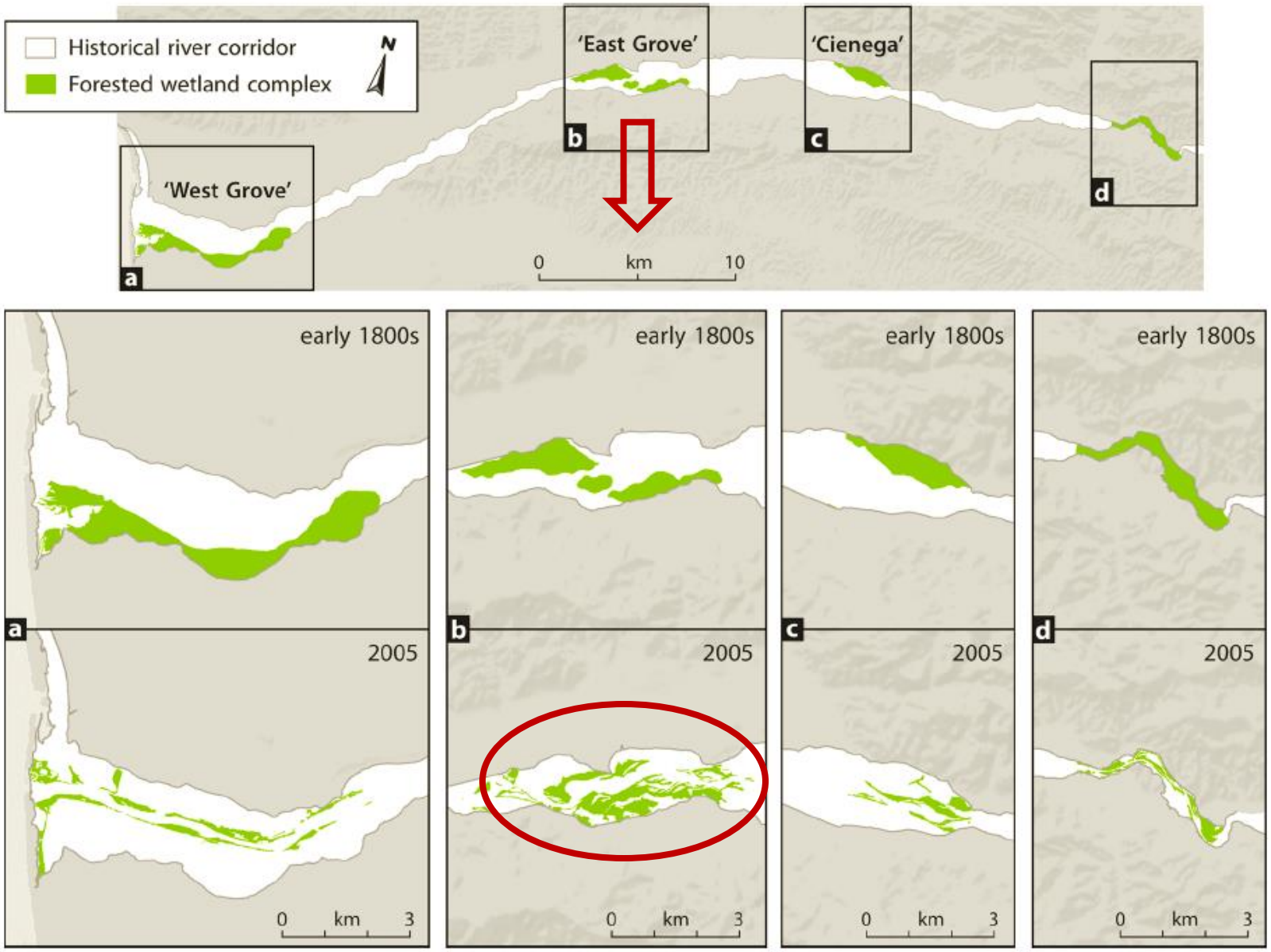
post-high flow

GROUNDWATER AVAILABILITY

- Gaining vs. losing reaches



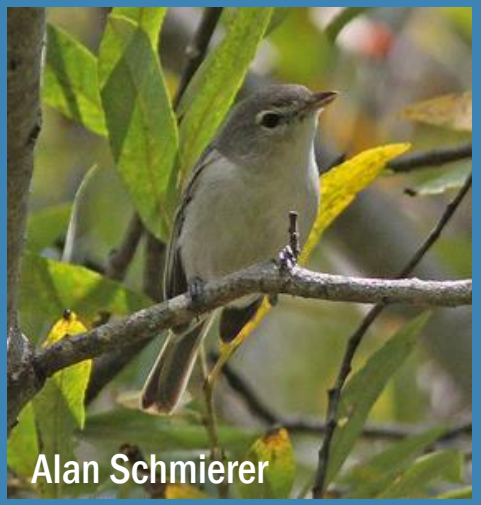
FROM PAST PATTERNS TO FUTURE POTENTIAL



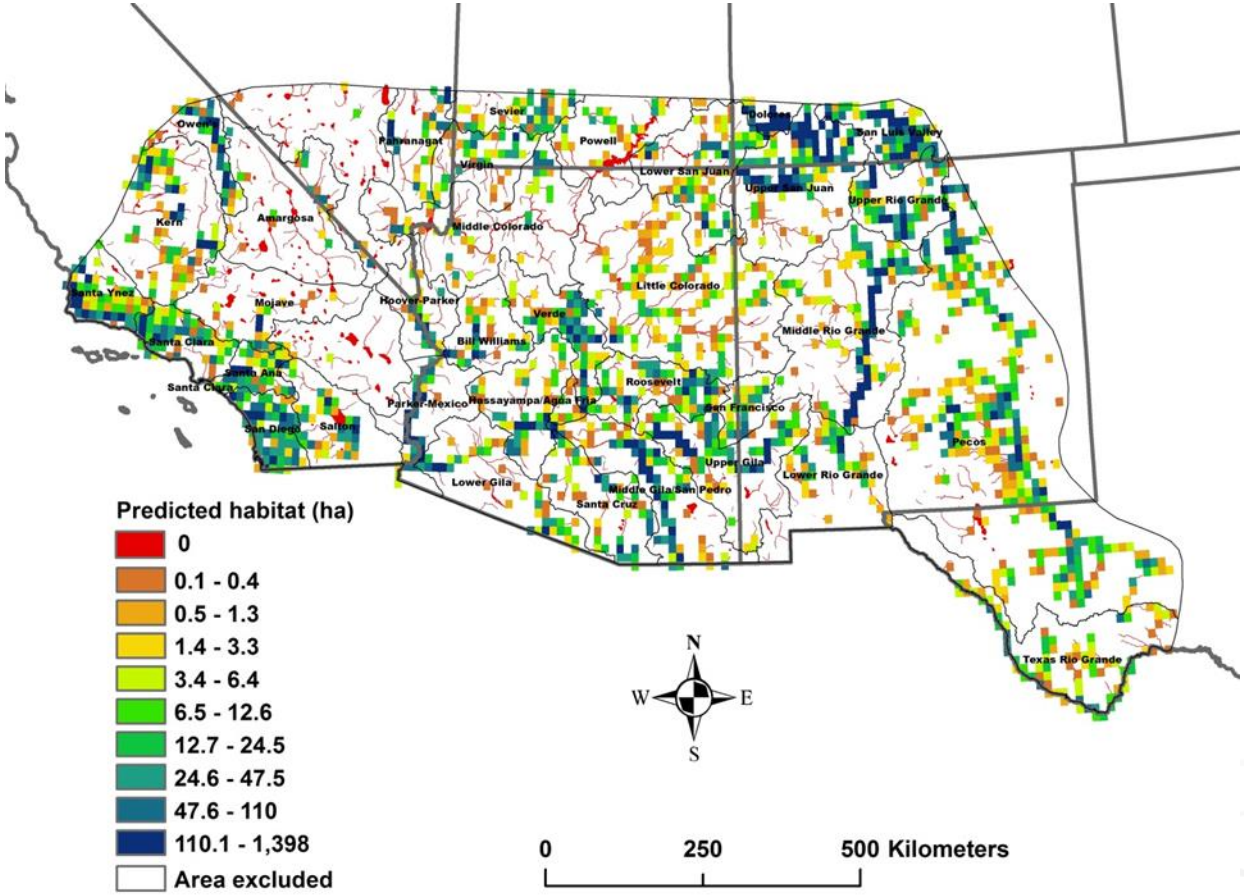
Beller et al. 2015. Landscape Ecology

Notable Species on the SCR… The Big 5

- **Least Bell's Vireo** : ~ 500 breeding pairs
- **Yellow Warbler:** 1000s of pairs
- **Yellow-breasted Chat:** low hundreds of pairs
- **Southwestern Willow Flycatcher**: <5 known breeding pairs?
- **Yellow-billed Cuckoo** : unknown # of breeding pairs

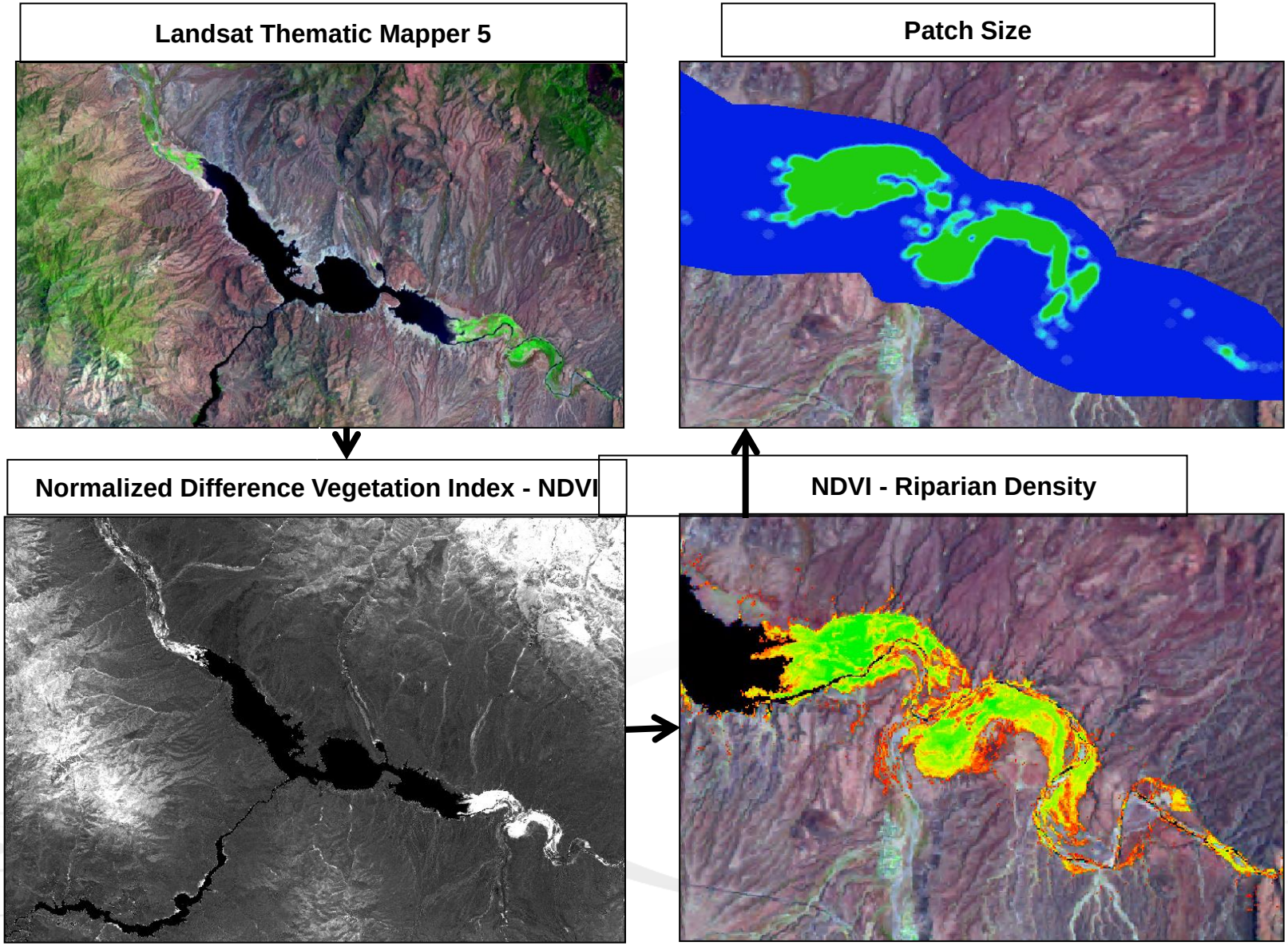


Use published satellite models to predict flycatcher and yellow-billed cuckoo habitat



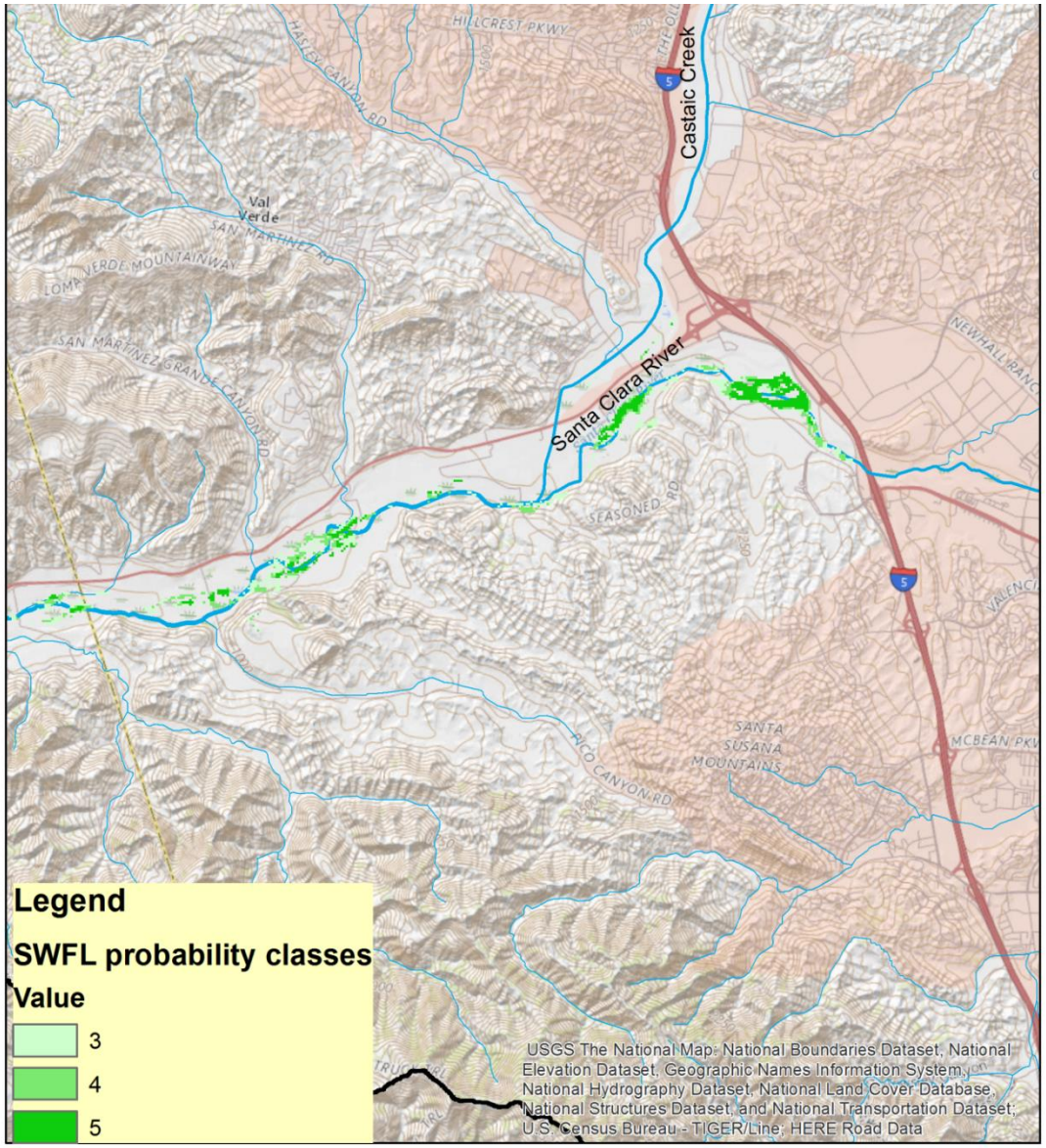
USGS Open-File Report 2016---1120. A Satellite Model of Southwestern Willow Flycatcher (*Empidonax traillii extimus*) Breeding Habitat and a Simulation of Potential Effects of Tamarisk Leaf Beetles (*Diorhabda* spp.), Southwestern United States

Significant predictor variables in flycatcher model: Roosevelt Lake, AZ



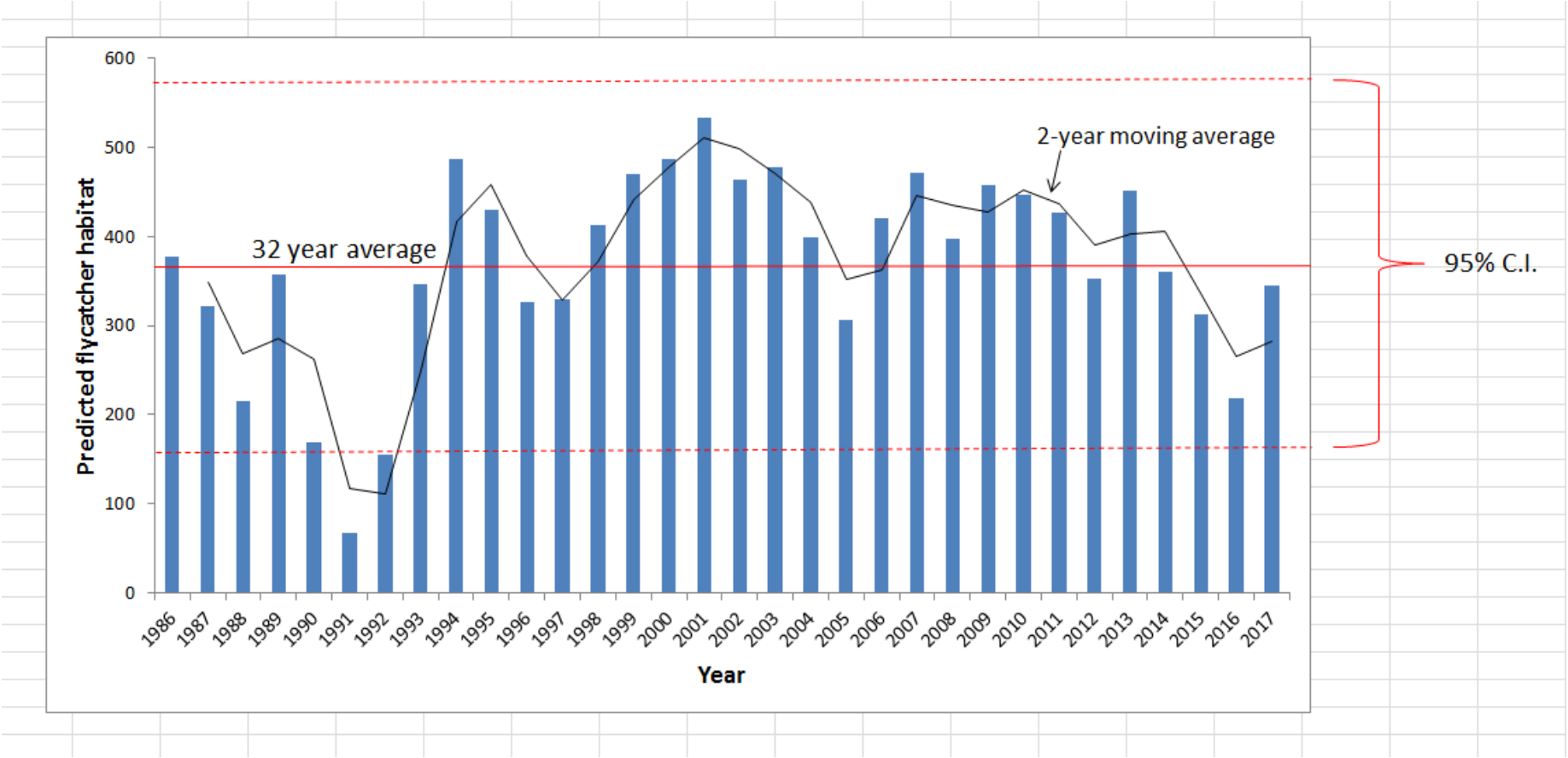
Hatten and Paradzick. 2003. A multiscaled model of southwestern willow flycatcher breeding habitat. J Wildlife Management 67: 774-788

Applying satellite model to Santa Clara River



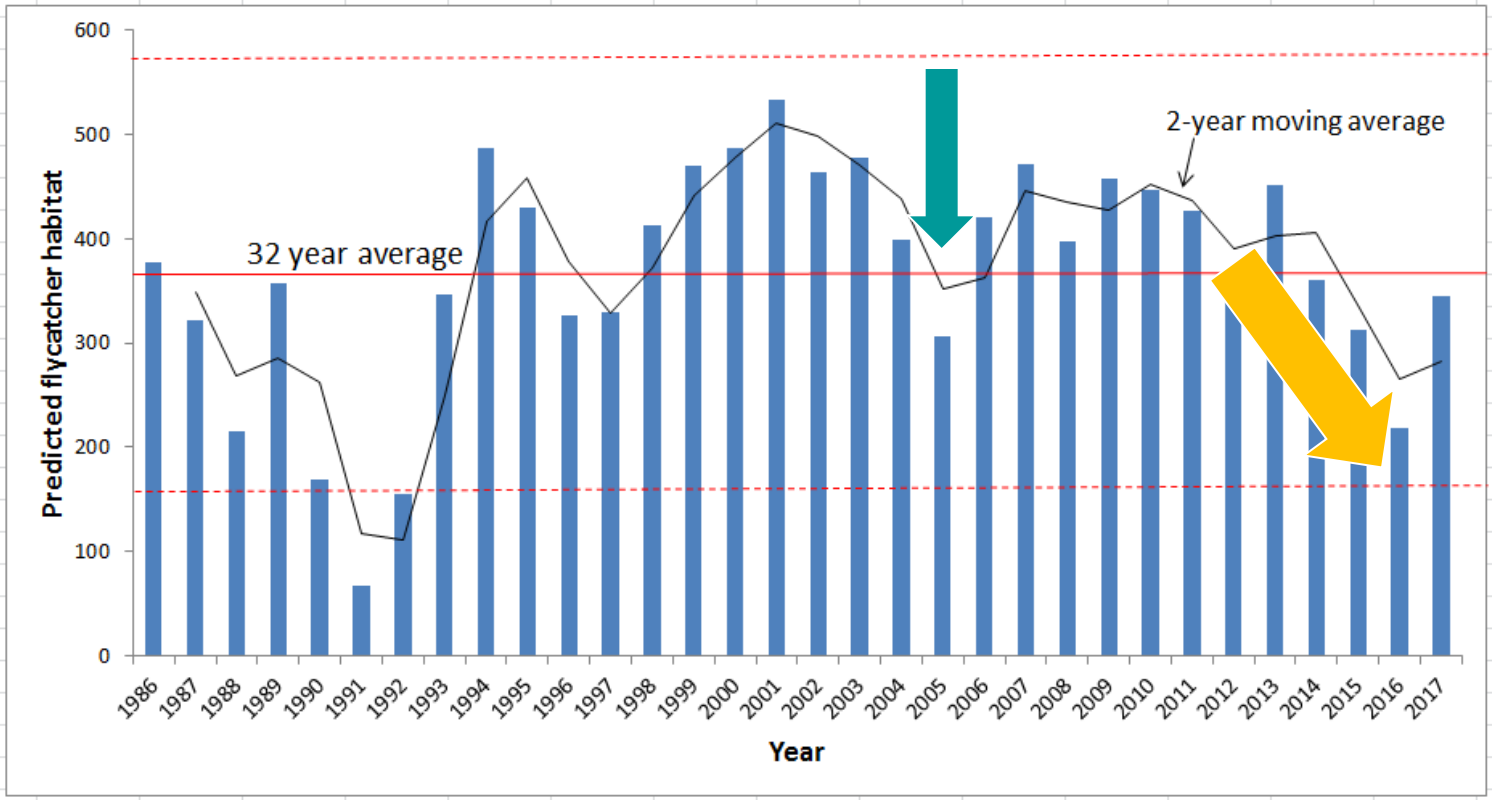
New version of satellite model runs in Google Earth Engine using JavaScript

32-year habitat time series for Southwestern Willow Flycatcher along Santa Clara River calculated with the satellite model



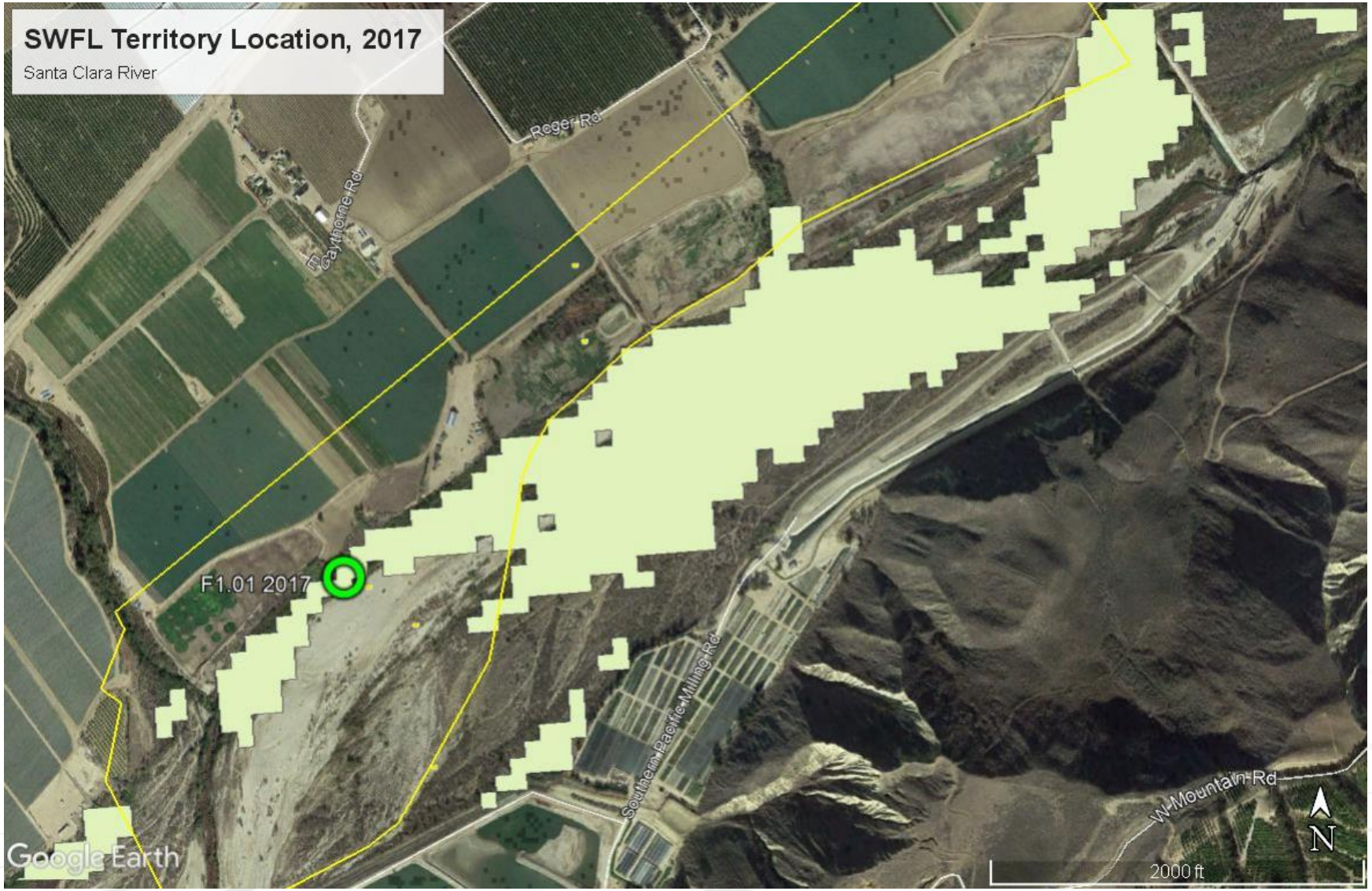
Initial examination of temporal variation in predicted amount of suitable SWFL habitat along the Santa Clara River seem to match well with known timing of flood disturbance (e.g., the 2005 El Nino flood event) and pronounced drought (2014-2016)

32-year habitat time series for Southwestern Willow Flycatcher along Santa Clara River calculated with the satellite model



Initial examination of temporal variation in predicted amount of suitable SWFL habitat along the Santa Clara River seem to match well with known timing of flood disturbance (e.g., the 2005 El Nino flood event) and pronounced drought (2014-2016)

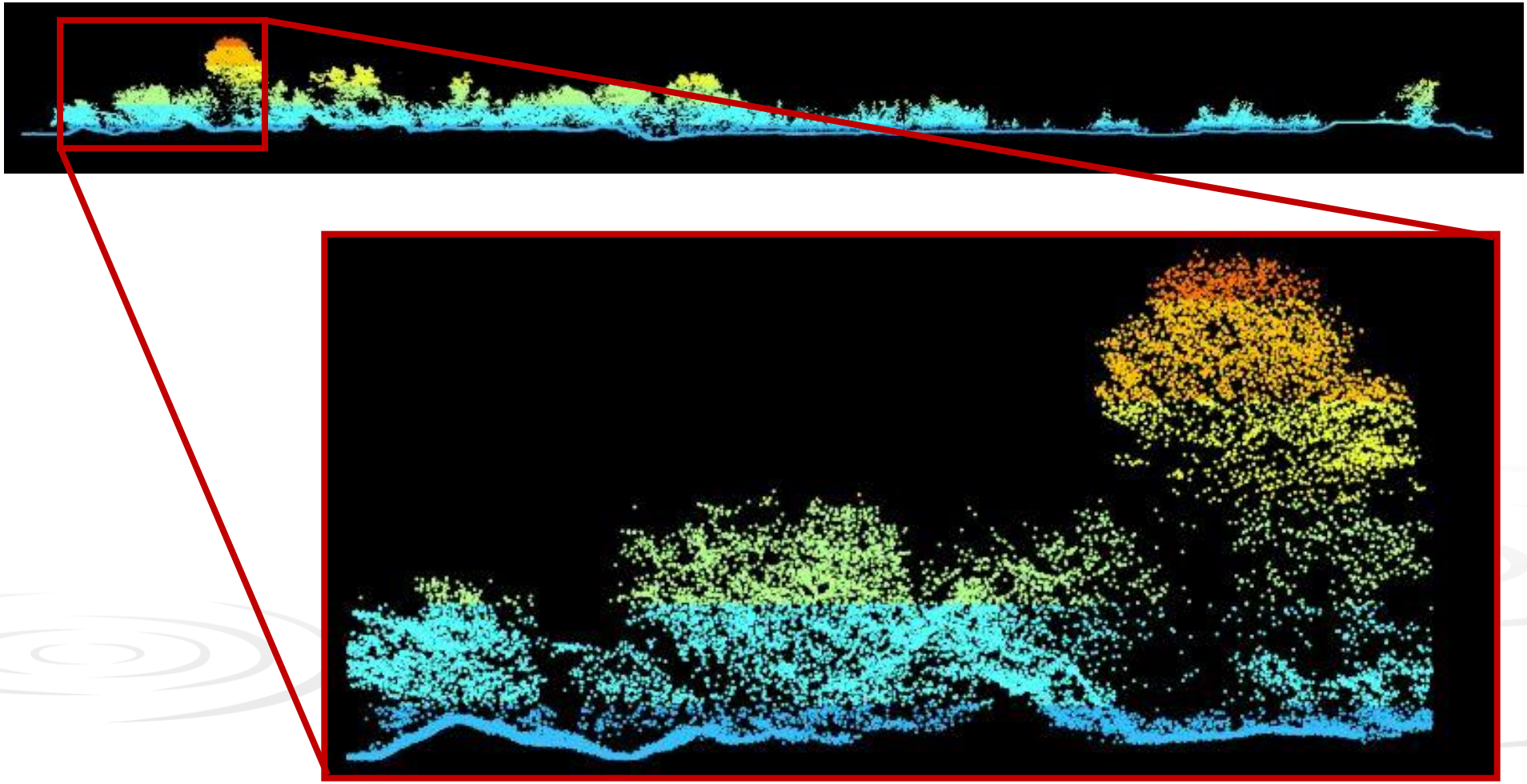
SWFL Modeled Suitable Habitat and Observed Territory in 2017



The General SWFL Model appear to do a good job of predicting suitable habitat based on the few known nest site locations from past years. The model is already proving to be a useful tool for designing river corridor scale survey & monitoring efforts. Next steps include calibrating the model with local bird data and using LIDAR-derived canopy height data to improve model performance

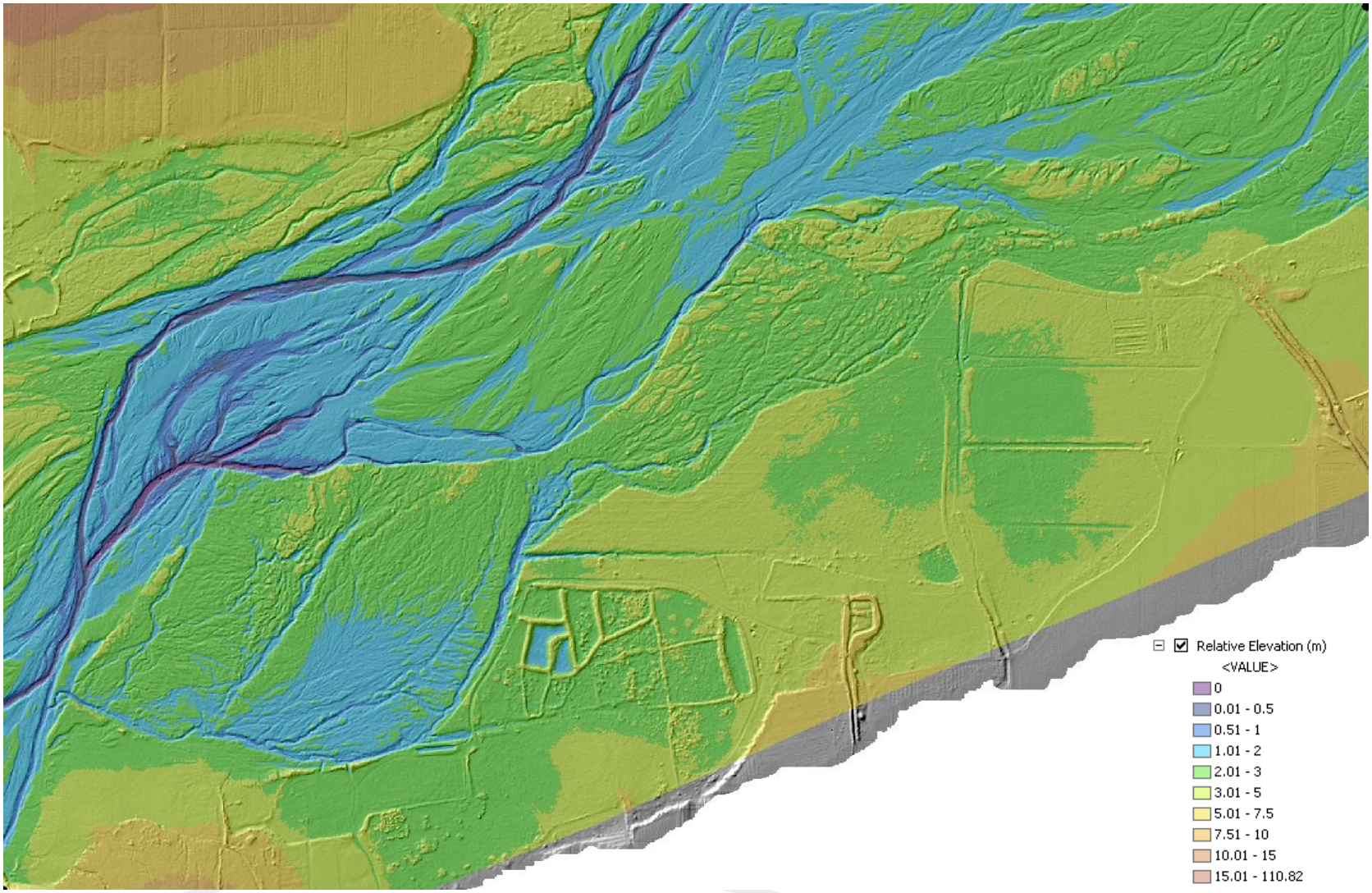
VEGETATION & HABITAT STRUCTURE

- NCALM high density LiDAR data collected in October 2015
- Habitat Modeling for Least Bell's Vireo, Southwestern Willow Flycatcher, and Yellow-billed Cuckoo



LIDAR Examples from East Grove Riparian Forest

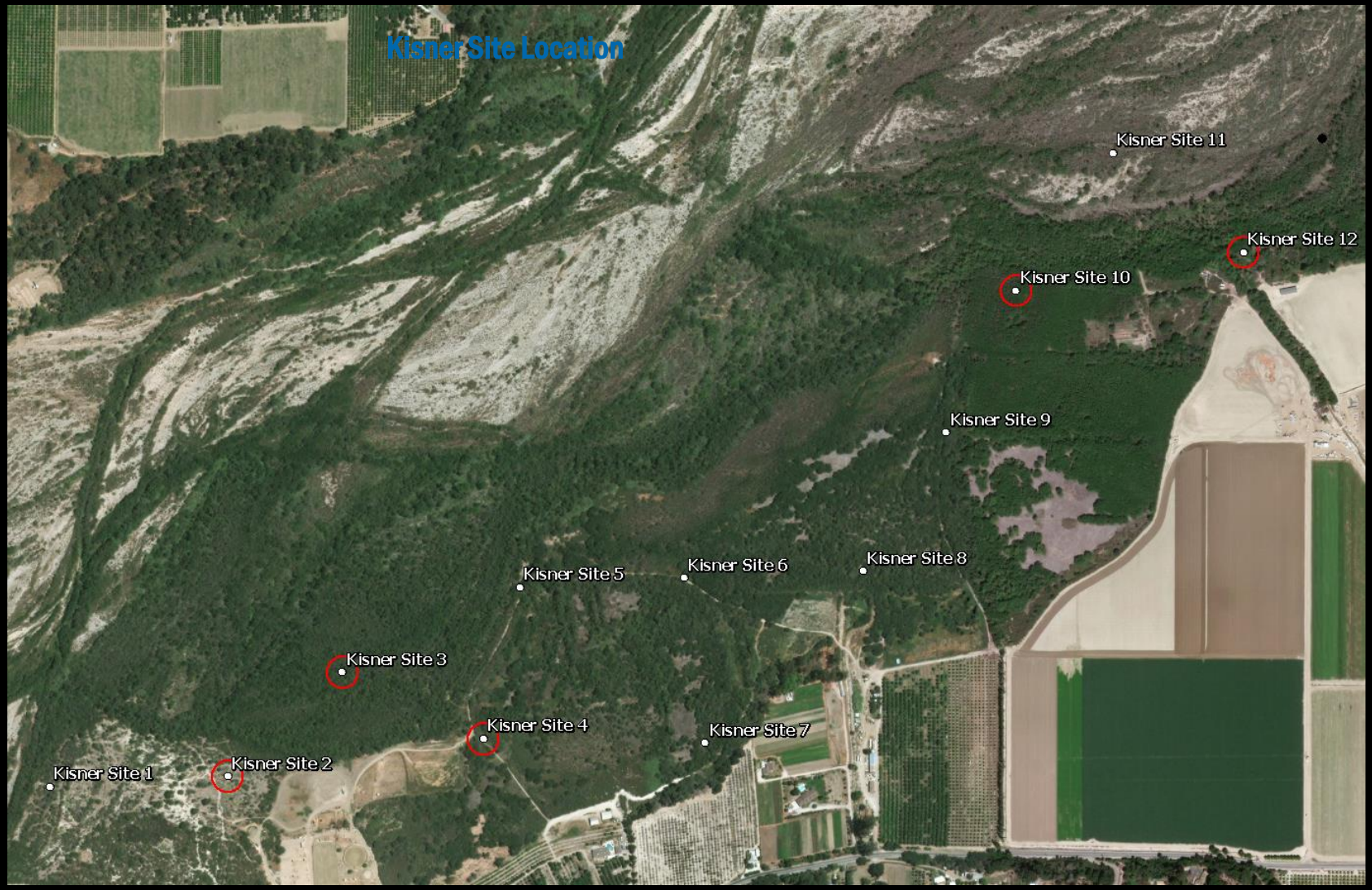
LIDAR Products: Topography and Relative Elevation



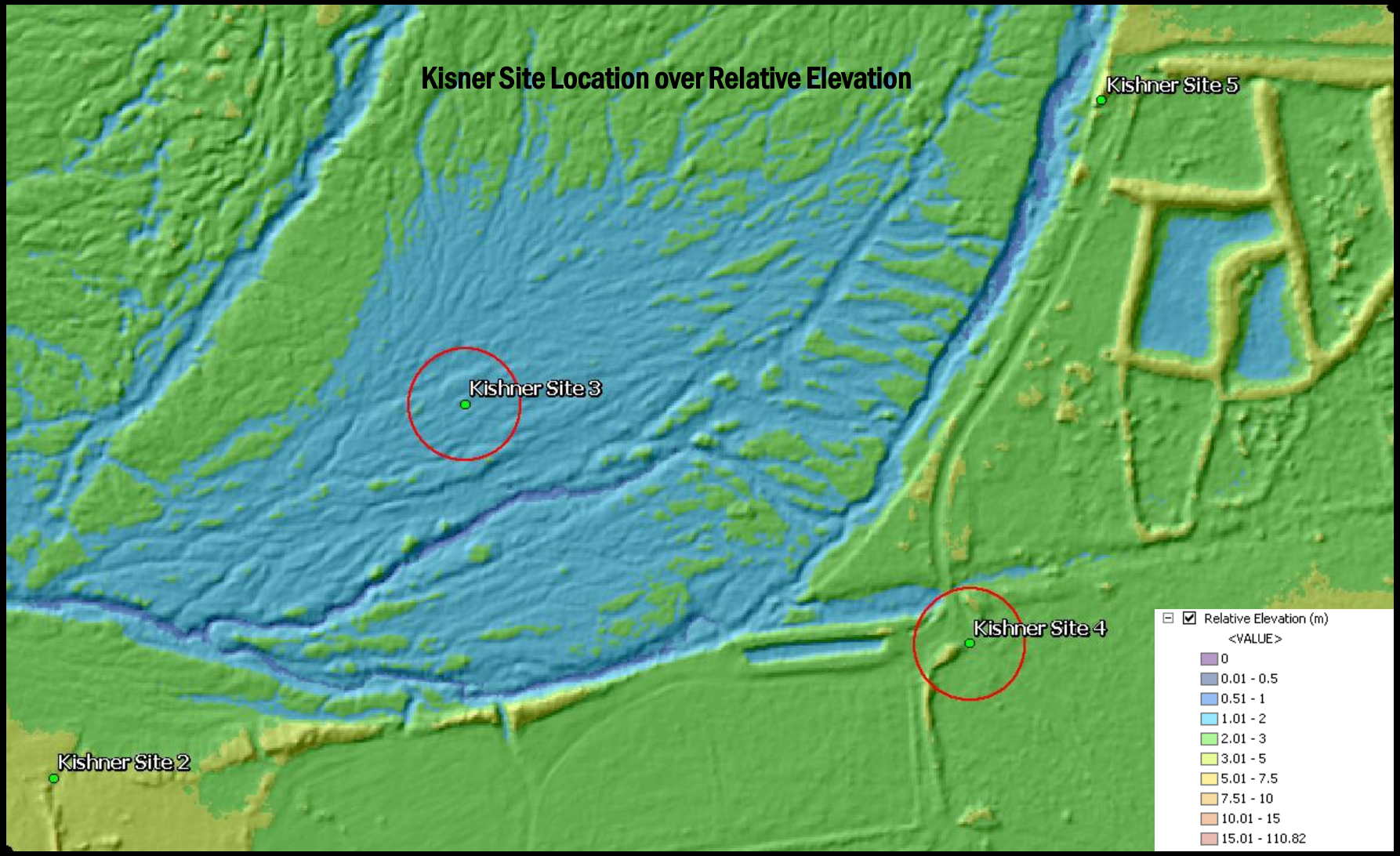
Relative elevation (height above river low flow water surface) is useful for identifying geomorphic landforms and can be used as an indicator of expected depth to groundwater and potential for establishment of various riparian plant species

LIDAR Products: Canopy Height

Canopy height of individual trees and vegetation stands can be derived from LIDAR point cloud data


Kisner Site Location
Kisner Site 11
Kisner Site 12
Kisner Site 10
Kisner Site 9
Kisner Site 8
Kisner Site 6
Kisner Site 5
Kisner Site 3
Kisner Site 4
Kisner Site 7
Kisner Site 2
Kisner Site 1

Kisner Site Location
Kishner Site 5
Kishner Site 3
Kishner Site 4
Kishner Site 2


Kisner Site Location over Relative Elevation
Kishner Site 5
Kishner Site 3
Kishner Site 4
Kishner Site 2
Relative Elevation (m)
<VALUE>
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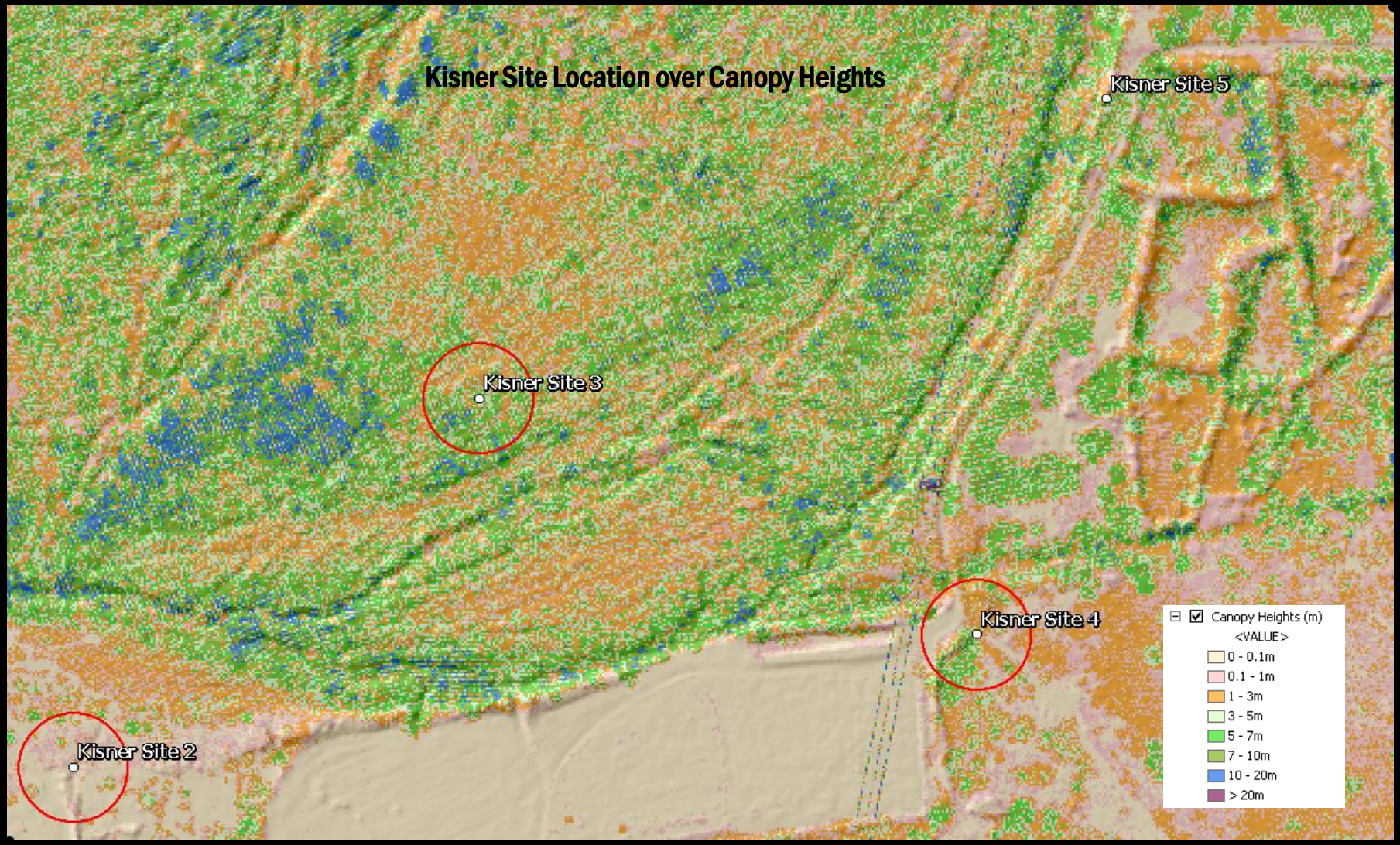
0.01 - 0.5
0.51 - 1
1.01 - 2
2.01 - 3
3.01 - 5
5.01 - 7.5
7.51 - 10
10.01 - 15
15.01 - 110.82


Kisner Site Location over Canopy Heights
Kisner Site 5
Kisner Site 3
Kisner Site 4
Kisner Site 2
Canopy Heights (m)
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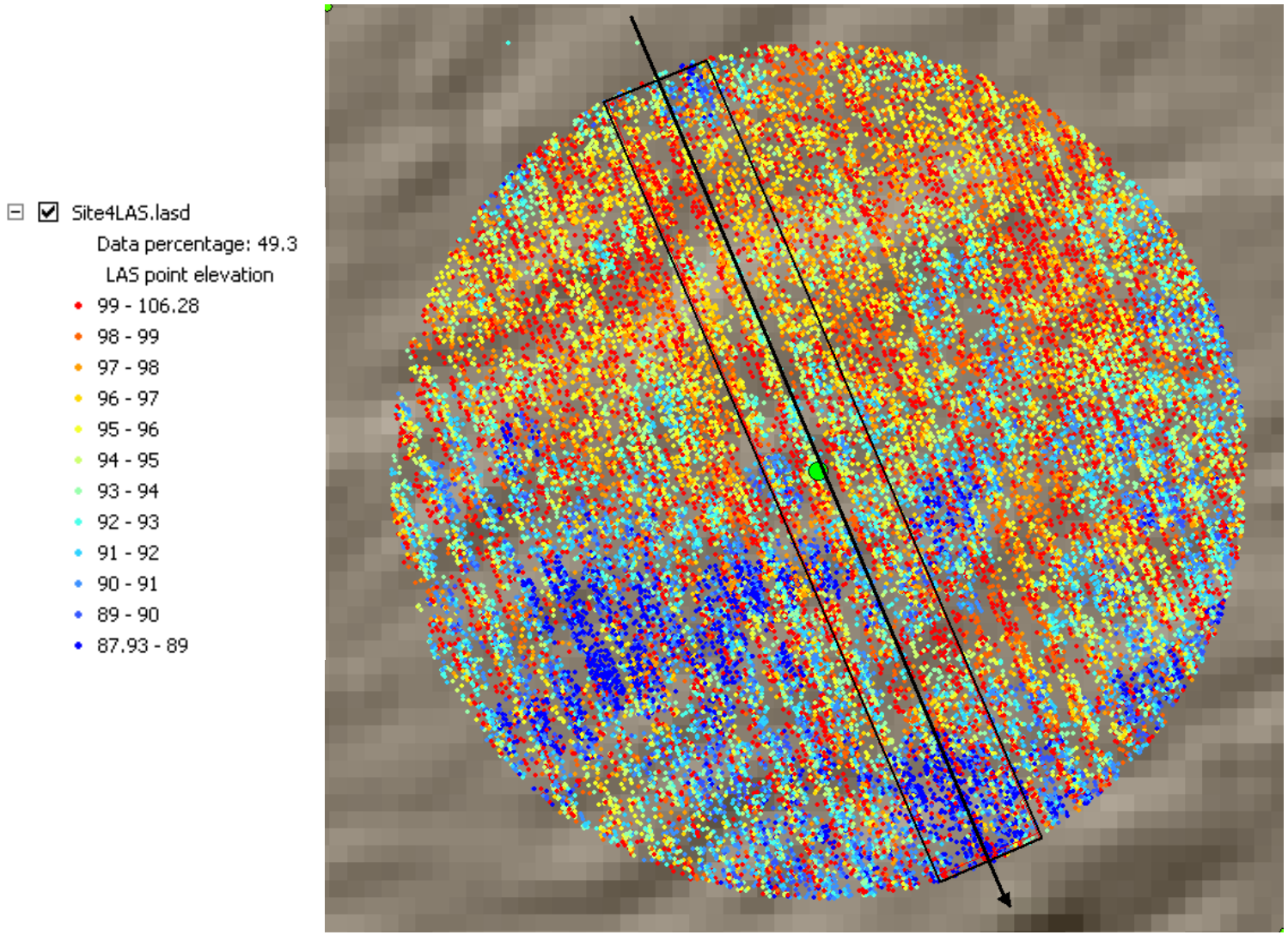
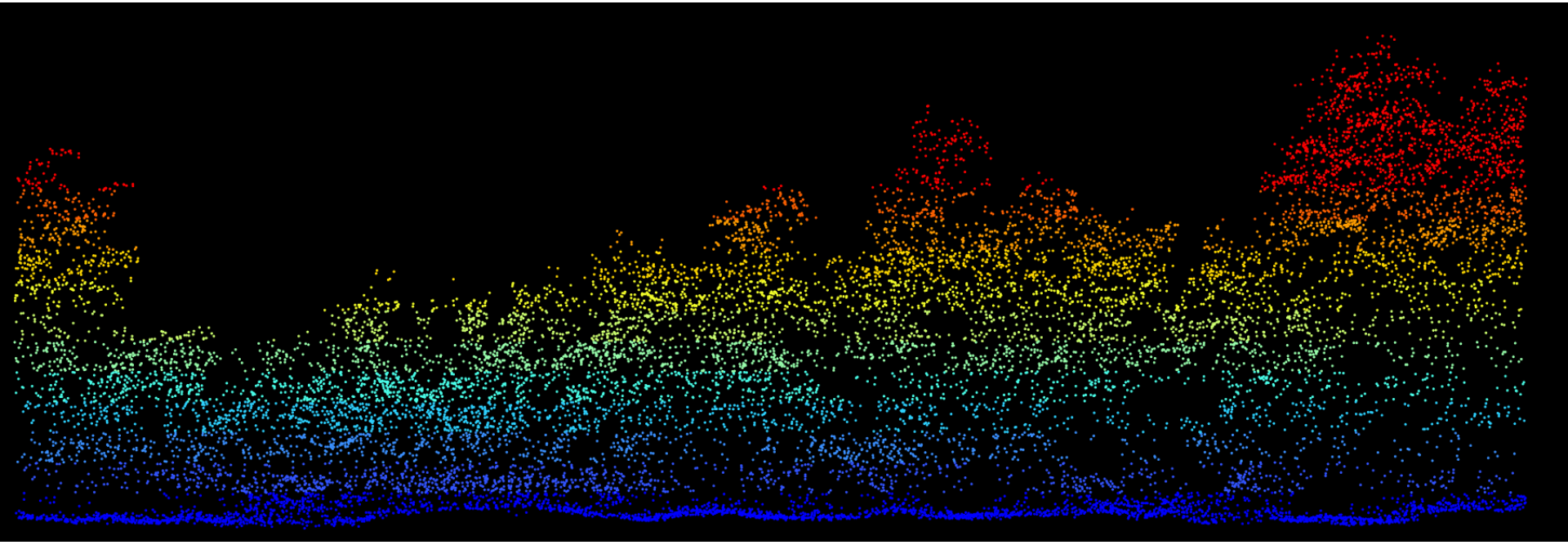
0.1 - 1m
1 - 3m
3 - 5m
5 - 7m
7 - 10m
10 - 20m
> 20m

Kisner Site 3
NW-SE XS Direction



25-m radius from bird point count station

Kisner Site 3 NW - SE

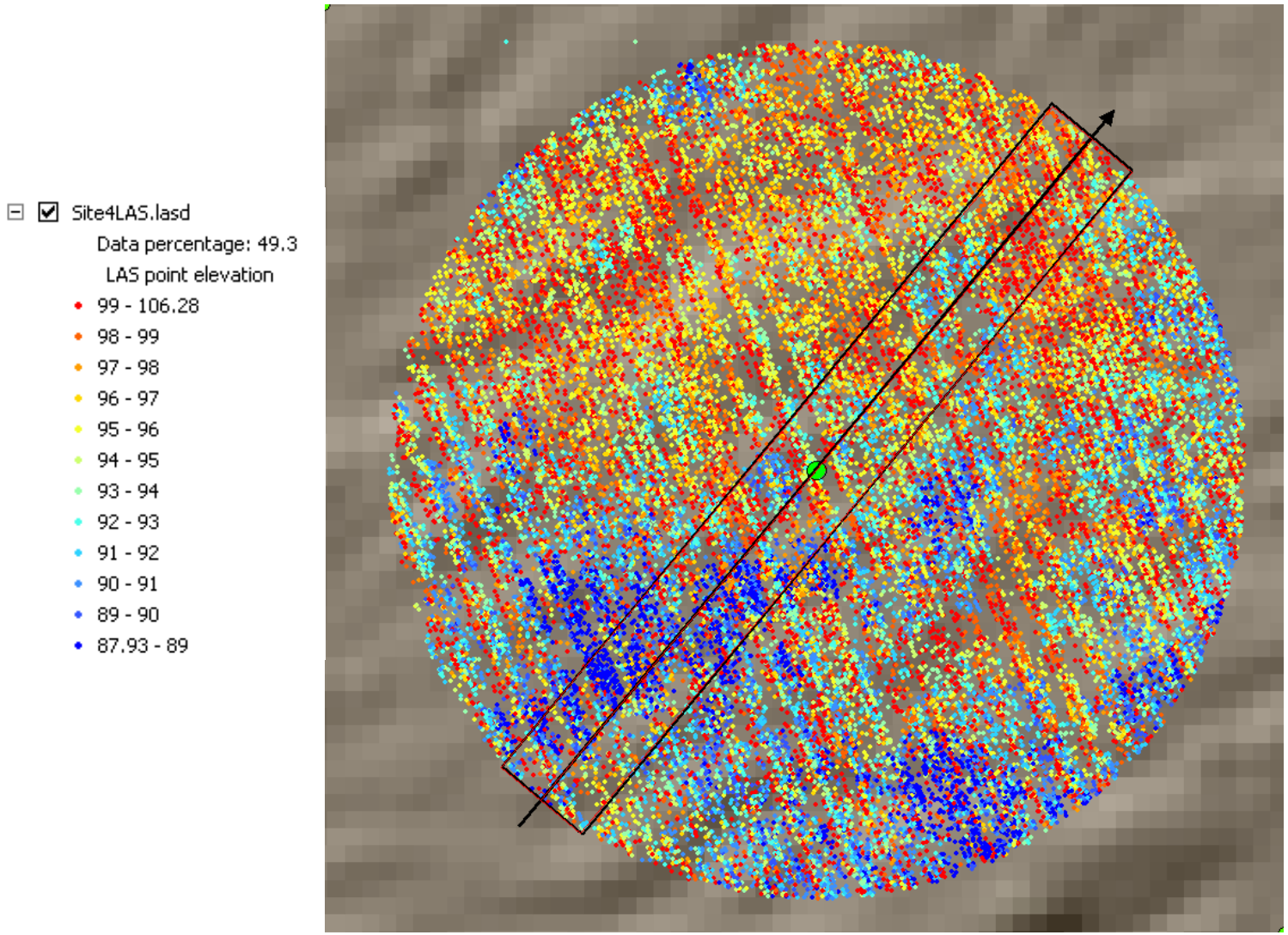


SE

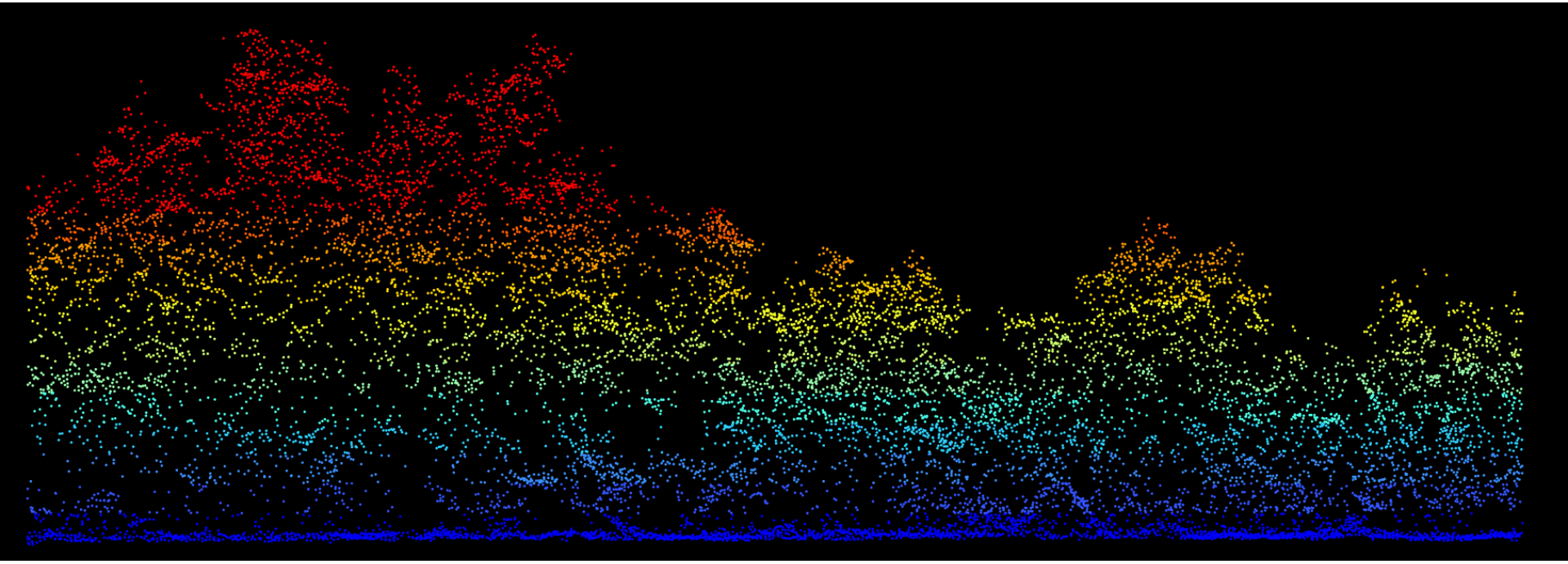
CENTER
Point Count Site

NW

Kisner Site 3
SW-NE XS Direction



Kisner Site 3 SW - NE

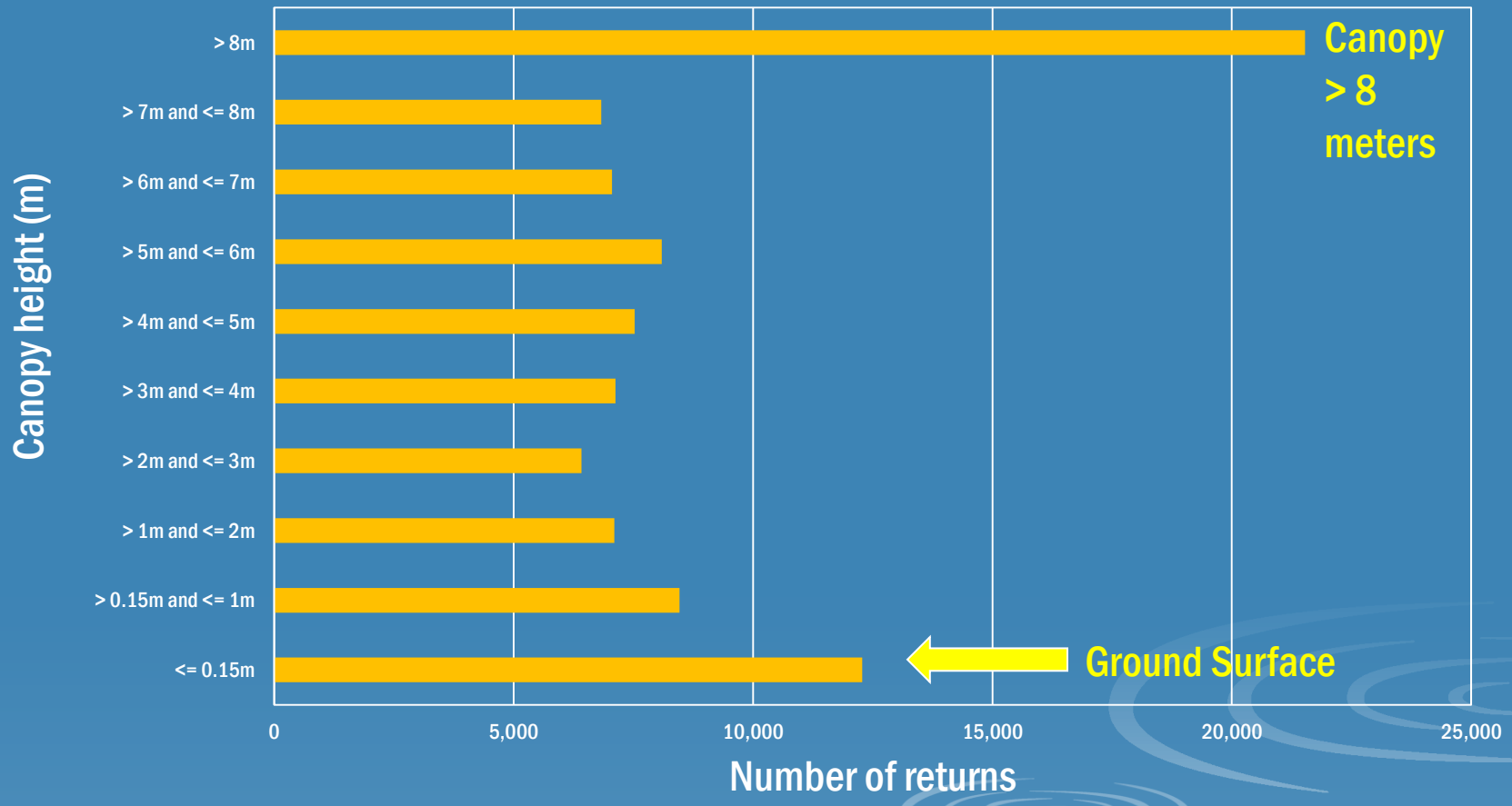


SW

Plot Center

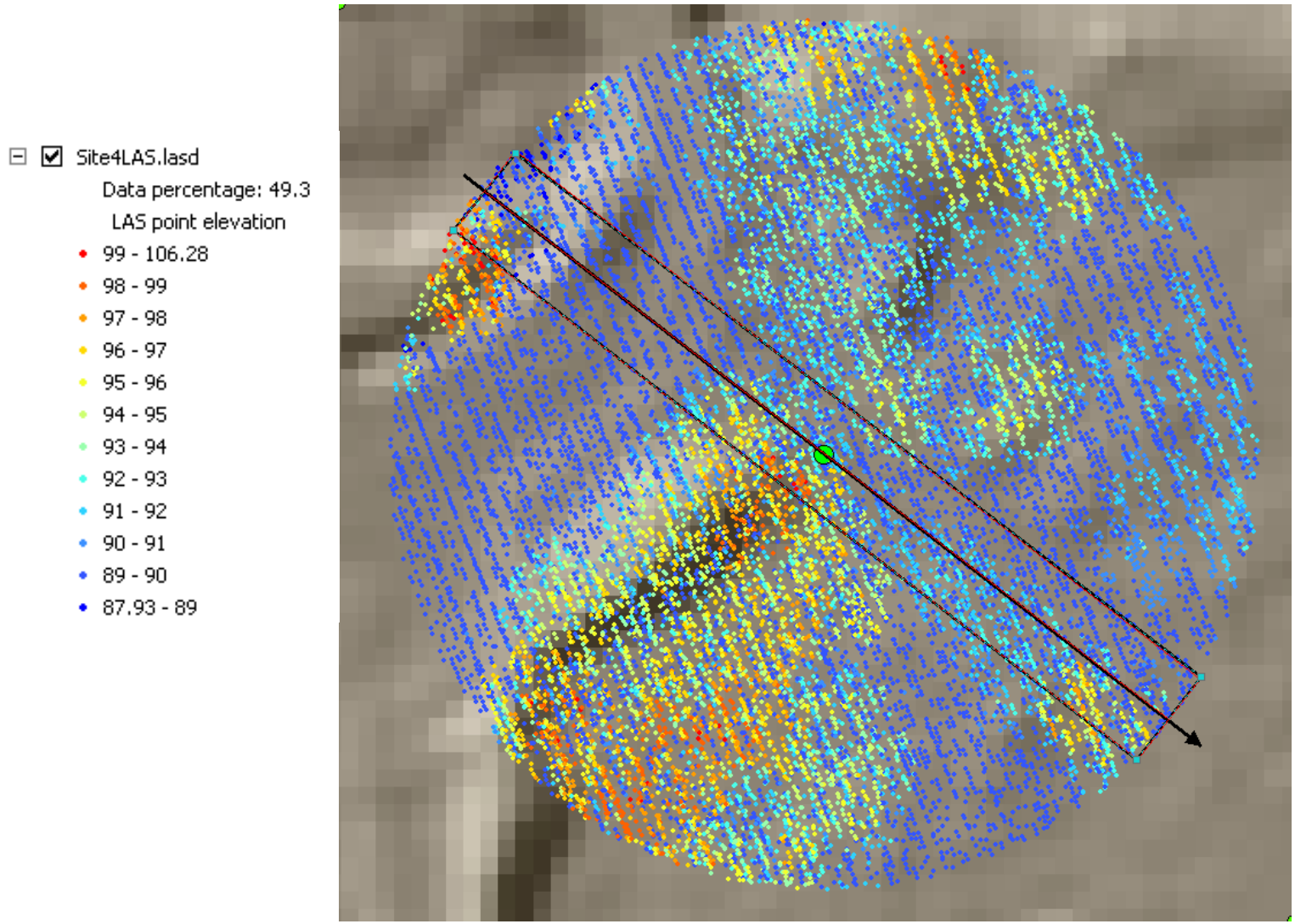
NE

Number of LIDAR returns by elevation category. Site 3. Santa Clara River

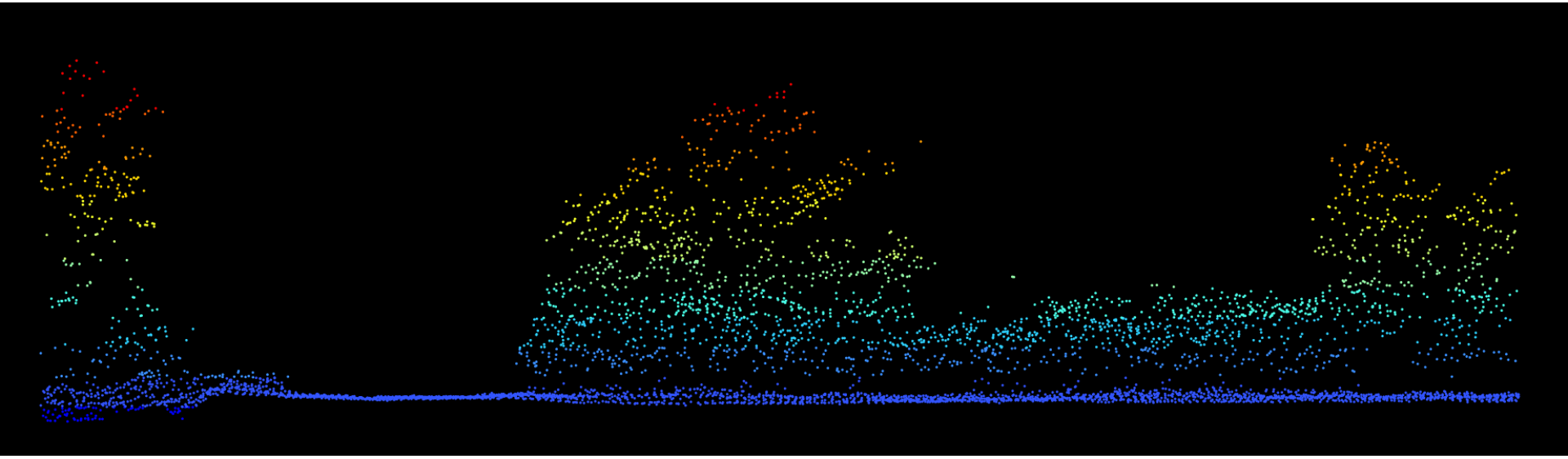


Next Step: see how LIDAR-derived assessment of vertical canopy structure relates to the Least Bell's Vireo habitat suitability model developed by Barbara Kus (1998) in Restoration Ecology 6(1): 75-82)

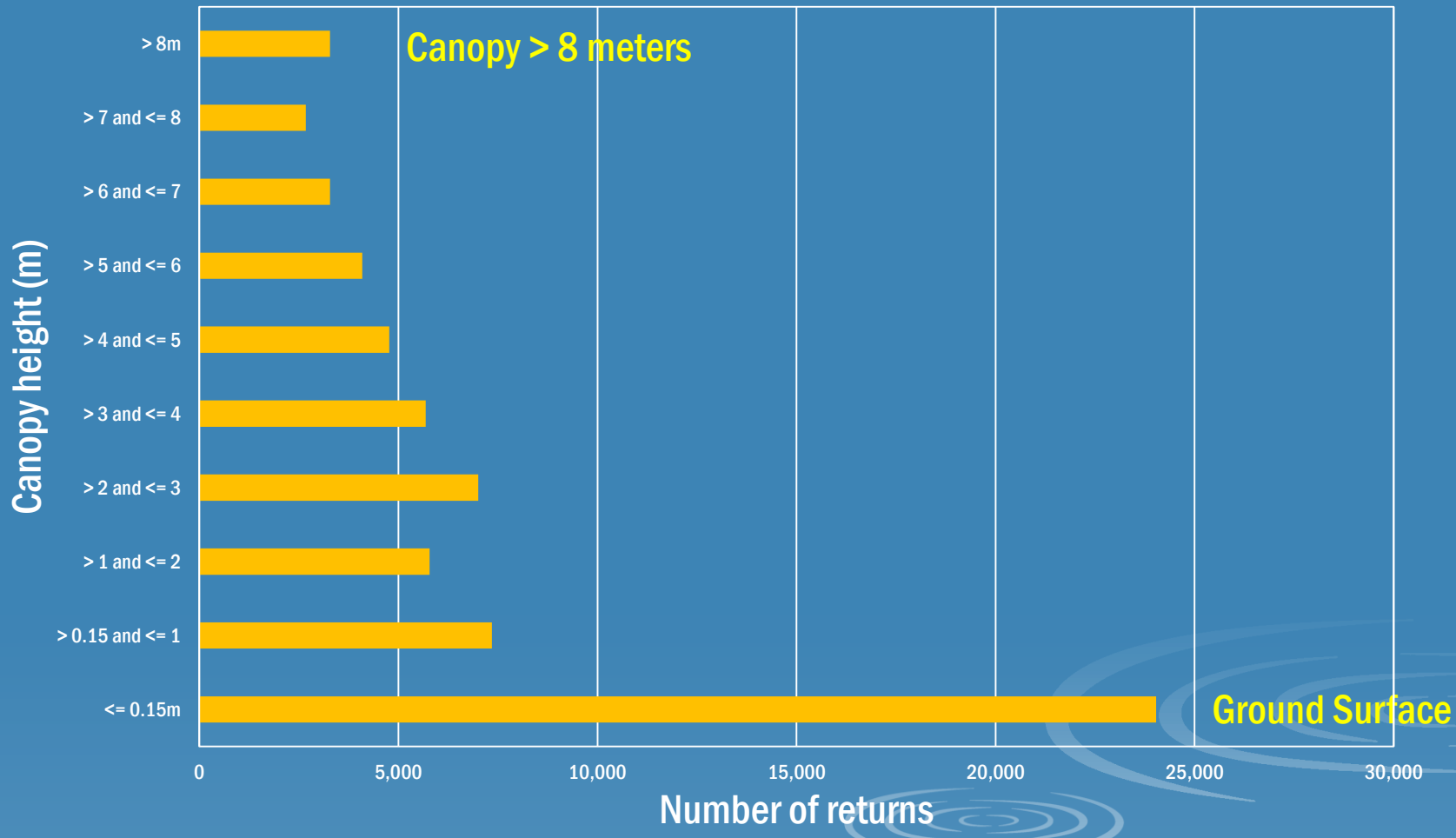
Kisner Site 4
NW-SE XS Direction

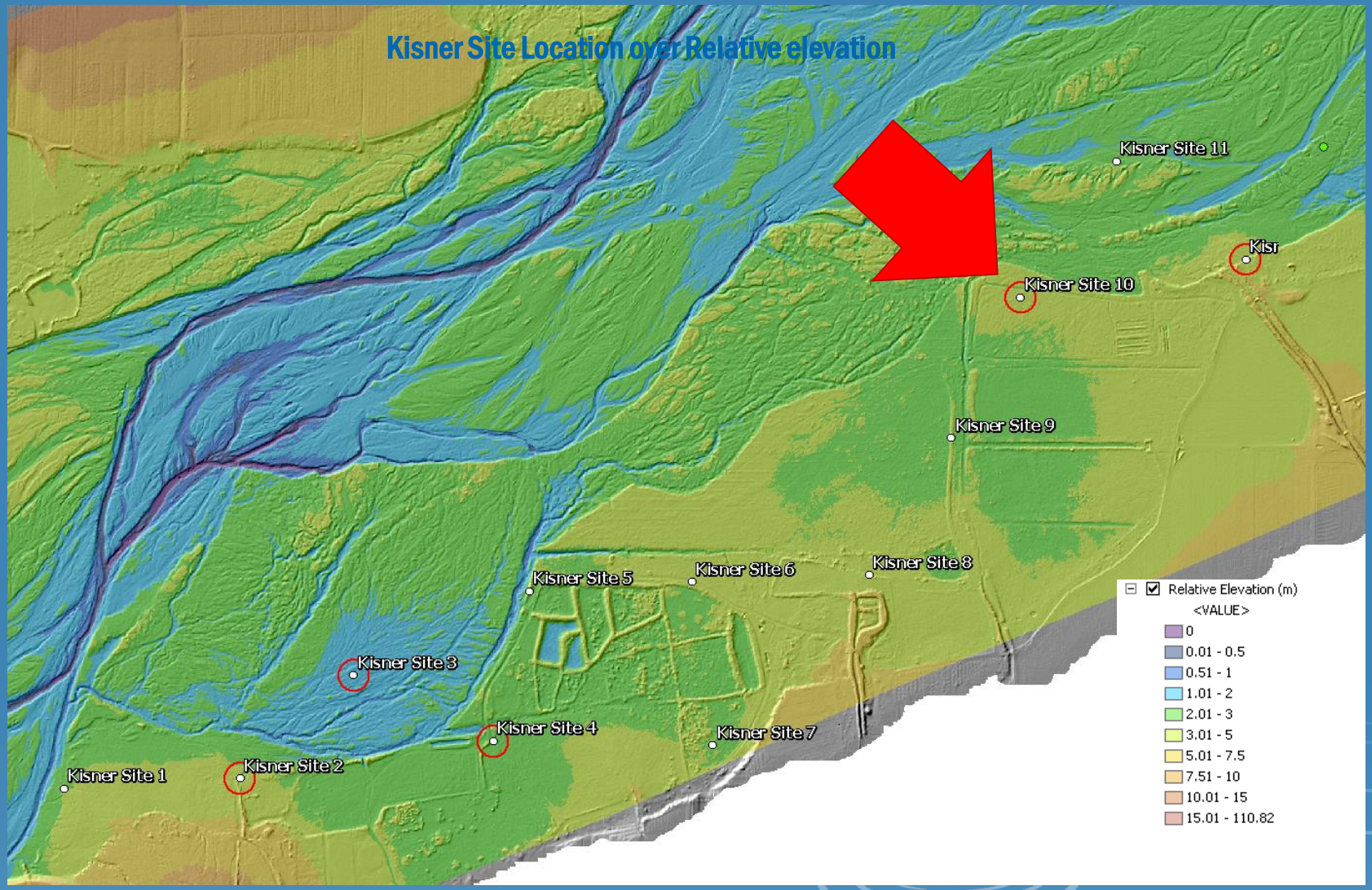


Kisner Site 4 NW - SE

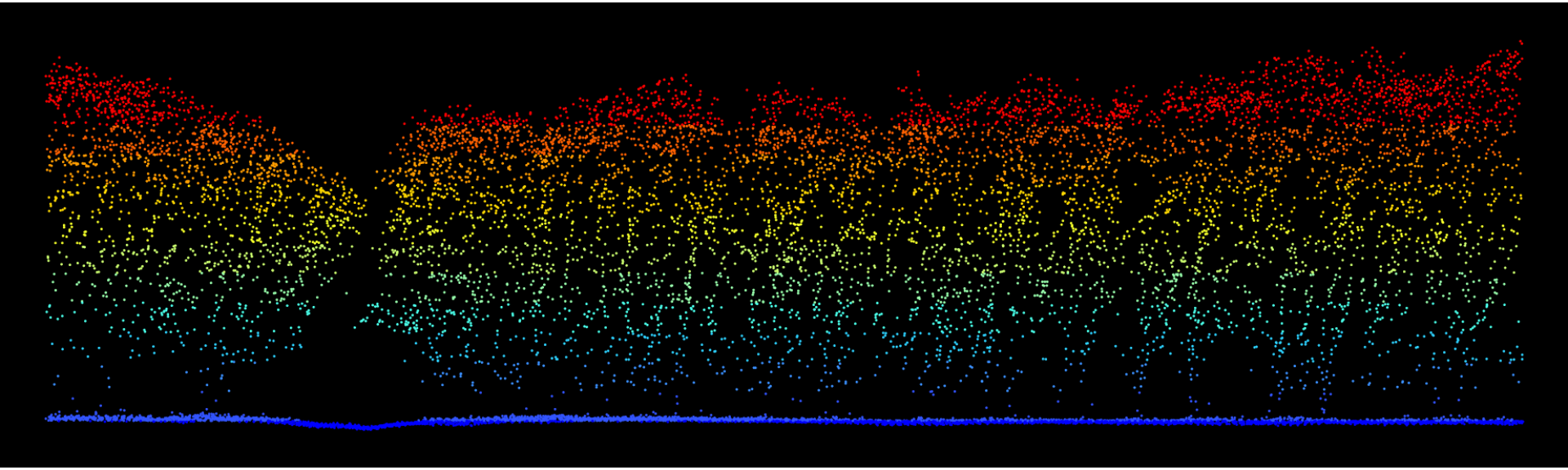


Number of LIDAR returns by elevation category.
Site 4. Santa Clara River



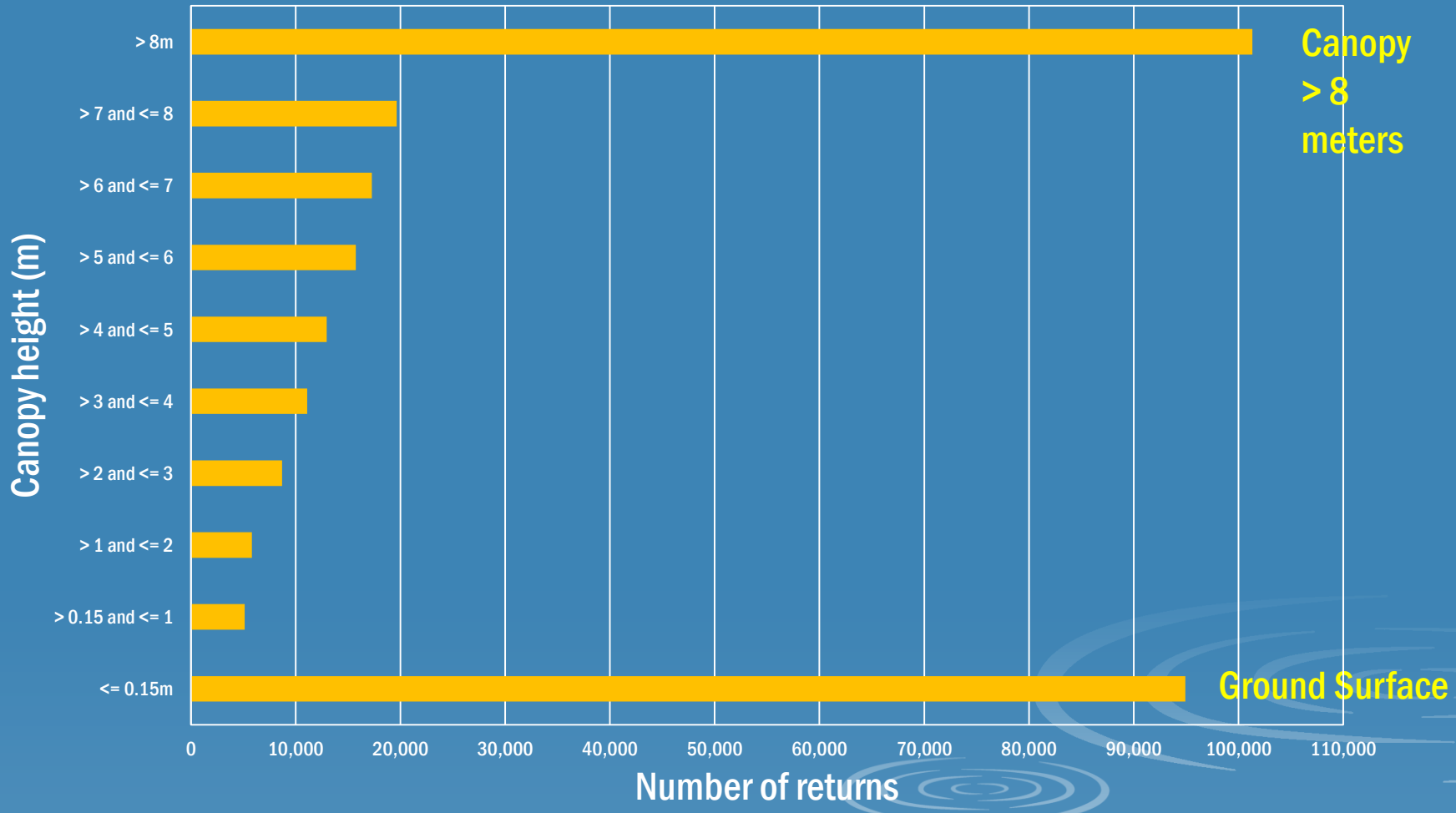

Kisner Site Location over Relative elevation
Kisner Site 11
Kisr
Kisner Site 10
Kisner Site 9
Kisner Site 8
Kisner Site 6
Kisner Site 5
Kisner Site 3
Kisner Site 4
Kisner Site 7
Kisner Site 2
Kisner Site 1
Relative Elevation (m)
<VALUE>
0
0.01 - 0.5
0.51 - 1
1.01 - 2
2.01 - 3
3.01 - 5
5.01 - 7.5
7.51 - 10
10.01 - 15
15.01 - 110.82

Kisner Site 10 NNE - SSW

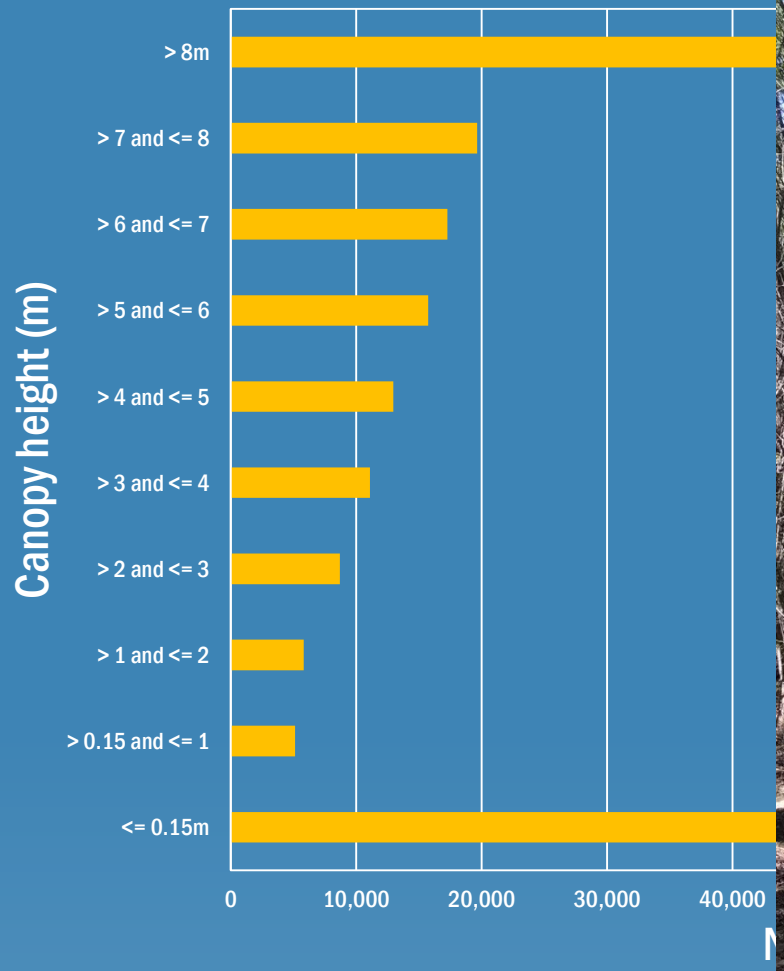


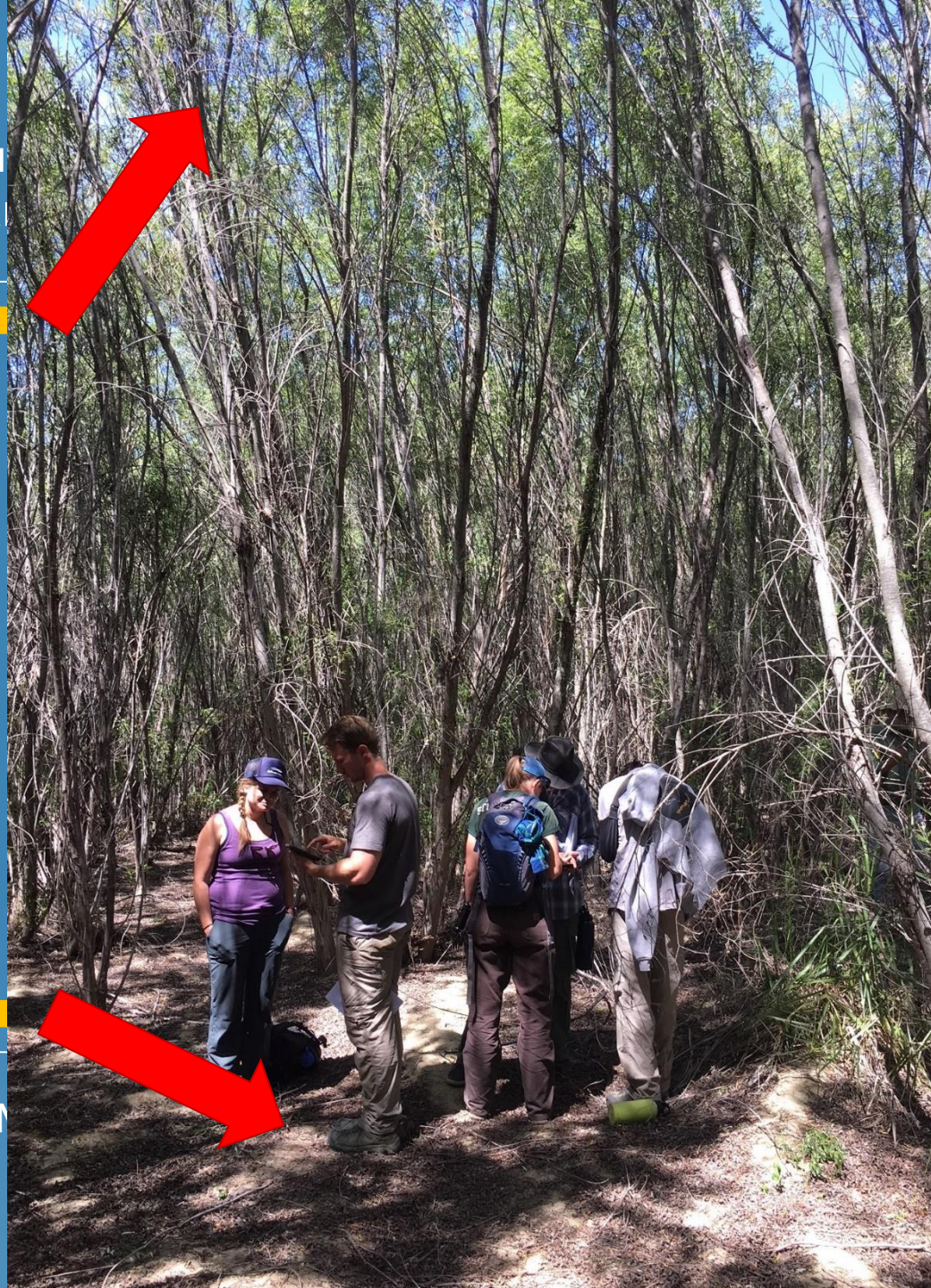
Example of an even-aged willow stand that recruited naturally after the 2005 flood event.
Yellow-billed cuckoo observed in this area during 2018 breeding season

Number of LIDAR returns by elevation category.
Site 10. Santa Clara River



Number of LIDAR retu
Site 10. Sa





NEXT STEPS

1. Collect ground-truth data on vertical structure using ‘stacked cube’ method
2. Compare LIDAR and stacked cube data
3. Conduct second year (2019) of breeding season surveys for SWFL and YBCU continue LBVI and general point count surveys
4. Assess habitat structure associated with known nest sites of least Bell’s vireo, southwestern willow flycatcher, and yellow-billed cuckoo
5. Use local data to calibrate existing or create new habitat suitability models to guide restoration and monitoring

FOR MORE INFORMATION

- Email: bruce@stillwatersci.com

Santa Clara River Parkway Website (includes project reports plus vegetation layers viewable with Google Earth):

- parkway.scrwatershed.org

- Stillwater Sciences Website
  - www.stillwatersci.com

EXTRA SLIDES & INFORMATION

INFORMATION ON USE OF RELATIVE ELEVATION AND CANOPY HEIGHT AS PART OF AN ECOHYDROLOGICAL APPROACH TO RIPARIAN RESTORATION:

- Orr, B. K., G. T. Leverich, Z. E. Diggory, T. L. Dudley, J. R. Hatten, K. R. Hultine, M. P. Johnson, and D. A. Orr. 2014. **Riparian restoration framework for the upper Gila River in Arizona.** Compiled by Stillwater Sciences in collaboration with Marine Science Institute at U.C. Santa Barbara, Columbia River Research Laboratory of U.S. Geological Survey, Desert Botanical Garden, and Colorado Plateau Research Station at Northern Arizona University. Prepared for the Gila Watershed Partnership of Arizona. http://www.stillwatersci.com/resources/Orr_et_al_2014_UpperGilaRiverRestorationFramework_Final_compiled.pdf
- Orr, B., M. Johnson, G. Leverich, , T. Dudley, J. Hatten, Z. Diggory, K. Hultine, D. Orr, and S. Stone. 2017. **Multi-scale riparian restoration planning and implementation on the Virgin and Gila Rivers.** In: B.E. Ralston and D.A. Sarr (eds.), *Case Studies of Riparian and Watershed Restoration Areas in the Southwestern United States—Principles, Challenges, and Successes.* U.S. Geological Open File Report 2017-1091, 116 p., https://doi.org/10.3133/ofr20171091.
- Orr, B.K., A.M. Merrill, Z.E. Diggory, and J.C. Stella. 2017. **Use of the biophysical template concept for riparian restoration and revegetation in the Southwest.** In: B.E. Ralston and D.A. Sarr (eds.), *Case Studies of Riparian and Watershed Restoration Areas in the Southwestern United States—Principles, Challenges, and Successes.* U.S. Geological Open File Report 2017-1091, 116 p., https://doi.org/10.3133/ofr20171091.

EXTRA SLIDES & INFORMATION

INFORMATION ON THE SWFL MODEL:

- Hutten, J. R. and C. E. Paradzick. 2003. **A multiscaled model of southwestern willow flycatcher breeding habitat**. Journal of Wildlife Management 67: 774-788.
- Hatten, J.R. and M. K. Sogge. 2007. **Using a remote sensing/GIS model to predict southwestern willow flycatcher breeding habitat along the Rio Grande, New Mexico**. U.S. Geological Survey Open-File Report 2007.
- Hatten, J.R. 2016. **A satellite model of Southwestern Willow Flycatcher (*Empidonax traillii extimus*) breeding habitat and a simulation of potential effects of tamarisk leaf beetles (*Diorhabda* spp.), southwestern United States.** Open-File Report 2016-1120. https://doi.org/10.3133/ofr20161120

APPLICATION OF THE SWFL MODEL IN RESTORATION PLANNING:

- Orr, B. K., G. T. Leverich, Z. E. Diggory, T. L. Dudley, J. R. Hatten, K. R. Hultine, M. P. Johnson, and D. A. Orr. 2014. **Riparian restoration framework for the upper Gila River in Arizona.** Compiled by Stillwater Sciences in collaboration with Marine Science Institute at U.C. Santa Barbara, Columbia River Research Laboratory of U.S. Geological Survey, Desert Botanical Garden, and Colorado Plateau Research Station at Northern Arizona University. Prepared for the Gila Watershed Partnership of Arizona. http://www.stillwatersci.com/resources/Orr_et_al_2014_UpperGilaRiverRestorationFramework_Final_compiled.pdf
- Orr, B., M. Johnson, G. Leverich, , T. Dudley, J. Hatten, Z. Diggory, K. Hultine, D. Orr, and S. Stone. 2017. **Multi-scale riparian restoration planning and implementation on the Virgin and Gila Rivers.** In: B.E. Ralston and D.A. Sarr (eds.), *Case Studies of Riparian and Watershed Restoration Areas in the Southwestern United States—Principles, Challenges, and Successes.* U.S. Geological Open File Report 2017-1091, 116 p.,

EXTRA SLIDES & INFORMATION

LBVI and YBCU MODELS

- Kus, B.E. 1998. **Use of restored riparian habitat by the endangered least Bell's vireo (*Vireo bellii pusillus*).** Restoration Ecology 6(1): 75-82.
- Johnson, M.J., J.R. Hatten, J.A. Holmes, P.B.Shafroth. **2017.Identifying western yellow-billed cuckoo breeding habitat with a dual modeling approach**. Ecological Modeling 347: 50-62. **http://dx.doi.org/10.1016/j.ecolmodel.2016.12.010**

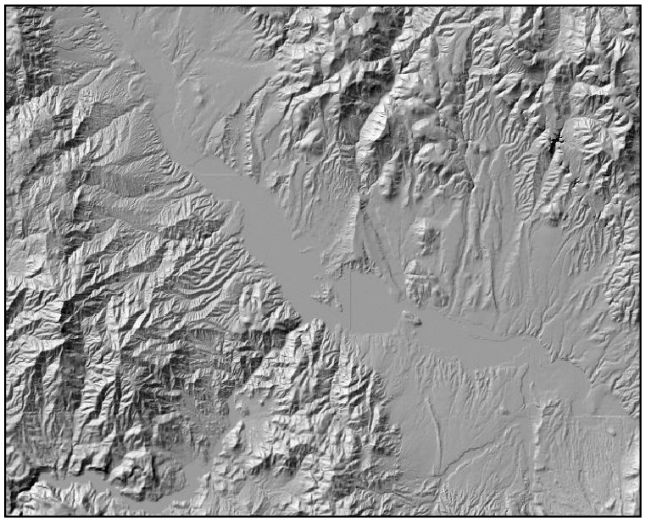
INFORMATION ON THE SANTA CLARA RIVER:

- Beller, E.E., P. W. Downs, R.M. Grossinger, B.K. Orr, and M.N. Soloman. 2015**. From past patterns to future potential: using historical ecology to inform river restoration on an intermittent California rive**r. Landscape Ecology, DOI 10.1007/s10980-015-0264-7
- Orr, B.K., and others. 2011. **Riparian vegetation classification and mapping: important tools for large-scale river corridor restoration in a semi-arid landscape**. Pages 212-232 *in* J. Willoughby, B. Orr, K. Schierenbeck, and N. Jensen [eds.], Proceedings of the CNPS Conservation Conference: Strategies and Solutions, 17-19 Jan 2009. http://www.stillwatersci.com/resources/2011orretal.pdf
- Stillwater Sciences. 2008. **Santa Clara River Floodplain Restoration Feasibility Study.** http://parkway.scrwatershed.org/wkb/projects/scrfeasibility.html
- Background on the **Santa Clara River Parkway Project** http://parkway.scrwatershed.org/parkwayplanning.html

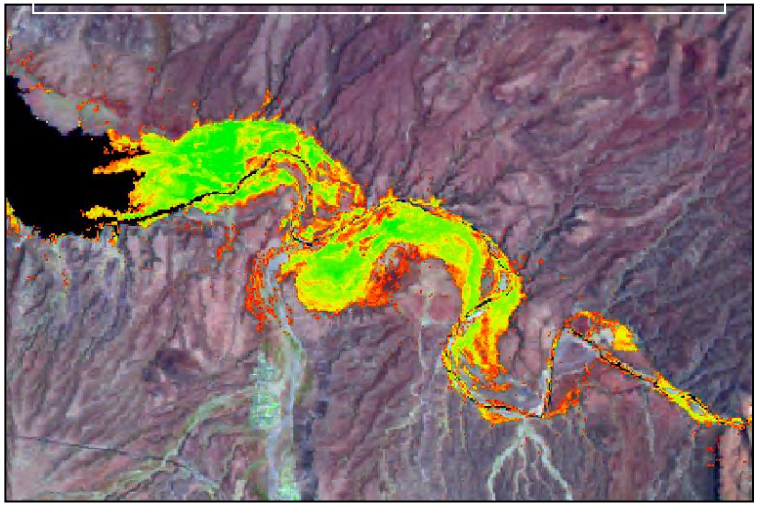
EXTRA SLIDES

Significant covariates in flycatcher model: Roosevelt Lake, AZ

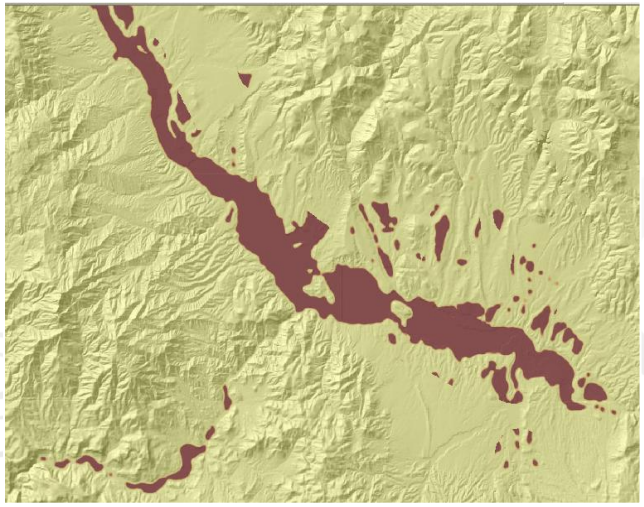
Digital elevation



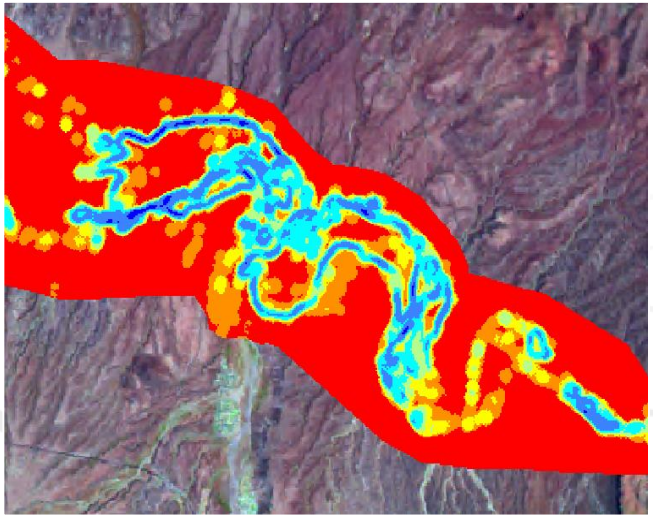
Calculate NDVI - Riparian Density



Floodplain Size

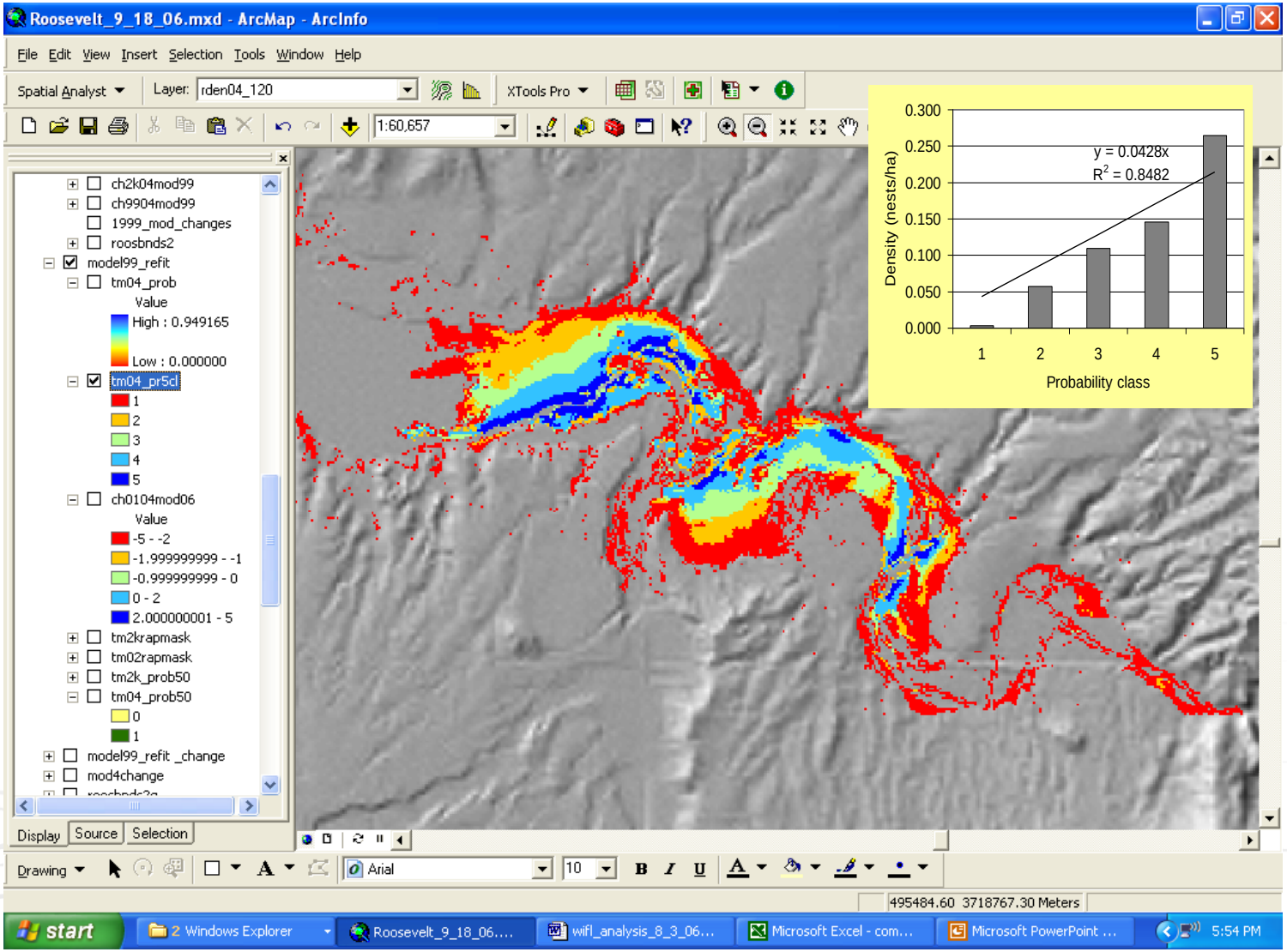


Heterogeneity in Riparian Density

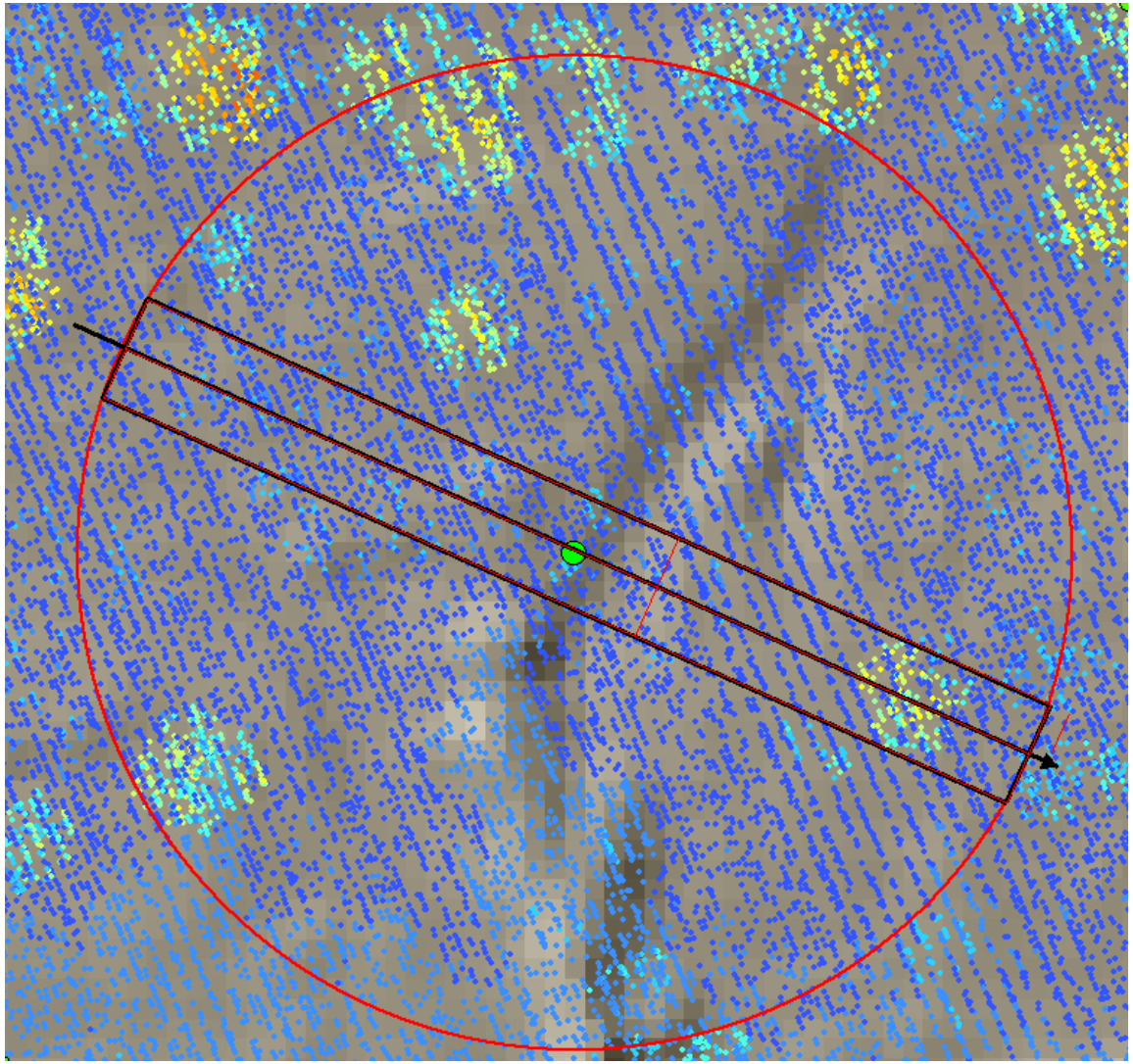


Reclassify model output into 5 probability classes: examine accuracy

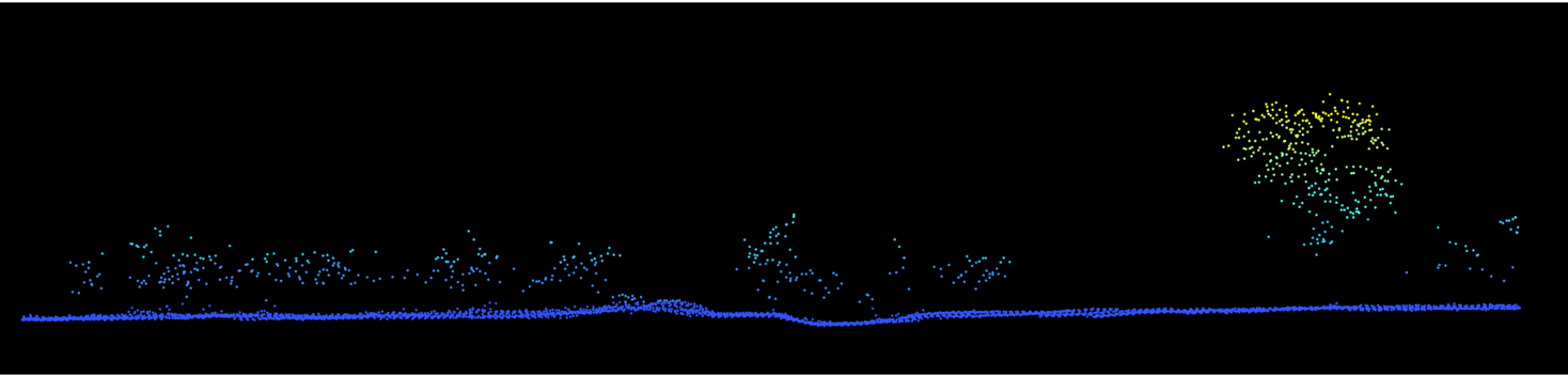
Roosevelt Lake: Salt River delta, AZ



Kisner Site 2
WNW-ESE XS Direction



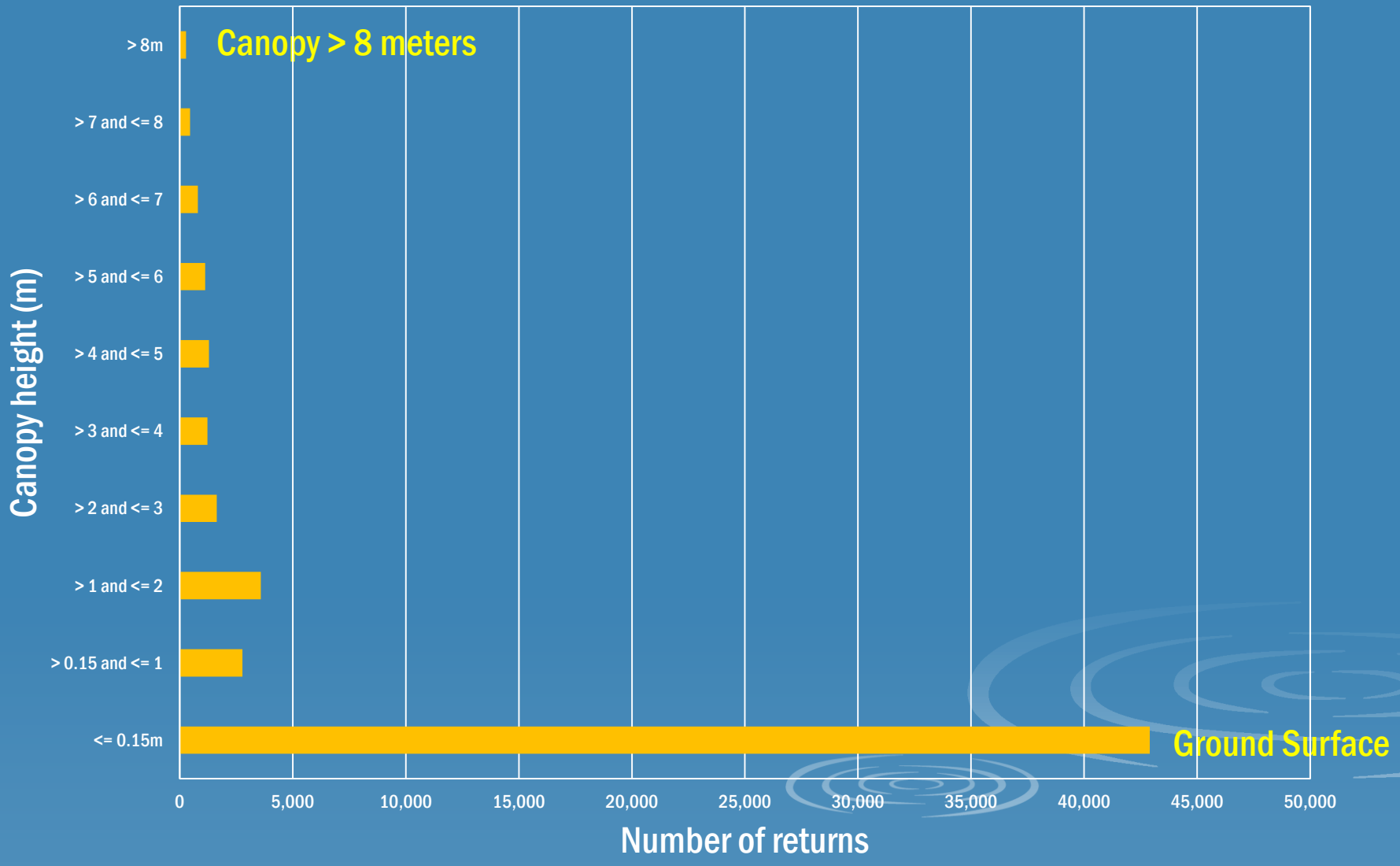
Kisner Site 2 WNW - ESE

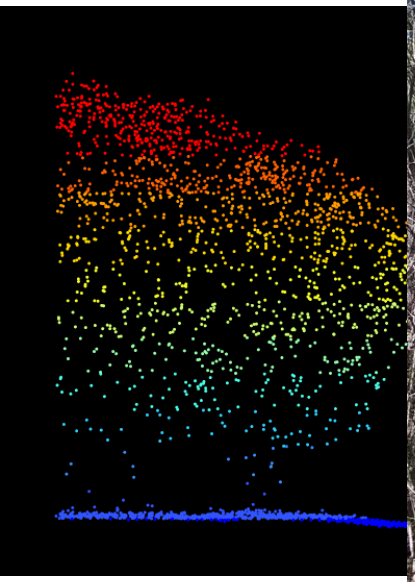


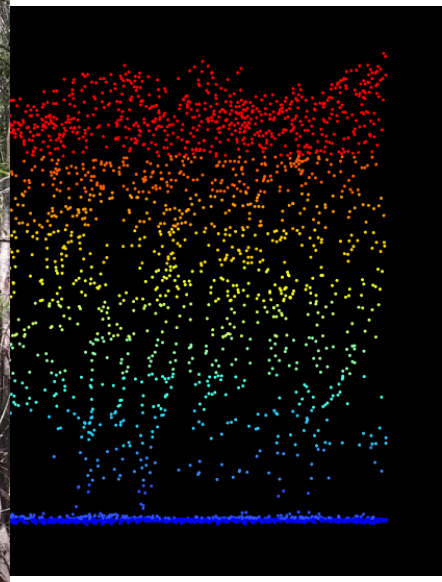
WNW

ESE

Number of LIDAR returns by elevation category.
Site 2. Santa Clara River







Example of an e