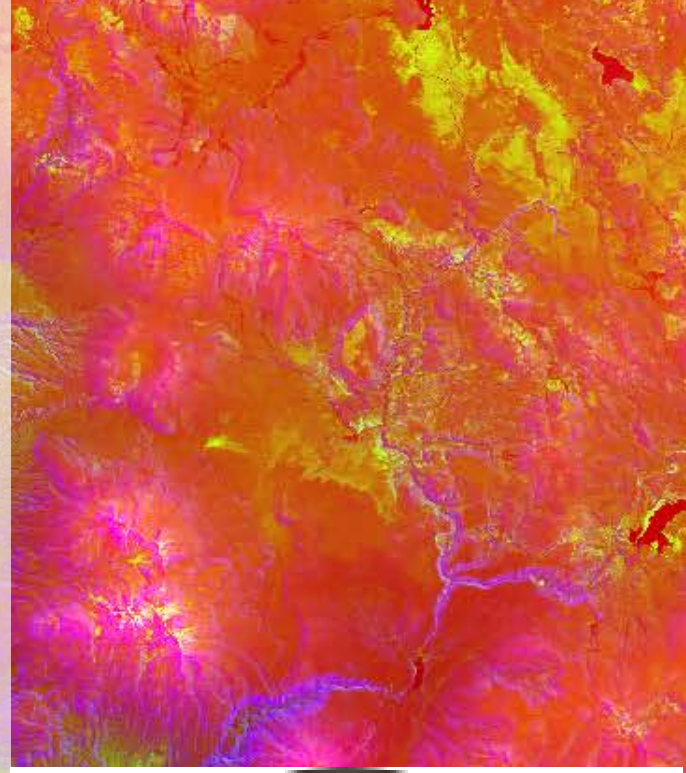
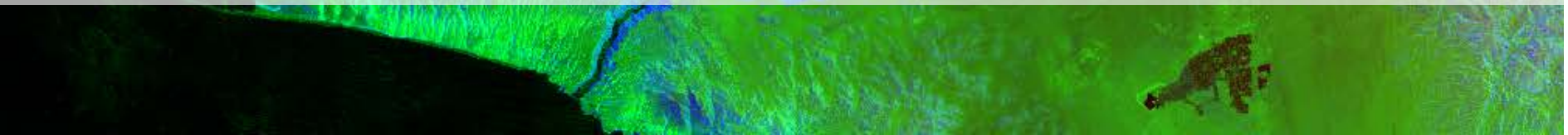
NEXUS Institute: Quantifying Four Decades of Arid-Region Agricultural Development in Arequipa, Peru using Landsat

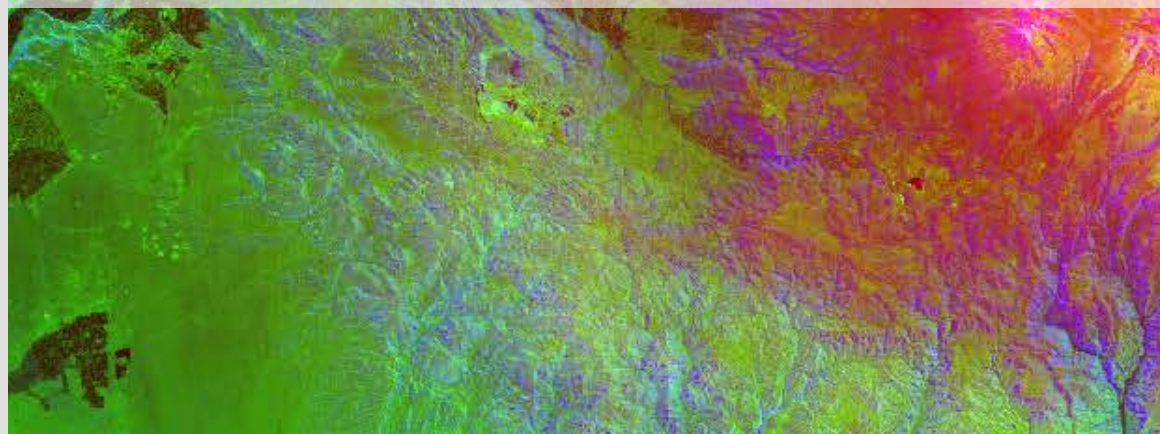


Zach Brecheisen, Nicholas Hamp-Adams, Edwin Bocardo Delgado, Martin Villalta Soto, Tim Filley, Darrell Schulze
Purdue University, GIS day 2019

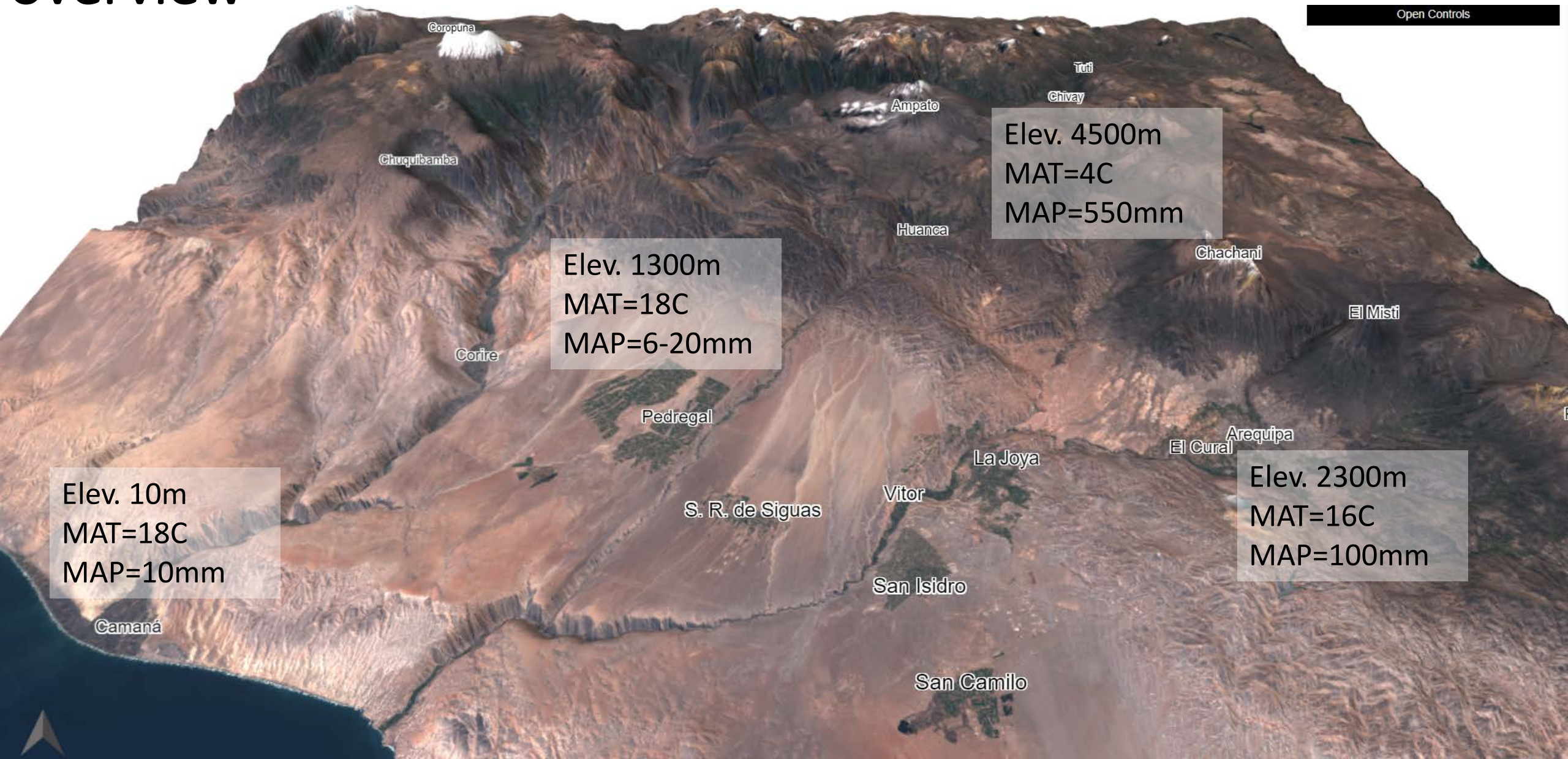


Outline

- Arequipa region climate overview
- Landcover classification methods
- Agricultural landcover change through tir
- Agricultural implications downstream
- Next steps: larger regional vegetation mapping



Arequipa region climate overview

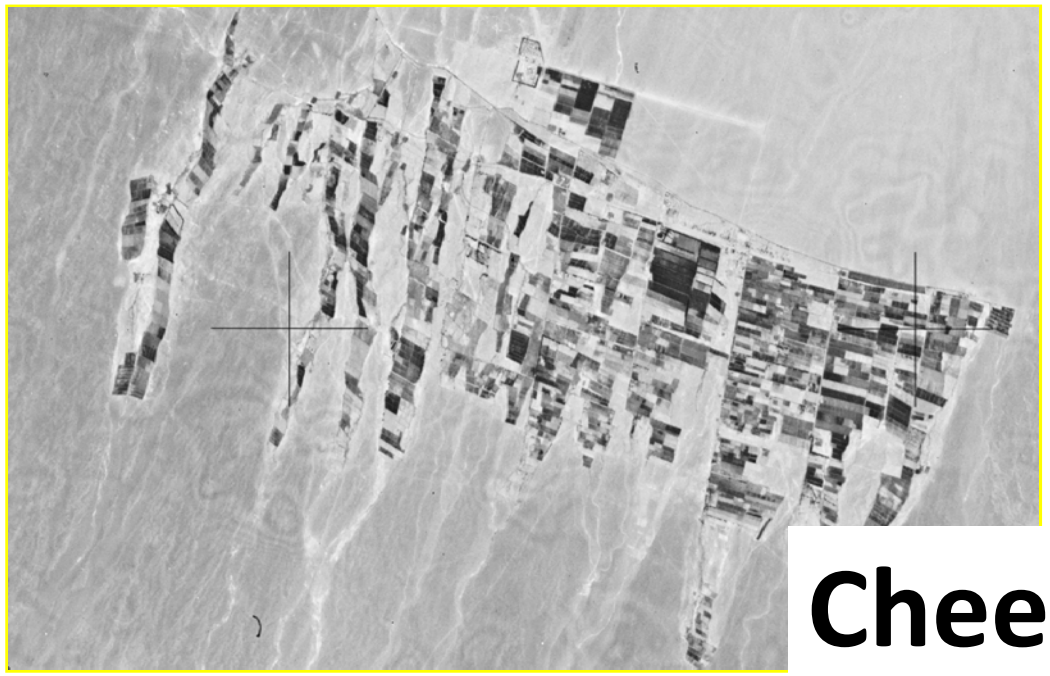


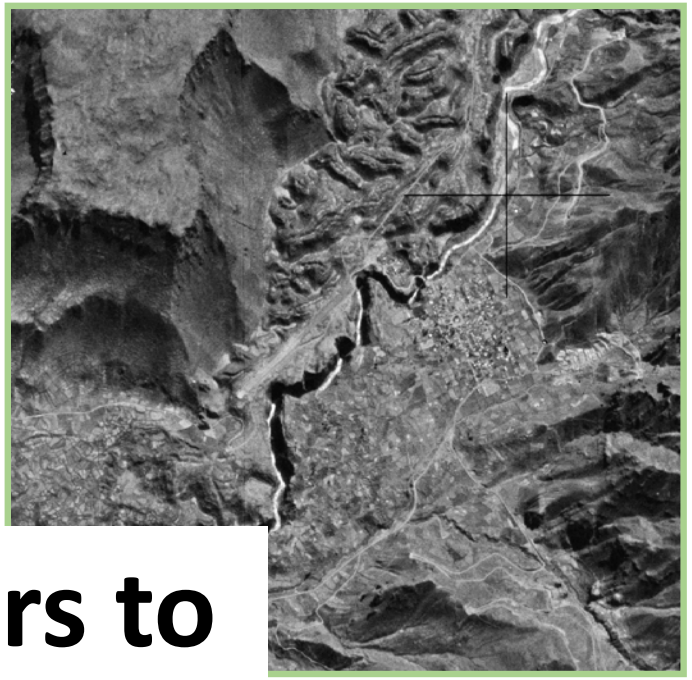
Methods: physiographic vegetation classification through time

- Method: Random forest raster classification in R along with command-line software TauDEM and Whitebox tools to derive terrain raster datasets
- Peruvian government-implemented vegetation mapping survey ~2015, comparable to USA-NLCD
- Training plots/fields were observed via field visits in 2018 and 2019 and via high resolution imagery from USGS Earth Explorer including: declassified 1966, 1977, 1978, and 1980 CORONA/Keyhole satellite imagery (KH-4A, KH-9-12 : KH-9-16), and Orbview3 imagery (2004-2007)
- Training areas were delineated to implement supervised classification of the Arequipa landscape.
- Landsat datasets used in classification obtained via Google Earth Engine:
  - Landsat1 (1972)
  - Landsat2 (1975, 1980)
  - Landsat5 (1984-2000, 2003-2009)
  - Landsat7 (2001, 2002, 2010-2013)
  - Landsat8 (2014-2019)
- SRTM DEM terrain derivatives are used for all years
- Miscellaneous datasets being curated/generated:
  - Road density
  - Population density

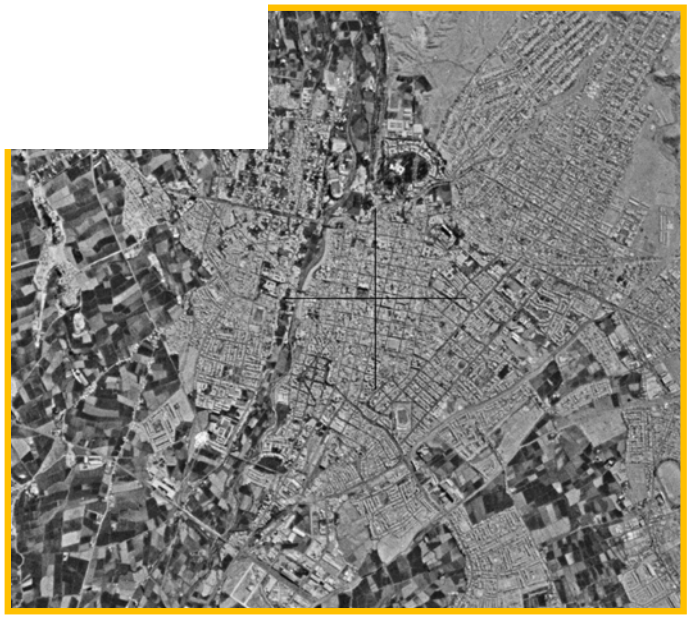
Historic Keyhole satellite imagery

Historic Keyhole satellite imagery





Cheers to Nick!



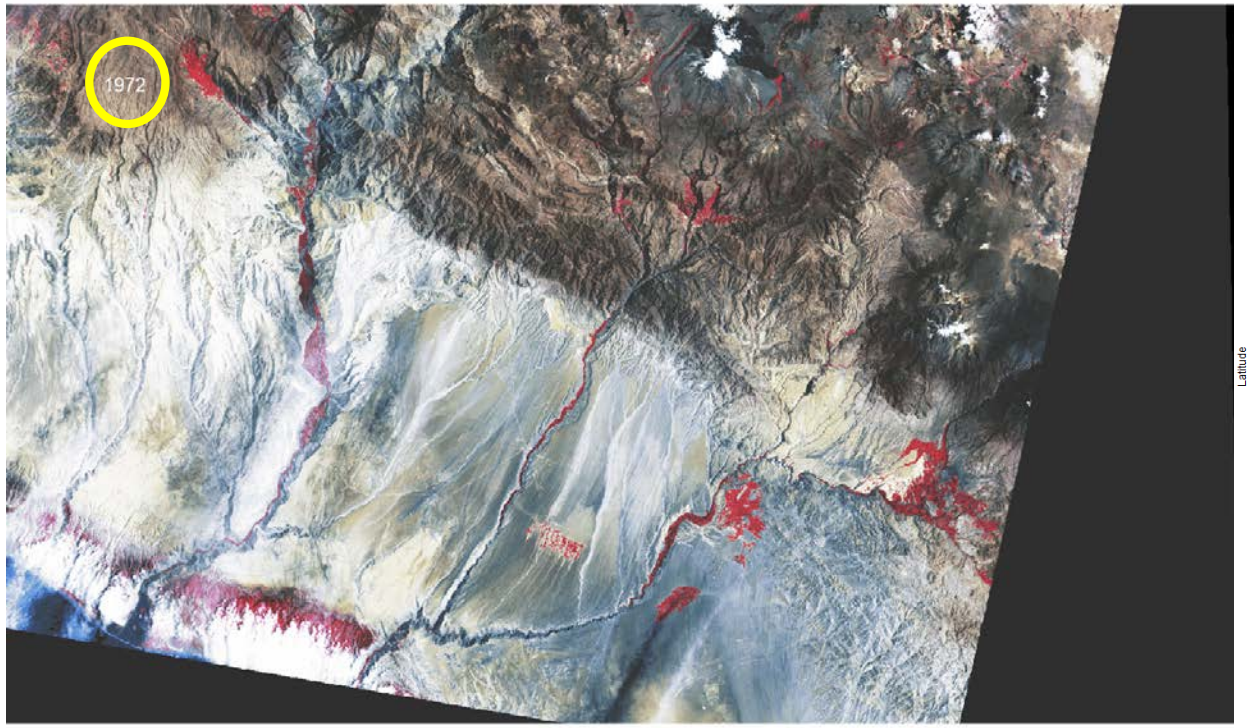
50 km

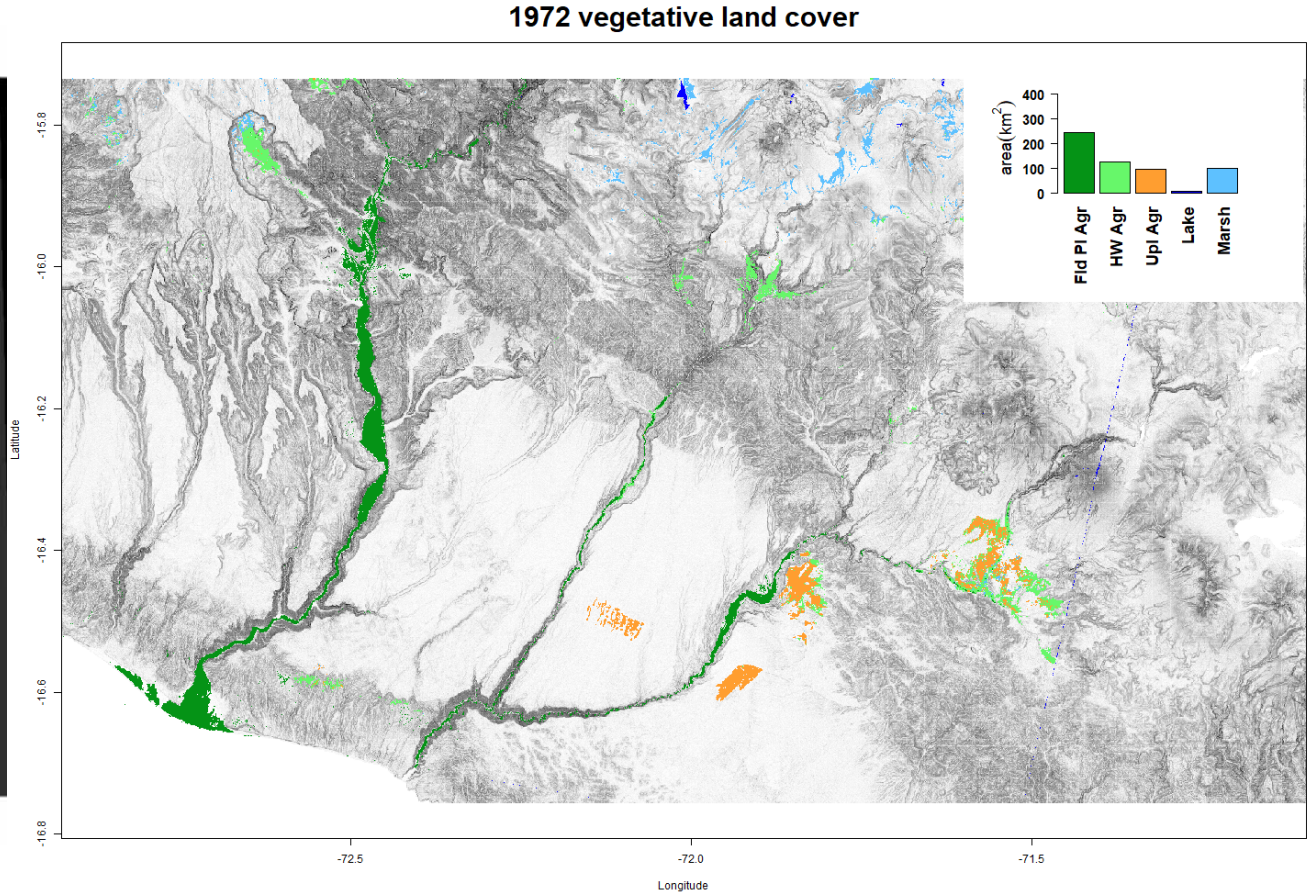
Spectral bands and topographic data used

- **Lansat:** blue, red, near infrared, shortwave infrared 1, shortwave infrared 2, normalized differential vegetation index (NDVI), enhanced vegetation index (EVI), soil-adjusted vegetation index (SAVI), “Tasseled-cap" image transformation, soil-adjusted total vegetation index (SATVI), normalized differential water index 2 (NDWI2), bare soil index (BSI)

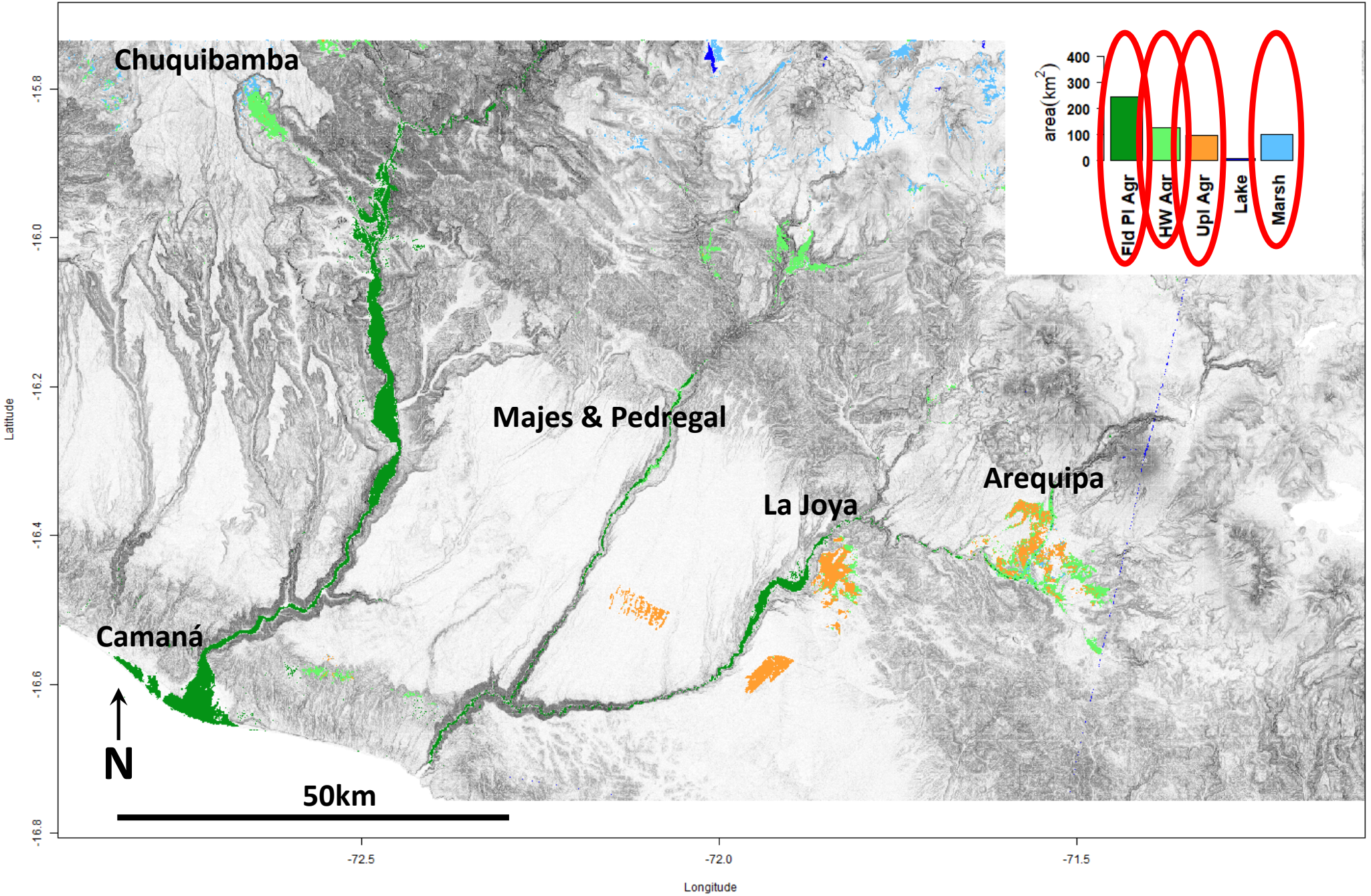
- **SRTM topography:** Slope, topographic position index (2 km), maximum elevation deviation index, d-infinity flow accumulation, standard deviation of slope

Initial efforts at sub-regional landscape Landsat agricultural mapping with very little training data

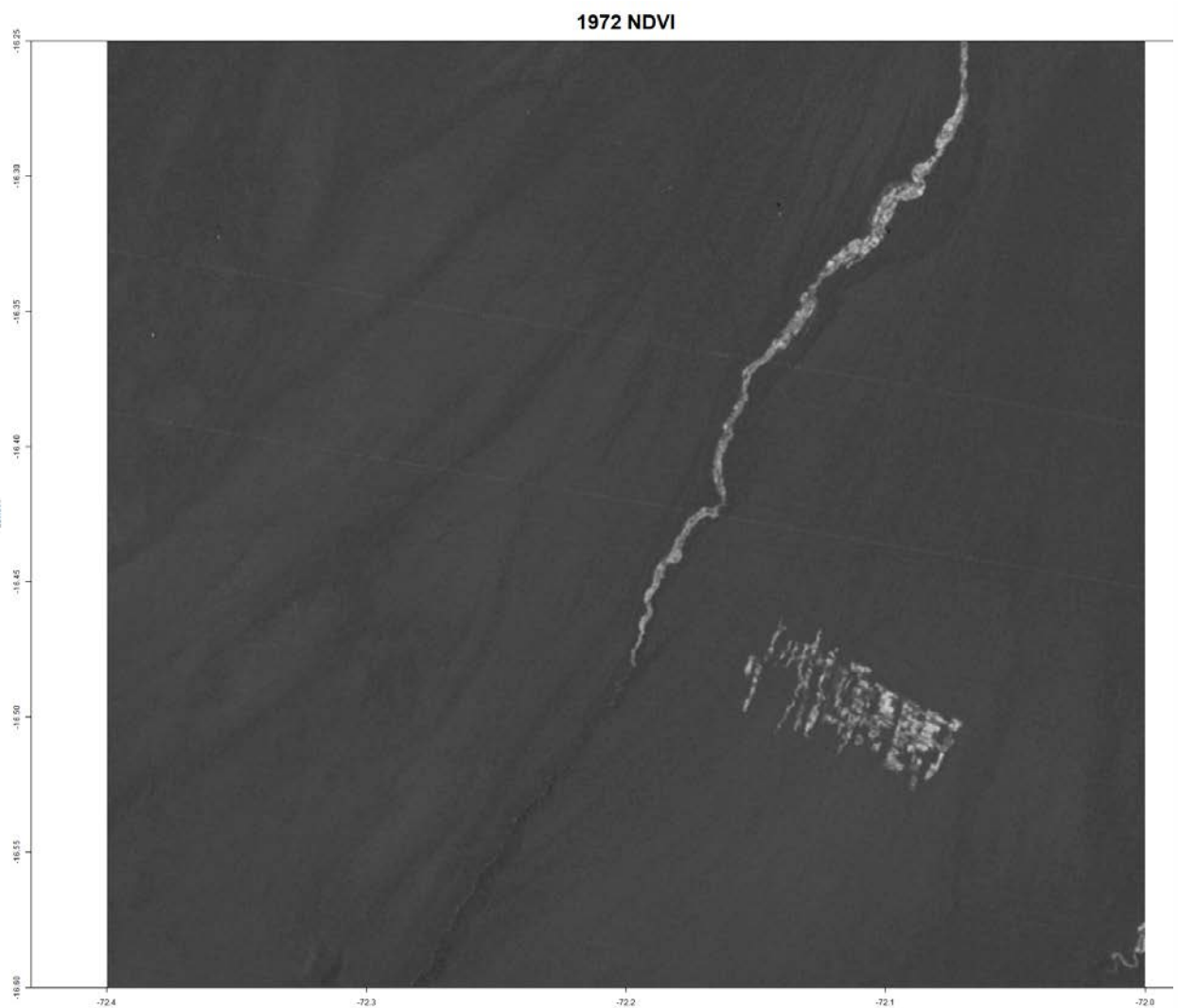


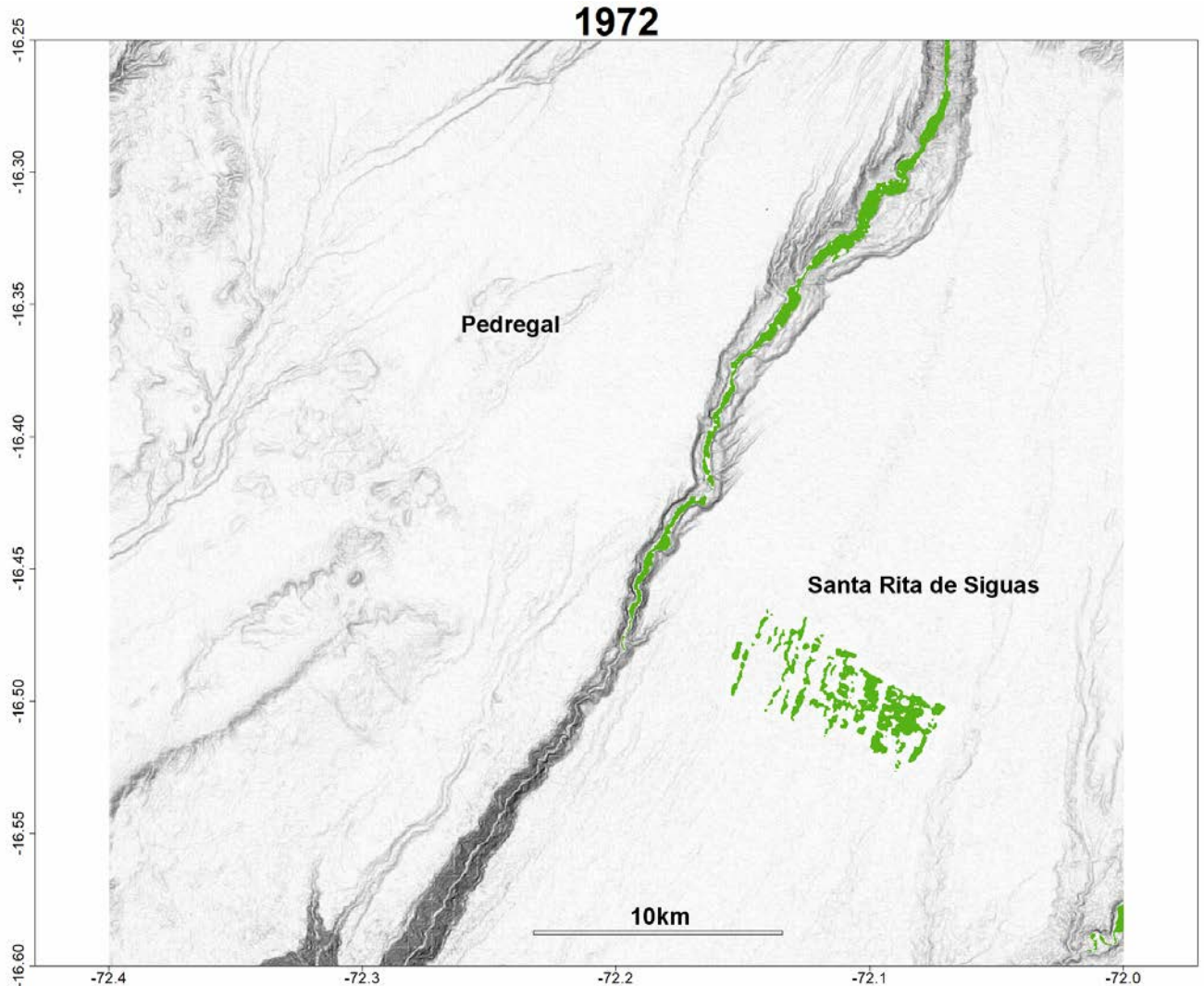


1972 vegetative land cover



Majes & Santa Rita de Siguas NDVI & agricultural expansion





Implications: expansion of upland irrigated agriculture

- Over last 30-40yrs: Floodplain Agriculture is consistent at ~250km^2 vs. Upland Agriculture which has nearly doubled in the sub-regional area from ~200km^2 to ~380km^2 in the last 35 years
- Downstream water pollution from pesticides and fertilizers and accumulations of leached salts
- Landslides and terrain instability
- This work provides the temporal context within which this socio-economic and ecological situation continues to unfold

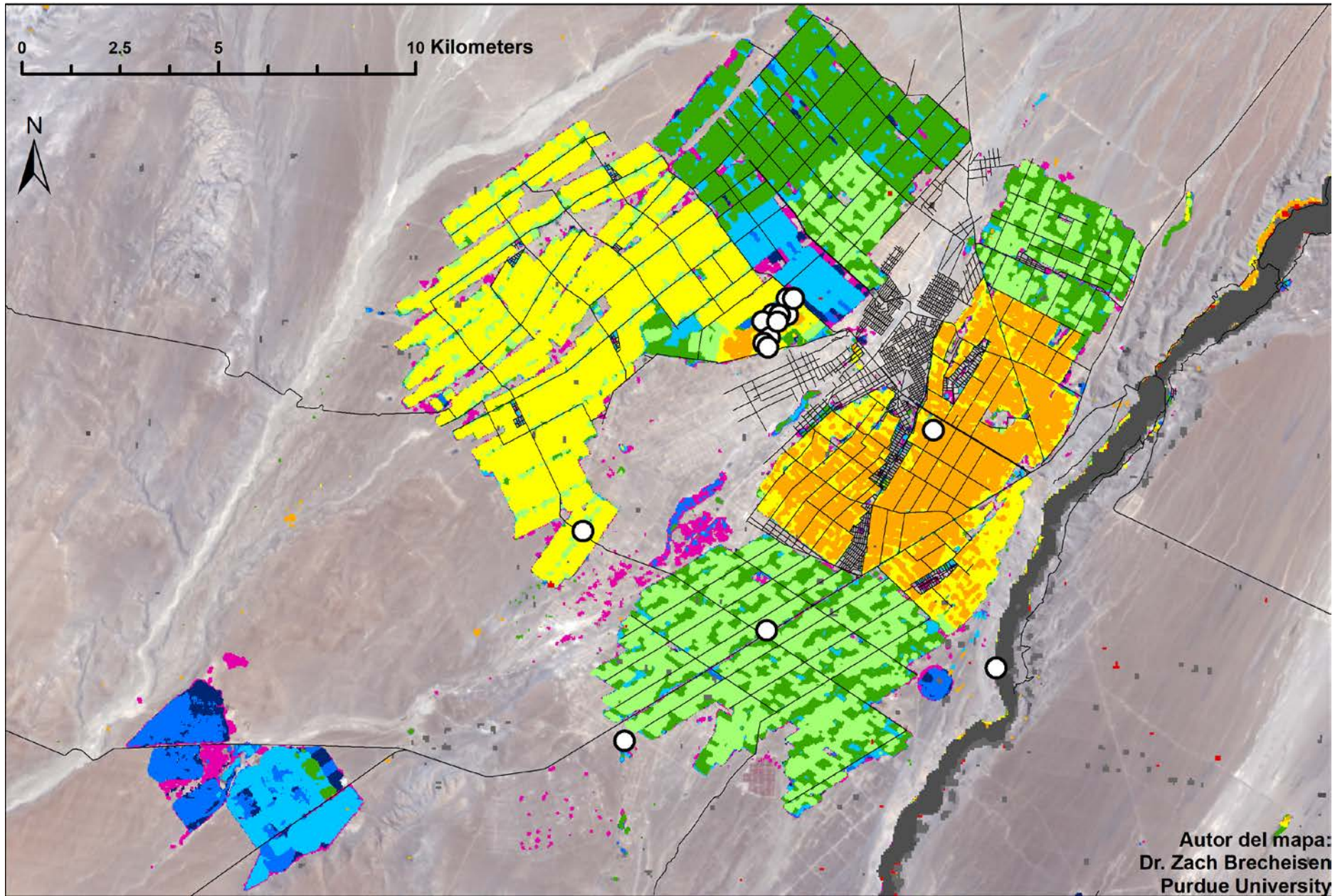
NEXUS: Colaboración entre UNSA y Purdue University

Periodo de inicial agricultura o vegetación vía imágenes satelitales

Nov-Dec Muestras de Suelos

Carreteras

1972 1975 1980 1985 1990 1995 2000 2005 2010 2015 2018

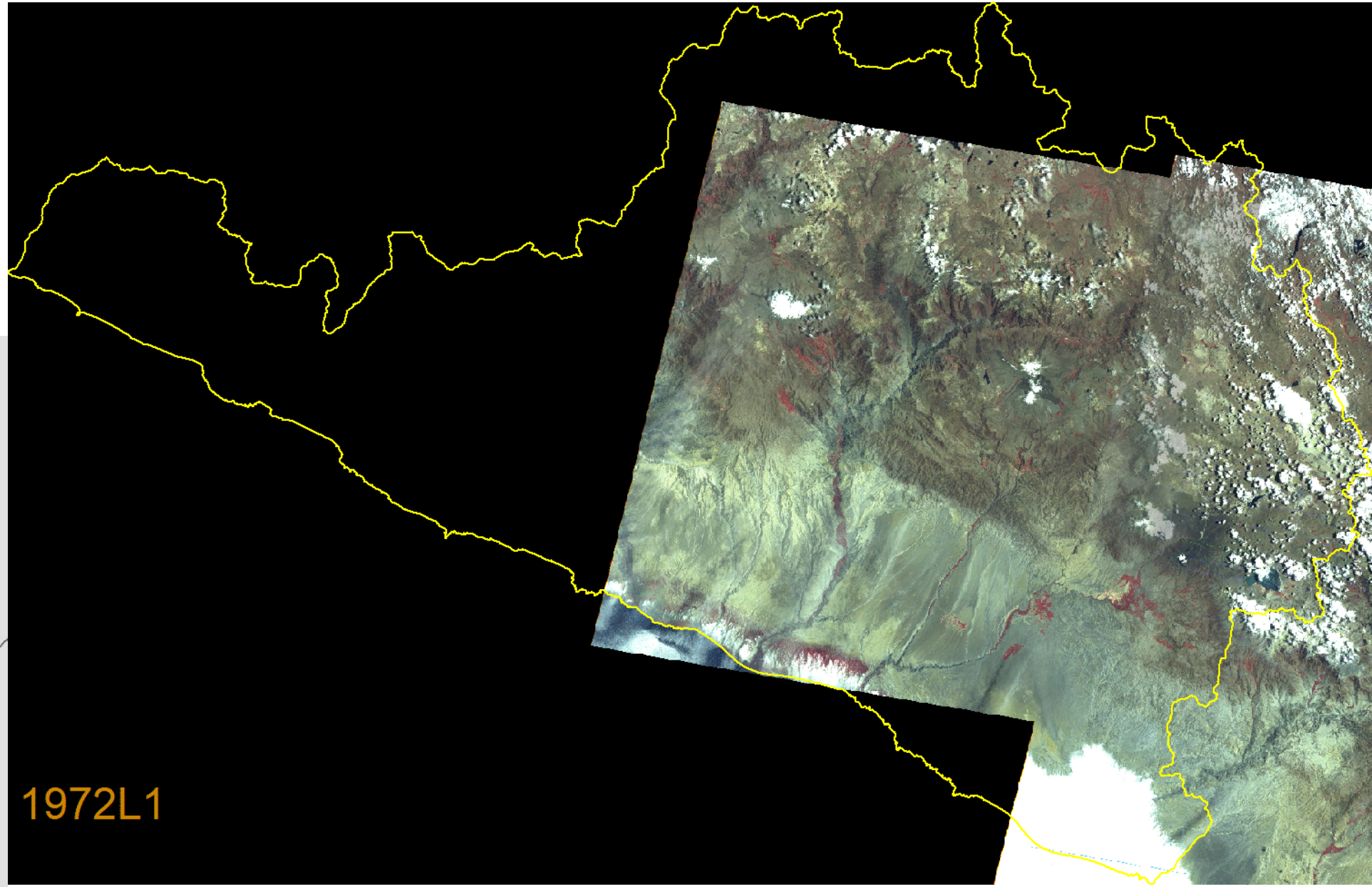



livingsmiles

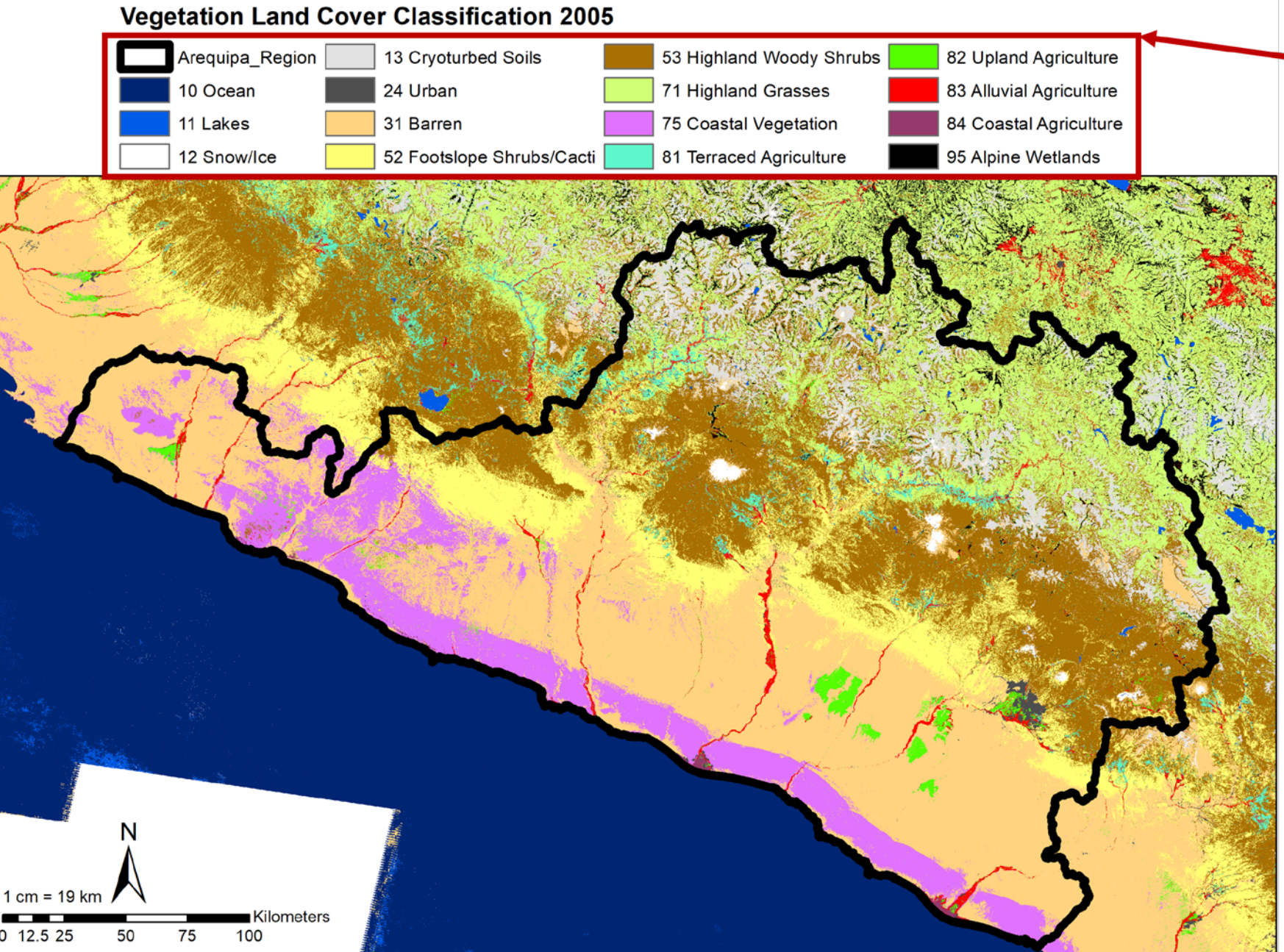

NORTHS

Next steps: whole-region all-vegetation mapping

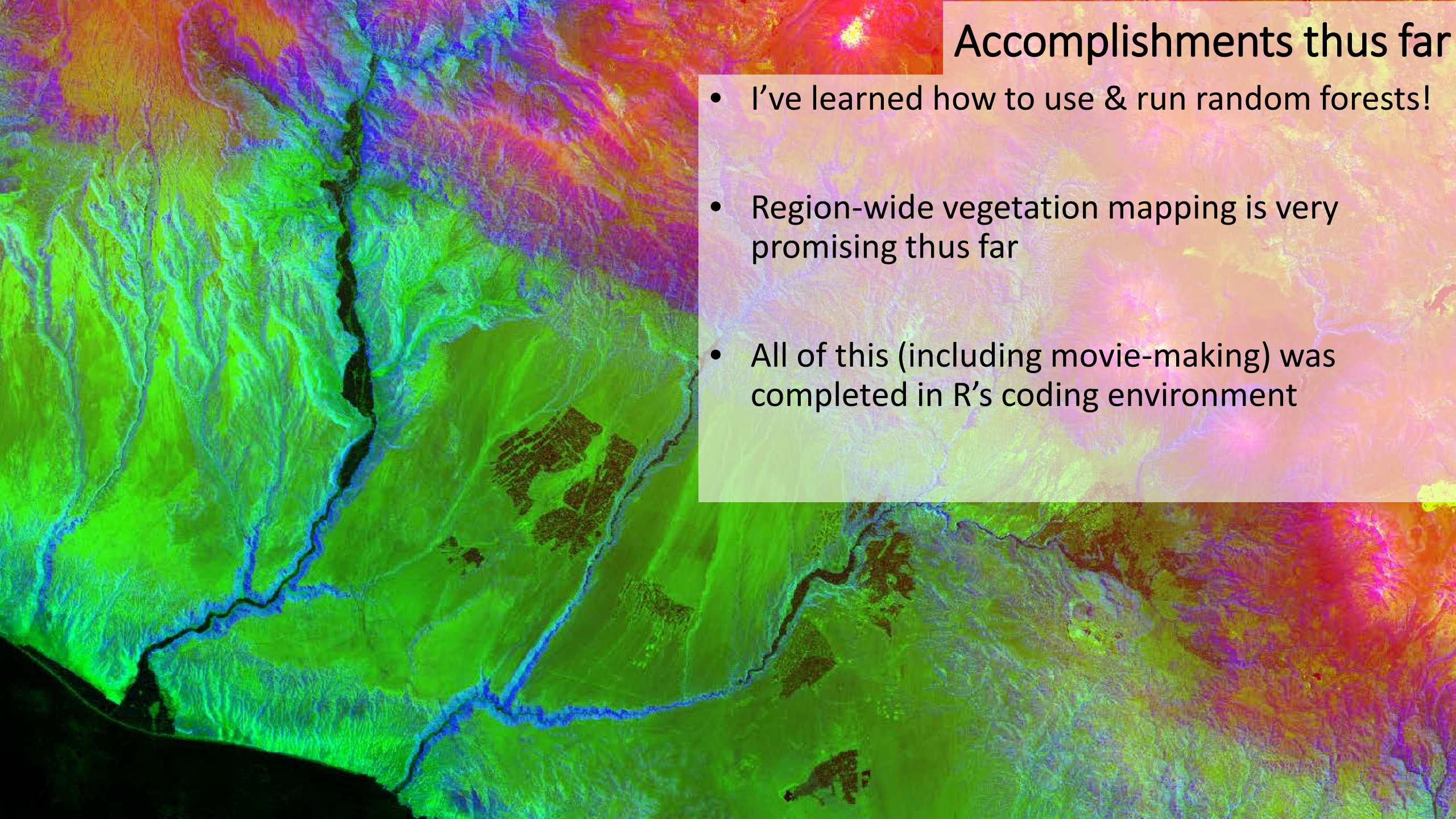
Using newly georectified high-resolution satellite imagery and Peruvian land survey information we seek to map vegetation across the entire region, 24,458 mi^2 = 63,346km^2



Whole-region all-vegetation classification first efforts



LCN	Description	Descripción	Area (km²)	% Cover	Est. % Carbon	C (km³)	% C of Total
11	Lakes	Lagos	133	0.20	0.00%	0.00	0.00
12	Snow/Ice	Nieve/Hielo	393	0.59	0.00%	0.00	0.00
13	Cryoturbed Soils	Suelos Crioturbados	4770	7.21	0.01%	0.48	0.07
24	Urban	Zonas Urbanas	248	0.38	0.00%	0.00	0.00
31	Barren	Sin Vegetación	20859	31.54	0.01%	2.09	0.29
52	Footslope Shrubs/Cacti	Cactaceas, Matorral, Puyas	7505	11.35	1.00%	75.05	10.58
53	Highland Woody Shrubs	Tolares, Pajonal, Yaretales, Queñuales	14140	21.38	1.00%	141.40	19.94
71	Highland Grasses	Cesped de Puna	7692	11.63	2.00%	153.85	21.70
75	Coastal Vegetation	Vegetación Costera	6916	10.46	0.05%	3.46	0.49
81	Terraced Agriculture	Agricultura en Terrazas	886	1.34	2.50%	22.16	3.13
82	Upland Agriculture	Agricultura en Mesetas	619	0.94	0.10%	0.62	0.09
83	Alluvial Agriculture	Agricultura Aluvial	787	1.19	8.00%	62.96	8.88
84	Coastal Agriculture	Agricultura Costera	190	0.29	10.00%	19.03	2.68
95	Alpine Wetlands	Bofedales	991	1.50	23.00%	227.95	32.15
Total			66130	100		709.03	100.00



Accomplishments thus far

- I’ve learned how to use & run random forests!
- Region-wide vegetation mapping is very promising thus far
- All of this (including movie-making) was completed in R’s coding environment

Next Steps

- Finish delineation of training & validation areas
- Develop protocol/algorithm for training area inclusion/exclusion in different time periods
- Run region-wide classification for 1970s, 80s, 90s, and 2010s
- Publish a paper!

Citations

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Acknowledgments

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- Universidad Nacional de San Augustine (UNSA)
- Purdue University

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Questions?
Suggestions?

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