# CSUGGEOGRAPHIC INFORMATION SCIENCE IN THE CALIFORNIA STATE UNIVERSITY SYSTEM VOLUME 15 - SPRING 2018

# San Francisco and Los Angeles



**Figure 1:** The 3DR Solo quadcopter with MicaSense RedEdge camera at Knuthson Meadow. **Figure 2:** Imagery of Knuthson Meadow collected from quadcopter flights and rendered using the Pix4d software suite.

# Multispectral Unpiloted Aircraft System

ultispectral cameras mounted on unpiloted aircraft systems (UAS) are playing an increasingly important role in precision agriculture, and provide great promise in biogeographical studies and land cover mapping. Use of near-infrared spectral bands and indices such as the Normalized Difference Vegetation Index (NDVI) for capturing vegetation health has been used since the 1970s in satellite platforms (e.g. Landsat). In recent years, low-cost UAS platforms and consumer grade (Canon S95) cameras used for digital surface modeling of gullies (Christian & Davis 2016) has also shown promise for mapping vegetation characteristics when modified to capture near infrared (NIR) (Christian 2015). Sensors such as the Parrot Sequoia and MicaSense RedEdge are

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DIRECTOR'S MESSAGE 2018



# Advances in Applied Geospatial Research in the CSU

In this issue of the CSU Geospatial Review, CSU scientists demonstrate an array of methods that apply advanced geospatial technologies on our campuses and field sites. At San Diego and San Jose, geospatial methods have been developed that are applied at the scale of the

campus, with Schempp and Jankowski (San Diego) investigating Wi-Fi coverage in relation to demand, and Redd and Sonvane (San Jose) applying 3D modeling for visualizing campus buildings. Remote sensing using satellite sensors and aerial photography are applied in studies from two campuses: Ridder (San Marcos) investigating the effect of population change on vegetation patterns near sampled villages in Cyprus using aerial photography and field transects to more accurately model vegetation changes; and Laney (Sonoma) relating payments for environmental services to flood patterns detected in Landsat imagery of ricelands in northern California. And drones are back in action following FAA's Part 107 option approved for research by CSU investigators. This issue features research from four campuses developing and applying innovations in small multispectral and hyperspectral cameras mounted on drones and kites to study: water stress in vineyards using hyperspectral imagery (Horney, Drake, Hurley and Predmore of CalPoly San Luis Obispo); meadow and urban vegetation (Davis of San Francisco and Qiu of Los Angeles); and the impacts of tsunami flooding on coastal shrub and mangrove vegetation of Sri Lanka, using kite aerial photography (Dellysse and Madurapperuma of Humboldt).

> Jerry Davis, *Director*, CSU GIS Specialty Center San Francisco State University

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Figure 1: Flood map developed from a Landsat image taken on Feb 22, 2014.

# Assessing Payments-for-Environmental-Services (PES) Projects In Support of Shorebird Habitat on Northern California's Riceland

ost-harvest flood regimes in the rice-growing region of Northern California provide surrogate wetland habitat for millions of migratory waterbirds along the Pacific Flyway (Elphick 2000). Shorebirds have not been thriving, however, because the shallow floods they require dissipate before many of these species have left the region (CVJV 2006). That habitat gap is caused by two different factors. Dry weather conditions can deplete growers' rain-fed floods, and rice growers purposely drain their fields to prepare for the next planting season. To date, it has not been clear when exactly each of these factors comes in to play, or how they interact with each other to produce the habitat gap (Schaffer-Smith et. al. 2017). This uncertainty has made it difficult for environmental managers to design appropriate interventions.

Despite that uncertainty, the Natural Resource Conservation Service (NRCS) and The Nature Conservancy (TNC) have been offering rice growers fiscal incentives to extend their floods using a policy instrument called "payments-for-environmentalservices" (PES). Most PES contracts focus on the month of February, and many permit growers to drain a quarter of their contracted fields each successive week throughout that month



Figure 2: Late-winter shallow-flood patterns under wet and dry weather conditions.

in order to mitigate the potential for those extended floods to delay spring planting and risk profitability (Strum et al. 2014). The 'incremental drawdowns' reduce the projects' conservation benefits for shorebirds, but they are considered necessary in order to lessen the apparent ag/wildlife conflict and ensure participation.

The purpose of this study was to assess how well the projects addressed shorebird needs. The first goal was to test three assumptions underlying the design of the projects: that the habitat gap emerges in February; that late-February flooding conflicts with dominant rice-management practices; and that rice growers cause the gap by draining their fields. The second goal was to determine whether PES-induced flooding has reduced the habitat gap.

Landsat images covering mid-January to April, and extending from 2000 to 2015, were used to develop over 50 individual flood-cover maps (e.g. Figure 1). NRCS and TNC contract records clarified how much of that flooding could be attributed to a PES project. Flood acreages were then grouped by weather condition and graphed sequentially by date, revealing latewinter flood patterns and PES impacts under wet and dry conditions (Figure 2). Shorebird needs were gauged from biological studies (e.g. Dybala et al. 2017). Grower surveys identified their preferred flood practices and their perceptions of the PES projects.

Results indicate that, during wet-weather conditions, there is no habitat gap in February. Rainfed flooding is sufficient to meet shorebird needs without PES support through the first week of March. Moreover, historical weather data suggests that late Februaries are wet more than 50% of the time. In dry conditions, a gap emerges in mid- to late-February, but not because growers are purposely draining their fields. In fact, many growers consider late-February floods beneficial, not competitive, to their management systems. Instead, the cost of water prevents many growers from maintaining their floods when rains fail. By mid-March, the situation changes. Flooding is no longer compatible with rice management systems, and that ag/wildlife conflict drives the habitat gap. In this context, PES proved successful at reducing the late-February dry-condition habitat gap, but only when the contracts did not allow for incremental drawdown. By late February, incremental drawdown had sacrificed too much flooding to remediate any habitat gap.

These results point to three changes that could increase PES impact and efficiency. First, February contracts should be more responsive to weather by, for example, including a cancellation clause for wet conditions. Second, they should not allow incremental drawdown as it is intended to ameliorate an ag/wildlife conflict that does not actually arise until March. Third, projects should support more flooding in March, when the habitat gap becomes severe in all weather conditions and when the ag/wildlife conflict becomes especially acute.

### REFERENCES

CVJV (2006) Central Valley joint venture implementation plan—conserving bird habitat. U.S. Fish and Wildlife Service, Sacramento, CA

Dybala, K.E., Reiter, M.E., Hickey, C.M., Shuford, W.D., Strum, K.M. and Yarris, G.S., 2017. A Bioenergetics Approach to Setting Conservation Objectives for Non-Breeding Shorebirds in California's Central Valley. San Francisco Estuary and Watershed Science, 15(1).

Elphick, C. S. (2000). Functional Equivalency between Rice Fields and Seminatural Wetland Habitats. *Conservation Biology*, 14(1), 181–191

Schaffer-Smith, D., Swenson, J.J., Barbaree, B. and Reiter, M.E., 2017. Three decades of Landsat-derived spring surface water dynamics in an agricultural wetland mosaic; Implications for migratory shorebirds. *Remote Sensing of Environment*, 193, pp.180-192.

Strum, K. M., K. Sesser, and M. N. Iglecia, 2014. Waterbird Habitat Enhancement Program: Bird-friendly Farming in California Rice Fields. Report to the California Rice Commission. [Internet]. [cited date]; # p. doi: http://calrice.org/pdf/waterbirdhabitatbro\_web.pdf

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# Optimizing Outdoor Campus Wi-Fi Coverage

ampus Wi-Fi connectivity is an important resource for any university, enhancing education and extending communication. Virtually invisible unless it's down, few people outside of campus IT departments consider the placement of Wi-Fi access points (APs) required to build these networks.

Constraints may include the presence of historical buildings which affect AP placement, and budgetary limitations that determine the quality and quantity of APs available. Spatial optimization models can provide practical solutions to these issues. A prototyping case study was conducted at SDSU, in collaboration with the telecommunications and network services (TNS) department, to investigate optimal AP placement schemas.

The study commenced with obtaining the various geographic data required to model the campus and the Wi-Fi conditions. The TNS department provided buildinginstallation suitability data that was digitized and combined with campus duress phones data into a point layer of potential AP locations. The AP units used at SDSU are the Aruba 275, and according to Jerrod Howard, Aruba's senior technical marketing engineer, its operational range of "50m radius... is a good ballpark" for the -65 dBm signal threshold recommended for most computers and mobile devices (Howard 2014; Crane 2017). Using this suggestion, a 50-meter buffer was created on all potential AP locations to derive a polygon layer of AP- coverage areas (Figure 1). The buildings polygon layer was rasterized into a continuous surface (30.48m resolution) and masked by the campus boundary polygon layer (Figure 2). This raster layer was reclassified as a binary surface of building and non-building cells, where the centroids of each non-building cell represented the user demand areas. The coverage areas polygons and the demand areas points were intersected to create a coverage matrix, which served as the input for two spatial optimization models.

The first is the *location set covering problem* (LSCP) model, its solution includes the minimum number of APs and their locations that are required to ensure all campus demand areas are covered (Toregas et al. 1971). The second is the *maximal covering location problem* (MCLP) model, which finds a solution that adheres to the constraint of a limited number of APs while maximizing coverage of demand areas (Church and ReVelle 1974).

The software package LINGO was used to compute the LSCP solution and two MCLP solutions. The LSCP solution indicated that if 119 out of 424 potential locations have an AP installed the coverage of campus-wide demand areas would be maximized (Figure 3). While no actual budgetary or AP availability information was used in the constraints for MCLP, models with p-values from 10 to 120 were computed and plotted against the number of demand areas covered (Figure 4). The LSCP result and two of the MCLP results (p = 35 and p=70) were visualized in ArcMap

and display potential AP locations and their coverage areas (Figure 5-6). Visualizing these model solutions can serve as a useful aid to TNS or IT department decision-makers who seek a methodological approach for determining AP placement. The results of either model's solution could be utilized to design a new schema, evaluate the current schema, or inform modification of the current schema.

Modeling of Wi-Fi demand areas can be further refined by accounting for installation height, line-of-sight obstructions, and user density. Locations of current AP installations, budgetary information, and technical details of the available AP units would better inform the coverage areas while helping to determine the p-value parameter for the MCLP approach for a more robust solution.

# REFERENCES

Church, R., and ReVelle, C. 1974. The maximal covering location problem. *Papers of the Regional Science Association*, 32: 101-119.

Crane, J. 2017, February. *Understanding WiFi Signal Strength*. Retrieved from https://www.metageek.com/training/resources/wifi-signal-strength-basics. html.

Howard, J. 2014, October 10. "Re: AP-275 Estimated Coverage?" [Online forum comment]. Message posted to http://community.arubanetworks.com/t5/Wireless-Access/AP-275-estimated-coverage/m- p/208647/highlight/true#M41443.

Toregas, C., Swain, R., ReVelle, C., and Bergman, L. 1971. The location of emergency service facilities. *Operations Research*, 19: 1363-1373.

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Figure 1: Access point coverage areas



Figure 3: LSCP Solution (119)



Figure 5: MCLP Solution (35)



Figure 2: Buildings and demand areas (30.48m resolution)



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Figure 4: Solutions from  $p = 1 \ 0$  to p = 120



Figure 6: MCLP Solution (70)



# Detection of Water Stress in Vineyards Utilizing UAV and Hyperspectral Imagery



# Figure 1:

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Top left: NDVI index, Top right: NSRI index, Bottom left: SR index, Bottom right: WI index

ince June 2016, Drs. Marc Honey, Aaron Drake, and Sean Hurley from California Polytechnic State University—San Luis Obispo have been conducting a three year longitudinal study that investigates the potential of using hyperspectral imagery collected from a Unmanned Aerial Vehicle (UAV) to detect water stress in vineyard crops in the hopes of discovering an algorithm that can better predict water stress in vineyards. Data were collected utilizing a Yamaha RMAX UAV and a SHARK hyperspectral imaging camera manufactured by Corning Corporation that covers the light spectrum from 400 to 1,000 nanometers (nm).

Utilizing ENVI (Harris Geospatial Solutions) software, four standard maps were developed from indexes seen in the literature that examine moisture stress. They include the Spectral Ratio index in the near infrared region (NSRI) (Liu et al., 2014); the water index (WI) (Gao, 1996; Penuelas et al, 1997); the normalized difference vegetation index (NDVI) (Rouse et al., 1973); and the simple ratio index (SR) (Jordan, 1969) (Figure 1). While these maps provided a visual representation that offered clues to water stress, they cannot be used as a predictive tool for how severe the water stress is in the plant. The research team at Cal Poly is investigating whether an algorithm can be discovered to link a subset of hyperspectral imagery bands to the water stress readings taken from a select group of plants.

To investigate the water stress of the plants in the vineyard, stem water potential data was measured from fifty randomly selected plants from "healthy" or "stressed" regions within the 12 acre dryland Cal Poly vineyard. The leaves from these plants were tested for moisture measured in bars of pressure in a PMS Model 600 pressure chamber. Field crews navigated the vineyards to each randomized sample location using the ArcGIS Online Collector cellphone application, where they photographed each vine they collected leaf samples from (Figure 2).

Figure 3 shows the average wavelength reading categorized by different ranges of pressure chamber readings. Lower ranges indicate less water stress, while higher readings indicated greater stress. At the highest pressure reading range (12-13.75) it can be seen that average wavelength reading are higher for spectral





**Figure 2:** Collector photo of vine with leaf pouches attached and equilibrating.

**Figure 3:** Average wavelength readings for differing ranges of pressure chamber readings (bars).

Variables <sup>1</sup>	Coefficients	T Stat	P-value	
Intercept***	6.91962	7.32580	2.5807E-10	
675.38**	0.00034	2.53688	1.3322E-02	
Vin 161**	1.30108	3.02541	3.4271E-03	
938.95*	0.00173	1.71260	9.1030E-02	
dif(553,432)	0.00023	1.60780	1.1220E-01	
1 * ** and *** represent significant lovel at a 0.10.00E				

\*, \*\*, and \*\*\* represent significant level at  $\alpha = 0.10, 0.05$ , and 0.001.

 Table 1: Linear Regression Model for Detecting Water Stress

 in Vineyards Using Hyperspectral Bands.

bands that are below 736.07nm. This provided the researchers with a clue regarding which bands in the imagery should be utilized for predictively detecting water stress.

Initial analysis of one year's worth of data utilizing linear regression modeling techniques demonstrated that the 675.83 nm and 938.95 nm spectral band wavelength readings have statistically significant predictive ability for estimating pressure chamber readings to detect water stress (Table 1). While not quite statistically significant at the 10%-level, the researchers found that examining the differences in the readings between the 553.72 nm and the 432.08 nm may offer another avenue for exploration on how to examine hyperspectral bands to detect water stress.

This project is still ongoing and has one more year of data collection and analysis that needs to occur. The research team is planning on using more sophisticated data analytic techniques in the future to examine the potentially deeply embedded relationship between hyperspectral bands and pressure chamber readings.

# REFERENCES

Gao, B. C. (1996). NDWI—A normalized difference water index for remote sensing of vegetation liquid water from space. *Remote sensing of environment*, 58(3), 257-266.

Jordan, C. F. (1969). Derivation of leaf area index from quality of light on the forest floor. *Ecology*, 50(4), 663-666.

Liu, L. Y., Huang, W. J., PU, R. L., & Wang, J. H. (2014). Detection of internal leaf structure deterioration using a new spectral ratio index in the near-infrared shoulder region. *Journal of Integrative Agriculture*, 13(4), 760-769.

Peñuelas, J., Pinol, J., Ogaya, R., & Filella, I. (1997). Estimation of plant water concentration by the reflectance water index WI (R900/R970). *International Journal of Remote Sensing*, 18(13), 2869-2875.

Rouse, J. W., R. H. Haas, J. A. Schell, and D. W. Deering (1973) 'Monitoring vegetation systems in the Great Plains with ERTS', *Third ERTS Symposium*, NASA SP-351 I, 309-317.

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# Developing a Coastal GIS Model of Sri Lanka to Pinpoint Areas at Risk from Tsunamis and SLR (Preliminary Study)

n December 26, 2004 over thirty thousand people lost their lives after an offshore earthquake caused a tsunami in Sri Lanka (Ramalanjaona, 2011). The alarming tsunami disaster was a wakeup call for managing coastal habitats in Sri Lanka and to mitigate the future impacts and identify coastal vulnerabilities. With a limited availability of high resolution images in Sri Lanka, kite aerial photography (KAP), which has been around since 1882 (Colwell 1997), can be useful to assess coastal bioshield mass and measure recovery efforts after a tsunami and identify ecosystem resilience in respect to sea level rise and climate change vulnerabilities. A simple kite aerial platform was fabricated with a Picavet rig (KAP, 2010) with two digital cameras, one unit modified just for the Near Infrared. KAP has several advantages, such as low-cost, high spatial/temporal resolution, and limited regulation, which is feasible to collect images in coastal habitats in Sri Lanka with moderate wind conditions. Our original framework had to be a simple helium balloon platform, however we had to give up the idea due to high helium costs in Sri Lanka (Ca \$500 per gas cylinder). A KAP platform was built for \$250, and was used for multiple samplings.

This objective of this study is to examine the coastal shrub and mangrove vegetation characteristics using KAP, normalized difference vegetation index (NDVI) and classification methods. This study focused on two coastal areas, namely Hambantota in the southern province and Ampara in the north-east province, where coastal habitats in this area were severely damaged by the 2004 boxing day tsunami. The acquired KAP images were mosaicked using structure-from-motion (SfM) analysis from Agisoft PhotoScan software. We mosaicked 70 images of RGB and NIR from several coastal shrub vegetation areas in Hambantota, while 492 images were mosaicked for mangrove vegetation in Ampara (Figure 1) with ground resolution of the ortho-images at 4 cm. The NDVI was created using NIR and red bands of the mosaicked ortho-images. The NDVI image was exported to ENVI to create region of interest (roi) for the mangrove vegetation. The NDVI roi statistics for mangrove features were created and exported to Excel. While reviewing the NDVI values, a threshold between 0.17 to 0.27 was assigned for mangrove vegetation. The NDVI image was reclassified using the NDVI thresholds to map mangrove areas (Figure 1). The results showed that the mangrove vegetation in both NIR ortho-image and classified image were comparable. KAP is useful to cheaply estimate mangrove extents and also feasible to extract mangrove species using object oriented feature extraction techniques in areas where licensing and budget constraint would exclude more mainstream methods





**Figure 1:** Mosaic NIR image of mangrove vegetation at Pothuvil, Sri Lanka (left) and classified mangrove vegetation and water class using NDVI thresholds (right)

One notable limitation of KAP was the use of portable GPS trackers on the kite platform which often lost their connection due to high wind condition and limited access to cellular towers. As a result of these shortcomings, we had to manually collect many of the ground control points to geo-reference the images and to create digital elevation model (DEM) for making sea level rise model. The implications of KAP as an affordable platform which produced a series of high resolution aerial images provided proof of concept for a larger study on risk assessment of coastal habitats. This study will further be used to develop a larger project which has already been supported by several agencies within the government of Sri Lanka.

# REFERENCES

Colwell, R.N. 1997. History and place of photographic interpretation. In: Philipson, W.R. (ed.), Manual of photographic interpretation (2nd ed.), p. 3-47. *American Society for Photogrammetry and Remote Sensing*, Bethesda, Maryland.

KAP, 2010. Notes on Kite Aerial Photography: Equipment

BETWEEN the CRADLE and the KITE LINE. http://kap.ced.berkeley.edu/ equip/picavet.html.

Ramalanjaona, G. 2011. Impact of 2004 tsunami in the islands of Indian Ocean: lessons learned. *Emergency medicine international*, 2011.

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# Virtual Visit: Developing a 3D Campus Map



**Figure 1:** Bird's-eye view of the San Jose State University Campus with Tower Hall showcased

hen visiting a campus, a map can become a helpful tool as it offers guidance and assists with planning. Chao (2016) analyzed user searches of a campus map and subsequently made recommendations on ways to improve the user search experience, such as through result retrieval methods and interface design. The locations searched for on a map are based upon a visitor's needs, so it would prove helpful to provide a personalized user search experience. Building a 3D model of the campus that can get explored virtually provides an additional perspective. The viewer is immersed in the campus environment, where exploration and experiences can take place prior to a physical visit. The goal of developing the 3D campus map was to provide visitors the opportunity to explore the campus and immerse themselves in the SJSU environment without being in the geographic location.

In order to develop the immersive experience, we used ESRI's CityEngine tool which transforms 2D GIS data from ArcGIS into smart 3D models. As CityEngine is integrated with ArcGIS, it leverages the highly detailed maps present in ArcGIS. This enables users to import/export any geospatial vector data. We used the "Get Map Data" option present in CityEngine, which allowed us to download the selected map data from ArcGIS Online. The map data had a creation timestamp of Mar 27, 2017, but the campus map had not been updated yet to reflect the most recent infrastructure. As a result, we provided them with feedback to update the campus map. The status of the request is "Planned for Future Update".

To build our experience, the first thing we needed was the BaseMap, and this was where CityEngine leverages from the highly detailed maps present in ArcGIS. Once we set the map extent and obtained the map data, we selected the area of

interest and used the "Generate" functionality of CityEngine. This generated models of the selected shapes. CityEngine used the building's base and data from ArcGIS to intelligently extrude a 3D building out of it. Careful review was required to ensure CityEngine generated buildings correctly and extra items generated were removed. At this point, the 3D buildings were just solid white boxes, and the next step was to add details to them. CityEngine had a couple of generic building styles that we could choose from. After selecting one of the default styles, we then selected each individual building and used the Facade Texturing feature of CityEngine to replicate the original building in the 3D model. Once we were satisfied with the 3D models, we used the export functionality to create a 360 VR experience and share it on the ArcGIS online portal. Now visitors using the ArcGIS 360 VR application on a compatible device can immerse themselves in our campus virtually. Visit the SJSU 3D Map on CityEngine.

# REFERENCES

Chao, Z. (2016). From query analysis to user information needs: A study of campus map searches. *Library Hi Tech*, 34(1), 104-129.

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# Multispectral Unpiloted Aircraft System from cover page

designed to capture multiple bands similar to what we've generally seen on satellite platforms, yet are suitable for small UAV platforms. For our research programs, we have identified MicaSense RedEdge sensors mounted on 3DR Solo quadcopters (Figure 1). This 5-camera system captures narrow bands of 465-485, 550-570, 663-673, 820-860 (NIR), and 712-722 (red-edge) nm suitable for processing in Pix4D. The red-edge band combined with NIR is useful for looking at seasonal moisture stress and species (Horler, Dockray, & Barber, 1983), with applications in meadows and wetlands as well as urban landscapes; Qiu and his students plan to use this technology to collect high spatial and temporal resolution data for studying urban landscapes and detecting moisture stress of green spaces.

We met up at the SFSU Sierra Nevada Field Campus to test out the systems in meadows in the Tahoe National Forest where Davis and colleagues are studying the impact of restoration projects on hydrology, channel systems (Slocombe & Davis 2014), vegetation, soils, and carbon and vapor flux (Castellvi & Oliphant 2017). Montane meadows in the Sierra have experienced a long history of degradation from railroad timber extraction and channel headcuts, and efforts to restore wetland properties have reestablished vegetation and soil characteristics that interact closely with meadow hydrogeomorphology (Loheide et al., 2009). Wet meadow vegetation requires a high water table, and this in turn influences the plant communities and related soil characteristics. The impacts of wetland degradation on carbon and snowmelt storage are also concerns related to climate change, and restoration efforts offer benefits in carbon sequestration and water storage.

Along with students in Geog 643 *Biogeomorphology* of *Sierra Nevada Streams and Meadows*, we developed a protocol for mapping these meadow systems using this technology. Flight plans were developed and deployed using the 3DR Tower app running on a Nexus 9 tablet, with 75% front and side overlap. In the most extensively sampled meadow, Knuthson, 14 soil and vegetation samples were collected along with 92 GPS points with linked photographs to aid in image classification. Field tests demonstrated that while the 3DR Solo batteries are listed as supporting flights for 25 minutes, 8 minutes is the limit to use for flights with the RedEdge mounted. Basemap imagery published on Mapbox were used to allow off-line mission planning at the site. Detailed guides to our protocol can be found at http:// geog.sfsu.edu/field-equipment/3dr-solo.

During July and August, three meadows were mapped, including 72 ha Knuthson Meadow, 13 ha of Loney Meadow, and 10 ha of Dry Creek Meadow, at flight heights of 80 m (Knuthson, Dry) or 120 m (Loney), producing a resolution of 5.6 or 8.3 cm, respectively. Maximum coverage by one flight (1 battery) was approximately 10 ha, at either 80 or 120 m altitude above ground level (at ~1500 m elevation). The resulting imagery (Figure 2) and derived indices such as NDVI are being used to detect hydrophilic root-mat producing vegetation species such as *Carex utriculata* and *C. nebrascensis* as well as channel development.

Results so far demonstrate the capabilities of this system for mapping species, moisture stress, and channels; a return to the meadows in spring and summer 2018 should allow us to look at the effects of recent restoration in one meadow (Loney) as well as seasonal patterns of growth and senescence in all meadows. Planned deployment in southern California should be very useful for modeling the environmental benefits contributed by trees, shrubs, and lawns to individual houses in terms of shade, cooling effect, and energy reduction. The multi-spectral capability of the system make it a perfect choice for mapping and monitoring meadows as well as urban vegetation to very fine scales.

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# REFERENCES

Castellvi F, Oliphant AJ (2017). Daytime sensible and latent heat flux estimates for a mountain meadow using in-situ slow-response measurements. *Agricultural and Forest Meteorology* 236, 15 April 2017, pp 135-144.

Christian P (2015). "Using low cost UAS and consumer grade cameras for environmental science research." Thesis, MS Geographic Information Science, San Francisco State University.

Christian P, Davis JD (2016). Hillslope gully photogeomorphology using structure-from-motion. *Z. Geomorphologie* 60, Suppl. 3, 059-078.

Horler, D. N. H., Dockray, M., & Barber, J. (1983). The red edge of plant leaf reflectance. *International Journal of Remote Sensing*, 4(2), 273-288. doi: 10.1080/01431168308948546

Loheide, S. P., Deitchman, R. S., Cooper, D. J., Wolf, E. C., Hammersmark, C. T., & Lundquist, J. D. (2009). A framework for understanding the hydroecology of impacted wet meadows in the Sierra Nevada and Cascade Ranges, California, USA. *Hydrogeology Journal*, 17(1), 229-246. doi: 10.1007/s10040-008-0380-4

Slocombe M, Davis JD (2014). Morphology of small, discontinuous montane meadow streams in the Sierra Nevada. *Geomorphology* 209: 103-113.

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# San Marcos



**Figure 1:** Study site overview map. Places Cyprus within the context of the Mediterranean and highlights study sites with reference to larger, populated areas, geographical features mentioned in the text, and the island's elevational gradient.

# Regeneration of Cypriot Native Plants following Agricultural Abandonment

bandonment of agrarian lands and lifeways reflect socio-economic factors and land management policies that contribute to the modernization and concentration of agriculture in highly productive areas, and drive rural-to-urban population movements. The resulting effects of land abandonment often vary regionally according to weather patterns, soil conditions, and socio-economic factors. On Cyprus, specific traditional land-use practices included silviculture, controlled burning, agriculture, grazing, and browsing. Contrary to general land abandonment patterns of the Mediterranean, the 1974 partition of the island resulted in the relocation of approximately one-third of its inhabitants, and quickly shifted the economy of the Republic of Cyprus from agropastoralism to light manufacturing and services.

Six villages (study sites) were selected randomly from villages that experienced population declines between 1960 and 2001, with ranges in elevation from approximately 70 to 1275 meters, and stretching around the western edge the Troodos Range (Figure 1). Site visits occurred during October and November 2009. Two plots were established per site and within each plot three 50-meter transects were placed 10 meters apart. Transects were established perpendicular to the transition zone between agricultural lands and the adjacent shrub or forested lands and centered between the two vegetation zones where delineation between the zones was detectable.

Small sub-shrubs such as *Sarcopoterium spinosum* and *Thymus capitatus* are important components of Mediterranean shrub lands, especially in Cyprus. Thus point-intercept and belt transects were utilized to assess the condition of the current vegetation. Point-intercept data were collected along all three transects while belt transects data were collected along the center transect only (Figure 2). For each transect all plant

species and the bottom layer type (e.g., soil, litter, rock) were recorded at 50 points, spaced 1 m apart. For belt transects, size classes were established prior to sampling (0-25 cm; >25-50 cm; >50 cm-1 m; >1 m) and each sub-shrub, shrub, or tree species with at least one-half of its base within 1 m of the centerline was counted.

Aerial images (1:10000 to 1:12000) for the years 1963, 1993, and 2008 were geo-referenced using eight to fifteen ground control points, registered to the 2008 image, and study sites were digitized onto the imagery, thus allowing for the collection similar parameters from the imagery as were collected in the field. All images were resampled to a common pixel resolution of 20 cm to capture ecologically important sub-shrubs and encroaching, immature shrubs and tree species.

Overall, native shrubs and trees are repopulating abandoned agricultural areas, with minor integration of introduced species. These results supplement previous Landsat-based characterizations that demonstrated a transition from agricultural land cover to shrub lands or forest, but are unable to distinguish between species. Further investigation is necessary to reveal whether the regeneration of native species actually simplifies the Cypriot landscape and reduces biological and cultural landscape diversity that is associated with traditional agricultural systems.

# REFERENCES

Department of Lands and Surveys, Republic of Cyprus

sensu Lansanta-Martinez, T., S.M. Vicente-Serrano, and J.M. Cuadrat-Prats. 2005. Mountain Mediterranean landscape evolution caused by the abandonment of traditional primary activities: a study of the Spanish Central Pyrenees. *Applied Geography* 25:47-65; Munroe, N.T., J. Fischer, J. Wood, and D.B. Lindenmayer. 2008. Revegetation in agricultural areas: the development of structural complexity and floristic diversity. *Ecological Applications* 19(5):1197-1210.

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**Figure 2:** Example of 1968 and 2008 aerial images used to determine changes in extent, percent cover, and type of vegetation. The 2008 image illustrates the three 50-meter transects used in the point and belt surveys at each study site.

