TRAINING THE NEXT GENERATION OF REMOTE SENSING SCIENTISTS THROUGH UNDERGRADUATE RESEARCH OPPORTUNITIES

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ABSTRACT

From cloud computing to no-cost Landsat data and low-cost data collected from Unmanned Aircraft Systems, remote sensing technology is changing faster than ever before at a time when the need for a highly trained and adaptive geospatial workforce is perhaps greater than ever. In this session, StateView panelists from AmericaView, a nationwide consortium dedicated to remote sensing research, outreach, and education, will share their successes in building the remote sensing workforce of tomorrow through a network of undergraduate research opportunities. StateViews may focus research on state-specific issues important to local and regional stakeholders, such as urban expansion, coastal studies, forestry, agriculture, or grazing; international research applications are also available. Presenters will share lessons learned as well as valuable insights about recruiting, training, and mentoring undergraduate students on data processing, information extraction, and presentation skills. This will be followed by a Q&A and discussion session.

KEYWORDS: Workforce development; UAS; Landsat 8; Resource Management; Environmental Change

INTRODUCTION

Geospatial technology is recognized as one of the high growth industries by the US Department of Labor (USDOL 2016). According to the US Geological Survey (USGS) and the US Bureau of Labor Statistics, increasing demand for accurate, and up-to-date geographic data coupled with the availability of technology has resulted in high demand for geospatial technicians and analysts with basic/entry- to advanced-level skills. Hence there is a need to train the future workforce in this field and create a pipeline of skilled workers to fill the growing demand in this arena.

Since 2002, AmericaView, through its StateView members, has been training undergraduate and graduate students in the applications of remotely sensed imagery, an important component of geospatial technology (Landenberger et al. 2011). Availability of no-cost multispectral Landsat (source: USGS), Sentinel 2-B (source: European Space Agency), and ResourceSat -2 (source: Indian Remote Sensing through USGS for North America) data has opened numerous opportunities for Earth Observation (EO) applications in the US and elsewhere.

The academic community in each StateView has incorporated these valuable images in their classroom and use them for training the next generation of geospatial analysts and technicians (Sivanpillai and Congalton, 2016). Students from various STEM disciplines have taken advantage of this opportunity available through the StateViews. This paper describes the methods used by five StateViews (Indiana, North Carolina, Texas, Vermont, and Wyoming) for training the next generation of geospatial experts. These activities represent only a part of the entire AmericaView effort in creating a network of research opportunities for undergraduate students; other examples can be found on the organization's website (www.americaview.org).

AMERICAVIEW

AmericaView is a "nationally coordinated network of remote sensing scientists and practitioners who work with the USGS Land Remote Sensing program (Landenberger et al. 2011)." AmericaView operates as StateView consortia in 41 states (GeorgiaView, TexasView for example) that are highlighted in blue below (Fig. 1).

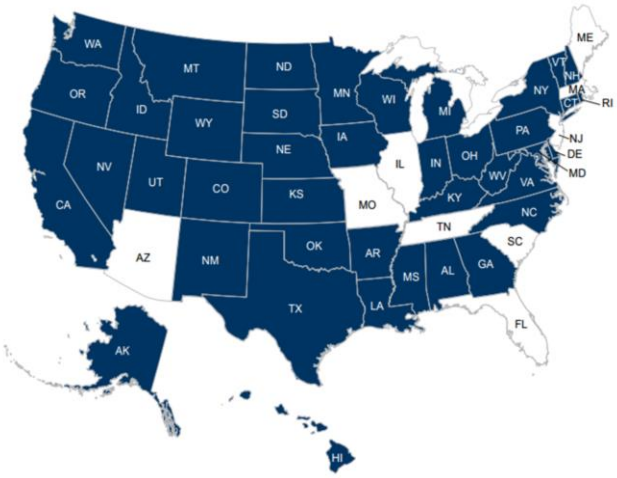

Figure 1. StateViews that are part of AmericaView, a nationwide consortium that works to promote remote sensing science and applications in the US. (Figure credit: AmericaView).

An academic institution, in partnership with other academic institutions, state, local and federal government agencies, non-profit organizations, leads each StateView and private sector companies in that state are part of the StateView consortium. Each StateView has the flexibility to organize its consortium and activities based on the needs and priorities of their state. StateViews have worked with government agencies and researchers in academia to apply geospatial imagery and allied technology such as GIS and GPS, to address natural resource management issues and disaster response activities (Dodge and Congalton, 2013). More information about AmericaView activities in education and outreach, applied research, and data distribution can be found in the organization's website (www.americaview.org).

TRAINING METHODS

StateViews use various approaches for recruiting and training undergraduate students in their state, and they can be grouped into two broad categories: internships and mini-grants. Through internships, students work with the StateView Principal Investigator (PI) in his/her laboratory. Some of these student interns would have enrolled in a remote sensing course taught by the PI while the rest could have been recommended by other faculty members in the StateView institutions. Mini-grants are often offered to student interns to work with Co-PI and other faculty members across the StateView institutions. These training programs could range from few weeks (e.g., disaster mapping) to semester-long activities StateViews also train the undergraduate students to present their findings in local, regional and national meetings and conferences.

Internships

Undergraduate interns work in the StateView PI's laboratory in an ongoing project or on a topic of mutual interest discussed and finalized with the PI. Interns receive training in defining project goals and objectives, obtaining image and ancillary data from appropriate sources, extracting information from imagery, and conducting QA/QC through accuracy assessment or comparing the derived products to ancillary data. StateView PIs have used this model to generate land cover change maps following events such as flooding, wildfires, etc. We highlight four examples below.

Post-flood mapping in North Carolina. Following the devastation left behind by Hurricane Matthew in eastern North Carolina (2016), the StateView PI recruited two undergraduate students who expressed interest in generating post-flood maps. PI and student interns discussed the project goals and developed a work plan. In this project they decided to assess the differences between the two flood events (Hurricanes Floyd and Matthew), and how the lessons learned from the 1999 flood (Floyd) influenced the state's preparedness ahead of the 2016 flood (Matthew).

Interns downloaded Landsat 7 and 8 data from USGS EarthExplorer and high resolution digital aerial images from the US Department of Agriculture (USDA) for interpreting land use and land cover types in the study area. Images and ancillary data were analyzed using ERDAS Imagine and ESRI ArcMap. They obtained *in situ* water and flood water data measured by gauging stations along the Tar River near Greenville, NC.

Data acquisition and processing through Unmanned Aerial Systems (UAS). VermontView recruits and trains between 15 and 30 undergraduate interns every semester. These interns work with full-time University of Vermont research staff member and a team leader who is a senior intern. During their tenure, students are exposed to a wide variety of remotely sensed datasets and projects that are scattered throughout the United States. The students work on small and large teams with other student employees, staff, and faculty. Technical know-how is only part of the job. While working in a fast-paced, team-centric environment, the students have to master skills of communication, teamwork, and budgeting. Standard operating procedures guide much of the work and the student employees help to revise and refine these procedures over the course of their employment. Students and mentors also engage in outreach to the public (Fig. 2).

Figure 2: Undergraduate students with VermontView PI Jarlath O'Neil-Dunne conducting a UAS demo for farmers at "Crop and Field Day."

Watching over Texas from Space. The TexasView PI trained an undergraduate student in selecting appropriate local data that K-12 teachers can use in their classroom to meet the State's Science Standards. Numerous K-12 teachers are interested in incorporating satellite and aerial images in their classroom to increase student involvement and address standards related to landforms. However, most teachers lack necessary resources to download and process images from various sources such as USGS, NASA, and ESA. Working with teachers, the TexasView PI and the intern were able to demonstrate different landforms and environmental hazards such as drought and floods. Several K-12 teachers participated in a workshop conducted by TexasView PI where they learned to access, use these images in their classrooms, and developed lesson plans incorporating these images (Fig. 3).

Figure 3: K-12 teachers in Texas are developing lesson plans around state standards-based outreach materials using the images downloaded and processed by a TexasView undergraduate intern.

Mapping burn severity in cooperation with federal agency. The WyomingView PI trained a student intern to generate a burn severity map (Fig. 3) from pre- and post-fire Landsat 8 data. The US Bureau of Land Management (BLM) Field Office provided both fire perimeter, and burn severity point/photo data following the *Ferris Mountain Prescribed Fire*. The intern learned to derive Normalized Burn Ratio (NBR) layers from Landsat data and combine them with the field data to generate a burn severity map of the study area (Figure 4). At the end of this project, the burn severity map was sent to BLM Field Office.

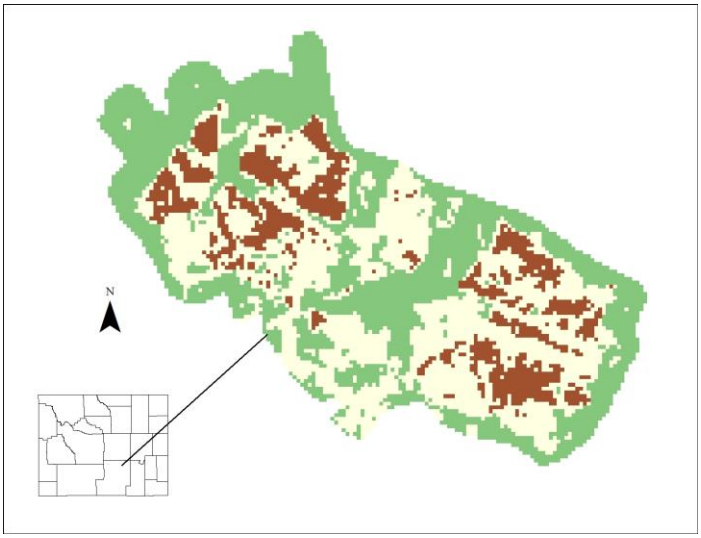

Figure 4: Burn-severity map derived from the Landsat 8 image acquired on June 20, 2013. Brown and light yellow colors represent medium- and low-burn areas, respectively, whereas green represents no-burn areas.

Mini-grants

StateViews solicit proposals from undergraduate (and graduate) students interested in conducting geospatial projects to address a natural resource or any problem involving the use of satellite or aerial images. Student interns have to identify a project mentor, usually a faculty member in any StateView institution, and submit a proposal describing the work plan. Depending on the available resources and the quality of the proposed work, mini-grants are awarded to the student interns. This mode of funding is often used for training students in other member institutions within the state and we highlight two such examples below.

Estimating tree canopy change in Indiana University. IndianaView awarded a mini-grant to an undergraduate student to map changes in tree canopy in the Bloomington campus. Using high resolution aerial images acquired in 2008 and 2012 the intern generated land cover maps and analyzed changes in tree cover (Figure 5). Findings from this study highlighted areas of the campus that witnessed decline of tree cover.

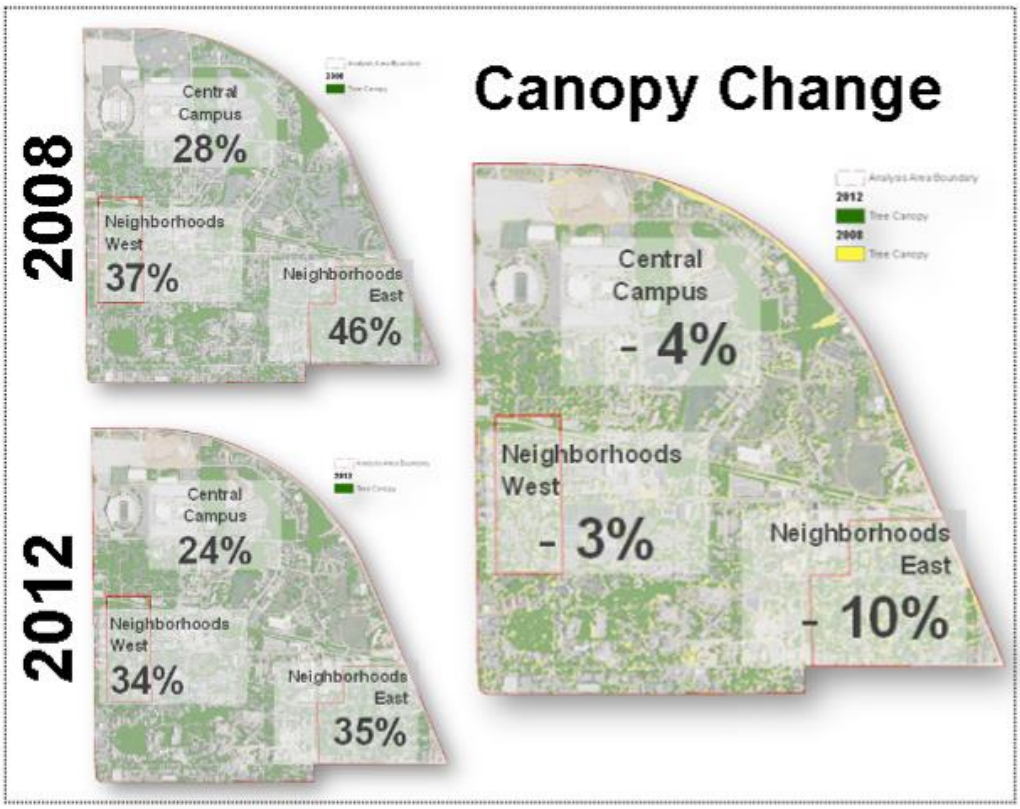

Figure 5: Tree canopy cover in Indiana University – Bloomington Campus was mapped using high resolution aerial images acquired in 2008 and 2012. Comparison of these images revealed that tree cover declined in all three sections of the campus. (Figure courtesy of: Burney Fischer and Shannon Lea Watkins, Indiana University)

Mapping thirty years of urban core expansion in Dallas Fort-Worth metroplex. An undergraduate student intern worked with Dr. Jennifer Jensen at Texas State University and mapped the expansion of Dallas Fort-Worth over a 20-year period using Landsat 5, 7, and 8 imagery. The study applied supervised classification in ERDAS Imagine, using the Multi-/Resolution Land Characteristics (MRLC) classification scheme. Post-classification change detection provided a series of land cover change "to" and "from" maps (Fig. 6) at five-year intervals and a summary report of class change statistics.

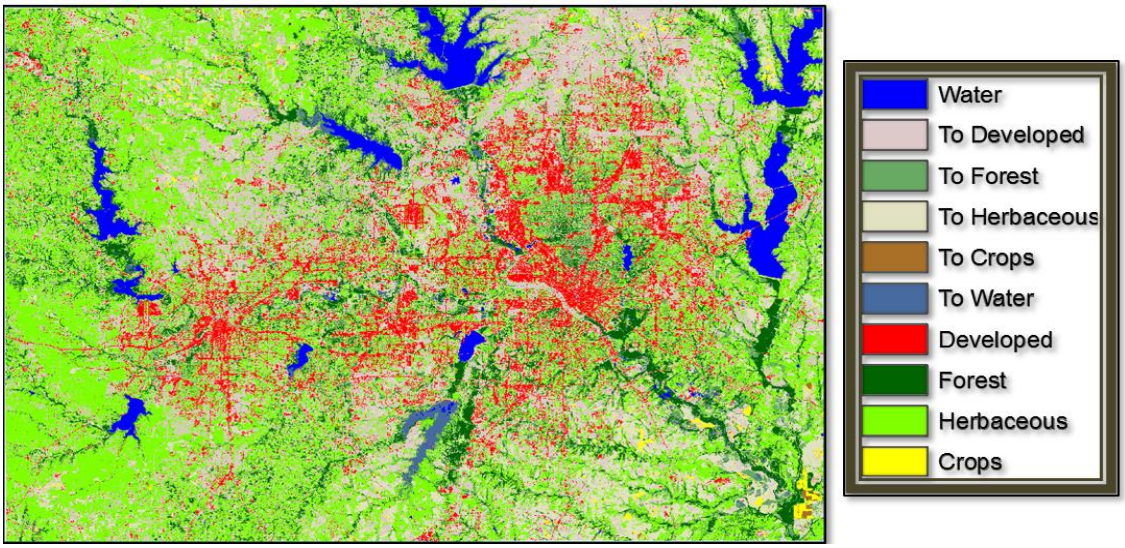

Figure 6. Landcover change in the Dallas-Fort Worth Metroplex, as interpreted by intern Andi Hollier. Focus on the deep red and light pink colors to see the advance in urban growth in the past 30 years.

BENEFITS

Examples mentioned in the preceding section highlight the many benefits of the training program. Other StateViews have similar training programs for recruiting and training the future force. First, student interns are able to gain additional image and data processing skills by working on these projects that cannot be gained from merely completing the course work. Second, interns learn presentation skills by reporting their findings in local and regional meetings. Finally, mentors can incorporate the findings from these projects in their coursework or research.

Interns

Working directly with their mentors, interns learn to work with various stages of a remote sensing project, starting from project planning to assessing the quality of maps derived from the images. Interns also get to interact with students with different academic backgrounds. At University of Vermont, interns work with other students who are majoring in civil engineering, environmental science, geography, forestry, wildlife biology, neuroscience, economics, and linguists. This unique collection of majors replicates the interdisciplinary work environment that our students will face when they leave the collegiate environment.

In most projects, the interns had an opportunity to consult or work with the users of the derived products. For example, the TexasView intern worked with K-12 teachers and developed educational materials using the images. She commented that the skills gained from this training further developed her "*ability to identify objects and environmental conditions through the use of satellite imagery. These skills will help me in my pursuit of a GIS certificate and in my future career goals of habitat restoration and conservation*." Another TexasView intern who worked with a faculty mentor in Texas State University stated that the "*project was a great opportunity to learn and practice remote sensing skills as well as gain valuable experience that will support a future career using remote sensing techniques. Shortly after completion of this project I was hired as an Image Data Scientist at Johnson Space Center*." WyomingView interns had the opportunity to present their work in multiple venues, and to interact with interns from other StateViews (Fig. 7).

Figure 7: WyomingView intern, Ryan Lermon (left) and North CarolinaView intern, Stephanie Moffitt (right) presenting their research findings in the Wyoming Undergraduate Research Day and Research and Creative Achievement Week respectively.

One WyomingView intern described the benefits of the internship as follows: "*the opportunity to work with more remote sensing data after I took the class last semester was exciting. I learned how to use ERDAS more efficiently and a few short cuts that I didn't know of from my first experiences with the program. I am glad to have had the chance to work with many different types of projects (water, fire, forest, etc.). I am interested to see what remote sensing experiences I will have in the future*." Another WyomingView intern commented "*I applied skills that I learned in the classroom to a real life project analyzing agricultural fields that I manage as a ranch-hand. During my research I gained a greater understanding of how Landsat imagery can be used to monitor healthy vegetation. I believe this internship has helped me become more confident in gathering data from remote sensing imagery, conducting an analysis to produce results, and drawing sound conclusions from my research*." Testimonials provided by the rest of the WyomingView interns can be found at http://wyomingview.blogspot.com/p/interns.html.

An IndianaView intern commented: *"Thank you so much for this scholarship and allowing me to have this wonderful opportunity! It sparked my interest about remote sensing. I attended the Kentucky GIS Conference last week, and I learned so much about mapping and remote sensing."* Almost all VermontView interns have been hired on by leading geospatial companies such as Google, Mapbox, and Planet. Others are working for engineering consulting firms or government agencies. Almost all past VermontView interns credit the UM Spatial Analysis Lab for helping them secure their first job or posting in graduate school.

Presentations meetings and conferences

Several StateViews train their interns to present their findings in local, regional and national meetings and conferences. For example, two North CarolinaView interns presented their research findings at the 2017 Research and Creative Achievement Week at East Carolina University. More than 50 WyomingView interns have presented their findings in the annual Wyoming Undergraduate Research Day event. One of the TexasView mentors commented that they "*learned how to improve our public speaking skills by creating multiple PowerPoint presentations and a final poster to present to an audience in Environmental Science, Forestry, Landscape Ecology and Spatial Science in the Arthur Temple College of Forestry and Agriculture*." Learning communication skills is required for students as part of their academic career, in addition to earning good grades in their classes. Presenting the findings from their own project work is one of the effective ways for the students to gain this valuable skill.

MultiSpec image processing software

Geospatial software used by the interns to complete their research might not be available in all academic institutions. MultiSpec (Multispectral Image Data Analysis System), a no-cost image processing software application, is used for training students in remote sensing applications at many colleges and universities. This no-cost software and documentation are available from https://engineering.purdue.edu/~biehl/MultiSpec/.

The PI for IndianaView at Purdue University has been involved in the development of this freeware image processing tool. MultiSpec has been used by undergraduates in classroom and online courses by many universities and small colleges both within the U.S. and in other parts of the world. MultiSpec includes basic functions for image display, unsupervised and supervised classification, feature extraction, feature enhancement, principal components, data file reformatting and several others for analyzing multispectral and hyperspectral remote sensing data in several different file formats.

Several tutorials are available for MultiSpec to help students and users learn image analysis procedures. MultiSpec has also been used in K-12 classes for which one example is the GLOBE program (www.globe.gov) and in outreach material such as that provided by the USGS (Table 1). Recently MultiSpec Online was used in a geospatial data session with 30-35 middle school students at the Turned Onto Technology and Leadership (TOTAL) Camp in the summers of 2016 and 2017 at Purdue University. The students worked on a flood mapping exercise using Landsat 5 data to learn about land remote sensing using supervised classification techniques.

Several AmericaView states use MultiSpec in their classrooms and have developed laboratory exercises on remote sensing science and applications. These instructional materials, and related resources can be accessed from the web sources listed in Table 1.

Table 1: MultiSpec tutorials are available from agencies and program through their websites.

General	
Intro to advanced levels	https://engineering.purdue.edu/~biehl/MultiSpec/tutorials.html
K-12 level exercises	
Viewing imagery with MultiSpec	https://americaview.org/program-areas/education/land-cover-lessons/
Flood analysis with imagery	https://americaview.org/program-areas/education/land-cover-lessons/ https://eros.usgs.gov/educational-activities
Urban Growth	https://eros.usgs.gov/educational-activities
Land cover classification	https://www.globe.gov/do-globe/globe-teachers-guide/biosphere

MultiSpec is not meant to replace the capabilities in the commercially available remote sensing packages but is to be used as a freeware solution for students to easily use on their own computers for augmenting the commercial packages and to learn the basics for handling remote sensing data. Originally developed for Macintosh and Windows desktop computers, MultiSpec has recently been adapted to run in the HUBzero collaboration platform so that it can be used within a web browser, allowing new user communities to be engaged through science gateways. MultiSpec Online (http://mygeohub.org/resources/multispec) provides teachers with another way to use MultiSpec without having to install the desktop tool.

CONCLUSION

Undergraduate research and internship opportunities provided by StateViews are an effective way to train the future workforce to meet the demand in the growing area of geospatial technology. Students graduating from these programs have gained valuable image and data processing skills that have resulted in a competitive advantage while seeking employment.

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