Service-Learning and Participation in a Capstone Spatial Science Course

David Kulhavy
Daniel Unger

Introduction

In this paper we demonstrate how PPGIS is used in spatial science by incorporating both service-learning and reflection within the Arthur Temple College of Forestry and Agriculture (ATCOFA) at Stephen F. Austin State University (SFASU). PPGIS incorporates technical skills, participation and meeting with constituents to foster social change; which mirrors a component of ATCOFA's mission statement. Schlossberg and Wyss (2007) used PPGIS and reflection in a community-based project developing a neighborhood service-learning project providing guidance on their integration within a teaching environment. They used student reflections to provide an overview of the process and to garner information on student outcomes after completion of the project. Their findings concluded that classroom-based PPGIS provided a positive learning environment; stressed the need for more community participation in the planning process; and that the timeframe of the projects was restricted by the 15 week course time. In developing a strategy for teaching a capstone spatial science course, a working knowledge of geographic information systems (GIS) is essential for ease of data entry, queries of a spatial database and preparation of a product suitable for the community user. The breath of the use of GIS is only limited by access to the user group and the compatibility of the data.

PPGIS is often considered "GIS in practice" (Sheppard, 1995). The use of PPGIS in service-learning works well in urban planning, landscape ecology and natural resources developing collaborative planning processes and disseminating spatial science information. In decision making

Abstract

Six undergraduate research projects were identified in a capstone spatial science course to demonstrate service-learning and reflection within a natural resource curriculum. Students met with state and national organizations and formulated plans for a Firewise certification program for a university; developed an historical trail encompassing cultural data into a spatial science database; assessed the geometric accuracy of the standard image bundle for DigitalGlobe's QuickBird multispectral imagery; developed a litter abatement program on a university campus; assessed the critical habitat of *Hibiscus dasycalyx*, the Neches River rose mallow, as a candidate for threatened species listing; and, assessed the utility of estimating the height of baldcypress trees, *Taxodium distichum*, from a distance using remotely sensed imagery. A Public Participation Geographic Information System (PPGIS) approach was used to incorporate service-learning into the course. Reflection was included as a critical component for students to evaluate their efforts during and at the conclusion of the projects. Results indicate that a combination of PPGIS and reflection produce a more inclusive spatial science product, heightens a student's experience, and produces a well-rounded society-ready spatial scientist.

using spatial science, local knowledge incorporation, spatial data analysis and the context of the spatial information leads to interactions of individuals and groups (Sieber, 2006). Brown (2012) reviewed PPGIS for regional and environmental planning developing a composite of attributes used in studies. Schlossberg and Shuford (2005) define PPGIS participants as stakeholders that bring knowledge or information to influence decisions.

The use of PPGIS within ATCOFA was adapted to an undergraduate senior level capstone course in spatial science. At the beginning of the course students were asked their knowledge of spatial science in the community or university and to outline a potential project. Students were adept at ArcGIS 10.1 (industry leading spatial science software emphasizing vector data; ESRI, Redlands, California) and ERDAS Imagine 10.1 (industry leading spatial science software emphasizing raster data; Intergraph, Norcross, Georgia). Once potential projects were chosen students entered into facilitated group discussions over potential skill building experience; shared skills and interacting with the community; and the value of a public-participation. Students were introduced to service-learning skills and the value of reflection as part of the capstone course.

Courses in spatial science lend themselves to service-learning and experiential educational opportunities and have historically incorporated aerial photographs, remotely sensed digital imagery via an aerial or satellite platform, GIS and global positioning systems (GPS) data. The capstone course in spatial science at ATCOFA combines strategic planning with stakeholders to achieve a result that is useful for the clients. The incorporation of PPGIS enhanced the learning experience by connecting students in the classroom with stakeholders for implementation of spatial science projects into land management decision making. The methods of Schlossberg and Wyss (2007) for incorporation of service-learning and reflection of interactions coupled with the concepts of Laituri (2003) for assessment of PPGIS case studies were utilized. Reflection of the activities chosen was an integral part of the course and increased the interaction of the students and the stakeholders. PPGIS links students and organizations to collect, analyze and interpret digital information and spatial data (Niles & Hanson, 2001). The components of Context, Connectivity, Capability and Content were utilized to evaluate the purpose, stakeholders, linkages, analysis, policies, infrastructure, computer literacy and data types and availability as the projects developed (Laituri, 2003).

Service-learning

To prepare the students for the PPGIS concept, service-learning was implemented and has the potential to reflect on and hone leadership skills through group dynamics and expert opinion (Newman, Bruyere, & Beh, 2007). Service-learning is course-based, meets identified community needs and provides reflection on the service to enhance course content and also personal values (Bringle, Hatcher, & McIntosh, 2006). Service-learning has three primary components: address a compelling issue; apply skills in an academic setting; and use purposeful reflection for student understanding for context in society. These components were used in the course as each project needed to solve (or try to solve) a compelling issue; needed to apply spatial science skills in an academic setting; and take time for meaningful reflection for the context of the course at SFASU, the community and the region. To further assess these skills, a poster, PowerPoint presentation and final manuscript were prepared for the stakeholders.

Reflection

To fulfill incorporating reflection in spatial science, students gained critical thinking skills in both practical and theoretical environments. Reflection for service-learning in spatial science needs to be continuous, connected, challenging, in context and an integral part of the learning process (Kolb, 1984; Hatcher & Bringle, 1997; Eyler, 2002; Hatcher, 2011). As spatial science depends on one step or activity leading to another, monitoring of the process is important in the decision making process. The main common denominator in the projects was the use of ArcGIS 10.1 to create a digital working environment that was continuously modified. Essential to the success of the projects was construction of an attribute table that could be queried for decision making.

One way to strengthen the service-learning process is to engage in effective and rigorous reflection (Eyler & Giles, 1999; Eyler, 2002). Using reflection in service-learning moves students from lower order thinking skills (identify, describe, apply) to higher-order thinking skills (analyze, synthesize, evaluate) based on Bloom’s Taxonomy of Educational Objectives. Early class periods were used to identify, describe and apply GIS skills to create a spatial database. Analysis, synthesis and evaluation were used to implement the findings. Prompting of questions using the rubric proposed by Ash, Clayton, and Atkinson (2005) included identifying and describing academic concepts that related to service-learning; application of the service-learning concept; analyzing and synthesizing the academic material in the context of experiences in learning. Evaluation of the material presented provides benefits for future learning. As spatial science requires an iterative process to complete tasks, the reflection portion provides a method to evaluate progress from the descriptive phase to the analytical phase. The hands-on approach to spatial science analysis lends itself to the overall functions of service-learning including critical reflection as a component that generates and deepens learning and reinforces higher order reasoning and critical thinking (Ash et al., 2005, Ash & Clayton, 2009).

Essential to effective service-learning is that the learning and service goals are integrated; experiences in the classroom and community are aligned with reflection activities and assessment; collaborative is evident; the pedagogy is flexible for capacity building for the participants (Felton & Clayton, 2011). The connection of the learning processes and outcomes makes service-learning for spatial science effective for learning and completing products but is challenging to implement in teaching (Felton & Clayton, 2011). University-community partnerships are imperative in developing service-learning opportunities for spatial science. Leitner, Elwood, Sheppard, McMaster, and McMaster (2000) categorized six models for delivery for community partnerships in spatial science including in-house GIS; university-community partnerships; publicly accessible GIS; map rooms; internet; and community GIS centers. The stakeholder-community relationship combined with communication and location of GIS set the framework for responsiveness to the needs of the stakeholders (Leitner et al., 2000).

In natural resource courses, students often work outdoors and evaluate data using spatial science. The learning approach that includes experiential learning components of active training for individuals to make learning and adaptive management are important skill sets in experiential learning in natural resources (Newman et al., 2007). GIS links technologies examining both the physical landscape and the human interactions with the landscape. The use of GIS for a particular community or locality can be used for problem solving (Laituri, 2003).

Using the concepts of Laituri (2003) these components were used to implement service-learning and provide an experiential learning environment. First is Context including purpose of the project or issue and does the problem consist of singular or multiple issues. What are the day-to-day decisions needed to arrive at a strategic outcome for both short-term and long-term gain? Second, are stakeholders represented and what are the partnerships being developed? Third are linkages with the partners as single or multiple agencies and development of professional backgrounds. Fourth is the unit of analysis, usually local or regional in our context. For Connectivity, the technology infrastructure and funding is identified across policies for facility use; and infrastructure of the GIS systems. The identification of an urban or rural setting is determined. Capabilities include the level of spatial science knowledge of the learner. For Content, data availability and information needed including public data often available at no cost; addition of new data collected; and qualitative or quantitative analysis of data. Schlossberg and Wyss (2007) suggest that a PPGIS course acts as a resource for service-learning and to take the project out of normal course requirements. They recommend developing an ongoing PPGIS laboratory to train and engage students in community projects independent of coursework.

Using these concepts, service-learning is implemented to fashion either user-requested products or GIS concepts developed for the local or regional community. Once projects are completed, an assessment is made of Context, Stakeholders, Linkages and Unit of Analysis following Laituri (2003). The inclusion of reflection in the process enhances the implementation and usefulness of the projects and provides continuity from one project to the next. Reflection gives students opportunities to include thoughts, feelings and subjective experience into courses (Molee, Henry, Sessa, & McKinney-Prupis, 2010). Service-learning is an effective pedagogy to link learning with addressing of society (Molee et al., 2010) and in natural resources service-learning promotes the context of the environment to promote learning and development (Easton & Monroe, 2009). In training natural resource professionals, learning and adaptive management need to become part of the approach to problem solving (Newman et al., 2007). By integrating adaptive management on a personal level, these individuals may be more successful in professional management needing these skills.

By incorporating community-based research early in the course, the students could meet with university (or community) members to participate in the project (Checkoway, 1997; Schlossberg & Wyss, 2007). The points are made to connect university knowledge in a way that is understandable to the local community. Incorporating service-learning enhances the experience by improving communications with stakeholders, increases the access to GIS knowledge and builds university-community partnerships (Checkoway, 1997; Schlossberg & Wyss, 2007). The benefits of the partnerships are that university often bears costs of software, hardware and data.

Community partners often do not have the GIS data sets, so university partners are important in supplying the data (Leitner et al., 2000). As Obermeyer (1998) states, students use a variety of approaches of GIS and spatial science tools to complete a project while keeping the stakeholders informed and appraised of decisions.

Context includes the type of technology and the setting for the PPGIS. These are developed in the context of service-learning to solve an issue or a problem. Within service-learning students: learn and develop with active participation in organized service experiences that meet community needs; are integrated into the curriculum for structured student time to think and interact; are provided opportunities to use newly acquired skills and knowledge with community participation; and extend their education outside the classroom into the community to foster relationships (Schlossberg & Wyss, 2007). The stakeholders work together with the participants and agencies. Reflection is an important part of the interaction as multiple feedback is required as an integrative process. This process provides focus as the project is defined and changes are made. The unit of analysis begins as a local project and expands as the details of the projects demands this. Linkages to agencies include university, community and regional cooperation. Context of the PPGIS projects includes contact with stakeholders and linkages to participants and agencies (Laituri, 2003).

Components

Components of the course included six projects (Table 1) developed to implement the PPGIS method while developing partnerships. The projects ranged from implementation of a national Firewise project at a university; adding cultural and social data to an historic trail within a GIS database; establishing GIS control points to evaluate the geometric accuracy of DigitalGlobe's QuickBird standard image bundle; using ArcGIS 10.1 to create a litter abatement project for a university campus; developing a digital photomosaic obtained from GoProHero3 images while using Python code to automate the mosaic process; and using remotely sensed data to evaluate and visually display baldcypress tree characteristics for streamside stabilization.

To assess the projects, they were defined in context of Simple to Complex with single or multiple issues with decisions made on a day-to-day basis or long-term strategic outcomes. Stakeholders are those that assisting in the decision-making of the projects and how involved they are in the partnerships and linkages as either single or multiple agencies. Trust refers to the relationship of the participants based on background and experience. Most of these projects were local with regional implications. For Content, preexisting spatial data was available for four of the six projects for spatial data.

For the Firewise project (Tables 2 & 3), students installed fuel load plots in the SFASU university forested area and entered data into the ATCOFA ArcGIS 10.1 GIS database. At this time reflection on the project included evaluation of components of the study and how each of those affected the outcome. Following this, students contacted the coordinator of the National Wildfire Working Group, Wildfire Urban Interface Team (WUI) for a fuel reduction plan. The Texas A&M Forest Service state coordinator for WUI visited the students at the university and recommended a plan for fuel reduction. This plan was approved and implemented and the students applied for Firewise designation with SFASU becoming the first Firewise university in the United States. Students received recognition from the SFASU Board of Regents. Further reflection led to poster development and presentations at national forestry conferences.

Table 1. Spatial science projects developed through service-learning.

Project	Outcome
Firewise Communities/ USA® Recognition Program	SFASU was the first university to implement the Firewise program. An integrative process was used to identify community, install fuel measurement plots, construct an ArcGIS 10.1 GIS data set and set up queries to determine fuel load concentrations. Agency personnel were contacted and fuel loads were reduced; recognition was achieved by the Board of Regents at SFASU and the Firewise Communities program.
Ghost Trail Historic Trail Development	A 16 km trail was constructed in Nacogdoches, Texas incorporating historical data and constructing a data file in ArcGIS 10.1 to query the data for context of the information. A workbook was produced incorporating GIS locations and historic trail information and locations.
Accuracy Assessment of QuickBird Imagery	The geometric accuracy of QuickBird imagery was assessed by comparing established GPS control points in Nacogdoches, Texas with coincident raster pixels within the QuickBird image (Unger, Kulhavy, & Hung, 2013).
Litter Control	The campus of SFASU was divided into sections for groups to keep areas clean. A rating system was developed to assess litter with 0, no litter; 1, light litter; 2, moderate litter; 3 heavy litter; and 4 extreme litter. These ratings were added to an interactive ArcGIS 10.1 GIS database to update ratings. Groups were assigned to reduce litter. Digital images of litter were incorporated into the ArcGIS 10.1 GIS database and map product for use in litter clean up.
Neches River Rose Mallow Spatial Distribution	A GoProHero3 digital camera was used to create a mosaic of constructed garden plots. Data were mosaicked using Python code to rectify the images and create a digital map for query. The method was modified to evaluate distribution and location of the Neches river rose mallow, a species with limited distribution and incorporated into an ArcGIS 10.1 GIS database.
Baldcypress Evaluation	Pictometry® hyperspatial imagery was used to assess baldcypress tree height on a stream right-of-way (Unger, Kulhavy, Williams, Creech, & Hung, 2014b).

Data for the Firewise project was information rich including fuel load sampling database points, forest stand structure, GPS location of areas needed for fuel reduction and entry of data into an ArcGIS 10.1 GIS database for spatial queries of fuel reduction areas (Table 3). The context of the project was moderate in complexity combining fuel sampling and fuel reduction. Students established measurement plots for fuels based on Deeming, Burgan, and Cohen (1977), Reeves (1988), Reeves and Lenhart (1988) and Sikkink, Luter, and Keane (2009). Decisions and linkages were made weekly in consultation with stakeholders with the Texas A&M Forest Service, ATCOFA, the City of

Table 2. Context defining the complexity of the PPGIS projects identifying the stakeholders, agency linkages; and the unit of analysis (after Laituri, 2003).

	Components					
Case Study	Context: Purpose	Stakeholders		Linkages		Unit of Analysis
	Simple → Complex	Daily Decisions → Strategic → Outcomes	Marginal→ Mainstream → Elite	Single→ Multiple Agencies	No Trust → Trust	Local Regional Global
Firewise	▼	▼	▼	▼	▼	▼
Ghost Trail	▼	▼	▼	▼	▼	▼
Accuracy Assessment	▼	▼	▼	▼	▼	▼
Litter Abatement	▼	▼	▼	▼	▼	▼
Rose Mallow Assessment	▼	▼	▼	▼	▼	▼
Baldcypress Height	▼	▼	▼	▼	▼	▼

Nacogdoches, and the National Wildfire Working Group. Fuels were identified by ATCOFA students and the Student Association of Fire Ecology (SAFE) and removed by the Texas A&M Forest Service after consultation with ATCOFA and SFASU based on the Community Wildfire Protection Plan Guide (Texas A&M Forest Service, 2012). Students with SAFE presented the plan and the removal of fuels to the SFASU Board of Regents. The project was conducted on a local basis but can be expanded to a regional or national scale.

For the Ghost Trail (Tables 2 & 3), historical data were incorporated into ArcGIS 10.1 as part of a 16 km walking trail. Reflection on use of the trail resulted in participants completing the President's Challenge for physical fitness. Once the trail was developed, it was accepted into a national trail database. Data were incorporated as written documentation of cultural and social points of interest along the trail and a workbook was printed for use as an historic trail guide. Data were from public sources and primarily qualitative. New data included updates to the route of the trails and additional information at each location resulting in additions to an ArcGIS 10.1 GIS database and reprinting of the trails booklet (Table 3). Decision making was on a biweekly basis in consultation with the City of Nacogdoches, Texas and ATCOFA. The East Texas Research Center in the SFASU Steen Library was used as a reference for local historical information. A GPS map of the trail was local but the techniques for implementing historical data and an ArcGIS 10.1 GIS database can be expanded to other locations.

Table 3. Content for data availability and data types. Format, type and quality of data reflect location and how it is negotiated in cyberspace (after Laituri, 2003).

	Components			
Case Study	Content: Data Availability		Data types	
	Continuums			
	Information Rich → Information Poor	Public → Sensitive	New Data → Existing Data	Qualitative→ Quantitative
Firewise	▼————	▼————	——▼——	▼————
Ghost Trail	——▼——	———▼—	—▼———	▼————
Accuracy Assessment	▼————	—▼———	▼————	————▼
Litter Abatement	▼————	—▼———	——▼——	—▼———
Rose Mallow Assessment	————▼	————▼	▼————	————▼
Baldcypress Height	▼————	▼————	——▼——	————▼

An accuracy assessment (Tables 2 & 3) was developed for DigitalGlobe's QuickBird's multispectral image data of 2.44 by 2.44 meters spatial resolution encompassing the city of Nacogdoches, Texas. ERDAS Imagine 10.1 softwere was used to onscreen digitize 33 traffic line locations using a Trimble GPS Pathfinder® Pro XRS unit (Unger et al., 2013) (Table 2). To evaluate the geometric accuracy of the QuickBird data, the 33 individual traffic lines were compared to real-world Universal Transverse Mercator easting and northing coordinates of the 33 traffic line locations. Students found that QuickBird data were well within the stated positional error for a panchromatic and multispectral image bundle and can be used as a backdrop image to on-screen digitize GIS vector data (Unger et al., 2013).

For litter abatement (Tables 2 & 3), the SFASU campus was divided into segments based on litter accumulation on a scale of 0 (no litter) to 4 (excessive litter) and incorporated into an ArcGIS10.1 GIS database for cleanup. A university group was formed to assist in clean up and mapping. The project was selected by the Clinton Global Initiative for presentation as a method to galvanize groups and individuals in campus clean ups. The Don’t Mess with Texas program came to campus and celebrated the campus clean up. Presentations were made at EarthDay celebrations in Nacogdoches, Texas and with the SFASU gardens conservation education initiative. The project is continuing with target litter removal in less accessible areas of the campus forests and trails.

Hibiscus dasycalyx, the Neches River rose mallow (Tables 2 & 3), was recently added for consideration as a threatened or endangered plant (Federal Register, 2011). Its category for review was C, priority 2 for Texas. “We continue to find that listing this species is warranted but precluded as of the date of publication of this notice.” (Federal Register, 2011, p. 66421). *Hibiscus dasycalyx* is a high priority listing. In the Federal Register (2012, p. 55968), *Hibiscus dasycalyx* was listed as a threatened species under the Endangered Species Act of 1973, as amended. *Hibiscus dasycalyx* was under consideration since 1997. Under the listing, 76 ha of critical habitat were designated in Cherokee, Houston, Trinity, Harrison and Nacogdoches Counties, Texas. To investigate the distribution of the Neches River rose mallow after a 1995 planting in Nacogdoches County, two GPS waypoints identifying the location of *Hibiscus dasycalyx* were located and plants, stalks and flowers were counted at the end of the 2013 growing season. Plants were located by measuring to each plant from one of two known GPS points. The project was completed in consultation with the Piney Woods Native Plant Center (PNPC), SFASU and a private property tract. To locate flowers, a GoProHero3 camera was mounted on a pole at 3 m in height and images were taken of plants and flowers. The images were mosaicked using Python code to rectify the images and create a digital map for query. The method was modified to evaluate distribution and location of the Neches River rose mallow, a species with limited distribution and incorporated into an ArcGIS 10. 1 GIS database.

In 2013, ATCOFA partnered with the County of Nacogdoches 911 District, the City of Nacogdoches, and the Nacogdoches County Appraisal District to purchase 2013 Pictometry hyperspatial imagery. Working with these agencies and the PNPC, students calculated the height of 60 baldcypress trees on the SFASU campus in April and May of 2013. On-screen estimates of tree height using Pictometry data were compared to field-measured tree height. The mean actual tree height of 23.20 feet when compared to Pictometry estimated mean tree height of 23.29 feet had a linear regression of R^2= 0.999 (Unger et al., 2014b) indicated Pictometry estimated tree height is no different that field measured tree height. An additional 500 baldcypress tree heights were measured with Pictometry data as part of a stream corridor stabilization project with the PNPC. The project was reviewed with the Nacogdoches County Appraisal District partner. Once the baldcypress were located and measured, they were transferred to ArcGlobe for a visual assessment of the trees within a GIS interface. As a follow up project for height comparisons, students used a clinometer, a laser range finder, a telescopic height measuring pole and on-screen Pictometry measurements to estimate light pole height using multiple oblique angles within a web-based interface and found that Pictometry height estimates were significantly more accurate than both clinometer and laser range finder for height estimates (Unger, Hung, & Kulhavy, 2014a).

Conclusion

Reflection is an essential component of service-learning in PPGIS. Each group produced a poster and PowerPoint presentation for a professional conference and these were presented in local, regional and national meetings. Groups met with stakeholders to discuss their findings and how to continue to incorporate these in environmental settings. The addition of reflection as a formal requirement required students (and stakeholders) the time to analyze the projects and add additional goals as needed.

The production of the Ghost Trail project within an interactive ArcGIS 10.1 database allowed students the ability to update the project as monuments were relocated along the trail; or the trail was rerouted around construction areas. The production of the GIS database led to rapid changes in the trail map and the production of both an updated trail map and a revised booklet. Firewise produced a national product and SAFE is continuing to monitor the SFASU forest and work with the Texas A&M Forest Service, Wildland Urban Interface team to reduce fuel hazard. The accuracy assessment of DigitalGlobe's QuickBird imagery led to increased accuracy of ATCOFA images produced in both ERDAS Imagine and ArcGIS. Comparisons of land cover change over time were facilitated by the process. Litter abatement led to changes in times of litter pick up to early mornings to reduce liter accumulation. Student groups formed litter clean up teams and included work hours in the Presidents Volunteer award. Continual additions to the interactive ArcGIS database monitors litter and information is utilized to send student groups and other volunteers to targeted cleanup areas. Once these litter areas are cleared, the GIS database is updated. For the Neches River rose mallow, the ArcGIS and Pictometry databases can continue to be updated for each plant. Continued monitoring will assist with designation of critical habitat. Once Pictometry data was considered to be accurate for measuring baldcypress tree height, students continued to assess surface land area measurements, solar panel roof area measurements and building heights with Pictometry data.

Within ATCOFA, a student's ability to "use geospatial technologies, to collect, analyze and convey spatial data in multiple formats" is rated as both high importance (4.25 out of 5) and high performance (4.04 out of 5) (Bullard, Coble, Coble, Darville, Rogers, & Stephen-Williams, 2014). By presenting to stakeholders and continued discussion, each group added to and refined their project leading to professional presentations and publications. Results indicate that a combination of PPGIS and reflection produce a more inclusive spatial science product, heightens a student's experience, and produce more well-rounded society-ready spatial scientist (Bullard et al., 2014).

References

Ash, S. L., & Clayton, P. H. (2009). Generating, deepening and documenting learning: The power of critical reflection for applied learning. *Journal of Applied Learning in Higher Education*, 1, 25-48.

Ash, S. L., Clayton, P. H., & Atkinson, M. P. (2005). Integrating reflection and assessment to capture and improve student learning. *Michigan Journal of Community Service Learning*, 11, 49-60.

Bringle, R., Hatcher, J., & McIntosh, R. (2006). Analyzing Morton's typology of service paradigms and integrity. *Michigan Journal of Community Service Learning*, 13, 5-15.

Brown, G. (2012). Public participation GIS (PPGIS) for regional and environmental planning: Reflections on a decade of empirical research. *URISA Journal*, 24(2), 7-18.

Bullard, S., Coble, D., Coble, T., Darville, R., Rogers, L., & Stephen-Williams, P. (2014). *Producing 'society-ready' foresters: A research-based process to revise the Bachelor of Science in Forestry curriculum at Stephen F. Austin State University*. ATCOFA Monograph 1-2014, Arthur Temple College of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

Checkoway, B. (1997). Reinventing the research university for public service. *Journal of Planning Literature*, 11(3), 307-319. http://dx.doi.org/10.1177/088541229701100301

Deeming, J. E., Burgan, R. E., & Cohen, J. D. (1977). *The National Fire Danger-Rating System-1978*. USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-39, Ogden, Utah, pp. 63.

Easton, J., & Monroe, M. C. (2009). *Enhancing natural resources programs with service learning*. IFAS Extension, University of Florida, Gainesville, Florida.

Eyler, J. (2002). Reflection: Linking service and learning—linking students and communities. *Journal of Social Issues*, 58(3), 517-534. http://dx.doi.org/10.1111/1540-4560.00274

Eyler, J. S., & Giles, D. E. (1999). Where's *the learning in service-learning?* San Francisco, California: Jossey-Bass.

Federal Register. (2011). *Endangered and Threatened Wildlife and Plants; Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule, Part II*. Department of the Interior, Fish and Wildlife Service, 50 CFR Part 17, October 26, 76, 207, 66370-66434.

Federal Register. (2012). Endangered *and Threatened Wildlife and Plants; Determination of Status, for Texas Golden Gladecress and Neches River Rose-mallow and Designation of Critical Habitat; Proposed Rule, Part III*. Department of the Interior, Fish and Wildlife Service, 50 CFR Part 17, September 11, 77, 176, 55968-56026.

Felten, P., & Clayton, P. H. (2011). Service learning. *New Directions for Teaching and Learning*, 128, 75-84. http://dx.doi.org/10.1002/tl.470

Hatcher, J. A. (2011). Assessing civic knowledge and engagement. *New Directions for Institutional Research*, 149, 81–92. http://dx.doi.org/10.1002/ir.382

Hatcher, J. A., & Bringle, R. G. (1997). Reflection. *College Teaching*, 45(4), 153-158. http://dx.doi.org/10.1080/87567559709596221

Kolb, D. A. (1984). Experiential *learning: Experience as the source of learning and development*. Upper Saddle River, New Jersey: Prentice-Hall.

Laituri, M. (2003). The issue of access: An assessment guide for evaluating public participation geographic information science case studies. *URISA Journal*, 15, 25-32.

Leitner, H., Elwood, S., Sheppard, E., McMaster, S., & McMaster, R. (2000). Modes of GIS provision and their appropriateness for neighborhood organizations: Examples from Minneapolis and St. Paul, Minnesota. *URISA Journal*, 12(4), 45-58.

Molee, L. M., Henry, M. E., Sessa, V. I., & McKinney-Prupis, E. R. (2010). Assessing learning in service-learning courses through critical reflection. *Journal of Experiential Education*, 33(3), 239-257. http://dx.doi.org/10.5193/JEE33.3.239

Newman, P., Bruyere, B. L., & Beh, A. (2007). Service-learning and natural resource leadership. *Journal of Experiential Education*, 30(1), 54-69. http://dx.doi.org/10.5193/JEE.30.1.54

Niles, S., & Hanson, S. (2001). *A new era of accessibility: Or is it?* Workshop on Access to Geographic Information and Participatory Approaches Using Geographic Information Systems. Spoleto, Italy, December 6-8.

Obermeyer, N. J. (1998). The evolution of public participation GIS. *Cartography and Geographic Information Systems*, 25(2), 65-66. http://dx.doi.org/10.1559/152304098782594599

Reeves, H. C. (1988). *Photo guide for appraising surface fuels in east Texas: grass, clearcut, seed tree, loblolly pine, shortleaf pine, loblolly/shortleaf pine, slash pine, longleaf pine, and hardwood cover types*. Center for Applied Studies, School of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

Reeves, H. C., & Lenhart, J. D. (1988). Fuel weight predictions equations for understory woody plants in eastern Texas. *Texas Journal of Science*, 40(1), 49-53.

Schlossberg, M., & Shuford, E. (2005). Delineating “public” and “participation” in PPGIS. *URISA Journal*, 16(2), 15-26.

Schlossberg, M., & Wyss, D. (2007). Teaching by doing: PPGIS and classroom-based service learning. *URISA Journal*, 19(1), 13-22.

Sheppard, E. (1995). GIS and society: Towards a research agenda. *Cartography and Geographic Information Systems*, 22(1), 5-16. http://dx.doi.org/10.1559/152304095782540555

Sieber, R. (2006). Public participation geographic informations systems: A literature review and framework. *Annals of the Association of American Geographers*, 96(3), 491-507. http://dx.doi.org/10.1111/j.1467-8306.2006.00702.x

Sikkink, P. G., Luter, D. E., & Keane, R. E. (2009). *Field guide for identifying fuel loading models*. U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-225.

Texas A&M Forest Service. (2012). *Community wildfire protection plan guide*. Wildland Urban Interface Program, Mitigation and Prevention Department, College Station, Texas, Retrieved from http://texasforestservice.tamu.edu/uploadedFiles/FRP/New_-_Mitigation/Unsafe_Debris_Burning/CWPP2.pdf

Unger, D. R., Kulhavy, D. L., & Hung, I. (2013). Validating the geometric accuracy of high spatial resolution multispectral data. *GIScience and Remote Sensing*, 50, 271-280. http://dx.doi.org/10.1117/1.JRS.8.083590

Unger, D. R., Hung, I., & Kulhavy, D. L. (2014a). Comparing remotely sensed Pictometry® web-based height estimates with in situ clinometer and laser range finder height estimates. *Journal of Applied Remote Sensing*, 8(1), 1-14.

Unger, D., Kulhavy, D., Williams, J., Creech, D., & Hung, I. (2014b). Urban tree height assessment using Pictometry hyperspatial 4-inch multispectral imagery. *Journal of Forestry*, 112, 1-5.

About the Authors

David Kulhavy is the Lacy Hunt professor of forestry within the Arthur Temple College of Forestry and Agriculture at Stephen F. Austin State University in Nacogdoches, Texas. His specializations include remote sensing and spatial analysis of the impact of forest insects and diseases on the forest environment.

Daniel Unger is a professor of spatial science within the Arthur Temple College of Forestry and Agriculture at Stephen F. Austin State University in Nacogdoches, Texas. He specializes in the quantification and qualification of natural resources via the disciplines of remote sensing, GIS, and GPS.