Project Narrative
Water and Sustainability: Educative curriculum using online mapping tools to support teacher and student learning

1. OVERVIEW
The project is an integrated education and extension proposal that addresses the AFRI Challenge Area *Water Resources*, interwoven with strong elements of the Challenge Area *Agricultural and Natural Resources Science for Climate Variability and Change*. The core of the project is a three-day professional development (PD) workshop for secondary school teachers developed by a multidisciplinary team at the University of Connecticut (UConn) that includes expertise in water resources, land use, climate science, science education, and geospatial technology. The PD workshop is designed to immerse teacher participants both in the real world of their local landscape, and in the virtual world of online mapping tools that can help them to understand how their local landscape affects, and is affected by, the global landscape in which it is embedded. Participants will work through an educative module, organized into sessions approximating five to seven classroom periods, that uses both the real and virtual worlds to explore the dynamics of local water resources and the anthropogenic issues that affect them. On the last day, they will take the PD module that they have just finished and tailor it for their own use in teaching their students; they will leave with a personalized *Water and Sustainability* science unit.

The concept of water is the unifying theme at the foundation of this professional learning experience. Complementary themes and tools such as sustainability, problem solving, and geospatial technology will support the main focus on water resources, which will be examined from a global, state, and local perspective. A learning module involving exploration and problem-solving related to water quality and quantity and its relation to land use change – and through land use change to issues of biodiversity, climate, agricultural viability – will be enhanced by the use of cutting-edge online mapping tools created by the UConn Center for Land Use Education and Research (CLEAR). Importantly, the learning module will draw on the three-dimensional learning framework outlined in the *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Research Council [NRC], 2012) and the *Next Generation Science Standards* (NGSS) (NGSS Lead States, 2013). In this framework, three-dimensional learning involves engaging students in science and engineering practices to use disciplinary core ideas and crosscutting concepts to explain phenomena or solve problems. On the last day of the PD workshop, teachers will be active participants in adapting a similar module for enactment in their classrooms with their students, using CLEAR tools to tailor exercises to their particular local area. Participants will leave with a well-developed module that focuses on major Earth and Space Science topics that are actualized through a local lens and in a problem-solving environment. Additionally, it is expected that the module will serve as an anchor for supporting teacher learning, so that they are capable of planning and teaching additional modules with their students that take advantage of these and similar online mapping tools, and that draw on the three-dimensional NGSS framework for learning.

The project team will build a project website as an ongoing resource for participants and for other interested teachers. The website will include resources used in the PD workshop, as well as additional instructional videos and demonstrations suitable for use in the classroom. The website will also be linked to other resources, such as those offered through the Environmental Systems Research Institute (Esri), including Esri's ConnectED mapping initiative that was announced by President Obama in 2013 (White House, 2013). A listserv will also be created, initially for teacher participants but open to all secondary school teachers, to support curricular enactments of the *Water*

and Sustainability theme. The goal is to build a community of practice within which teachers with common pursuits, varied expertise, and different resources can support and learn from each other.

In this three-year project, the PD workshops take place in Years One and Two, with follow-up evaluation in Year Three to assess teacher learning, teacher practice, and student learning outcomes related to teacher participation in PD workshops. The recruitment of teachers from low-resource schools in disadvantaged areas will be prioritized. There will be no cost to participants.

Skill gaps and academic challenges

As noted in the RFP, the President's Council of Advisors on Science and Technology (PCAST) concludes that a focus on secondary school science programs is critical to improving the flagging performance of American students in the science, technology, engineering and mathematics (STEM) disciplines and for addressing the talent pool and pipeline for a strengthened workforce in the food, agriculture, natural resources and human sciences (FANH) (PCAST, 2012; Moore, 2001; National Center for Educational Statistics 2006). The need for STEM learning opportunities for underrepresented students in rural and urban areas is well documented (Byars-Winston et al., 2010; Lee, 2010, 2011; NSF, 2013). For example, unsatisfactory performance in science by these students is linked to poor self-perceptions of their ability to "do" science and a disconnect between school science experiences and real world application (Bauer 2002). In high poverty urban areas, students' sustained interest in science is closely associated with how they envision science experiences as relevant to their future (Basu and Calabrese Barton 2007). In addition, there are many demonstrated benefits in connecting these populations with the environment around them (DeFelice et al., 2014; Levine et al., 2007; Reist et al. 2015).

Our approach to addressing these challenges is to weave together two elements that, in very different ways, are ubiquitous in relevance to everyday life: the subject matter of water resources and the use of interactive online resources. Leonardo da Vinci said "*Water is the driving force of all nature*." The theme of water in our three-day workshop will explore the dynamics of this most critical of natural resources, with an emphasis on its ubiquitous role in the lives of teachers and students alike. A water theme facilitates the connection of larger scale issues (i.e., global and state natural resources) to local environmental problems such as water availability, water quality and emerging contaminants. In addition, it allows an easy connection to related issues of land use change, and through land use to the issues of climate change and agricultural viability. This emphasis is logically aligned with the *Framework* and NGSS, as priority is given to engaging students in science practices (e.g., modeling, developing explanations) to use disciplinary core scientific ideas to explain phenomena or solve problems of societal concern (in this case, those identified in the NGSS *Earth and Human Activity* Disciplinary Core Idea: natural resources, natural hazards, human impacts on earth systems, and global climate change).

Within the context of water resources, we will use a combination of real world field experiences and interactive online mapping to make the global-to-local connection by grounding teacher learning in the environment immediately around them. Because online geospatial technologies are highly personalized (through interactive mapping) and widely accessible (through the internet), we have found them to be very popular with teachers (see Section 2) and a teaching resource far beyond just a vehicle to access packaged information. The National Research Council's report *How People Learn* (Bransford, Brown, & Cocking, 2004) helps further articulate the benefits of technologies like the interactive online mapping tools included in this project:

Many new technologies are interactive . . . [making it] easier to create environments in which students can learn by doing, receive feedback, and continually refine their understanding and build new knowledge . . . new technologies can also help people visualize difficult-to-understand concepts . . . [students] can work with visualization and modeling software that is similar to the tools used in nonschool environments, increasing their understanding and the likelihood of transfer from school to nonschool settings . . . What has not yet been fully understood is that computer-based technologies can be powerful pedagogical tools—not just rich sources of information, but also extensions of human capabilities and contexts for social interactions supporting learning (pp 206-207).

Project Goals

The goals of this project are:

- To provide participant teachers with a grounding in a far-reaching topical theme, water resources, that is well-suited to connect global issues to regional and local issues, and is the focus of many disciplinary core ideas identified in the NGSS.
- To bring cutting-edge internet geospatial technology into secondary school classrooms, not just as an information-seeking resource, but as an effective and adaptable teaching tool for developing and using models and knowledge construction.
- To develop educative curricula that help teachers and students to use STEM/FANH cross-cutting concepts as identified in the *Framework* (NRC, 2012)(e.g., patterns, cause and effect, proportion and quantity, systems and system models, stability and change).
- To integrate climate science, including how it relates to agriculture, using water sustainability as the underlying thread.
- To integrate this new effort with ongoing education and extension efforts at UConn.
- To collect and present both formative and summative evaluative evidence of the effectiveness of our approach related to teacher learning, teacher practice, and student learning, and share this with colleagues throughout the country.

2. RESEARCH, EDUCATION AND/OR EXTENSION ENVIRONMENT

(a) Key Personnel's Experience

The project brings together productive collaborators from several disciplinary units of the University of Connecticut, all with extensive experience in the education or extension environments. The project is an outgrowth of ongoing efforts of these units, and critically addresses significant needs communicated to team members by teachers. Each of these units brings a complementary set of skills and experience to the proposed project.

Department of Natural Resources and the Environment (NRE): NRE, within UConn's College of Agriculture, Health and Natural Resources, established the Natural Resources Conservation Academy (NRCA; nrca.uconn.edu) to help connect adolescents with local environments through conservation and land use planning. To support this mission, the NRCA founder, Dr. Volin (Professor and Head of NRE and Director of UConn Environmental Sciences Program), and the NRCA program coordinator, Dr. Cisneros (NRE Extension faculty member), work closely with an extensive network composed of: (1) faculty from UConn's NRE, CLEAR, and Center for Environmental Sciences and Engineering (CESE); (2) over 50 community partners from conservation organizations and government agencies, and; (3) over 100 high school teachers/educators from throughout Connecticut. Via the collaborative efforts of this network, the NRCA has engaged students from across the socioeconomic spectrum and from a range of life

experiences (e.g., many come from Connecticut's most densely populated and economically disadvantaged urban centers and represent multiple ethnicities). The students are connected to natural resource science in new and exciting ways: first, by integrating cutting-edge technology and web-based tools in the hands-on study of the local environment during a one-week intensive field experience at UConn; and second, by tackling relevant local environmental issues during a seven-month community conservation project. Because the NRCA model has been very successful at igniting student interest in the environment and creating partnerships that generate service projects that produce real results, the response to the program by the NRCA teacher network has been overwhelmingly positive, with over half of the educators expressing a need for similar training for themselves. Thus, we envision that the proposed PD workshop will create synergies with the NRCA, better serving teachers in the growing NRCA network while greatly increasing the number of youth participating in NRCA-related curriculum.

Neag School of Education: Drs. Moss and Campbell both have extensive experience supporting pre-service professional learning in their current roles as university science teacher educators. In addition, they both bring extensive experience leading successful science teacher professional development projects. As an example, Dr. Campbell is currently the PI for multi-state National Science Foundation Discovery Research K-12 (DRK12) project that has demonstrated success in supporting teacher learning, teacher practice, and student learning. More specifically, Dr. Campbell and his colleagues have been able to demonstrate how teacher practice and teacher learning have been improved by the PD model enacted in this project and have been able to demonstrate how students of teachers participating in the project have scored significantly higher than students of teachers not participating in the project (Campbell et al., 2015; Longhurst et al., under review). Similar to what is being proposed in this current project, Dr. Campbell's project was grounded in educative curriculum as a learning anchor for supporting teacher professional learning and subsequently engaging students in classrooms. In sum, the co-authored middle school curriculum materials for four multi-day science modules created as part of Dr. Campbell's NSF DRK-12 project have been implemented by more than 35 middle school science teachers with more than 7,000 students in Utah since 2011 (e.g., Campbell et al., 2012). Additionally, at a collaborating site in New York, the same numbers of science teachers and students have been positively impacted by the project. Beyond this, Drs. Moss and Campbell co-lead a state-level project that supports Institute of Higher Education science education faculty, cooperating teachers, and pre-service science teacher professional learning related to implementation of NGSS.

Center for Land Use Education and Research (CLEAR): CLEAR is a partnership of the Department of Extension and NRE (above), both within the UConn College of Agriculture, Health and Natural Resources, and the Connecticut Sea Grant College Program. CLEAR investigators Arnold, Chadwick and Wilson have a combined 55 years of experience in developing and teaching workshops for lifelong learners with a topical focus on water resources and/or geospatial technology. All CLEAR programs have a strong connection to both the USDA Land Grant and NOAA Sea Grant university networks, and within these networks CLEAR has been a national leader in the role of Extension in both land use education (Arnold, 2000a) and the use of geospatial technology for education (Arnold et al., 2000b; Rozum et al., 2005). Many CLEAR projects have a long history of competitively-funded USDA projects that have successfully taken Connecticut innovations to a national audience. This includes USDA NIFA support of geospatial technology training for water resource research and extension faculty within the Land and Sea Grant networks, and a current project that expands the CLEAR-developed "Rain Garden" smart phone application to other states in the Land Grant system (13 states currently have working apps). Most important,

the CLEAR résumé includes the National NEMO Network (nemo.uconn.edu), a confederation of water quality/land projects in 30 states that was supported by three consecutive multiyear competitively-funded NIFA grants. CLEAR Extension faculty are active instructors in the NRCA (above), and have taught many individual classes for teachers as part of other programs. CLEAR's Geospatial Training Program has extensive experience in training adult learners on the use of geospatial technology and online mapping tools, training over 1200 people in the last 8 years.

Center for Environmental Sciences and Engineering: CESE, with a mission to catalyze multidisciplinary environmental research, education, and outreach, is a vital intellectual resource in support of the proposed project. CESE includes over 170 faculty members with expertise in biophysical, engineering, and social sciences. Many associated faculty members have expertise is water resources, biodiversity science, climate change, environmental economics and policy, and environmental modeling or statistical analysis. Dr. Willig, the Director of CESE, has been a participant and co-PI in a series of Long-Term Ecological Research Grants (1999-present) from the NSF that explore the interactions between the biota and biogeochemical processes in landscapes subjected to climate change and land use change. He has also been the PI or co-PI of a number of grants from the CT Department of Energy and Environmental Protection that support long-term monitoring of Long Island Sound and other water bodies in the state. Many CESE faculty members, including Dr. Willig, have been participants and leaders in the NRCA.

Immersive training and effective pedagogical strategies

The project will immerse teacher participants in a series of learning experiences similar to those they will be encouraged to facilitate with their students, where they navigate their way through an educative module that combines classroom experiences with field visits and online mapping activities. Here, an educative module, or educative curriculum more generally, is defined as a curriculum that fosters both teacher and student learning. This is accomplished with embedded facilitation guidance, so that as materials are used by teachers to engage in their own learning experiences, they subsequently are better able to use these materials to support student learning in their own classrooms (Davis & Krajcik, 2005). The module that teacher participants engage in as learners will then become the basis for the module that they will tailor for use in their classrooms. By experiencing the module as learners first (within both individual and group contexts), the teachers will gain a deeper understanding of the subject matter, the purpose of each component exercise within the module, and pedagogical strategies that prioritize sense-making about phenomena and problems as key to learning. After experiencing the module as learners, teachers will then don their teacher "hats" to: (a) reflect on the kinds of experiences they had in the module and how this might inform their work with students: (b) dig deeply into the pedagogical strategies, including discourse strategies and strategies for facilitating small group and whole-class discussion, and; (c) advise the project team on improvements to the modules. This experience will then position them to tailor the modules for their own classrooms and settings. The structure of the three days will also help participants to plan exactly how to implement this module with their students in their localized contexts (more on this in Section 3b, the workshop description). Finally, the workshop will emphasize outdoor field experiences and interactive online tools – both much more immersive environments than those experienced via traditional lectures.

(b) Extension and Education Environment

The UConn campus is an ideal site to focus on the role of land use and land use change on the health and sustainability of water resources. The campus is essentially split into two watersheds with very different landscapes and water management issues. The western portion of campus, contained

mostly in the Eagleville Brook watershed, is very densely developed and is in effect a small city within a rural area, with all the water quantity and quality problems associated with dense development. Eagleville Brook is an impaired watershed and the focus of the first impervious surface-based total maximum daily load (TMDL) regulation in the country (Arnold *et al.*, 2010). However, as a result of leadership by CLEAR faculty, since 2009 the campus has been transformed into a showcase of "low impact development" (LID) or green infrastructure practices. The wide variety of LID practices serve as an ideal resource for faculty research and student education, as well as an important resource for the NEMO Program's extension outreach; for instance, LID tours of the campus are requested by many outside groups including town officials, water conference organizers, and nonprofit organizations (Dietz et al., 2015). On the other hand, the eastern side of campus is noted for agricultural and natural (undeveloped) landscapes, including portions of the UConn Forest. This side of campus is in the Fenton River watershed, a public water supply watershed that has, at times, suffered from streamflow issues related to groundwater withdrawals by the university (Warner et al., 2006). This side of campus is also the focus of research and student education related to water resources. Additionally, the LERIS computing laboratory (Laboratory for Earth Resources Information Systems) on the UConn campus is equipped for geospatial research and is an ideal venue for geospatial education.

3. APPROACH

(a) Recruitment, Selection and Continued Support for Secondary School Educators

Participants for the PD workshop (25 participants per workshop) will be recruited from a multi-town geographic target area centered on populations of historically underrepresented STEM learners in both urban and rural areas. The initial targets (Year 1) include the state's two largest cities, Bridgeport and Hartford, as well as two rural areas, Meriden and Putnam, which are among the state's lowest performing school districts. The investigators currently have extensive networks and contacts with educators and schools across Connecticut, both through the Neag School of Education and through the NRCA (see Section 2a)(see letters of commitment). In addition to the large number of individual educators and schools across the State, we are also connected through contacts with key individuals (and their listservs) in nongovernmental organizations such as the Connecticut Science Teachers Association, the Connecticut Outdoor and Environmental Education Association, and CT Green LEAF Schools.

Past recruitment efforts by the NRCA have been very successful. On average, the NRCA receives between 40-45 applications each year, surpassing the number of students the NRCA can currently accommodate. Since its founding, the NRCA has worked with 92 high school students across Connecticut, representing diverse ethnicities (30% identified as Asian, African American or Hispanic) and socioeconomic groups (55% required financial assistance and 23% were enrolled in the federal Free/Reduced Lunch Program). The diverse cohorts of students participating in the program derives from the many personal visits made by the NRCA coordinator to schools in urban areas – visits that have created many personal connections with teachers at these schools. We will continue to use the NRCA model to recruit underrepresented groups of teachers by personal visits to schools in a diversity of communities, with extra efforts in economically disadvantaged urban centers or to some of Connecticut's lowest preforming schools.

(b) Nature of Participant Activities

The project is an integrated education and extension proposal, although the potential for future research is very much on the agenda of the investigators. As noted, the project principals have

extensive experience in both disciplines. In the case of this project, national award-winning extension teaching expertise from CLEAR will be combined with the theoretical and applied experience of the Neag School of Education, and the practical experience of the field-based NRCA. The key activity will be the development, implementation, and evaluation of a three-day professional development (PD) workshop for high school science teachers. Table 1 (next page) is a summary of the workshop as currently planned, showing major blocks of time, activities, and how each activity relates to both the USDA AFRI ELI/PD-STEP goals and the *Next Generation Science Standards*. This outline has been informed by the advice of several secondary school science teacher contacts.

A number of key elements characterize the *Water and Sustainability* PD workshop:

- The topical focus will be water resources, with ties to the water resource impacts of land use and climate change, and related impacts on biodiversity, habitat and agriculture.
- Participants will complete a cohesive unit on water that relates directly to particular NGSS core ideas and stresses cross-cutting concepts such as: patterns; cause and effect; proportion and quantity; systems and system models, and; stability and change.
- To facilitate the transfer of teacher learning to student learning, the workshop module will be structured, to the extent possible, to correspond in duration to classroom teaching periods so that teachers are prepared to enact a 5-7 class period module with their students when returning to their classrooms.
- The module will be framed using the NGSS three-dimensional learning framework such that learners are introduced to important tools (e.g., geospatial mapping tools), science practices, and disciplinary core ideas in the midst of their attempts to explain phenomena or solve problems. In this, participants will not only develop more flexible knowledge in how to use these tools, practices, and ideas, they will also understand how features of scientific activity support authentic human pursuits.
- The field experiences will use the UConn campus at Storrs as a location that is well-suited to investigate urbanized, agricultural, and rural or natural landscapes, and their dependence on or affect on water resources (see Section 2b).
- The online interactive mapping exercises will support teacher participants and result in their creation (and eventually in their students' creation) of localized mapping products as educative tools for better understanding local water issues, including a "mapbook" atlas of local maps and an ArcGIS Online Organization account for their school provided by Esri.
- Having experienced the *Water and Sustainability* unit as learners, the participants will be enabled to focus their teaching expertise and experience on making suggestions to the investigators on ways to improve the unit, and using their new online mapping skills to tailor the unit to their particular classrooms, town, or watersheds.

This PD experience aspires to connect water resource science and issues at the global, state, and local scales, with the goal of addressing several key teaching and learning challenges identified by key national education reports, such as those by the National Research Council (*How People Learn*) and National Academy of Sciences (*A Framework for Science Education*), and the subsequent development of the *Next Generation Science Standards*. On Day One, we will begin at the global and state levels to provide appropriate context for a resource as critical as water ("*numerous studies demonstrate that the curriculum and its tools, including textbooks, need to be dissected and discussed in the larger contexts and framework of a discipline,"* NRC 2012*).* The afternoon of Day One will be spent in the field investigating local water resources and the land around them, focusing the participants' attentions on local, community-level resources and issues, so that their workshop

experiences "*relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technical knowledge*" (NGSS, 2013). The field experience will highlight the role of land use in the health of water resources, and will make use of both qualitative and quantitative scientific observations, while emphasizing science as a way of knowing. UConn's main campus is ideally suited for this purpose (see Section 2b), but the goal is to make all field activities replicable (or at least adaptable) to water resources in the teachers' local communities.

Day	Topic	Activity Type	NGSS Framework	AFRI ELI & PD-STEP Framework
1	**Introduction & Setting the Problem**			
AM	PD goals, instructors, & take-home resources			
	The question you will investigate: *What is the health of your local water resources, and why?*			
1	**Water and Our Changing Landscape**			
AM	A review of water resource science and issues: global to state to local	Lecture aided with use of online "Story Map"	Earth & Space Science Core Area	Water Resource Challenge Area
PM	Field exploration on UConn campus: the impacts of land use on water resources across a gradient of urban, agricultural and rural landscapes	Field observations & discussion	Science Practices: scientific inquiry	• Immersive learning; • Changing instructional approaches to effectively identify skill gaps and challenging conceptual areas
2	**The Water & Sustainability Module**			
AM	Exploring water and other natural resources using CLEAR online mapping tools	Lecture followed by individual exercises	• Earth & Human Activity Core Idea; • Human Sustainability Topical Bundle; • Cross-cutting Concepts: scale; patterns, similarity & diversity; proportion & quantity; stability & change	• Immersive learning; • Integrating innovations in science into professional development programs
PM	Connecting to ConnectED: using free online education resources to explore and create maps with your students	Lecture followed by individual exercises		• Immersive learning; • Exploring self-sustaining web-based approaches for professional development
	Bringing it home: making maps, conducting analyses and testing predictive models for your local town or watershed	Lecture followed by team exercises		• Immersive learning; • Changing instructional approaches to effectively identify skill gaps and challenging conceptual areas
3	**Tailoring Your Own Module**			
AM	Teams comment on module and group makes consensus changes if desired	Group discussion	Supports these key criteria of Core Ideas: • Provides a key tool for understanding or investigating more complex ideas and solving problems; • Relates to the interests and life experiences of students or connected to societal or personal concerns that require scientific or technical knowledge	• Changing instructional approaches to effectively identify skill gaps and challenging conceptual areas; • Creating and replicating best practices to improve student success outcomes
	Individual work on final module templates and lesson plan for their students	Individual work assisted by instructors		
PM	Work continues on individual projects	Individual work assisted by instructors		

Day Two will focus on geospatial technologies. Mapping tools and technologies engage several critical elements of STEM education and instruction and can enhance understanding and problem solving across many disciplines (Esri, 2012). A critical feature of the three-day workshop is the integration of innovative teaching tools focused on online mapping, which only in recent years has made geospatial data and analysis accessible to non-technical users (Henry & Semple, 2012). Websites like Bing Maps and Google Maps have introduced the public to remote sensing imagery and intuitive web mapping tools. Companies heavily invested in geospatial technology, including the industry leading Esri, have developed robust web tools including ArcGIS Online which make possible the creation and publication of customized online maps and mapping apps. Additionally, global positioning system (GPS) technology has permeated our day-to-day activities and is now

integrated into most mainstream consumer devices on the market, from smartphones and wearable technology to navigation systems in cars and remote controlled hobby drones. All of these advances represent a paradigm shift in the field of geospatial science that have enabled broad access to a host of location-based technologies and terabytes of geographic information. However, the rapid proliferation of available geospatial tools and resources has created a new challenge for users in identifying and selecting the appropriate tools to use for targeted purposes; this extends to the field of teaching, for which there are limitless applications of geospatial technology but significant barriers to exposure to these technologies. To truly realize these new pathways to STEM knowledge, "value-added" access for new learners – including teachers -- must be created through tailored learning experiences that speaks to their interests and helps them to discover and engage with the applications of the technology that are meaningful and useful. This is evident in research like that from Hudicourt-Barnes (2003) that demonstrated how urban language-minority students can engage in meaningful high-level scientific reasoning when engaged in classrooms that respect their interests and sense-making abilities. Additionally research like that of Anastopoulou et al. (2012) or Soong and Mercer (2011) has demonstrated the benefits that can come from engaging students in meaningful applications of technology in school science settings. In this, the NRC report (2012) emphasizes that innovative use of technology is a qualitative change to traditional pedagogical methods: *Technology can give teachers license to experiment and tinker. It can stimulate teachers to think about the processes of learning, whether through a fresh study of their own subject or a fresh perspective on students' learning. It softens the barrier between what students do and what teachers do. When teachers learn to use a new technology in their classrooms, they model the learning process for students; at the same time, they gain new insights on teaching by watching their students learn. (p. 226)*

CLEAR faculty have been among the first in the nation to develop and teach online mapping tools (Rozum et al., 2005; Dickson et al., 2011), including, as noted, a national USDA NIFA Water Program project to train research and extension faculty throughout the Land Grant system. In this proposed integrated project, the PD workshop will focus on two goals: (1) personalizing map-making by introducing neighborhood level data from two CLEAR online mapping tools, *Connecticut Environmental Conditions Online* (CT ECO) and *Connecticut's Changing Landscape* (CCL), and; (2) familiarizing teacher participants with *ConnectEd* resources created by industry leader Esri, and the underlying technology of creating maps online using ArcGIS Online, all in the context of local phenomena or problems that are meaningful and interesting to them.

To ensure educators have an understanding of the science underlying the mapping resources and have the ability to convey it in their own classrooms, the morning of Day Two (Table 1) will begin with a primer on geospatial technologies including an introduction to geographic information systems, the global positioning system, and remote sensing. These technologies will be explored further through tailored, hands-on interaction with the CT ECO and CCL websites (note: more information on CT ECO, CCL and ConnectEd is included in Facilities and Other Resources). CT ECO is a statewide resource invested in sharing environmental and natural resource maps and information with the general public. It includes a variety of online maps and tools for investigating local resources including features such as protected open space, farmland soils, wetland soils, aquifer protection areas, water quality classifications, and drainage basins. In addition, CT ECO is the primary resource for accessing and interacting with several dates of high resolution aerial orthoimagery. Connecticut's Changing Landscape is a remote-sensing based land cover study that has investigated 30 years of land cover change, as well as subsidiary analyses of riparian land cover, impervious cover and agricultural field/soil analysis (see Wilson et al. 2015).

The CCL website, along with the CCL Story Map (a new kind of interactive map, see Facilities and Other Resources), provide a compelling look at how the landscape has evolved in both urban and rural settings across Connecticut. Together, they provide educators with a wealth of information that is directly relevant to topics covered in their classrooms. Through guided, hands-on exercises and with facilitation by CLEAR's geospatial educators, participants will use these web tools to investigate their local watershed and make connections between the natural and physical features on the landscape and how they may be connected to water quality and quantity in their watershed; this will relate directly to the field investigations of the previous day's exercises. The product of this teaching module will be a digital "mapbook" of the local watershed, highlighting key resources and changes to the landscape over time. The mapbook can be used throughout the curriculum to inform discussion topics and engage in critical skills such as problem solving and decision making.

The second part of Day Two will introduce educators to a revolutionary program developed by Esri as part of the White House ConnectED Initiative to connect K-12 schools and/or programs to free online mapping tools and activities, based on the robust online mapping program ArcGIS Online (White House, 2013). Esri has developed a ConnectED website (see Facilities and Other Resources) to provide information about how schools can register for a free ArcGIS Online account, access subject-focused, and standards-based instructional materials. Teachers can also connect with GIS professionals called "GeoMentors" in their area that are willing to help facilitate the integration of GIS mapping into their classrooms. The Esri ConnectED website and ArcGIS Online provide a wealth of information for educators, but to date these important resources are being underutilized since only a small percentage of schools in Connecticut are currently registered for a free ArcGIS Online Organization subscription (Esri Geomentors website, 2016). Accordingly, the afternoon of Day Two will introduce educators to ArcGIS Online and the ConnectED resources. In addition to hands-on guided exercises highlighting the functionality of ArcGIS Online, this learning module will demonstrate how local mapping resources from CT ECO and CCL can be integrated with customized ArcGIS Online maps to enhance the application of these mapping tools to meet localized learning objectives and connect learning concepts.

(c) Institutional Support

Institutional Climate: This project is nested at the boundaries of multiple institutions and positioned to meet goals of enhancing K-12 education locally in schools across Connecticut, at the Connecticut State Department of Education level, at UConn, and in the U.S. more broadly. The Connecticut state timeline for implementation of NGSS requires the support and collaboration of local stakeholders and universities to develop materials that embody the vision of teaching and learning articulated in the *Framework* and NGSS. In addition, the state timeline specifically identifies the recognized need for science teacher professional development in 2016 - 2018 to support the implementation of NGSS, a timeline that matches very well with the work plan of this PD proposal. Similar timelines have been articulated in other states (e.g., Reiser, 2013; NRC, 2015).

At UConn, the Provost's *New Academic Plan*: *Creating Our Future: UConn's Path to* Excellence (UConn, 2013) explicitly articulates a goal of *Excellence in Public Engagement* in support of UConn's institutional mission. This project targets this UConn goal by creating extended opportunities for UConn STEM faculty members and educational researchers to work closely with teachers from K-12 schools to design, test, and refine the *Water and Sustainability* module described above as an anchor for supporting even broader K-16 learning through "mutually beneficial exchange of knowledge and resources in a context of partnership and reciprocity" (p. 41). Finally,

this project is nested within the broader national context of NGSS implementation whereby 19 U.S. states, representing more than half of the nation's K-12 students, have adopted NGSS (Figure 1, NGSS Adoption Map, 2015). And, for those states not adopting the NGSS, most have committed to the *Framework* as a core foundational document grounding revisions to their current state's science standards. This means that this project is also well positioned to meet a national goal (NRC, 2015) of developing, refining, and sharing both an effective professional development model and curriculum that will be broadly useful in NGSS adopting, as well as *Framework* committed, states.

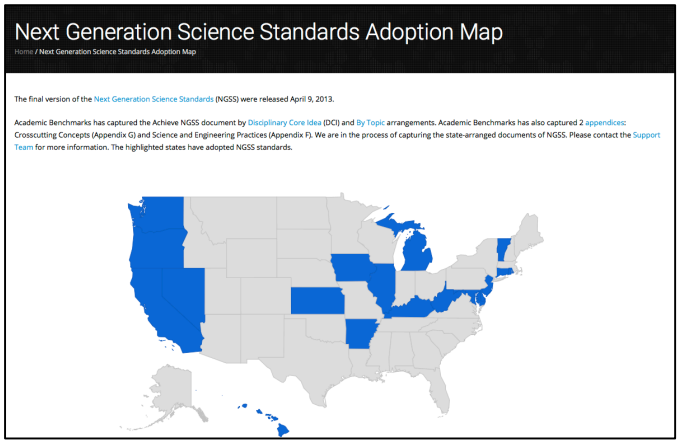

Figure 1. 19 states that have adopted NGSS as of 2015

Sustaining the Model: In addition to the PD workshop, we propose to set in place several mechanisms to facilitate the formation of a *community of practice* among the participants and other interested teachers. First, we will create a listserv so that teachers using the new *Water and Sustainability* module and the ConnectEd resources can share information and learn from each other's experiences. Second, we will create a *Water & Sustainability* website dedicated to this PD program, with links to resources and instructional modules used in the course, as well as other resources as they become available. In addition, we want to re-emphasize that sustainability is a major benefit of the use of online geospatial resources, which are free, available 24/7, and well within the technical capabilities of the average secondary school teacher given a small amount of support. Finally, the investigators – both individually and collectively – have extensive records of success in procuring external funding for their research, extension and education activities (see investigator CV's for more information). This includes external funding for longstanding, ongoing FANH-oriented programs such as the NEMO, NRCA and CLEAR's Geospatial Training Program.

4. Project Evaluation and Reporting

(a) & (b) Evaluation plan and timeline, and approach for evaluating both PD and subsequent student outcomes

A newly hired Extension Evaluation Specialist (May 1, 2016) in the UConn College of Agriculture, Health and Natural Resources will collaborate with educational researchers from the Neag School of Education (i.e., Drs. Campbell & Moss) to conduct the evaluation and reporting for this project. The evaluation will focus on the project's work, contributions, and quality of outcomes by addressing the following evaluation questions:

1. What is the quality of the three-day workshop, follow-up support, and resources (e.g., online mapping resources) provided to participant teachers? To what extent is the workshop and follow-up support designed to foster NGSS three-dimensional learning and immersive experiences for learners (teachers and students) and address the varied needs of the teachers and students in their classrooms?
2. To what extent do teachers:
    a. Deepen their understanding of disciplinary content related to water and sustainability and online mapping tools?

   b. Increase their knowledge of and skill in using various online mapping tools and understanding of the utility of these tools for solving real-world problems?
   c. Better align their instruction with that envisioned in NGSS three-dimensional learning related to immersive learning experiences for students?
3. To what extent do students of participating teachers:
   a. Deepen their understanding of disciplinary content related to water and sustainability and online mapping tools?
   b. Increase their knowledge of and skill in using various online mapping tools and understanding of the utility of these tools for solving real-world problems?
   c. Increase their achievement in science on standardized state-level assessments?
4. To what extent is the project successful at disseminating project materials within Connecticut and nationally?

Formative Evaluation: The formative component will focus on monitoring the quality of project activities and provide feedback that facilitates reflection and allows the project to make mid-course corrections where needed. In Year 1, an external advisory board will provide critique of the *Water and Sustainability* module and design of the three-day workshop. The external advisory board will consist of a water and sustainability content expert, a professional development expert, and local high school science teacher. At least one member of the advisory board will observe a portion of the three-day workshop in Years 1 & 2 and provide written feedback. Additionally, the Extension Evaluation Specialist will administer post-workshop questionnaires to all participants, soliciting perspectives on the quality of the workshop learning experiences, suggestions for improvement, and intentions to enact the *Water and Sustainability* module in their classrooms. Each year, the Extension Evaluation Specialist will interview a small sample of participants focusing on the quality of the workshop learning experience and follow-up support, and how teachers are applying the knowledge and skills from the workshop in their classrooms more broadly. In addition, in Years 1 and 2, the external advisory board, using a review template provided by the Evaluation Specialist, will conduct an independent review of the project and provide feedback to the project.

Summative Evaluation: The summative component will focus on examining impacts of project activities using data collected throughout the project. More specifically, the post-workshop questionnaires and sample of participant interviews collected during Years 1 & 2 will be used to answer evaluation question 1. To answer evaluation questions 2 & 3, the Extension Evaluation Specialist will collaborate with project leaders to develop assessments that can be embedded into the three-day workshop sessions as authentic tasks that provide evidence of improvements in participants' knowledge and skills. These same assessments will then also be embedded and administered to students in teacher participants' classrooms. To answer evaluation 2c with respect to better aligning instruction with NGSS three-dimensional learning related to immersive learning experiences for students, an NGSS aligned teacher assessment survey developed by Hayes, Lee, DiStefano, O'Connor, and Seitz (in press) will be administered to teacher participants at the end of each academic year following their engagement in the summer PD three-day workshop. The survey uses a "retrospective pre-approach" that has proven useful with surveys when respondents are likely to change their perceptions of initial knowledge/preparedness as they learn more about a topic (Goedhart and Hoogstraten 1992; Howard et al. 1979; Klatt and Taylor-Powell 2005; Lamb 2005; Pratt et al. 2000). To answer evaluation question 3c, CT state-standardized assessments will be used to compare a representative group of participant teachers' students to a control group of non-participating teachers' students. Finally, website metrics, desegregated by location of site visitors will be used to answer evaluation question 4.