Project Summary

The Gulf of Maine Watershed SRN will focus on four interdependent Grand Challenges that require integration of interdisciplinary research and knowledge: food security, energy development, water for the future, and societal metabolism in a resource-constrained world. To support the research, a dynamic, open-source Digital Commons will be developed for the upload, download, selection, analysis, and display of geospatial and non-geospatial data, imagery, charts, graphs, photos, videos, stories, textual information and metadata relevant to the coupled human and natural systems in the Gulf of Maine Watershed. The place-based research, particularly in its incorporation of cross-case comparisons across governance structures and multiple scales, will inform our understanding of global scale processes. In addition, rigorous evaluations will test whether research networks that connect university researchers with diverse external partners and stakeholders improve the transition to sustainability by enhancing key indicators of social capital and collective efficacy, and whether these enhancements in turn are associated with outcomes consistent with adaptive capacity. Tools such as social network analysis will be used to evaluate the entire SRN as well as the many sub-networks associated with individual grand challenges and stakeholder groups. A conceptual framework for building resilience and adaptive capacity and connecting scientific knowledge and societal action will be evaluated and adjusted throughout the research. Educational efforts are integrated across many scales; K-12 curriculum development, cross-institutional mentorship courses and training, a wide range of informal science education initiatives and partnerships and broad scientific communication to public audiences.

Intellectual Merit

The proposed research will advance our knowledge about the efficacy of intentional researcher and stakeholder networks to address complex coupled natural-human systems and the extent to which they can build capacity for understanding and addressing complex problems. The SRN will also contribute to knowledge creation in the four specific Grand Challenges that rely on data, analyses, information and approaches from multiple disciplines that will be enabled through the Digital Commons and the social network. Multiple and complex relationships and tradeoffs between food production, ecological services, food insecurity and obesity across many scales will be understood. Scales of governance in the region overlay effective development of integrated water resources management, in particular impacting adaptation strategies for climate change and understanding geographical and social distributions of ecosystem service provision and use. Integrated methods will be developed to understand social, economic and biophysical tradeoffs and barriers to local and secure energy expansion. New methods to understand the determinants of material and energy metabolism of communities at different scales will be developed relying on data and methods from economics, engineering, demography and social science.

Broader Impacts

Strong networks across academic institutions and stakeholders will be developed to help address key societal issues across the Gulf of Maine Watershed and models will be deliberately created to apply lessons globally. Engagement of stakeholders in the networks will rapidly build capacity for linking scientific knowledge and societal action. Ultimately, we expect our SRN to help transition the region towards sustainability. Focused evaluation will identify those aspects of our SRN that are most effective and ripe for replication in other coastal watersheds. Diversity initiatives will target underserved groups including populations of refugees and ethnic minorities, youth with disabilities, and those living in isolated rural areas through after-school programs, teacher institutes and workshops, and engagement of citizens and students through participatory action research initiatives. Formal education efforts will reach K-12 through graduate students, and will provide innovative, cross-institutional opportunities through interdisciplinary, team-based coursework. Cross-institutional classes, seminars, “mutual mentoring,” cross-generational research teams and training will broaden participation. Informal science education initiatives will reach wide audiences; communicating science workshops will be delivered for SRN and network members to share best practices and broaden participation in science communication.
1. RATIONALE AND VISION

The sustainability challenges associated with the contextual nature of dynamic coupled natural–human systems, and the myriad of factors influencing connections between knowledge and action, underscore the need for strategies that can rapidly build capacity for understanding and addressing complex problems. Creating networks of research institutions and diverse stakeholders is an important strategy for building such capacity to analyze and help solve societal problems. However, an implicit assumption regarding such research networks is that they produce more innovative and relevant scientific advances than traditional research efforts, in which institutions and investigators work independently. One of the overarching research thrusts of this Sustainability Research Network (SRN) is to evaluate whether the structure, function, and dynamics of the research network affect the ultimate impacts of the research, including social outcomes such as trust, reciprocity, co-learning, and shared knowledge, which in turn are expected to facilitate resilience and adaptive capacity within coastal watersheds.

Using the Gulf of Maine Watershed (GMW) as a model system, we will employ a case study approach to focus on four grand challenges: food security, energy development, water for the future, and societal metabolism. For each of these challenges, interdisciplinary research teams will collaborate with a diverse network of stakeholders to co-define problems and co-develop solutions. Such collaborations will also serve as laboratories for cross-cutting research to understand and strengthen links between scientific knowledge and societal actions (K–A).

Our research is organized around an initial conceptual framework depicting the coupled natural-human system in which the GMW SRN is nested (Figure 1). The framework is derived from recent interdisciplinary scholarship focused on driving forces that influence cumulative social and environmental stressors, sustainability, and impacts (Bunch et al., 2011). For example, strategies that enhance ecosystem integrity also have the potential to impact food production, public health, infrastructure resiliency, social equity, and economic development. Prior frameworks have been developed (Kristensen, 2004; Hughes, 2003; Pickett, 2005, Ernston et al., 2010; Bunch et al., 2011) to facilitate our understanding of the social influences or “drivers” associated with ecosystem changes that impact sustainability, and to further specify dimensions of vulnerability and resilience across local, regional, and global scales (Turner, 2003). Our framework is intended to be a starting point for the GMW SRN; it will be applied and adapted collaboratively throughout the process using continuous developmental evaluation (Patton, 2010). A revised framework will be used to inform future research agendas, practice initiatives, and policy recommendations.

2. PROPOSED RESEARCH, NETWORK ACTIVITIES AND GRAND CHALLENGES

The GMW SRN will address four grand challenges of coastal watershed resilience by integrating research and knowledge from the natural sciences, engineering, computational sciences, social and behavioral sciences, and the humanities, as well as from a broad range of external participants. The network will consist of four overlapping and integrated components (Figure 2). The broadest component is the Stakeholder Network that consists of researchers and community partners (e.g., resource managers, planners, - government representatives, educators, not-for-profits, business, industry, social institutions) involved in defining the research agenda and co-creating knowledge to address the four grand challenges. The Stakeholder Network will work to ensure that the project generates “use-inspired research” (Clark, 2007), meaning that research questions, methodological approaches, data, and analyses will be developed and performed in a manner that is legitimate and useful to stakeholders and supports a key crosscutting theme of Linking Knowledge with Action (K–A).

Nested within the Stakeholder Network is the Researcher Network, consisting of interdisciplinary researchers from across the GMW who will work collaboratively with the Stakeholder Network to perform detailed data collection, synthesis, and analysis. Interdisciplinary research, knowledge, and viewpoints will be supported and integrated via the GMW Digital Commons. Envisioned as dynamic and creative, the Digital Commons will be an open source, integrated, web-based, geographically referenced data and image management infrastructure and analysis system that allows for the upload, download, selection, analysis, and display of geospatial and non-geospatial data, imagery, charts, graphs, photos, videos, stories, textual information and metadata relevant to the coupled human and natural systems in the GMW. The Digital Commons infrastructure will be based on the open source GeoNode/GeoDjango web GIS software. This flexible and scalable system will build upon UNH expertise with similar systems (e.g., the Environmental Response Management Application used in the Gulf oil spill, GMW Information and Characterization System,
Figure 1. Conceptual Framework for Sustainability that will be tested and adapted by the Gulf of Maine SRN. Description of Boxes #3-11: 3. Vulnerability - Conditions that result from stressors that accumulate over time and at various scales. 4a. Sensitivity - Affects the response to a stressor or exposure; Risk regulators - Mediate between stressors (2c) and sensitivity (4a) to exposures. Examples: Green infrastructure, growth management policies, sustainable energy sources; 4b. Exposures - (negative) - toxins, poor air quality, obesogenic environments; (positive): clean water, availability/affordability of healthy food; Coping (5b), Resilience (5a), Adaptation (6b), and Capacity (6a) - The process of building capacity to adapt to stressors. Examples: K- A dissemination, local food production in tribally owned farms; 7a, c. Place Based Human/Environmental Conditions - e.g., socioeconomic inequities, obesity, increasing food insecurity, land use/land cover change, increasing magnitude and frequency of coastal and inland flooding; loss of farmland and forestland; diminished fish and shellfish stocks; 7b. Grand Challenges and Collaboratively Defined Research Focus Areas - e.g., Food Security, Energy Development, Water for the Future, Societal Metabolism; 8. Social Networks and Bridging Social Capital - e.g., social ties, trust, reciprocity, and co-creation of knowledge to support resilience and adaptive capacity; 9a-9b. Adaptive management, transition management (TM), adaptive governance- Example: TM assesses mutual stakeholder adaptation against a set of collectively defined goals. SRN activities are expected to support more inclusive, participatory, and accountable management and governance structures that create and sustain social justice. 10. Place Based Impacts - e.g., maintenance of ecosystem services; 11. External Impacts - e.g., use of knowledge and processes generated by the SRN to increase resilience in national and global contexts.

Historical Atlas of Marine Ecosystems), other regional assets (e.g., Ecosystem Indicator Partnership, Northeastern Regional Association of Coastal Ocean Observing Systems, Northeast Coastal and Ocean Data Partnership), and publicly available government and non-government data from static and...
dynamically served archives and sensor arrays. This Digital Commons will provide access through intuitive interfaces and international standards-compliant web services to heterogeneous data and information at the heart of the interdisciplinary analytic efforts to understand the coupled human-natural GMW. A key challenge and research question for the SRN is how best to integrate analyses of natural and social science data (e.g., watershed data based upon natural boundaries with municipal/state data and decision making based upon political boundaries; qualitative with quantitative data) and how best to develop the Digital Commons so it serves as a rich resource for research, decision making, and education.

As envisioned, the structure of our SRN provides flexibility to evolve as the research proceeds. Our intention is to build a focused network that engages researchers from the University of New Hampshire (UNH), University of Maine (UMaine), University of Southern Maine (USM) and our stakeholder groups. Once established and functioning, we will purposely evolve to include more institutions and stakeholders from Atlantic Canada and eastern Massachusetts.

The fifth component of our SRN focuses on integration of educational content and pedagogy across formal and informal settings. The SRN will provide innovative opportunities for K-12 through doctoral student training, and informal science education through traditional programs and scientific communication with public audiences.

**Grand Challenges**

Coastal areas are home to more than 50% of the human population and represent a complex intersection of climatic, ecosystem, economic, and social processes. They are focal points for urban development, recreation, land use change, and resource extraction made possible by diverse ecosystems that provide a range of critical services. Coastal systems are vulnerable to complex stressors resulting from natural-human system interactions and provide a dynamic laboratory to advance understanding of temporal and spatial patterns of vulnerability and resilience. The GMW extends from headwaters in the Northern Forest in Canada and the US to the Gulf of Maine and Bay of Fundy and is home to more than 10.8 million people. Current population growth is greater than 1% per year, and there is an ongoing migration toward the coast. Relevant spatial and temporal gradients include: land use (e.g., urban to suburban to rural); governance mechanisms (international, federal, state, provincial, and municipal); predominant economic activity (e.g., resource extraction, manufacturing, tourism, knowledge based); topography (mountains to coastal plain); ecosystems (freshwater to estuarine to coastal/marine), and sociodemographics (e.g., income inequality, recent influxes of immigrants).

By combining, visualizing, and analyzing data across disciplines and developing generalizable models at a variety of scales, the GMW SRN will produce new knowledge and inform societal actions that are consistent with a transition towards sustainable development. The GMW SRN seizes the opportunity to directly connect and leverage $40 million of NSF investment in the Maine and NH EPSCoR programs that focus on sustainability science research and the dynamics of social-ecological systems and services. Additional leverage includes research funded by NOAA (e.g., National Estuarine Research Reserves; Sea Grant, Climate Program Office), NSF (e.g., Long Term Ecological Research and National Ecological Observing Network), EPA (e.g., National Estuary Program), and USDA. While there is a growing body of research across the GMW related to particular sustainability issues, the SRN will play a vital role in facilitating specific and intentional cross-disciplinary interaction that will simultaneously extend disciplinary efforts and transcend theoretical, methodological, and epistemological boundaries to enhance the communication and use of scientific knowledge.

In addition to reflecting a changing climate (Wake et al., 2008), over-arching spatial and temporal variations in landscape change provide an integrative template for understanding and developing place-
Based solutions to our four grand challenges. Given its inclusion of three US states (ME, MA, and NH) and two Canadian provinces (Nova Scotia and New Brunswick), the GMW affords consideration of landscape dynamics in contrasting federal and sub-federal governance systems; private and public land ownership patterns; urban, suburban, and rural systems; and ecological and economic shocks. Comparing the home-rule governance structures across three New England States (upwards of 1,000 cities and towns) with the provincial structures in Nova Scotia and New Brunswick allows for tests of the influences of governance scale on vulnerability and resilience. Recent scholarship in political science suggests that place-based research, especially analyses that incorporate cross-case comparisons across governance structures, can also inform our understanding of global scale processes. For example, research suggests that governance structures similar to those found in the GMW, characterized by multiple governing authorities with considerable independence to produce norms and rules within specific domains, may be associated with environmental benefits at multiple scales (Ostrom, 2010). Similarly, scrutiny of urban-rural interactions and landscape change enables testing of competing hypotheses about generalizable and contextual patterns of responses to societal challenges; assessment of the sensitivity of coupled natural-human dynamics to social, biophysical, and technical infrastructure networks; and feedback loops between demographic shifts, landscape change, and ecosystem change, as shown in Fig.1. Similarities and differences across the communities of these areas create significant potential for cross-case comparisons, learning, and exchange with respect to the four grand challenge areas described below.

(i) Food Security

A social movement for a sustainable food system in New England is well underway, with a goal to produce 80% of healthy calories from locally sourced food by 2060 (Food Solutions New England, 2011). However, agricultural expansion in the GMW can profoundly alter ecosystem functions related to flows of nutrients, water, carbon, and energy through ecosystems and across watersheds, with consequences for the sustainability and resilience of coupled natural-human systems. Local food economies (e.g., fisheries, dairy, agriculture) have deep historical roots in the GMW, and are currently witnessing renewed growth. However, affordable, locally-grown food remains beyond reach of many residents. Several research teams are currently studying different facets of the food system, but these efforts remain fragmented, and the SRN will play a vital role by catalyzing their integration. For example, researchers have identified, categorized, and mapped food insecure areas in NH, access to types of food providers, and diet-related morbidity and mortality. Data on the perceptions of vulnerable populations with respect to food access, physical infrastructure and attributes of the built environment, and alternative food production models (e.g., a USDA funded, tribally owned farm) is also being collected by researchers in NH and ME, respectively.

Another emerging issue that cuts across the four grand challenges is related to meeting the growing demand for locally produced food in the GMW, while ensuring the sustainability of multiple ecosystem services to both urban and rural populations including energy provision. Conversion of forests to agriculture could transform New England’s forests from their current role as net carbon sinks to net carbon sources, with positive feedbacks on climate warming (Zheng et al. 2011), while intensification of agricultural production could lead to greater export of nutrients and sediment and declining water quality (Alexander et al., 2008).

Other researchers have been working closely with local fisheries groups and aquaculture associations to assist in marketing their products and to identify hotspots for biological mercury levels that include the southern coastal region areas of NH and ME (Evers et al. 2007). Exploring new ways to combine and visualize data from the various efforts described above would build a strong foundation for innovative, interdisciplinary analytic approaches, including systems modeling, multi-level modeling, and participatory modeling (Daniell, 2006), that have not been possible previously due to lack of interdisciplinary model inputs at appropriate spatial and temporal scales. Tradeoffs between food production and ecosystem services have not fully incorporated important social data inputs, such as the dual threats of obesity and food insecurity that can coexist at the household, neighborhood, municipal, and even broader levels. Many natural science models do not fully incorporate rich contextual data on perceptions of persons who are ultimately affected by the systems under study, and whose values, beliefs, and behavior are key components of generating sustainable solutions and viable policy recommendations. Similarly, social and health scientists rarely have access to comprehensive, integrated place-based data on environmental trends, such as changes in land use and land cover, physical
infrastructure, and climate change, that influence human exposure trajectories and may contribute to our understanding of dynamic disease patterns. These data limitations have constrained analytic approaches in epidemiology and other social sciences, which have largely relied on linear, regression-based models to study non-linear, complex systems. Integrated data inputs and a more comprehensive methodological toolbox will not only facilitate social learning across the SRN (Newig, 2005; Reid, 2010), but will simultaneously increase the potential for more credible, relevant scientific outputs that resonate with diverse end-users. For example, SRN outputs can inform the Nutrition and Obesity Policy Research and Evaluation Network (NOPREN), a national thematic research network funded by Centers for Disease Control and Prevention to conduct transdisciplinary nutrition- and obesity-related policy and environmental research. Our existing partnership with Harvard University’s NOPREN team will ensure this link.

(ii) Water for the Future
The GMW is rich in water resources, and has a history of large scale human intervention that spans four centuries. Water infrastructure in the region includes separate and combined sewer systems, hydropower, water supply reservoirs, groundwater extraction, abandoned canals, waste water treatment plants, stormwater drainage systems, thermal power plant cooling, limited but growing irrigation, and water for recreation. These engineered services coupled with increasing demand and changes in land use and climate have overwhelmed the natural hydrologic and environmental cycles upon which they ultimately depend. Water stresses such as surface and groundwater pollution, low flows, flooding, and stressed ecosystems are now occurring. Moreover, the growing low income, recent immigrant communities in the watershed are bearing a disproportionate amount of the stress. Management of these stresses will require a multidisciplinary coordination with the other research themes, which all have significant implications for water demand.

Governance and regulation of water resources is fragmented among a variety of agencies and local governments, each charged with a specific mission (e.g., protecting ground water, supporting fisheries, reducing flood hazards, reducing pollution). Many of these functions support each other, but others, such as human and ecosystem supplies, are often in conflict, and research related to resources commonly focuses on a single aspect or outcome. Successful watershed-based planning requires institutional and human behavior changes and synthesis of information and data about natural and social phenomena. Our ongoing research into the human dimensions of watershed management, such as environmental justice and obstacles and incentives to adaptation to climate change, will benefit from the increased interaction with researchers investigating social and economic drivers of changes in watersheds, the economic consequences of decision-making, the societal metabolism of water in different economies and implications of significant local food production.

A growing body of research examines land use practices and the resulting impacts upon hydrology, water quality, and habitat integrity. Altered urban hydrology and urban watershed renewal are core concepts being examined for multi-parameter stressor responses. Examples include contributions of land use management strategies and green infrastructure to flooding resiliency under present and future climates and influences of urban renewal efforts, demographic change and land use/land cover change on watershed and ecosystem response. This knowledge is a central component for the development of remediation strategies for the existing built environment and for minimizing impacts from new development in communities (Roseen et al, 2011). The GMW SRN will provide the tools and related research to accomplish this.

Another cross-cutting research theme in the GMW is the relationship between urban and rural areas, and local versus distant ecosystem services. Rural areas provide sources of clean water for water supply and recreation, water for cooling of thermal power plants, and, in some cases, rivers or coastal areas to assimilate wastes; they also support livelihoods of extractive economies and are rapidly changing demographically. Moving both areas towards sustainability will require more urban water re-use (Daigger, 2009) and associated decrease in stresses on ecosystems.

All of these research areas will be connected using the principles of Integrated Water Resources Management, a participatory planning and implementation approach to making management and development decisions for water resources. It considers potential effects on all of the different yet interdependent uses of water resources. It builds on a foundation of stakeholder input to identify and address the needs of a sustainable environment and the many different and competing social and economic interests and relies on data and information about populations, economies and values in
addition to physical science and engineering (US Council on Environmental Quality (2009), USAID (2002), CA DWR (2009)).

(iii) Energy Development
Numerous public-private partnerships are currently underway that position the GMW as a research leader in wind, tidal, and biofuel energy. Successful development of these new energy sources and technologies, however, usually requires understanding by citizens. On the supply side, production of new energy sources can provide significant local economic benefits, but may also entail real or perceived social (e.g., new biofuel facilities may increase traffic and reduce tourism) or environmental (e.g., wind turbines can kill birds and bats; service roads increase erosion) costs. On the demand side, consumers need to be educated about the usefulness, economic benefits or significant external benefits (e.g., environmental or fuel security benefits) that new energy technologies may provide. Providing a secure and sustainable energy future from local and broader social and ecological perspectives requires synthesis of information from many disciplines and the productive co-learning that a robust researcher and stakeholder network can provide. Our goal is to use a sustainability science approach that integrates physical sciences, social sciences and engineering to better understand the barriers and the catalysts that surround energy production and consumption. Our SRN leverages significant progress already being made in GMW wind, tidal and biofuel development. We will use integrated methods to understand the social, economic and biophysical tradeoffs and barriers to renewable energy development in the GMW. Empirical data necessary to make informed decisions at all levels (citizen to policy-maker) will be provided through an integrated social science/engineering approach to all aspects of energy development. The project will also increase knowledge of how citizens evaluate technological solutions to sustainability problems, and how to better communicate the science associated with potential solutions to complex societal grand challenges.

(iv) Societal Metabolism in a Resource-Constrained World
A key determinant of sustainability relates to the throughput of materials and energy in economies and societies, with a clear relationship between GDP and mass/energy flow (Bringezu et al, 2004). Wealth brings with it the ability to purchase goods and services which have energy and material requirements, while resource constraints combined with global change may disproportionately affect disenfranchised populations least able to adapt. Material and energy metabolism may vary significantly by industry type (e.g., societies with an economic base associated with forest harvest products with those dependent on knowledge-based services) while geographical distribution of material and energy use may also vary considerably (e.g., most of the material and energy associated with computer use may be in other countries where the raw material extraction and processing occur). We propose to develop the methods to permit mass and energy flow analysis of regional, place-based economies and societies, and to apply these methods along wealth and economy-type gradients in the GMW. This research relies on traditional methods of industrial ecology but requires data from many different disciplines to succeed (Ayres, 1994).

Method development focuses on the use of demographic and economic data to downscale national level data on material and energy flow associated with industrial sectors and to upscale finely resolved flows that have been developed for individual industries or business types. Specific materials evaluated in this work will depend on the interaction with stakeholder groups but may include timber and forest products and derivatives (e.g., carbon), geological materials, major commercial elements and compounds, major industrial chemicals, water, and energy sources. Scenario analyses for future conditions will be cross-cutting with the other grand challenges; some examples that may result include major shifts in local food production, changes in types of economy (forest products vs. eco-tourism vs. high-tech. manufacturing), and community wealth.

(v) Network Evaluation
Rigorous evaluations are recognized as being critically important to sustainability and natural resource management (Conley and Moote 2003; Mandarano 2008). Thus, a fifth and overarching research theme will consist of an innovative evaluation designed to test whether a research network that connects university researchers with diverse external partners enhances key indicators of social capital and collective efficacy (Lin,1999), and whether these in turn are associated with outcomes consistent with adaptive capacity (Pretty, 2003). Social network analysis (SNA) is an established social science research
tool that is increasingly being applied to the study of researcher-stakeholder relationships to increase K-A capacity. While scholars have promoted sustainability science as a solutions-driven endeavor that inherently requires transdisciplinary research, there have been few studies of social capital creation in sustainability science, either among researchers, among stakeholders, or between researchers and stakeholders. Our evaluation will specifically test whether the SRN generates measurable differences in social ties over time, reflecting changes in bridging social capital (Woolcook, 1998).

SNA will be used to evaluate the entire SRN as well as the sub-networks associated with each grand challenge. To identify researchers and stakeholders, we will use a positional boundary of the network and multiple control groups of non-SRN research networks, combined with a pre-post, mixed methods design. Measures of density, centrality, and broker indicators will be used to analyze the connectedness, patterns in information sharing, and strength and weaknesses of relationships. We expect that linkages between actors and institutions will increase as the SRN evolves, creating more opportunities for collaboration and knowledge sharing. This can lead to greater reciprocity, mutual understanding, shared values, and trust, which can in turn enhance innovation, resilience, and adaptive capacity. The SNA will be used within a developmental evaluation process (Patton, 2010) that will iteratively monitor the SRN’s goals, inputs, outputs, and outcomes, allowing the evaluation to adapt to the emergent properties of the SRN itself, and enabling the SRN to adjust and improve in “real-time” based upon the evaluation.

Two important aspects of our evaluation approach further increase its relevance to a broad community of stakeholders. First, results related to on-the-ground decisions, as well as more abstract results (e.g., perceptions of scientific rigor) will be validated by stakeholders who can attest to the specified attributes (CGIAR 2006; Corley, 2007). We will assess whether joint production of knowledge between scientists and decision makers results in research that is viewed as being more credible, salient, and legitimate (Rowe et al. 2009). Second, we will incorporate participatory action research (PAR) methods (Gray, 2010) derived from the social science, education, and public health literatures, to engage underrepresented groups who have historically been excluded from decision-making processes (e.g., women, lower income individuals, racial/ethnic minorities). PAR has emerged in recent years as a significant methodology for simultaneously evaluating interventions and facilitating adaptive capacity within communities (Goodman, 1998).

3. INTEGRATION OF RESEARCH AND EDUCATION

To address sustainability’s complexity and intergenerational ethical obligation, the GMW SRN will integrate research with formal and informal education in several novel ways (Miller et al., 2011; Jones et al., 2010). The SRN’s formal education efforts will reach K-12 through undergraduate students, and will provide innovative, cross-institutional opportunities for masters and doctoral student training through interdisciplinary, team-based coursework. SRN faculty and key stakeholders will co-advising and serve on masters and doctoral committees from partner institutions to foster cross-institutional mentorship. The SRN will leverage NSF’s significant investment in cyberinfrastructure through our EPSCoR funded projects to offer cross-institutional classes, seminars and training, and will integrate undergraduate students, especially from underrepresented and disenfranchised backgrounds, to participate in cross-generational research teams building upon the existing undergraduate research programs at UNH and UM. Additionally, several multi-institutional undergraduate classes will be offered via innovative curriculums that include distance learning. The project will develop novel “mutual mentorship” models (Scocnelli & Yun, 2007), in which multiple people serve as mentoring partners in non-hierarchical, collaborative relationships. This mutual model enables faculty to draw on the diverse range of experiences and knowledge of many team members while contributing as a mentor to others. The project will develop, test, and distribute a rich media library of sustainability curriculum resources for undergraduate students that is built upon the research and outputs of the SRN. Curriculum resources, including digital, adaptable tutorials and case studies, will be shared publicly using the Digital Commons under a creative commons license. Formal K-12 educational efforts will develop relevant materials aligned with state curriculum standards to integrate experiential learning models about GMW in collaboration with on-going efforts.

The SRN will integrate informal science education efforts that engage citizens and communities through collaboration with programs across the GMW region, including Acadia National Park, Seacoast Science Center and Mount Washington Observatory, after-school programs like Boys & Girls clubs and 4-H, and summer camp programs. These programs serve many underrepresented groups and will provide hands-on experiences for learning about sustainability; recruiting efforts will be leveraged by joining
networks developed by ME and NH EPSCoR. Based on NSF EPSCoR Communicating Science workshops, we will deliver ongoing workshops for faculty and student participants to learn best practices in communicating scientific results to public audiences, and will foster co-learning opportunities between all levels and facets of the SRN (Mooney & Kirshenbaum, 2009).

4. LEADERSHIP TEAM MEMBERS

University of New Hampshire:

Dr. Cameron Wake (PI) is an expert in regional climate change, sustainability science, engaged scholarship, and directs Carbon Solutions New England, a public-private partnership that promotes collective action to achieve a clean, secure energy future. He will provide leadership for the entire project and the leadership team and will contribute directly to the Water research theme.

Dr. Semra Aytur is a social epidemiologist with expertise in interdisciplinary research on natural and human systems and health implications for vulnerable populations. She will provide leadership to adapt the conceptual framework and will directly contribute to the work on food security, social capital, and linking K↔A through participatory action research methods across all research focus areas.

Dr. Kevin Gardner is an expert in industrial ecology and life cycle assessment. He will provide leadership in the societal metabolism thrust and connection with the NH EPSCoR program.

Dr. Paul Kirshen is an expert in integrated assessment of water resources and also climate change impacts and adaptation related to water, urban infrastructure, and the coastal zone. He will provide overall leadership in interdisciplinary research and lead the Integrated Water Resources Management research.

University of Maine:

Dr. Kathleen Bell is an expert in the economics of land use and land cover change and spatial modeling of linkages between economic, social, and environmental systems. She will provide overall leadership in interdisciplinary research and lead cross-cutting land use and land cover research.

Dr. David Hart is an environmental scientist with substantial experience leading solutions-driven interdisciplinary research programs. He is currently the Research Project Director of Maine's Sustainability Solutions Initiative. Supported in part by a 5-yr., $20 million NSF-EPSCoR grant, this innovative program involves 100+ faculty from 30+ disciplines, 50+ graduate students, and 100+ undergraduates from 11 Maine universities and colleges working in partnership with diverse stakeholders to help solve sustainability-related problems in and beyond Maine.

Dr. Laura Lindenfeld’s research focuses on stakeholder collaboration and community engagement around sustainability issues. Her scholarship seeks to understand how research-based strategies for linking knowledge with action can help create solutions to pressing sustainability issues. She is also an expert in food, culture, and sustainability. She will provide overall leadership on the SRN's K↔A and sustainable food components.

University of Southern Maine:

Dr. Charlie Colgan is Chair of the Community Planning and Development Program and a regional economist with particular expertise in the Gulf of Maine. He will provide leadership in regional economics and also energy economics, where he is currently conducting research on transformative technologies for energy efficiency, particularly for transportation. He is on the core faculty team of Maine’s Sustainability Solutions Initiative EPSCoR.

Dr. Jack Kartez is an applied social and environmental scientist, professional planner, environmental mediator and trainer, and associate director of the U.S. EPA Region 1 USM-based Environmental Finance Center (EFC). Dr. Kartez’s role is to provide expertise in and lead workshops and scenario-based games as well as provide planning skills. He is on the core faculty team of Maine’s Sustainability Solutions Initiative EPSCoR.

Dr. Samuel Merrill is Director of the U.S. EPA Environmental Finance Center at USM. As such, he will contribute his expertise in community planning and climate change adaptation as a non-funded project participant.
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