**YEAR 2 ANNUAL REPORT OF THE
NATIONAL SOCIO-ENVIRONMENTAL SYNTHESIS CENTER**

Reporting on Activities from September 2012 to August 2013

Introduction

SESYNC (să-sink) is a national research center supported by a Cooperative Agreement from the National Science Foundation (NSF) to the University of Maryland (UMD). The Center funds the world's leading social and natural scientists to travel to the Annapolis facility and work intensively in transdisciplinary groups to advance fundamental research on socio-environmental (S-E) problems. The formal mission of the Center is to foster synthetic, actionable scholarship related to the structure, functioning, and sustainability of S-E systems.

The concept of a synthesis center is new to many people. Those familiar with other synthesis centers may find the concept of synthesis at SESYNC much broader than what they are accustomed to from past experiences. SESYNC serves scholars from a very diverse array of disciplines including, for example, environmental science, economics, sociology, psychology, political science, policy, planning, and design. The methods used by scholars in these disciplines are highly heterogeneous and their scholarly cultures differ tremendously. Given that SESYNC was formed to help bridge these differences, it is essential that we embrace epistemological diversity. This goal is reflected in the following definitions and the philosophy of service:

Socio-environmental synthesis is a research approach that accelerates the production of knowledge about the complex interactions between human and natural systems. The approach involves distilling or integrating data, ideas, theories, or methods from the natural and social sciences. This method may result in new data products, particularly ones that address questions in new spatial or temporal contexts or scales, but it also may involve evaluating textual or oral arguments, interpreting evidence, developing new applications or models, or identifying novel areas of study.

Actionable socio-environmental science is scholarship with the potential to inform government, business, household, or individual decisions that affect the environment and its ability to meet the needs of humans now and in the future.

SESYNC Goals

SESYNC's main goal is to accelerate the discovery of solutions to socio-environmental (S-E) problems. Our path to achieving this goal includes: 1. advance the S-E synthesis process (the Center as experiment); 2. provide the opportunity to a broad community through Center programs and structures; and 3. fully integrate Center activities and programs under a common framework. SESYNC organizes our activities under five overarching focus areas, each containing specific goals and objectives. We use this structure to help us set priorities, develop annual and long-term work plans, and provide the basis for assessments, both internal and external, over the next five years. Each focus area represents an essential commitment by SESYNC to meet the needs of our user communities and the many audiences we want to reach.

1. Scholarly Production of Knowledge through Synthesis

> GOAL I: Empower researchers from diverse natural and social science disciplines to advance discovery and problem solving related to the structure, function, and sustainability of S-E systems

> GOAL II: Advance scholarship and practical foundations needed to nurture and grow the capacity for environmental synthesis and its relevance to problem solving

> GOAL III: Foster synthesis innovation related to the structure, function, and sustainability of S-E systems

2. Education for Scholarship and Capacity Building

> Goal IV: Develop education programs that building S-E science synthesis capacity at a variety of levels

3. Enhancing Policy Relevance and Informing Decisions

> Goal V: Build and enhance the S-E science to policy link

4. Cyber-leadership and Scientific Support

> Goal VI: Build a sustained cyber-capacity and state-of-the-art IT infrastructure to support novel synthesis research

> Goal VII: Foster engagement with the cyber community and develop training and community-based efforts directed to advancing synthesis capacity

5. A Robust and Adaptable Administrative Infrastructure

> Goal VIII: Another main goal is the development of an assessment and evaluation plan structured by key questions and data collection. Data will be measured by output metrics, process metrics, and outcome metrics.

THE CENTER AS EXPERIMENT

Accomplishing our goals requires deep inter- and transdisciplinary interactions. Bridging disciplines is not easy, and many scholars have worked for decades on ways to promote inter- or transdisciplinary work. Additionally, fostering actionable science is an extremely difficult task. Because of this, SESYNC uses a structured engagement process for: 1. facilitating the co-development of Themes and associated questions that are of mutual interest to social and natural scientists, and have the potential to be actionable; identifying specific services (cyberinfrastructure, group facilitation, geospatial analysis, etc.) that accelerate each team's progress; and fostering synthesis and discovery across funded projects. To achieve these objectives the SESYNC leadership team and staff are actively engaged with the synthesis scholars whose projects we fund.

SESYNC is thus an experiment in the sense that we adapt and change based on an evaluation model that captures lessons learned along the way that can enhance S-E synthesis in the future. Given the short history of interdisciplinary research, and the even shorter history of studying team science, a reflexive experimental approach is best for capacity-building (Fiore 2008[1], Stokols et al. 2008[2], Lyall et al. 2011[3], Salas et al. 2012[4]). By using an adaptive organizational model, we hope to foster the continuing evolution of SESYNC to maximize progress by the S-E scholarly community and to grow the synthesis process.

Our approach to "SESYNC as an experiment" is based on developing sets of hypotheses on how to accelerate discovery of solutions to S-E problems. Since we believe that this over-arching goal requires growing the S-E synthesis _process_ and fostering _actionable_ science, many of our hypotheses focus on these core objectives. Since we wish to rapidly evolve and adapt to meet the needs of the community, we have adopted a developmental approach to Center management (Patton 2011[5]). This approach emphasizes learning from the work being done at SESYNC, and a formative evaluation process to guide our efforts at this stage of the Center's evolution. Assessing the desired outcomes that are associated with each objective is a long-term process that will ultimately require the use of summative evaluation approaches.

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[1] Fiore, S. M. (2008). Interdisciplinarity as teamwork: the science of teams. _Small Group Research_ 39: 251–277;

[2] Stokols, D. et al. 2008. The ecology of team science. Am J Prev Med 35(2S): S96–S115.

[3] Lyall, Catherine, Ann Bruce, Joyce Tait, & Laura Meagher. (2011). _Interdisciplinary Research Journeys: Practical Strategies for Capturing Creativity_. Bloomsbury Academic, London.

[4] Salas, E., S.M. Fiore, M. P. Letsky. 2012. _Theories of Team Cognition: Cross-Disciplinary Perspectives._ Routledge Press

[5] Patton, Michael Q. (2011). _Developmental Evaluation: Applying Complexity Concepts to Enhance Innovation and Use._ Guilford Press, New York.

Integrating All Activities

At SESYNC, we strive to integrate research with education, link knowledge to action (actionable science), associate outreach with policy or broader engagement, and incorporate cyberinfrastructure. For each of these four areas, we welcome unsolicited synthesis proposals at any time through our core programs (e.g. Ventures, Workshops, Fellowships), and we actively solicit synthesis proposals for fundamental research related to each area. The latter topic is particularly important given our goal of growing the *process of synthesis*—how individuals and teams "learn" to synthesize across disciplines.

SESYNC's commitment to actionable science involves the integration of "knowledge users" into our practices and programs. Knowledge users are diverse, and come from government agencies, NGOs with on-the-ground conservation and environmental management missions, multi-lateral aid, development, and environmental agencies, philanthropies, and the business community. Knowledge users are so-named, not because they are not researchers (in some cases they are), but because they reside in institutions whose missions require the application of knowledge. We deliberately integrate these users at the front-end of our programs, so that they can co-generate and plan the work we support within the research community. Additionally, knowledge users are represented on our External Advisory Board (EAB); have been a part of our strategic planning and Theme Identification planning meetings; and are targeted in meetings with groups like the World Bank, U.S. Department of Agriculture, NOAA, Army Corps of Engineers, U.S. Geological Survey, and philanthropies like the Packard Foundation. Our Venture and Pursuit programs reflect the extensive involvement of knowledge users as participants, and in some cases, principal investigators. As of April 1, 2013, 36% of our Pursuit, Venture, and Workshop participants, and 15% of our PIs, have come from non-academic institutions.

The primary focus of SESYNC's education agenda is to build capacity for S-E synthesis research and practice. We seek to identify the knowledge, skills, and attitudes necessary to excel at S-E synthesis both as individuals and as members of interdisciplinary teams, and to develop methods for improving S-E synthesis performance through education. We approach these goals by offering programmatic opportunities at various levels, catalyzing research on synthesis learning, developing an S-E synthesis research community through opportunities to practice S-E synthesis, and developing teaching tools to increase the exposure of students to S-E synthesis concepts and practice. Efforts toward the development of an S-E synthesis education research community have involved diverse groups of scholars around two essential questions: 1) what are the attributes of an effective S-E synthesis practitioner, and 2) what are strategies for teaching those attributes?

Examples of funded efforts include coordinated Workshop and Venture research projects that are synthesizing scholarship on how and why students learn to synthesize discipline-spanning information. This Venture is also developing in-class modules for the instruction of S-E synthesis and assessment instruments for measuring their impact. The development of these modules has been a powerful professional development tool as well, by increasing the sophistication of the faculty participants' understanding of S-E synthesis and their confidence in its use in their teaching and research.

A final example of SESYNC's high level commitment to advance the science of synthesis education through research is the recent request for proposals we posted under a new Theme: "Learning to Integrate across Natural and Social Sciences." This Theme is stimulating the formation of transdisciplinary Pursuit teams to synthesize information across the learning, information, and environmental sciences, on the theory and practice of developing key S-E synthesis skills.

SESYNC has an array of cyberinfrastructure services that not only facilitate, but also accelerate, the work of our supported participants and fellows. In brief, the services offered include: support for researchers needing on-site and remote access to state-of-the-art infrastructure for collaboration, data management and analysis, and high-performance computing. Through a formalized process of engagement, SESYNC also offers a significant level of individualized assistance with data access, management, and sharing, as well as assistance with issues related to interoperability, computational problems, software, and geospatial analysis. This process integrates cyberinfrastructure into SESYNC-supported projects, both by supplementing the technical expertise of project teams, and by soliciting PIs to think from the beginning about the data, computational, and staff resources they will need to generate desired research products. In addition to our standard collaboration resources and state-of-the-art video conferencing software, we have provided customized resources and/or in-depth consultation with multiple several groups. Examples of these activities include: establishing an ArcGIS server to allow groups to share and visualize spatial data layers; working iteratively with a group to configure a document repository for quickly categorizing and searching thousands of documents; and, assisting several teams with conceptualizing and coding a relational database which can be accessed directly by statistical software (R) and shared with natural resource collaborators. Additionally, SESYNC's has been awarded two supplemental NSF for cross-center cyber collaborations and to integrate cyberinfrastructure and education.

The founding partners of SESYNC (University of Maryland, University of Maryland Center for Environmental Science, and Resources for the Future—RFF) are active **institutional collaborators** in co-sponsoring activities and providing scholarly input and financial contributions to build the Center. The collaboration with RFF is quite deep with strong intellectual ties, active engagement with Center leadership, and co-sponsorship of events such as a workshop held in May 2013: "Ingenuity as a Response to Ecological Loss: Its Promise and Limits". Collaborations with the University of Michigan have been facilitated by Dr. Joan Nassauer. Education collaborations have included development of the S-E synthesis study co-led by investigators from the Cary Institute of Ecosystem Studies, Coppin State University, Gallaudet University, and Washington State University–Vancouver. Collaborations related to cyberinfrastructure extend beyond the two NSF supplemental awards mentioned above. A notable example is the collaboration with the Renaissance Computing Institute to conceptualize and prototype a software institute to accelerate discovery in water science and foster collaborations among software engineers and domain scientists. SESYNC also has significant international collaborations including the collaborative development of a synthesis Theme and funding opportunity co-led by the Helmholtz Centre for Environmental Research (UFZ), the Synthesis Unit (sDiv) of the German Centre for Integrative Biodiversity Research (iDiv), and SESYNC.

Overview of Funding Programs

SESYNC has developed a variety of integrated programs to support S-E synthesis. The structure of these programs allows us to make advances in areas of national and international priority, while accommodating the need for innovation and knowledge generation around emerging problems or opportunities. Our core programs involve individuals or teams of researchers working, both separately and in coordinated efforts, to help meet S-E challenges. We encourage links to policy and outreach. Integrated fellowships and educational programs are key parts of the programmatic structure. Additional details on each of these programs and application instructions are on our website, www.SESYNC.org.

- **Pursuits:** The range of important S-E questions SESYNC scholars can address is immense. Thus, we organize SESYNC's major research programs—**Thematic Pursuits**—around a series of rotating *Themes* that are co-developed by a diverse community of scholars, and potential users of that information, through a facilitated process. We hypothesized that progress toward addressing the key challenges associated with a Theme will be accelerated by having a portfolio of projects in which there is engagement and synergy between project teams. The portfolio should collectively lead to actionable science while fostering co-learning, sharing databases, and developing computational and visualization tools that may benefit multiple projects. Portfolios are meant to enhance the success of individual Pursuits while leveraging activities to achieve greater overall outcomes for a Theme. Ideally, a Theme: is important across scales and contexts; is tractable through synthesis; provides opportunities for fundamental scholarly discovery in multiple disciplines; has non-trivial social and environmental components; and has potential for societal impacts.

- **Ventures** are synthesis projects related to emerging issues and opportunities that are not related to an on-going SESYNC Theme. We encourage high-risk/high-reward or time-sensitive synthesis projects in this category, but are open to a variety of activities including, for example, the opportunity to develop innovative concepts and/or tools, new pedagogical research related to S-E synthesis, and testing theories of teaching synthesis.

- **Workshops** are single meetings focused on a broad topic, or set of related topics, during which up to 40 participants engage in one or more of the following activities: summarizing/synthesizing the state-of-the-art on the workshop topic; identifying future directions; exploring novel opportunities for synthesis; or developing educational or cyberinfrastructure products. Applicants describe how the Workshop could lead to actionable science focused on the sustainability of S-E systems or build capacity through education or cyberinfrastructure. Organizers engage young and diverse investigators, as well as those from disciplines, that have not typically interacted with S-E discipline researchers.

- **Short Courses** are on topics relevant to S-E systems, the synthesis process, data management and analysis, or cyberinfrastructure tools. Short courses held at SESYNC are typically 3–10 days, and SESYNC provides substantial support for participants.

- **Fellowships** are available for postdoctoral scholars, visiting or sabbatical scholars, and graduate students.

Accomplishments to Date

i. Major Activities:

To date, SESYNC has focused its efforts on implementing programs that actively engage and support an interdisciplinary community of scholars interested in addressing important environmental problems. We have built a programmatic and research infrastructure that meets the Center's original vision, while retaining the flexibility to adapt to meet the emerging needs of scholars who are conducting innovative synthesis research. Briefly, SESYNC has:

• Implemented broad outreach/engagement processes leading to the development of six thematically structured RFPs. Five of these have been competed resulting in the initiation of portfolios of synthesis projects (Pursuits). The Education RFP is in progress.

• Provided support for non-thematic synthesis projects (Ventures) that are responsive to emerging or urgent needs or special opportunities to develop new tools and approaches.

• Conducted a variety of topically-focused Workshops that have been both instructive and catalytic for participants.

• Proactively engaged social science scholars to focus on environmental problems by initiating a new program: Foundations for S-E Synthesis.

• Engaged a broad network of participants spanning wide disciplinary boundaries and established linkages to knowledge users who help co-define problems and opportunities for actionable outcomes.

• Implemented and adapted a highly iterative process to support and enhance innovation in these research projects and to support the team science needed to conduct them.

ii. Significant results:

Since its inception, SESYNC has received 96 proposals for synthesis projects across Pursuits, Ventures, and Workshops programs. Of these, 39 have received support, including 10 workshops initiated by SESYNC leadership and staff. The Center solicited proposals for 6 Themes to date. Proposals for the Education Theme are currently under final review. Center leadership and staff have also proactively initiated 6 Foundations of S-E Synthesis projects.

iii. Funded Synthesis Activities:

Pursuits:

- 2012T1-003: Evaluating relationships among human health and welfare, ecological condition and natural resource governance (B. Fisher, T. Ricketts)

- 2012T1-005: Creating a global database of how different populations within cities are dependent on freshwater ecosystem services (R. McDonald, D. Balk)

- 2012T1-006: Rural forest communities at a tipping point? Trends and actionable research opportunities (B. McGill, K. Bell)

- 2012T1-009: Synthesis to link understanding, planning, and management of urban ecosystems in China (W. Xiang. J. Nassauer)

- 2012T1-011: Urban ecological sustainability: Multi-level governance of water, energy and carbon in the Northeast mega region of the United States (S. Pickett, J. Connolly)

- 2012T2-003: Globalization of the live plant trade: Informing efficient strategies for reducing non-native pest invasion risk (R. Epanchin-Niell, A. Liebhold)

- 2012T3-003: How will businesses speak biodiversity? Novel and adaptive uses for ecosystem services data (S. Duncan, S. Elliott)

- 2012T3-004: Monitoring the direct links between ecosystems and people (H Tallis, B. Reyers, S. Andelman)

- 2012T3-005: Incorporating values and assessing social and environmental trade-offs in managing for ecosystem services (L. Olander, D. Urban)

- 2012T3-007: Solving the mystery of marine protected area (MPA) performance: Linking governance, conservation, ecosystem services, and human well-being (H. Fox, R. Pomeroy)

- 2013T3-008: Integrating biodiversity and ecosystem services into sustainable global climate mitigation scenarios (G. Hurtt, J. Edmonds)

- 2013T5-001: Towards socio-hydrologic synthesis: modeling the co-evolutionary dynamics of coupled human, water and ecological systems (T. Troy, M. Sivapalan)

- 2013T5-006: Social-ecological system resilience, climate change and adaptive water governance (B. Cosens, L. Gunderson)

- 2013T5-008: Climate change and water resources adaptation: Decision scaling and integrated eco-engineering resilience (L. Poff, J. Matthews)

Ventures:

- Founding Education Venture: Experiment in teaching the S-E synthesis process (A. Berkowitz, D. Hawthorne)

- 2012V-002: State policies to transform undergraduate STEM education in support of global sustainability (C. Middlecamp, M. George, J. Ramaley)

- 2012V-003: International Forestry Resources and Institutions (IFRI) research on forest social ecological systems for actionable science (A. Agrawal, P. Newton)

- 2012V-004: Using spatial data and analysis to understand the human impacts of ocean acidification (L. Pendleton, S. Cooley, L. Suatoni)

- 2012V-006: Linking biodiversity and ecosystem services: From expert opinion to prediction and application (B. Cardinale, E. Barbier)

- 2012V-009 (co-funded with NCEAS): Understanding how land-use change impacts the dynamics of vector-borne and water borne infectious disease of humans and domestic livestock (A. Dobson, N. Bharti)

- 2012V-011: Macroevolution of ecosystem services from trees (J. Cavender-Bares, S. Polasky)

- 2012V-012 (co-funded with NIMBioS): Integrating human risk perception of global climate change into dynamic earth system models (B. Beckage, L. Gross, A. Zia)

- 2013V-018: Advancing research on the perception, role, and function of urban green infrastructure by bridging the SESYNC synthesis process with an open community engagement process for software development (B. Minsker, S. Ahalt, L. Band)

- 2013V-019: Renewable energy from wastewater: A synthesis of the agricultural, energy, and transportation sectors and environmental tradeoffs (S. Gabriel, L. Olson, E. Gilmore)

Foundations for S-E Synthesis:

- 2012F-001: Sociological perspectives on non-state actors in environmental governance (D. Fisher and C. Sirianni)

- 2012F-002: The limits of environmental governance (A. Agrawal)

- 2012F-003: Large-scale natural resource conservation and restoration: Issues of governance (L. Scarlett and M. McKinney)

- 2012F-004: Time scales and the interplay between human response and management and ecological and ecosystem dynamics (A. Hastings)

- 2013F-005: Contributions of psychology to S-E problem solving (S. Clayton, P. Devine-Wright)

- 2013F-006: Food security, equity, and ecological sustainability: A multi-indicator, process oriented framework for food systems research (M. Jahi Chappell and H. Whitman)

Workshops:

- 2012W-002: Citizens science, butterfly monitoring & cyberinfrastructure (L. Ries)

- 2012W-003: Socio-environmental synthesis education: Goals, resources, & tools (D. Hawthorne)

- 2012W-004: Visualization technologies to support research on human-environment interactions (J. JaJa)

- 2012W-005: Learning exchanges for conservation: An examination of lessons learned (LExCELL) (L. Jenkins, S. Peckham)

- 2012W-006: Advancing tools and visualization techniques for representing modeled ecosystem service outcomes in simulated multi-player game environments (R. Costanza, L. Waigner)

- 2012W-007: Social networking and priority scholarship (R. Berndtson, J. Kramer)

- 2012W-008: Macro-evolution of ecosystem services (N. Kraft, W. Fagan)

- 2012W-011: Linking S-E science to S-E change (T. Miller, L. Olsson)

- 2012W-012: National Science Foundation cyberinfrastructure meeting (M. Palmer)

- 2012W-014: Creating a water science software institute (M. Palmer, B. Minsker)

- 2012W-015: Globalizing our understanding of rural land use change (J. van Vliet, E. Ellis)

- 2013W-016: Cyberinfrastructure coordination for multi-user research facilities: CI information exchange and cyber challenges working group (M. Smorul)

- 2013W-017: Cyberinfrastructure education in biology (M. Shelley)

- 2013W-019: SESYNC proposal writing workshop for graduate students (D. Hawthorne)

- 2013W-020: NAKFI Microbial Services/Keck Futures Initiative (C. Febria)

- 2013W-023: Linking local consumption to global environmental impacts (K. Hubacek and K. Feng)

Short Courses:

- Teaching S-E synthesis with case studies (C. Wei, B. Burnside, J. Che-Castaldo, D. Hawthorne)

- Interactive visualization tools for S-E data (M. Smorul, J. Jaja)

iv. Key outcomes or Other Achievements

SESYNC serves as a platform for a broad community of scholars and knowledge users. A key outcome from our first 16 months has been to engage a highly diverse research community who are now working with center support. Participants came from 163 cities and 17 countries, including 41 different states, plus Washington, DC, within the United States. Researchers came from 192 different institutions or organizations. Of participants reporting for both race and ethnicity, 85% self-characterized as Non-Hispanic/White, 6% as Non-Hispanic/Asian, 4% as Hispanic/White, 1% as Non-Hispanic/Asian and White, 3% as Non-Hispanic/Black or African-American, and 1% as a combination of the above including Native Hawaiian or other Pacific Islander.

For those participating in SESYNC's demographic survey, 37% of participants characterized themselves as natural scientists, 27% as social scientists, 7% as both natural and social scientists, and 21% as "other," with the remaining reporting a combination of or more than one of these selections.

SESYNC 's trans-disciplinary approach emphasizes active engagement of knowledge users. From data collected from January 2012 through March 2013, 72% of Center participants came from academic institutions, 17% from the non-governmental sector, 2% from business/industry, and 9% from federal or state agencies. Of the 28% of participants classified as knowledge users—those whose primary role is not to conduct research and who are more directly linked to decision

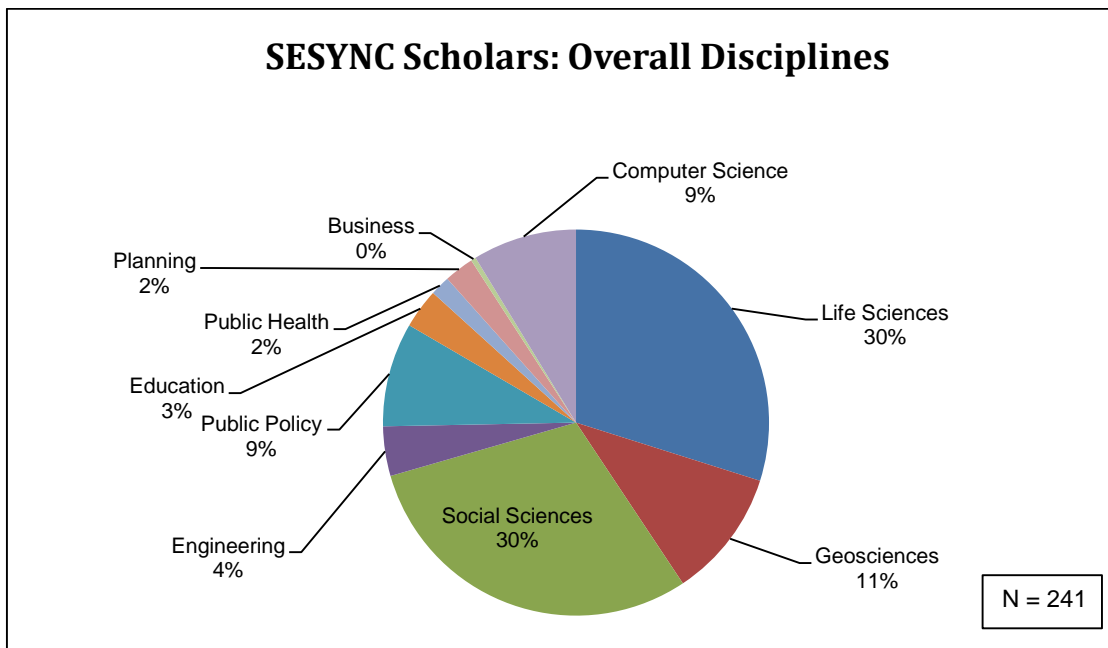making—60% were from NGOs, 32% represented government agencies, and 8% were from the business/industry sector.

Table 1. Demographics of Pursuit team leads and proposed team members

RFP	Team Leads (%)				Composition of Proposed Team (%)			
	Natural Scientists	Social Scientists	Male	Female	Natural Scientists	Social Scientists	Male	Female
Theme I*	63	37	78	22	55	45	61	39
Theme II*	44	56	56	44	48	52	78	22
Theme III*	62	38	93	7	49	51	61	39
Theme IV**	38	62	88	12	46	54	68	32
Theme V**	62	38	69	31	62	38	69	31
Theme VI**	47	53	21	79	45	55	49	51

 *Data from proposals receiving support   **Data for all proposals currently under review

A more detailed look at how participants self-report their disciplines shows considerable diversity with respect to the specific areas of scholarship. (See figures below)

SESYNC Scholars: Overall Disciplines

Computer Science 9%
Business 0%
Planning 2%
Public Health 2%
Education 3%
Public Policy 9%
Engineering 4%
Social Sciences 30%
Life Sciences 30%
Geosciences 11%
N = 241

SESYNC Scholars: Life Sciences and Geosciences

Earth and Environmental Sciences 20%
Biology 11%
Botany 1%
Chemistry 2%
Ecology 43%
Atmospheric and Oceanic Sciences 7%
Ornithology 1%
Entomology 2%
Conservation 13%
N = 99
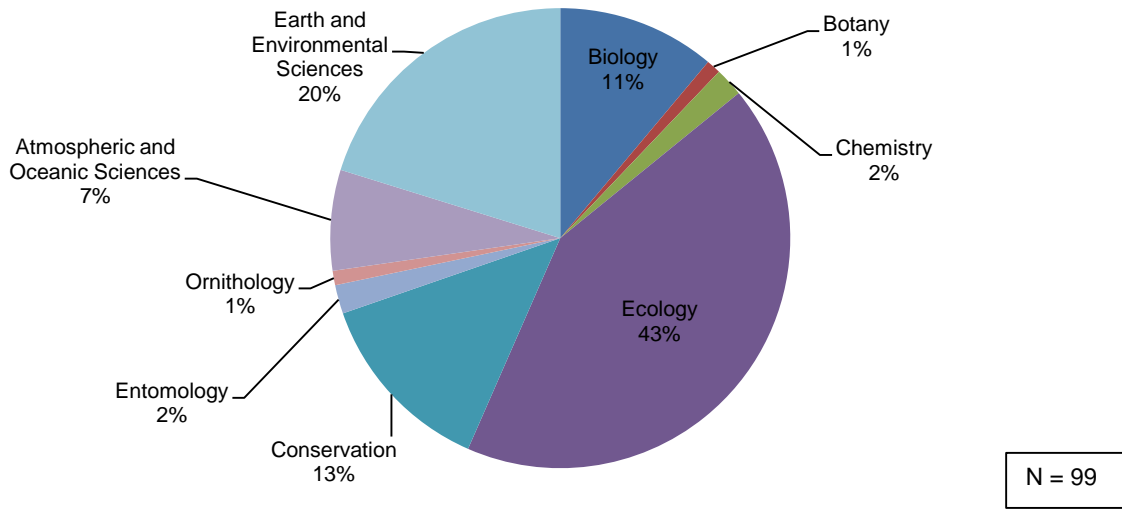
SESYNC Scholars: Social Sciences

Sustainability Science 7%
Anthropology 5%
Governance/ Political Science 4%
Ecosystem Services 6%
Sociology 15%
Economics 10%
Natural Resources and the Environment 6%
Environmental and Natural Resource Economics 18%
Science of Team Science 1%
Geography 25%
Demography 3%
N = 72