https://ntrs.nasa.gov/search.jsp?R=20120003434 2019-08-30T19:38:24+00:00Z

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

Southeastern Region
neon
National Ecological Observatory Network

Southeast Ecological Observatory Network (SEEON) Workshop on Ecological Sensors and Information Technology

Report of Second SEEON Workshop

Space Life Sciences Laboratory
John F. Kennedy Space Center, Florida
26-28 February 2004

Sponsored by
University of Florida
National Aeronautics and Space Administration, Kennedy Space Center, Florida
and
Dynamac Corporation, Life Science Services Contract, Kennedy Space Center, Florida

Workshop Organizers

Lori N. Jones, NASA, Kennedy Space Center
Dr. Michael Binford, University of Florida
Dr. C. Ross Hinkle, Dynamac Corporation

Southeast Ecological Observatory Network (SEEON) Workshop on Ecological Sensors and Information Technology

Report of Second SEEON Planning Workshop

Contents

Executive Summary

A fundamental goal of the new National Science Foundation (NSF) initiative National Ecological Observatory Network (NEON) is to provide timely and broad access to the ecological data collected at NEON sites. Information management and data collection will be critical components to achieving this goal and a successful NEON implementation. The Southeast Ecological Observatory Network (SEEON) working group recognized the importance of information management and sensor technology in its first planning workshop and recommended that interested parties in the region come together to discuss these subjects in the context of the needs and capabilities of a southeast regional ecological observatory network.

In February 2004, 28 participants from 14 organizations including academic institutions, state and federal agencies, private and non-profit entities convened at the Space Life Sciences Laboratory (SLSL) at the Kennedy Space Center, Florida for two days of presentations and discussions on ecological sensors and information management. Some of the participants were previously involved in the first SEEON workshop or other meetings concerned with NEON, but many were somewhat new to the NEON community. Each day focused on a different technical component, i.e. ecological sensors the first day and cyber-infrastructure the second day, and were structured in a similar manner. The mornings were devoted to presentations by experts to help stimulate discussions on aspects of the focal topic held in the afternoon.

The formal and informal discussions held during the workshop succeeded in validating some concerns and needs identified in the first SEEON workshop, but also served to bring to light other questions or issues that will need to be addressed as the NEON planning and design stages move forward. While the expansion of the SEEON community meant that some of the presentation and discussion time was needed to help bring the newcomers up to speed on the goals, objectives and current status of the various NEON efforts, the additional perspectives and technical expertise included in this workshop helped fuel some valuable interdisciplinary discussions that will need to continue to bring SEEON and NEON to fruition. Participants agreed that continued discussions of SEEON are needed to keep up the momentum and that the southeast region must continue to be represented at the national level. It is vital that the all the regions continue to push things forward for NEON to succeed.

Introduction

The fundamental goal for the National Ecological Observatory Network (NEON) is to provide timely and broad access to all ecological data collected at the NEON sites. Two important conclusions of the workshop on 16-18 October 2003, held at the Savannah River Ecology Laboratory Conference Center were to form a Southeastern Ecological Observatory Network working group (SEEON), and to hold a second workshop concerned with information technology (IT) and sensor technology needs for NEON/SEEON. The sixth workshop on NEON supported by the National Science Foundation (NSF), concerned with information management, suggested that 25-50% of the annual budget of each observatory, and 50-75% of the National Coordinating Unit (NCU), be devoted to information management. Much of the remainder of the budgets of each observatory will be spent on data collection, infrastructure implementation and maintenance. The two day workshop at Kennedy Space Center (KSC) on SEEON Sensor and Information Technology was initiated because of the critical role of information management and infrastructure in NEON as demonstrated in the recommendations from the previous workshops.

Workshop Goals and Structure

The two-day workshop included 28 participants, representing both ecological and technological disciplines (Appendix A).

The objectives of this second SEEON workshop were to:
1. To discuss the state of the art in environmental sensors, and NEON sensor requirements;
2. To describe current capabilities and expertise in ecological (IT) and sensors in the southeastern U.S.;
3. To learn of IT and sensor approaches and advances in other regions;
4. To propose productive pathways to effective IT and sensor technology deployment;
5. To develop a report that describes current capabilities and future efforts for IT and sensors in a SEEON/NEON.

Prior to the workshop, participants were urged to read the second and sixth reports of NSF-supported workshops, the National Research Council (NRC) report on NEON, the Report of the First Southeastern NEON Planning Workshop held at Savannah River Ecology Laboratory (SREL), and the recent solicitation (NSF 04-549) from the NSF for the National Coordinating Consortium.

The workshop consisted of morning presentations from experts in sensors, sensor webs, and information management, followed by afternoon task groups focused on specific aspects related to sensor and cyber-infrastructure needs. The workshop agenda is given in Appendix B. The first day was focused on sensor and sensor web technology while the second day focused on cyber-infrastructure.

Sensor Technology Presentations

The first morning of the workshop there were seven formal presentations that covered aspects of sensor technology from both current and future systems. They were as follows:

1. Mike Binford and Ross Hinkle – This was a summary of recent activities from the NEON program especially the recent NSF activities/discussions, a statement of objectives for the

SEEON workshop, and a summary of the previous workshop discussions on sensor technology and information systems.

2. Steve Harper – This was a summary of the SREL workshop findings and recommendations which were focused on major ecological questions.

3. Sam Durrance – This was a brief summary of the history and planned development of a new sensor system to be put aboard the International Space Station. The project is being coordinated by the Florida Space Research Institute. The Station High-sensitivity Ocean Research Experiment (SHORE) will place a Multispectral Filter Array Imager to collect remotely sensed data through the Space Station Window Observational Research Facility (WORF). Opportunities and types of data that could be collected from NEON sites were covered with a discussion on the potential utility for meeting NEON objectives and needs for remote sensing and landscape analyses.

4. Robert Knox – This was an overview of the remote sensing technologies available, the types of data that can be collected and the current and planned platforms that could support NEON projects.

5. Tim Short – This was an overview of state-of-the-art in-situ underwater mass spectrometry and the various platforms that can be used to collect data. It included a discussion of autonomous and remotely operated vehicles that are being used and developed for environmental sampling.

6. Dan cooper-This was an overview of Raman LIDAR and its application to remotely measure evapotranspiration above a tree canopy in a natural system.

7. Kevin Delin-This was an overview of Sensor Web project technologies and included examples of specific applications. A demonstration was performed in which several sensor web pods were deployed in the conference room and communication between pods and room temperatures were monitored online in real-time. Information on Sensor Web can be found at http://sensorwebs.jpl.nasa.gov.

Ecological Sensor Breakout Groups

Three breakout groups focused on sensors for three domains of NEON ecology that were aggregations of the six "grand challenges" defined in the NRC report. The groups were designated to, at a minimum, have an ecologist, sensor expert, and data/information management expert as part of the composition of the group. A discipline expert was identified to lead the discussion within each group and other workshop participants were asked to join the group aligned with their interest or expertise. The three domains for discussion were Environmental Change (i.e. NRC challenges related to ecological implications of climate change and land-use and habitat alteration), Ecosystems (i.e. NRC challenge related to ecological aspects of biogeochemical cycles), and Species (i.e. NRC challenges related to biodiversity, species composition and ecosystem functioning, invasive species and ecology and evolution of infectious diseases). These aggregations were consistent with a diagram of the patterns and processes with which NEON is concerned and first presented at the SREL workshop (Figure 1).

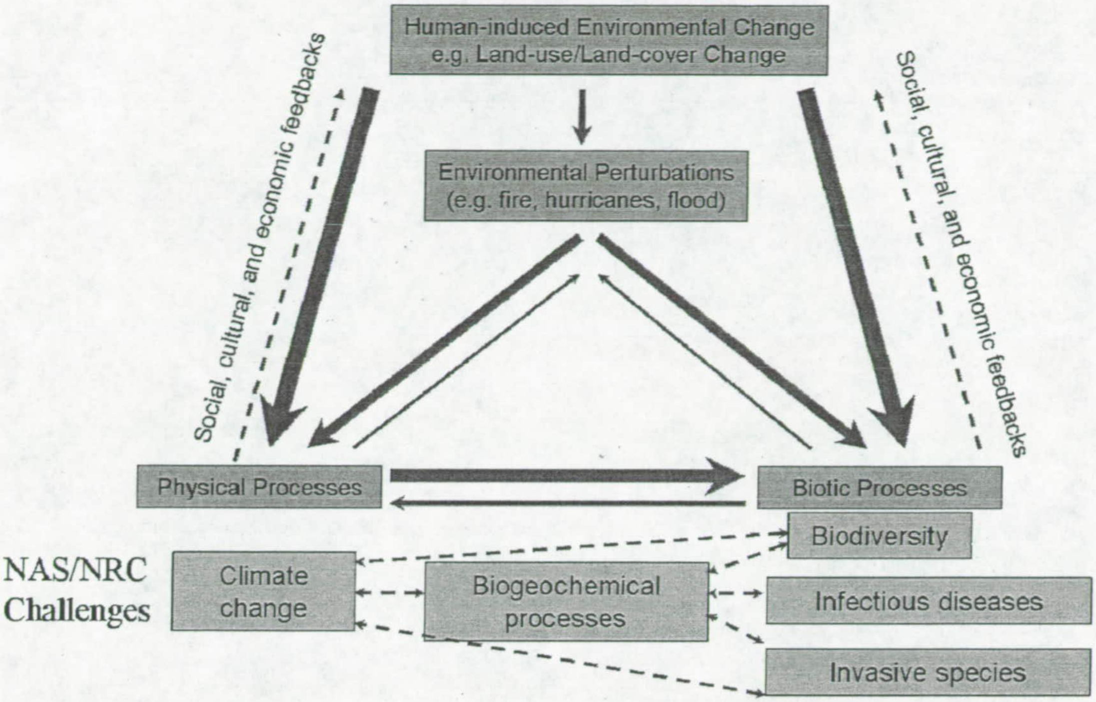

Fig. 1 Diagram showing NRC challenges in the context of current understanding of relationship between biotic and abiotic processes.

Species Breakout Group
Members: Hilary Swain (leader/facilitator), Kevin Delin, Jeff Harris, and John Porter.

This group was charged with addressing species monitoring and sensor needs in the context of the three grand questions related to biodiversity and ecosystem functioning, ecology and evolution of infectious disease, and invasive species. The group agreed that the current state of the art for species monitoring is "rather crude and pathetic" mostly technology poor. Measurements tend to be an inventory of things that provide a snapshot in time that are mostly point locations that are scale dependent.

Examples of measurements range from ecosystem microbial DNA profiles, to radio tracking collars with GPS capability, to acoustic/video arrays, to sentinel chickens for West Nile virus detection. There are a number of measurements that are needed but that are beyond our readily available detection systems (e.g. moth pheromones at very low levels). The group discussed the concept of "hijacking" biology as a means of greatly advancing detection systems, i.e. geo-bio-chemo-electromechanical sensors. This is seen as a high potential for sensor growth which is represented by systems such as bioluminescence sensors that are developed from the insertion of lux genes in microbes that are turned on by the presence of certain environmental parameters or chemicals in the environment. Another biosensor would be use of nematode movements (wiggling) to detect toxic gases. Many of these types of systems are lab based and not field tested. They are limited by longevity, triggering mechanisms to turn the system on and off, mechanisms to store and download the data, and quantification beyond just presence and absence of the detected item.

The monitoring and detection of infectious disease development, spread and impact to ecosystems is a mixed bag of techniques at different scales and different levels of resolution. There is a vast array of possibilities in technology that can be applied to this area. Remote sensing for red tide and algal blooms (individual species are difficult to detect from satellites) is already in use. Development is needed in the areas of biotelemetry (animal health as well as behavior), movement and location of plant pathogens (chemical sensing) to plant pests (sound detection of insects). How about bioluminescent canary plants that glow when certain enzymes associated with an environmental stress are turned on?

Biotelemetry has great promise for ecological monitoring, yet the systems are still relatively crude. They are still primarily systems that provide only movement/location data. There is need for the ability to continuously look at such aspects as body temperature, heart rate and other behavioral characteristics. Acoustic and/or video arrays also have great promise for the monitoring and tracking of species. There are still issues associated with bandwidth for video and data storage. The best of all worlds would be a network of biotic and abiotic sensors on the same network with centralized data acquisition and analyses.

The costs for the development and implementation of networks of biosensors is still relatively unknown but is expected to be very expensive. Many federal agencies have the need and are developing such sensors such as the National Institutes of Health in the biomedical community, the Department of Homeland Security for protection bioterrorism, and NASA in the search for extraterrestrial life.

Environmental Change Breakout Group

Members: Steve Harper (leader/facilitator), Bob Knox, Tom Powell, Alexis Thomas, and Allen Turner.

The group began with a discussion of what is meant by "environmental change". It was suggested that scientists need to be careful to explicitly define this term, as differences in perspectives and experiences may lead to misunderstandings of what constitutes change. This was believed to be especially true for those ecological systems that change slowly relative to human perceptions. With this in mind, we discussed major research questions, sensor needs, and information management goals within this broad topic.

Major Questions

How do we measure and quantify environmental change given that it is constantly occurring? Change is an ongoing process, and it becomes important to establish a baseline as a meaningful point of reference. However, it is not readily apparent which point in time (e.g., pre-settlement, pre-industrial, current) should be used for this purpose. Additional complexity is introduced when one considers that current changes are occurring within the context of historical changes. It was recognized that legacy effects and historical contingencies can influence current patterns and processes. How do we account for these unique trajectories of change? Spatiotemporal scales may influence what we even consider to be a significant change. Rising CO_2 levels, declining densities of large predators, and increasing habitat fragmentation are all examples of gradual, persistent changes that are occurring over broad scales; while such changes may be relatively subtle at any given location or time, their consequences may be profound and long-lasting, if not irreversible. Further difficulties in documenting environmental change arise when it is recognized that there are multiple types of change occurring simultaneously.

How do we incorporate socioeconomic factors within studies of environmental change? It was recognized that humans ultimately are the driving force behind many, if not all, of the major environmental changes of concern. For example, cultural aversion to fires influences forest management practices, property rights influence patterns of development, and market forces influence the type and extent of land-use practices. The group acknowledged that the expertise and knowledge of urban and regional planners, political scientists, and economists must be leveraged if we are to incorporate socioeconomic factors within an ecological observatory. Can we predict future land use changes? Again, an understanding of human behavior will be critical for predicting future change. It was discussed how there exist, at the county level, transportation plans projected out 20 yrs. into the future; while roads and other infrastructural changes obviously will influence the environment, plans for such changes are generally not taken into consideration by ecologists. Similarly, the group discussed how tax assessments and other useful information could be obtained from departments of revenue and other agencies to better understand and predict environmental change.

How do we assess the consequences of environmental change? We need to be concerned with documenting and quantifying the direct, secondary, and cumulative effects in the recent past, the present, and foreseeable future. As described above, this approach should include natural, cultural, and socioeconomic factors. We discussed how there are many types of environmental change occurring simultaneously, and the cumulative effect of these is likely not simply an additive function. Further, we recognized that there are both structural and functional consequences of change, but that it is not clear the extent to which these are interrelated.

How do we scale information collected to study environmental change? The group discussed the need to better relate information collected from ground-, aerial-, and satellite-based sensors. Considerable attention will also need to be focused on how project-based information can be scaled to the region, and how region-based information can be scaled to the continent and beyond. As an example, we talked about how improvements could be made for studying carbon dynamics. There is a need for new remotely-sensed metrics (i.e., better than LAI or NDVI) to understand carbon dynamics at broad scales, and one goal might be to determine remotely any ongoing stresses and system responses using hyperspectral information collected on a frequent basis. However, any remotely-derived metric must be validated in the field. Thus, it would also be helpful to have an automated, ground-based system to study leaf area dynamics to understand foliage light attenuation on a daily basis. How can the information collected at these two disparate scales best be integrated? While the scaling of information may be challenging, it is clear that significant advances could be applied towards understanding environmental change.

Sensor Needs

There is a need for those involved in establishing an ecological observatory to interact closely with scientists and engineers who develop sensors. It was hoped that the objectives of an ecological observatory might guide the development of future satellite-deployed sensors, but the likelihood of such a strong influence was questioned. We discussed how contracts will need to be established with commercial operations to obtain remotely-sensed information. In this case, it was expected that the needs (and finances) of an ecological observatory could influence the timing and extent of information able to be obtained from existing sensors.

There is a need to preserve existing information. Historic photographs and land records will provide important insight into how and why the environment has changed over time. A concerted effort to adequately archive this information, much less to make it accessible to researchers, is lacking. While not technically a sensor need, it was recognized that much of this information would be irreplaceable if lost. Similarly, there is a need to ensure the continued availability of existing remotely-sensed information; important systems such as Landsat should be maintained into the future (or new systems should be backward-compatible) in order to provide repeat coverage. Consistency is needed if we are to bridge diverse data sets and describe long-term changes.

There is a need to increase the spatiotemporal resolution of current sensors. For example, we discussed how advanced sensors are needed that can nondestructively estimate the aboveground biomass of individual trees; current estimates based on volume are ±25%, whereas ±1-2% would be more adequate for understanding carbon dynamics. The specific sensors that are needed to describe and understand environmental change will vary considerably depending upon the questions being asked.

Information Management

The group discussed the need to standardize data management to allow consistency and intercalibration among sites. An ecological observatory will need to adopt an industrial design approach, such as that employed by AmeriFlux, where there is well-defined data standardization and a mobile system for inter-site calibration. However, it was also discussed how data standards should act as a floor rather than as a ceiling, an approach that will allow the development and implementation of cutting edge technologies as they emerge. The group anticipated that it will be quite challenging for an ecological observatory to continually reinvent and replace existing infrastructure while simultaneously maintaining a coherent approach for information management.

Finally, we discussed the need for an ecological observatory to deliver relevant data products to a wide audience, including scientists, decision makers, and the general public. This will require the processing of huge volumes of data, an unprecedented situation for most in the ecological sciences. To this end we will need fast and reliable approaches for conducting QA/QC and managing information. Similarly, a powerful data engine will be required to glean, compile, summarize, and display information.

Ecosystems Breakout Group

Members: Jeff Luvall (leader/facilitator), Rosvel Bracho, Daniel Cooper, Manny Gimond, Christopher Romanek, and Tim Short.

The group spent much of the time identifying and discussing two of the most important questions to address in terms of ecosystem processes (i.e. cycling of water, energy & nutrients).

- How does ecosystem change affect the quality of human habitation?
- How do ecosystems respond to climate change and anthropogenic stresses?

The group then asked what current sensors were available to address these questions and identified many types of sensors for measurements of water, energy and nutrients. Sensors and measurements for water and energy exchange for both *in situ* and remote sensing applications include temperature, relative humidity, eddy covariance, LIDAR, satellite (e.g. AVHRR, Modis, GOES, ASTER), aircraft scanners (e.g. mutispectral visible/IR), rain gauges, and gauged weirs. Sensors for nutrient cycling (e.g. carbon and nitrogen) include LIDAR, LIBS (direct carbon), FTIR, and mutispectral visible/IR.

In the cases of the sensors mentioned, there may be good accuracy for discrete point in time, but poor spatial and temporal coverage. Spatial resolution for some sensors may be too coarse for ecosystem research applications. Costs may be high for the measurements in initial capital, operational and human terms. Limitations may be placed on the use of these sensors either because of spatial or temporal resolution, sensor cost or cost to access and/or process the data. There are problems with the current suite of sensors now and possibly in the future.

Federal agencies identified that may be sources of funding or are responsible for these types of sensors and/or applications include Department of Defense, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, National Science Foundation, and the Environmental Protection Agency. The ecological community needs to identify our remote sensing needs, and urge agencies to fill those needs. While we do not know that we as a community have the necessary weight to be successful, we do know that the only chance we have for success is to speak as a community with a clear voice.

Group discussions turned to looking at some sensor and measurement applications that are on the cutting edge when it comes to ecosystem research applications including LIDAR, carbon storage and fluorescence. When the group asked the questions "What would I like to measure?" one of the most important answers was carbon uptake, which now is mostly modeled. The direct measurements of carbon uptake by a system using remotely sensed data would enable a much better understanding of the carbon cycle.

Information Management Presentations

The second morning of the workshop there were four presentations that covered topics related to on of the most critical challenges inherent in a National Ecological Observatory Network: information management. The presentations were as follows:

1. Allen Turner- This presentation summarized the importance of NEON and identified some of the most important considerations in an endeavor of this magnitude: scale, scope, customers, evolution, and data. NEON presents many challenges that must be met, users must recognize that NEON is not just for them, and that by setting realistic goals and expectations, NEON can be successful.

2. Alexis Thomas- This presentation was an overview of the Florida Geographic Data Library and underscored some of the issues related to managing and disseminating large amounts of spatial data.

3. John Porter- This presentation summarized some of the challenges of ecological databases and lessons learned form Long-Term Ecological Research information management.

4. Billy Payne and Mark Provancha- This presentation was an overview of the efforts of the KSC Earth Systems Modeling and Data Management Lab in migrating and integrating the large and varied ecological, environmental, and spatial data sets into a data management system.

Cyber-infrastructure Breakout Groups

The second day two breakout groups focused on cyber-infrastructure. The model for discussions of cyber-infrastructure was a regional NEON with multiple "satellite" data collection sites connected to "core" facilities. Two groups were identified along with leaders to focus the discussions in the afternoon breakout sessions. One group was charged to design a regional cyber-infrastructure for a "core" facility while the other group was to design the cyber-infrastructure for a data collation "satellite" site. The other workshop participants were asked to join the group that better aligned with their interest or expertise.

Satellite Site Breakout Group

Members: Joseph Delfino (leader/facilitator), Dan Cooper, Kevin Delin, Manny Gimond, Jeff Luvall, Tom Powell, Tim Short, Allen Turner, and John Weishampel.

The initial discussions centered on the scope and detail of effort that should be provided at the SEEON sites. The group agreed that SEEON sites should have a combination of "core" sites and "satellite" sites and that there should be two levels of activity. Level 1 activities include measurements at core and satellite sites involving intensive, continuous data collection at a high frequency. Level 2 activities involve periodic data collection at high intensity with extensive resource needs. Much of the discussion revolved around types of measurements at these two activity levels.

Level 1 Activity

The purpose of the level 1 activity is to obtain uniformly distributed data sets at all core and satellite sites. Measurements to be made within each medium are identified in the following list.

<u>Atmosphere</u>

- solar radiation
- PAR
- temperature, precipitation, relative humidity, wind (measure vertical profiles – radiosonde, etc.)
- dry deposition

<u>The Atmosphere/Lithosphere interface</u>

- evapotranspiration
- net radiation

<u>Hydrosphere</u> (wherever possible, water and gas fluxes should be measured, as appropriate)

- Wetlands
    - wet/dry cycles
    - soil and plant delineation
    - albedo/reflective characteristics

- Surface Waters (lakes, streams, rivers, springs, and coastal/estuarine environments)
    - trophic level [nutrients, chlorophyll a; calculate index?]
    - water quality parameters
    - watershed characteristics
    - flow characteristics (USGS data)

- submerged aquatic vegetation: characteristics (type, map)
- emergent aquatic vegetation
- albedo/reflective characteristics
- salinity
- If the Savannah River should be incorporated into a SEEON network, then artificial and natural radioisotopes should be measured – as tracers.

Biosphere

- biomass: height, age, cover
- land cover classification/land use
- leaf area index
- species composition
- topography
- fire management units/managed burning frequency
- canopy characteristics
- albedo/reflective characteristics
- ecological dynamics

Lithosphere

- soil map
- soil moisture
- soil chemistry (pH, conductivity, nutrient status)
- general soil hydrology
- ground water quality (well logs, water quality, soil cores)
- soil porosity and transmissivity

Urban Environment

- land cover/specific uses
- impervious areas (percent cover)
- runoff
- transition from high to low density; impact?
- zoning plan (planned disturbance)
- past/current/future development projections
- albedo/reflective characteristics
- land use/transportation infrastructure
- surface thermodynamics (heat exchange)
- the urban fringe

Rural Environment

- agricultural activity
- crop types/yield/rotation
- animals
- fertilizer/pesticide use
- zoning plan (planned rate of disturbance)
- past/current/future development projections
- land use/transportation infrastructure
- albedo/reflective characteristics
- surface thermodynamics (heat exchange)

To obtain much of the data listed above, the use of remote sensing via aircraft and satellite technology is assumed. Spectral analysis, albedo, etc. need to be connected among land, water and biomass sectors.

Information Technology Infrastructure/Data Access

- employ micro IT sensor webs (as demonstrated in Kevin Delin's presentation.)
- establish a central data facility for archiving data and to facilitate information and data dissemination
- satellite sites should "mirror" core sites, and transmit data to dedicated core sites
- data sets need to have accompanying metadata
- hierarchical data format (HDF) should be employed for data inputted to a core site and extracted/transmitted from a core site
- quality assurance/quality control needs to be established at the onset of data collection, storage, etc.
    - documentation is mandatory
    - integrate SEEON QA/QC with NSF QA/QC initiative
    - SEEON levels of authentication need to be established
    - there needs to be redundancy and resiliency
    - employ local standard time for record keeping
    - screening software needs to be provided for data review
    - peer review spot checking and field audits need to be done
    - data need to be flagged based on established QA/QC confidence levels and specific criteria
    - the data flow will ultimately on depend on cost factors, demand, etc.

Level 2 Activity

The Level 2 activities will be experimentally driven and site specific with its own unique infrastructure needs. Measurements to be made within different mediums and at core and satellite sites are indicated in the following list.

Atmosphere

- Core site
    - Level 2 activities may include the Level 1 activities listed above plus specific instrumentation for site unique experiments. Specific sites will have unique identities. It is possible that "mobile" sites could be developed, depending on the design of the experiments.
    - atmospheric chemistry plus physical monitoring

- Satellite site
    - site specific atmospheric measurements. The discussion group did not want to go any further into detail at this level, preferring to leave such details to the principal investigators who will ultimately use a site for their research.

Atmosphere/Lithosphere interface

- Core site
    - Level 1 activities plus
    - energy/mass flux
    - deploy sonic anemometer
    - monitor 3 dimensional wind field
    - AmeriFlux-type measurements: carbon dioxide and water vapor

- Satellite sites
    - Site specific activities will depend on depend on planned experiments.

Hydrosphere

- Core site
    - Level 1 plus
    - higher order instrument capability (this may present issues regarding ownership and priority of use)
    - plankton/nekton/plant characterization
    - aquatic biota taxonomy

- Satellite site
    - Site specific activities will depend on planned experiments.

Biosphere

Core and satellite sites will include Level 1 activities plus additional ones driven by planned experiments and site specific needs.

Lithosphere

- Core site
    - Level 1 plus
    - microbial ecology and taxonomy
    - long term and short term carbon pools
    - soil heat flux
    - vertebrate/invertebrate organisms assessment and flux
    - higher organism assessment
    - biomass measurements
    - characterize biogeochemical cycles

- Satellite sites
    - aquatic biota taxonomy: algae, plants, zooplankton, etc.

The group also discussed some issues related to developing and implementing SEEON/NEON cyber-infrastructure that should be considered in further planning. Below are issues and questions deemed important:

- Costs of establishing core and satellite sites will be high and depending on levels of funding that may eventually be available. Prioritization of scientific measurements, frequency, IT infrastructure, etc. will become critical to the success of the SEEON venture.
- Mechanisms need to be developed for establishing connections between the core site and a satellite site
- Once a network among core and satellite sites has been established, how should new cooperating satellite sites be integrated into the network?
- What type of protocol is needed to approve a core site and its operations?
- How will ownership of the sites be established?
- Data ownership will need to be discussed and resolved. How long with the actual core or satellite site operator be entitled to sole use of any data before releasing to it the network and collaborating scientific community?
- A follow-up SEEON Workshop should discuss mechanisms of coordination among SEEON efforts and state and local agencies.

Core NEON Facility Breakout Group

Members: John Porter (leader/facilitator), Steve Harper, Jeff Harris, Bob Knox, Billy Payne, Chris Romanek and Alexis Thomas.

The "Core" group was charged with developing a model for cyber infrastructure at the SEEON "core" site. The group identified the functionality we expected to be provided by the "core," discussed different models for a "core" site (distributed and centralized), and identified personnel requirements to meet functional objectives. The discussion within the group was wide ranging. Much of the discussion took the form of enunciating the "visions" of the individual group members from the perspectives of both data contributors and data users. Once these visions had been presented, common elements were identified and discussed.

The specific functions the "core" would be expected to fill are:

- **Establish standards** – Standards that would need to be developed include: metadata, georeferencing, data formats, and frequency of collection and submission of data. The core should establish these standards in collaboration with both the national-NEON level and with sites at the satellite level. These standards would be living documents and would be refined and modified over time.
- **Quality Assurance and Quality Control (QA/QC)** – When data is submitted, it must be subjected to a rigorous QA/QC analysis of both the metadata and the data. Suspect data would be flagged or returned to the contributor for revision. A sufficiently rigorous QA/QC inspection would constitute an automated form of peer review, with data of poor quality being rejected.
- **Develop a Data Catalog and Query Capabilities** – The core will need to be responsible for cataloging and making searchable submitted data. A variety of query forms will be required, such as intelligent subject-based queries (e.g., google.com), seamless, sophisticated spatial and temporal queries (that include ways to deal with issues of grain, extent, and continuity) and visualization browse tools (e.g., animations, graphics). Basic and advanced query systems might be either local or distributed – linking either to NEON-wide or satellite resources. Once identified, the associated metadata and data should be easily available and contact information for the contributing investigator (to fill in any information gaps in the metadata) should be available.
- **Education and Training** – NEON participants and researchers will need to be trained in the use of standard operating procedures. Similarly, individuals and institutions outside SEEON will need to be educated on SEEON goals and activities. The core site will need to prepare educational materials, such as best practices guides) that address both "about SEEON" and "about data," and to couple these materials with training activities. The core should also curate and maintain the "institutional memory" (e.g., reports, white papers, publication lists etc.) for SEEON.
- **Curation and Distribution of Data** – The core will be responsible for maintaining and distributing data. Off-site backups of all databases are a necessary component of curation. When distributed, data should be provided in the form requested by the user, with appropriate access control. For selected classes of data, value-added (pre-integrated) data should be available. Data should be versioned and users of data should be notified when updated versions of the data they hold become available (data subscriptions).
- **Software Development** – Several of the tasks listed will require development or adaptation of software tools such as converters, search engines, etc. Development of open source is desirable in the NEON context, as it permits the entire community to contribute.

There was substantial discussion within the group about the roles of the core relative to the satellite sites. The general consensus was that if computational resources were clustered at the core or were distributed among the satellite sites, made little difference in the long run functionality of the system. Access and access control are more important than physical location in a networked world. The expectation is that at least some satellite sites will be "thin clients," depending heavily on the resources of the core for operations. Other satellite sites, with more substantial on-site resources, might replicate or even undertake primary responsibilities for some core functions.

A brief discussion of personnel was conducted which identified the following potential core site personnel:

- **Director** – oversees functioning of the system
- **Roving support and education specialist** – works with users and help promulgate standards use
- **Programmer(s)** – develop needed software tools and systems
- **Network Administrator** – maintains network and network security systems
- **Systems Administrator** – maintains computers and needed security systems
- **Database Administrator** or **Data Manager** – Develop and maintain database systems and conduct QA/QC analyses

It was the consensus of the group that although all of these roles are important, it might be able to contract out some services. Additionally, personnel might be "staged," with individuals added over time. Some personnel, such as programmers, might be less in demand as the system becomes fully operational and no longer needs as much development work.

Next Steps

Although time did not allow an extensive discussion on the next steps, participants did identify some possible near term steps. One of those steps identified was a third SEEON workshop that might focus on other federal agencies that had not participated previously, e.g. a workshop in Atlanta, Georgia that could included the Centers for Disease Control and the U. S. Geographic Survey, or on SEEON governance. Another potential focus for a third workshop could be public outreach. Funding for these types of activities may become more available once NEON becomes more formally organized, but it was recognized that much of the work is needed at the local/regional level. Continuing SEEON discussions are important to keep up the momentum. Other next steps may include building collaborations to do NEON-type research prior to the actual initiation the national network. Most of all it was agreed that it was very important that the regions continue to push things forward and that the southeast region should continue to be represented at the national level.

Tour of SLSL, KSC & MINWR

On the second day of the workshop, most of the participants attended a tour of the laboratories in the new Space Life Sciences Laboratory facility at KSC where the workshop was being held. The facility was opened in September 2003, and is the result of a partnership between NASA, Kennedy Space Center, and the State of Florida. Laboratories toured in the approximately 100,000 square foot facility included Analytical Chemistry, Microbiology, Molecular Biology, and the Phytotron that support NASA Bioregenerative Life Support research activities as well as other research endeavors.

During the final day of the workshop a small group of participants attended a field trip through KSC, Cape Canaveral Air Force Station, and the Merritt Island National Wildlife Refuge (MINWR) focusing on ecological research sites and important ecosystems. KSC is located on approximately 57,000 ha of land on the east coast of central Florida. Less than ten percent is developed and used for NASA operational activities with the remaining land managed as part of the MINWR.

Acknowledgements

The organizers of this workshop would like to thank the Information Technology, Facility Support and Research staff at the Space Life Sciences Laboratory for helping to ensure a smooth and successful workshop and laboratory tour. We appreciate the efforts of Joseph Delfino, Steve Harper, Jeff Luvall, John Porter, and Hilary Swain in leading the breakout group discussions and in providing summaries of those discussions for this report. We thank all those who made presentations during the workshop: Dan Cooper, Kevin Delin, Sam Durrance, Steve Harper, Robert Knox, Billy Payne, John Porter, Mark Provancha, Tim Short, Alexis Thomas, and Allen Turner.

Appendix A

Workshop Participant Contact Information

Michael Binford
Department of Geography
University of Florida
mbinford@geog.ufl.edu

Rosvel Bracho
National Research Council
brachor@si.edu

Daniel Cooper
Los Alamos National Laboratory
dcooper@lanl.gov

Joseph Delfino
Department of Environmental
Engineering Sciences
University of Florida
jdelf@eng.ufl.edu

Kevin Delin
Jet Propulsion Laboratory
Kevin.delin@jpl.nasa.gov

Sam Durrance
Florida Space Research Institute
SDurrance@fsri.org

Manuel Gimond
Dynamac Corp.
Kennedy Space Center
gimonm@kscems.ksc.nasa.gov

Carlton Hall
Dynamac Corp.
Kennedy Space Center
HallCR@kscems.ksc.nasa.gov

Steven Harper
Savannah River Ecology Laboratory
University of Georgia
harper@srel.edu

Jeffrey Harris
Savannah River Ecology Laboratory
University of Georgia
harris@srel.edu

C. Ross Hinkle
Dynamac Corp.
Kennedy Space Center
hinklcr@kscems.ksc.nasa.gov

Lori N. Jones
NASA
Kennedy Space Center
Lori.N.Jones@nasa.gov

David Johnson
Smithsonian Institution
Kennedy Space Center
johnsondp@si.edu

Robert Knox
NASA
Goddard Space Flight Center
Robert.G.Knox@nasa.gov

Jeff Luvall
NASA
Marshall Space Flight Center
Jluvall@nasa.gov

Billy Payne
Matrix Information Systems Inc.
Kennedy Space Center
wvpayne@mail.matrixis.com

John Porter
Dept. of Environmental Sciences
University of Virginia
JHP7E@virginia.edu

Tom Powell
Smithsonian Institution
Kennedy Space Center
powellt@si.edu

Mark Provancha
Dynamac Corp.
Kennedy Space Center
ProvaMJ@kscms.ksc.nasa.gov

Christopher Romanek
Savannah River Ecology Laboratory
University of Georgia
romanek@srel.edu

John Sager
NASA
Kennedy Space Center
John.C.Sager@nasa.gov

Tim Short
Center for Ocean Technology
University of South Florida
tshort@marine.usf.edu

Burt Summerfield
NASA Kennedy Space Center
Burton.R. Summerfield@nasa.gov

Hiliary Swain
Archbold Biological Station
HSwain@archbold-station.org

Alexis Thomas
Geoplan
University of Florida
alexis@geoplan.ufl.edu

Cassondra Thomas
National Research Council
ThomaCR@kscems.ksc.nasa.gov

Allen Turner
Department of Agricultural & Biological Engineering
University of Florida
aeturner@ifas.ufl.edu

John Weishampel
Department of Biology
University of Central Florida
jweisham@mail.ucf.edu

Appendix B

Workshop Agenda

Southeastern Region
neon
National Ecological Observatory Network

Southeast Ecological Observatory Network (SEEON) Workshop on Ecological Sensors and Information Management

February 26-28, 2004
Space Life Sciences Laboratory
Kennedy Space Center, Florida

Agenda

Thursday, February 26, 2003

8:30 am	Registration, coffee, bagels
9:00 am	Welcome (KSC Deputy Center Director Dr. Woodrow Whitlow)
9:10 am	Introductions, overview of workshop and statement of objectives (Mike Binford & Ross Hinkle)
9:20 am	Review of NEON/SEEON activities (Mike Binford) Summary of previous workshops on NEON information and sensor technology (Mike Binford)
9:30 am	Summary of SREL Workshop with Emphasis on Major Ecological Questions (Steve Harper)
9:45 am	SHORE Sensor (Sam Durrance)
10:00 am	Break
10:15 a.m.	Remote Sensing technologies (Robert Knox)
10:45 am	Underwater mass spectrometry, autonomous and remotely operated vehicles (Tim Short)
11:15 am	Raman LIDAR (Dan Cooper)
11:45 am	Lunch
12:30 pm	Sensor Webs with Demo (Kevin Delin)

2:00 pm	Discussion and recommendations for SEEON sensor needs (Mike Binford)
4:00 pm	Summary of discussions and recommendations
6:30 pm	Dinner at Dixie Crossroads Restaurant

Friday, February 27, 2004

8:30 am	Coffee and bagels
9:00 am	Summary of previous day's discussions and findings and goals for today (Allen Turner)
9:30 am	Geospatial Data (Alexis Thomas)
10:00 am	LTER data management (John Porter)
10:30 am	Break
10:45 am	Demo KSC Environmental Information Management System (Billy Payne, Mark Provancha)
11:30 am	Tour of the Space Life Sciences Lab
12:30 pm	Lunch
1:30 pm	Discussion and recommendations for SEEON information management/networking
4:00 pm	Summary of discussions and recommendations
4:30 pm	Wrap-up
5:30 pm	Adjourn (Dinner on your own)

Saturday, February 28, 2004

8:00 am – 12:00 am	Field trip of the KSC field sites (Ross Hinkle & Lori Jones)