

# A grassroots approach to sensor and science networks

Ecologists have long recognized that increasing pressure on the planet's resources has sent us down a path of unprecedented environmental degradation, toward a future with high uncertainty about the availability and quality of ecosystem services. In response, funding agencies have invested in large research programs at both national and international scales. In the US, the proposal is to fund these programs at levels unprecedented in the history of the National Science Foundation's Biology Directorate – hundreds of millions in startup and tens of millions annually in operations and maintenance costs. To control costs, these large programs face pressure to replace large numbers of less intensively equipped sites with a smaller number of heavily instrumented sites. As a result, many scientists who feel passionately about participating may find it difficult to contribute ideas and data from their local study sites. How might we answer big questions, using sensor networks in ways that engage the broader ecological community?

The international, grassroots model offers a unique approach for confronting the challenges of doing networked science across large geographic extents. Advances in technologies are making automated sensing systems affordable for ecological research programs of all sizes. Hundreds, if not thousands of “sites” that stream sensor data exist around the globe. The human and technological resources are tremendous, but this population lacks the cohesion to act in a coordinated fashion. Fortunately, advances in networking, computing, data storage, and cyberinfrastructure are enabling a diversity of scientists to form virtual communities that work across institutional and national boundaries. However, some of the biggest challenges in coordinating such a network of scientists lie in the social component.

Science is about people, and the egalitarian approach of the grassroots network speaks to that. The science agenda of this network is the agreed-upon agenda of the community – participants help decide its future and have a stake in its products. Community trust is developed when members share data, contribute expertise, and emphasize flexibility to develop multiple solutions to common network issues. A representative governance structure empowers individuals and rewards initiative, while being sensitive to cultural differences. A flat organizational structure allows for tight feedback between on-the-ground science and network policy and contributes to “buy-in” by all participants.

If ecologists truly want to participate in the global effort of studying the world's ecosystems, it is incumbent on us to get organized. The Global Lake Ecological Observatory Network (GLEON) is one example of how this can be done. GLEON is emerging as an international, grassroots network of lake and reservoir ecologists and information technologists focused on the study of lake processes and how those processes influence society. With GLEON, we seek to capitalize on the aggregate heterogeneity of sites, technologies, and scientific approaches in order to exploit the potential offered by lake sensor networks. Much of our success to date can be attributed to the grassroots paradigm on which GLEON was founded. Its open system encourages both participation and innovation. Each individual has access to the collective expertise and experience of the network, enabling rapid advancement at the site level. Its international focus provides a forum for heightened awareness of the issues confronting lakes and reservoirs at the global level. This approach allows individual scientists to pursue interesting leads, resulting collectively in a flexible and responsive network that evolves to address new scientific questions in tandem with changing technology. Two other excellent examples of grassroots networks funded from private and public sources are the Coral Reef Ecological Observatory Network and the National Phenology Network.

How do we develop a synergy between these grassroots networks and the larger, centrally funded programs under development? It starts with recognizing that each community has something to offer the others. It requires effort to build the trust necessary to operate collectively, and it requires a cyberinfrastructure that enables data and model sharing. It also requires a balance of funding opportunities that support a diversity of organizational models. Ecology is venturing into the realm of big science, but, as we do so, let's remember that the ecological community consists of many individuals willing and eager to contribute, if given the opportunity.



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