Report to the National Science Foundation

From the

Third Workshop on the Development of a National Ecological Observatory Network (NEON)

Held at the

Santa Fe Institute

Santa Fe, New Mexico

3-4 May 2000

This workshop was held to provide advice to the National Science Foundation regarding the organization and management of a National Ecological Observatory Network. Workshop participants enthusiastically endorsed the effort to establish an ecological observatory network that would provide the infrastructure to enhance research in all of field biology. As noted in the second workshop report, NEON will provide an integrated network of regional research platforms instrumenting the environment. Individual NEON observatories will provide resources to focus on local to regional scales. Collectively, they form a resource to address research questions at national and continental scales. NEON observatories will provide the infrastructure for the field biological research community through core data collection, instrumentation, and laboratory facilities. The specific objectives of the third workshop were to address key issues regarding: (1) the management structure of an individual observatory in the network, (2) network-level management and interactions, (3) management interactions between NSF and individual observatories, and the network as a whole, and (4) evaluation criteria for individual observatories and the network as a whole.

Thirteen participants with management-level experience from the biological, oceanographic, and physical sciences (see attached List of Participants) met at the Santa Fe Institute on 2-3 May 2000 to address four primary agenda items (see attached Agenda): (1) General management challenges, (2) Operations, (3) Governance, and (4) Evaluation of NEON.

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1. General management challenges

During this segment of the workshop, participants addressed the issue of optimal configuration for a NEON observatory, including number of consortium members, geographic scale of an observatory. In addition, participants addressed the general issues of observatory management, and network-wide management. The latter two issues were addressed more fully by participants in the Governance breakout group. The results of that discussion will be reported under the Governance section of this report.

During the second NEON workshop, a conceptual design for a NEON observatory was proposed such that all activities were to take place at one intensive field observation site. This site would have intensive field observation infrastructure as well as the supporting laboratories for sample preparation and analysis. Essentially, this model created a strong site-based focus to an observatory, although it was acknowledged that sensor arrays could be distributed to some distant sites. Such a model served as the starting point for discussion of optimal configuration of an observatory, including the need and desire for satellite sites and accommodation of some analytical capabilities off the field site.

Workshop III participants expressed concern that the effort to restrict all activities to a biological field station would create tremendous stress on the field station infrastructure and environment. Questions were raised about the ability of field stations to house additional scientists and people employed by the observatory. In particular, the vast majority of field stations do not have the physical infrastructure to support the state-of-the-art analytical capabilities that are expected of NEON. Although much of the research infrastructure acquired through the NEON MRE funds would be for field-based instrumentation (meteorological stations, canopy cranes, rain-out shelters, instrumentation for wireless core data collection, etc., see Workshop II report), the processing of biological materials at remote field stations (e.g., DNA sequencing, stable isotopes) requires considerable laboratory space and personnel that do not currently exist at most field stations. The participants expressed concern that NEON funding could not be used for bricks-and-mortar enhancements of field stations or other consortium members. In addition, participants noted that allowing NEON-based infrastructure development on a university campus as a support facility related to the field-based operations was likely to be more sustainable. This would reduce the need for what may be unreasonable expectations of large-scale enhancements of personnel and infrastructure at field sites, enhance the university-based commitment and support of NEON, and provide a work environment that is more conducive to recruiting and retaining the best technicians, support personnel and investigators.

During the following discussion, the model structure of a NEON observatory was modified to what was described in the first workshop report as the "octopus model." This model includes an intensively instrumented base site with associated satellite sites that may have sensor arrays, single sensors, or no instrumentation of any kind. The latter could be part of the biodiversity observatory component of a NEON observatory where instrumentation may not be necessary. Since the original discussions of NEON, there was always the intent to have an intensive, focal site as the base of operations for each NEON observatory. Thus, the issues at the NEON III Workshop were to determine how many satellite sites should an observatory support, what type of instrumentation should be placed at the satellite sites, and at what geographic scale should they be arranged. Given the desire to leave as much creativity as possible in the hands of the investigators, the participants recommended that the spatial scale of an observatory should be determined by what can be afforded and appropriately serviced within instrumentation and operations budgets, and the heterogeneity of the region being observed. The workshop also concluded that the scale of an observatory may change over time. New members may be added to an existing consortium through other state or federal partners and program, or through new funding opportunities. Thus, the initial configuration of an observatory should not be viewed as the final configuration. Indeed, proposals should consider an initial design that has the potential to expand the scale and scope of the initial NEON configuration.

The following recommendations were put forward in response to the discussion regarding the design, spatial scale, and infrastructure needs of NEON:

- In order to focus discussion on design and management, workshop participants recommended that

NEON be focused around a very broadly based, general research question, "What is the pace and nature of biological change." Individual observatories would have a broadly defined observatory-specific theme that would be consistent with this overarching NEON question.

- The workshop strongly endorses the octopus model in which an array of satellite sites, instrumented to various degrees as necessary, is associated with the central or core observatory.

- In an effort to provide some funding for needed construction costs at field stations, it was recommended that NSF allow the use of up to $2.0 million of NEON infrastructure funds for bricks and mortar subject to a 1:1 match from the consortium to be applied towards construction costs. This has the advantage of providing investigators the opportunity to leverage NEON funds to enhance infrastructure needs as part of any observatory. The workshop also strongly recommends that NSF allow the use of up to $2.0 million of NEON money for infrastructure even if the matching requirement is dropped.

- The workshop strongly recommends that some analytical capabilities be enhanced at consortium member institutions, rather than concentrating all activities at the core field site. However, to achieve NSFs goal of creating a clearly defined ecological observatory, the workshop recommends that NSF adopt the following overarching philosophy for a NEON observatory, "Each observatory should maximize the capability of data collection, processing, and analysis at the intensive field site." This encourages a design that will place as much infrastructure as possible at the intensive site, but allow for flexibility in allowing some well-justified capabilities to occur off-site.

- As with previous workshop recommendation, participants in this workshop strongly recommend that observatories include partnerships with federal, state, and local inventory, monitoring and research programs.

The original design plans for NEON call for the establishment of a NEON coordinating body in FY2002. The purpose of the coordinating office would be to coordinate network-level capabilities of NEON, enhance cooperation among observatories, help develop standards for instrumentation, measurements, informatics and metadata for all core data sets, lead efforts in technology development and dissemination to NEON observatories and the broader research community, and serve as a focus for public outreach and education efforts. The workshop strongly recommends that this coordinating body be competed in FY 2001 as the first three observatories come on line, rather than in the following year when sites 4-7 are selected.

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2. Operations

As a starting point for discussion, it was proposed that each NEON observatory would receive an annual operations budget of $1.25 million. This budget was to cover personnel, supplies, service contracts, maintenance, etc., of each observatory. In order to maintain each observatory as state-of-the-art, NSF plans to provide periodically funds to replace, upgrade and enhance infrastructure at each observatory. The breakout group then addressed the following issues: (a) minimal cost of operations, (b) user fees, (c) coordination costs, (d) other costs.

a. MINIMAL COST OF OPERATIONS

Positions to add to the list provided by NEON II

- Project Scientist

- Education/Outreach
- Community Relations
- Logistics Coordinator/Hand Holder
- Systems Administrator

In spite of the fact that there are many commonalties among sites, the workshop participants noted that in fact the variance in the operating costs among observatories will be staggering depending on land ownership, partners in the consortium, existing facilities/services and potential for economies of scale. The group derived the following cost estimates:

	$ Millions
Salaries and Benefits, core, w/some regional variation	$1.00
Salaries and Benefits, site specific	$0.25
Services and supplies (tel, specimen storage cases, paper/ pencils; non- research and research core, vehicle operation)	$0.25
Facilities O & M (electricity, rent, water, land mgmt costs)	$0.10
Travel	$0.05
Networking costs	$0.15
Coordination costs (internal as well as with central and other NEON sites)	$0.05
Outreach costs (marketing, publications, public programs)	$0.05
15% for depreciation for annual small equipment maintenance/replacement	$0.10
50% avg. for indirect (excl. major equipment upgrades)	$1.00

Summary:

$1.25M personnel

$0.75M non-personnel

$1M indirect

Total : $3.0 M per year for operations

(Service contracts usually work out to 10-15% of the cost of the equipment.)

Based on this cost assessment, it was determined that $1.25 million per year was inadequate to support a NEON observatory. It is expected that NSF will provide at least $2.0 million per year in operations, but this still falls short of the estimated $3.0 annual cost. However, these cost estimates assume most jobs are full FTE's, yet some may not be. The estimates are based on full indirect cost rates. Thus, it is conceivable that the annual operations budget may provide more than 80% of necessary costs. Still, this shortfall in funds must be accounted for in some other manner. This led to the discussion of user fees.

The $3.0 million estimate does not include annual major equipment upgrades which are to be funded separately. There was considerable discussion as to whether it is desirable to set up a discretionary fund for such NEON requests at NSF. Should observatories be expected to compete for equipment funding through core program competitions - Given the strong infrastructure needs of NEON, it does not seem appropriate to have the observatories approaching existing programs to enhance site infrastructure. This creates a situation in which the observatories may drain core program budgets. On the other hand, having

set-aside funds for NEON observatories to enhance their capabilities does create a have vs. have not situation. After much discussion, the workshop recommends that NSF plan to provide funding sources to keep the NEON observatories with state of the art equipment through regular upgrades and new acquisitions, and that these funds should not be a drain on resources from core programs that are the life-line of many individual investigators.

b. USER FEES

Noted that food and housing is not included in the expense budget. Support for these costs will be provided to investigators through competitive grants with funding from NEON pool of research dollars.

In addition, there is a high cost of providing the platform and the data, and there will be a need to generate other funds to make up the difference. Sites may need to develop means by which they will have to generate a portion of their operating budget via development, grant writing. Given that all core data are freely accessible, no user fees should be charged for use of core data. Potential means for gathering user fees include: (1) subscription/membership, (2)recharge fees (lab fees), (3) day-use fees, (4) grants directly through the NEON site (traditional and non-traditional sources), and (5) contracts with and grants from other federal and state agencies.

Several issues regarding user fees need to be resolved. In particular, who sets the rates (central coordinating facility or the local sites) - Will there be differential rates for students vs. senior investigators - Will in-kind/matching funds be allowed rather than user fees - Will it be possible to conduct specific negotiations with the host site to reduce overhead costs -

c. COORDINATION COSTS

See the operating budget for coordinating costs applicable to each observatory.

Should the central coordinating office be empowered to serve as a strong force for network-level compliance, or should that power be dealt with by NSF and the peer review process -

The first three sites are ostensibly going to determine the functions of the coordinating office. BUT our sense is that it should be a relatively strong office; none of the three sites should get any money until they decide what the data standards will be and, based on those standards, determining what the coordinating office will do relative to those standards.

The tension on the workshop committees of the three meetings and in the community is the question of whether NEON is big science or not, or more appropriately the infrastructure and technology for big-question science. It is the sense of this committee that NEON represents big science. As such, this NEON III committee raised the option, considered good, to have an advisory committee to NSF, independent of the NEON process, to advise NSF on the big questions a NEON could address. Such a group is currently meeting as an NRC subcommittee. The workshop participants recommend that NSF coordinate with this NRC committee, which is currently charged with defining what the grand challenges in ecology are, and how NEON can be designed to address these grand challenges.

Coordinating office needs to include the cost of marketing/coordinating to other disciplines. It is expected that coordinating office personnel may need to write grants and contracts, as well.

d. OTHER ISSUES

Inflation should be estimated at 3-4%/year.

Figure that investment in operations is large at the beginning (operating costs are higher to start, then drop a bit and then build up).

Seasonal use needs to be figured into management planning for each observatory.

The first decisions need to be strategic, long range, and network-level based, not just relating to the science.

One of the key issues that was not addressed by the NEON III workshop is how to parse out the $10M in MRE funds over the three year funding cycle:

- Core Equipment (common to all)
- Discretionary Equipment (site variation)
- Bricks and Mortar

The group recommends that initial funding allocations be used to develop the specialized instrumentation for the first three NEON observatories, and that core equipment be brought on line later in their 3 year funding cycle, at least for the early awardees. This will allow coordination of purchase and of core equipment among awardees at least in years 1 and 2 during which a total of 7 observatories will be established. By delaying core equipment purchase in year 1 of the first sites selected, they can coordinate purchase and perhaps gain economy of scales with the second and possibly the third cohort, at least for some big ticket items.

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3. Governance

The workshop participants recommended that NEON observatories and the entire network adopt the following governance structure (Figure 1). Each observatory will be funded via a cooperative agreement to a single institution that serves as the fiduciary entity for a given observatory. Consortium members receive funds via subcontracts from the fiduciary entity. Each observatory will have an external advisory committee. All observatories will interact with the NEON Network Office coordinating facility. This facility will have the responsibilities described earlier in this report. The primary agenda

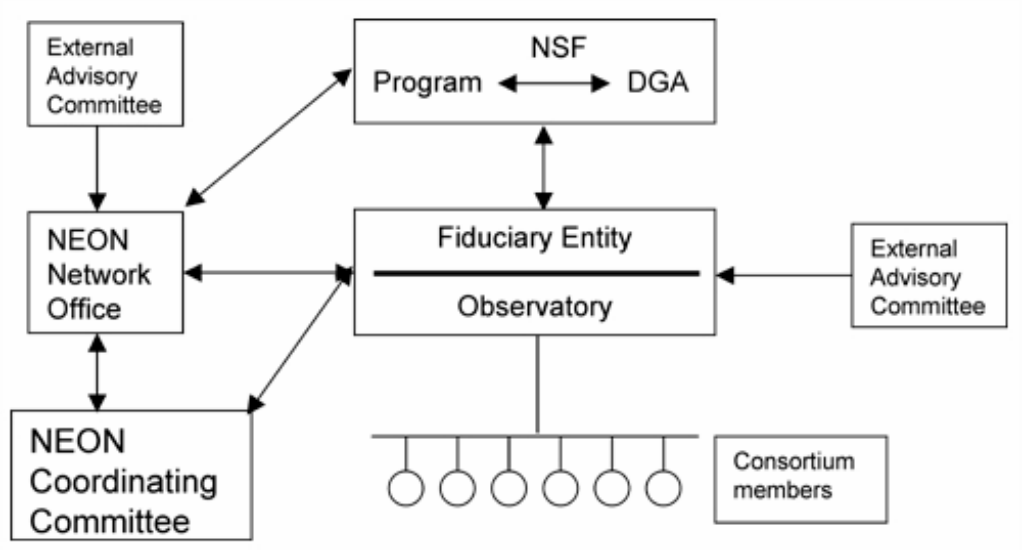

Figure 1. Schematic diagram of the governance structure of a NEON observatory and its relationship to the NEON Network Office.

for the coordinating committee will be Network level business and setting priorities for Network Office activities. The workshop strongly recommends that the Network Coordinating Office be established at the same time as the first three sites are selected. Funding levels for the Coordinating Office were not determined by the workshop, but should be a minimum of $2.0 million per year, which would provide funds for technology development and training, along with the baseline coordinating and outreach activities that the office should perform. The network office will require several FTEs: A Director, an Operations Manager, Information management specialists, Technicians, Outreach Specialist, and administrative support staff. The goal of the NEON Network Office will be to amplify the capabilities of the NEON Network. The office should provide coordination and oversight of NEON activities. Within this effort, standing committees should be established (e.g., Users Committee, Technology Committee, Data Committee) to guide Network Office activities and coordinate efforts among the observatories in the network.

One of the challenges to be addressed is the ability of the Network Office to wield influence over the individual observatories. **The success of NEON will hinge on whether or not the sites are truly coordinated and cooperative**. This requires considerable standardization of protocols, at least to the level that methods and data are easily comparable among observatories. Ideally, core data will be collected whenever possible with the same instrumentation and analytical protocols at each observatory. The Network Office should have some mechanism to insure that each observatory conforms to network protocols, and to ensure that the Network Office has the authority corresponding to its responsibility to ensure success of the initiative (per evaluation criteria). This will be difficult under the planned governance structure given that funding for observatories and the network office come directly from NSF.

One mechanism to insure cooperation is the peer review process. The workshop participants recommend that NSF conduct regular site visits to each observatory. Criteria for evaluation of each observatory and the Network as a whole are discussed below.

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4. Evaluation

Observatory-level evaluation

Participants recommend that NEON observatories be evaluated based on (1) management of the observatory by the host institution and consortium members, (2) use by the scientific community, and (3) quality of the research (core activities and externally funded research) conducted at the observatory.

Because the essence of NEON is the establishment of research platforms for the use of the field biology research community, then each observatory must be evaluated on its management as a research platform. Criteria include (1) the ability to attract high quality users by having in place the appropriate infrastructure that fits the vision of the field and beyond, (2) the ability to attract different disciplines and to identify gaps and intersections in research activities, (3) maintenance of state-of-the-art equipment, quality core data sets, and high standards of quality assurance/quality control, (4) access to data and quality data management, (5) quality of support personnel and services.

Each observatory should conduct regular oversight of the scientific activities by developing questionnaires for user to assess needs, and scientific productivity. It will be important to track time, use of equipment and facilities, and to highlight accomplishments. Such surveys and assessments will also help to determine what research gaps exist and to summarize what users have learned. Observatories should set clear targets for activities, core measurements and research products. Outcomes should be clearly articulated to managers, politicians and the general public.

Finally, each site will be evaluated on financial and budget management. Issues regarding user fees must be addressed up-front. User fees should not be set so high as to discourage visitors use of the site.

Network-level evaluation

Periodic assessment of the accomplishments of the network of observatories must address a number of relatively intangible issues which can be grouped under the following headings: Science Gains, Technological Gains, Data Gains, Education Gains, and Process Gains.

The committee feels that each of these five are appropriate criteria for the evaluation of the entire network to ensure success of the initiative. It seems to this group that much of the responsibility to address these criteria will lie with NSF management and at the Coordinating Office. Given the need to ensure that the authority of governance goes with the responsibility, NSF is strongly encouraged to consider the overall network management in light of these criteria, and ensure that the network office has the authority to govern, and that the individual observatories recognize that their success also depends on a rolling down of these criteria. In addition, it is important that NSF ensure that there are indicators of each of the criteria to ensure success of each criterion.

Science Gains. One of the key goals of NEON research will be to derive higher resolution data that truly integrate space and time. This general issue has been a challenge for ecological and evolutionary biology for some time, and NEON should provide the foundation for integrated research that addresses important scaling issues regionally and nationally. Indeed, an important evaluation issue will be to determine whether or not NEON research addresses national-level questions. These should be big questions, such as the overarching theme of NEON, "What is the pace and nature of biological change - " Such "big questions" should be on par with the big issues in other disciplines, e.g., Is the universe open or closed - As research accumulates at these observatories then it should be possible to determine if the field has moved forward significantly and has it moved faster as a result of NEON.

Technology gains. NEON is poised to serve as a testbed for major initiatives like nanotechnology. One key topic will be whether or not NEON helps to drive technology development in ecology and evolutionary biology. NEON should allow field biology researchers to be proactive in technology development, especially in the area of nanotechnology, rather than being reactive to developments in other disciplines.

Data gains. The network should be evaluated on its leadership in information access and management. The Network Office should lead efforts to improve methods for data archiving, sharing, use and visualization. A key criterion will be data interoperability. Can data be shared seamlessly across the network of observatories - Are data being used to develop ecological forecasting models -

Education gains. NEON sites will serve as ideal platforms for outreach to K-12 education. Each observatory should develop a plan to secure RAMHSS (Research Activities for Minority High School Students) funding. It will be expected that observatories will compete for REU sites, UMEB and IGERT awards to promote training of undergraduate and graduate students, ultimately increasing human resource diversity in field biology. Observatories should develop technology training activities for research scientists and students as part of large-scale education and outreach efforts. Finally, public outreach will be an extremely important activity for NEON observatories. These observatories should regularly inform the public regarding important scientific issues.

Process gains. A primary goal of NEON will be to drive the shift from multidisciplinary to integrated research. This will lead to important gains in the sociology of sciences. These changes, on the other hand, will require changes in the way individuals are evaluated at their home institutions and by funding agencies. The emphasis on integration and collaboration leads to more collaborative research projects and multi-authored papers which will challenge traditional mechanisms of assessment for tenure and promotion.

5. Draft Agenda

NEON III Workshop

Management of NEON

Wednesday 3 May, 2000

8:00 AM - Refreshments

8:15 AM - Introductions

8:45 AM - Summary of NEON goals

- - Q&A from workshop participants

9:45 AM - Charge to the group

10:00 AM - Break

10:30 AM - Issue 1 - General Management Challenges. The first issue will be discussed by the full group of workshop participants.

- The general questions to be addressed are: What is the optimal configuration for a NEON observatory - What is the optimal or desirable size of a NEON consortium and team - What is the optional spatial array of consortium members regionally - This discussion will be led by **Jim Gosz**, rapporteur for the full session will be **Leonard Krishtalka**.
- In addition to these general questions, there are two clear levels of management that need to be addressed. The first is management of an observatory within the network. This discussion will be led by **Jim Tiedje**. How does an observatory maximize efficient use of shared equipment - What is a reasonable workload to expect on field and laboratory facilities at an observatory - What are the appropriate on-site logistics for researchers using an observatory, especially in regard to the balance of local interests versus the broader research community - What is the best mechanism for interactions among individual observatories and NSF -
- The second level of complexity is network-wide management. The discussion leader will be **Ken Johnson**. What is the best mechanism to foster communication and cooperation across the network - Is there a means by which the distribution of research projects and workload can be distributed across network -

12:30 PM - Lunch

1:30 PM - Issue 2 — Operations: Breakout group 1. Group leader: **Peter Arzberger**, rapporteur: **Sara George**. This breakout session will be charged with addressing the following standardization issues raised during the NEON II workshop:

- Review the operational needs of NEON observatories relative to a $1.25 M/year operating budget. Identify areas where cost recovery (e.g., fees for service) might be required to meet operational expenses. Such a review should consider the effects of inflation over a 30-year period and its impact on operating budgets. In particular, an independent assessment of the costs of running and maintaining a NEON observatory should be conducted, based on the components identified in this report (i.e., staff salaries, networking expenses, operating and administrative costs (e.g., telephones, copying, maintaining equipment), and facilities costs (e.g., electricity, physical upkeep, heating/cooling). What is possible for the estimated costs of $1.25M/year of total operating costs - What are the real costs -
- Develop cost estimates for the coordination aspects of the network.

1:30 PM - Issue 3 — Governance: Breakout group 2. Group leader: **Gary Sanders**,

rapporteur: **Jim Reichman** This breakout session will be charged with addressing the following governance issues raised during the NEON II workshop:

- Develop a model of governance for NEON and the types of institutional entities that might advance NEON network coordination. In particular address start-up and steady-state models.
- The regional consortium nature of NEON observatories and the model for both the sharing existing field research resources and the distribution of new, NSF NEON observatory resources is the key question that must be resolved if NEON is to become the exceptional national resource its promise holds. The scientific community and NSF planners need to close this gap before the final design of NEON is determined**.**

4:00 PM - Report sessions

5:00 PM - Break for day

Thursday, 4 May 2000

8:30 AM - Reconvene

8:45 AM - Issue 4 — Evaluation of Program. Discussion leader: **Jim MacMahon**, rapporteur: **Hilary Swain**.

- Identify measures for a successful NEON site, the network, and the coordination body.

10:00 AM - Break

10:30 AM - General Overview and summary of workshop. Discussion led by **Leonard Krishtalka**

12:00 PM - Adjourn

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6. NEON III

Participant List

2-4 May 2000

Peter Arzberger, Executive Director
San Diego Supercomputer Center
National Partnership for Advanced Computational Infrastructure

Sara George, Director, University of Utah Museum

Ellen Goldberg, Director, Santa Fe Institute

Jim Gosz, Professor of Biology, University of New Mexico
Chair, LTER Executive Committee, Chair ILTER Committee

Ken Johnson, Professor, Monterey Bay Aquarium Research Institute
Member, UNOLS Governing Board

Leonard Krishtalka, Director, University of Kansas Museum

James MacMahon, Vice Provost, Utah State University

Doug Posson, Regional Coordinator, USGS/BRD Western Region Coop Units

Jim Reichman, Director, National Center for Ecological Analysis and Synthesis

Gary Sanders, Manager, LIGO

Hilary Swain, Director, Archbold Biological Station, President Elect, Organization of Biological Field Stations

James Tiedje, Director, Center for Microbial Ecology, Michigan State University

James Ulvestad, Division Head of Scientific Services, National Radio Astronomy Observatory

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