National Ecological Framework – is now available

1. **Brief description of the project**:

John Richardson, in EPA Region 4, has led the work on two projects using GIS data sets including National Land Cover Data, protected areas data, Nature Conservancy portfolio areas and others for over 10 years. The projects identified important ecological areas and how to connect them so they continue to function as viable ecological systems and not become fragmented pieces which are not sustainable. The National Ecological Framework (NEF) is a GIS-based model of the connectivity between the remaining natural landscapes in the lower 48 United States. It was developed as a guide for protecting the natural ecosystem services and processes that provide clean air, pure water and sustainable land uses. Potential uses for the NEF include: maximizing ecological connectivity, thus sustaining the production of ecosystem services; guide conservation efforts of important ecological services; improve placement of wetland mitigation banks; protection of sole source surface water areas; better highway planning to minimize ecological disturbance; and guide connectivity to help mitigate ecosystem changes due to climate change.

The NEF is an update to the Southeastern Ecological Framework (SEF) developed in 2001. The purpose of both the SEF and NEF was to develop a mapped data set of ecologically important areas that are connected with a hub/corridor model. In 2002 the SEF was favorably reviewed by the EPA Science Advisory Board. The Region 4 team won a national gold medal for the SEF and an innovative means of packaging and distributing the GIS data, maps, an environmental education video and related information.

The Region 4 SEF model was developed as a cooperative agreement led by John Richardson and the University of Florida between 1998 and 2001. The methodology used to develop the SEF is based on a hub and connector approach originally developed by Tom Hoctor, Reed Noss, and Larry Harris at the University of Florida. The SEF was created, at a scale of 90 meters, using the best data and information available at the time including the 1992 National Land Cover Database (NLCD). Methodology for the NEF closely followed that of the SEF with a few enhancements and improvements to the data developed for the cost surface analysis, connectivity and contiguity analysis. Improved input data sets used in the NEF included USGS Protected Areas Database, first order stream catchments with natural land cover, US FWS Critical Habitats, Roadless Areas, The Nature Conservancy Portfolio sites, and a variety of others which John developed using grid processes for contiguity spatial analysis. Additional data from the National Conservation Easement Database (NCED) became available after the NEF draft was completed. Approximately 85% of the NCED is accounted for by the NEF and the auxiliary connections to the NEF.

John Richardson led the efforts for the current National Ecological Framework (NEF) as an update to the SEF but using newer NLCD data (2001 through 2010), and also other newly available national data sets. Fortunately, John recognized that improvements in technology and better data sources, allowed us to: 1) improve the resolution from 90 meter (SEF) to 30 meters for the NEF; 2) expand the project to cover the lower 48 states; and 3) do it with in-house GIS staff and equipment available in Region 4. In order to develop linkages between the ecological hubs, a cost surface was required. The least-cost-path (determined by the least human disturbance) between significant ecological hubs was used to define the corridors to connect the hubs. Good linkages between hubs utilize the least cost between the hubs and thus indicate the best locations for sustaining the ecosystem services. The cost surface used for the SEF was somewhat subjective. John however, improved the one used for the NEF and it is a

quantitative measure of the human disturbance on the landscape. The cost surface for the NEF is based on the eMergy principles of ecologist H.T Odum (1996) and the work of Brown and Vivas (2005).

John designed and integrated the data sets so they will provide the maximum amount of information with the least amount of effort to retrieve information. For example, the grid cells of the NEF have multiple attributes which tell the user if the cell is within the NEF or not, but also if it is a Hub, Link or Auxillary Connection. Other useful grids are combinations of several grids. John designed them to provide a centralized source of information about each grid cell. One of the combination grids provides information on why each cell was included in the NEF or reasons for being excluded. Another of the combination grids contains information on the original input data layers that correspond with that cell. As a result of John's efforts we not only have the National Ecological Framework but also the means of determining why any location was included or excluded.

2. **Who asked for the project and how they benefited**:

The Environmental Council of the States (ECOS) is a national association of State Directors of Departments of Natural Resources. In 2001 their national meeting was in Georgia, where the Southeastern Ecological Framework was presented to them. As an organization ECOS wrote an official request to the EPA Administrator at the time, Steve Johnson, asking for EPA to support the development of the Ecological Framework at the national level in order to be used by all of the states and their adjoining neighbors. Administrator Johnson contacted the Region 4 Administrator, at that time, to see if this was possible and what resources would be needed to do so. The Region 4 Administrator responded with written support to produce the National Ecological Framework and to make it available to the public.

Benefits from the NEF include being the first science based connectivity model of the best remaining natural lands which provide important ecosystem services for the lower 48 states. Natural resources managers at local, county, state, county, state, regional and national levels can use the information. In addition to developing the NEF, John Richardson has also produced a GIS tool which works with the National Cost Surface to connect any location in the lower 48 states to the NEF by the path of least environmental cost or human disturbance. This can help organizations whose lands were not included in the NEF, for reasons such as being too close to undesirable land (i. e. heavily urbanized or largely agricultural conditions), to connect to the larger national framework. Providing a tool to local, county and state agencies gives them science based information to determine how they can connect to the NEF and be part of a much bigger effort for environmental protection. Such connections allow their public to personally experience natural areas which provide ecological services and often recreation as well. At the same time, their patch of natural landscape is no longer isolated, and by it being connected to a larger framework increases the likelihood of its sustainability along with the ecological services it provides. The tool which John developed is free of charge and often shows alternate options for connectivity, thus providing flexibility to groups interested in connecting their lands to the NEF.

3. **Individuals responsible for the project**:

John Richardson, Ph.D. was the project leader, primary data set developer and spatial analyst. He was assisted by Neil Burns, Ph.D. and Robyn Polinsky in Region 4. John developed innovative approaches for data set development allowing for efficient recall of information in the final product regarding the input layers. Additionally, John single-handedly developed a science-based national cost

surface, with 30 meter resolution and a quantitative means of measuring human impacts to the natural environment. John's understanding of systems ecology, database development, spatial analysis while using a variety of tools available through Arc GIS in innovative ways deserves recognition at a national level. He resolved issues and limitations of the ESRI software by developing logical approaches to testing the software and getting it to perform. Not willing to just accept the results from the GIS processes, he then tested the outputs for results which were reasonable. He used some of the more esoteric grid processes in Arc GIS to create the NEF because it simply cannot be done with vector data analysis. Raster analysis is a powerful tool, but underutilized within EPA. Inasmuch, John relied on his ability to solve technical challenges such as commands not performing consistently in different versions of the software and finding ways to overcome the size limitations of national data sets.

4. **Significance of the project to EPA**:

EPA does not own or manage land but our mission is to protect human health and the environment. We provide technical assistance and science-based guidance to natural resources management agencies and organizations. However, EPA Water Programs in Region 4 use the NEF, and some of the input data sets developed by John Richardson to determine locations of important headwater regions as well as the landscape condition of the watershed or catchment. EPA Emergency Response units often need to know the locations of important ecological resources in the event of accidental release of contaminants or cleanup efforts after hurricanes and large storm events. The NEF is the first national GIS product of this kind and along with the input data sets will assist anyone who needs that information. This project also fits very well with the efforts of the Office of Research and Development (ORD) Ecosystems Services Research for protection of ecosystem services.

5. **Access to the project and associated data sets**:

The NEF grid, associated datasets, metadata and three Word documents describing the methodology and results are available to any EPA computer at \\d0404jr4ec008\GIS\NatEcoFramework\ There is a map project called *NEF_all.mxd* and the Word documents are: NEF documentation97_03; NEF_Readme; NEF_brochure. These resources are being provided to interested parties outside the EPA firewall by a variety of means. It is intended to be uploaded to the Geo Platform once the process for uploading grids of this size can be resolved. Also, it is intended to be included in ORD's National EnviroAtlas. John also converted the NEF grid to a vector data set. More people are familiar with using vectors than grids so this makes the results available to a wider audience. Additionally, the NEF and some of the input layers developed by John are included in another GIS-based project, the Watershed Index, which is also a national-level project. The Watershed Index summarizes the land conditions of over 88,000 12-digit HUCs in the lower 48 states. The first graphical interface is complete and improvements are being made with assistance from Water staff in Region 4 and EPA Headquarters.

References

Brown, M.T., and M.B. Vivas. 2005. Landscape development intensity index. Environmental Monitoring and Assessment 101:289-309.

Odum, H.T. 1996. Environmental Accounting: Emergy and environmental decision making. John Wiley & Sons, Inc., New York.