A network of experimental forests and ranges: Providing soil solutions for a changing world

Mary Beth Adams

USDA Forest Service, Timber and Watershed Laboratory, Parsons, WV 26287, USA, Email mbadams@fs.fed.us

Abstract
The network of experimental forests and ranges of the USDA Forest Service represents significant opportunities to provide soil solutions to critical issues of a changing world. This network of 81 experimental forests and ranges encompasses broad geographic, biological, climatic and physical scales, and includes long-term data sets, and long-term experimental manipulations. Examples of knowledge gained from individual experimental forests and ranges, and from cross-site studies of these valuable research sites are provided herein.

Key Words
Research networks, experimental forests, long-term research.

Introduction
The Experimental Forests and Ranges (EFRs) of the Forest Service, U.S. Department of Agriculture, were established to represent major forest vegetation types of the United States, to help provide science-based answers for management of the nation's forests and ranges, and to serve as "outdoor classrooms" to educate land managers and the public. The first Experimental Forest, Fort Valley Experimental Forest in Arizona, was established in 1908. Data collected from EFRs during the last 100 years can be used to address regional and continental scale questions about forest and range management, key forest ecosystem processes, wildlife habitat requirements, watershed management, and other topics, including soil processes. Research from the network of 81 Experimental Forests and Ranges can also address critical questions related to soil productivity, carbon storage, protection of water quality, remediation of pollution, and help provide soil-based solutions for our changing world.

Why this network?
The network of EFRs spans broad geographic and environmental ranges, from the tropical forests of St. Croix in the US Virgin Islands and Hawaii to boreal forests in Alaska (Figure 1) (Adams *et al.* 2008). The elevation of these research properties ranges from 30 meters (m) (Silas Little Experimental Forest in New Jersey) to 3500 m in the alpine Glacier Lakes Ecosystem Experiments Site (GLEES) in Wyoming. The EFRs occur in 26 provinces or ecoregions defined by Bailey (1995), representing more than 55% of the area of the continental U.S. The coterminous United States has 38 Holdridge life zones (Lugo *et al.* 1999), of which at least 14 contain experimental forests or ranges. The network also includes six subtropical life zones in the Caribbean, 5 tropical life zones in Hawaii and several boreal zones in Alaska. Sites in the EFR network represent 11 of the 12 soil Orders in the U.S. Soil Taxonomy System (Table 1, Soil Survey Staff 2006), and most parent materials from volcanics to alluvial materials to solid rock to organics and glacial materials. This broad geographic spread, covering nearly 50 degrees of latitude, results in the network reflecting a great range of temperature, precipitation, and vegetation conditions (Lugo *et al.* 2006). There are even experimental forests located within or near large urban areas (Baltimore Ecosystem Study, Maryland, and San Dimas Experimental Forest, California) addressing questions of urban ecosystem structure and function and the wildland/urban interface.

The network of EFRs also includes sites with extensive long-term data sets on climate, vegetation, and hydrology. Hydrological and meteorological data have been collected at most experimental watersheds for decades, in some cases for as long as 70 years, and are now easily accessed through a web-based data harvester system (www.fsl.orst.edu/climhy/hydrodb/). Long-term soil data are not as common, but examples do exist of important contributions to understanding long-term soil processes, such as the Calhoun Experimental Forest in South Carolina. There, long-term observational and experimental studies of soil processes have examined soil change at multiple time scales, from the decadal to millennial.

Table 1. Soil Orders represented within the USDA Forest Service Network of Experimental Forests and Ranges.

Alfisols
Andisols
Aridisols
Entisols
Gelisols
Histosols
Inceptisols
Mollisols
Oxisols
Spodosols
Ultisols

The work is particularly noteworthy for documenting soil recovery processes following abandonment after protracted agriculture for cotton (*Gossypium hirsutum*) and associated accelerated soil erosion, followed by planting to loblolly pine (*Pinus taeda*) (Richter and Markewitz 2001).

Many EFRs also are sites for long-term manipulative research, which help us to understand the effects of various disturbances on ecosystem processes and components over longer temporal scales. For example, a long-term study of the effects of silvicultural practices on Appalachian hardwood forest composition and growth on the Fernow Experimental Forest (West Virginia) was recently used by Davis *et al*. (2009) to compare carbon storage resulting from these different cutting practices over a 55-year-period. Many of the Experimental Forests have similar research studies evaluating silvicultural treatments over multiple decades which could be used to address these questions on regional to national scales. The long-term silvicultural and fire ecology study sites on the Escambia Experimental Forest (Alabama) have provided "living laboratories" available to university and agency researchers working to unravel the interconnecting processes essential to restoring the once-extensive longleaf pine (*Pinus palustris*) forest ecosystem.

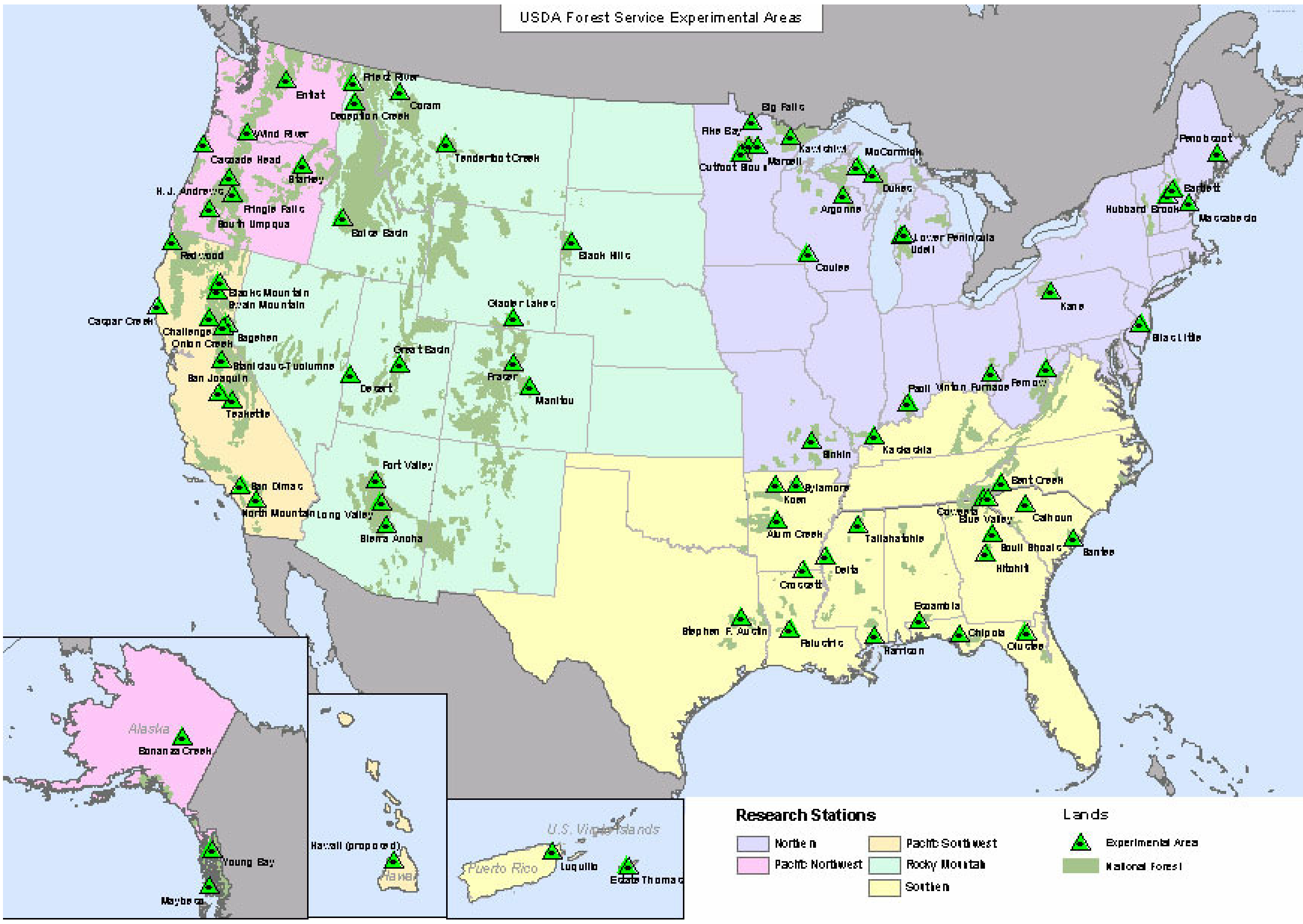
Because EFRs are dedicated to long-term research, they provide an excellent opportunity to understand ecosystem processes over many decades. For example, research at Hubbard Brook Experimental Forest (New Hampshire) was instrumental in documenting acidic deposition and its effects on soil and water chemistry in north America. Data from more than 50 years of research on the Marcell Experimental Forest in Minnesota has been used to understand peatland functions in northern ecosystems, develop peatland hydrologic models, and develop research and monitoring programs that have later expanded nationally and internationally.

Opportunities Associated with EFRs

Finally, there are opportunities associated with the network of EFRs. These arise from the ability to link studies from different ecoregions, soil or vegetation types to study landscape scale processes and questions. For example, as part of studies of carbon dynamics under the USDA Global Climate Change Program, scientists are linking intensive ground-based measurements of carbon stocks, forest growth, and climate from experimental forests with spatially extensive but coarse resolution measurements. Through this work, scientists at the Bartlett Experimental Forest in New Hampshire, the Marcell Experimental Forest in Minnesota, the Fraser Experimental Forest in Colorado, and GLEES are linking landscape monitoring to carbon management at a scale relevant to local land management decisions.

The opportunity also exists for studying impacts of human activities by using manipulative experiments at a variety of sites, or to conduct experiments with similar treatments at several EFRs. Because EFRs are set aside for manipulative research, these experiments are protected for the long term – much longer than is generally possible in an academic setting. Opportunities exist to address important issues relative to challenges of managing forests and ranges in a changing world, using long-term data available from EFRs. For example, at Priest River Experimental Forest in Idaho, daily weather records dating back to 1911 have been used in large-scale models to predict continental scale vegetation changes resulting from climate change.

Finally, the Forest Service network of EFRs is linked with other research and monitoring networks, further increasing the information available, and the opportunities for synergistic research efforts. These networks include the National Atmospheric Deposition program, the Long-Term Ecological Research (LTER) network and National Ecological Observatory Network (NEON) of the National Science Foundation, and the Long-Term Soil Productivity study, to name only a few. The Forest Service EFRs also are part of a larger USDA association of long-term research sites, particularly suited to addressing issues of a changing world (Moran *et al*. 2008).



References

Adams MB, Loughry L, Plaugher L Eds. (2008) Experimental Forests and Ranges of the USDA Forest Service. General Technical Report NE-321 (Revised) [CD-ROM] (USDA Forest Service, Northern Research Station Newtown Square, PA).

Bailey RG (1995) Description of the ecoregions of the United States. 2nd ed. rev. and expanded Misc. Pub. No. 1391 (rev.) (USDA Forest Service, Washington, DC).

Davis SC, Hessl AE, Scott CJ, Adams MB, Thomas RB (2009) Forest carbon sequestration changes in response to timber harvest. *Forest Ecology and Management* **258**(9), 2101-2109.

Lugo AE, Swanson FJ, Gonzalez OR, *et al.* (2006) Long-term research at the USDA Forest Service's Experimental Forests and Ranges. *Bioscience* **56**(1), 39-48.

Lugo AE, Brown SL, Dodson R, Smith TS, Shugart HH (1999) The Holdridge life zones of the conterminous United States in relation to ecosystem mapping. *Journal of Biogeography* 26, 1025-1038.

Moran MS, Peters DPC, McClaran MP, Nichols MH, Adams MB (2008) Long-term data collection at USDA experimental sites for studies of ecohydrology. *Ecohydrology* **1**(4), 377-393.

Richter DD Jr, Markewitz D (2001) Understanding Soil Change. (Cambridge University Press. Cambridge, UK).

Soil Survey Staff (2006) Keys to Soil Taxonomy, 10th ed. (USDA-Natural Resources Conservation Service, Washington, DC).