INTERNATIONAL CO-OPERATIVE PROGRAM ON ASSESSMENT AND MONITORING OF AIR POLLUTION EFFECTS ON FORESTS: THE SIERRA ANCHA EXPERIMENTAL FOREST, ARIZONA

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At the end of the 2007 Fiscal Year, the Experimental Forests and Ranges (EFR) Synthesis Network Committee awarded funds to 18 sites to establish a strategic ICP Level II (described below) synthesis network in the United States. Eleven Experimental Forest were selected to be included in the network, as well as seven Long Term Ecological Research (LTER) sites. This will give the USFS R&D a ICP Level II Network starting this year, the only one in North America (see Appendix). Each site will include a NADP weather station, UV Radiation Monitors and Ozone Sensors. The Sierra Ancha Experimental Forest (EF) was chosen to be part of this network, because it is the most southern EF in the contiguous US and because it is downwind from Phoenix, Arizona, one of the nation's largest metropolitan areas.

OBJECTIVES

The main objective of the proposed network is to strengthen the role of the EFR by providing more internationally standardized data which will benefit the entire US EFR network - all 77 sites. The network will contribute to a better understanding of the relationships between the condition of forest ecosystems and anthropogenic (in particular air pollution) as well as natural stress factors through intensive monitoring on a number of selected permanent observation plots and to study the development of important forest ecosystems.

Further, the network will provide a deeper insight into the interactions between the various components of forest ecosystems by compiling available information from related studies, and in close co-operation with the ICP on modeling and mapping will contribute to the calculation of critical levels/loads and their exceedances in forest ecosystems. Ideally this will improve collaboration with other environmental monitoring programs as well and contribute to the monitoring activities to other aspects of relevance for forest policy at national and global level, such as effects of climate changes on forests, sustainable forest management and biodiversity in forests. Lastly, the network will provide policy-makers and the general public with relevant information.

The Sierra Ancha EF in particular plays three important roles in this network: (1) it is the southernmost EF in the contiguous US; (2) it is downwind from the nation's fourth largest metropolitan area; and (3) it is the driest EF in the network.

BACKGROUND

The International Co-operative Program on Assessment and Monitoring of Air Pollution Effects on Forests (ICP) was launched in 1985 under the Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE) due to the growing public awareness of possible adverse effects of air pollution on forests. ICP Forests monitors the forest condition in Europe, in cooperation with the European Union using two different monitoring intensity levels. The first grid (called Level I) is based on around 6000 observation plots on a systematic transnational grid of 16 x 16 km throughout Europe. The intensive monitoring level comprises around 800 Level II plots in selected forest ecosystems in Europe. Currently 40 European countries and the US participate in the ICP Forests network.

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METHODS

Study Site

The Sierra Ancha Experimental Forest, located on the Tonto National Forest about 48 km northeast of Globe, Arizona, was established in 1932 as a research area devoted to studying watershed management. This 5,364-ha experimental area is typical of watershed and vegetation conditions throughout the Southwest, particularly in Arizona.

The climate, soil, and physiography are typical of much of the southwestern region, and are particularly representative of the Verde, Salt, and Upper Gila watersheds. The Sierra Ancha lies along the crest of the Sierra Ancha Mountain range and includes areas between 1,082 to 2,354 m in elevation. Vegetation types within the forest range from semidesert shrub and grassland to the pine-fir forests at higher elevations.

Climate

Precipitation averages about 850 mm at the higher elevations at Workman's Creek, 635 mm at the intermediate elevations (1,460 to 1,830 m) surrounding the headquarters, and 410 mm at the lower elevations.

Soils

Geology of the range is complex with sedimentary, metamorphic, and igneous rocks uplifted in a dome like structure. Thick formations of Dripping Springs quartzite, dissected by deep canyons or with intrusions of diabase and basalt plugs and sills are common in much of the forest. Troy sandstone occurs at higher elevations.

Vegetation

Eight vegetation types have been identified on the Sierra Ancha including, from the high elevations to low; mixed conifer, mountain park, ponderosa pine, chaparral, oak woodland, desert grassland, desert shrub, and riparian. Fifty-seven percent of the vegetation is covered by chaparral shrubs.

Research, Past and Present

Research studies on watershed management problems in woodlands, chaparral, ponderosa pine, and pine-fir forests were conducted on the sites that ranged in size from several square meters to complete watersheds comprising several thousand hectares. The Sierra Ancha is still maintained as a research site under the administration of the Rocky Mountain Research Station. Many of the earlier watershed studies have been concluded and the results published.

Set-up Considerations

One important selection criterion is that the Level II plots in a country should be located in such way that the most important forest species and most widespread growing conditions in the respective country are represented. Within the plot, the situation shall be as homogeneous as possible regarding tree species, stand type and site conditions. Whenever possible, plots should be selected that have been monitored during the last years. The great advantage of existing data on air quality and meteorological parameters from nearby stations should be taken into consideration whenever establishing Level II plots.

The plot has a minimum size of 0.25 ha. Each plot is surrounded by a buffer zone with a minimum width of 10 m, if possible. There should be no differences in the management of the plot, its buffer zone and surrounding forest, e.g, management operations should be comparable and fencing should be limited to a minimum. However, the disturbance of the monitoring activities should be minimized. Trees felled in the plot or in the buffer zone should be registered and if possible used for increment analysis. The standard Level II-plot design is shown in the appendix.

In principle, all trees in the total plot are to be included in the sample for the tree assessment, e.g, crown inventory, increment assessment. In the case that the plot has many trees in a dense stand, a sub-plot may be defined to be used for these surveys. The size of the sub-plot at the time of the installation of the plots should be large enough to give reliable estimates for theses surveys for a minimum of 20 years, preferably throughout the life of the stand.

A minimum of at least 20 trees in the sub-plot should be available in this period. The installation of a plot comprises its detailed description, including stand and site characteristics and other available

information on the history of the plot, or other nearby monitoring stations.

Efforts to complete the set of data on as many plots as possible are important. The best option is to carry out all the surveys on as many plots as possible. If it is not possible to equip all plots in a country, it is strongly recommended to concentrate the continuous measurements on soil solution, meteorological parameters, deposition and ambient air quality at a smaller number of plots. These plots are best selected taking into account the need of statistical analysis.

If all measurements mentioned under points a - k (Table 1) are carried out at the same plot, this plot is then called a key plot. All countries are invited to establish at least 10% of their Level II plots as key plots. While all Level II plots contribute at a certain degree to improve the understanding of the cause-effect relationship (objective b) the key plots will provide the supplementary information necessary to fulfill objective c (to provide a deeper insight into the interactions between the various components of forest ecosystems by compiling available information from related studies).

Table 1: Surveys carried out on Level II plots

Survey	Frequency	Intensity
Crown condition	at least annually	all plots
Soil (solid phase)	every 10 years	all plots
Soil solution	continuously	part of the plots
Foliage	every 2 years	all plots
Deposition	continuously	part of the plots
Ambient air quality	continuously	part of the plots
Meteorology	continuously	part of the plots
Forest growth	every 5 years	all plots
Ground Vegetation	every 5 years	all plots
Phenology	several times per year	optional
Litterfall	continuously	part of the plots
Remote Sensing	preferably at plot installation	optional

Data Collection

The exact protocol for data collection in the US ICP Level II network is still to be determined. Once the instrumentation described below has been installed and set-up two station personnel will travel probably on a monthly basis to the Sierra Ancha EF to download the data which is collected continuously. This data includes:

Meteorology

Meteorological measurements will be taken on a continuous basis using an automated weather station described below. A NADP type wet/dry collector will also be deployed.

Water Flow

Streamflow will be measured on three supercritical, trapezoidal flumes located on the Workman Creek North, Middle and South Forks. Water yield based on stage height and flume ratings will be measured with modern electronic stage height sensors. Stream stage heights are converted to flow volumes based on hydraulic rating formulas.

Ambient Air Quality

Ambient air quality is measured by two methods: (1) a Ozone monitor measures atmospheric ozone in the concentration range 1.5 ppbv to 100 ppmv using the established technique of UV absorption at 254 nm. These data are recorded with a data logger which will be downloaded during site visits. (2) Passive samplers will collect samples for nitric oxide, nitrogen dioxide, sulfur dioxide & ammonia.

Most likely these samples will be shipped to the PSW Riverside station for testing and analysis. Again the exact protocol is yet to be determined.

Soils

Soils are evaluated every ten years (solid phase) as well as continuously (liquid phase). The solid phase evaluation will begin in 2008, after monitoring instrumentation has been installed. Soil solutions will be collected together with the other continuously compiled data and will is collected by an integrated soil and groundwater pollution monitoring unit. The sampler will collect soil water, soil gas, monitor soil moisture, temperature and conductivity, and store soil water samples in the soil until further analysis can be performed.

Vegetation

Overstory composition, understory, and forest floor will be determined on the established monitoring site at given time intervals (Table 1).

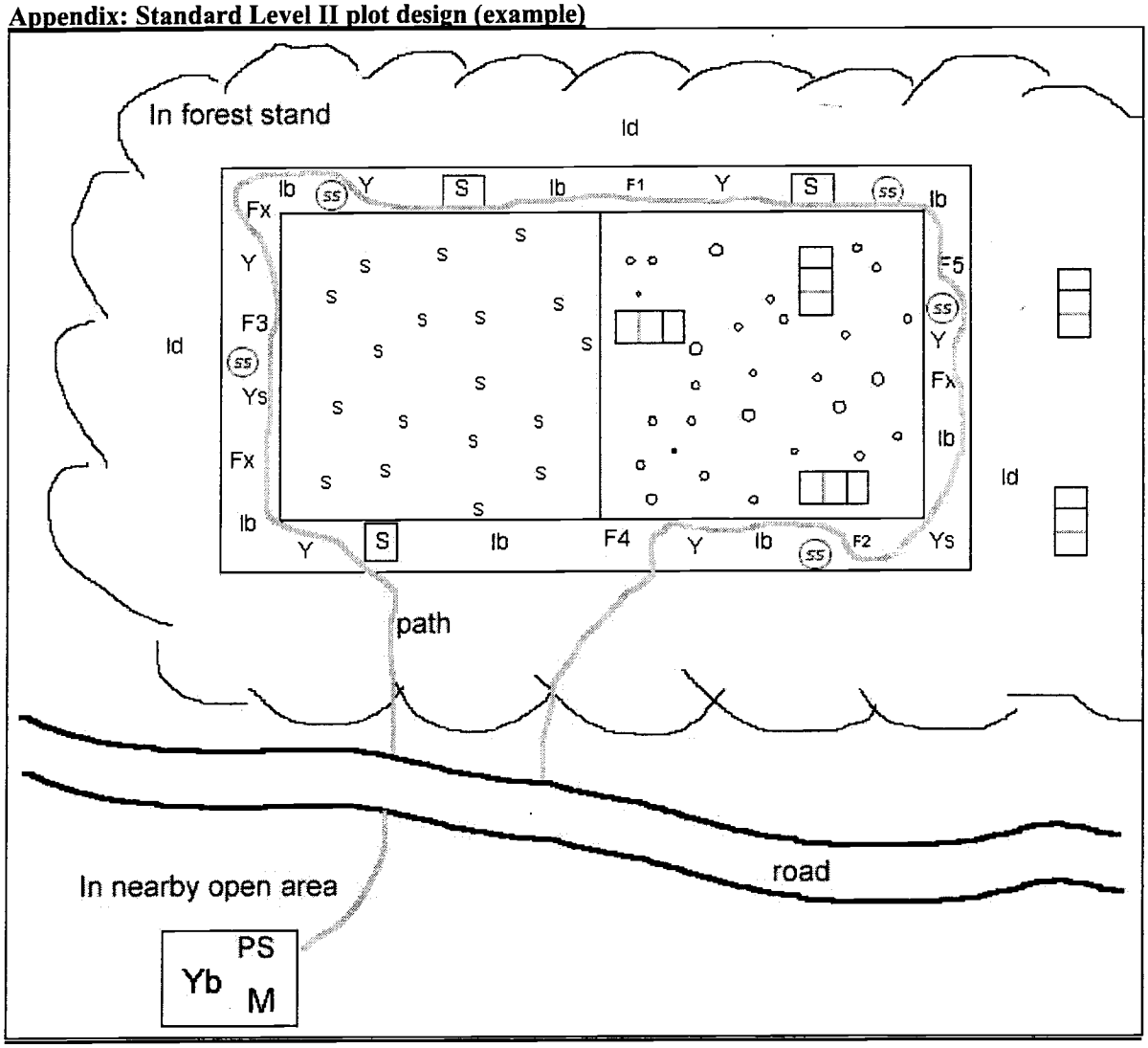
Litterfall

Throughfall collection systems will be located throughout the monitoring site and will be co-located with the lysimeters and near the deposition samplers. The physical samples will be collected on a monthly basis with the remaining continuously recorded data.

BENEFITS OF THE RESEARCH

The data collected at the Sierra Ancha Experimental Forest will contribute to a better understanding of the relationships between the condition of forest ecosystems and anthropogenic (in particular air pollution) as well as natural stress factors through intensive monitoring on a number of selected permanent observation plots and to study the development of important forest ecosystems. Further, the results will provide a deeper insight into the interactions between the various components of forest ecosystems by compiling available information from related studies, and in close co-operation with the ICP on modeling and mapping will contribute to the calculation of critical levels/loads and their exceedances in forest ecosystems. Ideally this will improve collaboration with other environmental monitoring programs as well and contribute to the monitoring activities to other aspects of relevance for forest policy at national and global level, such as effects of climate changes on forests, sustainable forest management and biodiversity in forests. Lastly, the network will provide policy-makers and the general public with relevant information.

Appendix: Standard Level II plot design (example)



Crown assessment
o Tree for crown assessment (yearly)

Soil (every 10 years)
s Location for soil sampling (minimal disturbance)
S Location for soil pit

SS Soil solution samplers

Deposition and ambient air quality
Y Throughfall collector
Ys Stemflow collector (in beech mandatory)
Yb Bulk or wet-only collector
PS Passive Samplers
(always located outside fence)

Foliar
Fx Tree x for foliar sampling (2-yearly)

Increment
o Trees for increment measurement DBH (5-yearly)
Ib Trees for increment measurement bores (once)
Id Trees for increment measurement disks (once)

Meteorology
M Meteorological equipment

Ground vegetation
? ? ? Ground vegetation sampling areas