Proposal Title: Ecosystem management to improve productivity of forest soils following wildfire and intensive management

Foreign Country: Italy

Please select only one activity

___ x Research Collaboration (up to 3 years for projects worldwide)
____ China Scientific and Technical Exchanges (airfare to and from China not provided)

Please select the one category that best describes the subject area of the proposed activity

___ Food Security
___x Sustainable Agriculture and Natural Resources Management
___ Food, Agriculture, and Forestry Technology Use, Marketing, and Trade

U.S. Principal Investigator

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Foreign Principal Investigator

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Start Date of Activity: May 1, 2003
End Date of Activity: September 31, 2004
Funds Requested for Year 1 $9,370 Year 2 $15,000 Year 3 $0
TOTAL AMOUNT REQUESTED $24,370

U.S. Principal Investigator's Signature: __________________________

U.S. Institution Official's Signature: __________________________

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Title

_Ecosystem management to improve productivity of forest soils following wildfire and intensive management_

Abstract

Soil is the medium for plant growth and ultimately long-term forest productivity. Changes in soil properties, therefore, have large implications for sustainable natural-resource management. Two important soil changes not well documented or understood are: the effects of intense wildfire and the effects of tree harvesting across a range of soils with different degrees of weathering. Wildfires that burn trees, plants, and litter—if they are hot enough—can deplete important nutrients by losing them as a gas. Losses through post-fire erosion and leaching are possible too. A set of experimental plots were inadvertently burned in the massive 500,000-acre Biscuit wildfire this past summer in southern Oregon. Because the soils, vegetation, and wildlife and had been sampled in great detail before the fire, we have been provided with a unique opportunity to quantify fire effects. A separate, landscape-scale management experiment and retrospective study, with extensive geographic-information-system-based data, facilitates comparing effects of past management on soils with different degrees of weathering by holding other factors as constant as possible. This collaboration combines the well-recognized expertise of Dr. F.C. Ugolini, at the University of Florence, Italy with that of U.S. collaborators undertaking these studies. The U.S. will benefit from Dr. Ugolini’s recent breakthrough work in Italy on soils that are quite similar to those in these studies. Likewise, findings from these studies are likely to apply to emerging issues on Italian forest soils.

Description

Introduction.

Two research projects, led by the USDA Forest Service, Pacific Northwest (PNW) Research Station, underway on National Forests in western Oregon would greatly benefit from collaboration with the internationally known, soil scientist, Dr. Fiorenzo Ugolini (professor, University of Florence, Italy). Dr. Ugolini is uniquely suited to assist in these studies because of his previous work in the forests of western North America (e.g., Ugolini 1968, Ugolini et al. 1973, 1988, and 1991, Bormann et al. 1995), and because of his recent work on coarse fragments in soils in Italy (Agnelli et al. 2000, 2001; Ugolini et al. 1996, 2001).

The Oregon research projects are briefly described first. The anticipated contributions from, and collaborations with, Dr. Ugolini on these projects are then stated as specific SCRP objectives. The Research and Scientific Exchanges Division has not previously funded a related activity of ours.

Effects of the Biscuit fire on long-term forest productivity

The SCRP funds would augment a major study of fire effects on soil in southern Oregon, that we have strong indications will be funded by the Joint Fire Science Program (final negotiations are underway). The Biscuit wildfire burned more than half of the Siskiyou National Forest (500,000 acres) in 2003, including 2 of 3 100-acre blocks of the PNW Research Station’s long-term ecosystem productivity (LTEP) experiment.
(http://www.fsl.orst.edu/ltep), near Gold Beach, OR. Each block has 7 15-acre experimental units with varying vegetation composition and amounts of woody debris (fig. 1).

**Figure 1.** The LTEP experimental design (note the control plot is not shown). Early succession favors pioneer plants; mid succession seeks pure Douglas-fir; and late succession is a thinning and underplanting of shade-tolerant trees and shrubs. About 15% of the standing biomass was left on the ground in the low organic matter removal treatment.

The Biscuit wildfire burned all units in one block at high temperature—we know it exceeded 660 °C because most of the aluminum tags attached to grid points and trees melted. The fire completely burned all shrubs, smaller plants, rotting wood, and upper soil organic matter, and killed most trees on this block. The temperature appears hot enough to have volatilized most of the N and S and much of the P and K on the site. Further nutrient losses to erosion and leaching are possible as well.

Firefighters set fire to a second block, trying to burn out fuels in advance of the then wildly out-of-control wildfire. This backburn did not melt as many aluminum tags or kill as many plants, and thus represents an intermediate fire intensity. A third block was fully spared from the fire. Because these units were intensively sampled before the fire (before and after the LTEP treatments were installed) they represent an unparalleled opportunity to quantify effects of different fire intensities. Soils were sampled on a 25-m grid system for a total of 271 quantitative pits to 30 cm depth. Samples were processed and stored in the LTEP sample archive in Corvallis, OR.

Major questions being addressed in the Biscuit fire study are:

- Quantify first-year ecosystem effects—over a spatially distributed range of fire intensity and severity—of the Biscuit wildfire and backburn, especially change in various indicators of long-term productivity such as organic matter (also indicates fire severity), nutrient capital, soil structure, erosion, and leaching;
- Evaluate the effects of experimentally added woody debris on fire intensity and severity; and
- Evaluate the effects of experimentally manipulated overstory and understory plants on fire intensity and severity, fire propagation to adjacent areas, and subsequent 1-yr effects on soils, and plant and animal succession.
In this study, with help from Dr. Ugolini, we expect to assess consequences of fire on long-term productivity and develop new approaches to simultaneously reducing fire risks while meeting other ecosystem objectives, including maintaining long-term productivity.

The Five Rivers landscape experiment and retrospective study

The SCRP funds would also augment a 16,000-acre, replicated landscape experiment and an associated 78,000-acre retrospective study underway on the Siuslaw National Forest in the Oregon Coast Range. The Forest—in partnership with the PNW Research Station, and Oregon State University—is implementing a landscape experiment that compares 3 strategies to reach goals of the Northwest Forest Plan:

- A **passive** approach that decommissions roads, and allows existing plantations and aquatic systems to achieve objectives on their own;
- A **continuous** approach that maintains roads open and thins plantations and restores streams more frequently and less intensively; and
- A **pulsed** approach that thins plantations and restores streams aggressively, then closes roads every 30 years before reopening them for further management.

These treatments are being established across 1300-acre portions of the road system (called roadsheds); they were replicated 4 times and were assigned treatments randomly. This landscape experiment, being implemented and monitored by the Siuslaw NF, serves as a model for adaptive management nationwide.

A retrospective study is planned on the entire Five Rivers watershed, to learn from past management and also serve as baseline data for the experiment. This study is supported by the PNW Research Station, but awaits full funding through pending proposals to the USDA National Research Initiative and the National Commission for Science on Sustainable Forestry.

Changes in biodiversity and long-term productivity will be compared to independent variables associated with ecosystem-development history, including stand-initiating disturbances (such as fires and clearcutting), other disturbances (by landslide, windthrow, herbivores, diseases, site preparation, and planting), initial soil conditions (extent the soil is weathered), topography (risk of landslides, slope, aspect), and landscape position (proximity to roads, streams, and areas with different histories).

The relations are expected to express themselves across the diversity of past disturbance and management histories (importantly limited in some ways) that can be found in Five Rivers. The great Yaquina fire of 1849, which burned nearly every tree and most logs across the watershed, created remarkably homogeneous initial conditions. The watershed also has a uniform soil parent material (uplifted ocean-deposited Tyee sandstone) that is extensively distributed in the Oregon Coast Range. Tree species diversity is low and some of the stands have among the highest biomass production in the temperate zone, presumably because of the mild climate, fertile soil, and abundant rainfall. These limits to variation help to compare forest areas with different ecosystem-development histories.
Three distinct soils are found developing on the Tyee sandstone in this watershed. The highly weathered Preacher series, perhaps deficient in base cations (Rojanasoonthon 1963, Bockheim and Langley-Turnbaugh 1997), is found on upper ridges and slopes without much history of down-slope mixing. The less weathered and more fertile Bohannon series is in areas that have been mixed by landslides and windthrow. The most common soil is actually a small-scale complex between the first two. This pattern should let us evaluate soil effects on standards and practices within and between stands, and at larger scales.

We have found a remarkable set of existing data in agency files, including 10 sets of aerial photos dating back to 1937, detailed records on management practices, extensive soil, vegetation, disease, and stream surveys, and over 2000 stand exam plots with measures of site index. All data are being incorporated into a detailed geographic information system that will allow for the landscape analysis described above.

Objectives of this Activity

Three objectives are proposed for U.S.-Italy collaboration that will fill key soils research needs the studies described above. The objectives stated below focus on the portion of the research that SCRP would fund.

1. **Evaluate effects of wild and controlled fire on forest soils.** Study of the Biscuit fire would be greatly augmented by adding Dr. Ugolini’s expertise on soil solution chemistry, soil development, and weathering. Dr. Ugolini will collaborate in interpreting changes in soils after fire of varying intensity, help to design sampling for leaching losses, and interpret implications for long-term productivity and soil development. Dr. Ugolini will also address a specific question on the effects of fire on cation-exchange capacity of clays heated by the fire. Whether hot fires can collapse clays can be tested with CEC and X-ray diffraction measures.

2. **Evaluate the role of coarse fragments in supplying nutrients and controlling tree growth on intensively managed forests.** Pioneering work of Dr. Ugolini in the sandstone parent material of central Italy—similar to the Tyee sandstones of the Oregon Coast Range—has established that coarse fragments (> 2 mm diameter) contain important easily weatherable minerals that disappear as particles become smaller than 2 mm (Ugolini et al. 1996, 2001; Agnelli et al. 2000, 2001). Trees, in concert with mycorrhizal hyphae, actively mine large particles by boring into them and releasing organic acids that weather minerals and release nutrients for plant growth (Jongmans et al. 1997, Yamanaka et al. 2003). Highly weathered soils, depleted in coarse fragments, may not be able to provide nutrients for maximum plant growth, and may be more susceptible to growth declines when nutrients are removed in harvesting. Collaborative research will focus on describing coarse fragments at a landscape scale and evaluating the interactions between coarse-fragment content, site index, and management effects.

3. **Increase international cooperation.** The SCRP funds would also facilitate exchange of research findings through seminars given at Oregon State University and at the University of Florence. Further, the well-equipped lab at the University of Florence can process soil samples at lower cost compared to available U.S. labs.
Benefits to U.S. Agriculture or Forestry

The U.S. will benefit from better understanding of Dr. Ugolini’s recent breakthrough work on soils in Italy by applying this understanding in two large U.S. studies. Benefits to U.S. forestry include improving and targeting silvicultural responses to chemical and physical changes in soil, caused by fire of various temperatures and as soils become highly weathered. For example, on hotly burned soils where a substantial portion of the nutrient capital has been volatilized, leached, or eroded away, planting of N$_2$ fixers and plants and microbial associates adapted to rocky substrate may help restore soil fertility. In soils with few coarse fragments, nutrient removals in harvesting and harvest frequency may need to be further assessed. These findings are likely to be immediately applied by the National Forest collaborators.

Benefits to the Cooperating Foreign Country

The research underway in the U.S. on understanding how coarse fragments may control tree productivity on rocky soils is also a priority research area in Italy. New knowledge may help to restore productivity of eroded lands in Italy. Fire effects on soils is becoming an increasing priority as well, because forests developed on pasture lands are beginning to be subjected to fire more often. Also, large-scale experiments are rare in Europe, and findings from U.S. studies will be of general interest.

Cooperative Arrangements

USDA Forest Service, PNW Research Station

The Research Station will manage SCRP funding, make arrangements for Dr. Ugolini, and facilitate fieldwork in Oregon. Substantial resources are available including field facilities, laboratories, computers, and offices. The Forestry Science Laboratory in Corvallis, OR is the 2nd largest Forest Service Research in the U.S., located on the campus of Oregon State University.

University of Florence

The University of Florence will provide salary support for Dr. Ugolini and will coordinate a field tour of soils research underway in Italy in 2004 in soils similar to the Oregon sites. The University will also make analysis services available for soil samples from these studies in their state-of-the-art soils laboratory on campus, in Florence.

Work Plan

Dr. Ugolini will visit for 2 months during the 2003 and 2004 field seasons (tentatively scheduled for the months of July and August). Living arrangements will be made in Corvallis and at field sites.

Objective 1

Dr. Ugolini will help meet this objective by advising U.S. cooperators on sampling and analytical procedures, assisting in interpreting data, and cooperating on co-authored publications. He will collect subsamples to assess CEC and X-ray diffraction. He will oversee soil analyses in Italy. U.S. cooperators will establish and carry out other aspects of the Biscuit fire study and provide support and personnel to assist in Dr. Ugolini’s role.
Objective 2

Dr. Ugolini will help meet this objective by advising U.S. cooperators how to predict coarse fragment content from existing soil, digital elevation, and geologic maps. Dr. Ugolini will work with U.S. cooperators to collect data on coarse fragment content on sites where site index has been measured. Combined data will be used to test landscape predictions and develop regressions between site index and content. U.S. cooperators will provide logistical support for Dr. Ugolini.

Objective 3

International cooperation between Italy and the U.S. will be enhanced through the exchange of knowledge on effects of soil changes on the productivity of forests. Dr. Ugolini will present a seminar at Oregon State University during both visits. Dr. Bormann will make a presentation at the University of Florence in September, 2004 describing the findings from both studies.

References


BERNARD T. BORMANN

Principal Plant Physiologist and Team Leader, Sustainable Ecosystem Productivity Team, Ecosystem Processes Program, USDA Forest Service, Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331

EDUCATION
1976 B.S. The Evergreen State College (plant ecology-soils).
1981 Ph.D. Oregon State University, Forest Science Dept. (forest physiology).

PROFESSIONAL EXPERIENCE
1981-present Research plant physiologist. USDA Forest Service, Pacific Northwest Forest and Range and Experiment Station, Olympia, WA, Juneau, AK, and Corvallis, OR.
1986-present Assistant (to 1992), associate (to 2000), and full professor (courtesy), Dept. of Forest Science, Oregon State University.
1989-present Team leader (PNW Long-Term Ecosystem Productivity Program and Sustainable Ecosystem Productivity Team, Ecosystem Processes Program). USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR.

RESEARCH GRANTS
1986-1989 Soil development and decomposition: effects of forest productivity in SE Alaska. P.I., USDA Competitive Grants Program. $120,000.
1996-2001 Effect of windthrow disturbance on decomposition-weathering feedback and watershed nutrient dynamics, P.I., National Science Foundation Grant, $390,000.

HONORS AND RECOGNITION
- Lead for the congressionally mandated Eastside Forest Health Assessment
- Lead for the Adaptive Management Process Workgroup commissioned by the Regional Interagency Executive Committee under the Northwest Forest Plan.
- Lead for the combined scientist manager team on adaptive management, assembled for the Chief’s Tucson conference on ecological stewardship (Bormann et al. 1999).
- Lead for the independent peer review of the proposed Coquille Forest Plan written for the Coquille Tribe; organized by the Oregon Governor’s office.
- Visiting professor at the Swiss Federal Institute of Technology in Lausanne, Switzerland, Fall 2000.
- USDA Honor Award 1996. Highest Departmental award, for superior service for “bridging traditional scientific-discipline and research-management boundaries, and improving theory on sustainability, long-term productivity, and adaptive management”.

PUBLICATIONS (limited to 5)
FIORENZO C. UGOLINI

Professor (Professore Ordinario "Chiara Fama") of Pedology
Dipartimento di Scienza del Suolo e Nutrizione della Pianta
Università degli Studi di Firenze (Florence) Italia
Piazzale delle Cascine, 15–50144, Firenze, Italy

EDUCATION
1953 College of Agriculture, University of Florence, Italy.
1957 B.S. Rutgers University, New Brunswick, NJ.
1960 Ph.D. Rutgers University, New Brunswick, NJ.

PROFESSIONAL EXPERIENCE
1960-1961 Assistant professor, Rutgers University, New Brunswick, NJ.
1961-1964 Assistant professor, Agronomy Department and Research Associate,
Institute of Polar Studies, Ohio State University, Columbus, OH.
1964-1990 Assistant (to 1966), associate (to 1973), and full professor of forest soils, University of
Washington Seattle, WA.
1990-present Professore Ordinario di Pedologia, Universita degli Studi di Firenze, Italia.

RESEARCH GRANTS AND EXPEDITIONS (examples)
1959-1981 Eight expeditions in Arctic, Alaska, sponsored by the N.S.F.
1962-1971 Five expeditions in Antarctica, sponsored by U.S. Navy and the N.S.F. Antarctic
Program.
1983-1988 Five expeditions to Svalbard, sponsored by the N.S.F.
1986-1989 Soil development and decomposition: effects of forest productivity in SE Alaska. Co-
P.I., USDA Competitive Grants Program. $120,000.
1991-1995 Four expeditions to Devon Island, Canada, sponsored by the N.S.F.
and by the Science and Technology University.

HONORS AND RECOGNITION (examples)
• NATO professorship, Institute of Geology, University of Milano, 1968.
• Antarctic Service Medal, awarded by the National Science Foundation, 1973.
• Fellow, Arctic Institute of North America, 1978.
• Burlington Northern Foundation, faculty achievement award for excellence in teaching, 1987.
• Visiting scholar, University of California, Davis, 2001.

PUBLICATIONS (recent, limited to 5; 85 refereed journal papers; 2 in Nature, 2 in Science)
rock fragments and fine earth from sandstone and siltstone derived soils and their availability to grass.
Ugolini, F.C., Corti, G., Agnelli, A., Piccardi, F. 1996. Mineralogical, physical, and chemical properties of
Ugolini, F.C., Dahlgren, R., LaManna, J., Nuhn, W., Zachara, J. 1991. Mineralogy and weathering
processes in recent and Holocene tephra deposits of the Pacific Northwest USA. Geoderma 51, 277–
299.
Ugolini, F.C., Dahlgren, R., Shoji, S., Ito, T. 1988. An example of andosolization and podzolization as
Budget

Research Collaboration Projects

The SCRP and foreign contributions are specific to SCRP objectives; the U.S. contributions represent leveraging of the large projects described in the Introduction.

FY 2003  (May 1 to September 31)

I.  SCRP Contribution:

International travel for Dr. Ugolini (Florence↔Portland) $2000  
Lodging and meals (as a Forest Service volunteer)  
($88 per day for 60 days) $5280  
Local travel (trips to field sites, 260 mi and 60 mi @$0.3/mi) $1090  
Supplies $1000  
Total SCRP contribution in FY2003 $9370

II.  U.S. Cooperating Institution(s):

In-kind support (JFSP grant) $320000  
Projected in-kind support (USDA NRI grant) $170000*  
PNW in-kind support, estimate $40000  
Siuslaw NF in-kind support, estimate $80000  
Indirect charges (USDA 19.5%) $1827  
Total U.S. contribution in FY2003 $511827  
  * pending

III.  Foreign Cooperating Institution(s):

In-kind for University of Florence (~$1500/wk) $12000  
Indirect costs for analytical laboratory $1000  
Total foreign contribution in FY2003 $13000

FY 2004  (October 1 to September 31)

I.  SCRP Contribution:

International travel for Dr. Bormann (Portland↔Florence) $2000  
Lodging and meals (2 weeks@120/day) $1680  
International travel for Dr. Ugolini (Florence↔Portland) $2000  
Lodging and meals (as a Forest Service volunteer)  
($88 per day for 60 days) $5280  
Local travel (trips to field sites, 260 mi and 60 mi @$0.3/mi) $1090  
Supplies $950  
CEC and X-ray analyses $5000  
Total SCRP contribution in FY2004 $15000
II. **U.S. Cooperating Institution(s):**

- In-kind support (JFSP grant) $127000
- Projected in-kind support (USDA NRI grant) $160000*
- PNW in-kind support, estimate $40000
- Siuslaw NF in-kind support, estimate $80000
- Indirect charges (USDA 19.5%) $2925

**Total U.S. contribution in FY2004** $309925

* pending

III. **Foreign Cooperating Institution(s):**

- In-kind for University of Florence (~$1500/wk) $12000
- Indirect costs for analytical laboratory $1000

**Total foreign contribution in FY2004** $13000

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**Combined FY2003 and FY 2004 budget**

I. **SCRP Contribution:** $10870

II. **U.S. Cooperating Institution(s):** $821752

(represents leveraging of the larger projects underway perhaps 5% is directly related to the SCRP activity)

III. **Foreign Cooperating Institution(s):** $26000