SERDP
Strategic Environmental Research and Development Program
Improving Mission Readiness Through Environmental Research

US Army Corps of Engineers

SERDP's SEMP

Ecosystem Management Project

CS-1114

Mr. William Goran, Project Manager

Dr. Harold Balbach, Research Coordinator

U.S. Army Engineer Research and Development Center (ERDC)

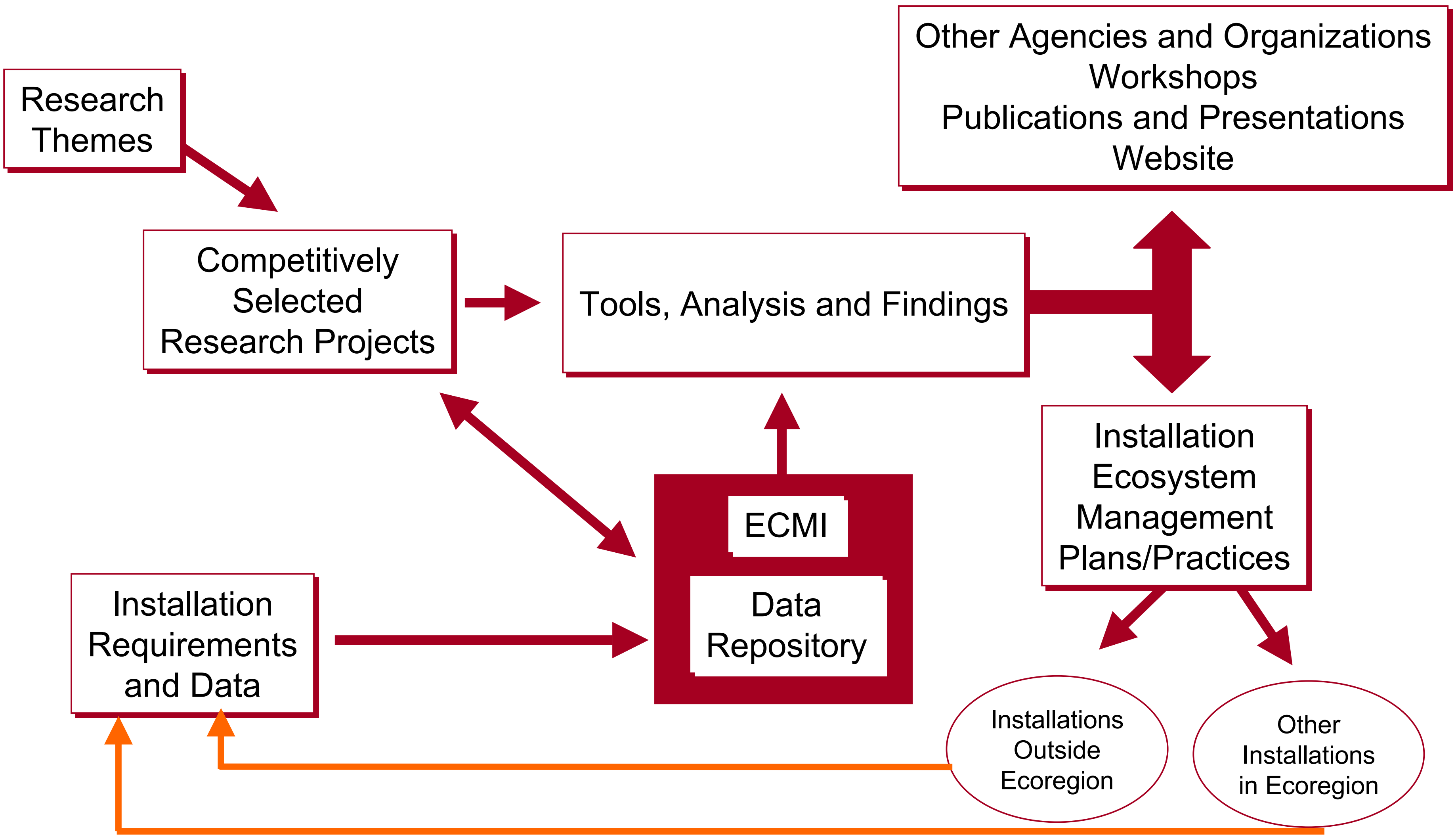
Scientific Advisory Board

15 October 2002

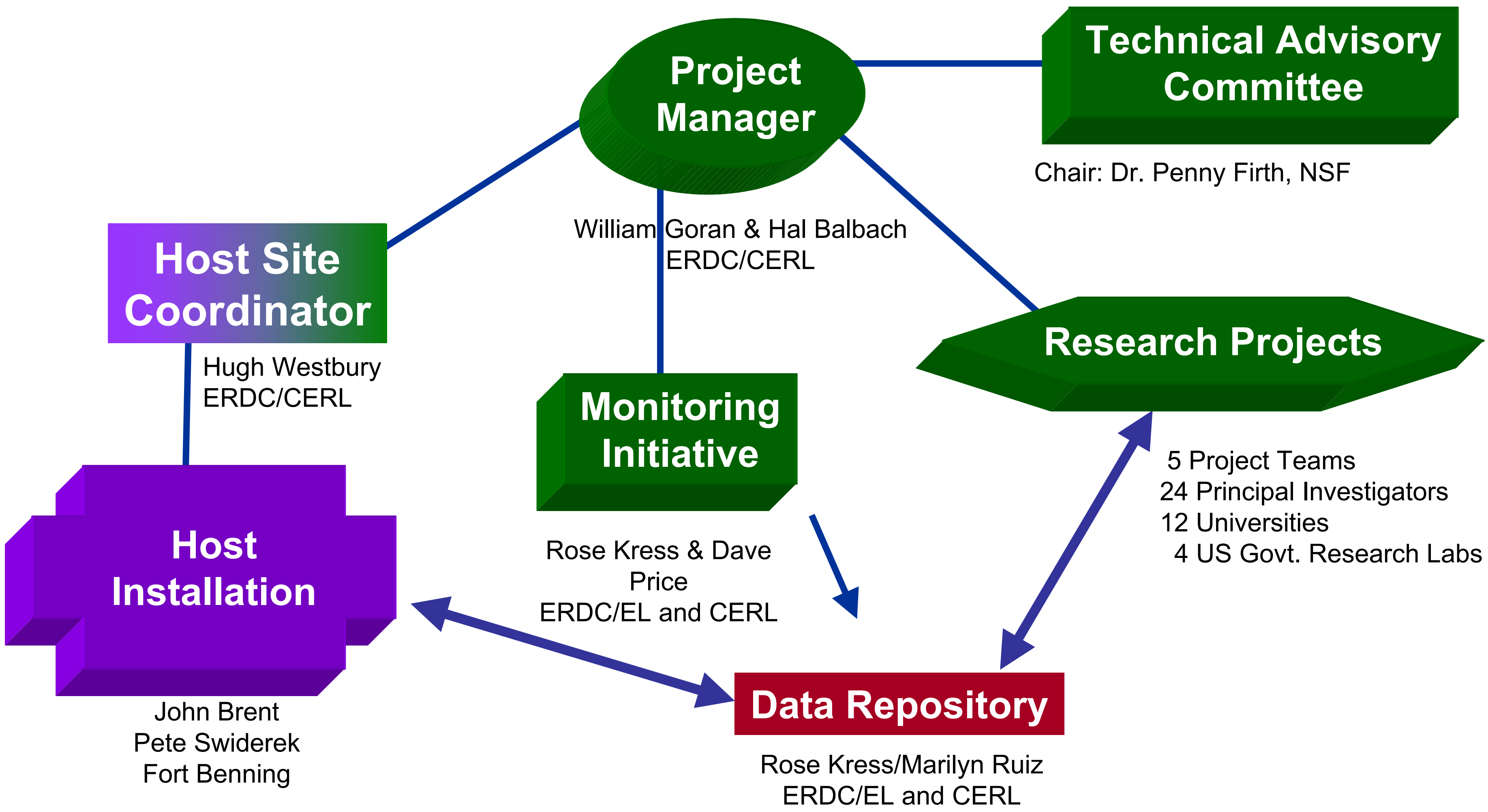
Purpose of SEMP

- To Address Knowledge Gaps Related to Ecosystem Management on Military Lands
- To Provide Land Managers with Resources to Understand and Better Manage Their Installations for Long-Term Use - Range Sustainability
- To Design and Test a Long-Term Baseline Monitoring Program on DOD Lands

Technical Approach



SEMP Organization Chart



Technical Advisory Committee for SEMP

- Dr. Mary Barber, Ecological Society of America, SAB Member
- Mr. Peter Boice, Director of Conservation Programs, Office of the Deputy Undersecretary of Defense, Installations & Environment, TTAWG Member
- Dr. Neil Burns, US Environmental Protection Agency, Region 4
- Mr. George Carellas, Chief, So. Regional Env. Office, US Army Env Center
- Dr. Roger Dahlman, Program Manager, U.S. Department of Energy, TTAWG Member
- Dr. Penny Firth, National Science Foundation, Committee Chair
- Dr. John Hall, The Nature Conservancy
- Mr. Ray Johnston, U.S. Department of Agriculture, Forest Service
- Mr. Richard McWhite, Natural Resources Chief, Eglin Air Force Base
- Dr. Brian Czech, Headquarters, U.S. Fish and Wildlife Service

Monitoring Initiative

Rose Kress, David Price, Harold Balbach
US Army Engineer Research & Development Center

PHASE I 1999 - 2001 **DESIGN**	PHASE II 2002 - 2005 **ADAPT**	PHASE III 2006 - **MAINTAIN**
Extended design, implementation and documentation	Adaptation based on: a) initial monitoring results b) SEMP research results c) land management experience	Long-term maintenance and technology upgrades

Objectives: TO: Characterize the long-term spatial and temporal dynamics of key ecosystem properties and processes

TO: Conduct baseline ecosystem monitoring in support of SEMP research

TO: Contribute to host site integrated monitoring plan at the ecosystem level

TO: Develop long-term ecological data set

SEMP Research Projects

Indicators

ORNL	Dr. V. Dale	Indicators of Ecological Change
University of Florida	Dr. K. R. Reddy	Determination of Indicators of Ecological Change
Prescott College	Dr. T. Krzysik ★	Development of Ecological Indicator Guilds for Land Management

Thresholds

ORNL	Mr. C. Garten, Jr. ★	Disturbance of Soil Organic Matter and Nitrogen Dynamics: Implications for Soil and Water Quality
The University of Georgia, Savannah River Ecology Laboratory	Dr. B. Collins	Thresholds of Disturbance: Land Mgmt Effects on Vegetation and Nitrogen Dynamics

Development of Ecological Indicator Guilds for Land Management
(CS-1114B)

Anthony J. Krzysik, Ph.D.

Ecological Research Institute
Prescott College

Brief to the Scientific Advisory Board

15 October 2002

PERFORMERS

Dr. Anthony J. Krzysik

Prescott College

Project Leader, Specialist in vertebrate, statistical, community, and field ecology

Dr. Harold E. Balbach

U.S. Army – ERDC – CERL, Specialist in ecology and military land management

Dr. John M. Emlen

USGS – BRD - WFRC, Specialist in theoretical ecology and ecological modeling

Dr. D. Carl Freeman

Wayne State University, Specialist in plant physiological and evolutionary ecology

Dr. John H. Graham

Berry College, Specialist in invertebrate, physiological, and genetic ecology

Dr. David A. Kovacic

University of Illinois, Specialist in ecosystems ecology, wetlands, nutrient dynamics

Dr. John C. Zak

Texas Tech University, Specialist in microbial and soil ecology

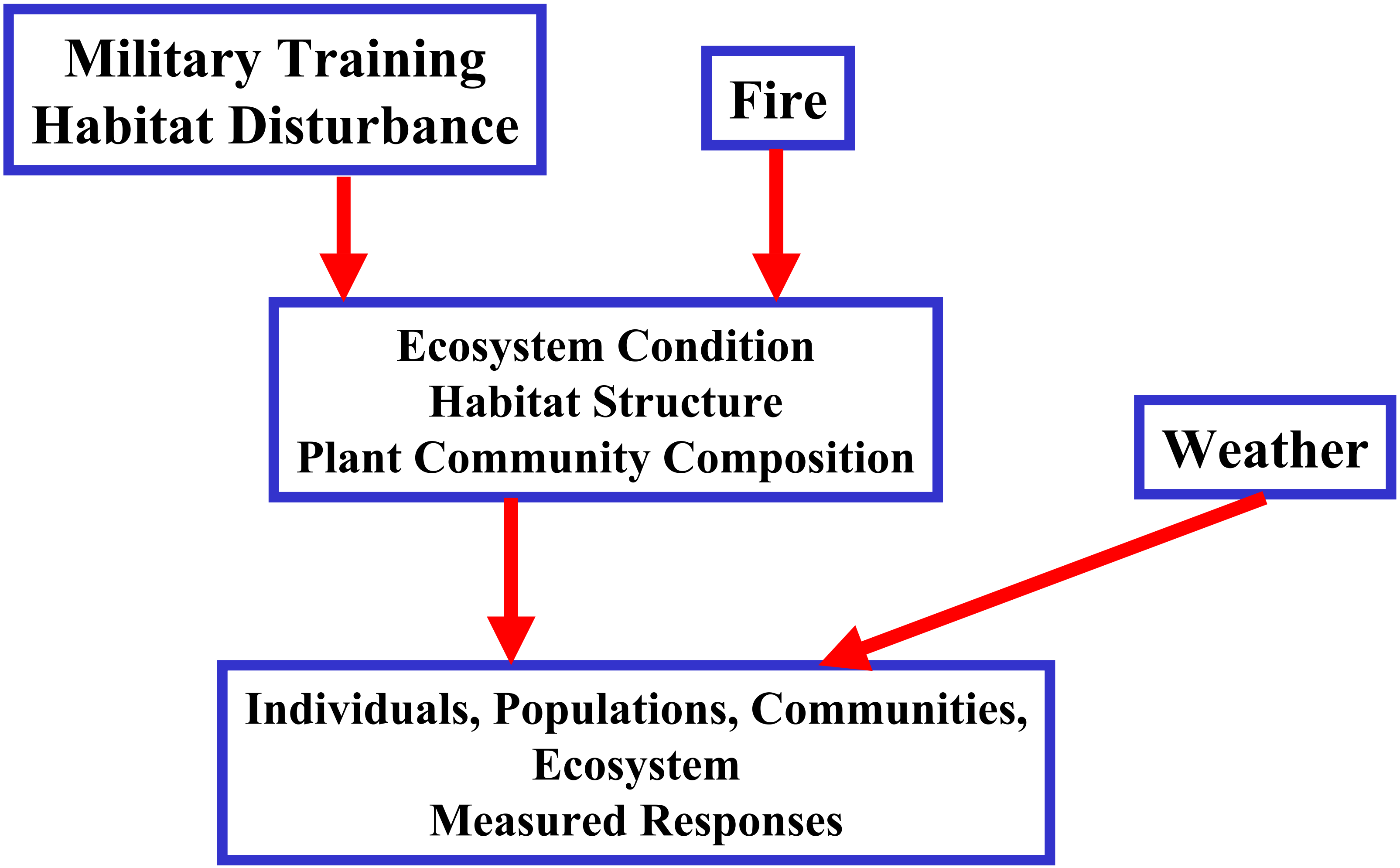
TECHNICAL OBJECTIVE

- Develop Ecological Indicators To
  - Track and monitor ecological changes
  - Provide early-warning or threshold detection
  - Quantify habitat condition and trends
- Based On
  - Simple metrics
  - Derived from associations with Ecological Processes, Community Attributes, and Physiological Stress
  - Based on classifying similar responses to Ecological Indicator Systems (Guild Construction)

TECHNICAL BACKGROUND

- Indicators have been used for over a century, but never in an integrated holistic ecological framework
- Ecological Guilds have been used to classify species based on similar trophic roles (e.g., food habits, foraging methods)
- This research uses guilds to classify Ecological Indicator Test Systems by their similar responses to disturbance and stressors

Disturbance to Ecological Systems are Complex



Ecological Processes

Linking Below Ground and Above Ground Components

Nutrient Dynamics
- decomposition
- transformation
- uptake
- leakage
- storage

Microbial Ecology
Soil Chemistry
Lysimeters

Primary Production Tissues
- photosynthetic
- support
- roots/tubers/bulbs
- reproductive

Photosynthesis
Transpiration
Development
Growth

Consumption
- species richness
- abundance patterns
- biomass

Population and Community Structure

Field and Lab Measurements

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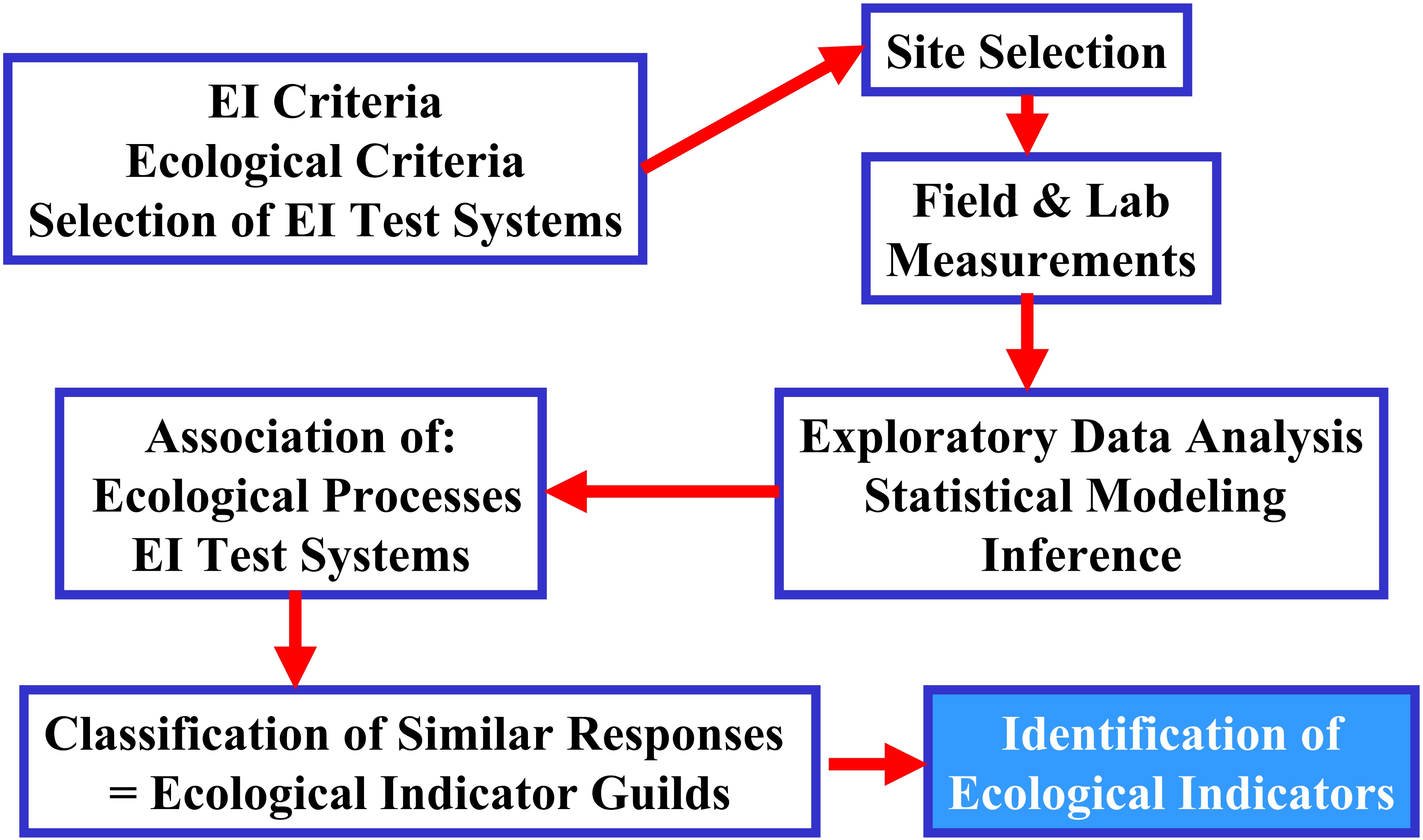
Improving Mission Readiness Through Environmental Research

Prescott College

Technical Approach
Ecological Indicators (EI)



Site Selection
Based on a Disturbance Gradient
3 sites selected in each disturbance class

High

Current mechanized-infantry training

H3

H1

Medium

Past training activities
Current foot traffic

M3

M1

Low

No military training
Minimal foot traffic

L2

L1

Ecological Indicator Test Systems in Disturbance Gradient

- Habitat Characterization
  - Physiognomy, Floristics, Physical Soil Properties
- Litter and Soil Chemistry
- Nutrient Flux and Leakage
- Microbial Communities
- Invertebrate Communities
- Plant Physiological Responses
- Developmental Instability (DI)
- Plant Community Spatial Interactions
- Vertebrate Communities

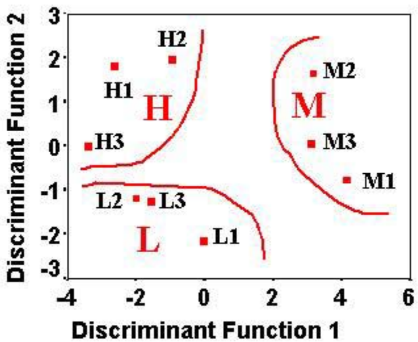
Analysis and Modeling
Exploratory, Inference, Ordinations

- Traditional Parametric and Nonparametric
- Discriminant Analysis
- Principal Components Analysis
- NonMetric Multidimensional Scaling
- Canonical Correspondence Analysis
- Detrended Correspondence Analysis
- Meta Analysis
- Community and Spatial Metrics
- Structural Equation Modeling

Habitat Characterization With Discriminant Analysis

Using 4 Habitat Parameter Sets

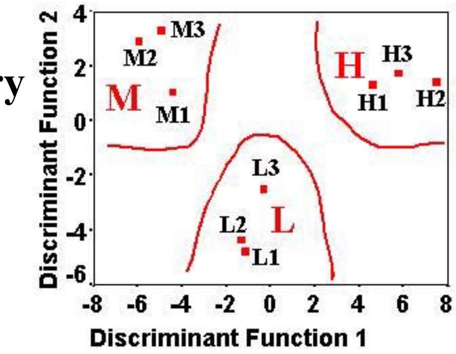
Ground Cover



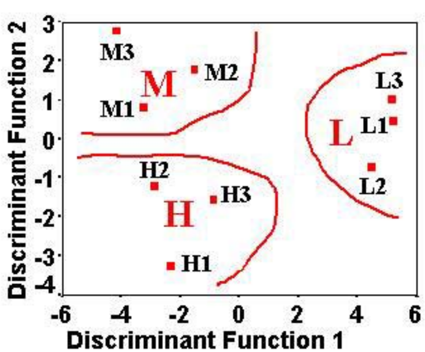
Percent: forbs, grass litter, bare ground

Woody Ground Cover

Percent:
sand blackberry
winged sumac
yellow haw
poison ivy



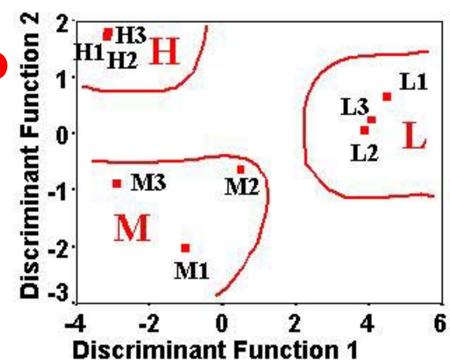
General Habitat



Mean & SD:
soil compaction
A-horizon soil depth
canopy cover

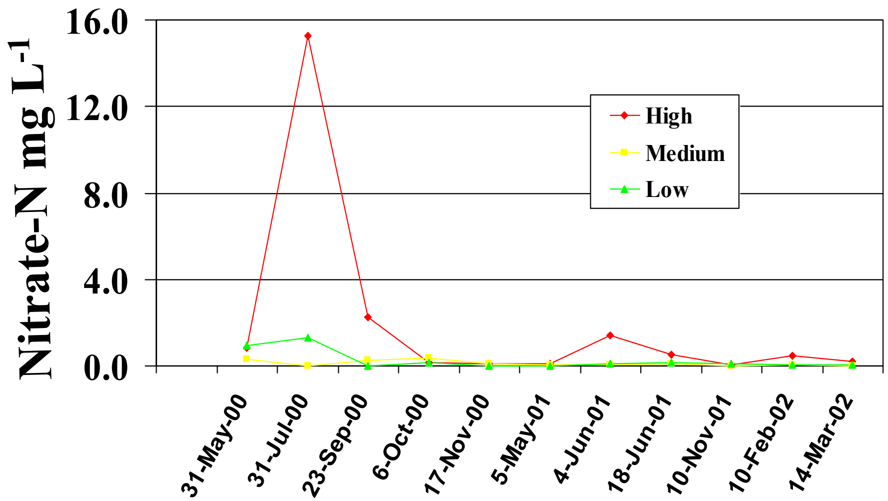
Tree Community

Density, Mean & SD of DBH:
mockernut hickory
flowering dogwood
hawthorn



Nutrient Leakage
(Nitrate – NO_3)

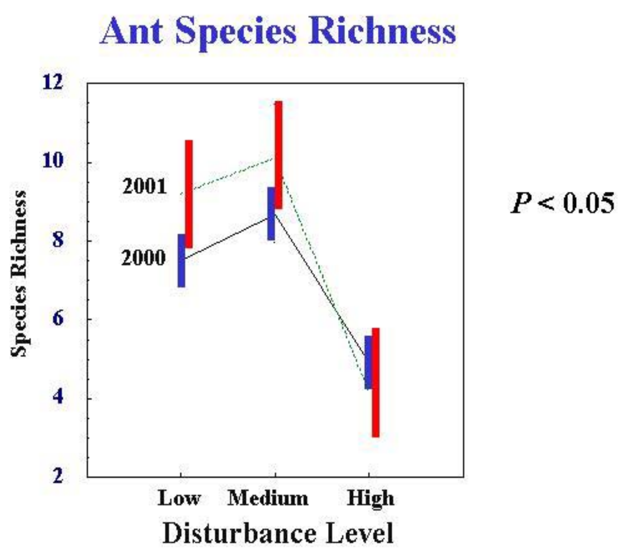
How does nutrient leakage vary along the disturbance gradient?



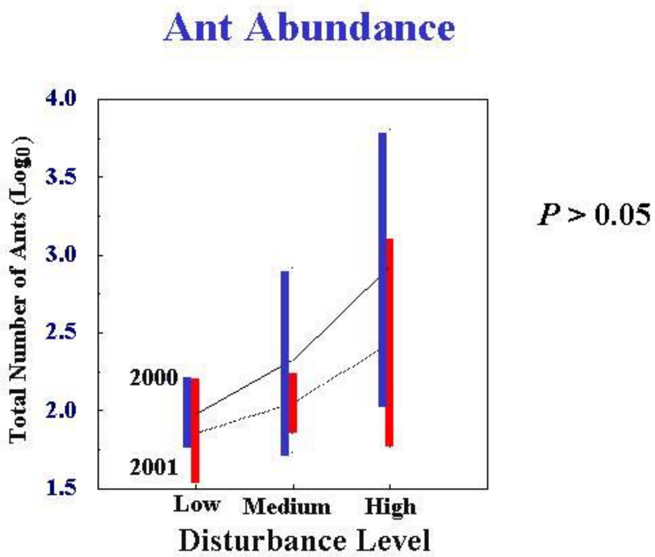
Ecosystem resilience depends on nutrient retention

Similar pattern for:
NH_4 PO_4 SO_4 Cl
Ca Mg K Na

Ant Communities



$P < 0.05$

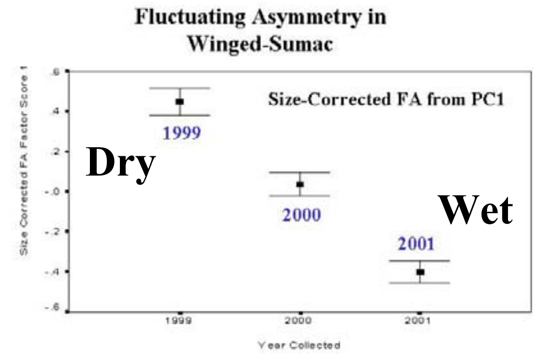


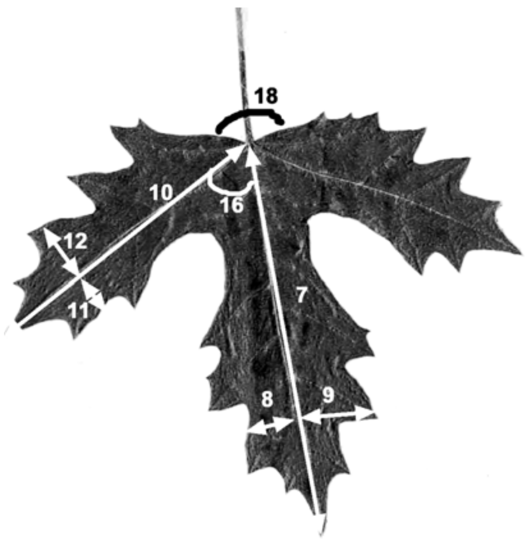
$P > 0.05$

Developmental Instability

DI and plant physiological metrics are demonstrating that plants are stressed at the HIGH disturbance sites

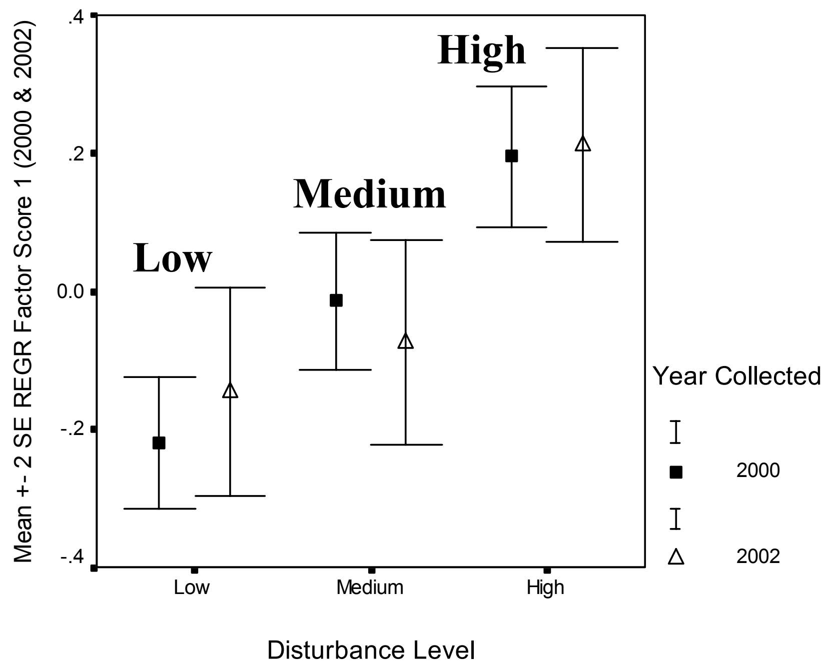
- Measured by *Fluctuating Asymmetry*
- More than 5,000 plants were examined
- Forbs were more sensitive than woody plants
- Drought had more effect than habitat disturbance
- Combinations of species and characters provided more reliable DI metrics





Cnidoscolus stimulosus

18 leaf measurements



Major Findings

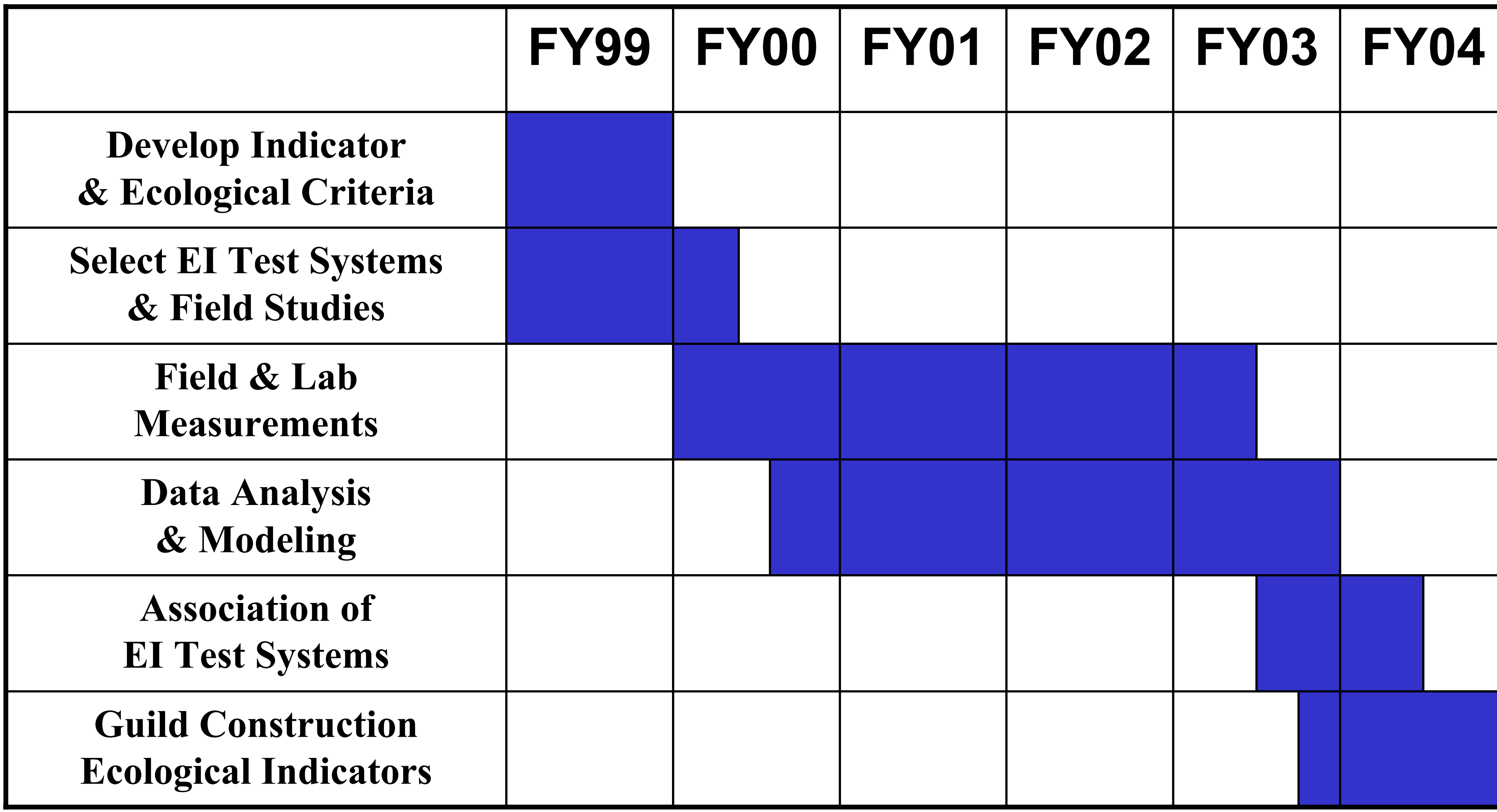
Low–Medium–High disturbance gradient effectively characterized and classified by Ecological Indicator Test Systems:

- Habitat metrics
  - Soil compaction important
  - Measures of variability important
- Plant community composition
- Invertebrate communities (ANTS most important)
- Microbial community function

Major Findings

- Multiple Indicator Systems (Guilds) will be required to monitor Ecological Conditions – Trends – Thresholds
- Some Ecological Indicators demonstrated that natural disturbance (e.g. drought) exert a Greater Effect than (human) habitat disturbance
- BUT less disturbed habitats exhibit a Resilience or buffering against perturbations
- Less disturbed sites more Stable on the basis of important Ecological Indicators:
  - Larger carbon pool
  - Faster nutrient regeneration
  - Lower nutrient leakage

Program Plan



DELIVERABLES

- Ecological Indicators for land management
- Methodology for developing Ecological Indicators (statistical and modeling approaches)
- Metrics for classifying land disturbance (Site Index)
- Identification Key for Fort Benning Ants
- Extensive ecological database for data depository
- Peer-reviewed articles
- Presentations and posters

DELIVERABLES

Presentations:

Ecological Society of America Meeting, Tucson, AZ, 8/02

Soil Ecology Society Meeting, Calloway Gardens, GA, 5/01

Posters:

2 at SERDP Symposium, Washington, D.C., 12/02

American Society of Agronomy Meeting, Indianapolis, IN, 11/02

Ecological Society of America Meeting, Tucson, AZ, 8/02

Student Research, Berry College, GA, 4/02

2 at SERDP Symposium, Washington, D.C., 11/01

2 at Student Research, Berry College, GA, 4/01

Publications:

13 manuscripts are in preparation

Disturbance of Soil Organic Matter and Nitrogen Dynamics: Implications for Soil and Water Quality

(CS-1114D-00)

C.T. Garten, Jr.

Environmental Sciences Division

Oak Ridge National Laboratory

BRIEF TO THE SCIENTIFIC ADVISORY BOARD

15 October 2002

PERFORMERS

Mr. Charles T. Garten, Jr.

Senior Research Staff Member
Plant, Microbial, and Ecosystem Sciences Group
Environmental Sciences Division, ORNL
Specialist in Terrestrial Biogeochemical Cycling and Soil Carbon and Nitrogen Dynamics in Forest Ecosystems

Mr. Tom Ashwood

Research Staff
Environmental Health and Risk Analysis Group
Environmental Sciences Division, ORNL
Specialist in Environmental Monitoring and Use of Geographic Information Systems to Support Land Management

Ms. Bonnie Lu

Technical Staff
Plant, Microbial, and Ecosystem Sciences Group
Environmental Sciences Division, ORNL
Laboratory Steward

RESEARCH GOALS

- To develop a better understanding of the effects of disturbance on key measures of soil quality (e.g., amounts of soil carbon and nitrogen, soil bulk density, and soil N availability)

Military Disturbance

- To determine if there are thresholds to soil quality that affect ecosystem recovery or sustainability (i.e., critical levels of soil N availability that limit desired future conditions)

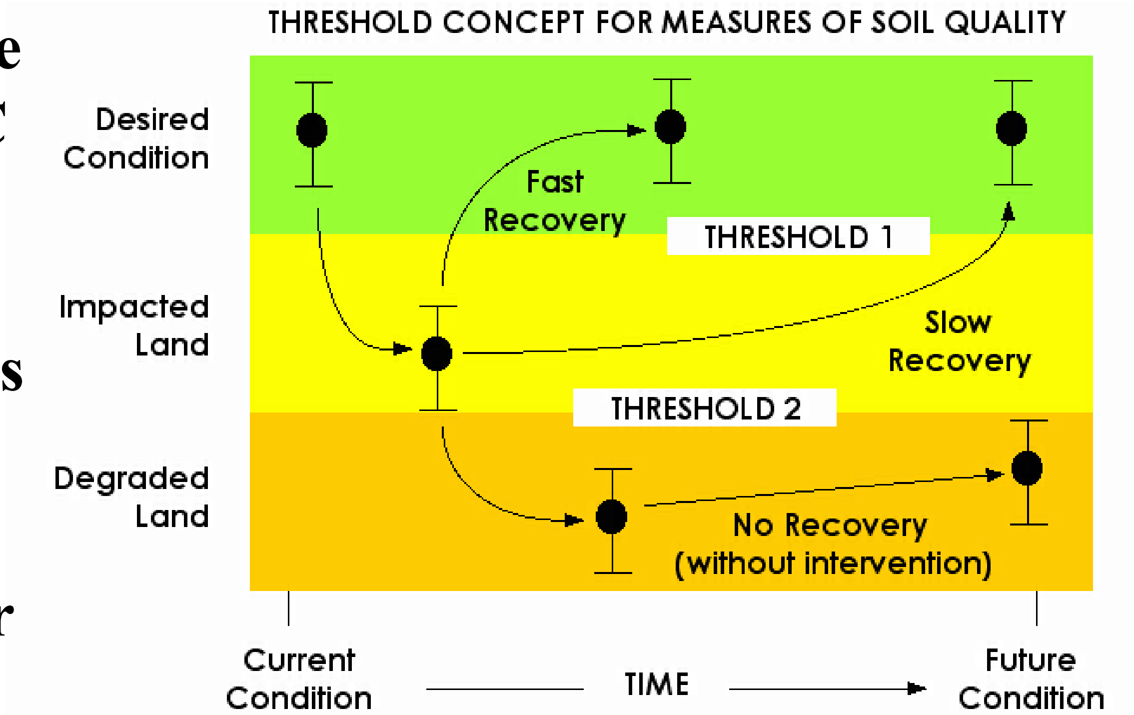
Forest Clear-cut

TECHNICAL OBJECTIVES

1. *Characterize the effect of disturbance and land cover* **on key measures of soil quality (completed 2002)**
2. *Determine thresholds* **that establish the potential for recovery of soil quality following site disturbance**
3. *Build simple dynamics models* **for different land cover categories to predict recovery of soil quality on disturbed lands**
4. *Field experiments* **(and observations) to calibrate models used to predict the recovery of soil quality**
5. *Spatial analysis of soil carbon and nitrogen dynamics* **to predict the effect of disturbance and land use change at Fort Benning**

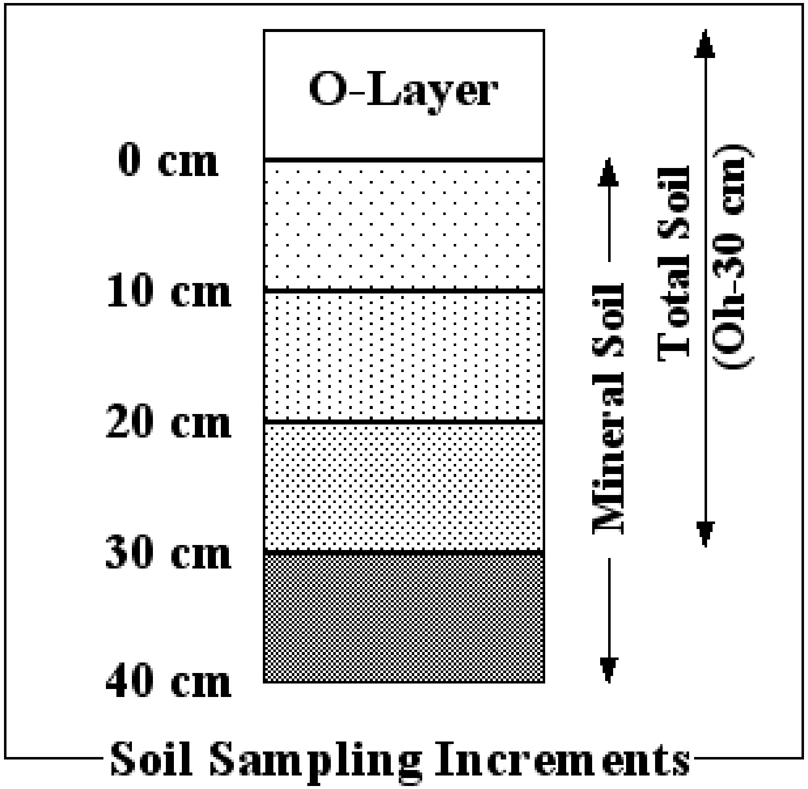
TECHNICAL BACKGROUND

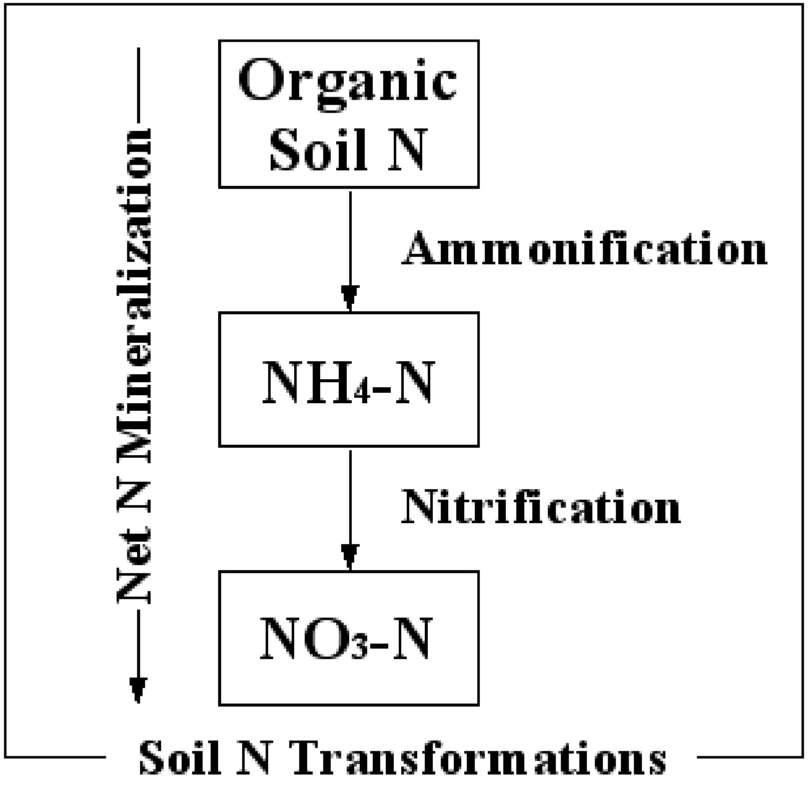
- Soil C and N dynamics, along with texture and structure, are determinants of soil quality (i.e., the ability of a soil to function in its natural condition or the suitability of soil for a particular use)
- Land use (or land use change) affects soil C & N dynamics
- Military activities impact soil properties
- Poor understanding of thresholds that affect the recovery or sustainability of ecosystems



TECHNICAL BACKGROUND

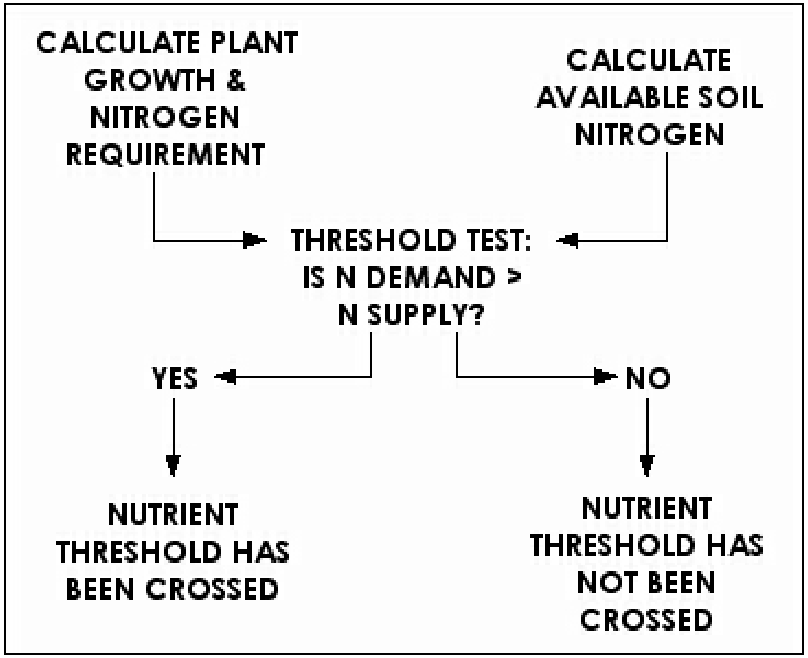
- Profiles of soil carbon and nitrogen concentrations (%) and stocks (g m^{-2})
- Estimates of soil bulk density (g cm^{-3}) (indicator of soil compaction)
- Extractable soil nitrogen and potential net soil nitrogen mineralization rates (indicator of soil N availability)





TECHNICAL BACKGROUND

- Modelling can be used to examine the predicted response of an indicator over a range of hypothetical disturbance levels
- The threshold model asks the question: "Are soil N supplies sufficient to meet the N demands of biomass associated with a desired future ecosystem condition?"
- Components of the model:
  (1) biomass dynamics
  (2) soil carbon and nitrogen,
  (3) plant N requirements,
  (4) excess soil N
- Issues specific to management and restoration can be addressed through the use of a nutrient threshold model



TECHNICAL APPROACH

Predict System Response to Disturbance and Identify Thresholds to Recovery

Build Mathematical Models:
1. Spreadsheet Models (simple)
2. Object Oriented Modelling (complex)

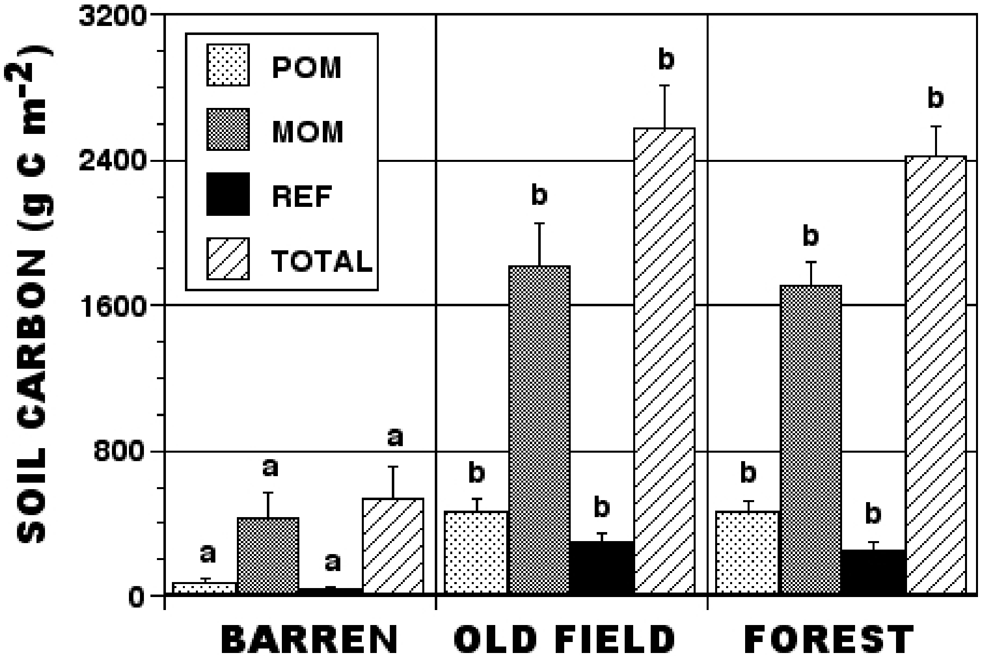
Field Measurements From:
1. Disturbance Gradients
2. Different Land Cover Categories
3. Forest Chronosequences

Old Longleaf Pine

Landscape Level Analysis of Soil Carbon and Nitrogen Dynamics (GIS Data + Field Data + Modelling)

EFFECT OF LAND COVER

- **Sampling sites classified into 5 land cover types: barren land, transitional vegetation, evergreen forest/plantation, mixed, and deciduous forest**
- **Land cover has a significant effect on key measures of soil quality including soil bulk density, soil N availability, soil C (below) and N stocks, and properties of the O-horizon**



POM = particulate organic matter (OM)

MOM = mineral-associated OM

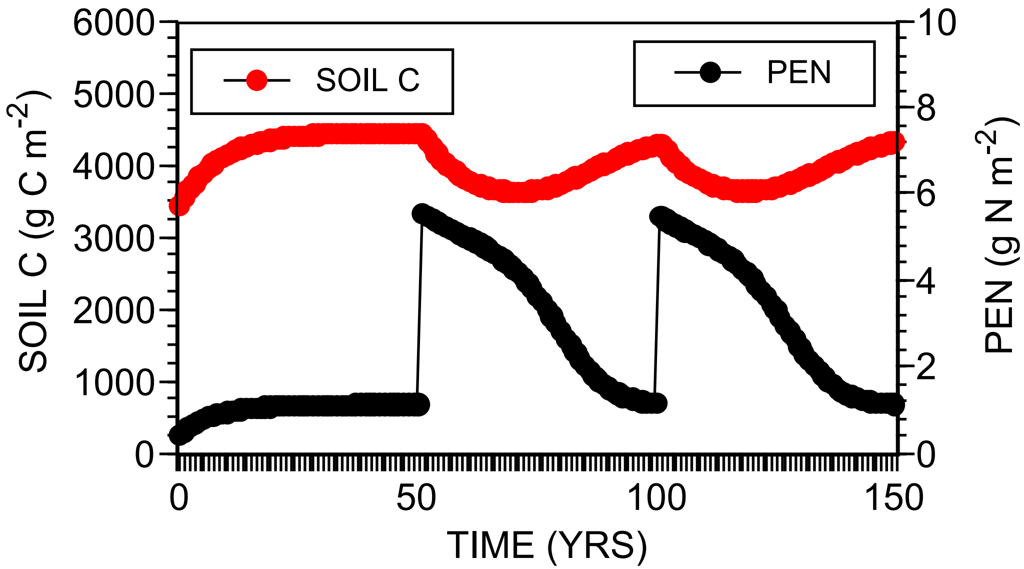
REF = refractory OM

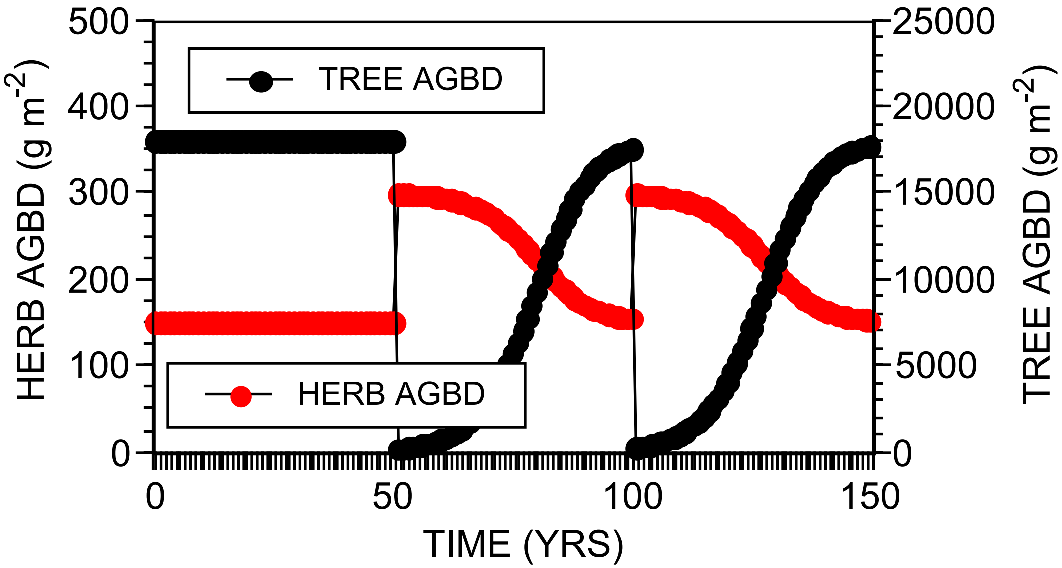
- **Barren land has poor soil quality relative to other land cover types**
- **The presence of long-term perennial vegetation is important to the maintenance of soil quality**

STELLA(R) MODEL

FOREST MANAGEMENT SCENARIO

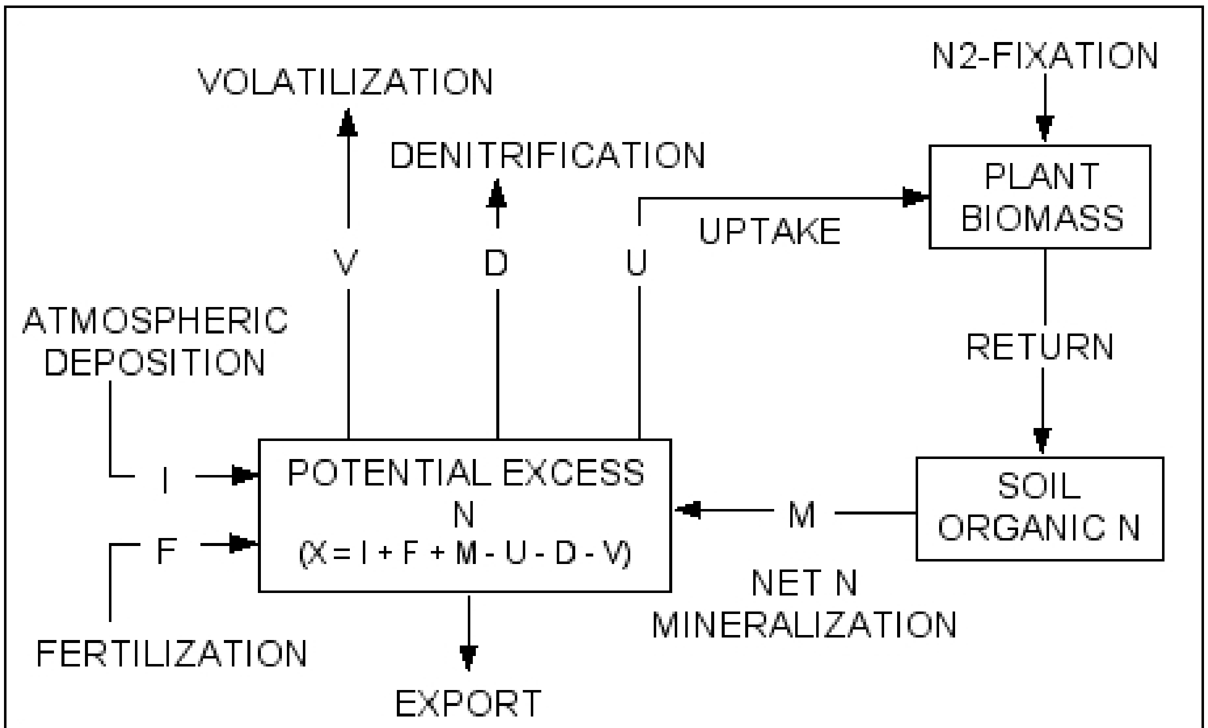
- **Includes feedback from available soil N (PEN) to forest growth (AGBD)**
- **Models herb and tree biomass (simultaneously)**
- **Models soil C as a single dynamic pool**
- **Can be used to predict recovery, system response to periodic disturbance (e.g., harvesting or fire), and a change in land use**

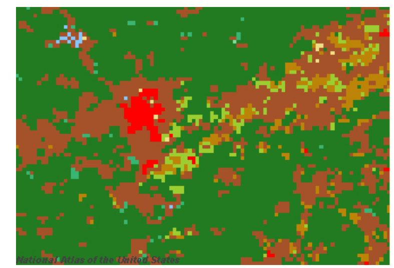




SPATIAL ANALYSIS

- **Field data can be interpreted in the framework of a model of potential excess nitrogen (PEN) on the landscape**
- **The mass balance model can be coupled with simple GIS tools to assess the potential contribution of nonpoint N sources to water quality**

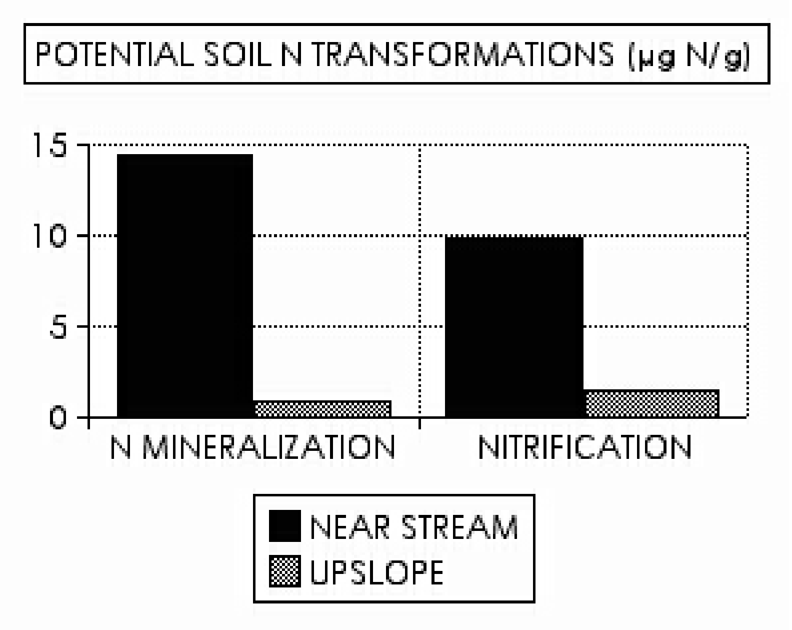




Translation of model results to GIS

DATA FROM FIELD STUDIES & LITERATURE

PROJECT STATUS



COMPLETED FIELD STUDIES INCLUDE THE ANALYSIS OF SOIL CARBON AND NITROGEN:

- Along gradients of military disturbance
- Under various land cover types
- Along gradients of forest recovery from clear-cutting
- At different topographic positions in a mature forest stand
- Along a longleaf pine chronosequence (5 to 82 year old stands)
- At barren sites recently planted in herbaceous grasses (restoration)

MODELLING:

- Incorporation of field and literature data into a modelling framework
- Development of preliminary spreadsheet and compartment models for predicting ecosystem response to changes in soil quality

MAJOR FINDINGS

- **Measurements related to *soil C and N appear to be good indicators* of soil quality (sensitive, easy to measure, predictable)**
- ***Barren sites can recover* a significant amount of soil C (organic matter) within 2 years after grass establishment**
- ***Forest clear-cuts* may exhibit a temporary increase in soil N availability and a temporary decline in soil C stocks**
- ***Near stream environments* are characterized by greater soil C and N stocks and greater soil N availability**
- ***Amounts of soil C* under long-term herbaceous vegetation are not markedly different from soil C stocks under forests**
- ***The turnover time of total surface soil C* appears to be relatively fast (≈9 years) in Fort Benning's warm climate**

DELIVERABLES

PRESENTATIONS:

- SEMP Research Coordination Meeting, Columbus, GA (11/00)
- ASA/CSSA/SSSA Meeting, Minneapolis, MN (11/00)
- SEMP Research Coordination Meeting, Columbus, GA (11/01)

POSTERS:

- Partners in Environmental Technology Technical Symposium and Workshop, Washington, DC (11/01)

JOURNAL ARTICLES:

- Effect of military training on indicators of soil quality at Fort Benning, GA (submitted to *Ecological Indicators*)
- Land cover differences in soil carbon and nitrogen at Fort Benning, GA (submitted to *Environmental Management*)

SEMP DATA REPOSITORY:

- Entered 2 data files dealing with studies of soil carbon and nitrogen along a disturbance gradient (12/01)

DELIVERABLES

- New basic information and understanding of soil carbon (amounts, vertical profiles, and various forms) and nitrogen dynamics (potential soil N transformations) under different land covers and disturbance regimes at Fort Benning, GA

- Mathematical models of soil C and N dynamics
- A nutrient resource threshold model for desired future ecosystem conditions based on soil N availability

- Data sets on soil carbon and nitrogen at Fort Benning for the SEMP Data Repository
- Posters and presentations

- Three (or more) peer reviewed articles that deal with soil quality indicators along disturbance gradients, differences in soil quality under different land covers, and nutrient threshold modelling

SERDP Strategic Environmental Research and Development Program
Improving Mission Readiness Through Environmental Research

PROGRAM PLAN

ornl OAK RIDGE NATIONAL LABORATORY

ACTIVITY	FY 00				FY 01				FY 02				FY 03			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1. Field studies: military disturbance gradients (soil samples provided by Virginia Dale)	■	■	■	■	■	■										
2. Field studies: land cover differences (based on FB LCTA plots)		■	■	■	■	■	■	■	■	■	■					
3. Field studies: disturbance gradients, forest clear-cutting, site recovery (NRCS)							■	■	■	■	■	■	■	■		
4. Field studies: K11 (pre-treatment and post-treatment soil sampling at select locations)							■	■	■	■	■	■	■	■		
5. Field studies: longleaf pine chronosequence (to provide data for threshold modelling)											■	■	■	■		
6. Modelling: parameterize models of soil C and N for calculating thresholds to soil quality									■	■	■	■	■	■	■	■
7. Modelling: landscape level assessment of potential excess N (GIS + field data + modelling)													■	■	■	■

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US Army Corps of Engineers®

Technical Advisory Committee Procedures

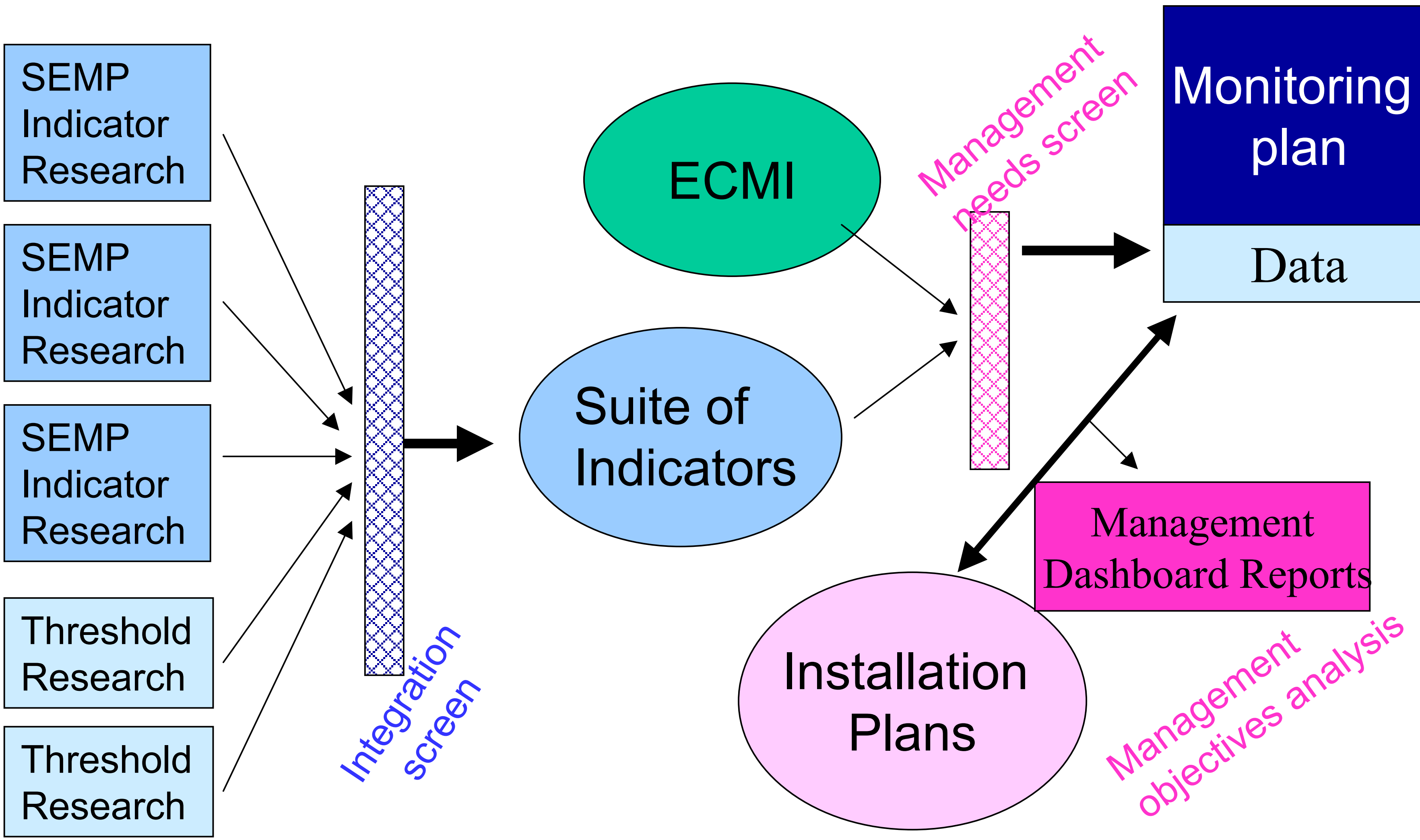
- Meet twice each year, plus numerous follow-on actions and subcommittees.
- Review all projects and monitoring effort.
- Identify issues, problems and recommend courses of action.
- Review and recommendations on SEMP budget (prioritize requests).
- Action Item Reports to SERDP Program Office, SEMP Project Manager, Host Site(s), and all SEMP performers.

Current TAC Recommendations and Priorities

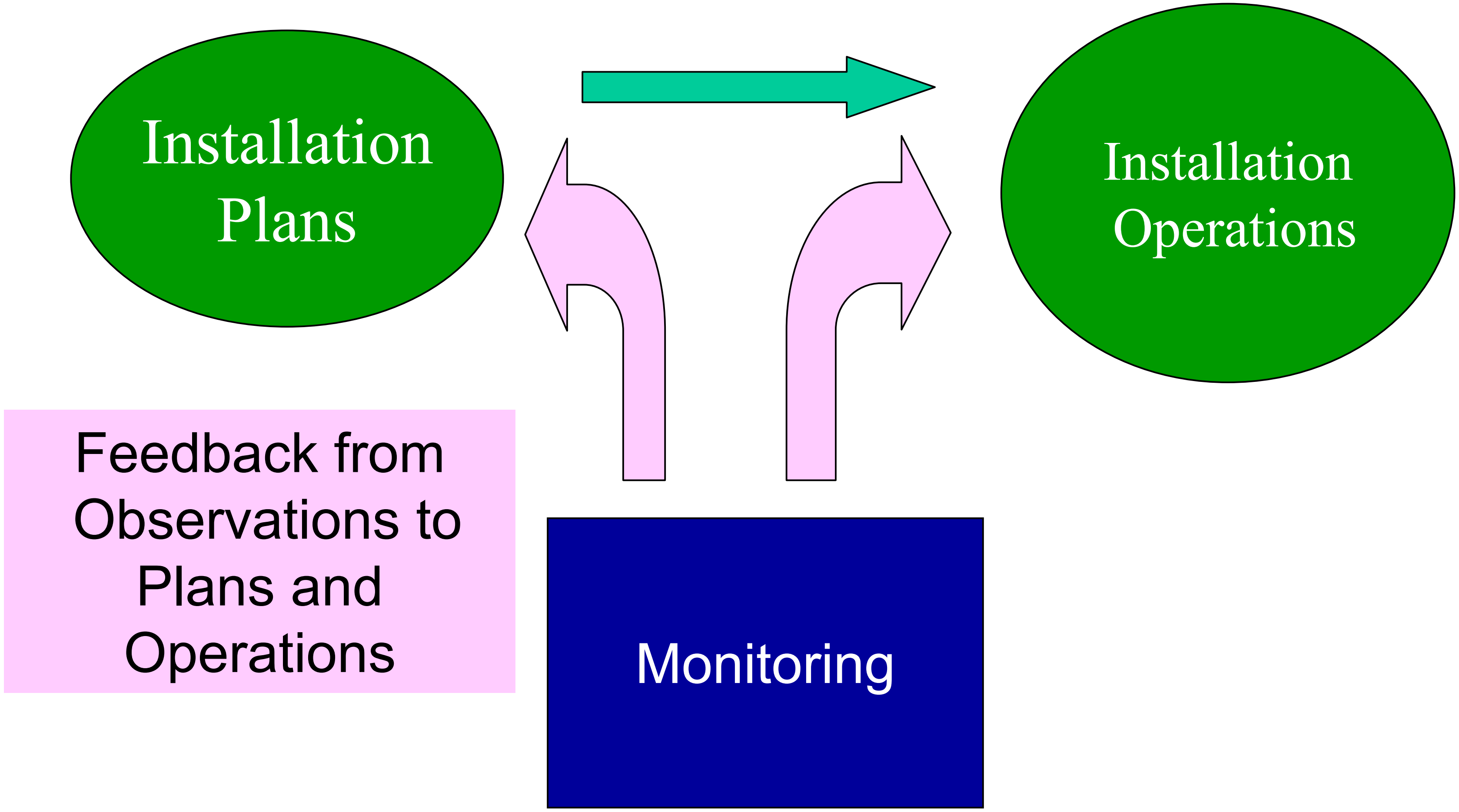
- Effort to integrate outcomes of SEMP research.
- Transition of SEMP outcomes into installation operations (and beyond).
- Improved validation of research results – Fall Line Testbed Project
- Enhanced coordination and teaming across projects
- Biogeochemical Processes – FY04 SON

SEMP Integration

= Research + Characterization + Management Needs

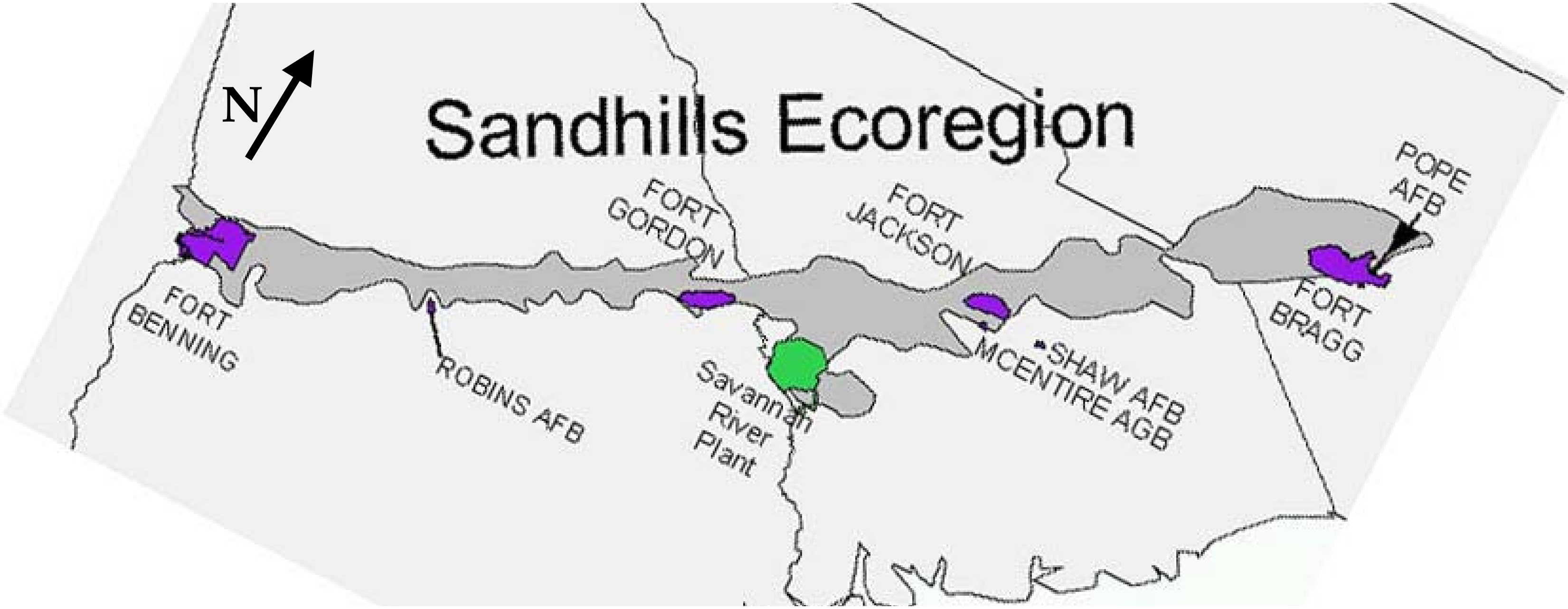


Transition of SEMP Outcomes in Installation Operations



Sandhills Initiative

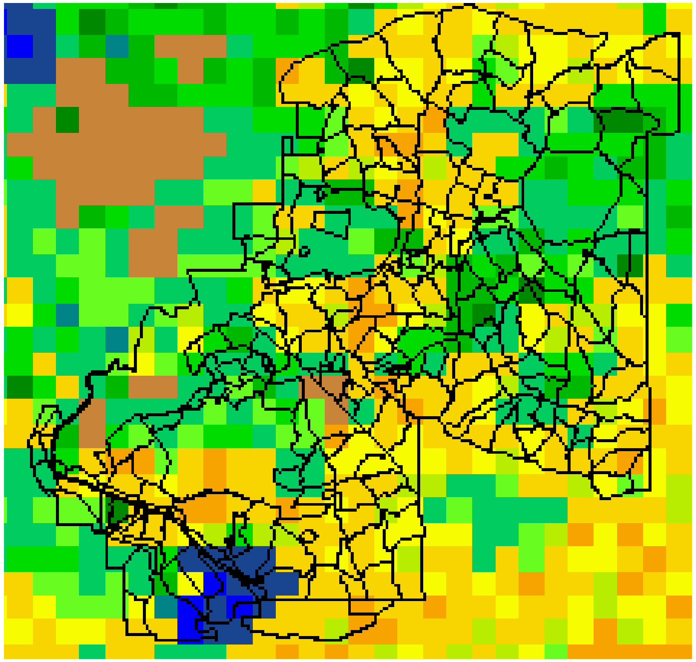
Research Project Extension Across the Region



- Inter-installation workshop March 2000
- Workshop Report 2001
- Fall Line Testbed proposed 2001; budgeted 2002-2005
- New SERDP (SREL) Fall line project funded 2002
- First proposals in review 2002
- Followup workshop 2004

FY04 SON

Carbon Budget - Productivity



Fort Benning, GA
MODIS Data Set: MODIS/TERRA NET PHOTOSYNTHESIS 8-DAY

L4 GLOBAL 1KM ISIN GRID V003
Date: 8 days ending 2001-03-14
Resolution: Original: 926.6254   Reprojected: 1339.2966 meters

SEMP History

Activity	95	96	97	98	99	00	01	02	03	04	05
Workshop	■										
Project Plan		■	■								
Indicator SON				■							
Indicator Field Work					■	■	■	■	■		
Threshold SON					■						
Threshold Field Work						■	■	■	■	■	
Validation								■	■	■	■
Integration Plan									■		
Carbon SON									■		

SEMP Program Plan 2001-2004

Description	FY01	FY02	FY03	FY04
Management				
Communication, Research Coordination, Plans, Reports, Meetings, Workshops	193.2	177.7	238.5	331.1
On Site Support				
Host Site Coordinator, Travel, Supplies, Field Vehicles, Radios	75.0	93.8	105.4	101.7
Data Acquisition and Analysis				
Monitoring, Data Repository, History of Use	460.0	570.0	524.0	406.0
FY99 SON -- "Change Indicators"				
Determination of Indicators of Ecological Change (Univ. of FL) -- CS-1114A-99	431.5	425.2	419.9	406.2
Developing Ecological Indicator Guilds (Prescott) -- CS-1114B-99	409.3	409.3	388.2	0.0
Indicators of Ecological Change (ORNL) -- CS-1114C-99	400.0	400.0	400.0	400.0
FY00 SON -- "Disturbance Thresholds"				
Disturbance of Soil Organic Matter and Nitrogen Dynamics: Implications for Soil and Water Quality (ORNL) -- CS-1114D-00	290.0	195.0	195.0	0.0
Thresholds of Disturbance: Land Mgmt Effects on Vegetation and Nitrogen Dynamics (SREL) -- CS-1114E-00	267.0	280.0	285.0	241.0
New SONs				
Productivity and Carbon Budget				800.0
Integration and Tech Transfer				
Expanded Tech Transfer (as extension to existing projects)	0.0	80.0	200.0	275.0
Integration Strategy and Implementation	0	0	200.0	200.0
Total Funding	**2526.0**	**2631.0**	**2956.0**	**3161.0**

Backup Slides

for

CS-1114

SEMP Management Briefing

15 Oct 02

SERDP
Strategic Environmental Research and Development Program
Improving Mission Readiness Through Environmental Research

US Army Corps of Engineers

Status of SEMP Research

- Three “Indicators” projects completing third full year of study
- Candidate indicators emerging
- Two “Thresholds” projects completing second full year of field study
- Results indicating further directions
- Research teams developing better understanding of local ecosystem processes and variations
- Integration of understanding across teams furthered through joint authorships and research coordination workshops
- Understanding of Site Index developed
- Adaptive Management analysis of Ft. Benning procedures initiated
- Tech transfer processes and inter-installation cooperation initiated

Developing Uniform Site Index

- "High" "Medium" and "Low" impact/disturbance categories showed unacceptable overlap
- In 2002 -
  - Agreement reached that no single measure would be adequate
  - Advisory Committee developed criteria for a measurement scale
  - Team leaders identified elements which showed most likelihood to reflect condition
  - Eight candidate factors proposed as reasonable for "plot" level rankings
  - "Landscape" level factors agreed to need further development
- Workshop scheduled for 30 Oct to agree on plan to implement
- All sites to be classified using index plan in FY03

SERDP
Strategic Environmental Research and Development Program
Improving Mission Readiness Through Environmental Research

Monitoring Data

US Army Corps of Engineers

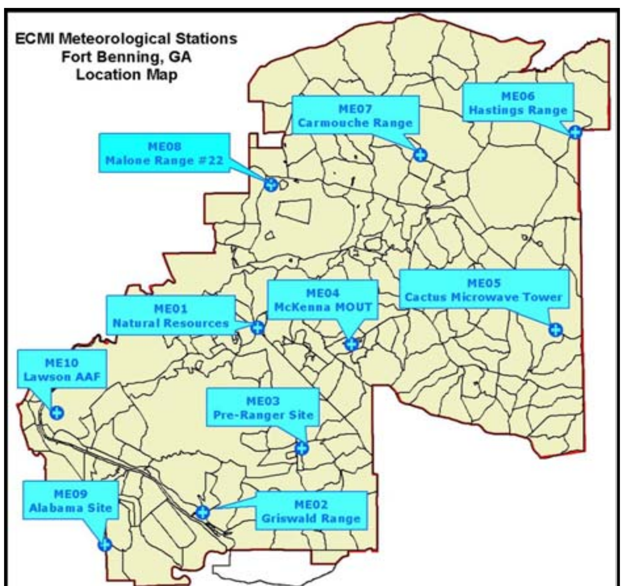
ECMI Meteorological Station Data
Monthly Summary Sheet

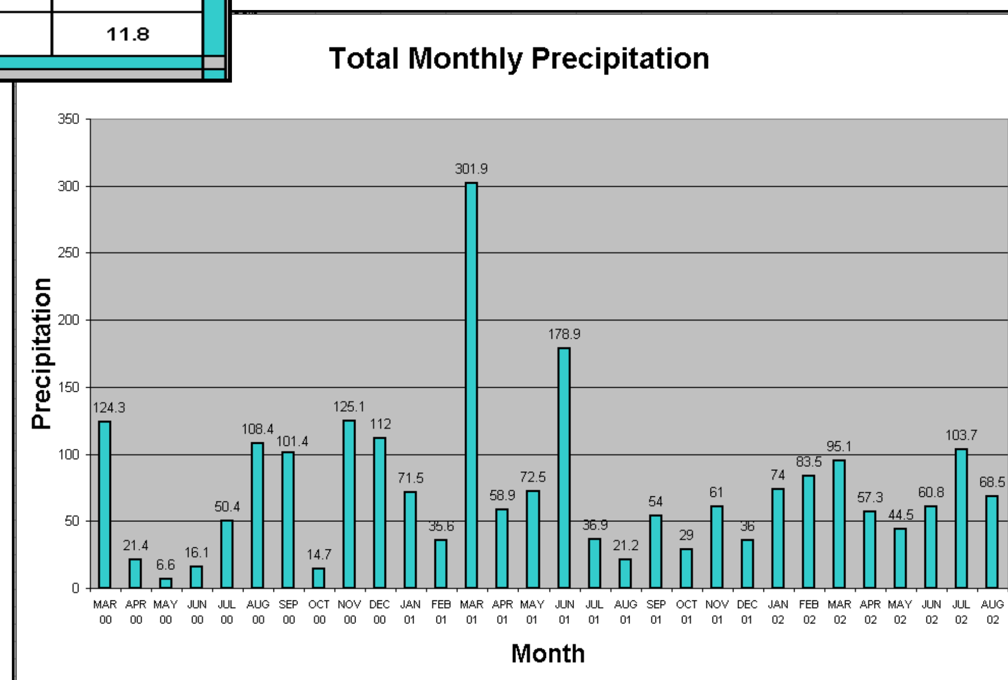
Met Station ID: ME08 - Malone Range (Range # 22)

Time Period Covered: August **2002** - Number of Observations: **1488**

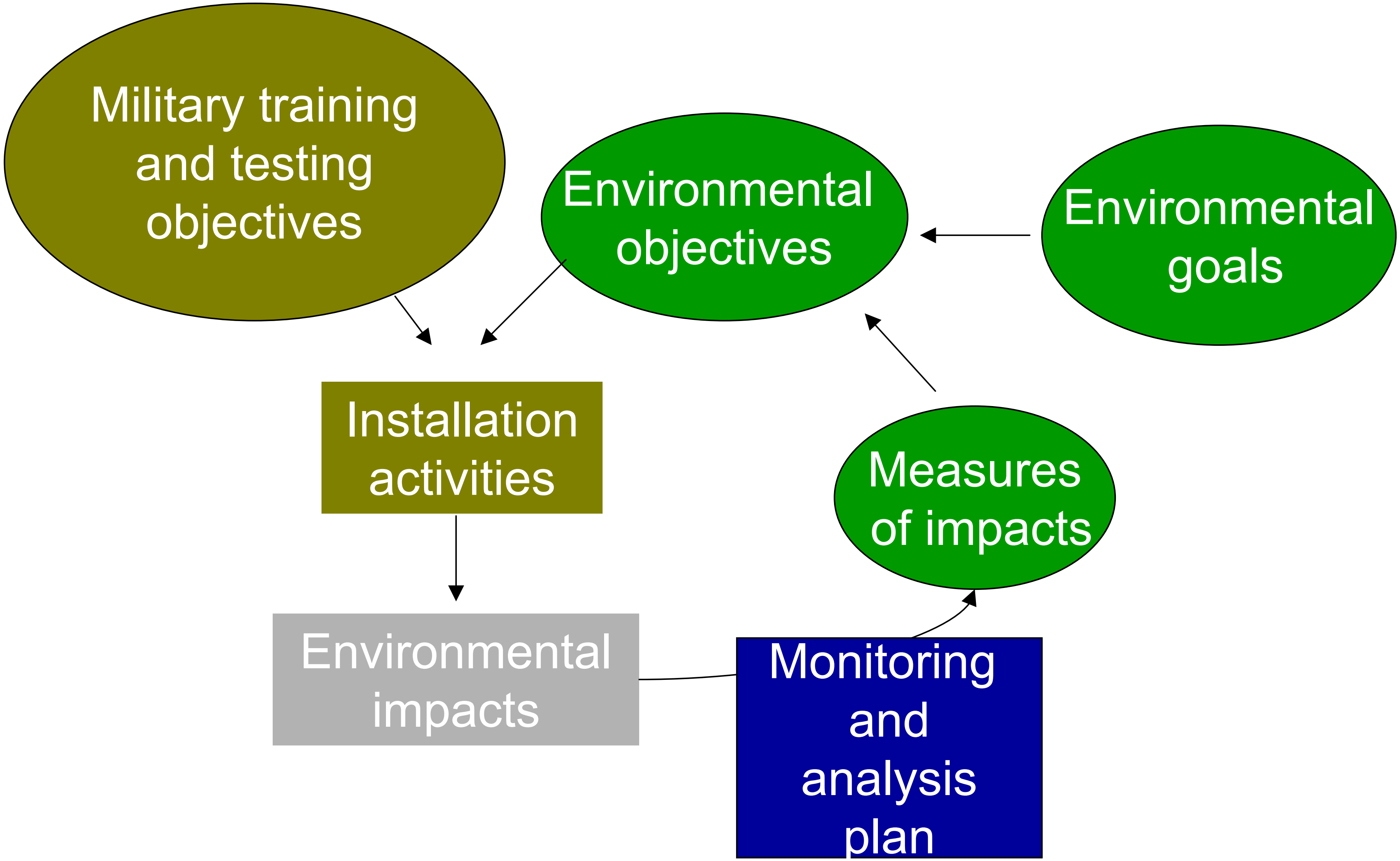
Meteorological Station Height:	Wind Sensors:	Air Temp Sensor:	UTM Easting:	UTM Northing:
approximately 10 feet	3.0 meters	1.5 meters	701525	3593400

Variable Measured (Unit of Measure)	Mean	Std Error	Minimum	Maximum
Air Temperature *(Degrees Celsius)*	26.2	0.1	16.1	37.4
Relative Humidity *(Percent Humidity)*	70.0	0.5	23.0	99.0
Barometric Pressure *(MilliBars)*	1019.8	0.1	1013.0	1028.0
Solar Radiation *(Watts / Square Meter)*	218.9	7.4	0.0	947.0
Wind Speed *(Meters / Second)*	0.9	0.0	0.0	3.6
Wind Direction *(Degrees from North)*	145.0	2.8	0.1	360.0
Precipitation *(Millimeters)*	0.0	0.0	0.0	11.8





How Monitoring Plan Fits into Overall Installation Activities



Slides for Background and Additional Information

Development of Ecological Indicator Guilds for Land Management

(CS-1114B)

Ecological Indicator Design Criteria

Modified from Proposal (Table 1)

- Ease of use for land managers
- Cost effective
- Ecological relevance & value
- Reflect ecosystem dynamics and physiological stress
- Quantifiable with statistical estimates of accuracy & precision
- Robust & multi-scale
- EcoRegion application
- Global methodology extension
- Symmetry: track degradation & recovery/restoration
- Reasonable response times
- Reliable, consistent, unambiguous
- Incorporation of natural variance
- Known sensitivity to temporal sampling window
- Association with suites of stressors

Application of Ecological Indicators for Military Land Management

- Training sustainability
- Ecosystem maintenance and sustainability
- Long-term productivity
- Multiple-use decisions and requirements
- Conditions & Trends in natural resources
- Timing and success of restoration efforts
- Environmental monitoring
- Legal mandates

Habitat Parameters
32 Metrics

- General Habitat

  Canopy Cover
  Soil Compaction
  Basal Area
  Soil Shear Stress
  A-Horizon Soil Depth

- General Ground Cover

  Forbs
  Woody
  Legumes
  Litter
  Grass
  Bare Ground

- Ground Cover by Taxa

  Woody, Forbs, Grass, *Opuntia*, *Yucca*, *Pteridium*

- Tree Community

  Species, Density, Mean & Std Dev of DBH

Discriminant Analysis

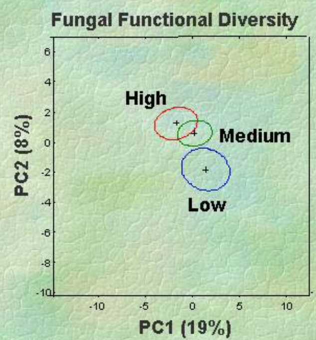
- Discriminant analysis weights the selected predictor variables (e.g., canopy cover, poison ivy cover, A-horizon soil depth, mockernut hickory density)
- Such that their linear combinations maximally distinguish (discriminate) among two or more predetermined groups (e.g., the 3 site disturbance classes)
- The first discriminant function possesses the highest discriminating power
- The second discriminant function is uncorrelated with the first (orthogonal) and is the next highest in discriminating power

Microbial and Soil Ecology

Microbial and Nitrogen Dynamics Differ Along the Disturbance Gradient

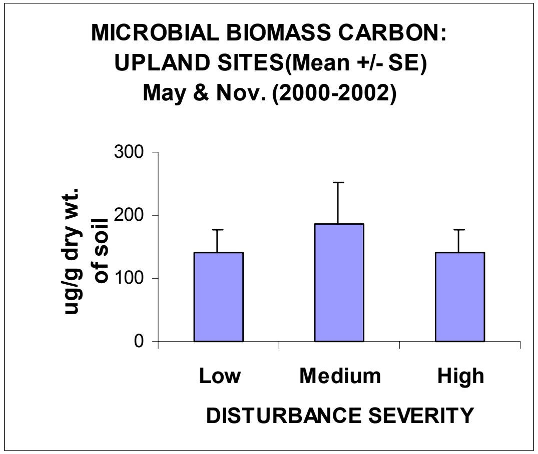
Note Reduced Microbial Carbon:
Low sites have higher turnover rates (biotic response)
High sites have higher soil temperatures and lower soil moisture (abiotic response)

Fungal Functional Diversity

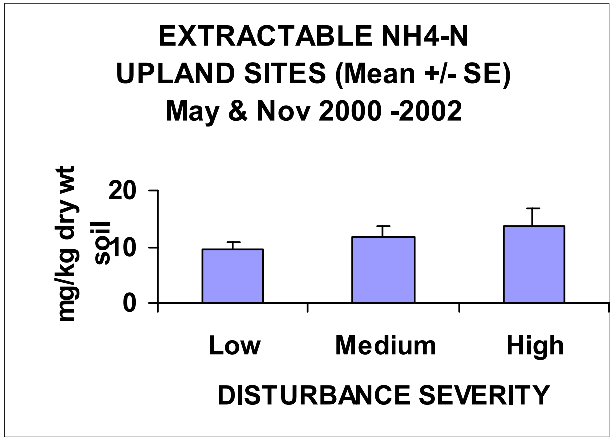


Principal Components Analysis

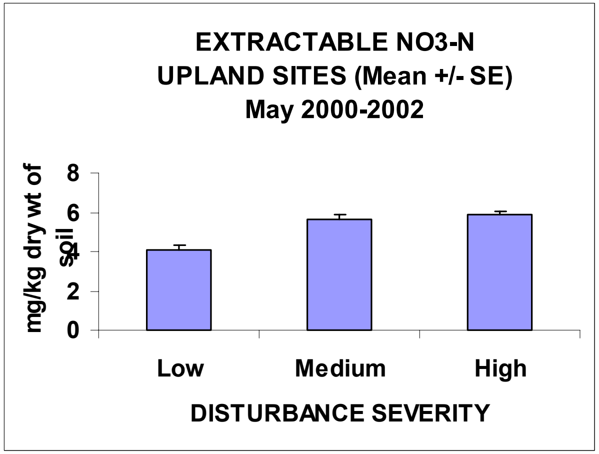
Microbial Carbon



Ammonium



Nitrate



Note higher nitrogen use at Low sites

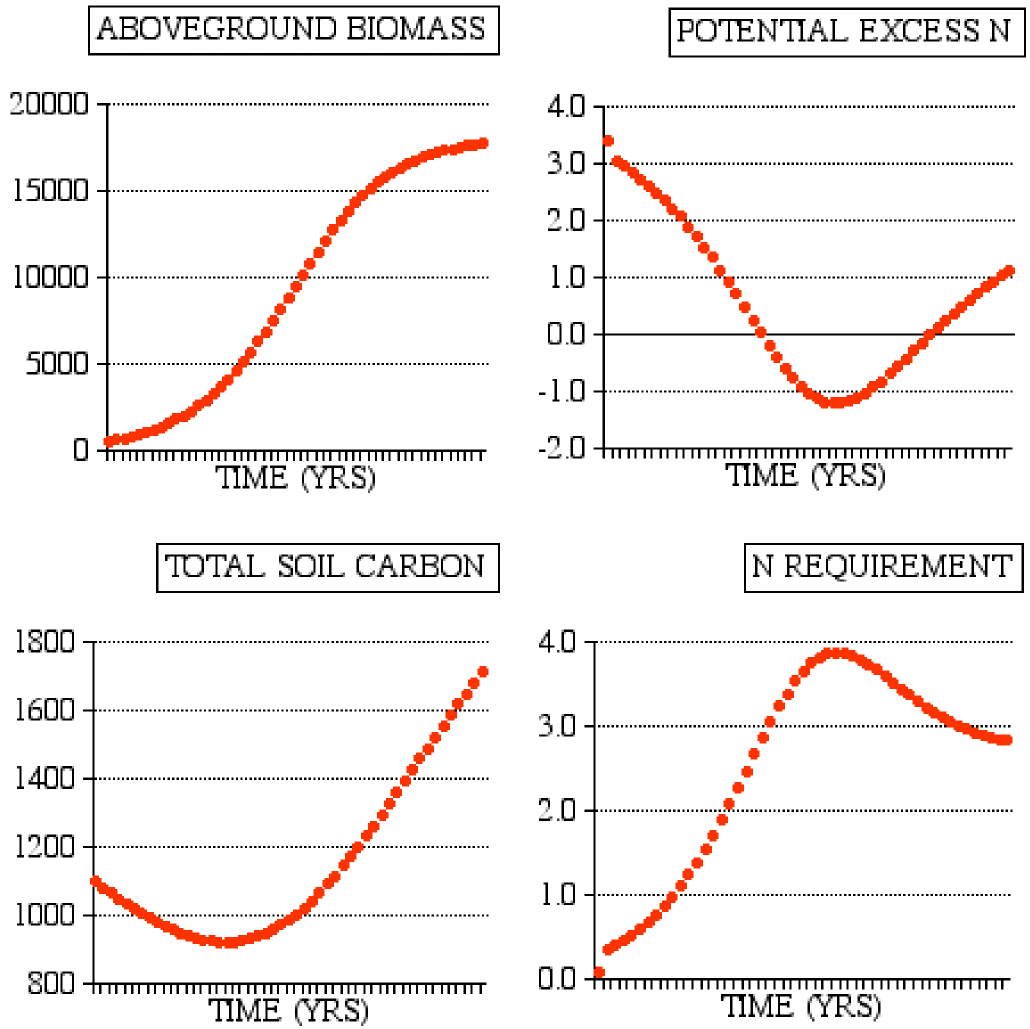
BACKUP SLIDES

Disturbance of Soil Organic Matter and Nitrogen Dynamics:

Implications for Soil and Water Quality

(CS-1114D-00)

SPREADSHEET MODELS



Example 50-Year Simulation for Forest Recovery

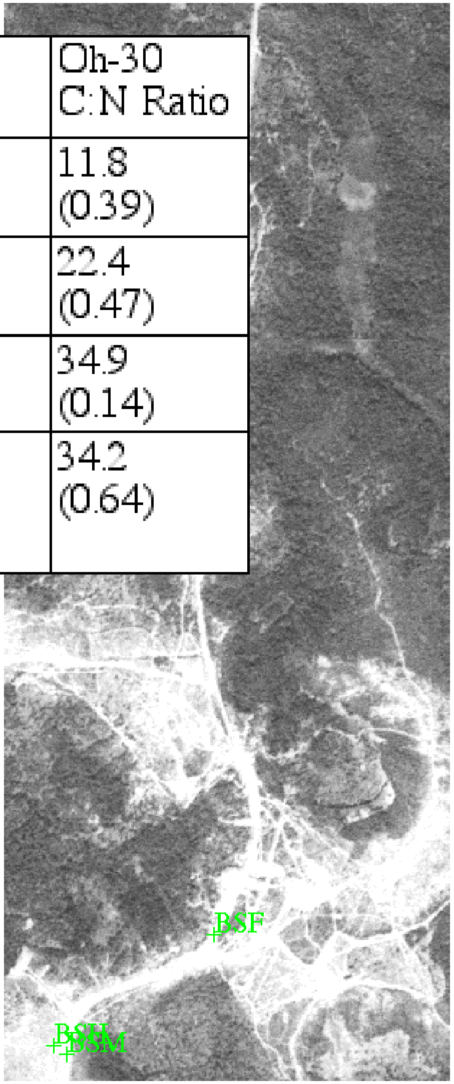
FOREST RECOVERY SCENARIO

- **Relatively simple method**
- **Calculates above- and belowground biomass**
- **Separates old and new soil carbon stocks**
- **Includes no feedback from available soil N to plant growth**
- **Models forest biomass or herb biomass (not both)**
- **Similar to NuCSS (Verburg and Johnson, 2001, Ecol. Modelling)**
- **Can be used to identify thresholds to recovery of desired future conditions**

HISTORICAL SITES

- **Past land use history can be an important factor in interpreting soil C and N dynamics**
- **Corona photographs from 1965 were used to identify sites that had changed or remained the same**

Land Cover	Sample size	Oh-30 g C/m^2	Oh-30 C:N Ratio
Barren (36+ years)	5	445 (0.24)	11.8 (0.39)
Old field (36+ years)	2	3961 (0.05)	22.4 (0.47)
Forests (36+ years)	5	4044 (0.44)	34.9 (0.14)
Pine forests previously barren in 1964	2	3506 (0.45)	34.2 (0.64)



- **Soil C stocks under 35+ year old forests and 35+ year old fields are similar (also supported by other data)**
- **Soil C:N ratios increase as ecological succession proceeds from barren land to old field to forest**
- **Sites with known histories can be valuable calibration points for the purpose of modelling**

PROGRAM FUNDING

	SERDP $K
Year 1	200
Year 2	290
Year 3	195
Year 4	195
Total	880

PROGRAM PLAN

Task 1 (FY00): Develop soil sampling plan based on GIS, complete surveys of soil C and N under different LULC categories, analysis of data, attend meetings and present progress reports (milestones completed)

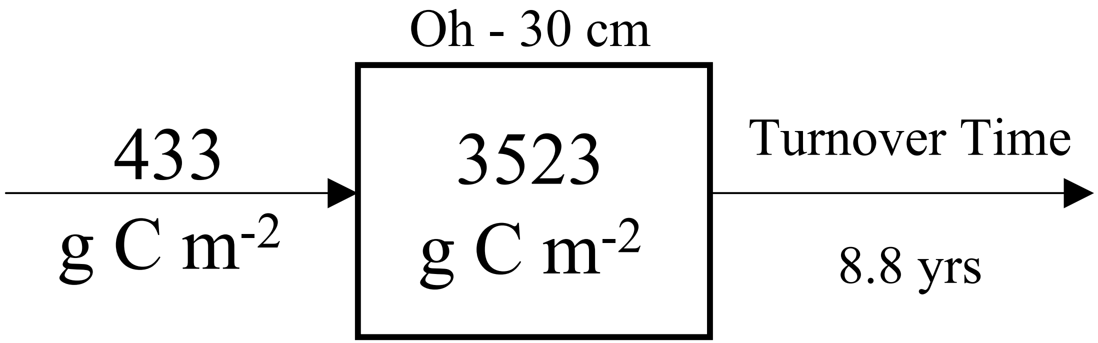
Task 2 (FY01): Establish study sites along disturbance gradients, complete analysis of net soil N mineralization along disturbance gradients, complete analysis of different types of soil carbon (POM and MOM), attend meetings and present progress reports (milestones completed)

Task 3 (FY02): Parameterize models of soil organic matter for different land cover types, complete planning of long-term field experiments to calibrate models of soil C and N, attend meetings and present progress reports (work in progress)

Task 4 (FY03): Complete mapping of soil C and N at Fort Benning, evaluate and interpret potential nonpoint sources of N to surface receiving waters, attend meetings and prepare final report (planned)

FIELD DATA: C TURNOVER

Data from longleaf pine chronosequence (Spring 2002)					
Stand Age in Years [ID code]	Basal Area (m^2/ha)	Foliage (g/m^2)	Estimated Litter fall (g/m^2)	AGBD (g/m^2)	Estimated C Input to Soil (g/m^2)
5 [K17Y]	0.20	7.4	4.2	--	3.8
10 [161-NR]	17.1	626	357	--	321
12 [T5Y]	13.2	483	275	--	248
56 [G5M]	18.7	684	390	14147	351
70 [G5A]	26.3	962	548	19687	494
75 [A14A]	29.9	1093	623	24072	561
82 [K17A]	17.2	631	360	14074	324



- **AGBD calculated using allometric equations from Mitchell et al. (1999)**
- **Longleaf pine needlefall is ≈57% of foliage biomass (Wiegert and Monk, 1972)**
- **Mean AGBD in mature stands is 17995 g m^{-2} (C.V. = 0.27)**
- **Soil C turnover (≈ 9 years) was calculated from 4 oldest sites**

LANDSCAPE EFFECTS

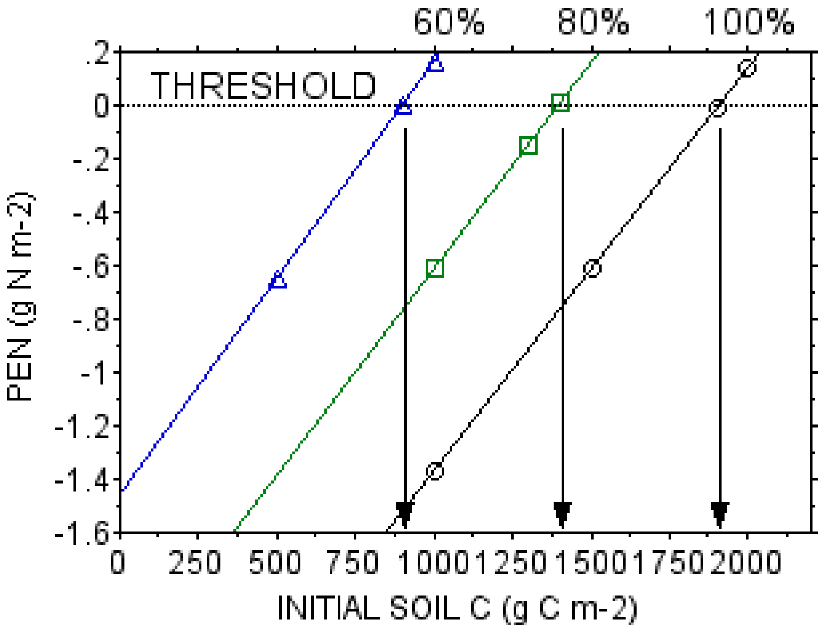
Differences in Riparian and Upslope Forest Soils						
Landscape position	Sample size	Oh-30 g C/m^2	Oh-30 g N/m^2	Initial extractable (µg N/g)	Net N min. rate (yr^{-1})	NO3-N Prod. in 12 weeks (µg/g)
Near stream	15	6064 (0.25)	184 (0.30)	4.16 (0.49)	0.086 (0.53)	9.87 (1.24)
Upslope forest	18	3227 (0.18)	94 (0.33)	1.39 (0.45)	0.016 (1.57)	1.43 (1.21)

NEAR STREAM

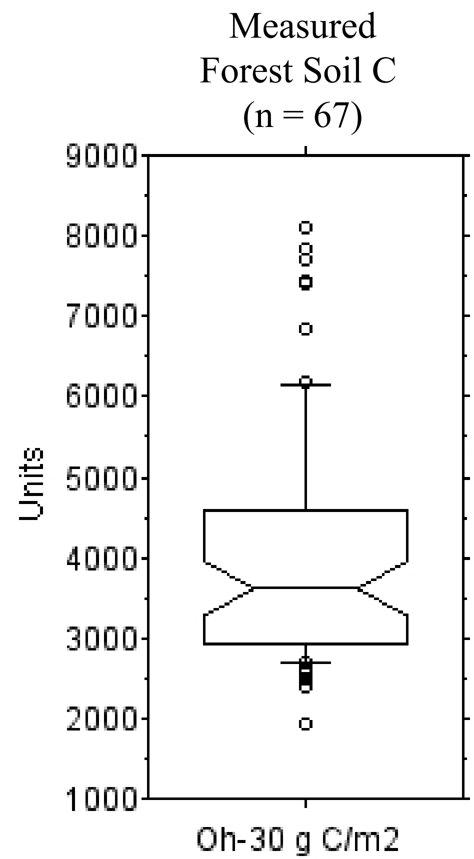
SLOPE

- **Soil carbon and nitrogen stocks, and soil nitrogen availability is greater in the near stream environment at the K-11 study site**
- **Assuming an annual litterfall of 408 g m^{-2} (Sharpe et al., 1980), the estimated annual soil C input is 367 g C m^{-2} and the estimated turnover time is 8.8 years up slope and 16.5 years near stream**

SPREADSHEET THRESHOLDS



- **Thresholds to recovery of a barren site were predicted with the spreadsheet model**
- The desired future condition (target biomass) was set at 18000 g m^{-2} (AGBD)



- **The threshold to forest recovery (i.e., the initial soil C stock) increased as the target forest AGBD increased**
- **Threshold to 100% AGBD was 1900 g soil C m^{-2}**
- **Field data indicate that 99% of all forests at Fort Benning occur on soils with >2000 g C m^{-2}**

INTEGRATION

Integration Within the ORNL Team 2 Project:

- **Field research on soil quality under different land covers helps to *establish initial conditions* for modeling nutrient thresholds**
- **Field research along disturbance gradients and forest chronosequences provides *calibration data* for threshold modeling (i.e., establish boundary conditions)**
- **Field research in K-11 (experimental disturbance site) will be used to *test effects of disturbance* predicted by the model**

Integration With Other SEMP Research Projects:

- **Research on thresholds by ORNL Team 2 has interfaced with research on *ecological indicators* by ORNL Team 1 (Dale et al.) along disturbance gradients and at the K-11 experimental site**
- **ORNL Team 2 is collaborating with SREL (another SEMP threshold project) to arrive at a *unified concept of ecological thresholds* as applied to military land management at Fort Benning**
- **ORNL Team 2 will utilize available *data from other SEMP research projects* for modeling nutrient resource thresholds to desired future conditions**
- **ORNL Team 2 is collaborating with J. Jacobs at University of Florida on developing a *hydrologic approach to landscape level modelling* of nitrogen at Fort Benning**

RESEARCH NEEDS

In future research, we will address the following needs (some identified in a white paper prepared for the SEMP TAC in Feb. 2002):

- Improved parameterization and calibration of the resource threshold model using data gathered from rehabilitated sites, Fort Benning's forest inventory, and other SEMP research
- Additional data on soil quality and soil carbon and nitrogen dynamics specific to longleaf pine (identified as a desired future condition in Fort Benning's IRMP)
- Additional data on target aboveground biomass values and growth rates associated with different desired future ecosystem conditions
- Utilization of GIS data to arrive at installation wide estimates of soil carbon and nitrogen stocks and potential excess nitrogen

These research needs are important because we believe the optimum strategy for land management and site restoration at military installations involves defining thresholds to soil quality, calculating the N inputs required to achieve desired future conditions, and evaluating fertilizer use in proximity to surface receiving waters.

QUALIFICATIONS & EXPERIENCE

Charles T. Garten, Jr.
Senior Research Staff, Environmental Sciences Division, Oak Ridge National Laboratory
Research Interests: Terrestrial biogeochemistry; soil carbon and nitrogen dynamics; applications of stable isotopes in ecology; sources and effects of nitrogen pollution; ecological modeling; radioecology; pollution impacts on the environmental and public health.
Employment History: Savannah River Ecology Laboratory (1973-76); Oak Ridge National Laboratory (1976-present)
Education: BS, Biology, Washington and Lee University (1970); Graduate studies, University of Alberta (1970-71); MS, Zoology, University of Georgia (1974); MSEH, Environmental Health, East Tennessee State University (2000)
Awards/Honors: UT-Battelle Technical Achievement Award for Sustained Research Accomplishments (2000); Annual Scientific Achievement Award, Environmental Sciences Division, ORNL (1989); Martin Marietta Energy Systems Technical Achievement Award (1989); Scientific Committee 64-23, National Council on Radiation Protection and Measurements (1996-present); Associate Editor, *J. Environ. Radioactivity* (1993-1996); Section Editor, *Nuclear Safety* (1978-1982); Alumni Advisory Board for Science and Mathematics, Washington and Lee University (2000- present)
Publications: Total = 109 publications (61 senior authored and 48 co-authored journal articles, book chapters, technical reports, and theses)
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