

Development of Ecological Indicator Guilds for Land Management

99SMP - 003P

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BRIEF TO THE SCIENTIFIC ADVISORY BOARD

3 August 1999

PERFORMERS

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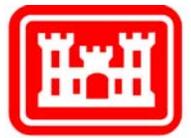
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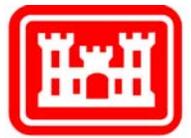
PROBLEM STATEMENT



Military training and testing lands must be efficiently and cost effectively monitored to assess ecological conditions and trends relevant to mission and ecosystem sustainability and the timing and success of restoration efforts.

An important land management tool is a suite of ecological indicators for early-warning detection of environmental changes related to military missions and other multiple land-uses.

TECHNICAL OBJECTIVE



What is the objective of this research?

To develop classes (Guilds) of Ecological Indicators based on population and ecosystem relevant design criteria and landscape scales, for monitoring ecological changes directly relevant to biological viability, long-term productivity, and ecological sustainability of military lands.

Important Capabilities:

- a) identify multiple-scale stressor effects independent of natural variability**
- b) with direct applicability to ecoregional contexts**
- c) approach applicable to any global ecoregion**

Technical Background

Ecological Indicator Systems

Indicator Species over a century of use

- microbes, algae, lichen, plants, protozoans, invertebrates (*aquatic*), vertebrates (*fish, birds*)
- wide applicability
 - environmental & resource management
 - assessment and monitoring of environmental quality
 - biodiversity trends

Technical Background

Ecological Indicator Systems

Ecofunction Groups **direct reflection of
community structure/function**

- **ecological function taxa (amphibians, woodpeckers)**
- **trophic structure, top predators**
- **pollinators and their specializations**
- **response to stressors**
- **strong interactors**

Technical Background

Ecological Indicator Systems

GeoIndicators **direct reflection of geomorphic and hydraulic environments**

- **abiotic template for biotic structure, function, interactions, and pattern**
- **strong technical foundations:**
 - **geomorphology, hydrology, sedimentology, pedology, geochemistry, geophysics, agricultural engineering**

Technical Background

Ecological Indicator Systems

Test Systems **selected ecophysiological responses
to environmental stressors**

- **Developmental Instability**
- **Microbial Activity: functional diversity & biomass**
- **Nutrient Flux: nitrogen**
- **Stress Metrics (plants): respiration,
stomatal conductance**
- **Primary Productivity: photosynthetic efficiency**
- **Interactions: community integrity**

Technical Background

Ecological Indicator Systems

Ecological Metrics **indices of ecological relevance**

- **indices of ecological viability (Karr's IBI, EPA)**
- **community structure, including composition**
 - **similarity and dissimilarity indices**
 - **interaction matrices**
- **metapopulation structure**
- **establishment of exotic species**
- **endemism**
- **landscape metrics**
 - **pattern, fragmentation, contagion**
 - **ecosystem richness and distribution**

Technical Approach

A brief overview

- **Development of ecological indicator design criteria**
- **Integrate 5 classes of ecological indicators with guild theory**
- **Incorporate multiple-scale measures**
- **Firm basis in experimental design and statistical analysis**

Technical Approach

Ecological Indicator Design Criteria

- **ecological relevance and value**
- **reflect community/ecosystem changes and dynamics**
- **reliable, consistent, unambiguous**
- **quantifiable, statistically based, estimable error rates**
- **robust (within & between ecoregions)**
- **natural variance incorporated as covariate**
- **cost-effective**
- **known sensitivity to temporal sampling window**
- **reasonable response times**
- **symmetrical (stress versus recovery)**
- **simple to implement**

Technical Approach

Integrate with Guild Theory

Conceptually appealing for classifying and organizing ecological elements and functions that exhibit similar environmental responses

- **5 Ecological Indicator Systems**
- **many pitfalls using guild construction**
 - **thorough literature review**
 - **rigorous analytical and quantitative framework required**
 - **a posteriori classification**
- **some guiding applications**
 - **vertebrate impact guilds in Mojave Desert in response to military training activities (Krzysik 1995)**
 - **avian response guilds to forest management (Szaro 1986)**

Technical Approach

Measures at Multiple-Scales

- **watershed level**
 - upland, riparian, aquatic ecosystem sites
 - within ecosystem spatial replicates
- **installation level**
 - ITAM data: birds and small mammals
 - amphibians
- **ecoregion level**
 - no sampling, but consideration of approaches

Technical Approach

Experimental Design Components

<i>Sampling Frame</i>	<i>Variance Contrasts</i>	<i>Variance Components</i>
Sites (Sub-Watersheds)	Indicator Responses	Main effects
Ecosystems	Landscape Heterogeneity	Within sites Between sites
Plots	Ecosystem Heterogeneity	Within ecosystems Between ecosystems
Samples	Microhabitat Heterogeneity	Within plots Between plots

Program Progress FY 99

- **Development of Cooperative Agreement between ERDC, USGS-BRD, and 5 universities**
- **Funds received by Federal PIs: 7 July 99**
- **Cooperative Agreement: almost completed**
- **Field site investigations at Fort Benning:
18-21 February and 20-22 July**
- **Initial pilot study for Developmental
Instability: 23-29 July**

Pilot Study for Developmental Instability

23-29 July 1999

Species Selection

Strong Cannalization-----High Phenotypic Plasticity

- **Uplands (Pine - scrub oak)**

*****Rhus copallina***

Winged Sumac

Vitis rotundifolia

Muscadine Grape

- **Riparian (red maple - sweet gum - black gum - bay)**

Liquidambar styraciflua

Sweet Gum

Ilex glabra

Inkberry

Sample Size = 40 plants per species per site

4 leaves per plant

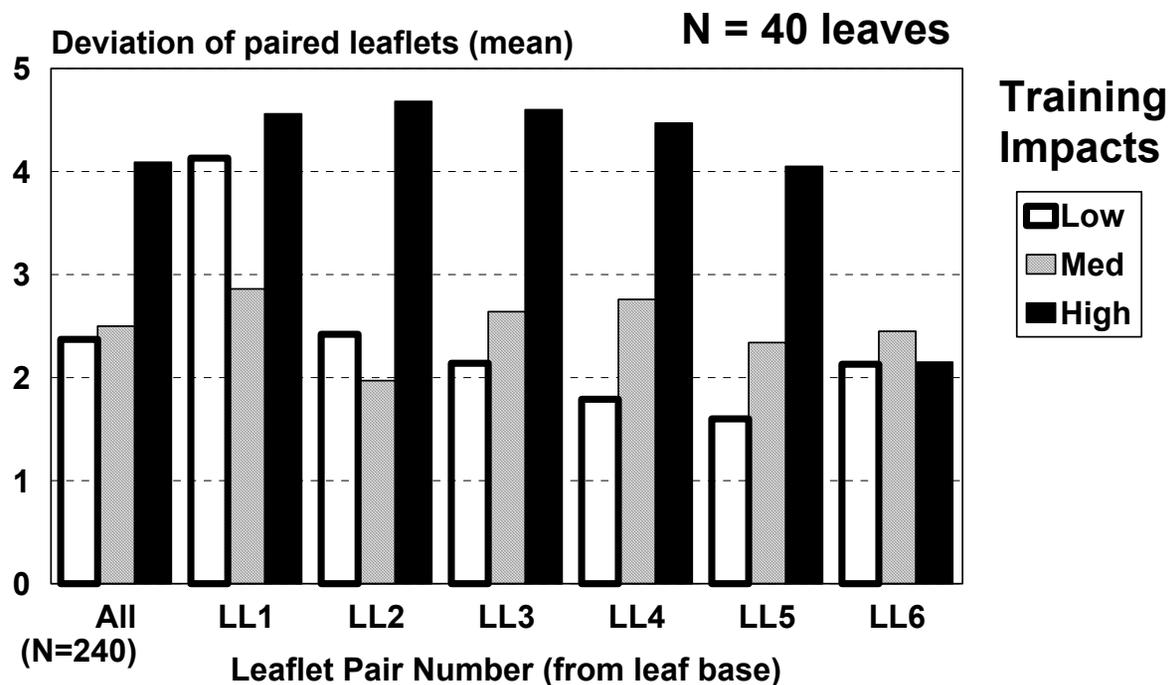
Pilot Study for DI: 23-29 July 1999

Data Analysis (partial)

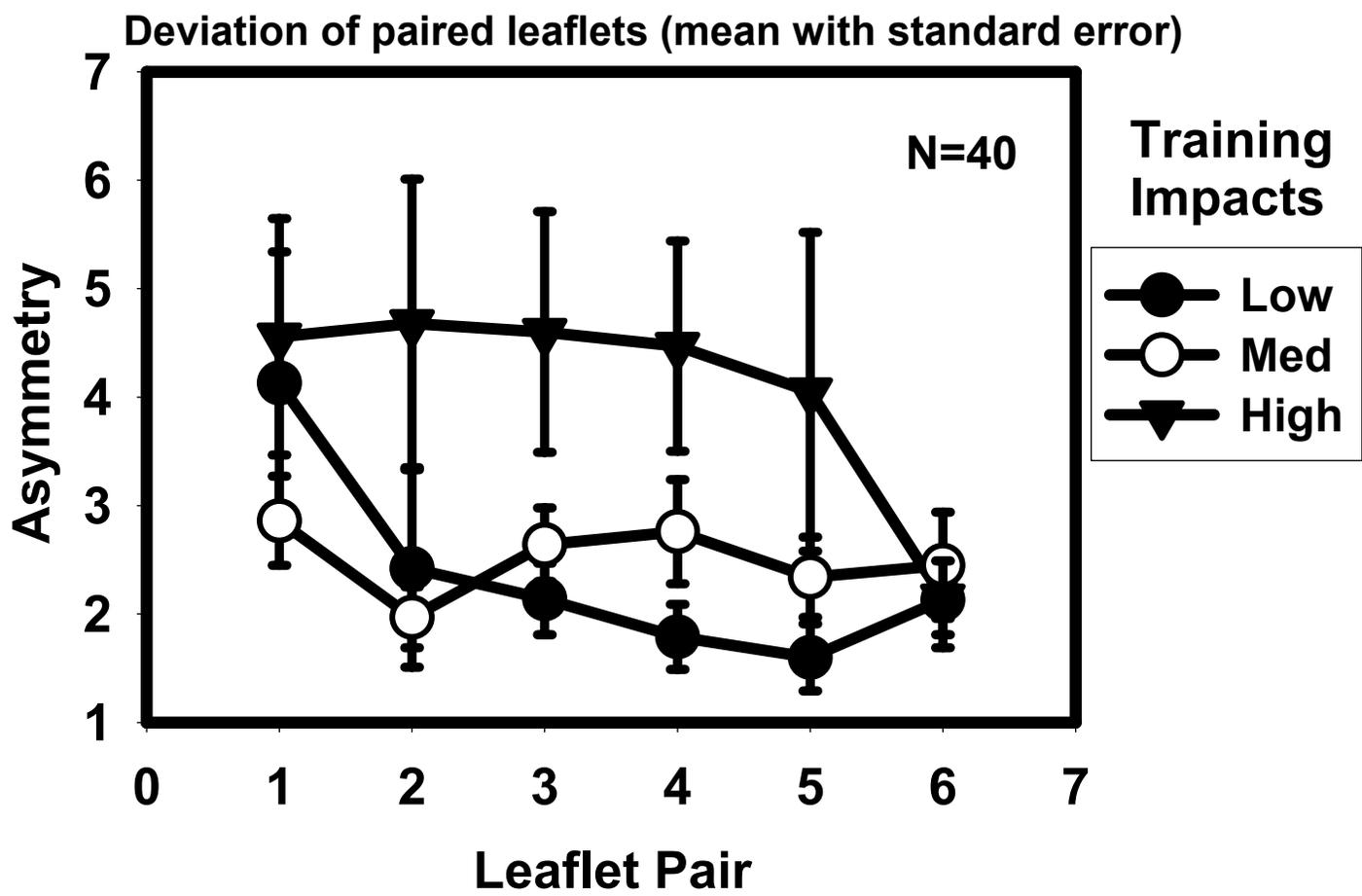
Uplands (Pine - scrub oak)

Species:	<i>Rhus copallina</i>
Leaf form	Compound leaves
Disturbance level:	high, medium, low
N sites at each level:	1
N plants at each site:	20
N leaves on each plant:	2
N pairs of leaflets:	6

Developmental Instability in *Rhus copallina* using 6 pairs of leaflets



Developmental Instability in *Rhus copallina*



Cooperation and Coordination

- **Site Selection**
 - ERDC, ORNL, and Univ. Florida
- **ERDC - ECMI project**
 - assistance in preparation of “Design Document”
- **Develop an e-mail link among all researchers to share information and new findings**
 - our first pilot study on Bonham watershed:
 - DI of *Rhus copallina* along a disturbance gradient

Program Plan

Year of Project (after reception of funds)

Year	1	2
Site/plot Selection	X	
Select Ecol Ind	X	X
Select Test System Elements	X	X
Pilot Field Study	X	
Field Experiments		X

Program Plan

Year of Project (after reception of funds)

Year	3	4	5
Adjustments to Field Expts	X	X	
Data Synth Guild Const		X	
Final Model Dev, TT			X

Program Funding (Thousands of Dollars)

Task	FY99	FY00	FY01	FY02	FY03	Total
GC, IS, EM, Stats	97	110	108	108	104	527
Physiol Ecol	124	96	98	98	94	510
Microb Ecol	61	67	69	69	65	331
GeoInd	56	62	64	64	60	306
N Flux	54	47	49	49	45	244
Total	392	382	388	388	368	1918

Deliverables

- **Ecosystem Assessment and Monitoring System**
 - based on classes (guilds) of ecological indicators
 - based on quantitative and metric attributes
 - detection of ecological change: predictive and thresholds
 - Applications and Operations Manual
 - Applications to other ecoregions (esp. Southwest)
 - Workshops on how to implement
- **Effects of military training on Southeastern ecosystems: technical report**
- **High emphasis on peer-reviewed publications**
 - specific findings (test system applications)
 - synthesis: applied applications of multiple indicator systems

Technology Transition

- **Ecological Indicator Guilds, with software**
 - **Ecosystem assessment and monitoring system**
 - **Monitor and manage ecosystems and landscapes (watersheds) at multiple scales in an ecoregional context**
 - **Applications workshop for installation personnel**
- **ITAM field demo and integration**
- **Land Managers provided with local, landscape, and regional context of all vertebrate subspecies for the Southeast**
- **Annual Progress and Technical Reports**
- **Peer-Review Publications**