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

US Army Corps of Engineers

ERDP's SEMP

Ecosystem Management Project

ECMI Plans and Progress

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

SEMP Research Coordination Meeting and
SEMP Technical Advisory Committee
28 – 30 October 2002

Ecosystem Characterization and Monitoring Initiative (ECMI)

Policy, Goals and Objectives

- **Department of Defense policy has established ecosystem management as its approach to management of military lands**
- **The goal is to maintain and improve the sustainability of military lands while supporting the DOD mission**
- **The Strategic Environmental Research and Development Program (DOD, DOE and EPA), has developed the SERDP Ecosystem Management Project (SEMP), in part to design, develop and demonstrate the ECMI concept**

Ecosystem Characterization and Monitoring Initiative (ECMI)

ECMI Concept and Objectives

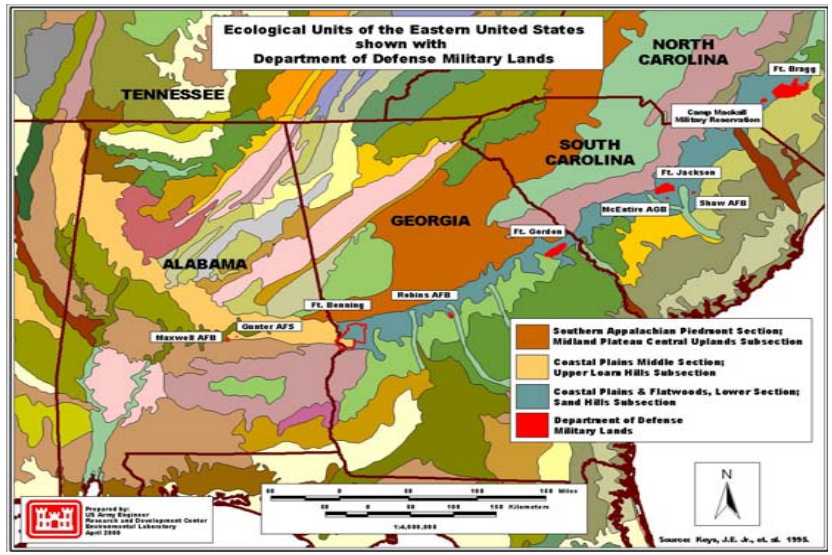
- **The ECMI was to develop a framework to characterize and monitor the long-term spatial and temporal dynamics of key ecosystem properties and processes to be beneficial to SEMP R&D efforts, military training, and land management operations in southeast US**
  - **baseline to support ecological research on Fort Benning, GA**
  - **baseline to support Fort Benning's integrated natural and cultural resource management plan**
  - **a long-term ecological data set to assess the relationships between land use, land management and sustainability**
  - **Collaboration with other agencies with complimentary data in the ecological region**

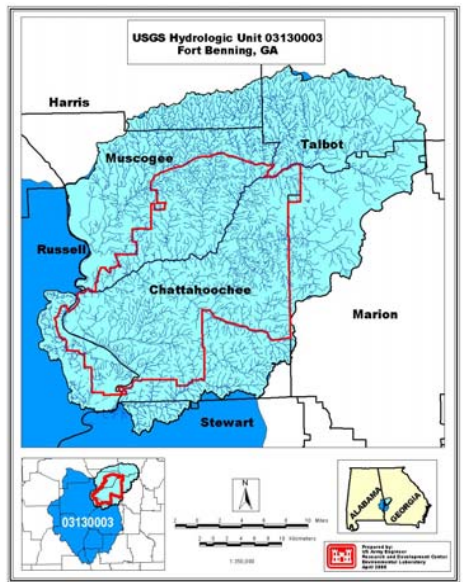
ECMI Thematic Component

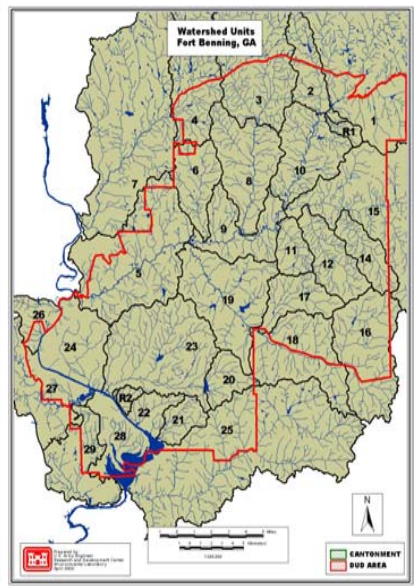
Ecosystem Processes and Properties	Thematic Monitoring Components	Component Description
Hydrologic flux and storage	Meteorology	Permanent, automated, full feature weather stations
	Surface water flow	Automated recorders; depth and velocity measured, stage-discharge calibrated
	Groundwater	Automated recording shallow wells; level only
Biological productivity	NPP	Regional images produced by NASA
	Aquatic productivity	Field measurements of periphyton primary productivity rate and algal food quality index
	Woody productivity	Field measured; rate calculated from dbh, height, crown, species relationships; co-located with installation forest inventory
	Vegetation density	Standard vegetation density indices derived from LandSAT Thematic Mapper imagery
Biogeochemical cycling and storage	Surface water quality	Automated recorders; temperature, pH, nitrate, turbidity, dissolved oxygen, specific conductivity
	Soil Erosion/deposition	Field measured erosion/deposition rates along permanent transects and quadrat surfaces
Decomposition	Aquatic decomposition	Field measurements of weight loss of submersed litter bags; decomposition rate, litter food quality , litter fragmentation rate
Maintenance of biological diversity	Aquatic macroinvertebrates	EPA standard Rapid Bioassessment Protocol (RBP) for benthic macroinvertebrates
	Land cover type	National Vegetation Classification System formation level land cover map derived from LandSAT Thematic Mapper imagery
	Land cover pattern	Fragmentation/spatial pattern metrics calculated from land cover map

ECMI Spatial Component

- Three spatial contexts
  - Regional is the portion of USGS HUC #03130003
  - Watershed scale refers to the watershed-based units shown
  - Installation scale refers to the Fort Benning boundary

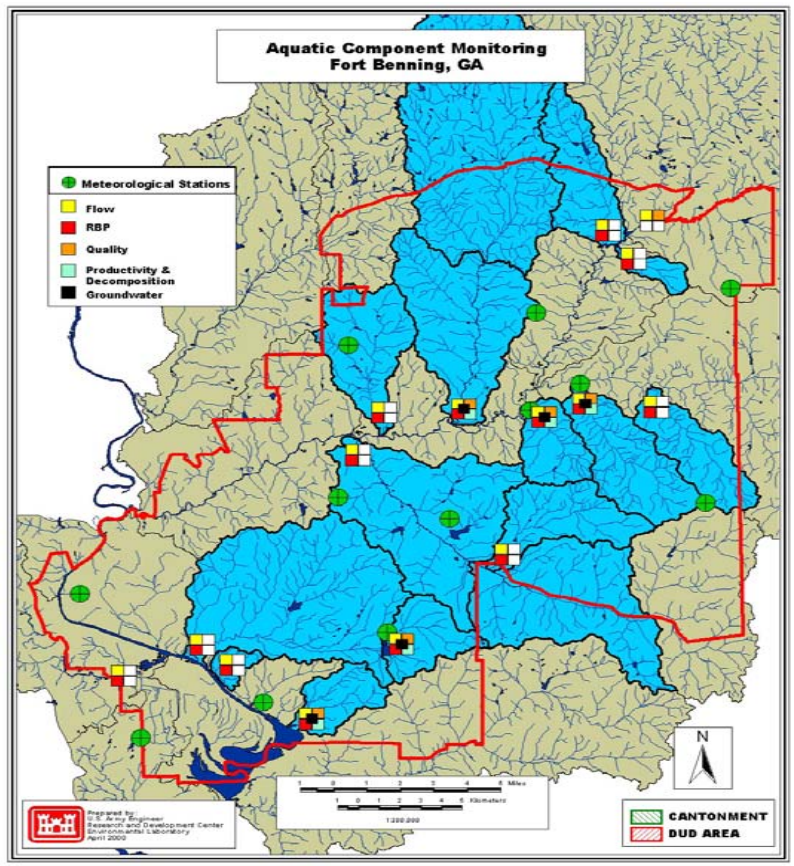






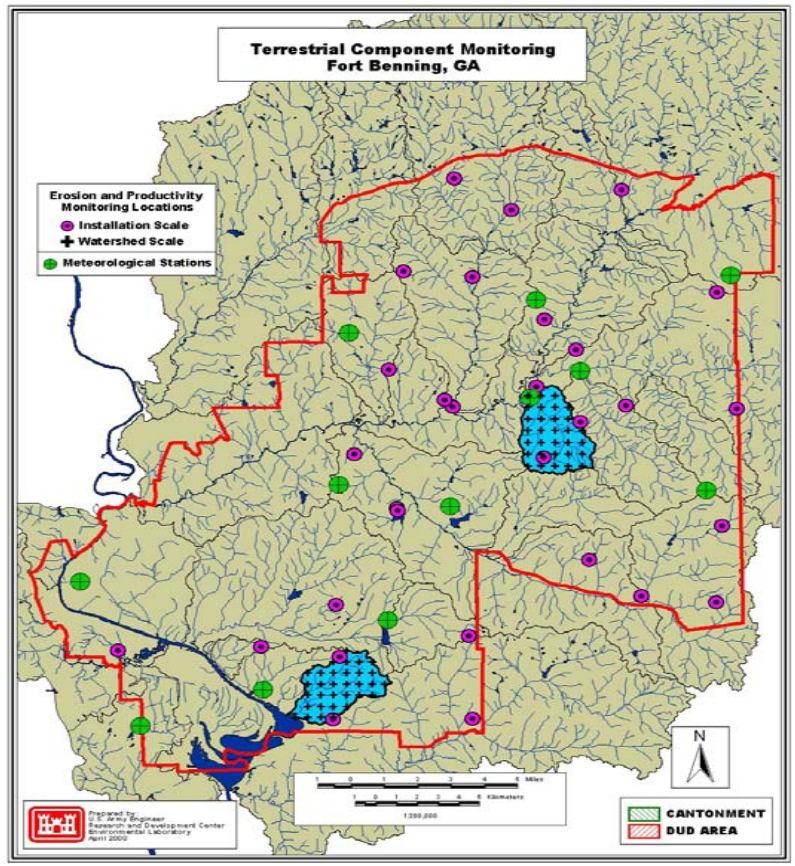
ECMI Aquatic Component

- Meteorology stations (10)
  - Represent installation and watersheds
- Surface water flow
  - 2 watershed locations
- Surface water quality
  - 6 full hydro stations at watershed locations
- Rapid Bioassessment Protocol (RBP)
  - 8-10 Watershed locations
- Aquatic productivity and decomposition
  - 5 locations
- Ground water level
  - 5 watershed locations



ECMI Terrestrial Component

- Net primary productivity (NPP)
  - Regional NPP obtained from NASA Earth Observing Satellite
- Land cover developed by processing LandSAT ETM imagery
  - Land cover type
  - Vegetation density indices
- Land cover pattern
  - Geostatistical processing
- Soil erosion/deposition and woody productivity
  - Watershed and installation scale



ECMI Status and Progress

PHASE I 1999 - 2001 **DESIGN**	PHASE II 2002 - 2005 **ADAPT**	PHASE III 2006 - 2020 **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

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

  - –conduct baseline ecosystem monitoring in support of SEMP research
  - –contribute to host site integrated monitoring plan at the ecosystem level
  - –develop long-term ecological data set

ECMI Components

- Meteorology
- Surface and ground water
- Soil erosion/deposition
- Land cover type, pattern, and woody productivity
- Aquatic macro-invertebrates, productivity, and decomposition (RBP)

Data Analysis and modeling

Meteorology

- 10 Automated Met Stations
  - Cell phone link
  - 7 sensors
- Sampling *F*p = 30 min.
- Retrieve daily
- Proof weekly
- Upload to repository monthly
- Cost $10K + $1.5K maintenance
- Problems, none

- Data and summary statistics
  - –Air temperature
  - –Relative humidity
  - –Barometric pressure
  - –Solar radiation
  - –Wind speed
  - –Wind direction
  - –Precipitation
  - –Evaporation (1 station)

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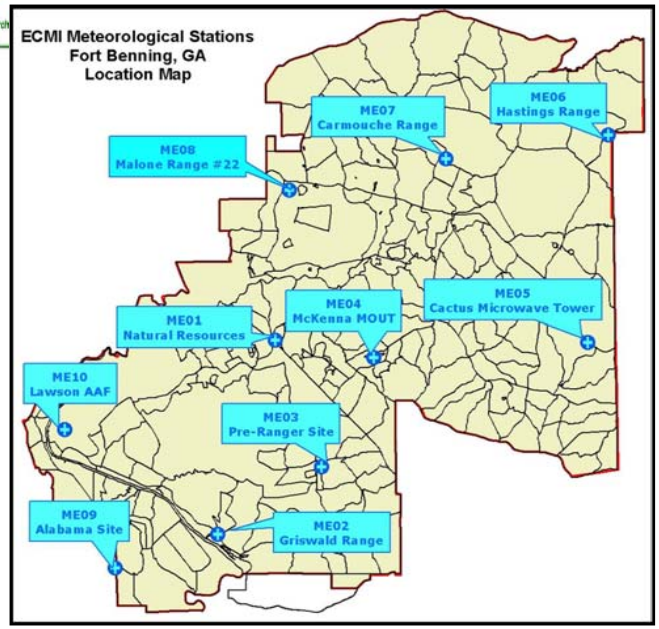
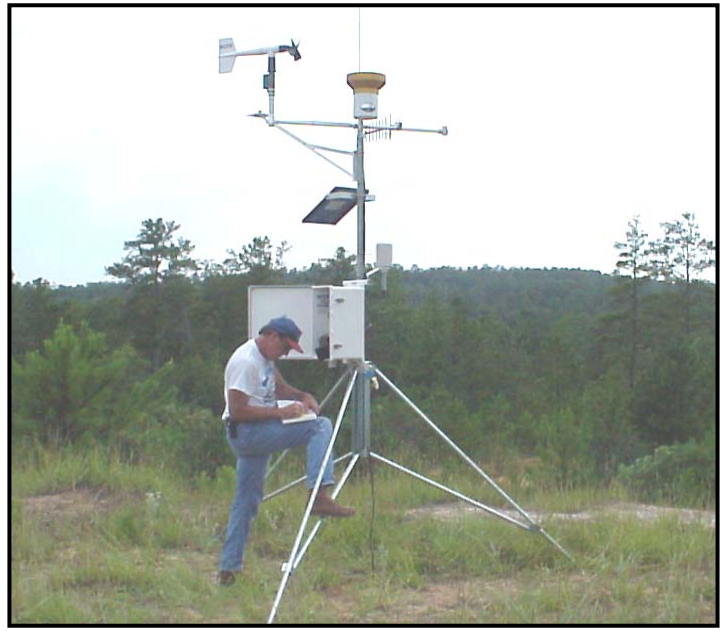
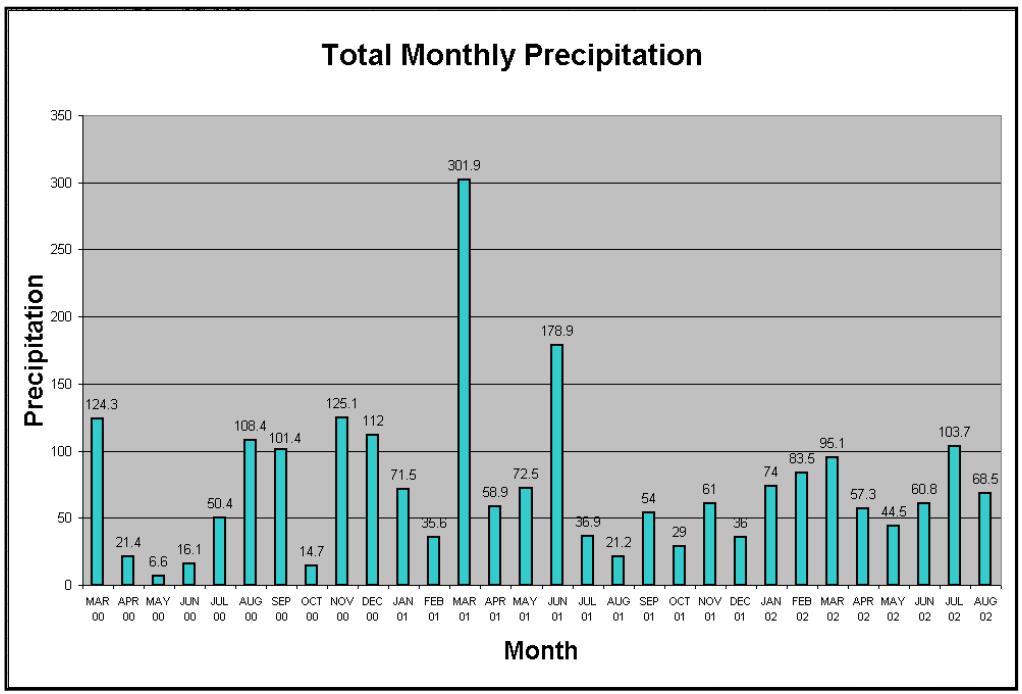






ECMI Meteorological Station Data
Monthly Summary Sheet

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

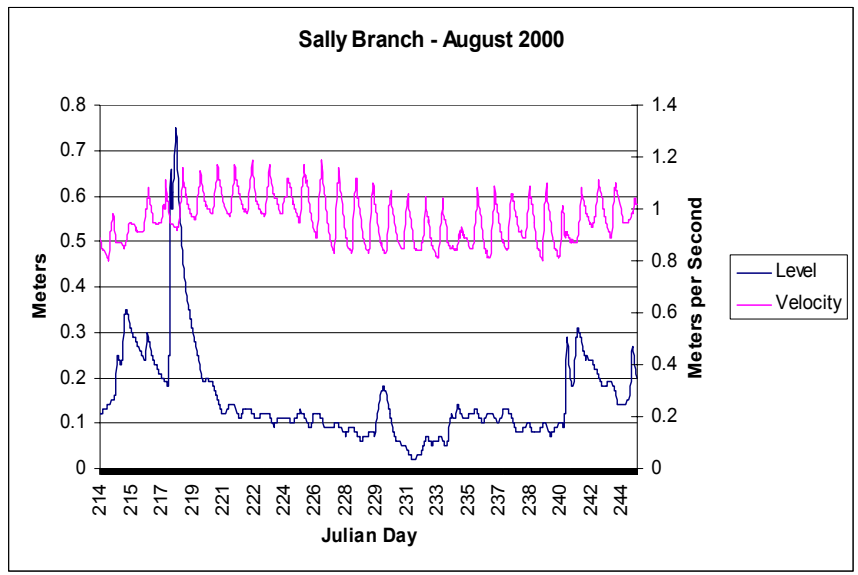
Time Period Covered: August **2002** - Number of Observations: **1488**

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

Surface Water

- Data and summary statistics
  - Flow/velocity
  - Level
  - Temperature
  - pH
  - Nitrate
  - Turbidity
  - Dissolved Oxygen
  - Specific Conductivity



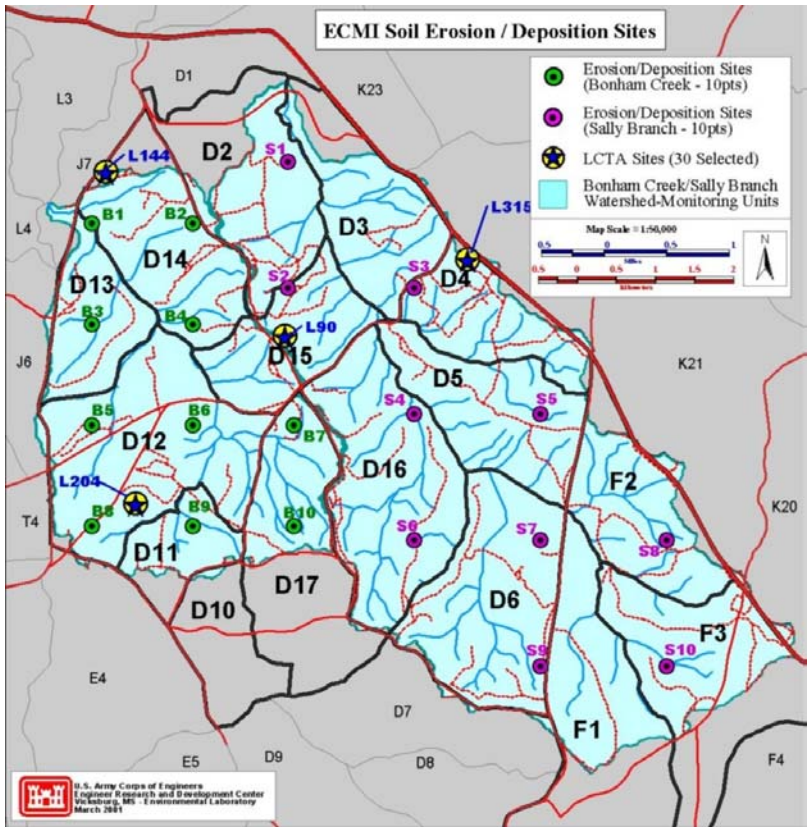
Ground Water Monitoring

- Ground Water Monitoring Wells.
- 4 Locations
  - Sally Branch Creek
  - Randall Creek
  - Oswichee Creek
  - Little Pine Knot Creek
- Mini-Troll Sensor
  - Samples Water Temperature
  - Depth
  - 30 Minute Intervals

Ground Water Monitoring

- Well Construction
  - 50 foot design depth
  - 2.5 inch PVC Casing
  - Stainless Steel Cap
- Data Retrieval
  - Digital data retrieval
  - Monthly Site Visit

Soil Erosion/Deposition Measurements

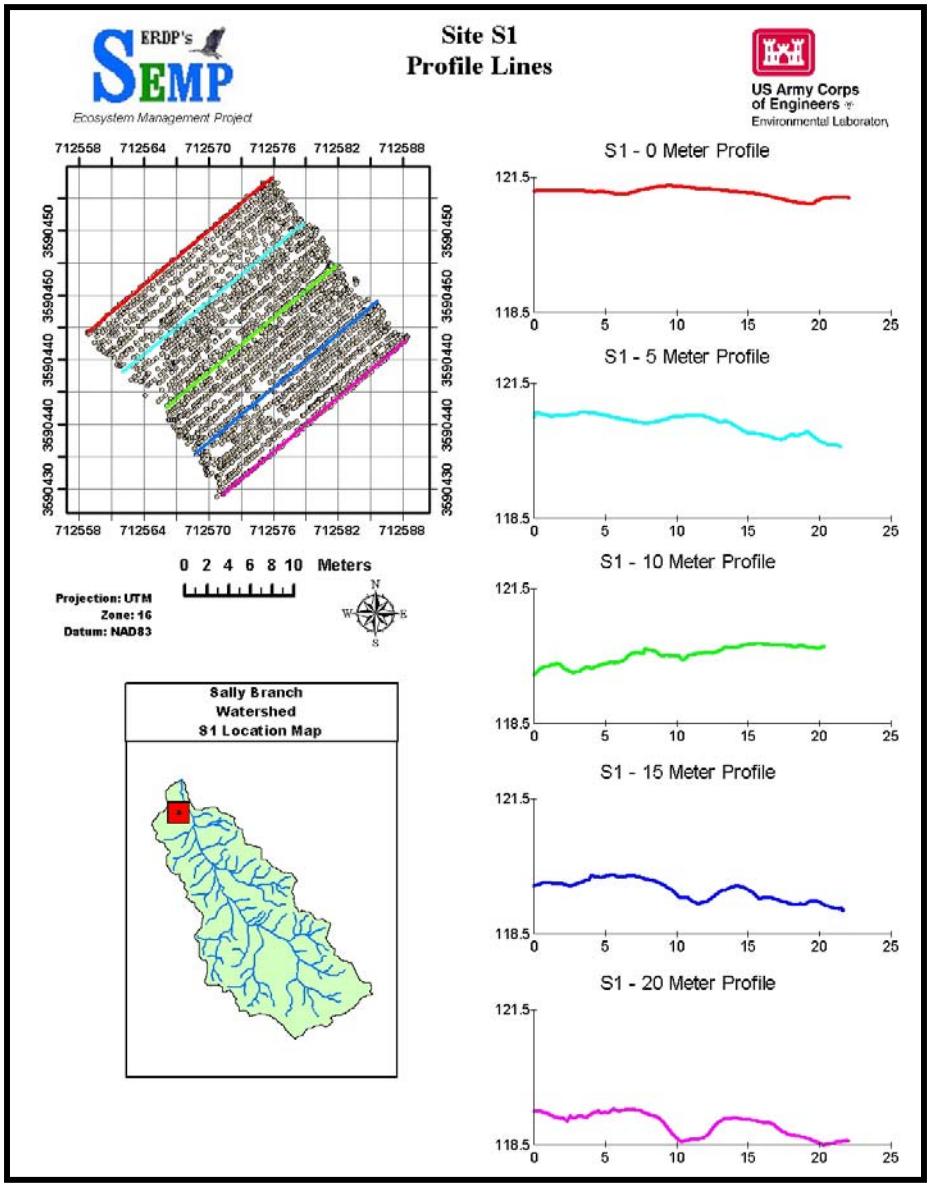


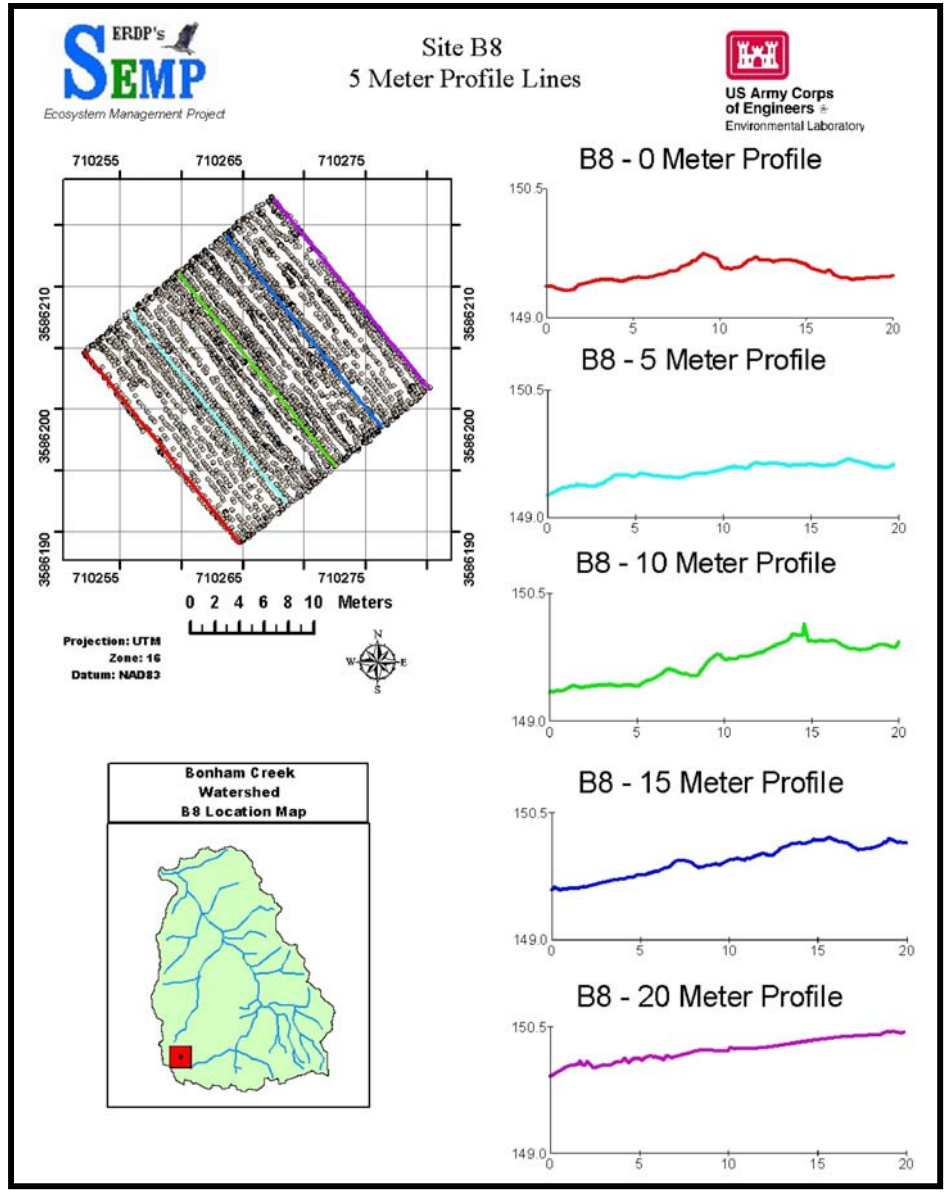
- 26 Sites Selected
  - 10 Bonham Creek Watershed
  - 10 Sally Branch Watershed
  - 6 selected from LCTA Sites
- High Resolution Topography Measurement
  - 0.5 m Grid spacing
  - 0.5cm vertical accuracy
- S-Tracker System used for Measurements

Erosion and Deposition S-Tracker

- Multiple Instrument/Data Integration
  - Automatic Robotic Tracking Theodolites
  - Prism mounted on wheel to follow terrain
  - Sampling Rate > 1 hz
- Repeatable Sampling Procedure

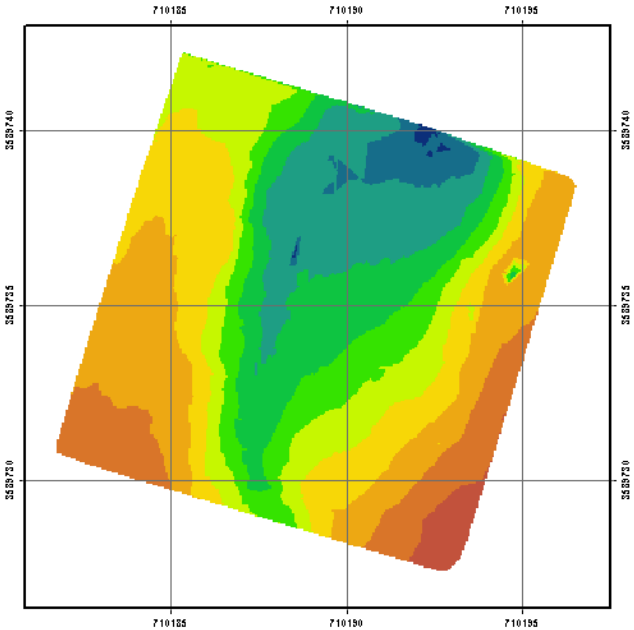
Erosion/Deposition



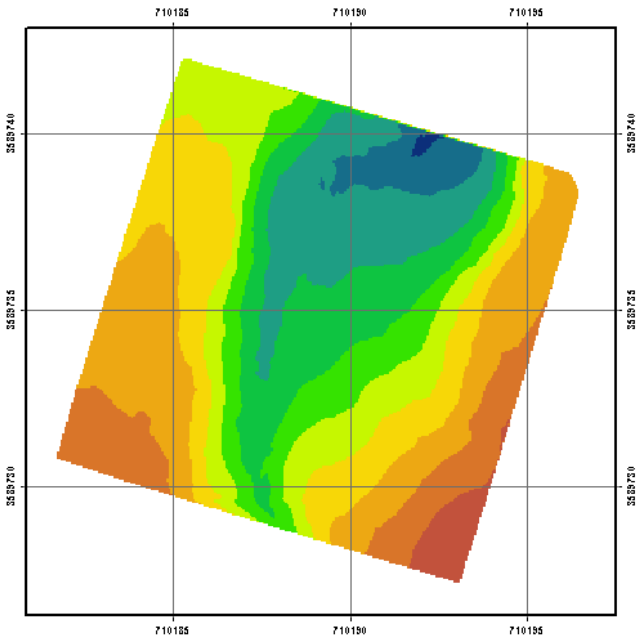


ECMI Plot Bonham Creek 1 – B01

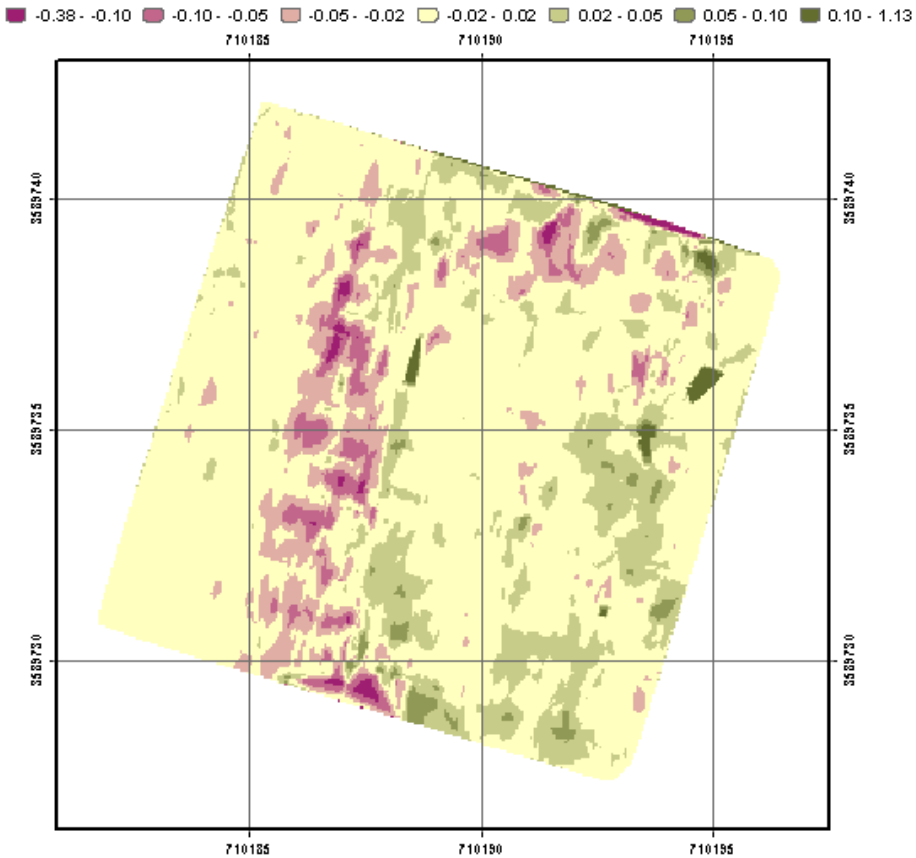
Surface Elevation GRID
April 2001



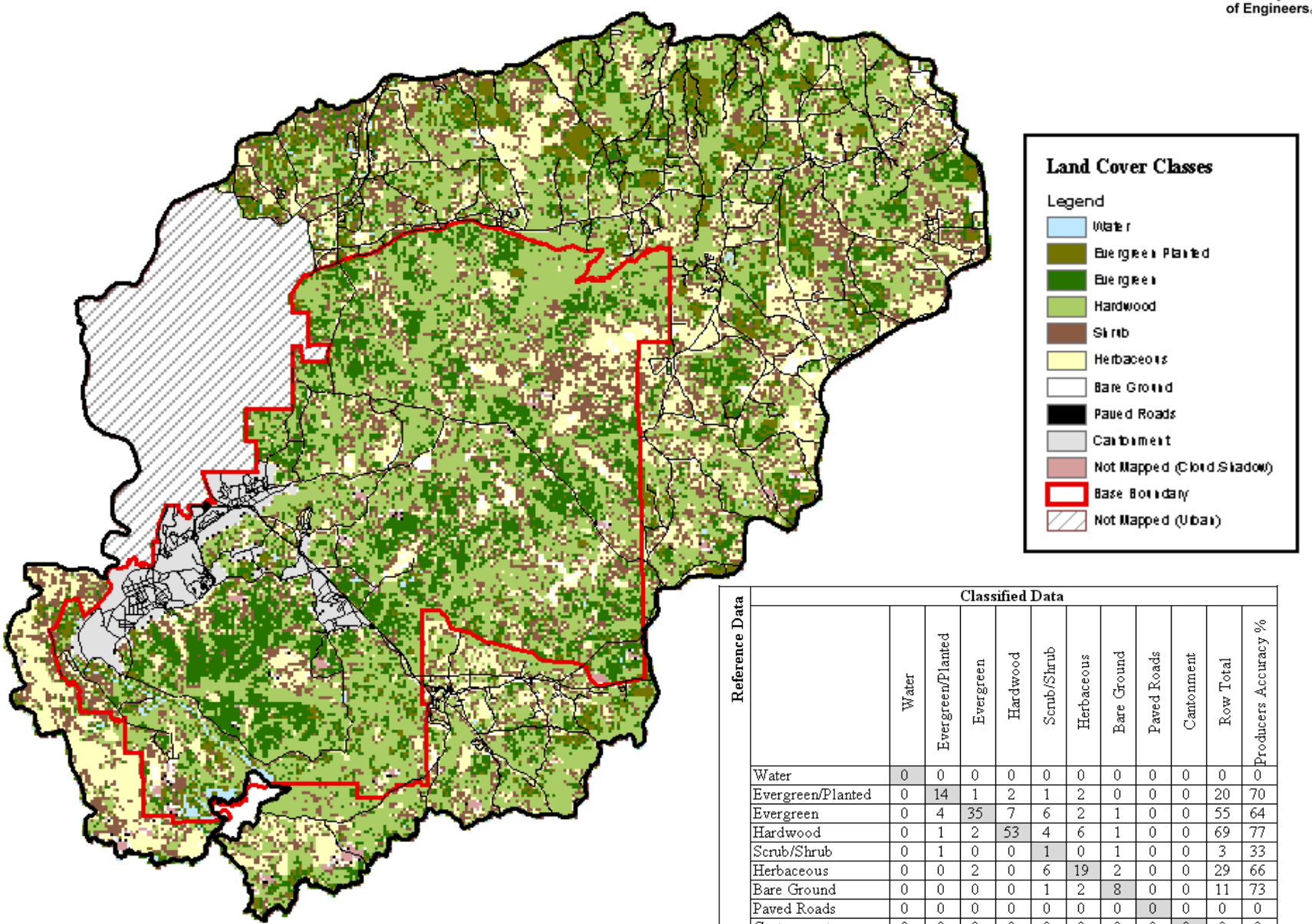
Surface Elevation GRID
April 2002



Surface Elevation Difference Plot
Dates of April 2001 and April 2002



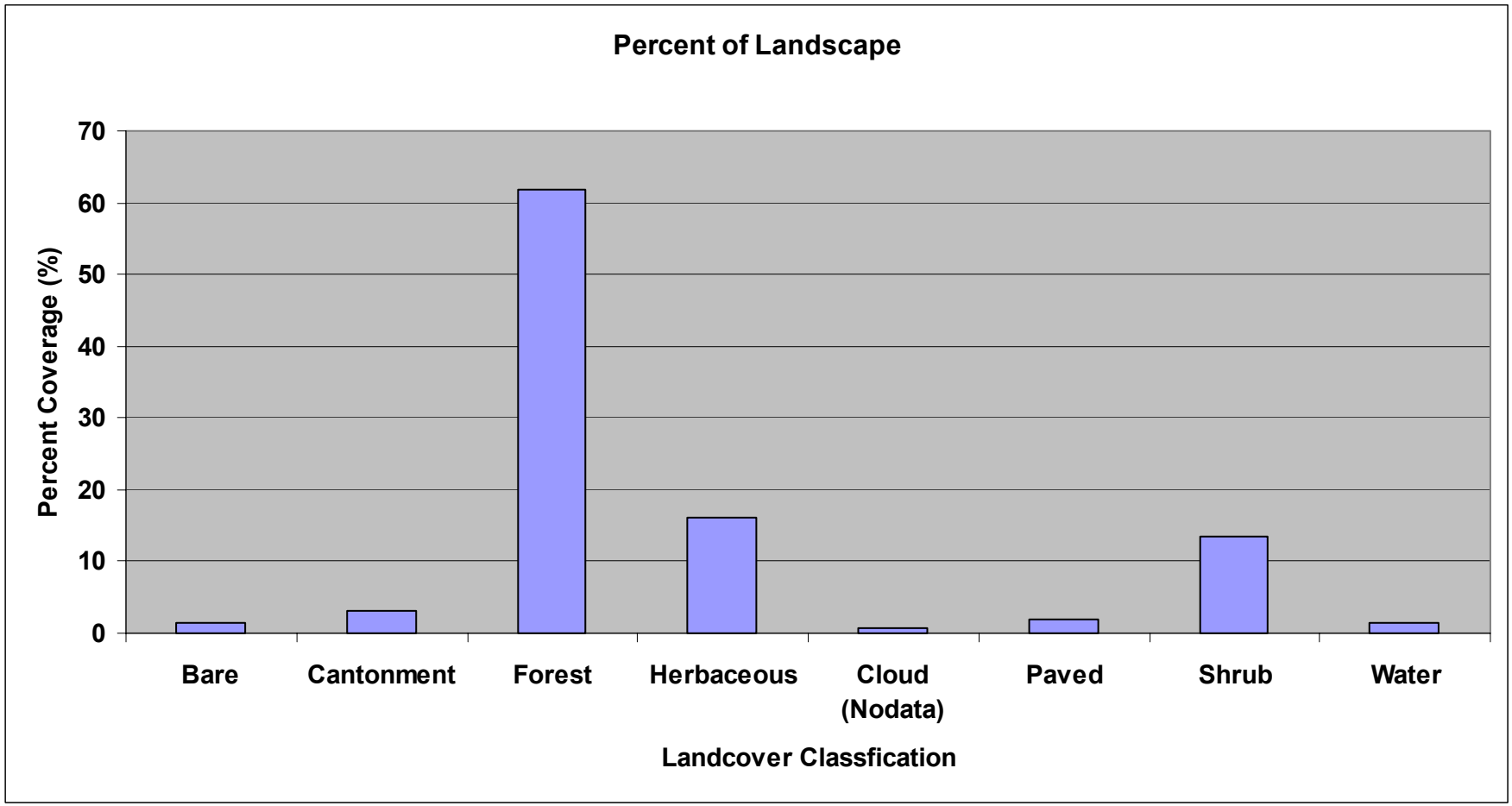
Landcover Classification



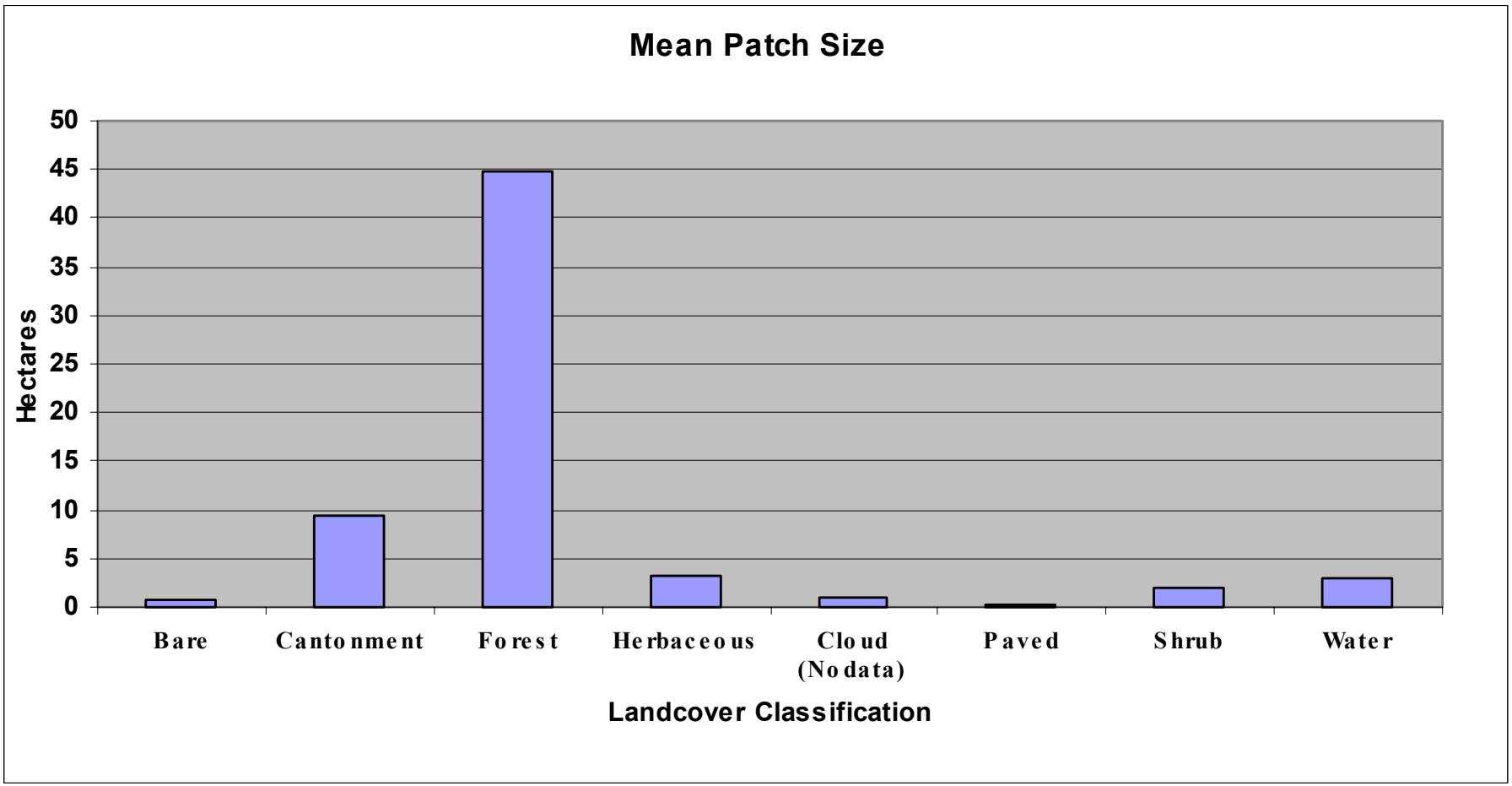
Reference Data	Classified Data									
	Water	Evergreen/Planted	Evergreen	Hardwood	Scrub/Shrub	Herbaceous	Bare Ground	Paved Roads	Cantonment	Row Total	Producers Accuracy %
Water	0	0	0	0	0	0	0	0	0	0	0
Evergreen/Planted	0	14	1	2	1	2	0	0	0	20	70
Evergreen	0	4	35	7	6	2	1	0	0	55	64
Hardwood	0	1	2	53	4	6	1	0	0	69	77
Scrub/Shrub	0	1	0	0	1	0	1	0	0	3	33
Herbaceous	0	0	2	0	6	19	2	0	0	29	66
Bare Ground	0	0	0	0	1	2	8	0	0	11	73
Paved Roads	0	0	0	0	0	0	0	0	0	0	0
Cantonment	0	0	0	0	0	0	0	0	0	0	0
Column Total	0	20	42	62	19	31	13	0	0	187	
Users Accuracy %	0.0	70	83	85	5	61	61	0	0		
Overall Accuracy = 69.5%											

Source Data: July 1999 LandSat7 TM Imagery
Release Date: September 2001
POC: David Price – ERDC-EL – Prided@wes.army.mil

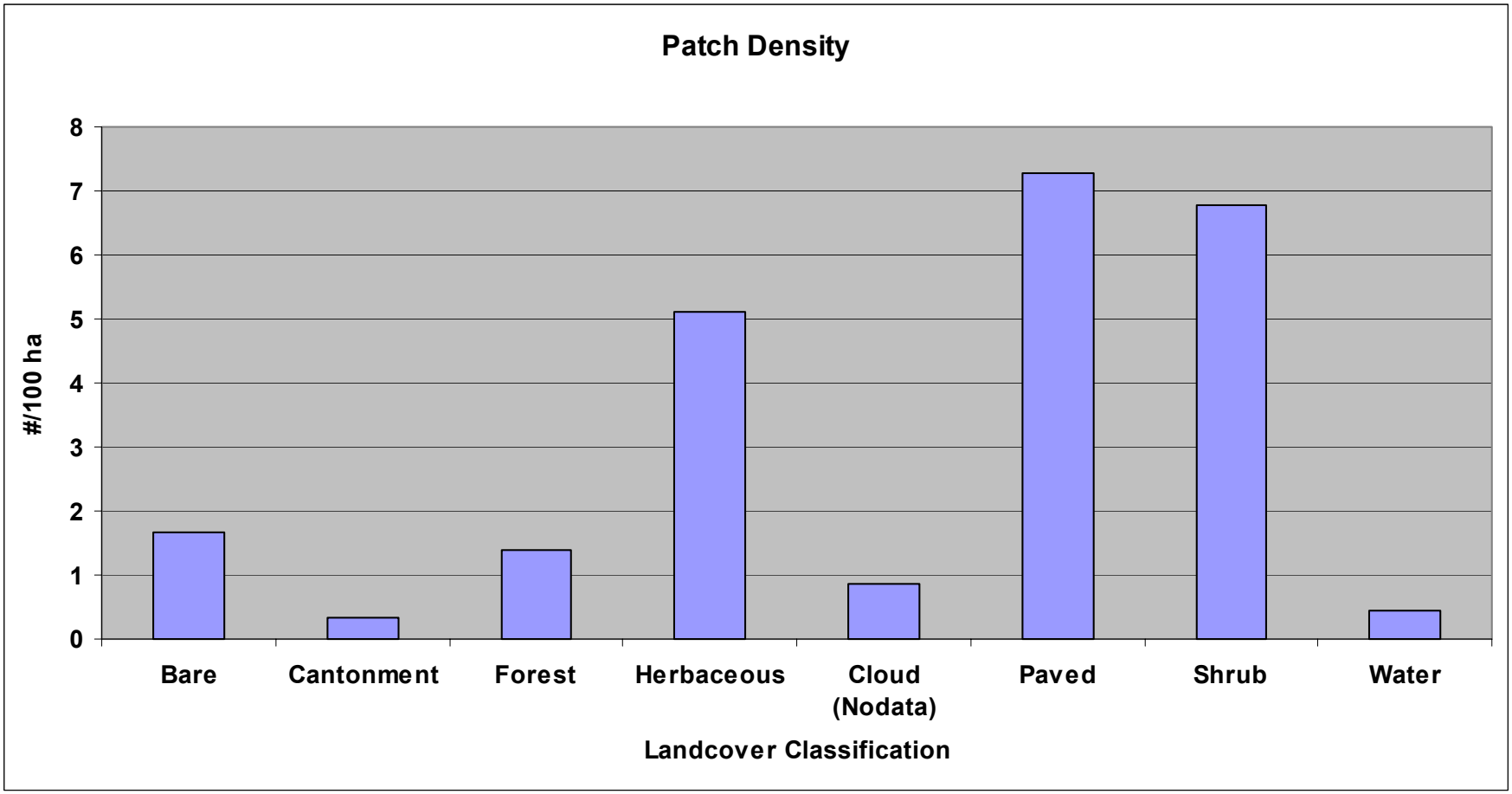
Landcover as Percentage of Landscape



Mean Patch Size by Landcover Class



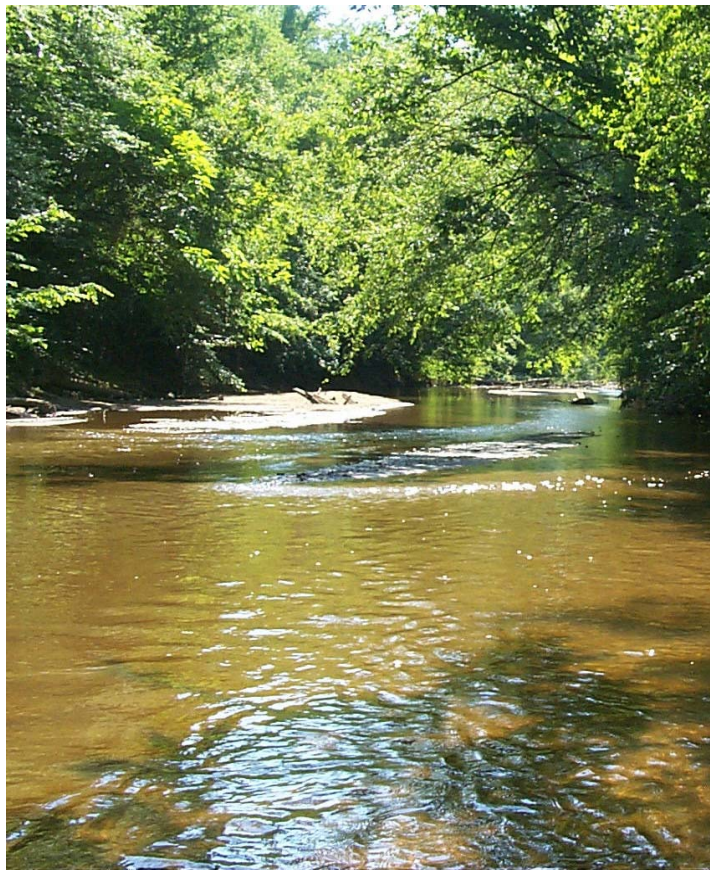
Patch Density by Landcover Class



Woody Productivity

- Woody productivity monitoring is being developed in conjunction with the installation INRMP, core monitoring teams, and the Forestry Program
  - Improved forest inventory protocol in development
  - Expert consultation with Dr. George Gertner, FY02
  - Initial woody productivity characterization will be based on forest inventory data from 2002
  - Aim is to develop this element of the monitoring system to fit the installation business process and be transitioned to the installation as a test case for the biological components of ECMI
  - Initial results anticipated during 2QTR FY03

Aquatic Monitoring



- Macroinvertebrates – Rapid Bioassessment Protocol
- Primary productivity
- Benthic decomposition rate

(The aquatic monitoring protocol is currently being revised and results will be presented separately during the Oct 2002 TAC meeting)

ECMI Ft. Benning Spatial and GIS Data

Current Number of Spatial/GIS Data Layers: 77

- Installation Boundary
- County Boundaries
- Ecological Units
- Forest Stands
- Geology *(1:100,000)*
- Lakes *(1:24,000)*
- Streams *(1:24,000)*
- Wetlands *(NWI)*
- Watersheds *(1st – 6th order)*
- Contours *(1:24,000)*
- ECMI Management Units
- Digital Elevation Model *(1:24,000)*
- Military Training Compartments
- Soil Surface Texture
- Soil Layer Properties *(1st – 3rd Layers)*
- 1928 Historical Soils – For Exclusion Zones
- Roads
- Burn Units
- Proposed Burns (16 years of burning plans)
- Prescribed Burns (18 years of actual burns)
- Wildfire Burns (18 years of wildfires)

ECMI Ft. Benning Field Data & Imagery Data

- Field Data
  - 10 ECMI Meteorological Stations
  - Data archived monthly for each Met. Station
  - 200+ comma delimited tabular data files
- Images
  - LANDSAT 7 Scenes
    - December 1999, July 2000, & January 2001
  - SPOT Image
    - February 1995
  - Two-meter DOQ's (80+ files)
    - November 1999
- Image Classification
  - LANDSAT 7 Landcover classification (Dec 99 & Jan 01)

Phase II
2002 - 2005

Adaptation

- Woody Productivity/Forest Inventory
- Aquatic Monitoring
- Monitoring Enhancements
  - –Carbon Budget & Terrestrial Productivity
  - –Other potential indicators from SEMP Research
- Water quality sampling strategy and improved sensors
- Access to meteorology data (Battle Lab and Land Management Branch) and improved sensors
- ECMI handoff to Installation

Relevance of ECMI for Installation Monitoring

- White Paper outline and plan
  - Translation of ECMI data from selected watersheds across entire installation
  - The challenges involved in a host installation executing the monitoring protocol in-house
  - The challenges involved in additional installations adapting the monitoring protocol
  - Scaling – How can data obtained at one scale be used to reduce uncertainty at the next higher scale

Monitoring Enhancements

- Candidate indicators or suites of indicators
- Land cover (vegetation) mapping and metrics
- Scaling – kriging/co-kriging, GIS based spatial linkage, ecological modeling tools
- Carbon cycling options (narrowing the focus)
  - Soil quality (measuring soil organic C with spatially intensive monitoring at low intervals)
  - Structure or function of the soil microbial community (biomass, respiration, enzyme activity, decomposition and mineralization on a seasonal basis)

Phase III
2006 - 2020

Vision

Future Technology Systems for Landscape Monitoring

- Reduced Ground Instrumented System cost by 2010 (10K to 6K for MET; 5K to 3K for WATER); Disposable, near maintenance-free systems by 2020 (cost 10K to 4K for MET; 5K to 2K for WATER

- Use of wireless sensors and network for wide area monitoring

- More effective use of acoustic, infrared, seismic, pressure, lidar, EM, and CCD sensor systems for wide-area monitoring.

Future Technology Systems
Landscape Monitoring

- Improved telemetry capability (radio, cell phone, satellite)
  - → 1200 baud analog cell-phone data to 5700 baud digital data by 2005
- Improved Communication Links for-- remote system programming.
  - → Storm - event programming
  - → Burning operations
  - → Special training activities

Future Technology Systems
Landscape Monitoring

- Improved Global Positioning Systems for
  - → Monitoring vehicle and personnel training activities within training compartments (may utilize developing military training applications for similar purposes)
  - → Delineation of landscape elements/features

- Improved Real-time Weather Radar for Wide-Area Monitoring of
  - → rainfall, winds, temperatures, etc

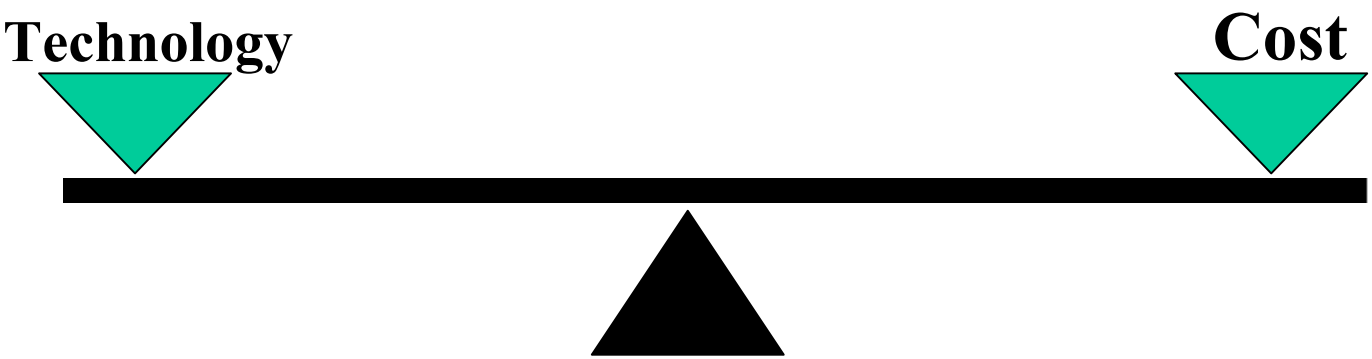
- Affordable High-resolution Satellite Data-- for wide area monitoring
  - → 0.5 meter black & white, 4 m multispectural, 8m hyper-spectral

Future Technology Systems
Landscape Monitoring

- Integrated Systems will allow for more real-time data collection
  - → GPS/Cell Phones/PDA/Wireless Internet Transmission
  - → Web mapping and web-based personnel/vehicle tracking
  - → GPS/GIS /RS-----RPV

- Software for improved analysis and visualization/display of monitoring data

ECMI Monitoring Tradeoffs



Technology is the driving force for cost-effective environmental/landscape monitoring.

ECMI Vision for the Future is:

- To continue the automation of data collection /monitoring to the fullest extent possible.
- To maintain "high quality" data collection efforts
- To conduct timely analysis to direct / redirect/ adapt monitoring activities
- To provide management-relevant data at a cost acceptable to installation managers

SEMP/ECMI Publications

Refereed Publications: none

Other Publications:

Published –

Hahn, D. Charles. 2001. Ground Control Survey at Fort Benning, GA. ERDC/EL TN-01-02, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Hahn, D. Charles, Mark R. Graves, and David L. Price. 2001. S-Tracker Survey of Sites for Long-Term Erosion/Deposition Monitoring. ERDC/EL TR-01-18, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Bourne, Scott, and Mark R. Graves. 2001. Classification of Land-Cover Types for the Fort Benning Ecoregion Using Enhanced Thematic Mapper Data. ERDC/EL TN-01-01, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Graves, Mark R. 2001. Watershed Boundaries and Relationship Between Stream Order and Watershed Morphology at Fort Benning, GA. ERDC/EL TR-01-23, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Kress, M. Rose. 2001. Long-Term Monitoring Program, Fort Benning, GA; Ecosystem Characterization and Monitoring Initiative, Version 2.1. ERDC/EL TR-01-15, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Hahn, Charles D., and David Leese. 2001. Environmental Data Collection at Ft. Benning, GA from May 1999 to July 2001. ERDC/EL TR-01-Dec, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Submitted-

Hahn, D. Charles. 2002. Evaluation of ECMI Instrumentation Deployed at Fort Benning, GA. ERDC/EL TN-02-XX, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

O'Neil, L. J., Lee, A., and Price, D. (2002). Terrestrial Productivity at Fort Benning, GA; A Feasibility Analysis: Ecosystem Characterization and Monitoring Initiative, ERDC/EL TR XX-XX, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Graves, Mark R., and Scott G. Bourne. 2002. Landscape Pattern Metrics at Fort Benning, GA. ERDC/EL TN-XX-XX, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Presentations:

National –

Price, D.L., and M.R. Kress. 2000. Ecosystem Characterization and Monitoring Initiative: An Ecological Baseline for Installations. 92nd Annual Meeting of the American Society of Agronomy. Minneapolis, Minnesota. November 2000.