Tennessee Watershed Modeling Tools

Southern Region Watershed Meeting, July 2005

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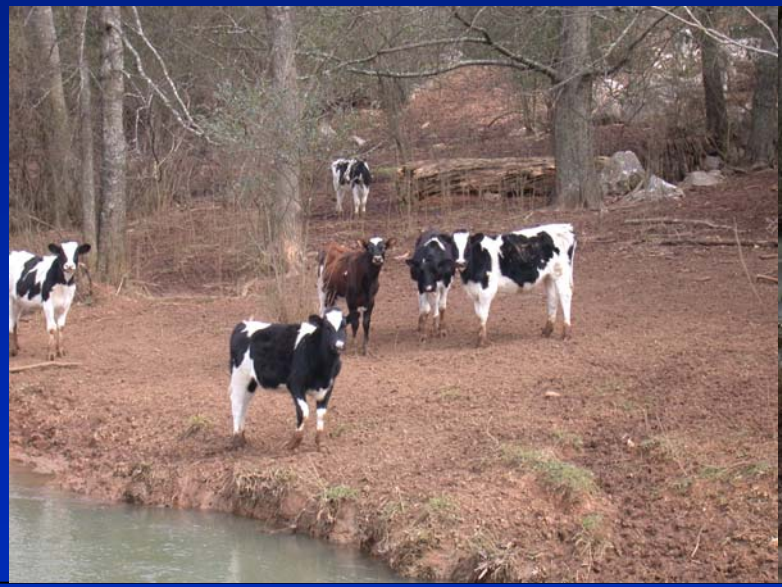
University of Tennessee Extension

Outline

- Land Use and Water Quality in Tennessee
- Watershed models
- Watershed planning tools: identify critical sources areas



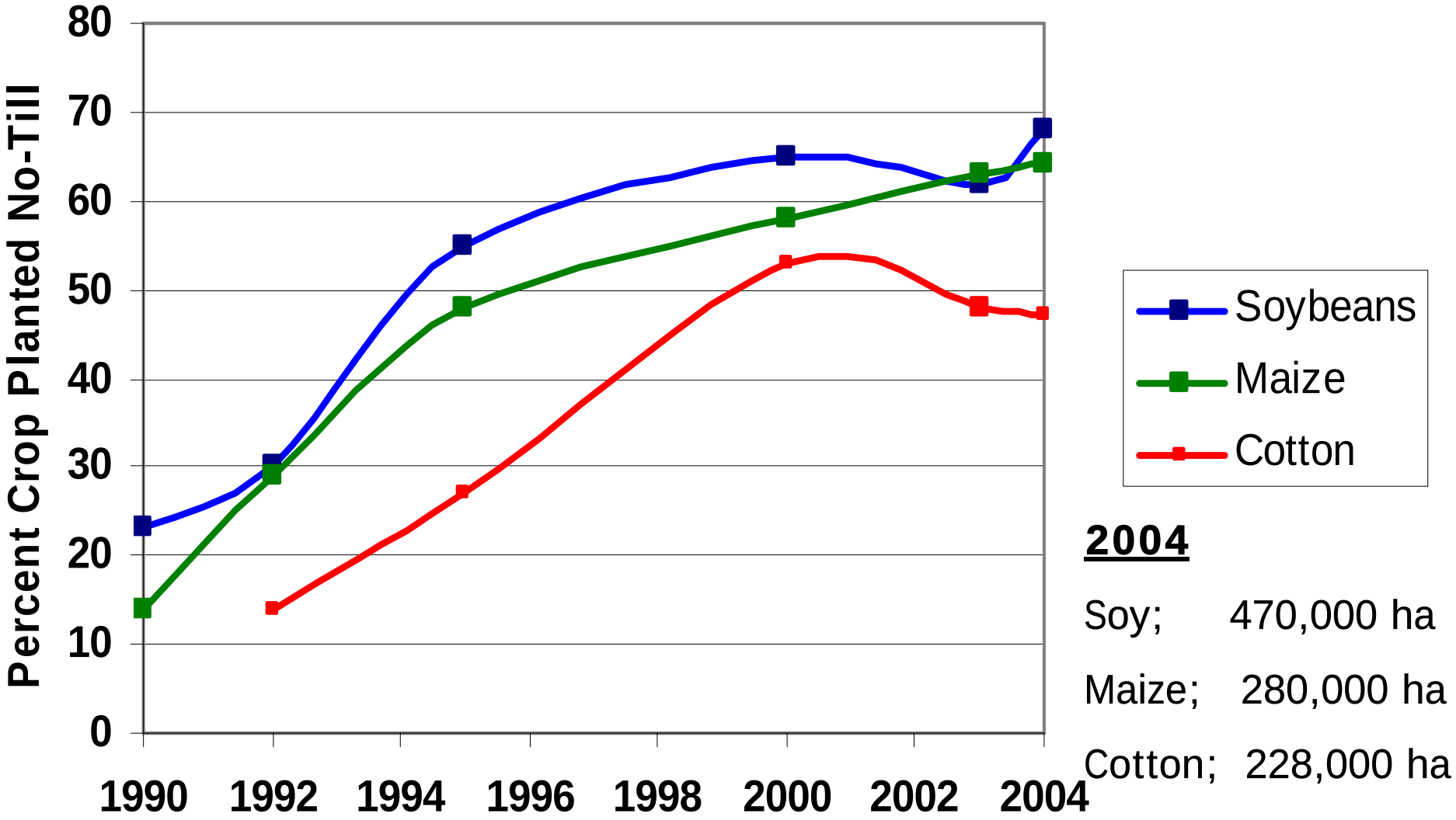
Water Quality in TN (2004)*

- Sources of Agricultural Pollution in Assessed Streams and Rivers
  - Grazing related 60 %
  - Crop related 37 %
  - Intensive Animal Ops. 3 %

* TN 305 (b) Report 2004

Land Use & Water Quality

- 44% of land in Tennessee is in agriculture
- Approximately 20% in row crops (most in no-till), 20% in hay and 30% in pasture
- Erosion and runoff are major water quality concerns – less under no-till and hay



Percentage of Major Crop Areas Planted with No-Till in Tennessee: 1990 to 2004 (Tennessee Dept. of Agriculture)

Watershed Models

- TMDL development – BASINS, HSPF
- University of Tennessee – AgNPS, SWAT etc.
- UT Extension Planning Tools: **I**ntegrated **P**ollutant **S**ource **I**dentification (IPSI) model; “simple” planning tool

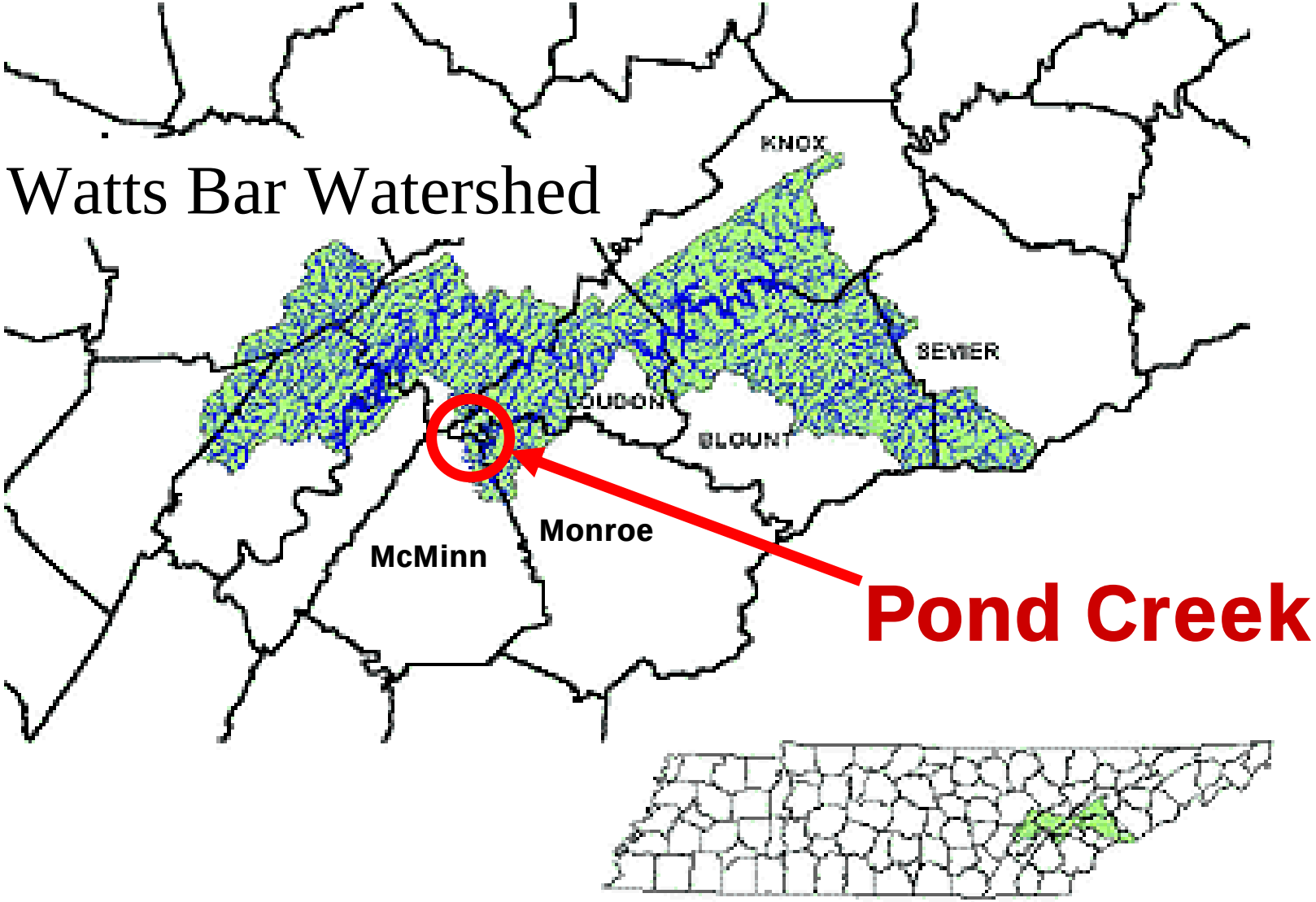
IPSI & Watershed Assessment

- Developed by Tennessee Valley Authority – modified by UT Extension
- Low altitude, infrared photos
- Photo Interpretation; land-use by field; urban, agriculture (crop land or pasture), forestland, barren land, disturbed areas and water etc.
- Estimate loads from USLE erosion estimates
- Run soil loss equation to estimate loads by land-use classes and sub-watershed

Erosion Estimates

- Use of Universal Soil Loss Equation (soil, climate, topography, land use)
- Soil Loss = A = R K L S C P
  - **R** (rainfall) and **P** (support practices) constant
  - **K** (soil), **L** (length of slope) and **S** (slope) varies by landscape position / elevation
  - **C** = varied land use (residue)
- Identify potential sources of erosion by sub-watershed

Watts Bar Watershed



www.state.tn.us/environment/wpc/wshed1.htm

Water Quality in Pond Creek

35.6 miles of Mud Creek, Greasy Branch and Pond Creek listed on 2002 303 (d) list as impaired for:

- Pathogens
- Nutrients (P and N)
- Sediments

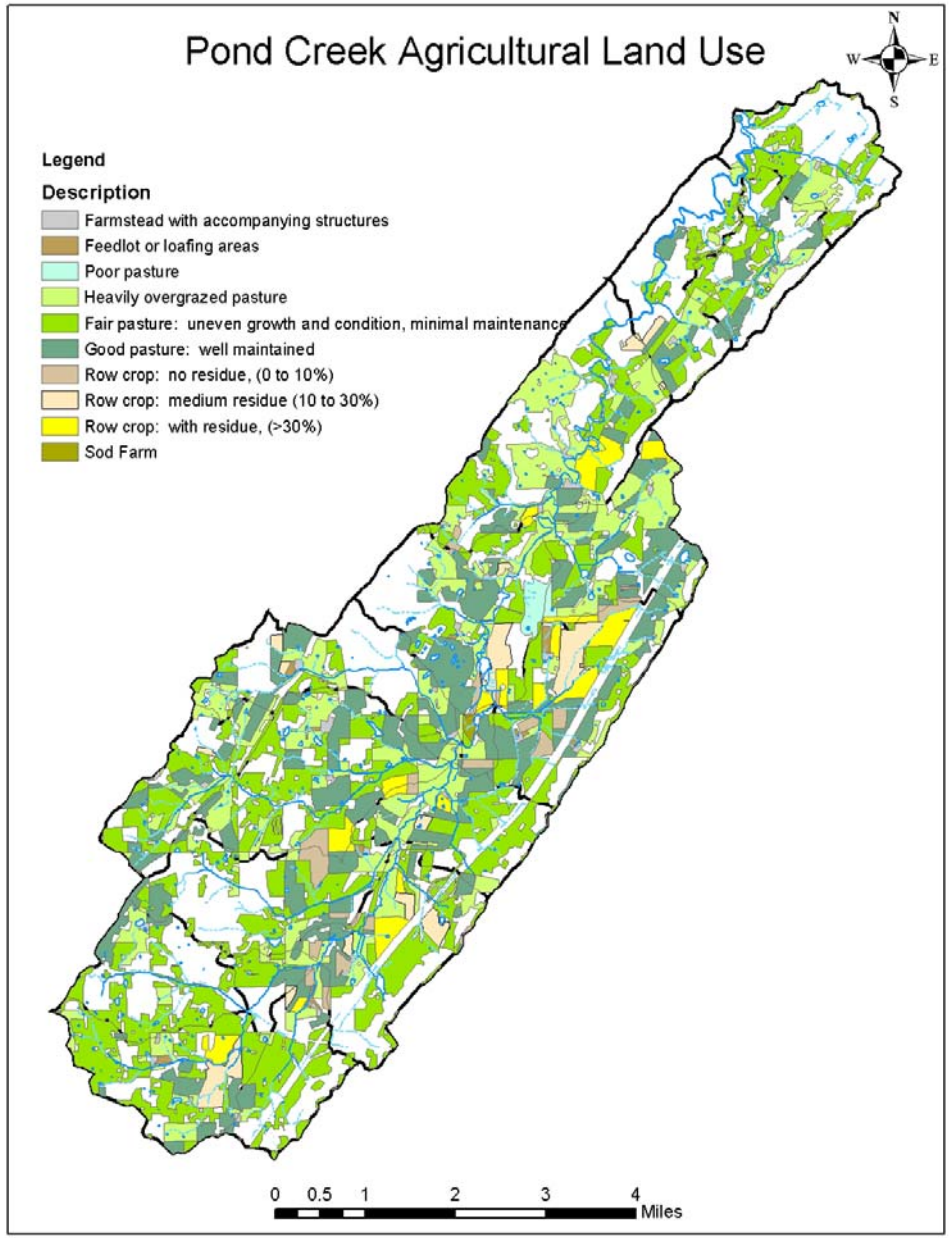
(E. coli and nitrates in 2004)

Primary cause “Pasture Grazing”

How much is coming from runoff, cattle in streams, bank erosion?

Pond Creek

- Pasture based beef and dairy operations
  - Total 9,432 ha (23,579 acres)
  - Pasture = 55%; 5,152 ha (12,880 acres)
  - Row crops = 7%; 623 ha (1,558 acres)
  - Forest = 26%; 2,454 ha (6,135 acres)



Agricultural Land Use

- **Crop Land**: based on residue cover
  - Row crop: no residue, (0 to 10%)
  - Row crop: with residue, (>30%)
  - Row crop: Medium residue (10 to 30%)
- **Pasture**
  - Good pasture: well maintained
  - Fair pasture: uneven growth and condition, minimal maintenance
  - Heavily overgrazed pasture
  - Poor pasture: sparse cover, shallow soils, steep slopes, often gullies

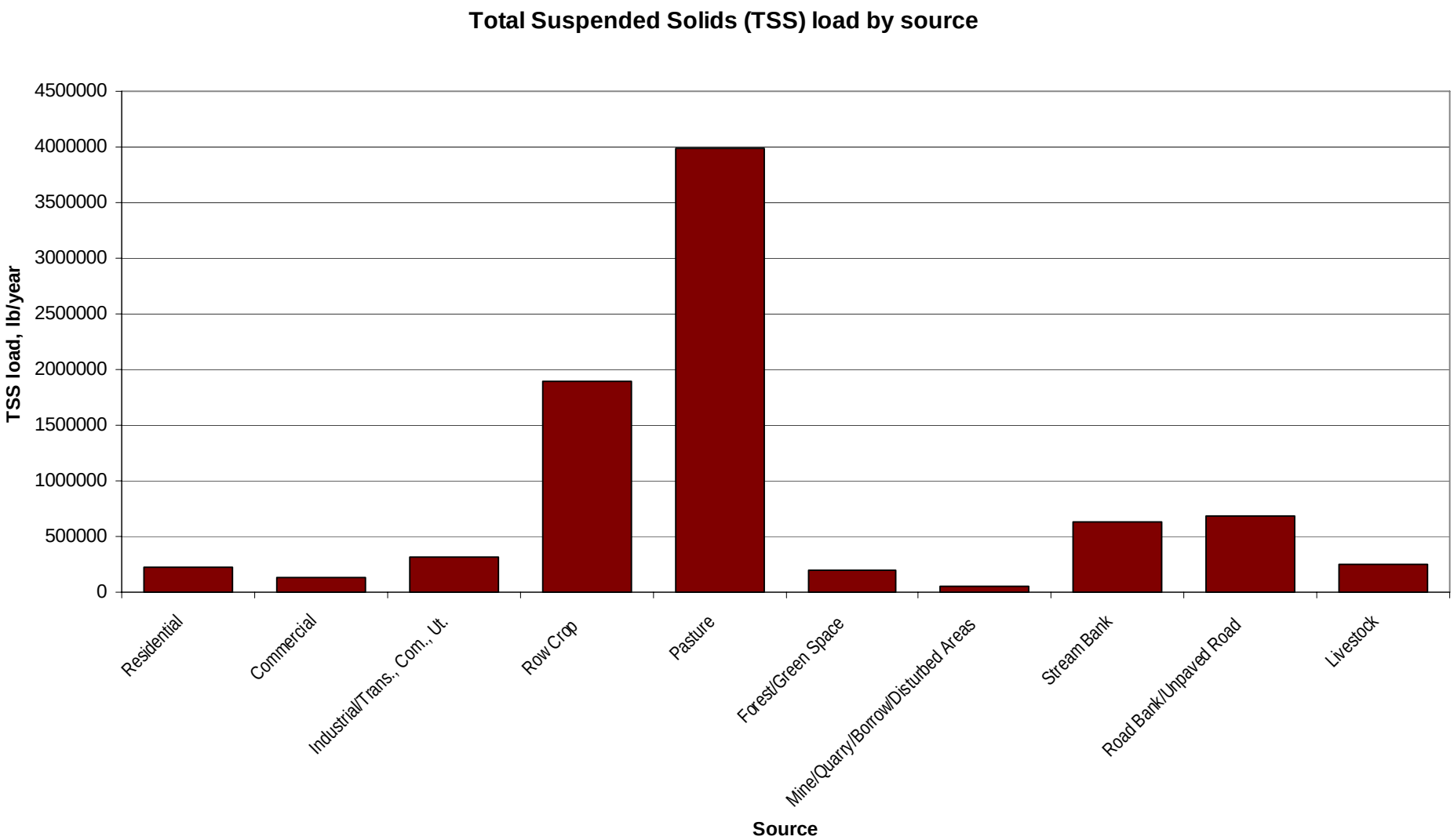

Fair

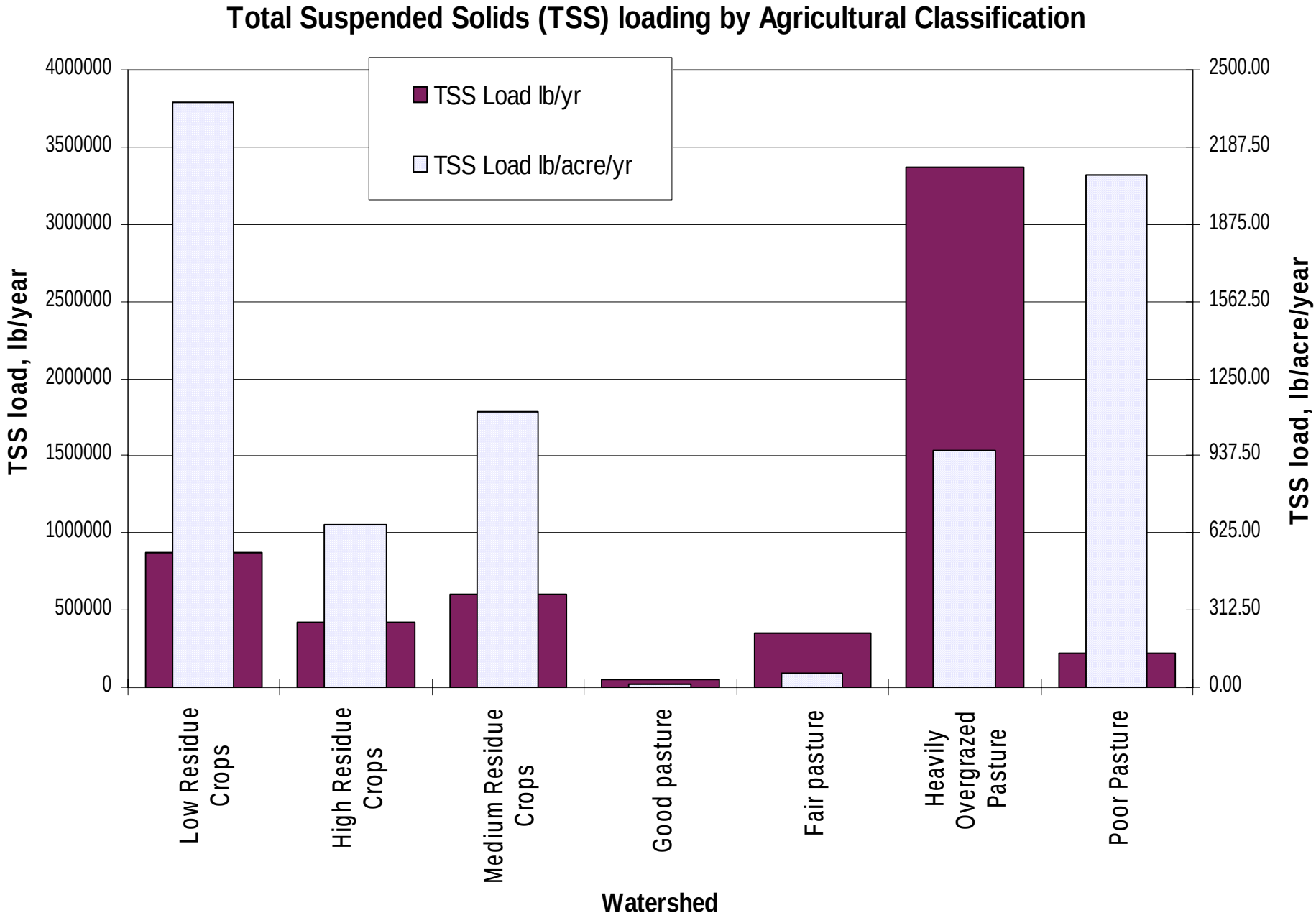

Good


Low-residue


Over-grazed

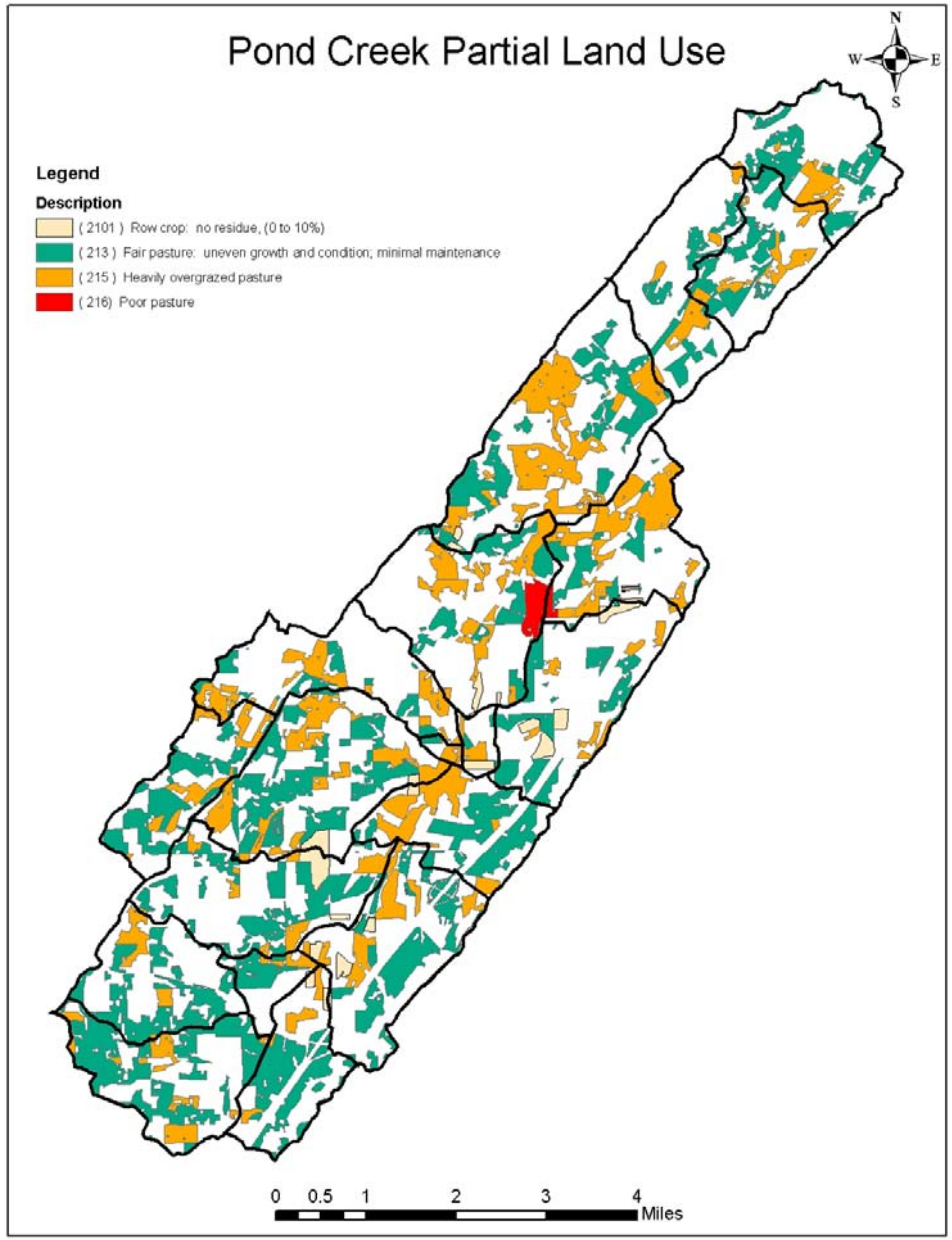
Suspended Solids: by source




Total Suspended Solids (TSS) loading by Agricultural Classification
TSS Load lb/yr
TSS Load lb/acre/yr
TSS load, lb/year
TSS load, lb/acre/year
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
2500.00
2187.50
1875.00
1562.50
1250.00
937.50
625.00
312.50
0.00
Low Residue Crops
High Residue Crops
Medium Residue Crops
Good pasture
Fair pasture
Heavily Overgrazed Pasture
Poor Pasture
Watershed

Suggested Target Areas

- Fair, poor and over-grazed pasture (40% all land use)
- Low residue row crops (1.6% all land use)
- Effective message and visuals for farmers – but how accurate is it?



Improving on IPSI Pollutant Loading Model (IPSI-PLM)

- Assumes uniform erosion by field
- Lack of account for support practices (p factor)
- Can we account for or identify “critical source areas”?
- How does IPSI compare with other approaches?

Models Compared

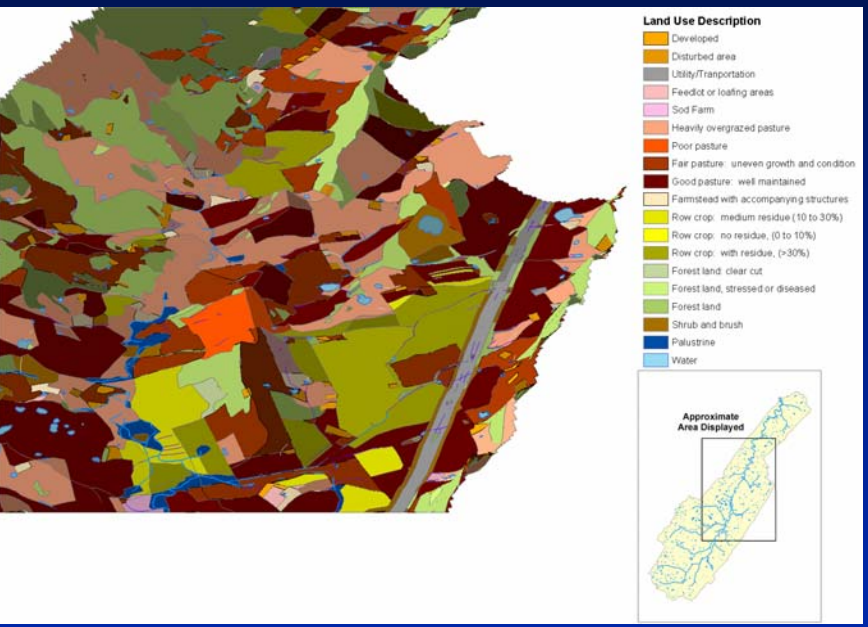
- The Contributing Area – Dispersal Area (CADA) – pollution model
- Unit Stream Power – Erosion/Deposition Model (USPED) – sediment model
- Universal Soil Loss Equation – sediment model

Methods

- ArcGIS 9.0 – model builder
- Ran CADA model with both detailed land use and NLCD 1992 land use.
- Ran CADA model with a range of export coefficient values
- Compared results of USPED, USLE and CADA models with IPSI-PLM results in Pond Creek.

CADA Overview

- Buffer Index
  - Uses DEM derived overland flow paths together with land cover maps of nutrient buffering land cover in the runoff dispersal area
- Topographic Index
  - Predicts relative soil moisture budgets using a relationship of the upslope contributing area, per contour length, and the pixel slope



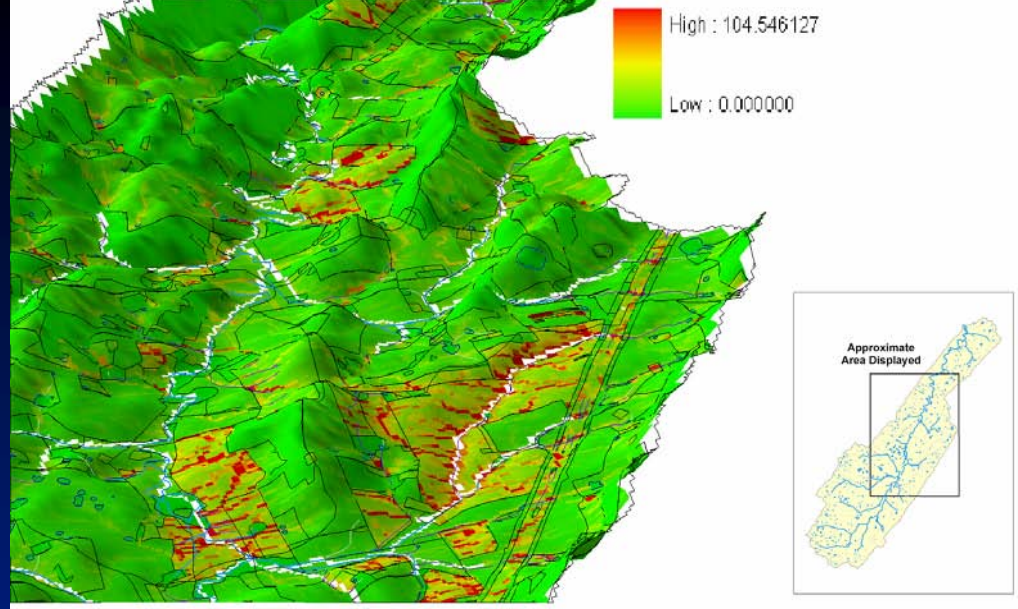


Figure 2a - CADA Map (units kg/ha)

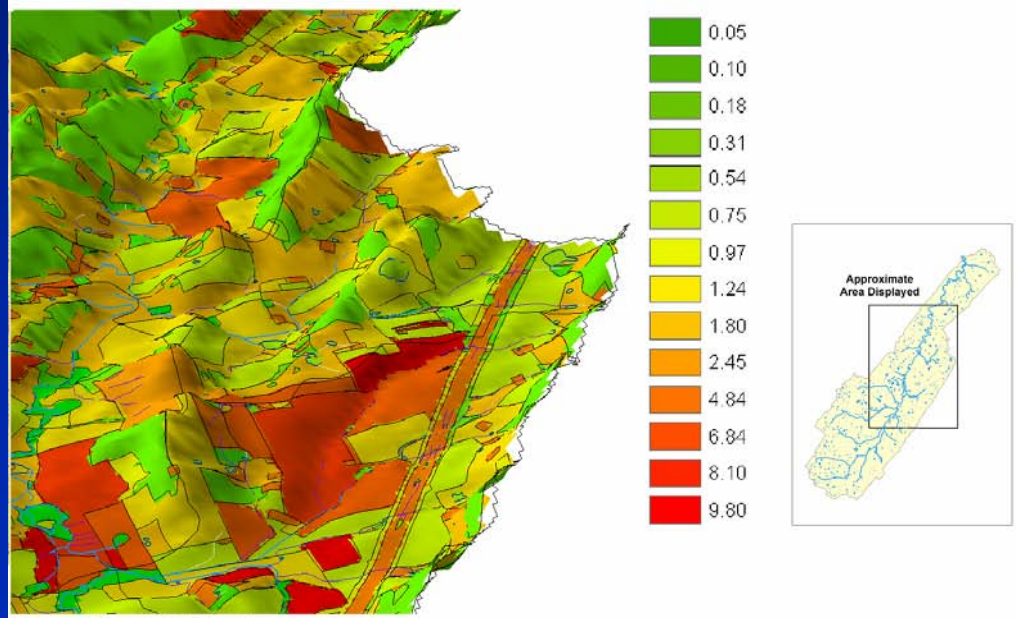
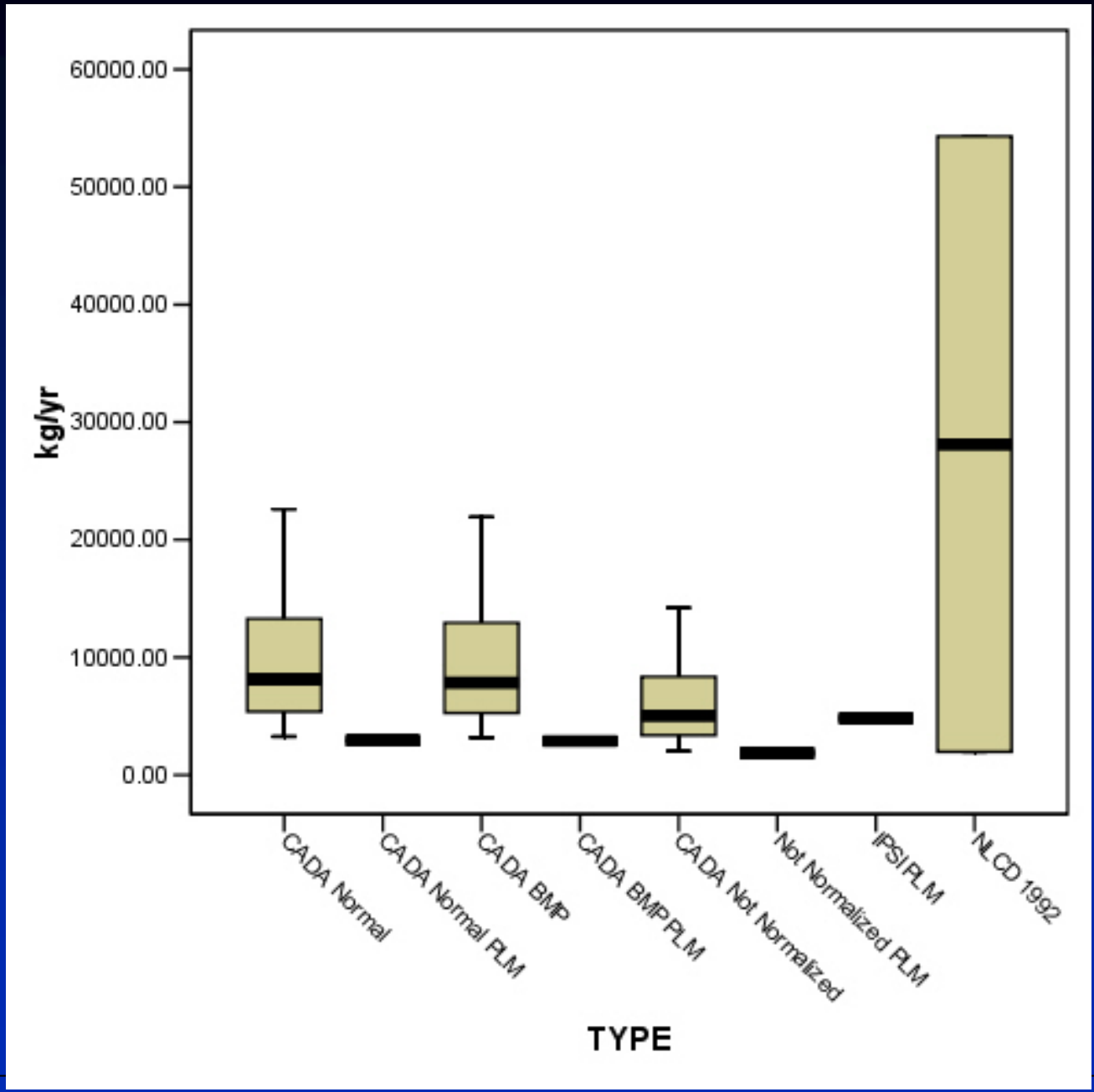
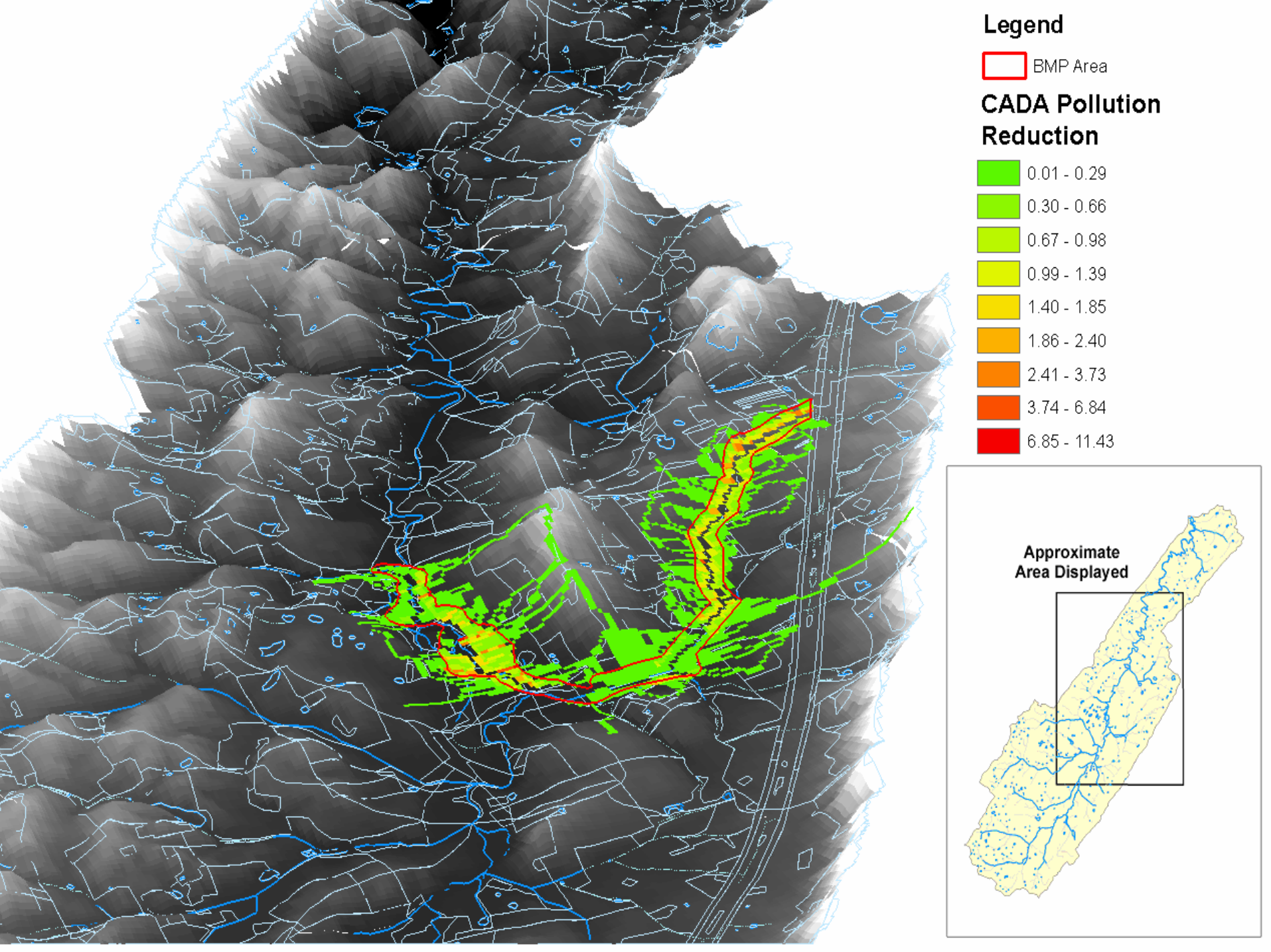


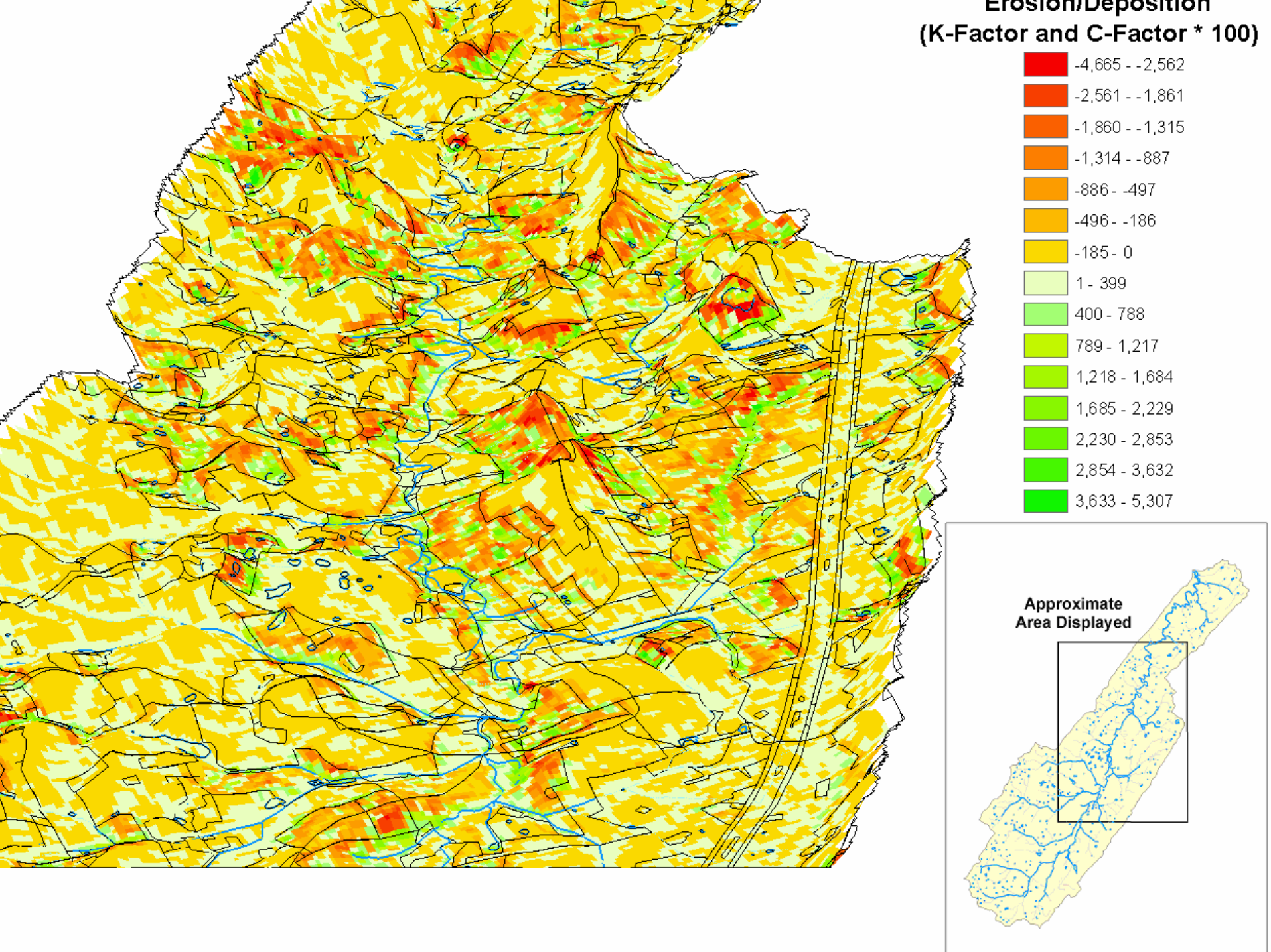
Figure 2b - ECV Map (units kg/ha)

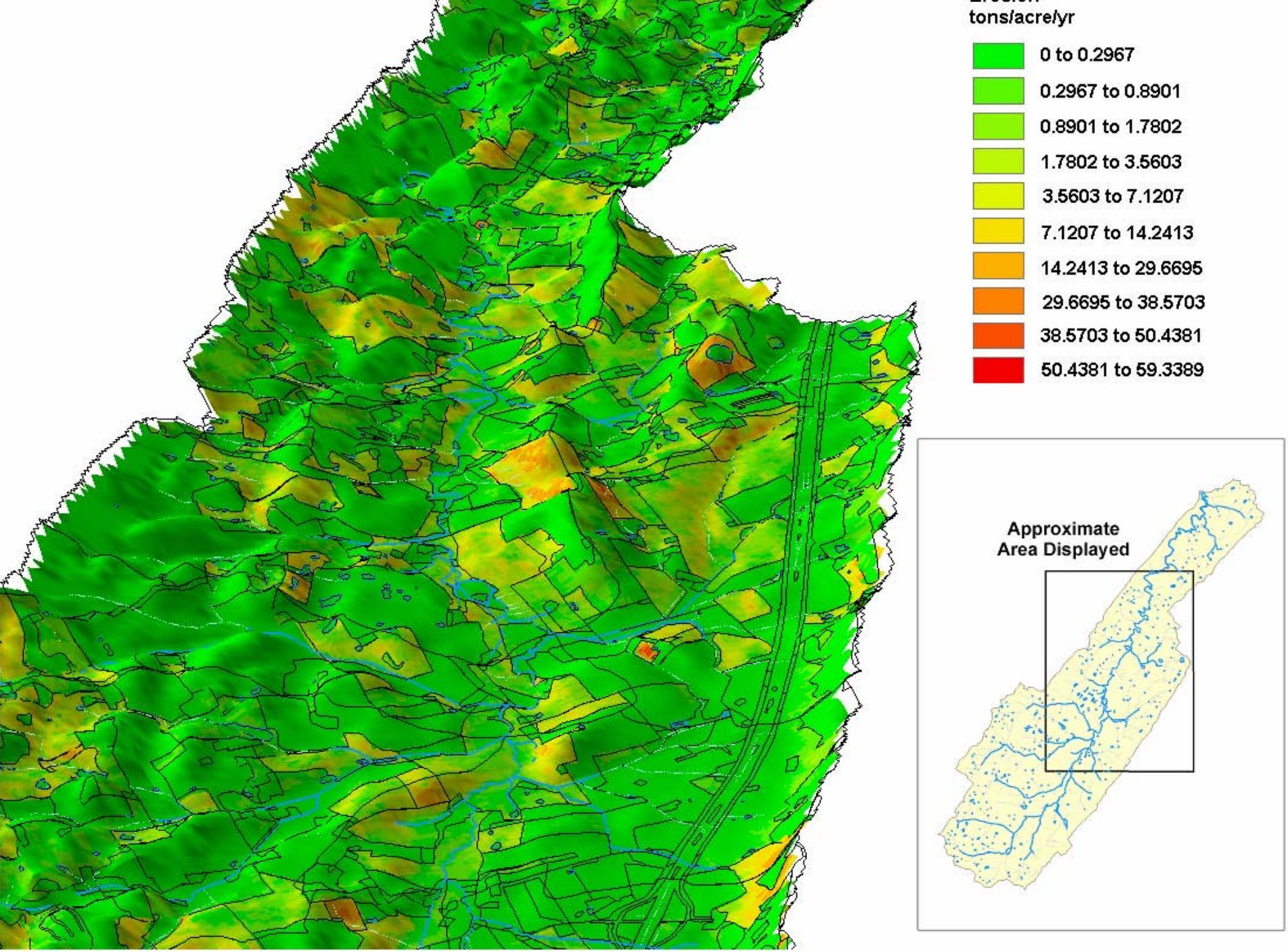

60000.00
50000.00
40000.00
30000.00
20000.00
10000.00
0.00
kg/yr
CADA Normal
CADA Normal PLM
CADA BMP
CADA BMP PLM
CADA Not Normalized
Not Normalized PLM
IPSI PLM
NLCD 1992
TYPE


Legend
BMP Area
CADA Pollution Reduction
0.01 - 0.29
0.30 - 0.66
0.67 - 0.98
0.99 - 1.39
1.40 - 1.85
1.86 - 2.40
2.41 - 3.73
3.74 - 6.84
6.85 - 11.43
Approximate Area Displayed

Unit Stream Power – Erosion Deposition (USPED) Model

- Modification of the USLE model
- Accounts for landscape-scale effects: uses the flow accumulation (drainage area) instead of the slope length to compute the topographic factor LS
- Computes the divergence of the sediment transport pattern detecting the areas where sediment loads increase (excavation/erosion) or decrease (deposition) and areas where it remains constant


Erosion/Deposition
(K-Factor and C-Factor * 100)
-4,665 - -2,562
-2,561 - -1,861
-1,860 - -1,315
-1,314 - -887
-886 - -497
-496 - -186
-185 - 0
1 - 399
400 - 788
789 - 1,217
1,218 - 1,684
1,685 - 2,229
2,230 - 2,853
2,854 - 3,632
3,633 - 5,307
Approximate
Area Displayed


tons/acre/yr
0 to 0.2967
0.2967 to 0.8901
0.8901 to 1.7802
1.7802 to 3.5603
3.5603 to 7.1207
7.1207 to 14.2413
14.2413 to 29.6695
29.6695 to 38.5703
38.5703 to 50.4381
50.4381 to 59.3389
Approximate
Area Displayed

Preliminary Erosion Results

- Annual sediment erosion calculations:
  - USPED median result (53,985 tons/year)
  - IPSI PLM under-estimated erosion? (32,876 tons/year)
  - USLE over- estimated erosion? (111,323 tons/year)

University of Tennessee - Summary

- Concerns about “TMDL models” used
- Few people working on watershed modeling; fewer on monitoring
- Watershed models or planning tools?
- Need improved resolution land-use coverage – 10m or better (satellite imagery??)
- Calibrate and compare IPSI, CADA, USPED models
- Funding: TVA, EPA 104(b) and 319
- Extension specialists / agents have little or no knowledge on watershed issues