Development of Landscape Indicators for Potential Nutrient Impairment of Streams in EPA Region 8

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EPA
United States Environmental Protection Agency

Region 8

Acknowledgements

- Daniel Heggem, ORD / NERL / Las Vegas
  - Presenter

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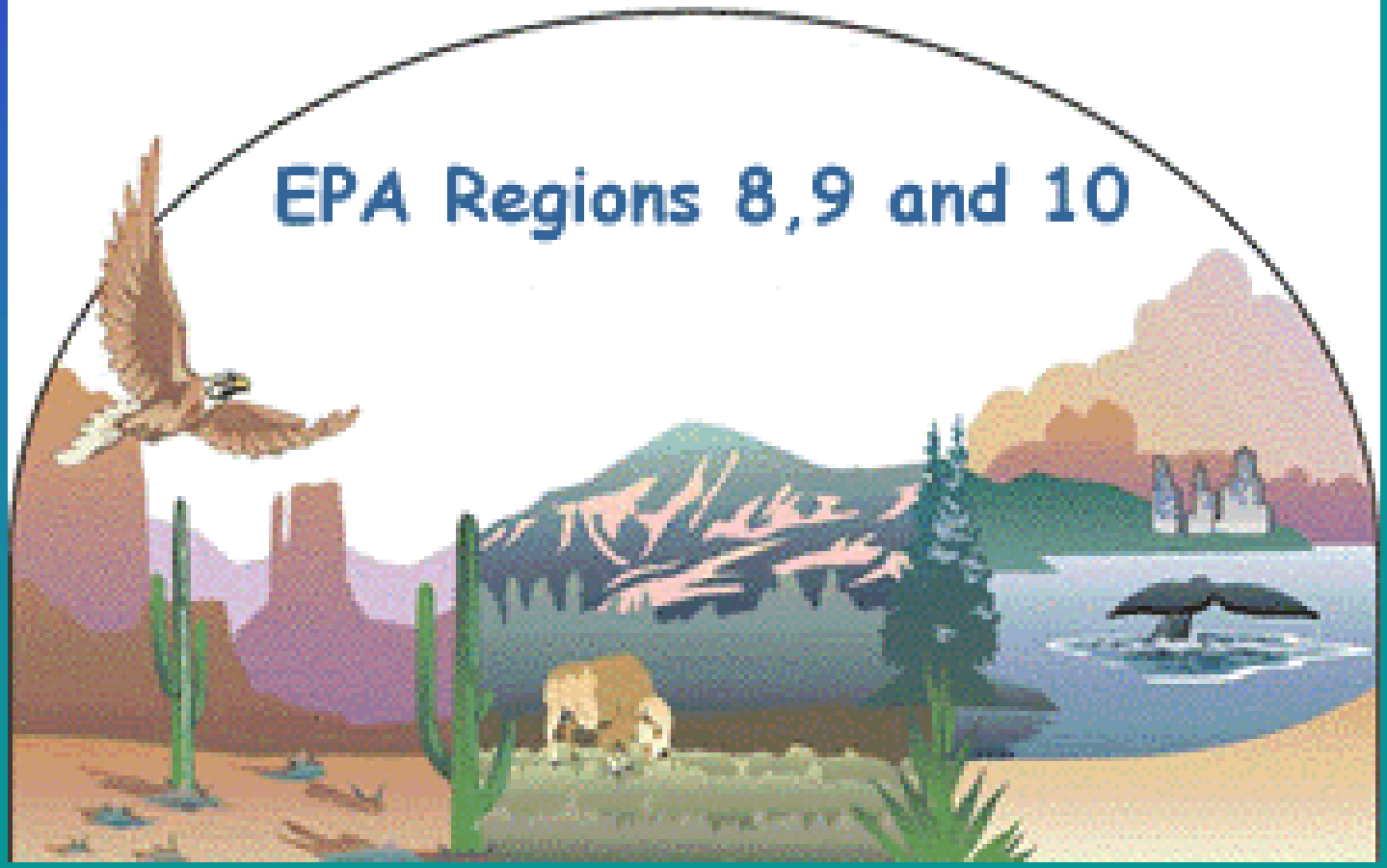
- Sarah Spaulding, USGS / BRD
  - Part of EPA Region 8 Team through an IAG
- Tony Selle, EPA Region 8

- The entire EMAP-West Landscape Team

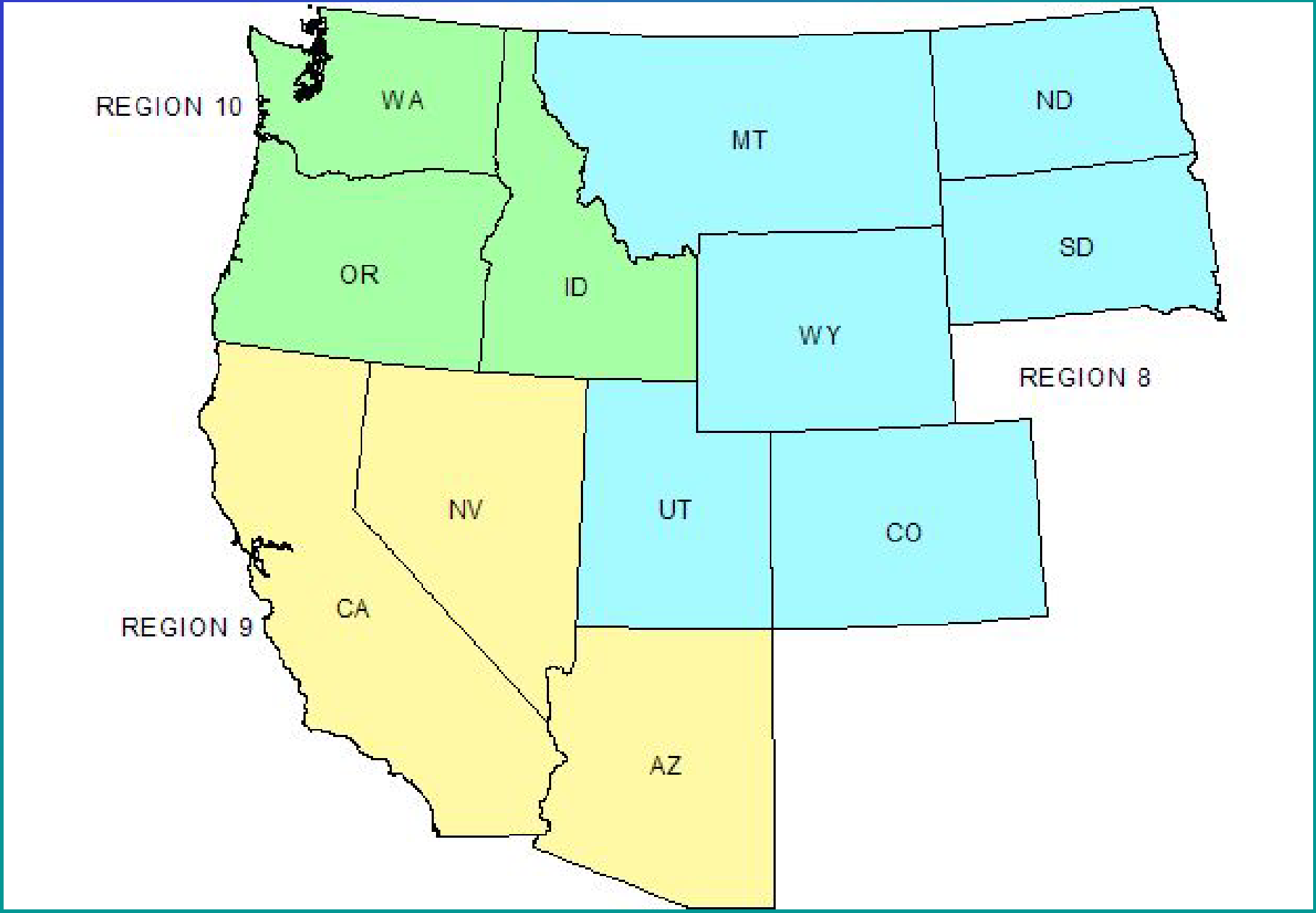
Presentation Overview

- EMAP-West Objectives and Approach
- EMAP-West Landscape Indicator Concepts for Stream Condition
- Landscape Assessment Questions
- Landscape Indicator Development
- Catchment and Metric Development
- Landscape Indicator Application
- Nutrient Model Development
- Current Development Status

EMAP-WEST



EMAP-West – EPA Regions 8, 9, and 10



What is EMAP-West in Region 8?

A demonstration of indicators and designs for assessing the ecological condition of streams

- partnerships between EPA/States/Tribes
- unbiased estimates of condition of ecological streams and rivers
- comparative ranking of stressors
- tools for bioassessment
- supporting framework for 303d process

EMAP-West Objectives

- **Estimate Current Status *(and Trends)* in Selected Indicators of Ecological Stream Condition on a Regional Basis with Known Confidence**
- **Estimate Geographic Coverage and Extent of Streams and Rivers**
- **Rank Stressors that affect Ecological Condition of Streams**
- **Seek Associations Between Ecological Stream Condition and Stressors**

Region 8 EMAP Objectives

- **Produce a regional assessment of the ecological condition of streams in the Region**
  - **Answering relevant questions of interest to stakeholders**
    - **EPA Programs, States, Tribes**
  - **Reporting by the Region, States, ecoregions (or aggregated ecoregions), large river basins, and other areas of interest**
- **Develop partnerships with ORD, States, Tribes, and USGS to perform the assessment**
- **EPA Technology Transfer to States and Tribes**
  - **(indicator development, assessment methods, monitoring design)**

Surface Waters (Rivers and Streams)

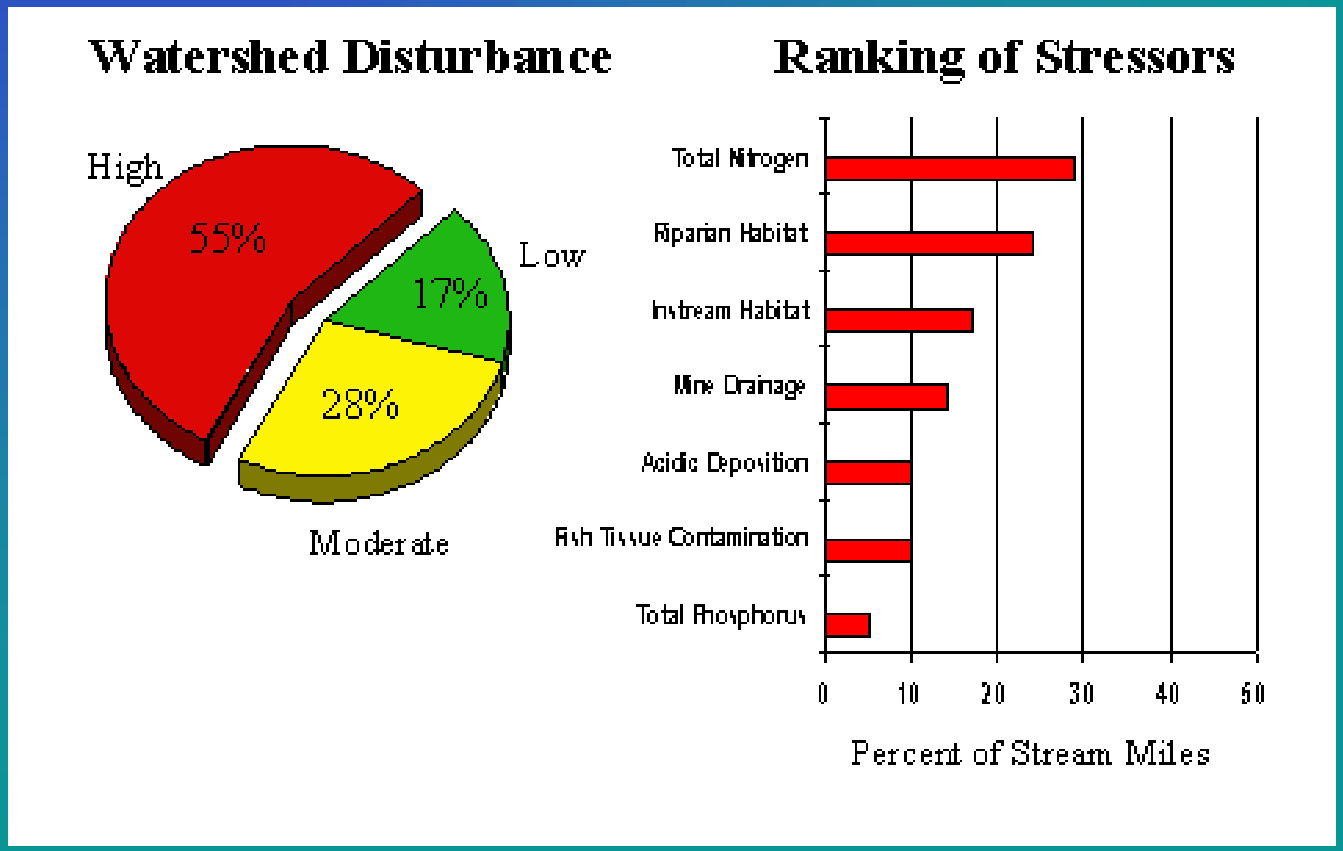
- Population Estimates of Condition for an Area with known confidence
- Ranking of Stressors
- Association of Condition and Stressors

Landscapes

- Predicted Conditions across an Area (WHERE?)
- Association of Condition and Stressors

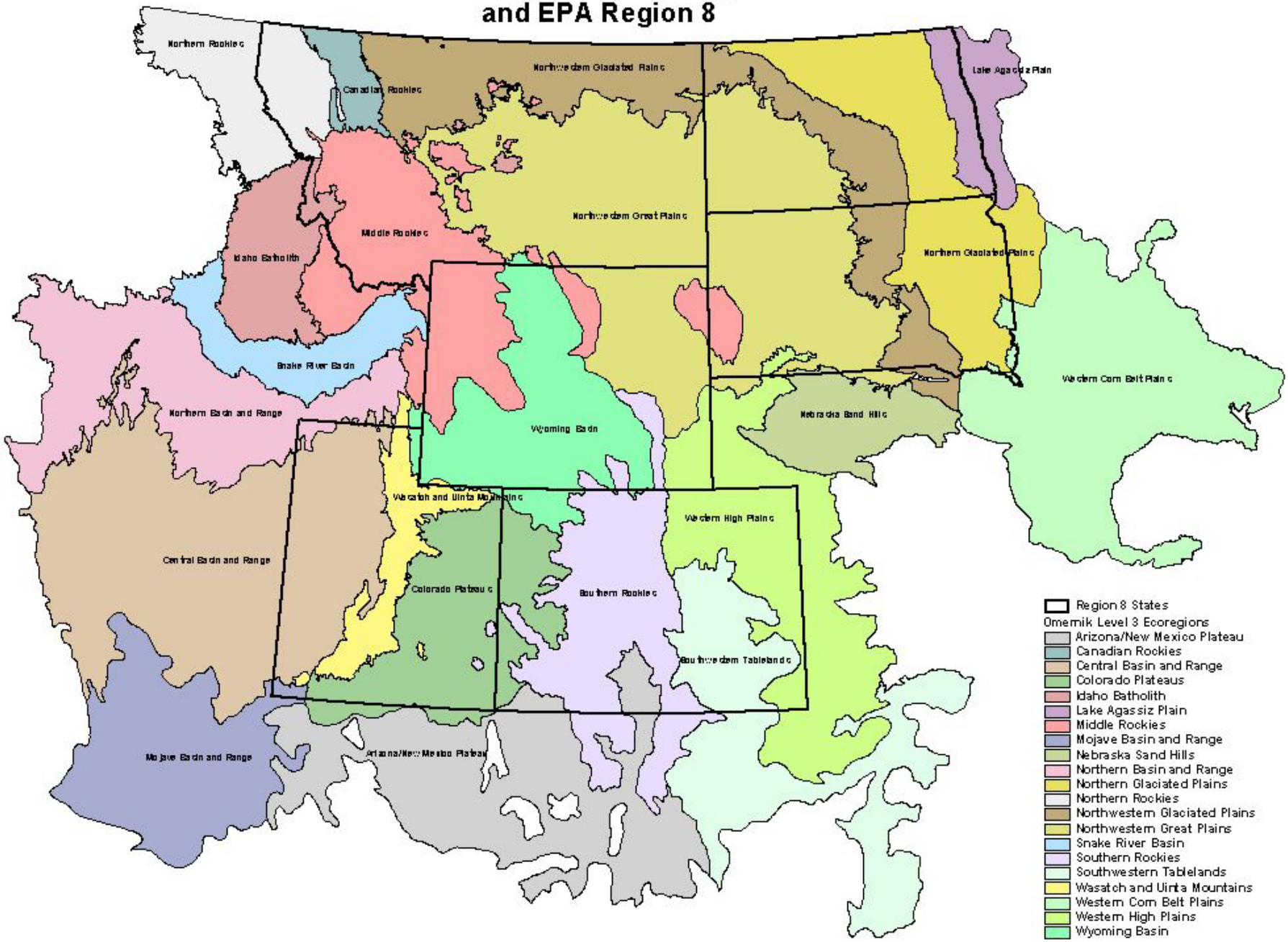
Surface Water Population Estimates

for streams within an assessment unit (i.e. Region, State, Ecoregion)



Landscapes

Omernik's Level 3 Ecoregions and EPA Region 8



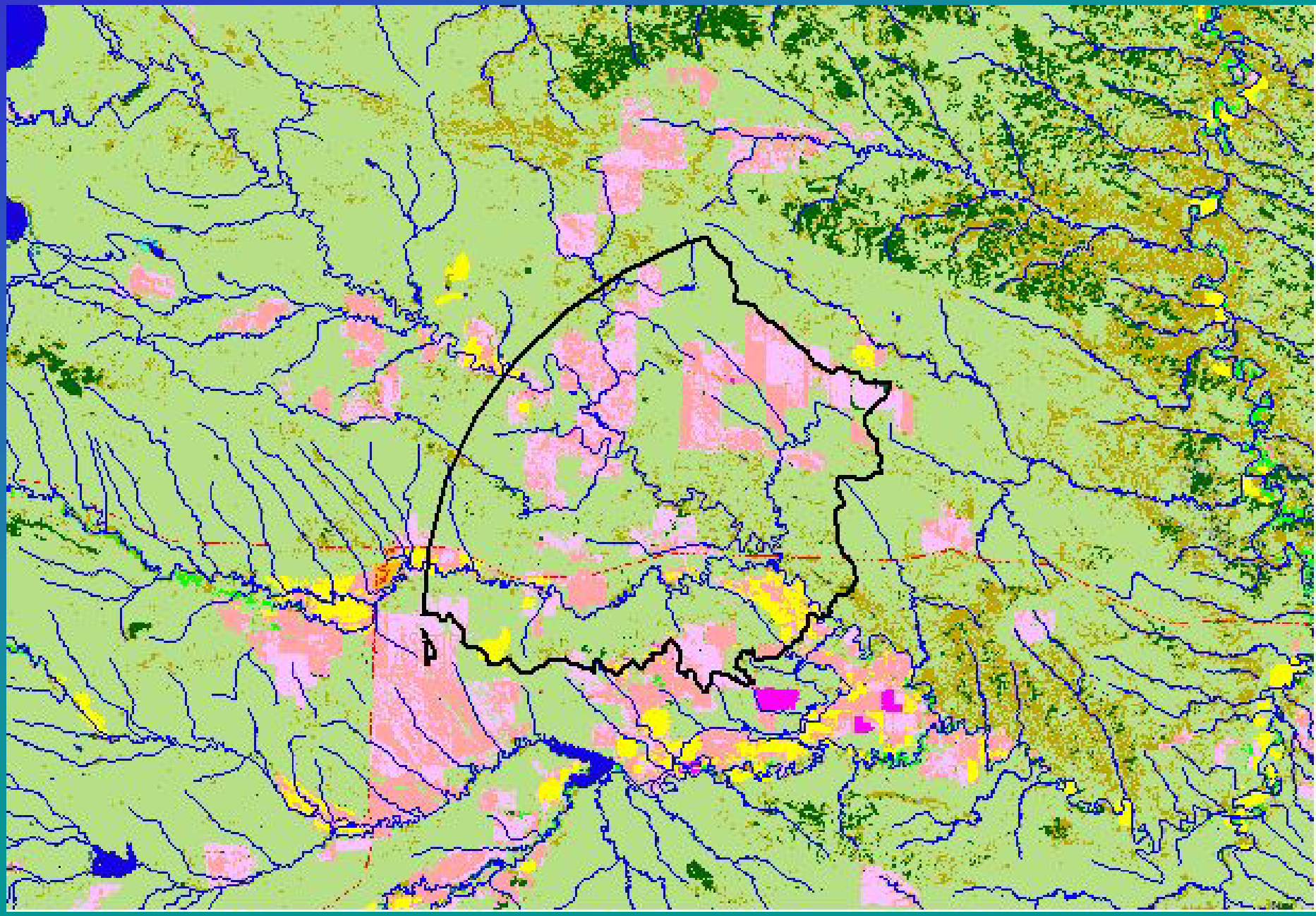
EMAP-West Landscape Indicator Concepts for Stream Condition

- **The ecological stream condition is often a function of the watershed composition and disturbance**

- **Many GIS data layers can be used to describe the watershed composition and disturbance**

- **Given an understanding of the relationship between condition and watershed composition and disturbance, models can be developed and applied to predict probable condition in other areas**

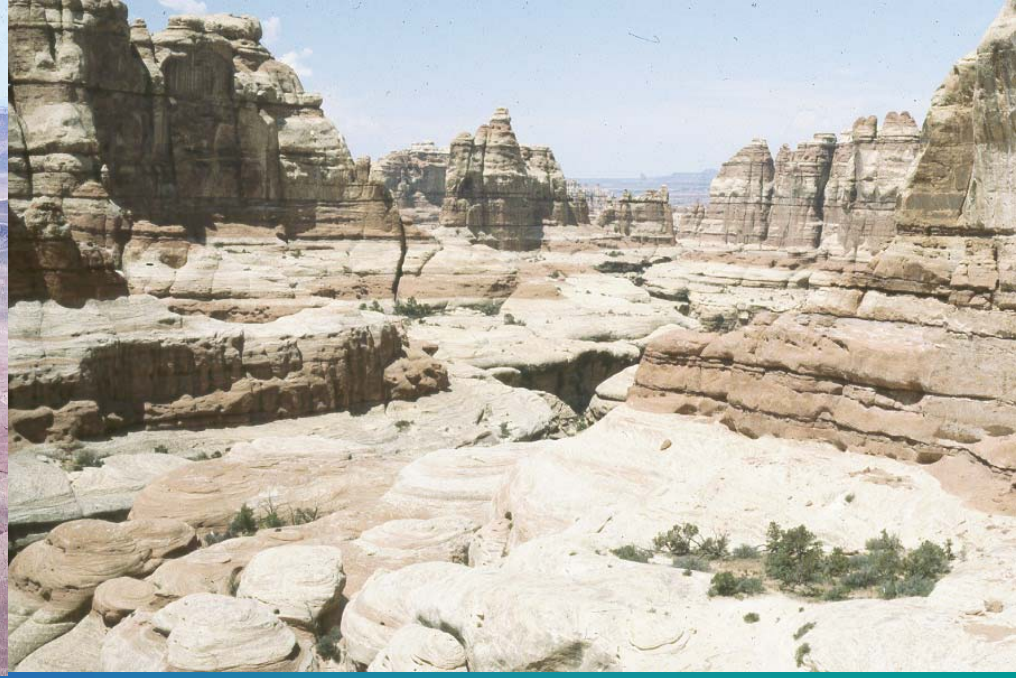
Land Cover and Streams in a Site Catchment



Lower Yellowstone

Southern Rockies

Colorado Plateau



NW Great Plains

Region 8 EMAP Assessment Questions

- ***Landscape Questions***
  - Where are the areas in each assessment unit that are in good, marginal, and poor condition?
  - What percent of (and how much) area in each assessment unit are in each land cover types? (agriculture, forest, developed, grasslands, barren land)
  - What is the distribution of land cover types in each assessment unit?
  - What percent of (and how much) area in each assessment unit has major anthropogenic impact?
  - Where are the locations of major anthropogenic impact in each assessment unit?
  - What percent of (and how many) stream miles in each assessment unit are adjacent to a road?
  - What is the percentage of forest and rangeland fragmentation in each assessment unit?

Region 8 EMAP Assessment Questions

- ***Landscape Questions***
  - What are the percentages of land cover types associated with minimally impacted streams (reference conditions) in each assessment unit?
  - What are the percentages of land cover types associated with streams in poor condition in each assessment unit?
  - What is the association between the integrity of riparian habitat and anthropogenic land cover in each assessment unit?
  - What is the association between biological integrity and the percent of public land ownership in the watershed in each assessment unit?
  - Where are the locations of potential habitat and biological impact from grazing in each assessment unit?
  - Where are the predicted areas of nutrient impairment in each assessment unit?
  - Where are the predicted areas of excess clean sediment impairment in each assessment unit?
  - Where are the predicted areas of salinity impairment in each assessment unit?

Landscape Analysis

- ***Landscape Characterization***
  - **GIS Data Layers**
  - **Landscape Metrics**

- **Stream Condition and Stressor Association** ***Landscape Indicators***
  - **Generation of Catchments for Surface Water Monitoring Sites**
  - **Generation of Landscape Metrics for Catchments**
  - **Landscape Model Development**
  - **Landscape Model Application**

EMAP-West Landscape Data

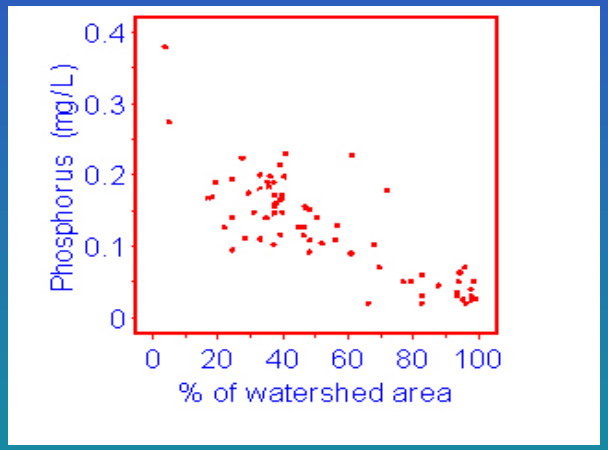
- Catchments for 2000, 2001, and 2002 Sites
- 1992 National Land Cover Dataset (NLCD)
- National Hydrographic Dataset (NHD) *(RF3)*
- Geographic Data Technology (GDT) Roads
- National Elevation Dataset (NED)
- STATSGO (NRCS Soils)
- EPA Ecoregions (Omernik Level 3)
- US Census Tiger 2000
- USDA Agricultural Census
- USGS GeoData (8-digit HUCS, Administrative, …)
- PRIZM, Geology, Mines, etc.

Oregon Phosphorus Example

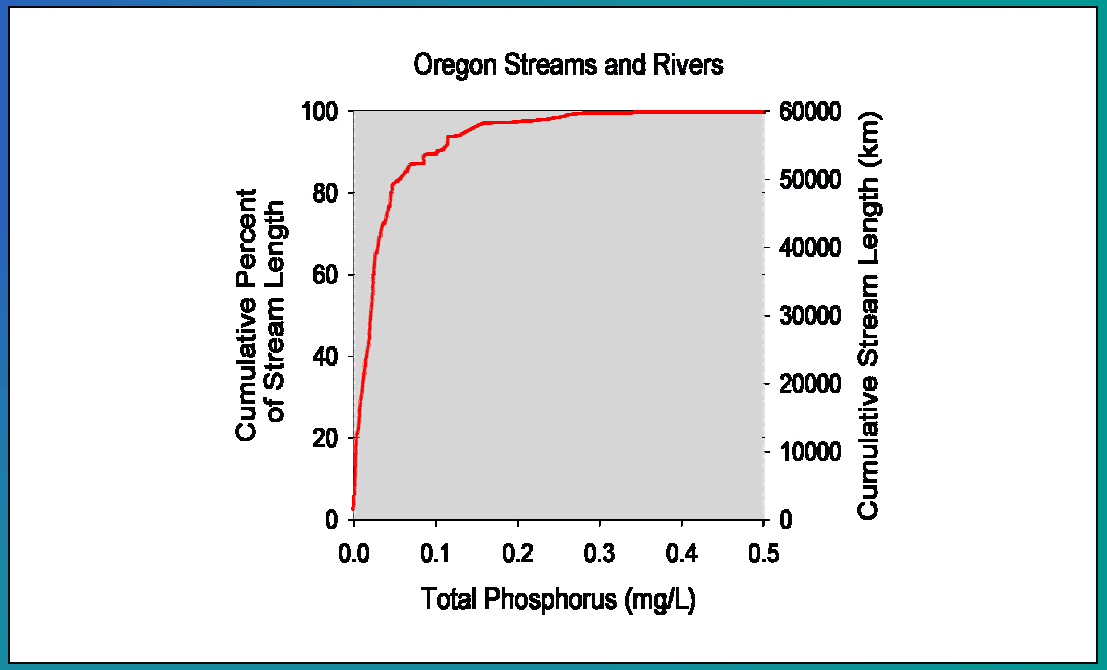
- **Simple Model**
- **One Independent Variable**
  - **Phosphorus as a function Natural Land Cover (Forest, Grassland) => more natural has low P; more anthropogenic disturbance has high P**
- **Full Catchments**

Draft of Total Phosphorus for the State of Oregon

Oregon Pilot Area
Observed vs. Predicted



Natural Land Cover



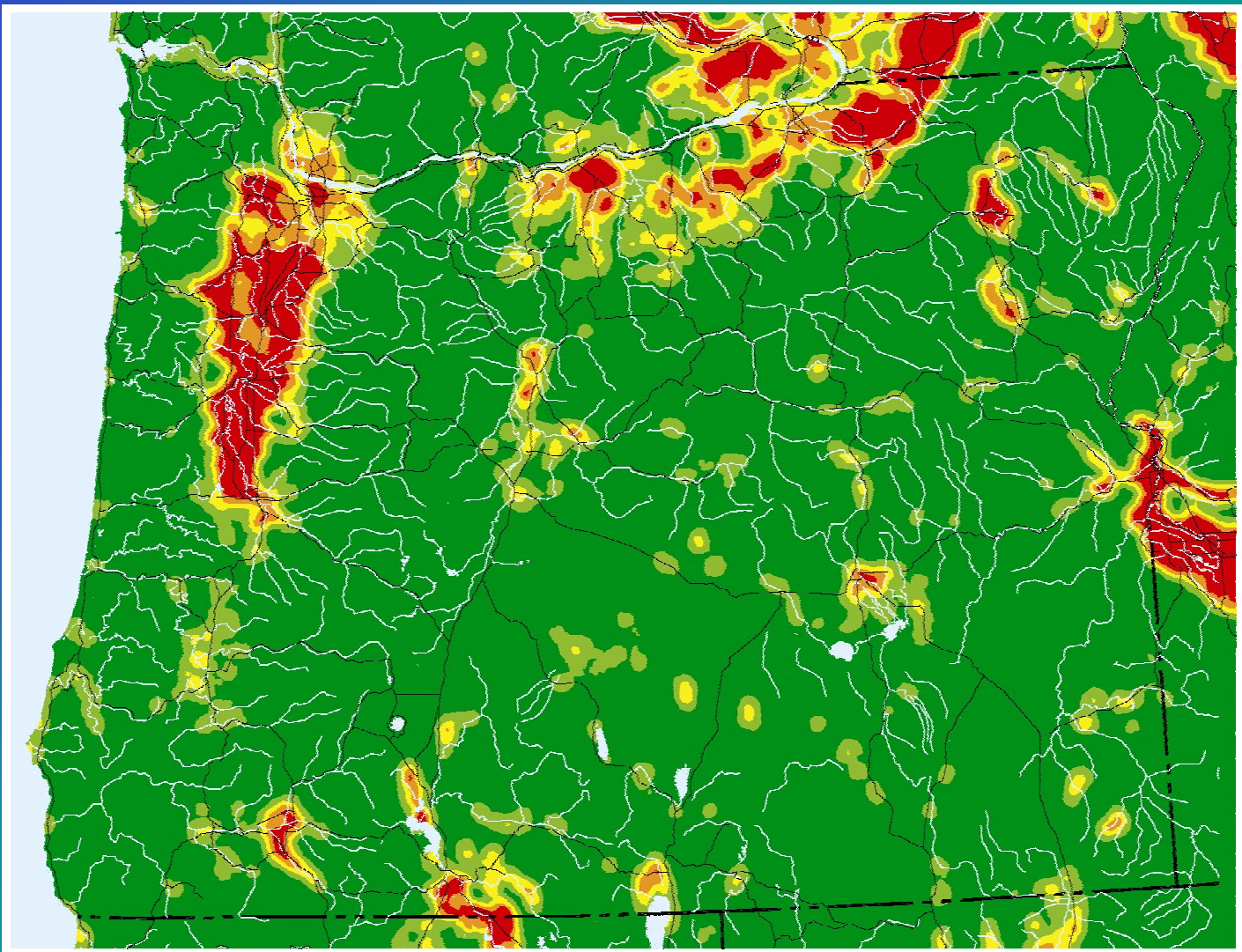
Integrated risk assessment for phosphorus in Oregon streams and rivers:

Left: relationship between natural land use/land cover and measured phosphorus concentrations in streams, statistically resulting in predicted phosphorus concentrations from this relationship:

Predicted Phosphorus = (0.518 – (.0034 * %natural land cover))^2

Right: cumulative distribution of phosphorus concentrations in population of flowing waters in the state of Oregon (from a probability survey). Ten percent of the stream length in Oregon has phosphorus concentrations exceeding the EPA criterion for flowing waters (0.1 mg/L); these streams are most likely to occur in the areas shown as yellow through red on the map in the next slide.

Predicted Phosphorus in Oregon Streams and Rivers

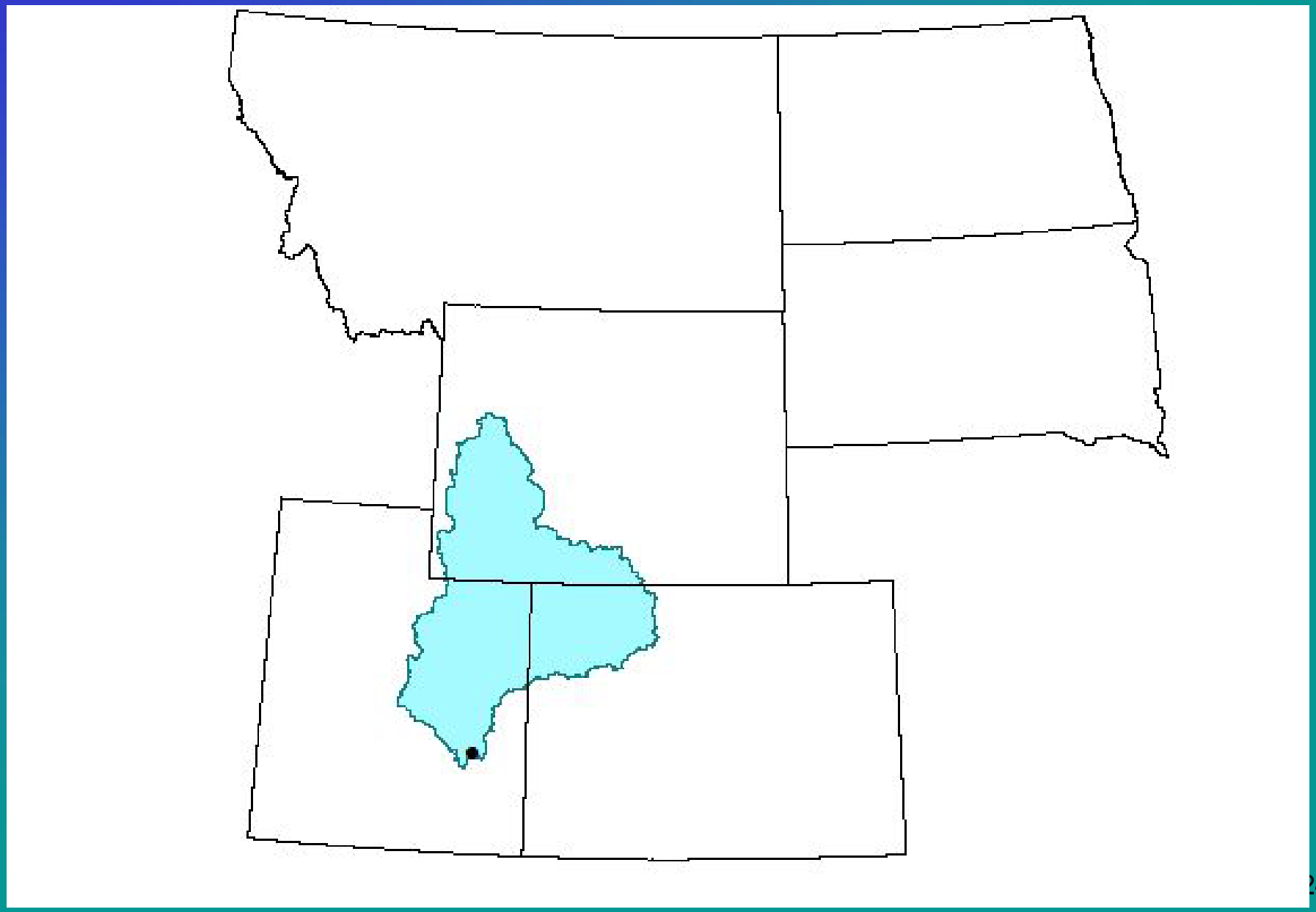


Phosphorus mg/L

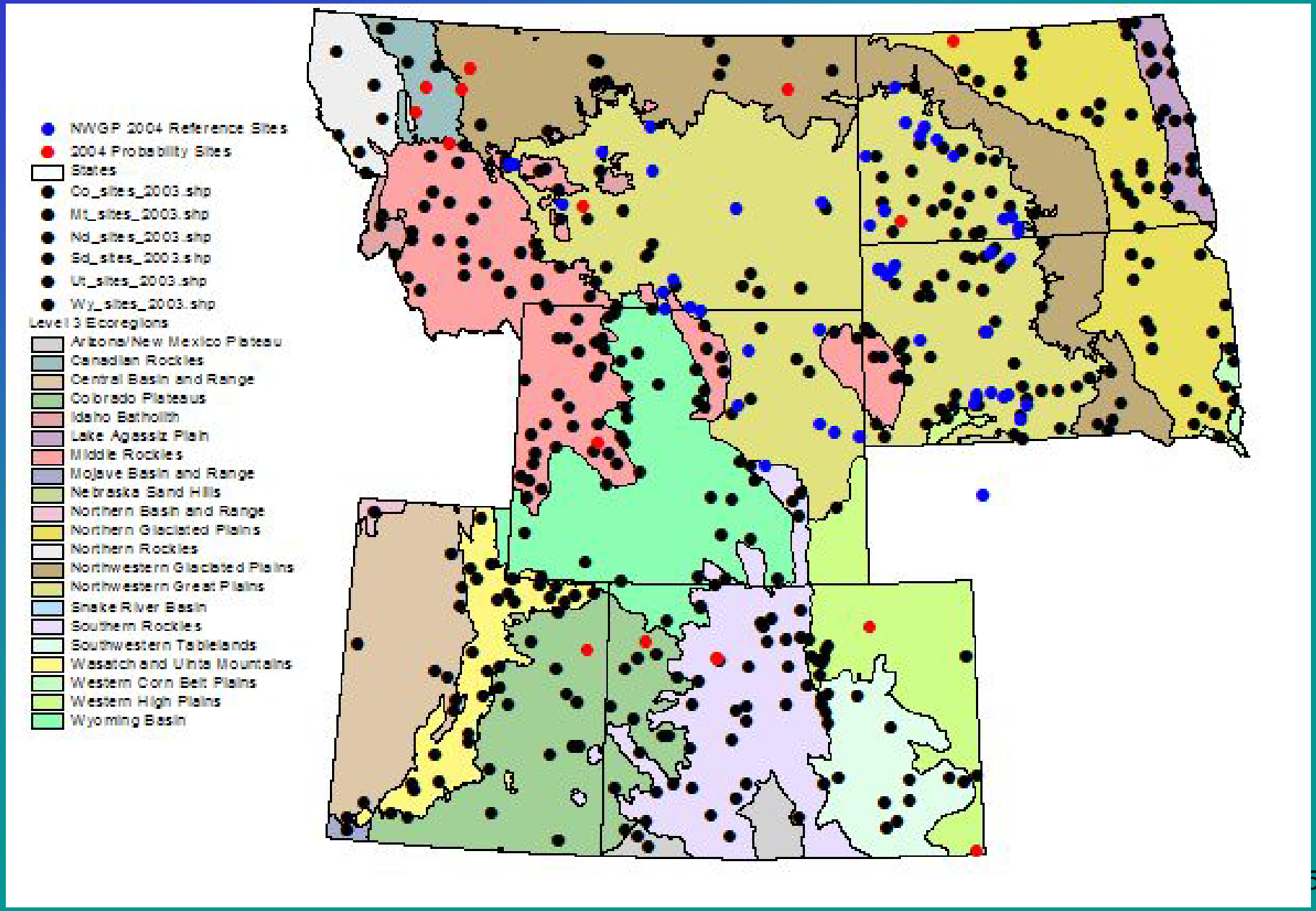
- > 0.2
- 0.15 - 0.2
- 0.1 - 0.15
- 0.05 - 0.1
- 0.00 - 0.05

Predicted Phosphorus = $(0.518 – (.0034 * \%\text{natural land cover}))^2$

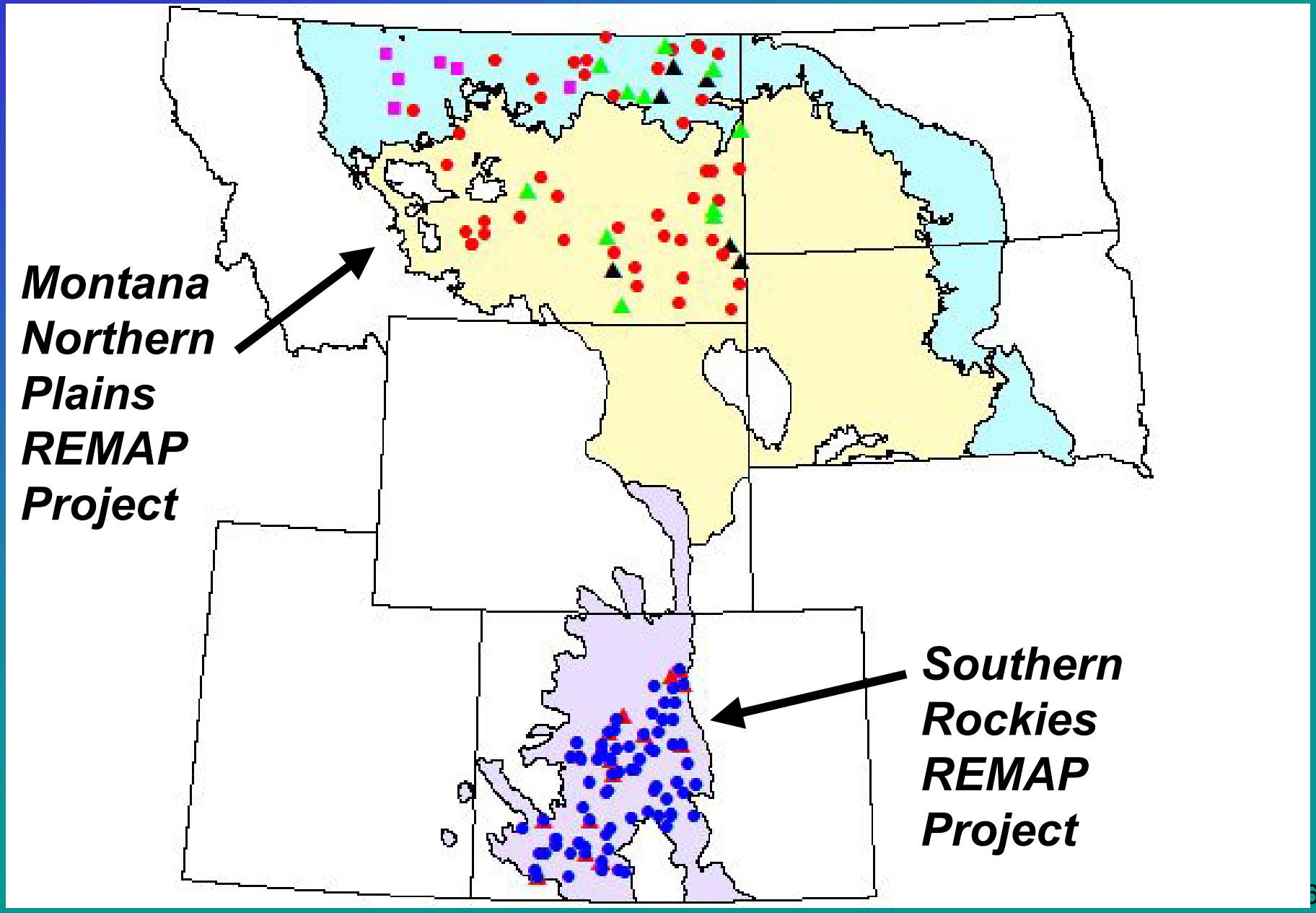
Full Catchment for a Green River Site



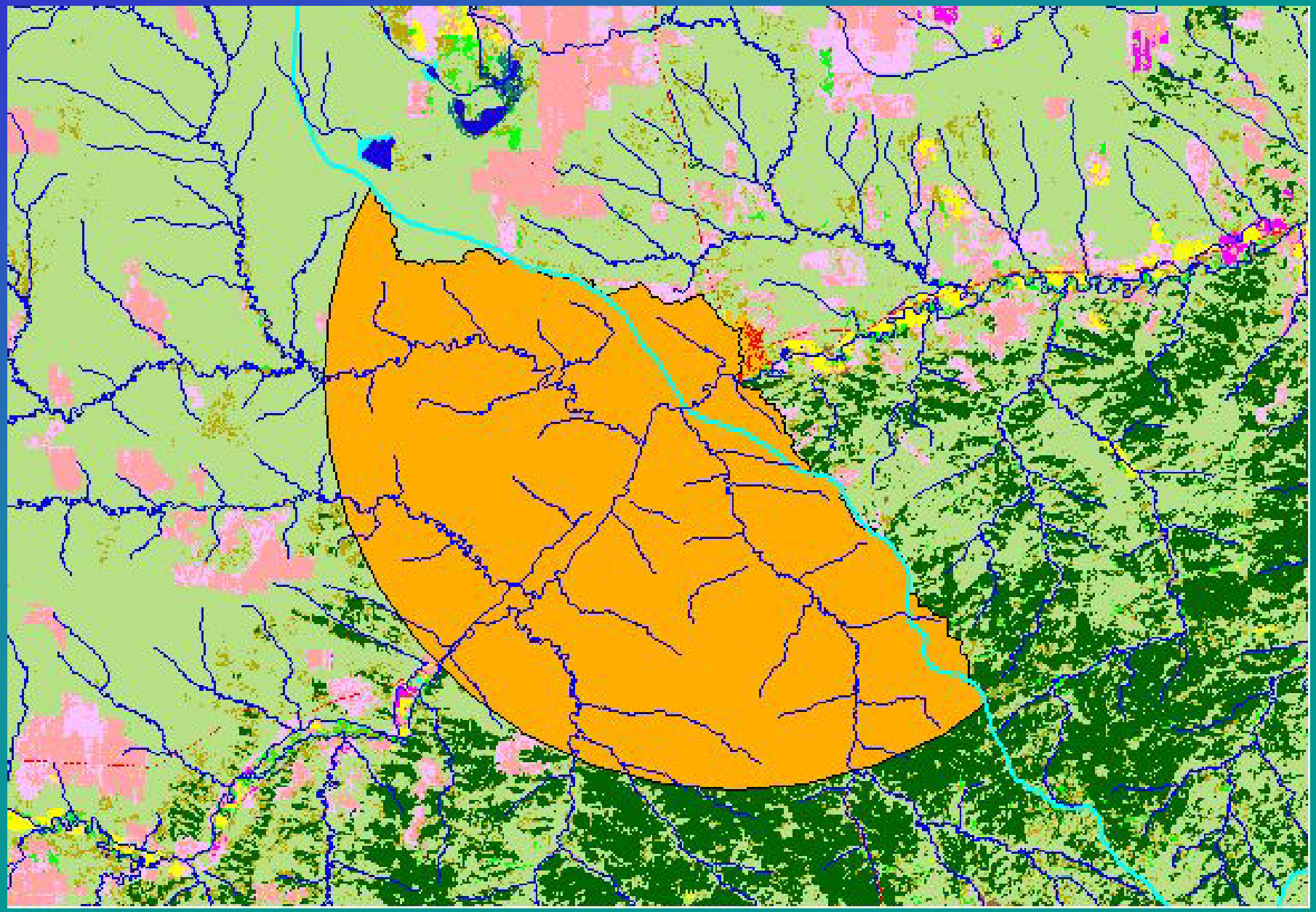
Region 8 EMAP-West Monitoring Status



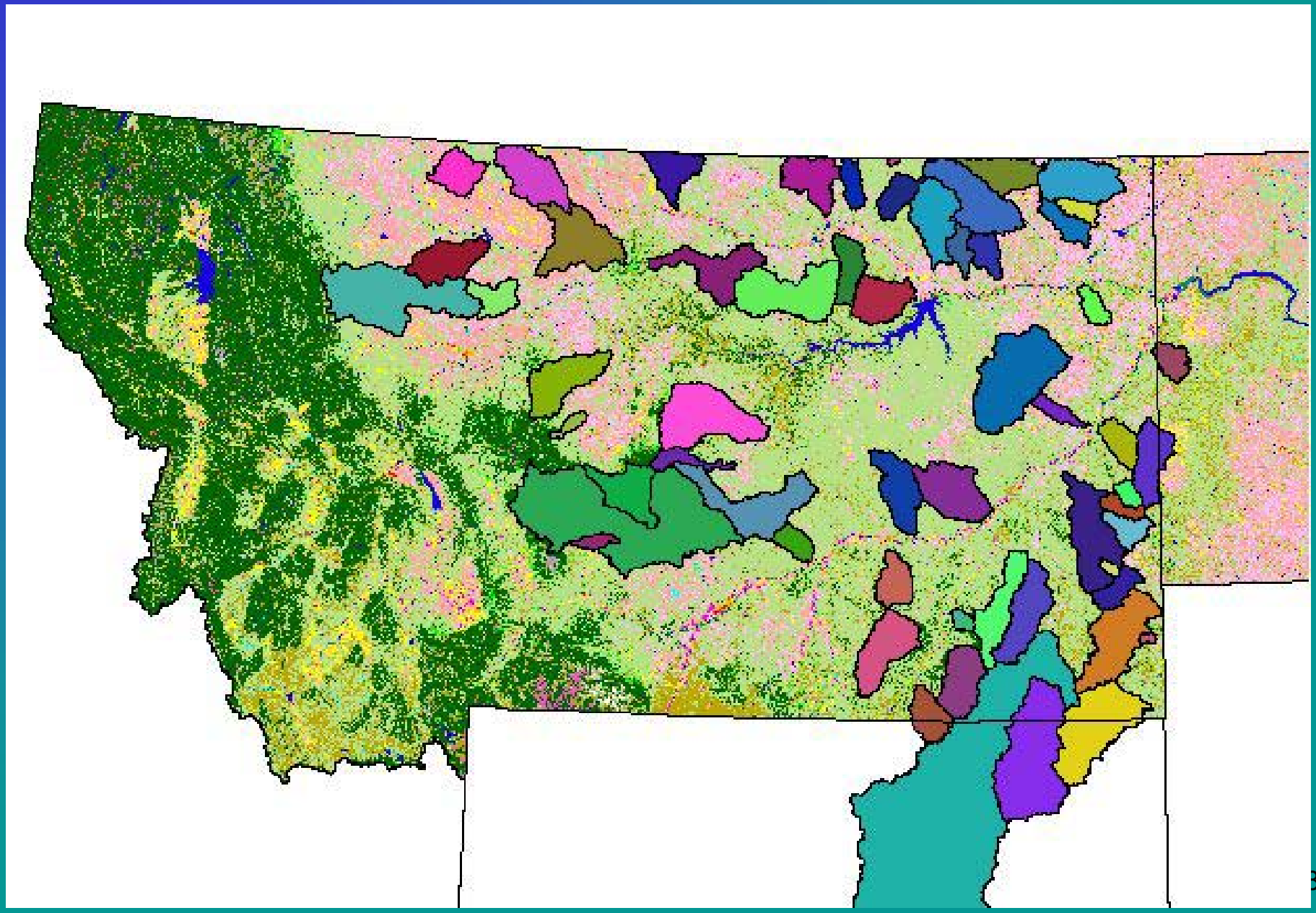
Montana Northern Plains and Southern Rockies



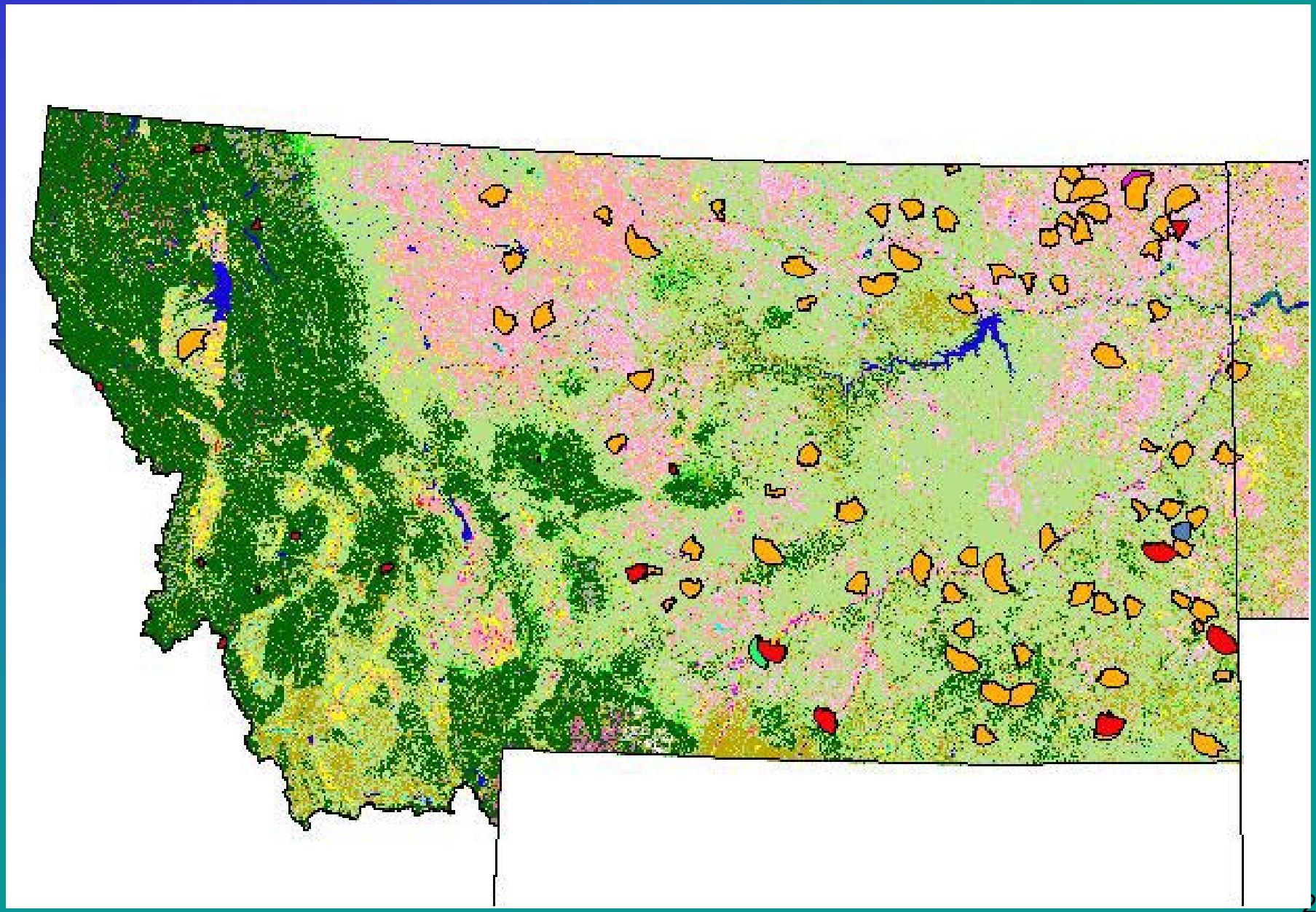
Catchment Definitions for EMAP-West



Full Catchments for MT Northern Plains Sites



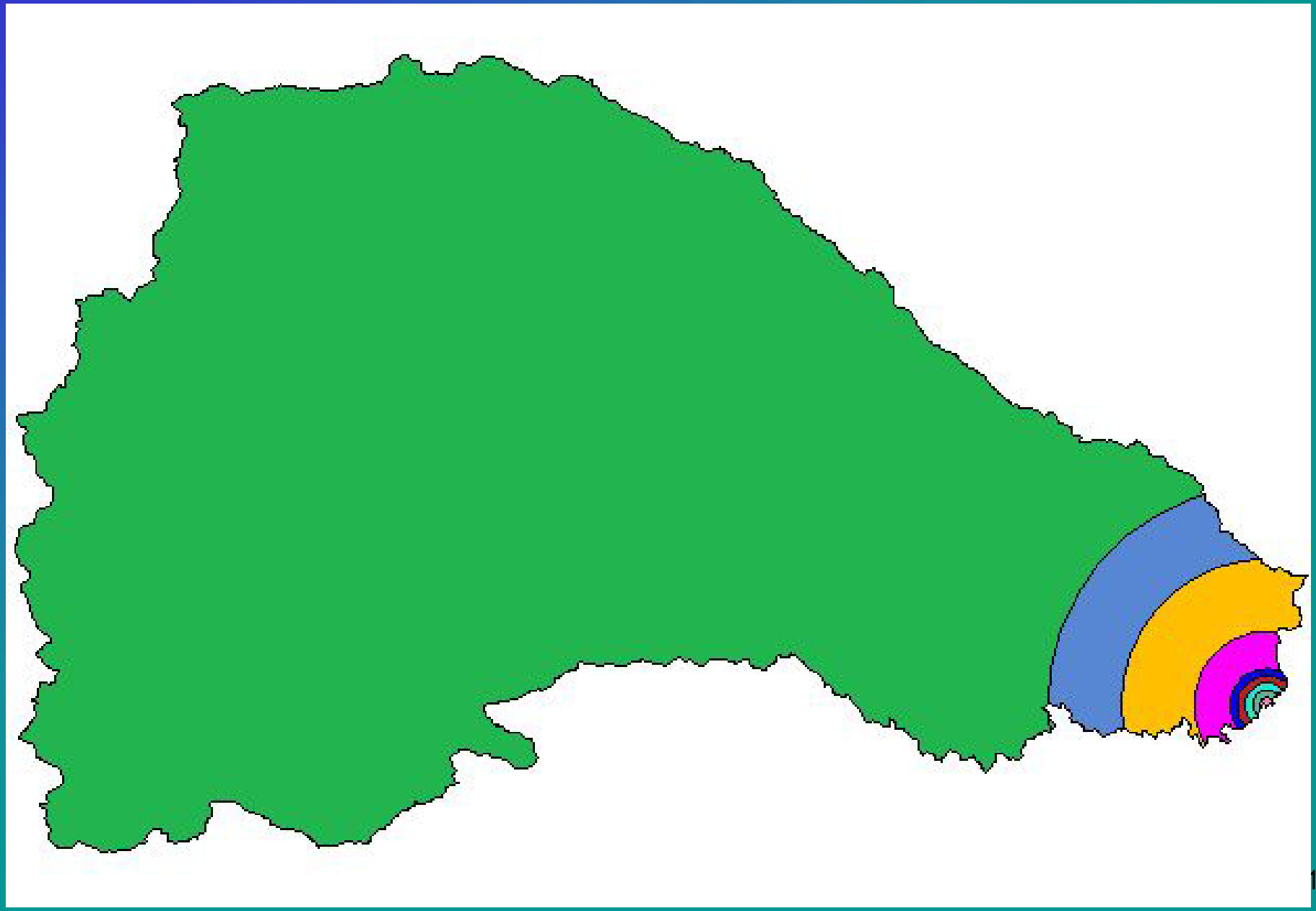
15 km clip of Montana Sites (REMAP, 2000, and 2001)



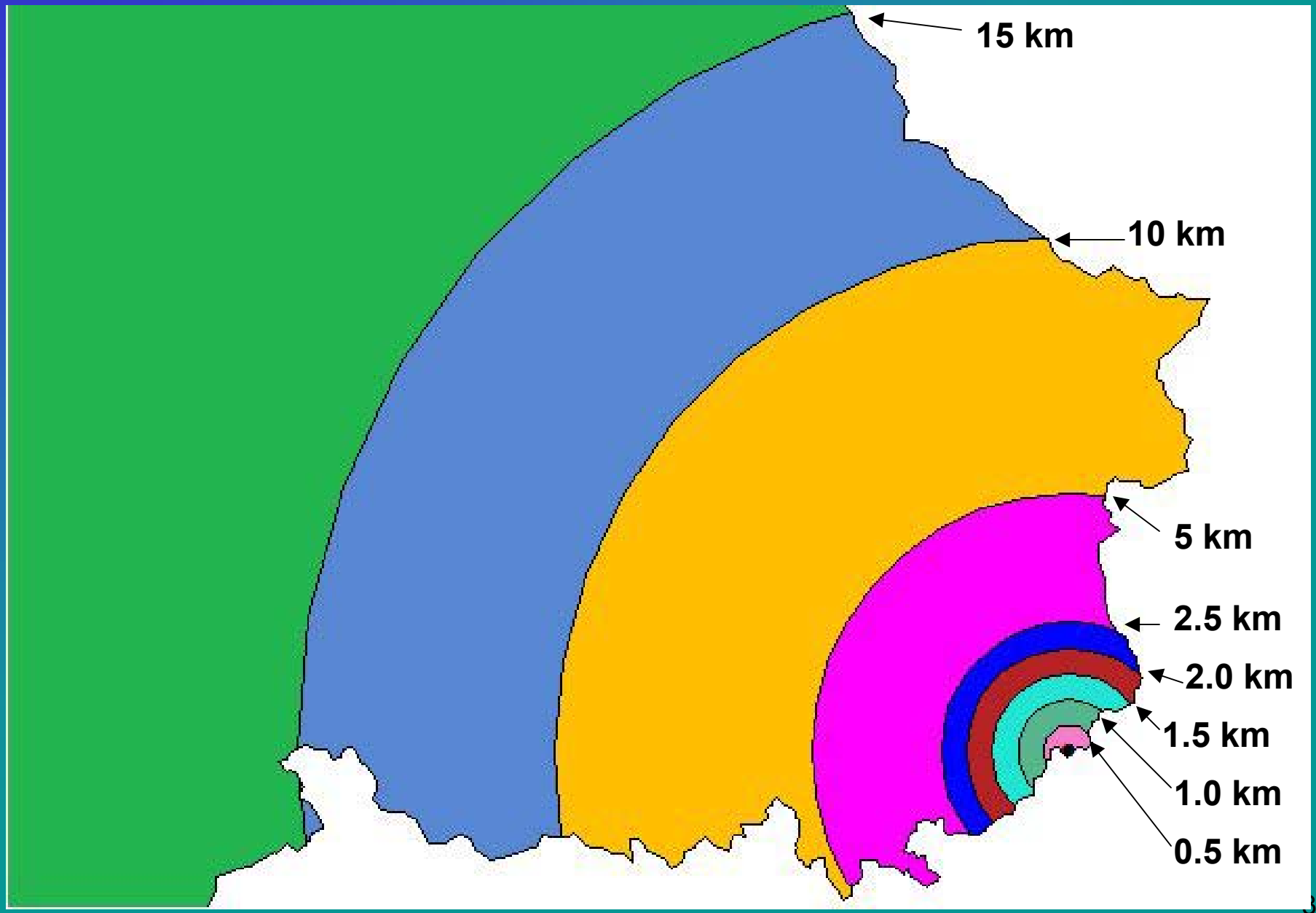
Catchment Definitions

- **Distance From Sample Sites** ***within Catchment***
  - **0.5 km**
  - **1.0 km**
  - **1.5 km**
  - **2.0 km**
  - **2.5 km**
  - **5.0 km**
  - **10.0 km**
  - **15.0 km**

Catchment with Distance from Site Clips



Distance from Site Clips

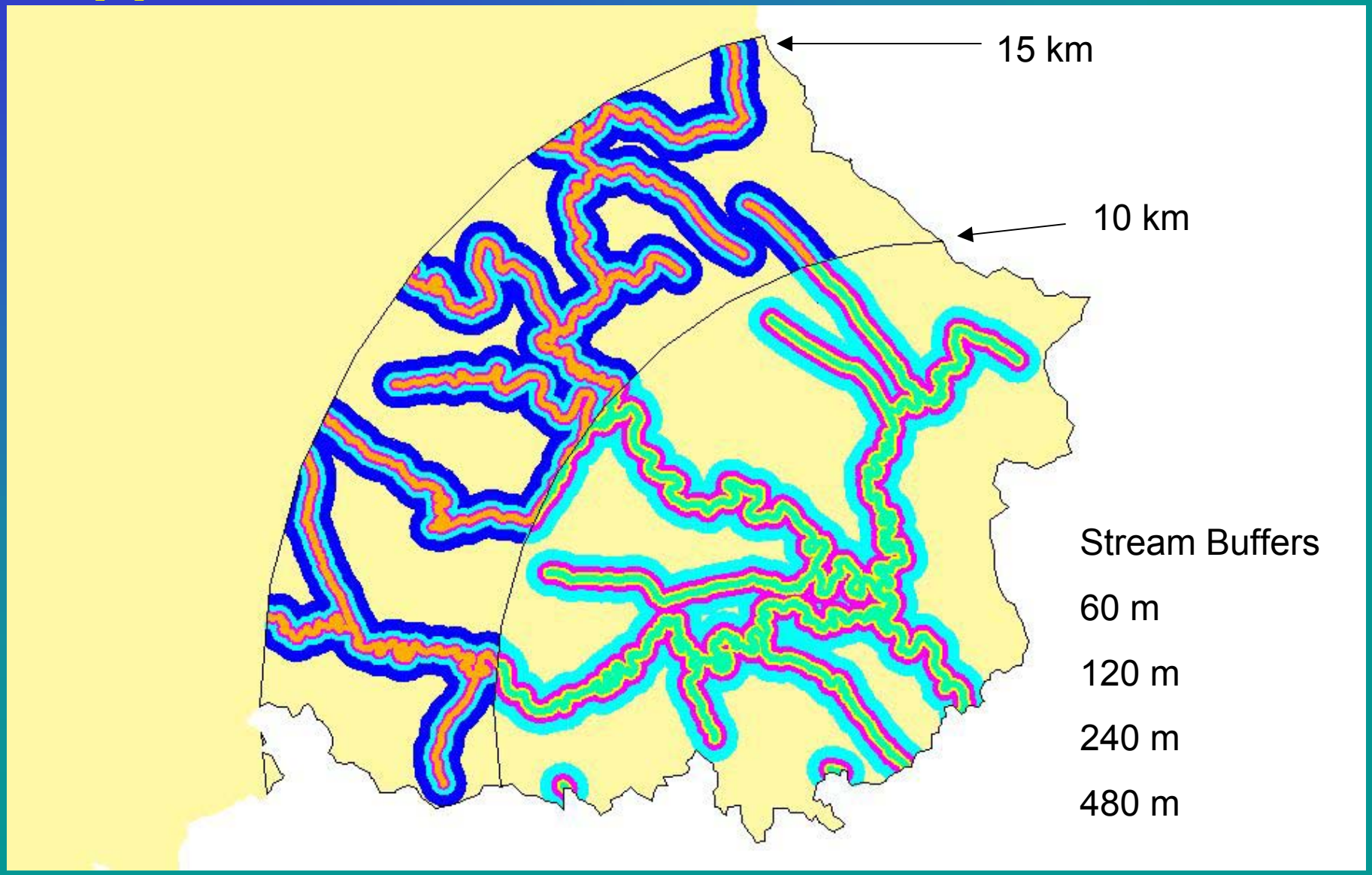


Catchment Definitions

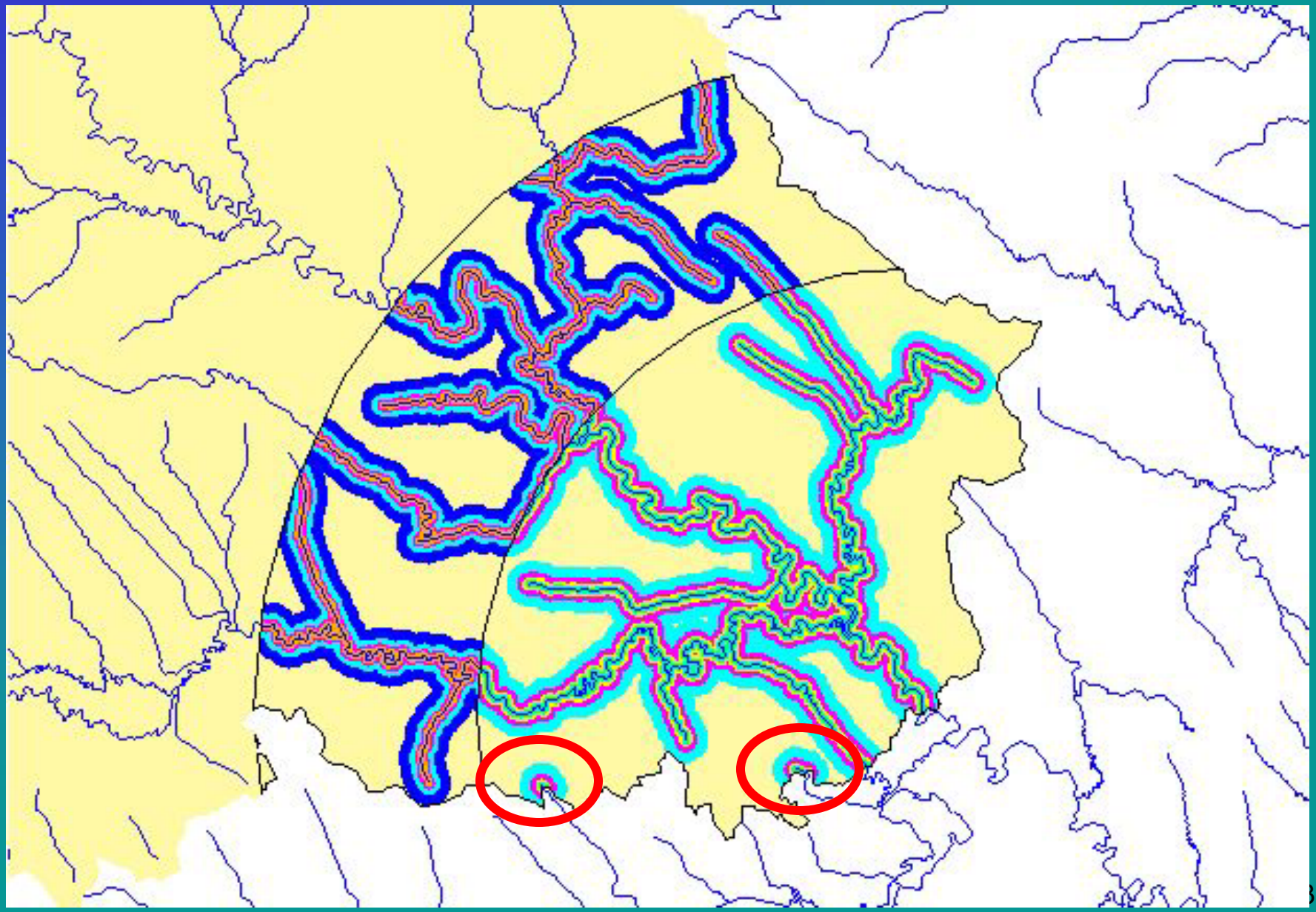
- **Buffer Distance From Stream** ***within Catchment***
  - **60 m**
  - **120 m**
  - **240 m**
  - **480 m**

  - **Buffer Distances from stream are also clipped by distances from sample site within catchment**

Buffer Distance from Stream are also Clipped with Distance from Sites



Processing Glitches – Stream Segments



Landscape Indicator Development for Potential Nutrient Impairment

The Model Concept is that

Nutrient Concentrations are a function of:

- **Anthropogenic Influence**
  - **Land Cover Classes with Loading Factors**
    - **Road Class translation into Land Cover classes**
  - **Potential Grazing Impact**
- **Atmospheric Deposition** ***(modeled)***

Landscape Indicator Development for Potential Nutrient Impairment

- **Clipped and Buffered Catchments produced for EMAP-West 2000, 2001, MT Northern Plains and Southern Rockies REMAP Sites**
  - ***Catchments for EMAP 2002 Sites underway***

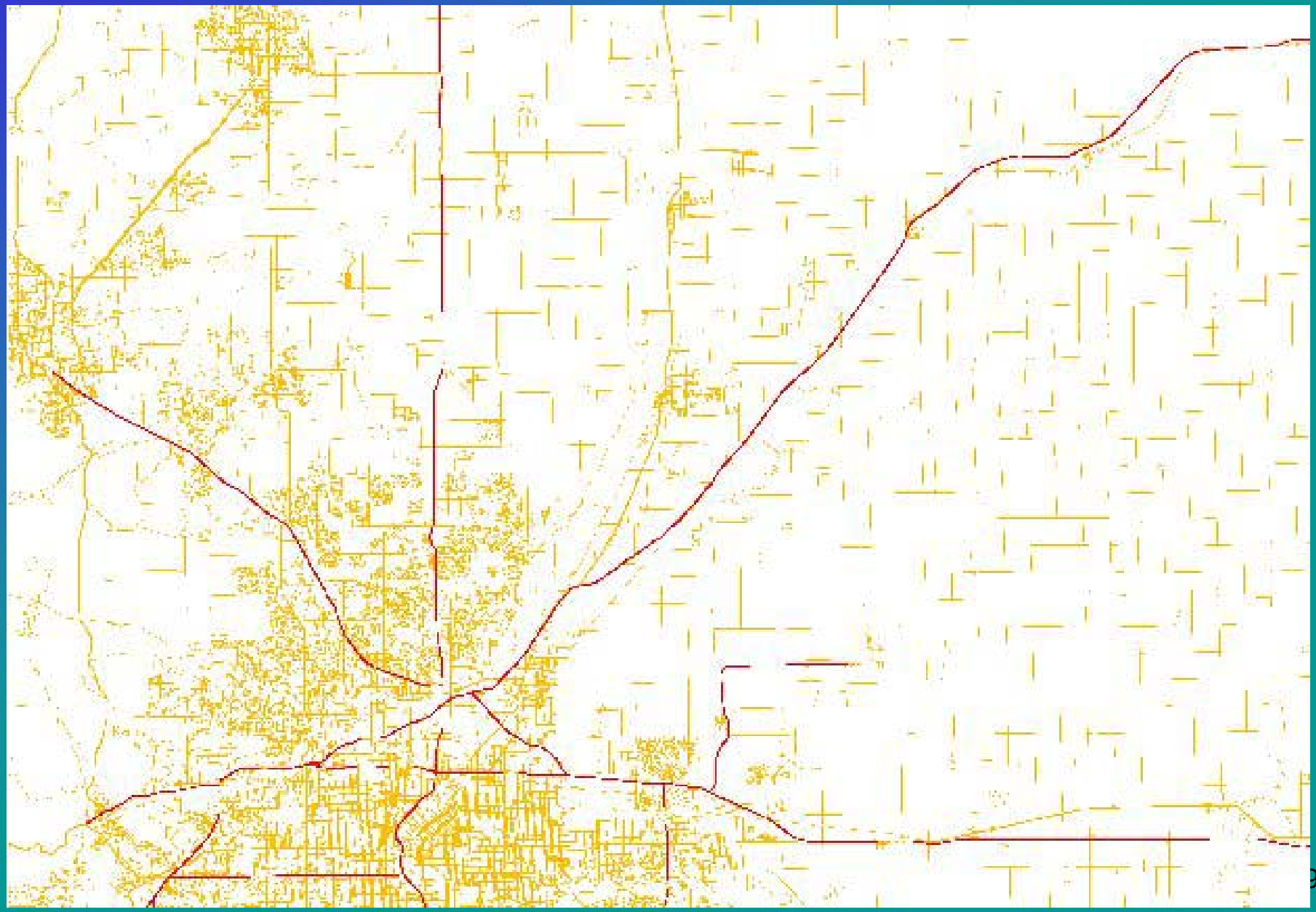
- **Modified Land Cover produced** ***(NLCD and Roads)***
- **Potential Grazing Impact** ***(Region-wide Model)***
- **Nitrogen Deposition Model** ***(acquired from OW)***

- **Landscape Metrics produced for catchments**
  - **PLOAD, NLOAD, and U_INDEX**
    - **From both NLCD and the modified NLCD (NLCD with roads)**
  - **Nitrogen Deposition**
  - **Potential Grazing Impact**

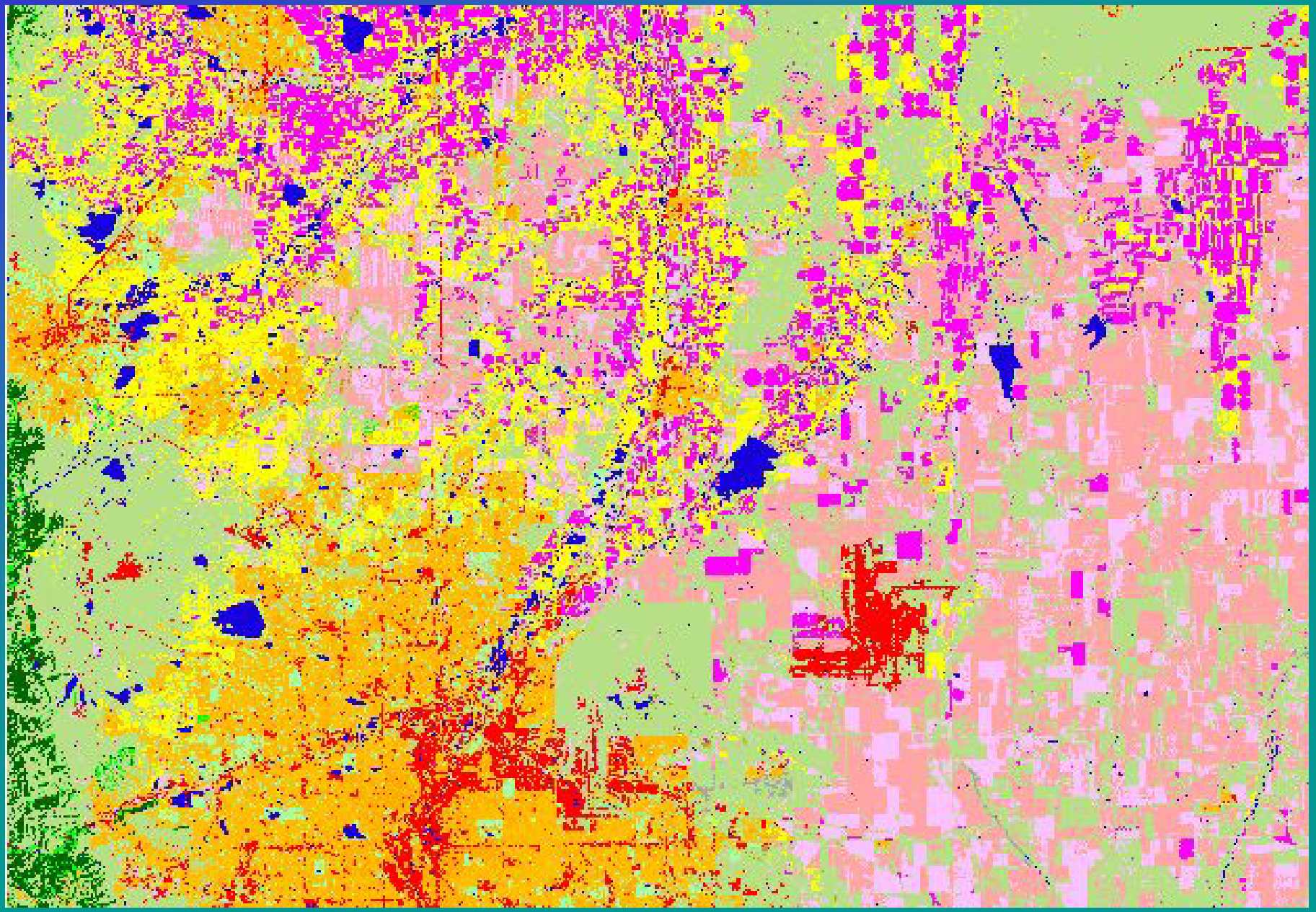
Development of the Modified National Land Cover Data (NLCD)

- **Conversion of Road Class to Land Cover Class**
  - **Generate separate Grids for each RD class**
  - **FCC A1x => NLCD 23 with 90m width**
    - **Interstate equivalents to commercial/transportation**
  - **FCC A2x => NLCD 21 with 90m width**
  - **FCC A3x => NLCD 21 with 30m width**
  - **FCC A4x => NLCD 21 with 30m width**
  - **Merge all Grids into one RD-NLCD grid**
    - **NCLD 23 class has priority**
- **Combine NLCD with RD-NLCD**
  - **Urban classes take priority**

Roads reclassified in Land Cover Classes



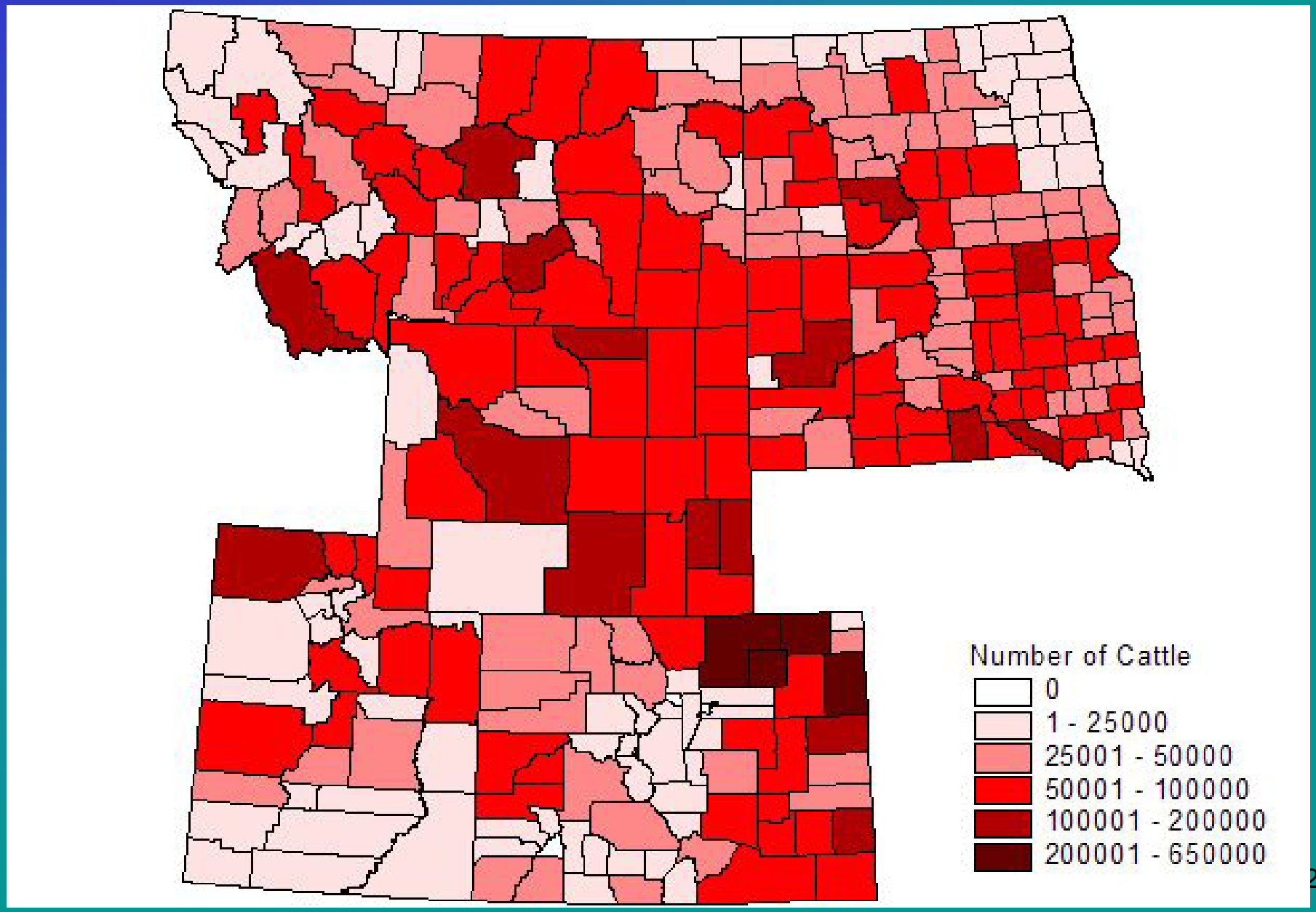
The NLCD classes for the same area



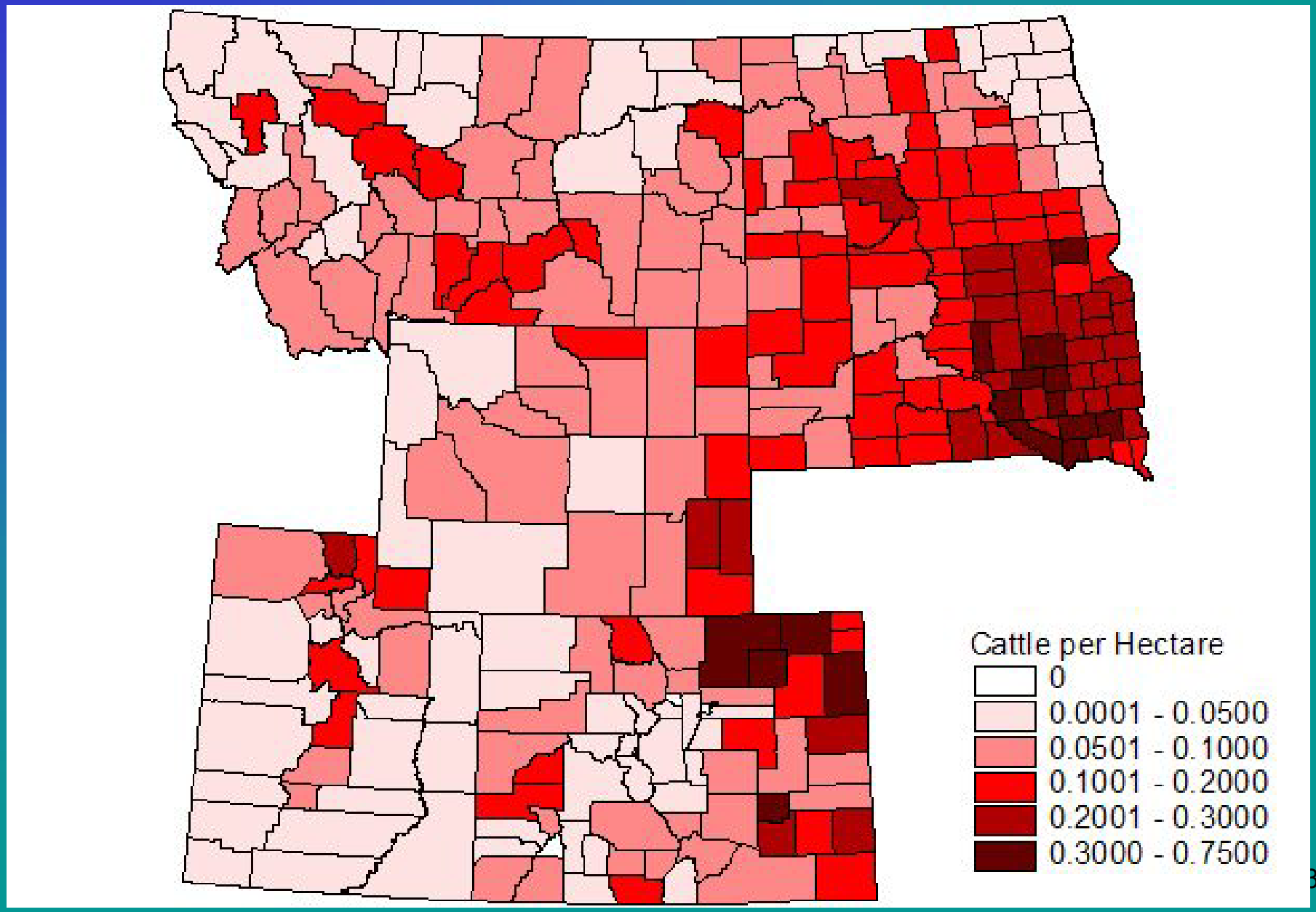
Development of the Potential Grazing Impact Model

- **Model inputs are:**
  - **Weighted Land Cover**
  - **Weighted Administrative Land Uses**
  - **Topographic Profile Index**
  - **Number of Cattle**
  - **Proximity to Streams**

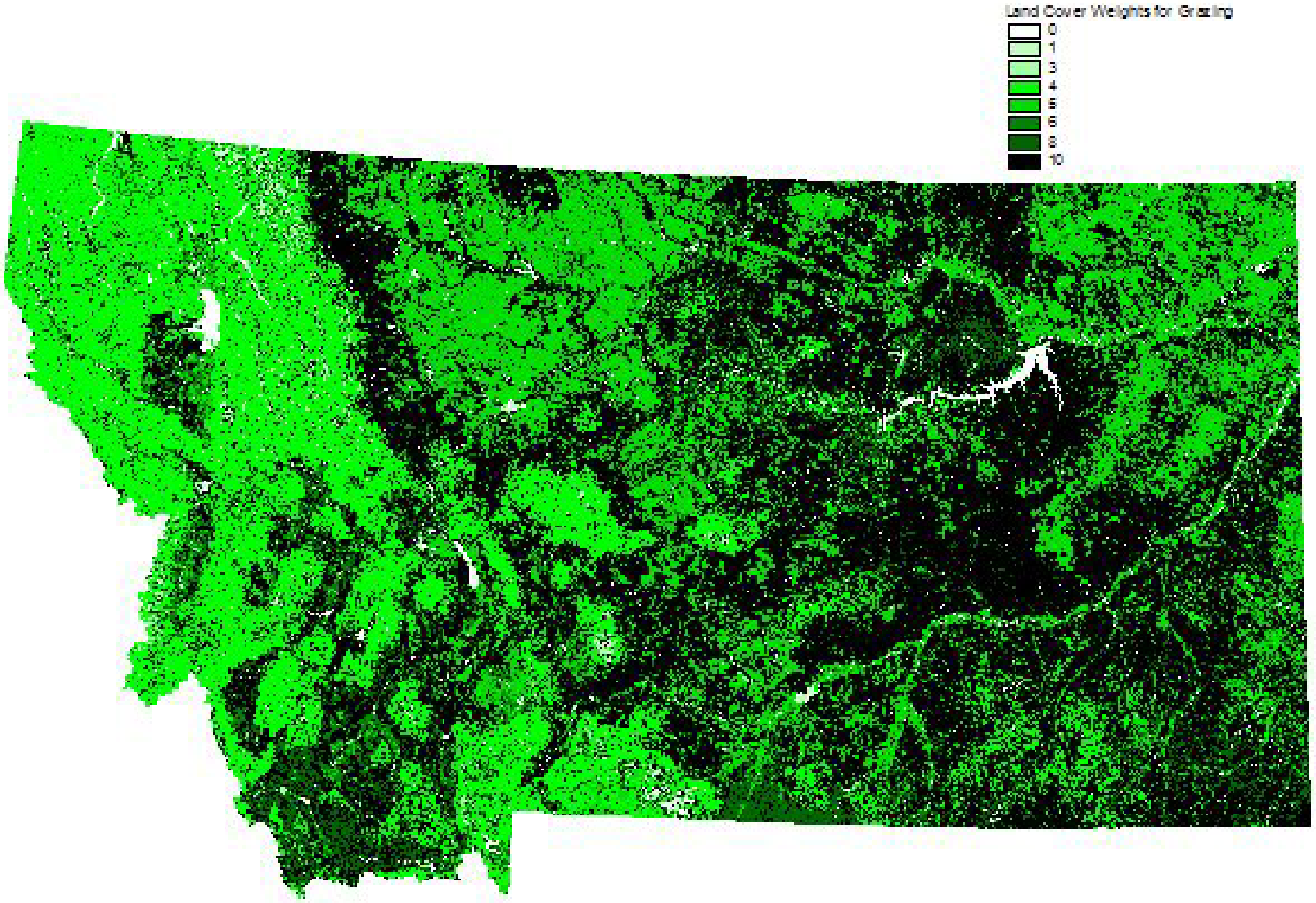
Number of Cattle in Each County in R8



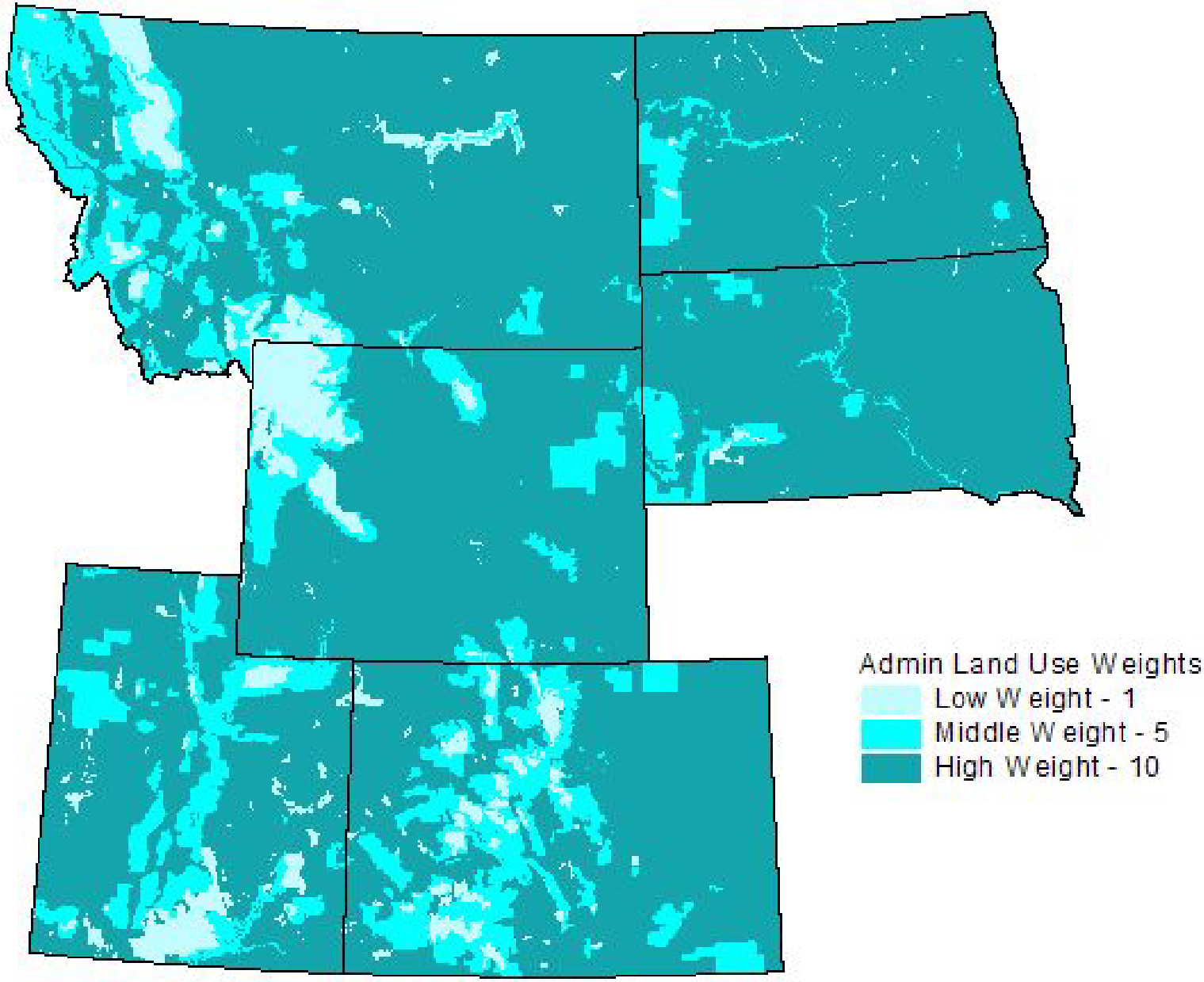
Cattle per Hectare in Region 8



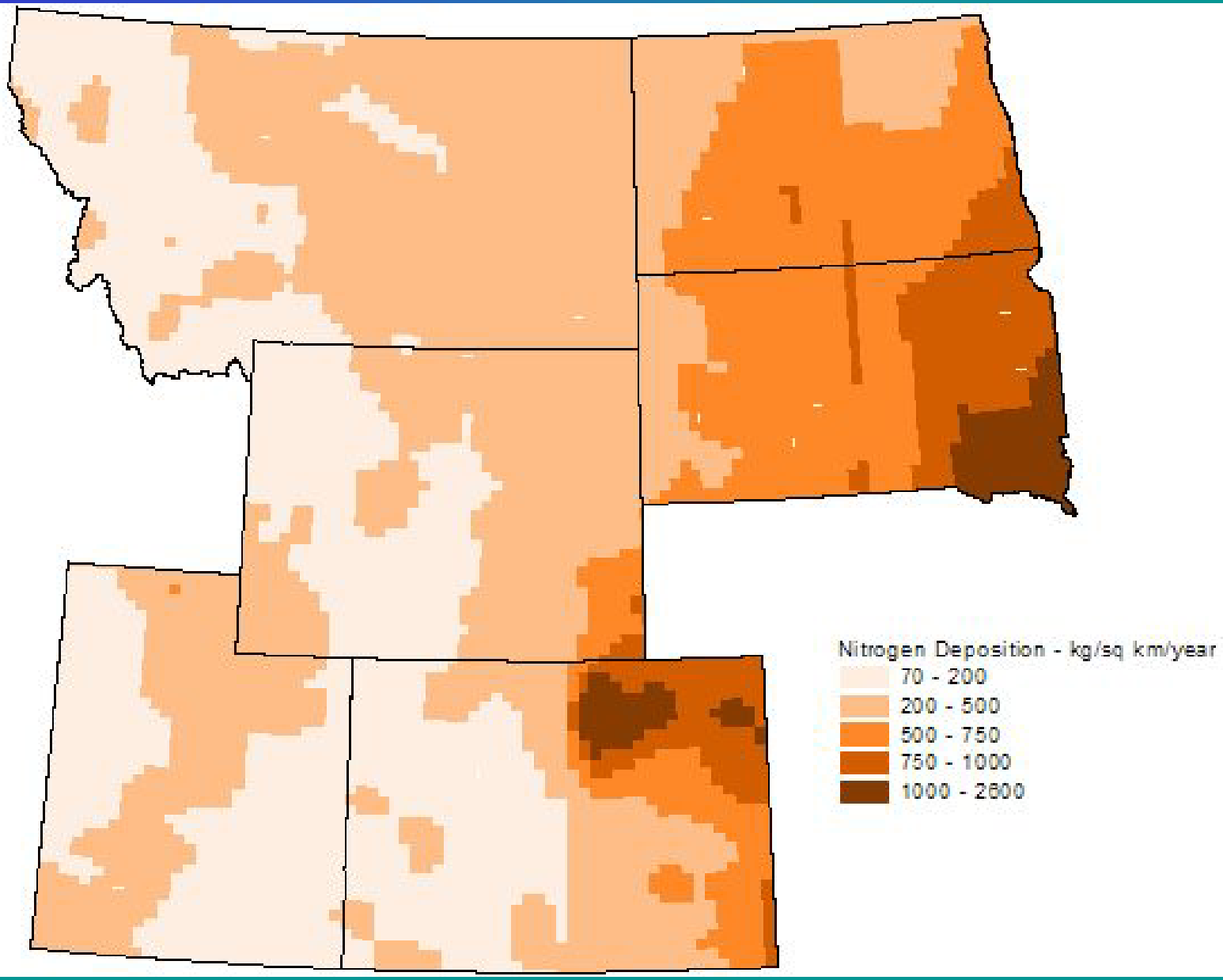
Montana – Land Cover Weighting for Grazing



Administrative Land Use Weighting for Grazing



Nitrogen Deposition – kg / sq km / year



Landscape Metrics – ArcView ATtiLA

ArcView GIS 3.3

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New Open

Views

Tables

Charts

Layouts

Example Catc
Example Catc
NP Full Catch
NP Landscap

NP Landscape Metrics

Nplm01_150c
Streams
Hucs8
States
Water Bodies
Mtlm00_150c
Mtlm01_150c
Mt0642_150c
Mt0599_150c
Nplm01_150c
Nps08_150c
Nps01_150c
Np017_150c
Mtnd_nlcd
Water
Snow/Ice
Low-intensity
High-intensity
Commercial/I
Bare Rock/Sa
Quarries/Strip
Transitional
Deciduous Fo

Landscape Characteristics

Reporting Unit: Nplm01_150c
Landcover: Mtnd_nlcd
ID Field: Npsite_id
Landcover Cell Size: 30

The current land cover class coding scheme is:

Anderson I | Anderson II | NLCD | SAA | Custom | Advanced

N_index, U_index
Pfor, Purb
Pwetl, Pagp
Pbar, Pagc
Pshrb, Pagt
Png, Puser

Slope: Mtnd_nlcd
Minimum Slope: 3
AgtSL, AgpSL
AgcSL, UserSL

Diversity (H, H', C, S)
Cover Classes: Original
Min. Patch Size: 1
Max. Separation: 0
FNumber, FLargest
FAvgSize, PLGP
FPatDens
Search Radius: 100
MDCP

Analysis Window: 9
Pff, pFEdge
pFPtch, pFPerf
pFTran, pFIntr

Forest Edge Width: 7
FEdge
FCore
Fea

Output: Metric values only

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Landscape Metrics – ArcView ATtiLA

ArcView GIS 3.3

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New Open

Views Tables Charts Layouts

Example Catc
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Mt0642_150c
Mt0599_150c
Nplm01_150c
Nps08_150c
Nps01_150c
Np017_150c
Mtnd_nlcd
Water
Snow/Ice
Low-intensity
High-intensity
Commercial/I
Bare Rock/Sa
Quarries/Strip
Transitional
Deciduous Fo

Human Stressors

Reporting Unit: Mtlm00_150c
Landcover: Mtnd_nlcd
ID Field: Site_id

The current land cover class coding scheme is:

Anderson I | Anderson II | NLCD | SAA | Custom | Advanced

	P	N
URB	1.2	5.5
PAS	0.9	5.0
RC	2.3	8.5
NRC	0.8	6.0
FOR	0.25	2.5
SHRB	0.04	0.4
NG	0.06	0.3
User	0.0	0.0

P_Load N_Load

Census1: Nplm01_150c
Pop Field: None
Census2: Nplm01_150c
Pop Field: None

POPDENS POPCHG

FOR	0.02	OG	0.10
HDR	0.60	HIC	0.90
LDR	0.40	User	0.00

PCTIA_LC

Stream: Streams
Roads: Streams
Class Field: Rch_code

RDDENS STXRD
RDLEN
PCTIA_RD
Within Distance: 30
STPRD

Run Select All Cancel

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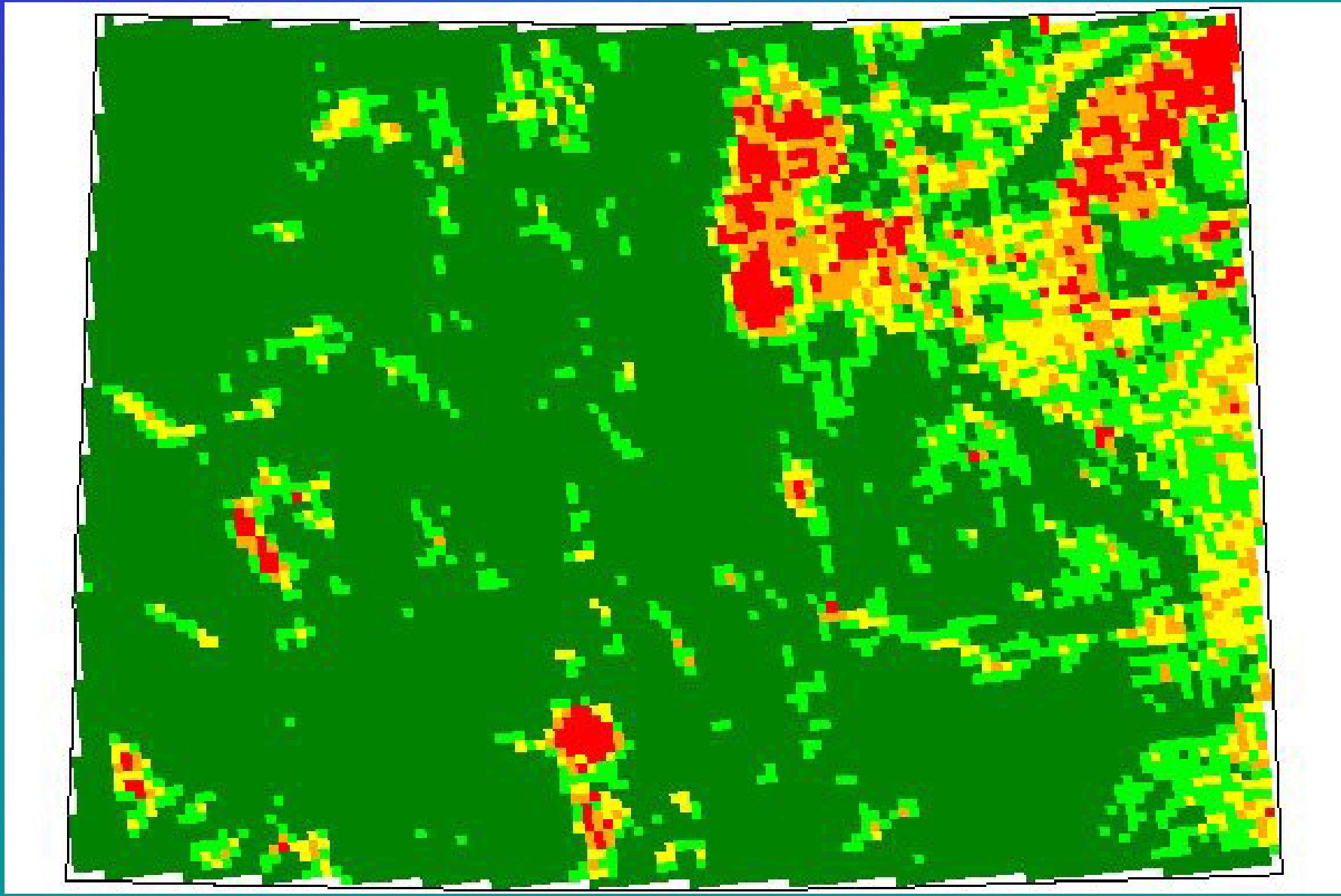
The Different Nutrient Landscape Indicator Models being examined

- **TN = *f* (NLOAD + Grazing Impact + Nit Dep)**
- **TN = *f* (NLOAD + Grazing Impact + Nit Dep)**
  - **with NLOAD derived from modified NLCD**
- **TN = *f* (U_INDEX + Grazing Impact + Nit Dep)**

- **TP = *f* (PLOAD + Grazing Impact)**
- **TP = *f* (PLOAD + Grazing Impact)**
  - **with PLOAD derived from modified NLCD**
- **TP = *f* (U_INDEX + Grazing Impact)**

Colorado – Potential Phosphorus (based only on land cover)



DRAFT

Yellow, orange, red – greater than 0.1 mg/L

Questions / Comments?