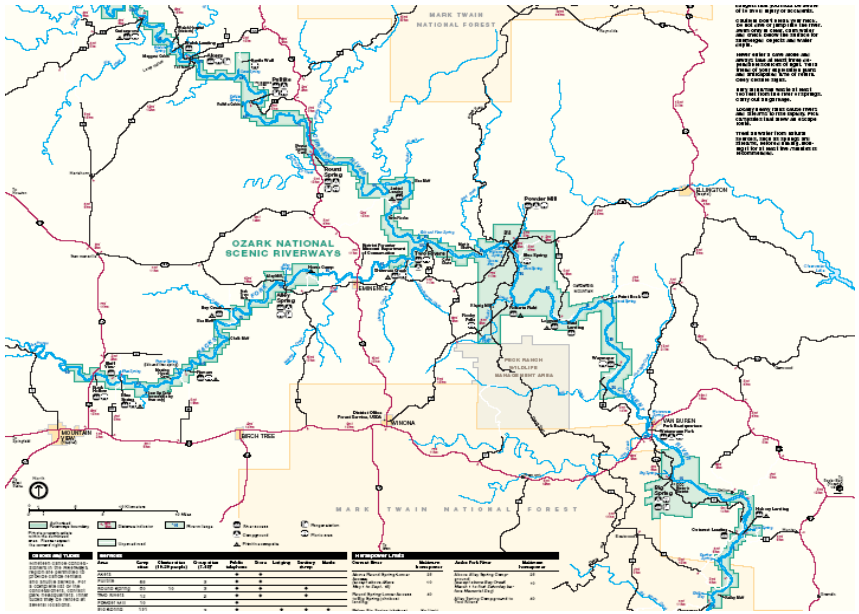
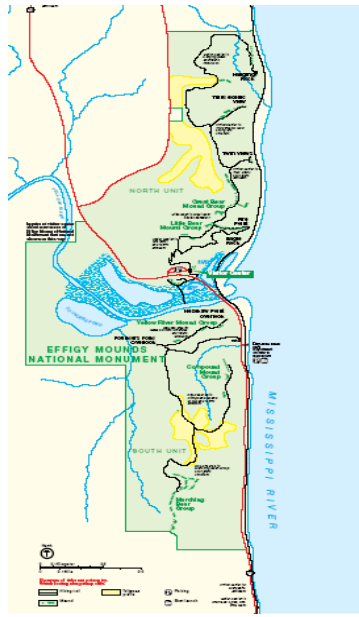
Watershed Condition Assessment

Effigy Mounds National Monument &
Ozark National Scenic Riverways





Scott P. Sowa
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School of Natural Resources
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2008 NPS-WRD Aquatic Professionals Meeting
February 12-14, 2008
Fort Collins, CO

Topics Covered

1) **Key elements of Watershed Condition Assessment**

2) **Framework and Indicators Used**

3) **Draft Results**

4) **Key issues and lessons learned**

Watershed Condition Assessment Goal and Key Elements

Goal:

Provide an ecological assessment of resource conditions (Health) that will assist managers in developing actions to reduce and prevent impairment of park resources

Key Elements:

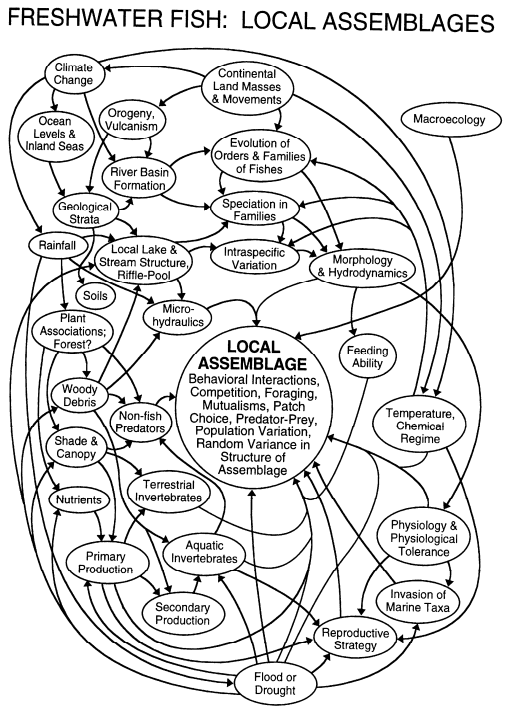
1) **Provide an initial set of science-based reference/baseline conditions** in a manner that can become more refined and quantitative over time, and help parks define Desired Conditions.

2) **Build upon existing park science & planning efforts** (e.g., GMP, I&M data, Water Resource Planning)

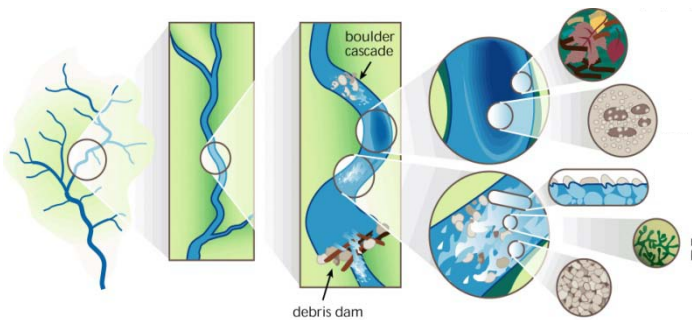
3) **Emphasize a strong geospatial component** in terms of the analytical process and resulting information products.

Ecosystem Health Assessment

- Ecosystems are:
  - Multi-component
  - Interacting biophysical systems
  - Hierarchically-structured

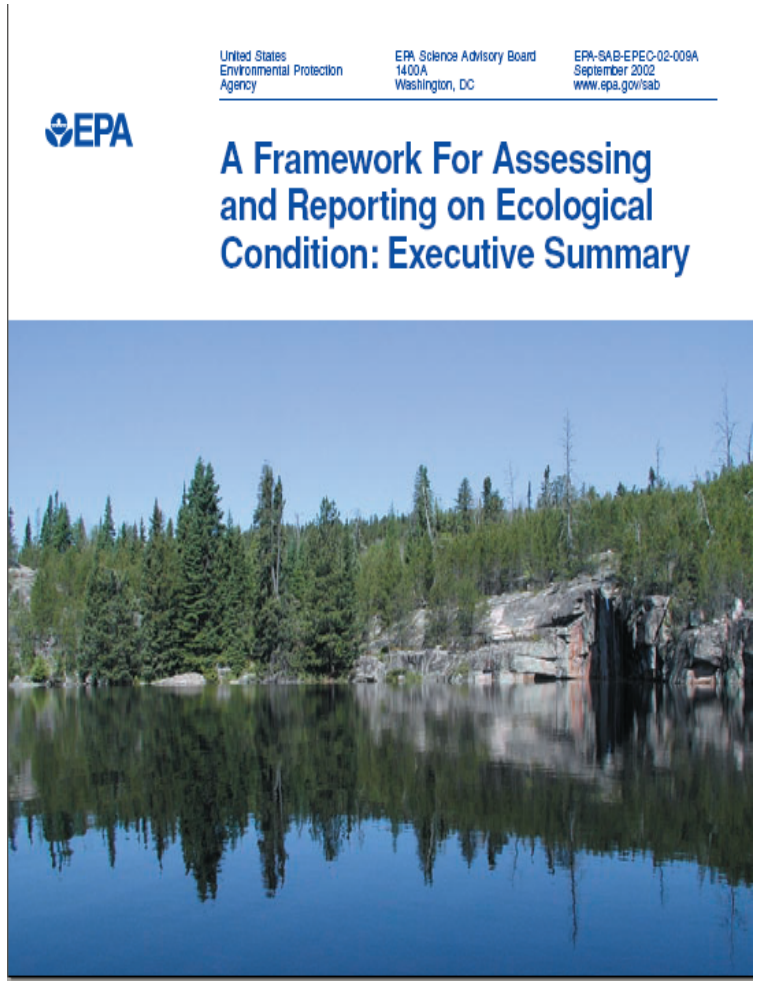


- No single metric or index is suitable
- Assessments must be multi-parameter and multi-scale



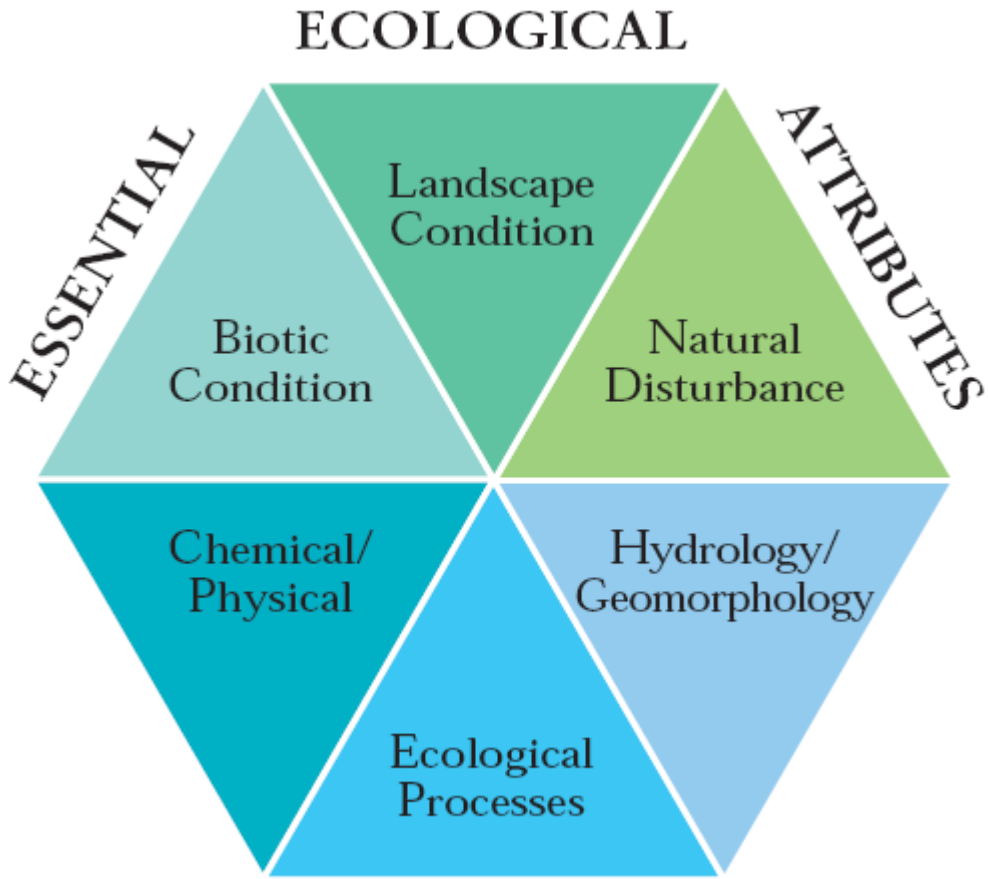
EPA Assessment Framework

- Developed by EPA Science Advisory Board
- Guide for developing “report cards” on ecological health/condition
- Provides an ecologically-based framework and examples of relevant indicators



Ecologically-based Framework

- Essential Ecological Attributes
  - 3 pattern
  - 3 process
- Processes create and maintain patterns
- Patterns affect how processes are expressed



Ecologically-based Framework

- EEAs have reporting categories and subcategories

- Categories and subcategories based on significant park resources and available data

Table ES-1. Essential Ecological Attributes and Reporting Categories

Landscape Condition
- Extent of Ecological System/Habitat Types
- Landscape Composition
- Landscape Pattern and Structure

Biotic Condition
- Ecosystems and Communities
  - Community Extent
  - Community Composition
  - Trophic Structure
  - Community Dynamics
  - Physical Structure
- Species and Populations
  - Population Size
  - Genetic Diversity
  - Population Structure
  - Population Dynamics
  - Habitat Suitability
- Organism Condition
  - Physiological Status
  - Symptoms of Disease or Trauma
  - Signs of Disease

Chemical and Physical Characteristics (Water, Air, Soil, and Sediment)
- Nutrient Concentrations
  - Nitrogen
  - Phosphorus
  - Other Nutrients
- Trace Inorganic and Organic Chemicals
  - Metals
  - Other Trace Elements
  - Organic Compounds
- Other Chemical Parameters
  - pH
  - Dissolved Oxygen
  - Salinity
  - Organic Matter
  - Other
- Physical Parameters

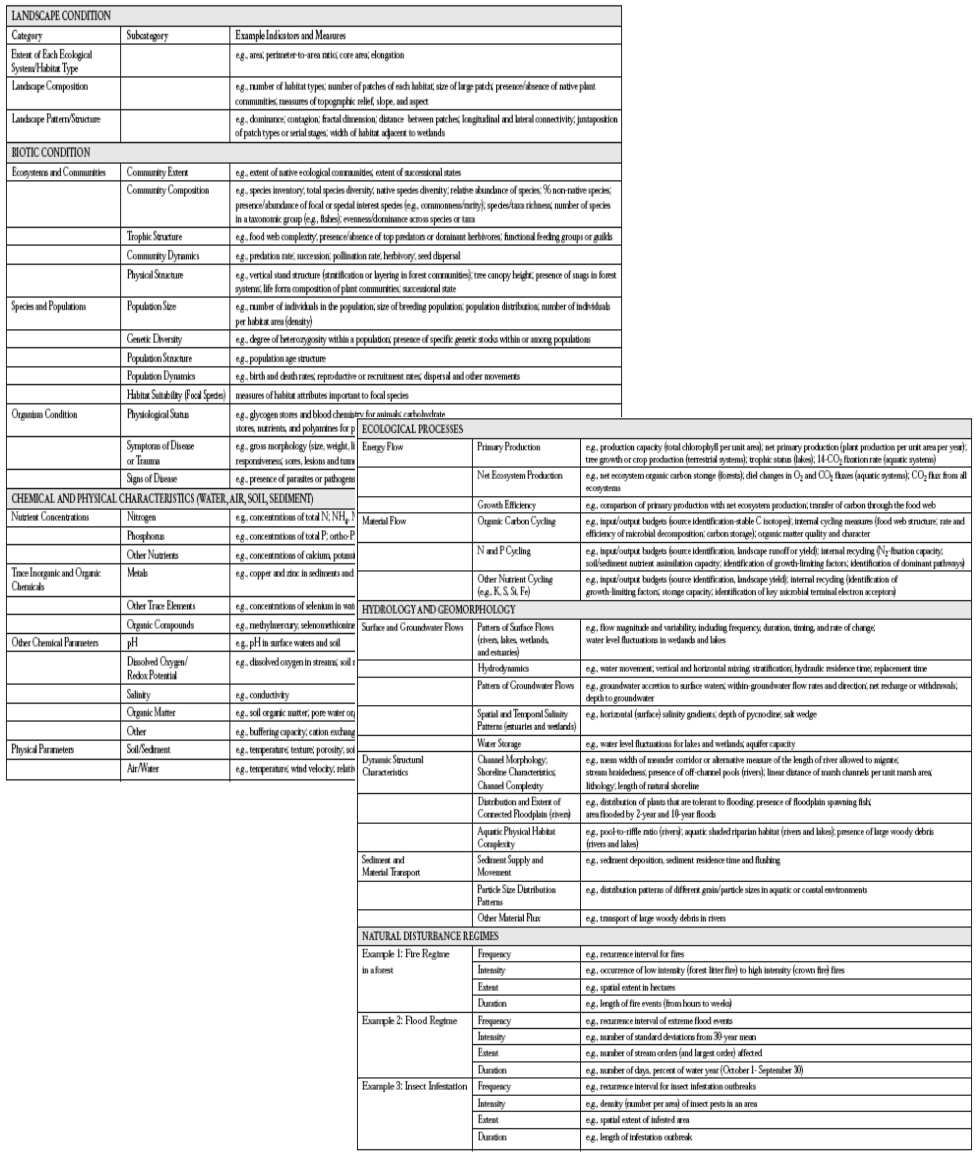
Ecological Processes
- Energy Flow
  - Primary Production
  - Net Ecosystem Production
  - Growth Efficiency
- Material Flow
  - Organic Carbon Cycling
  - Nitrogen and Phosphorus Cycling
  - Other Nutrient Cycling

Hydrology and Geomorphology
- Surface and Groundwater Flows
  - Pattern of Surface Flows
  - Hydrodynamics
  - Pattern of Groundwater Flows
  - Salinity Patterns
  - Water Storage
- Dynamic Structural Characteristics
  - Channel/Shoreline Morphology, Complexity
  - Distribution/Extent of Connected Floodplain
  - Aquatic Physical Habitat Complexity
- Sediment and Material Transport
  - Sediment Supply/Movement
  - Particle Size Distribution Patterns
  - Other Material Flux

Natural Disturbance Regimes
- Frequency
- Intensity
- Extent
- Duration

Ecological Indicators

- Issues
  - Numerous indicators
  - Little or no data for most indicators
  - Data is often temporally and spatially sporadic
  - Generally have to consolidate data from many sources
  - Data generally not standardized

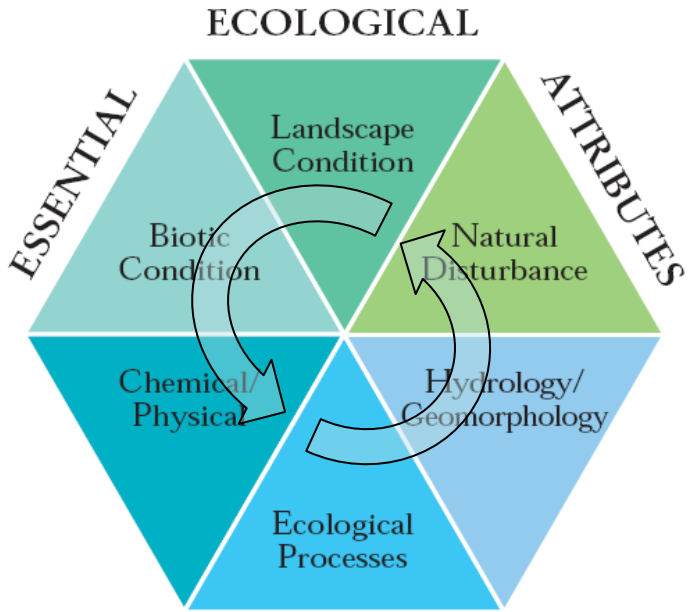


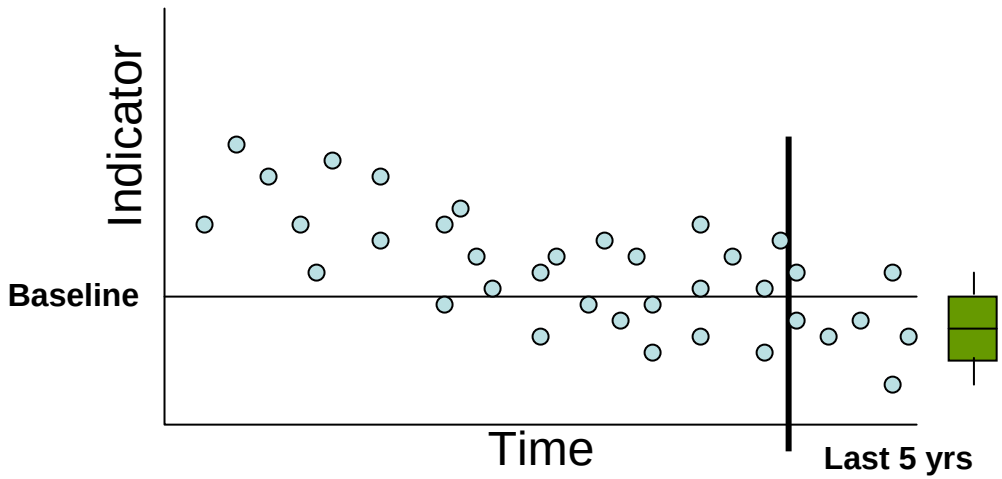
LANDSCAPE CONDITION		
Category	Subcategory	Example Indicators and Measures
Extent of Each Ecological System/Habitat Type		e.g., area; perimeter-to-area ratio; core area; elongation
Landscape Composition		e.g., number of habitat types; number of patches of each habitat; size of large patch; presence/absence of native plant communities; measures of topographic relief, slope, and aspect
Landscape Pattern/Structure		e.g., dominance; contagion; fractal dimension; distance between patches; longitudinal and lateral connectivity; juxtaposition of patch types or serial stages; width of habitat adjacent to wetlands
BIOTIC CONDITION		
Ecosystems and Communities	Community Extent	e.g., extent of native ecological communities; extent of successional states
	Community Composition	e.g., species inventory; total species diversity; native species diversity; relative abundance of species; % non-native species; presence/abundance of focal or special interest species (e.g., commonness/rarity); species/taxa richness; number of species in a taxonomic group (e.g., fishes); evenness/dominance across species or taxa
	Trophic Structure	e.g., food web complexity; presence/absence of top predators or dominant herbivores; functional feeding groups or guilds
	Community Dynamics	e.g., predation rate; succession; pollination rate; herbivory; seed dispersal
	Physical Structure	e.g., vertical stand structure (stratification or layering in forest communities); tree canopy height; presence of snags in forest systems; life form composition of plant communities; successional state
Species and Populations	Population Size	e.g., number of individuals in the population; size of breeding population; population distribution; number of individuals per habitat area (density)
	Genetic Diversity	e.g., degree of heterozygosity within a population; presence of specific genetic stocks within or among populations
	Population Structure	e.g., population age structure
	Population Dynamics	e.g., birth and death rates; reproductive or recruitment rates; dispersal and other movements
	Habitat Suitability (Focal Species)	measures of habitat attributes important to focal species
Organism Condition	Physiological Status	e.g., glycogen stores and blood chemistry for animals; carbohydrate stores, nutrients, and polyamines for p
	Symptoms of Disease or Trauma	e.g., gross morphology (size, weight, li responsiveness; sores, lesions and tum
	Signs of Disease	e.g., presence of parasites or pathogen
CHEMICAL AND PHYSICAL CHARACTERISTICS (WATER, AIR, SOIL, SEDIMENT)		
Nutrient Concentrations	Nitrogen	e.g., concentrations of total N; NH_3
	Phosphorus	e.g., concentrations of total P; ortho-P
	Other Nutrients	e.g., concentrations of calcium, potassi
Trace Inorganic and Organic Chemicals	Metals	e.g., copper and zinc in sediments and
	Other Trace Elements	e.g., concentrations of selenium in wat
	Organic Compounds	e.g., methylmercury; selenomethionine
Other Chemical Parameters	pH	e.g., pH in surface waters and soil
	Dissolved Oxygen/ Redox Potential	e.g., dissolved oxygen in streams; soil r
	Salinity	e.g., conductivity
	Organic Matter	e.g., soil organic matter; pore water or
	Other	e.g., buffering capacity; cation exchang
Physical Parameters	Soil/Sediment	e.g., temperature; texture; porosity; soi
	Air/Water	e.g., temperature; wind velocity; relativ

ECOLOGICAL PROCESSES		
Energy Flow	Primary Production	e.g., production capacity (total chlorophyll per unit area); net primary production (plant production per unit area per year); tree growth or crop production (terrestrial systems); trophic status (lakes); 14-CO_2 fixation rate (aquatic systems)
	Net Ecosystem Production	e.g., net ecosystem organic carbon storage (forests); diel changes in O_2 and CO_2 fluxes (aquatic systems); CO_2 flux from all ecosystems
	Growth Efficiency	e.g., comparison of primary production with net ecosystem production; transfer of carbon through the food web
Material Flow	Organic Carbon Cycling	e.g., input/output budgets (source identification-stable C isotopes); internal cycling measures (food web structure; rate and efficiency of microbial decomposition; carbon storage); organic matter quality and character
	N and P Cycling	e.g., input/output budgets (source identification, landscape runoff or yield); internal recycling (N_2-fixation capacity; soil/sediment nutrient assimilation capacity; identification of growth-limiting factors; identification of dominant pathways)
	Other Nutrient Cycling (e.g., K, S, Si, Fe)	e.g., input/output budgets (source identification, landscape yield); internal recycling (identification of growth-limiting factors; storage capacity; identification of key microbial terminal electron acceptors)
HYDROLOGY AND GEOMORPHOLOGY		
Surface and Groundwater Flows	Pattern of Surface Flows (rivers, lakes, wetlands, and estuaries)	e.g., flow magnitude and variability, including frequency, duration, timing, and rate of change; water level fluctuations in wetlands and lakes
	Hydrodynamics	e.g., water movement; vertical and horizontal mixing; stratification; hydraulic residence time; replacement time
	Pattern of Groundwater Flows	e.g., groundwater accretion to surface waters; within-groundwater flow rates and direction; net recharge or withdrawals; depth to groundwater
	Spatial and Temporal Salinity Patterns (estuaries and wetlands)	e.g., horizontal (surface) salinity gradients; depth of pycnocline; salt wedge
	Water Storage	e.g., water level fluctuations for lakes and wetlands; aquifer capacity
Dynamic Structural Characteristics	Channel Morphology; Shoreline Characteristics; Channel Complexity	e.g., mean width of meander corridor or alternative measure of the length of river allowed to migrate; stream braidedness; presence of off-channel pools (rivers); linear distance of marsh channels per unit marsh area; lithology; length of natural shoreline
	Distribution and Extent of Connected Floodplain (rivers)	e.g., distribution of plants that are tolerant to flooding; presence of floodplain spawning fish; area flooded by 2-year and 10-year floods
	Aquatic Physical Habitat Complexity	e.g., pool-to-riffle ratio (rivers); aquatic shaded riparian habitat (rivers and lakes); presence of large woody debris (rivers and lakes)
Sediment and Material Transport	Sediment Supply and Movement	e.g., sediment deposition, sediment residence time and flushing
	Particle Size Distribution Patterns	e.g., distribution patterns of different grain/particle sizes in aquatic or coastal environments
	Other Material Flux	e.g., transport of large woody debris in rivers
NATURAL DISTURBANCE REGIMES		
Example 1: Fire Regime in a forest	Frequency	e.g., recurrence interval for fires
	Intensity	e.g., occurrence of low intensity (forest litter fire) to high intensity (crown fire) fires
	Extent	e.g., spatial extent in hectares
	Duration	e.g., length of fire events (from hours to weeks)
Example 2: Flood Regime	Frequency	e.g., recurrence interval of extreme flood events
	Intensity	e.g., number of standard deviations from 30-year mean
	Extent	e.g., number of stream orders (and largest order) affected
	Duration	e.g., number of days, percent of water year (October 1- September 30)
Example 3: Insect Infestation	Frequency	e.g., recurrence interval for insect infestation outbreaks
	Intensity	e.g., density (number per area) of insect pests in an area
	Extent	e.g., spatial extent of infested area
	Duration	e.g., length of infestation outbreak

Basic Approach

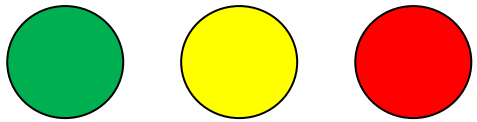
1) Select reporting categories
2) Select health indicators
3) Define reporting units (scales)
4) Compile existing data/reports
5) Define/quantify baseline conditions
6) Quantify current conditions
7) Measure deviation and assign rating
8) If possible, plot trends
9) Summarize in report
10) Deliver associated GIS products





Major Outputs/Products

- Qualitative or Quantitative Baseline or Desired Condition
- Condition Status Rating

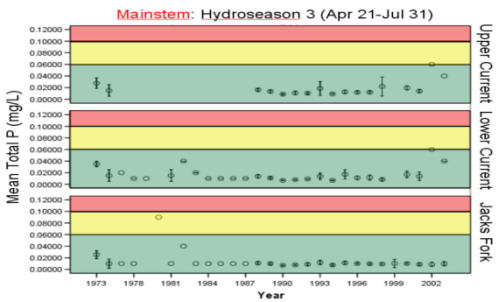


- Tabular results

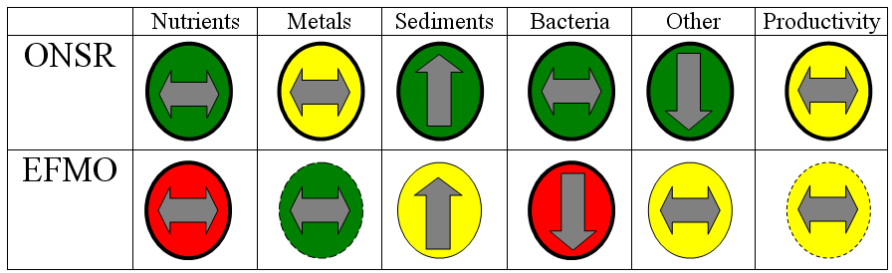
ONSR Condition

	Upper Current					
	Tributaries			Mainstems		
Rating	M2	Acres	%	M2	Acres	%
No Ranking	565200	139.7	9.4%	5587900	1380.8	27.0%
Good - 1	4296100	1061.6	71.4%	12067700	2982.0	58.3%
Neutral - 2	8300	2.1	0.1%	9300	2.3	0.0%
Bad - 3	1146700	283.4	19.1%	3023100	747.0	14.6%
	6016300	1486.7	100.0%	20688000	5112.1	100.0%

- Trend Plots

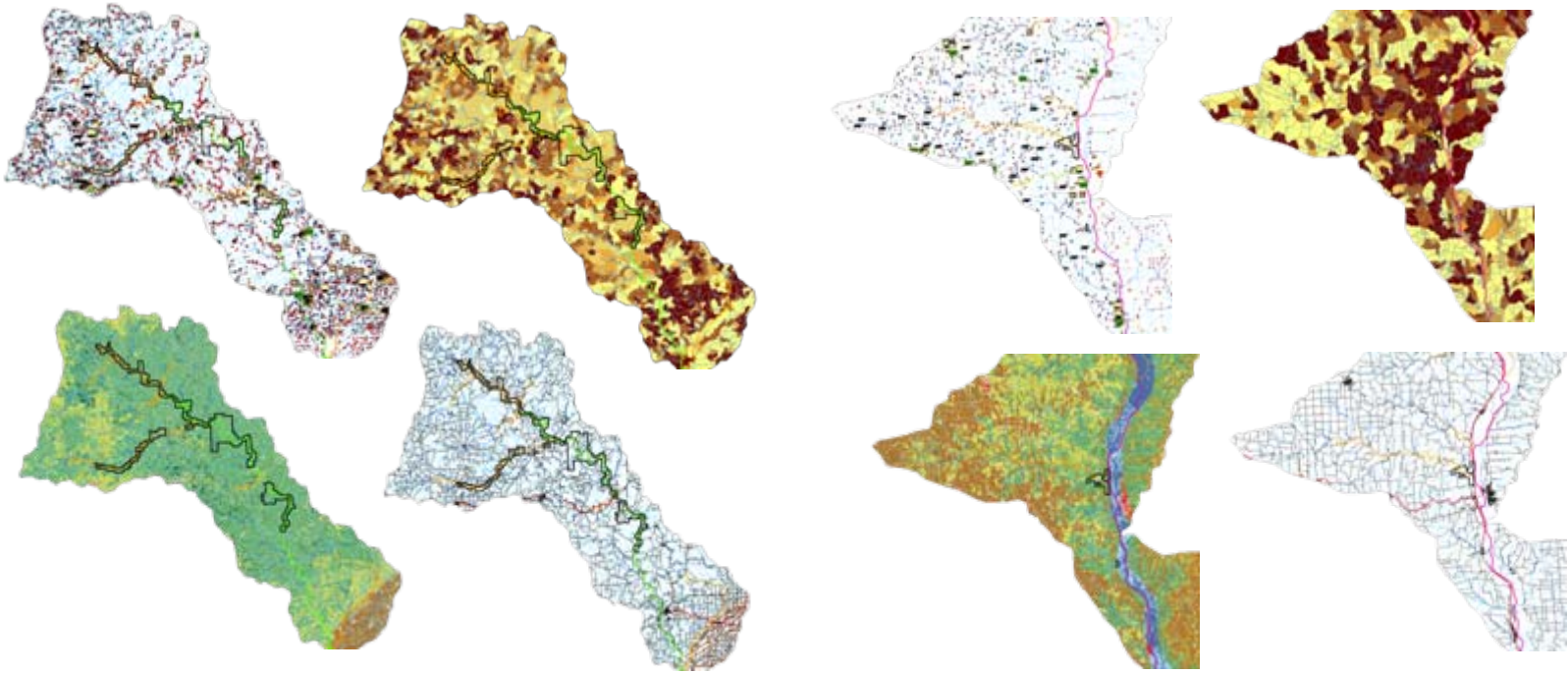


- Aggregated assessment of major categories



Major Outputs/Products

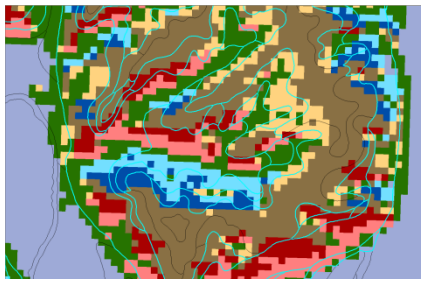
- Geospatial Data



- Report Covering:
  - Health Issues, Threats, Info/Data Gaps, Lessons Learned, Recommendations

Landscape Condition

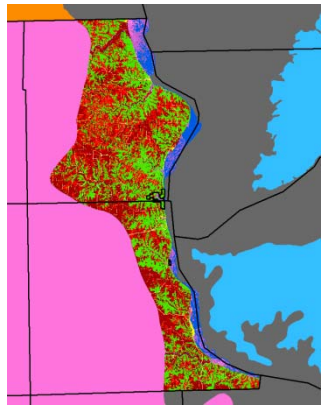
- **Reporting Categories**
  - **Upland and Riparian**
- **Reporting Units**



Site (30m grid cell)

Within Park

Park Buffer



Ecological Subsection

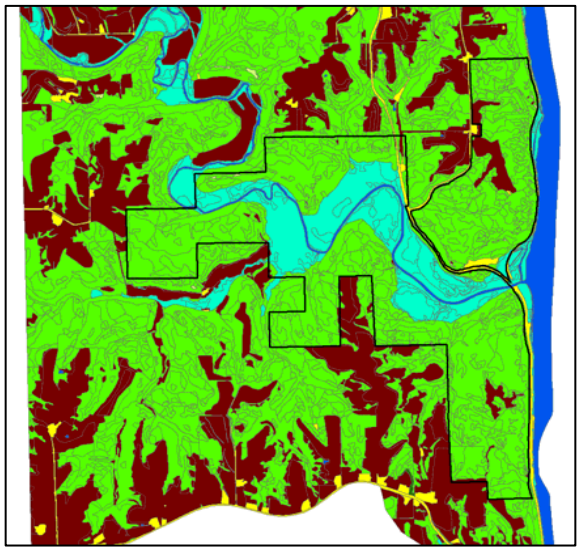
- **Data Sources**
  - **Desired Conditions: Modeled Historic Vegetation**
  - **Current Conditions: NLCD and Detailed Park Vegetation Maps**
  - **Trends: NA**
- **Measures/Indicators**
  1. **Number of Major Vegetation Classes**
  2. **Number of patches**
  3. **Average patch size**
  4. **Largest patch size**

Site Specific Landscape Condition

EFMO Area Within Boundary Entire Park

EFMO Current Vegetation

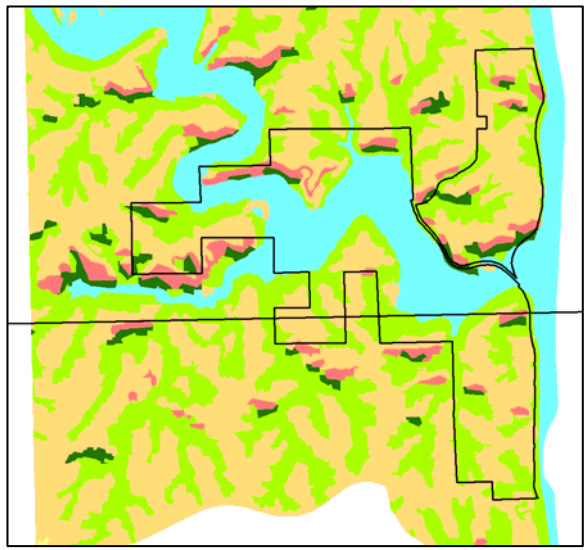
2005 USGS-NPS Veg Mapping Data



Lndscp_veg
- Deciduous Upland Forest and Woodland
- Evergreen Upland Forest and Woodland
- Mixed Upland Forest and Woodland
- Floodplain/Riparian Forest and Woodland
- Grassland
- Urban Impervious
- Water
- Barren

EFMO Potential Vegetation

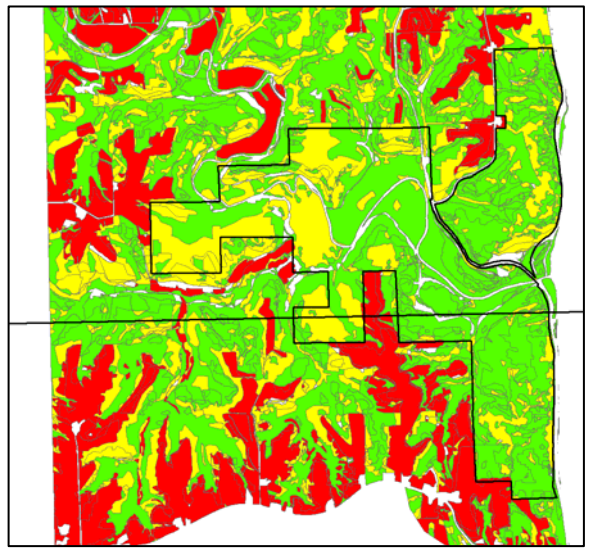
SSURGO Soils and ABS



pot_veg
- NCI Oak/Savanna
- NCI Oak/Savanna or C Tallgrass Prairie
- C Tallgrass Prairie
- NCI Maple-Basswood Forest
- NCI Dry-Mesic Oak Forest and Woodland
- NCI Floodplain Forest or NCI Wet Meadow-Shrub Swamp

Assessment Rankings

Current Veg vs. Potential Veg



Rating	%
No Ranking	5.61
Good - 1	67.28
Neutral -2	26.70
Bad - 3	0.41

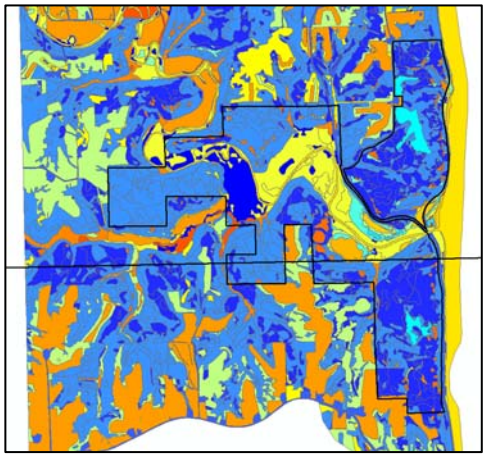
Veg Specific Landscape Condition

EFMO Area Within Buffer Entire Park

	CURRENT VEG									
POTENTIAL VEG	Silver Maple Temporarily Flooded Forest Alliance	Broadleaf Arrowhead Semipermanently Flooded Herbaceous Alliance	LAND_USE	Sugar Maple - American Basswood - (Northern Red Oak) Forest Alliance	OPEN_WATER	White Oak - (Northern Red Oak, Hickory species) Forest Alliance	Pondweed species - Coontail species - Waterweed species Permanently Flooded Herbaceous Alliance	Annual Close-grown Forbs and Grasses and/or Annual Row-crop Forbs and Grasses Formations (no Alliance assignments)	Reed Canary Grass Seasonally Flooded Herbaceous Alliance	Perennial Grass Crops (hayland, pastureland) Formation (no Alliance assignment)
North Central Interior Oak Savanna	0.32	0.00	0.53	60.09	0.00	25.08	0.00	0.64	0.00	4.16
North Central Interior Oak Savanna OR Central Tallgrass Prairie	0.03	0.00	3.83	31.97	0.04	16.86	0.00	21.63	0.00	16.84
Central Tallgrass Prairie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
North Central Interior Maple-Basswood Forest	0.63	0.00	3.33	59.29	0.25	18.65	0.03	2.67	0.10	8.31
North Central Interior Dry-Mesic Oak Forest and Woodland	1.75	0.13	2.96	62.80	0.27	16.85	0.13	2.56	0.13	2.43
North Central Floodplain Forest OR North Central Interior Wet Meadow-Shrub Swamp	30.18	2.53	2.60	3.50	27.03	0.49	6.25	11.14	6.50	1.49

Veg Specific Landscape Condition

EFMO Composition Within Boundary Entire Park

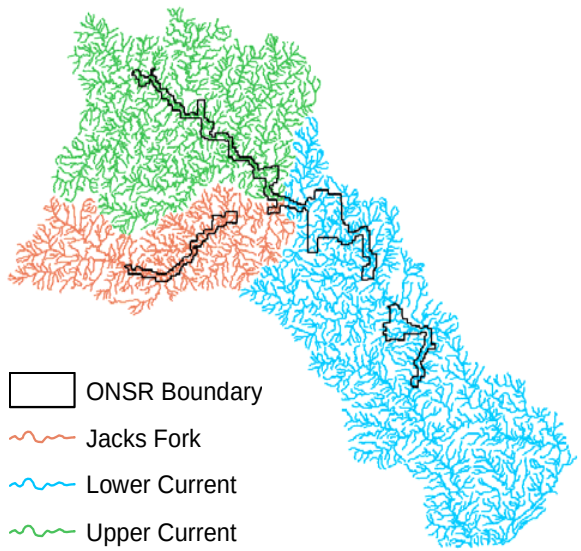


	Potential	Current	Difference	Potential	Current	Difference
	Number of Patches	Number of Patches	Number of Patches	Mean Patch Size (M2)	Mean Patch Size (M2)	Mean Patch Size (M2)
Deciduous Upland Forest and Woodland	**130**	**600**	**470**	**29,150**	**108**	**-29,042**
Floodplain/Riparian Forest and Woodland	**5**	**108**	**103**	**1,180,723**	**424**	**-1,180,299**
Grassland or Savanna	**42**	**30**	**-12**	**80,768**	**352**	**-80,416**
Mixed Upland Forest and Woodland		11			72	
Urban Impervious		7			3076	
Water		4			40,311	

Biotic Condition

- **Reporting Category:**
  - **Community composition: Fish**

- **Reporting Units**
  - **Stream Reach**
  - **Park subunits**
  - **Entire Park**



- **Data Sources:**
  - **Desired Conditions:** **Aquatic GAP Fish Models**
  - **Current Conditions:** **Heartland I&M Fish Community Data**
  - **Trends:** **NA**

- **Measures/Indicators**
  1. **# of Predicted but not Collected**
  2. **# Collected not Predicted**
  3. **# Shared**
  4. **Jacaard Similarity**

Biotic Condition-Community Composition

ONSR Fish Community Composition

Upper Current River

Collected Not Predicted	Predicted Not Collected	Shared
Emerald shiner	American brook lamprey	Banded sculpin
Mosquitofish	American eel	Bigeye chub
Northern Brook lamprey	Arkansas saddled darter	Bigeye shiner
Redspotted sunfish	banded darter	Black redhorse
Spotted bass	bigmouth buffalo	Blackspotted topminnow
Weed shiner	black bullhead	Bleeding shiner
	black buffalo	Bluegill
	black crappie	Central stoneroller
	bluntnose minnow	Chain pickerel
	brook silverside	Creek chub
	brown trout	Creek chubsucker
	channel catfish	Current River darter
	common carp	Fantail darter
	freshwater drum	Golden redhorse
	gilt darter	Green sunfish
	gizzard shad	Greenside darter
	largemouth bass	Hornyhead chub
	longnose gar	Largescale stoneroller
	Ozark chub	Least Brook lamprey
	paddlefish	Longear sunfish
	redfin shiner	Northern hog sucker
	sauger	Northern studfish
	shorthead redhorse	Ozark madtom
	skipjack herring	Ozark minnow
	slender madtom	Ozark sculpin
	walleye	Ozark shiner
	whitetail shiner	Rainbow darter
		Rainbow trout
		River redhorse
		Rosyface shiner
		Shadow bass
		Smallmouth bass
		Southern redbelly dace
		Striped shiner
		Telescope shiner
		Wedgespot shiner
		White sucker
		Yellow bullhead

Upper Current River	#
Collected not Predicted	6
Predicted not Collected	27
Collected and Predicted	38
Jacaard Similarity	62

Lower Current River

Collected Not Predicted	Predicted Not Collected	Shared
Creek chubsucker	American eel	American Brook lamprey
Current River saddled darte	Arkansas saddled darter	Banded sculpin
Emerald shiner	banded darter	Bigeye chub
White sucker	bigmouth buffalo	Bigeye shiner
	black buffalo	Black redhorse
	black bullhead	Blackspotted topminnow
	black crappie	Bleeding shiner
	blue sucker	Bluegill
	brook silverside	Bluntnose minnow
	channel catfish	Central stoneroller
	checkered madtom	Chain pickerel
	chestnut lamprey	Greenside darter
	common carp	Hornyhead chub
	flathead catfish	Largemouth bass
	freckled madtom	Largescale stoneroller
	freshwater drum	Longear sunfish
	gilt darter	Mosquitofish
	gizzard shad	Northern hog sucker
	golden redhorse	Northern studfish
	green sunfish	Ozark chub
	highfin carpsucker	Ozark madtom
	Johnny darter	Ozark minnow
	logperch	Ozark sculpin
	longnose gar	Pirate perch
	Mississippi silvery minnow	Rainbow darter
	mooneye	Redear sunfish
	Ozark shiner	Redspotted sunfish
	paddlefish	Rosyface shiner
	pugnose minnow	Shadow bass
	redfin shiner	Slender madtom
	sauger	Smallmouth bass
	shorthead redhorse	Spotted bass
	skipjack herring	Striped shiner
	spotted gar	Telescope shiner
	steelcolor shiner	Warmouth
	stippled darter	Wedgespot shiner
	walleye	Whitetail shiner
	white bass	
	white crappie	
	yellow bullhead	

Lower Current River	#
Collected not Predicted	4
Predicted not Collected	41
Collected and Predicted	37
Jacaard Similarity	55

Jacks Fork

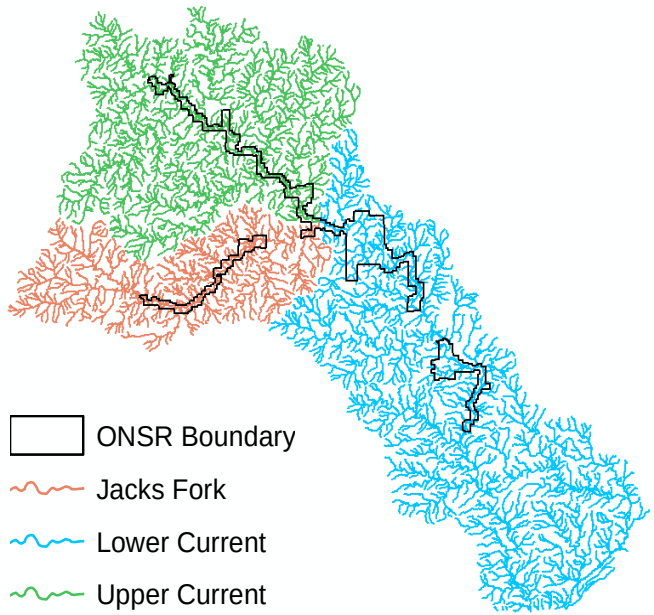
Collected Not Predicted	Predicted Not Collected	Shared
Emerald shiner	banded darter	Banded sculpin
Ozark shiner	bigeye chub	Blackspotted topminnow
White sucker	bigeye shiner	Bleeding shiner
	bigmouth buffalo	Bluegill
	black bullhead	Brook silverside
	black redhorse	central stoneroller
	bluntnose minnow	Checkered madtom
	central stoneroller	Current River saddled darter
	chain pickerel	Green sunfish
	chestnut lamprey	Greenside darter
	common carp	Hornyhead chub
	creek chub	largescale stoneroller
	creek chubsucker	Longear sunfish
	fantail darter	Northern hog sucker
	gizzard shad	Northern studfish
	golden redhorse	Ozark chub
	largemouth bass	Ozark madtom
	largescale stoneroller	Ozark minnow
	least brook lamprey	Rainbow darter
	Ozark sculpin	Rosyface shiner
	redfin shiner	Shadow bass
	redspotted sunfish	Slender madtom
	shorthead redhorse	Smallmouth bass
	warmouth	Striped shiner
		Telescope shiner
		Wedgespot shiner
		Whitetail shiner
		Yellow bullhead

Jacks Fork	#
Collected not Predicted	3
Predicted not Collected	24
Collected and Predicted	28
Jacaard Similarity	54

Biotic Condition

- **Reporting Category**
  - **Population Status: Fish**

- **Reporting Units**
  - **Stream Reach**
  - **Park subunits**
  - **Entire Park**



- **Data Sources**
  - **Desired Conditions:** **Predictive Models**
  - **Current Conditions:** **Heartland I&M Fish Community Data**
  - **Trends:** **Historic Fish Community Data (multiple sources)**

- **Measures/Indicators**

1. **Smallmouth Bass Relative Abundance**

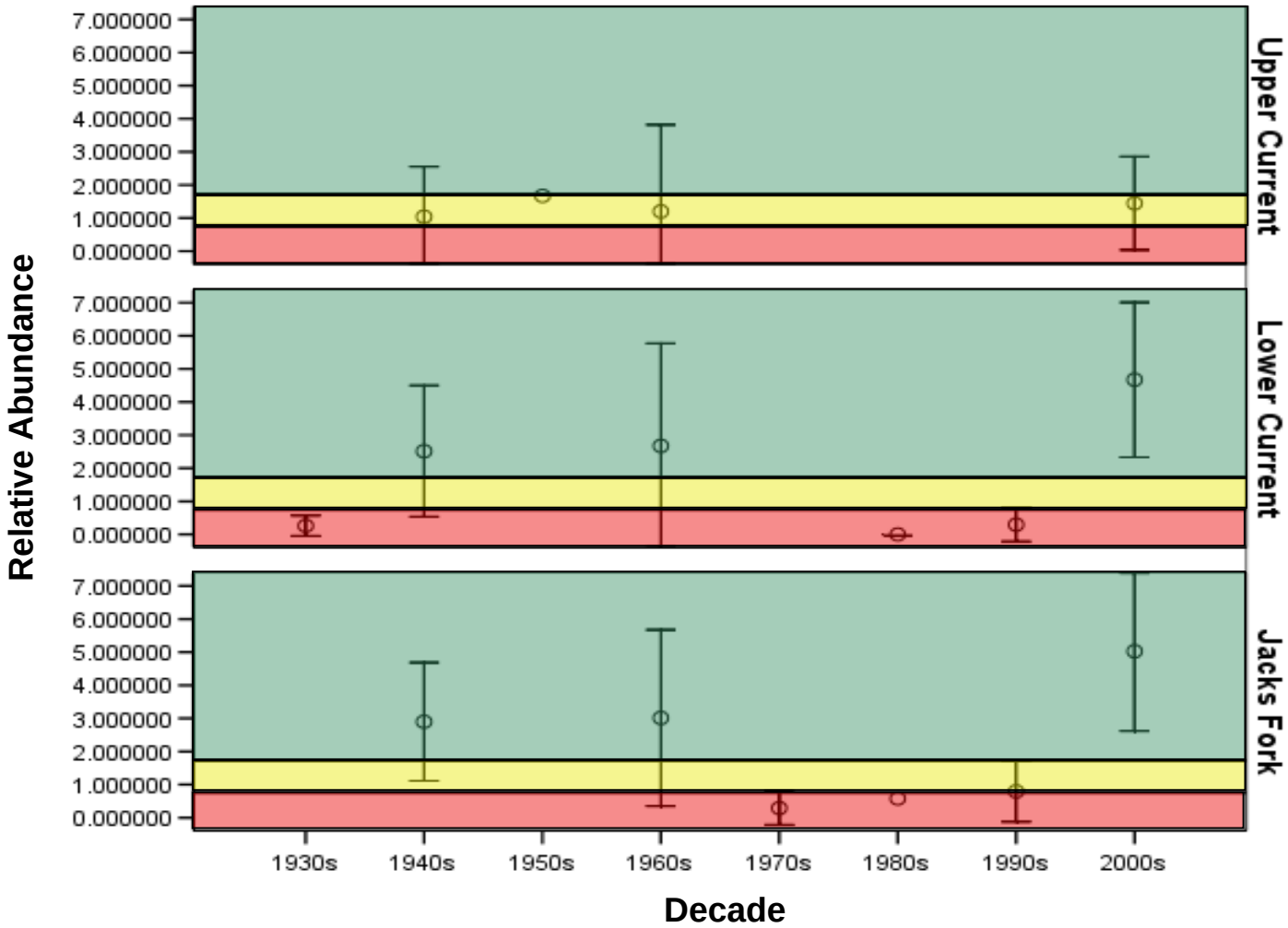
Biotic Condition – Population Status

ONSR: Smallmouth bass Relative Abundance by Site

Location	Park Unit	Observed Abundance	Predicted Abundance	Difference	Rating
CURRM01	Up. Current	0.79	1.73	-0.92	
CURRM02	Up. Current	0.48	1.73	-1.25	
CURRM03	Up. Current	3.07	1.73	1.34	
CURRM04	Low. Current	6.85	1.73	5.12	
CURRM05	Low. Current	4.96	1.73	3.23	
CURRM06	Low. Current	2.21	1.73	0.48	
JACKM01	Jacks Fork	3.17	1.73	1.44	
JACKM02	Jacks Fork	7.75	1.73	6.02	
JACKM03	Jacks Fork	4.16	1.73	2.43	

Biotic Condition – Population Status

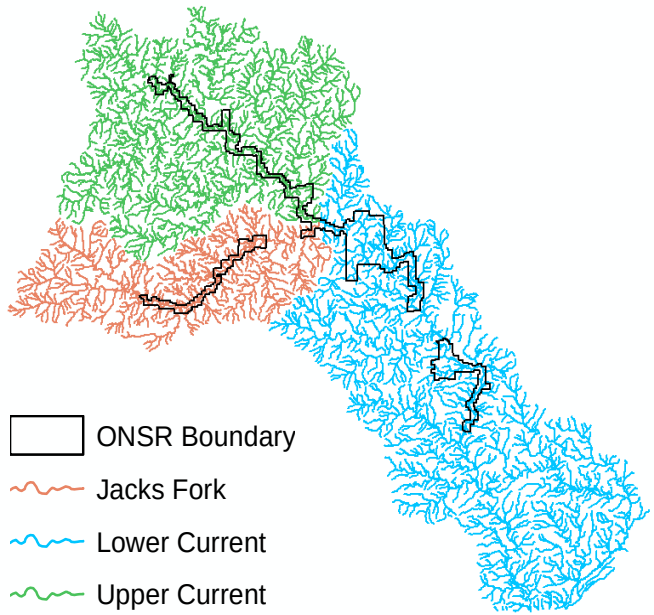
ONSR Smallmouth bass Relative Abundance



By Park Subunit

Biotic Condition

- **Reporting Categories**
  - **Organism Condition**
    - **Forest, Fish, Hellbenders**
- **Reporting Units**
  - **Park Subunits**
  - **Entire Park**



- **Data Sources**
  - **Desired Conditions: Professional Judgment**
  - **Current Conditions: Various Sources**
  - **Trends: Only for Forest Disease**
- **Measures/Indicators**
  1. **Areal extent of disease (Forest)**
  2. **% of diseased organisms (Fish and Hellbenders)**

Biotic Condition – Organism Condition

ONSR Signs of Disease

- Forest
  - Oliveria et al. (2001) and Lea (2006) significant Oak Decline due to various stressors that are increasing susceptibility to disease. Is expected to continue or worsen.

- Fish
  - HTLN Fish Community Data. Over 1,000 individuals examined in each park subunit. Less than 1% of individuals demonstrated signs of disease.

- Hellbenders
  - MDC survey data. Collected 23 Hellbenders from Upper and Lower Current River units. Over 65% of the individuals demonstrated signs of disease/deformities.

Chemical and Physical Properties

- **Reporting Categories**

WATER

1. **Nutrients (N and P)**
2. **Metals (Pb, Zn, and Cd)**
3. **Bacteria**
4. **Other Chem (pH and Cl)**
5. **Temperature and DO**

AIR

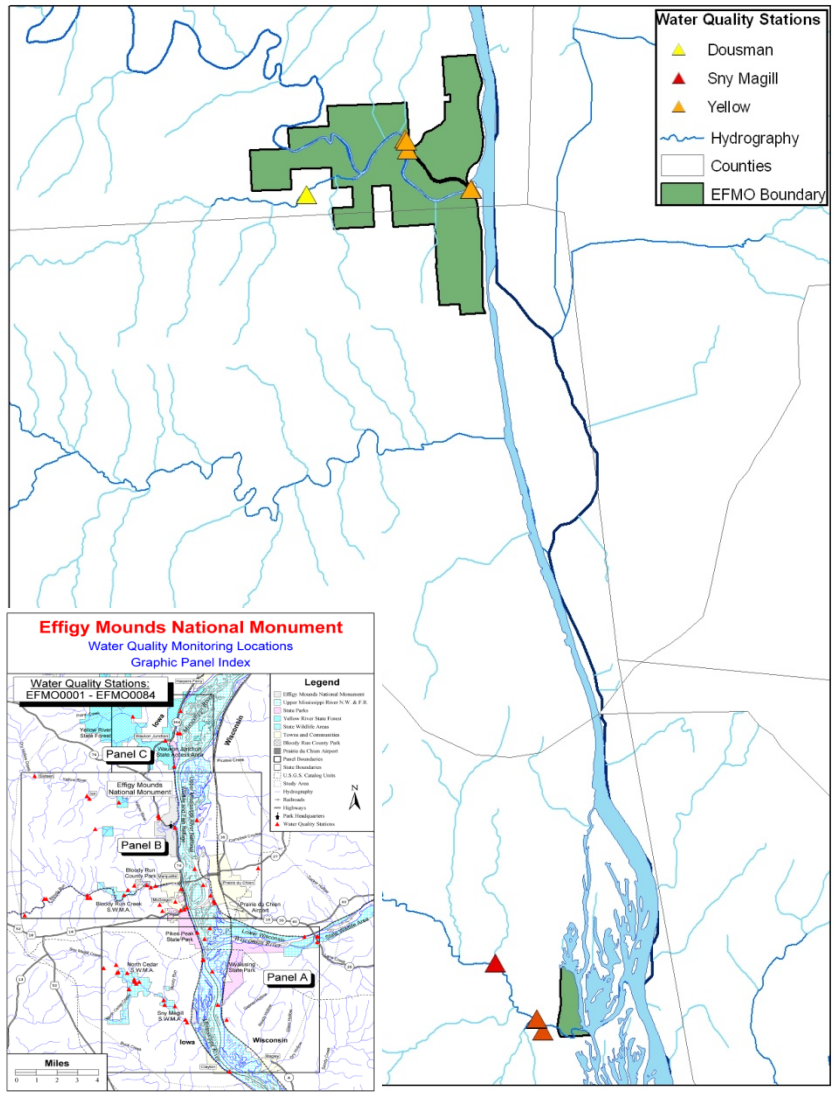
1. **Precipitation**
2. **Temperature**
3. **Nutrients (N, S, Ca, Mg)**
4. **Ozone**

- **Reporting Units**
  - **EFMO: Stream, Hydroseason, and Month**
  - **ONSR: Park Subunit, Mainstem, Spring, and Tributary, Hydroseason, and Month**
- **Data Sources**
  - **Desired Conditions: EPA Standards or State Standards**
  - **Current Conditions: HTLN and STORET**
    CastNet and NADP data
  - **Trend Data: NPS Baseline water quality inventory**
    CastNet and NADP data
- **Measures/Indicators**
  1. **Concentrations**
  2. **Deposition**
  3. **Many others**

Chemical and Physical Properties

EFMO: Water

- Data sources:
  - 11 stations
  - Date range: 1973-2007
- Spatial strata
  - Stream
    - Yellow River, Dousman, Sny Magill
- Temporal Strata
  - Hydroseason
    - 1: Sep1-Feb14
    - 2: Feb15-Apr19
    - 3: Apr20-Aug31
  - Month (for temperature)
- 11 Parameters
  - 96 distinct comparisons



Chemical Properties: Water

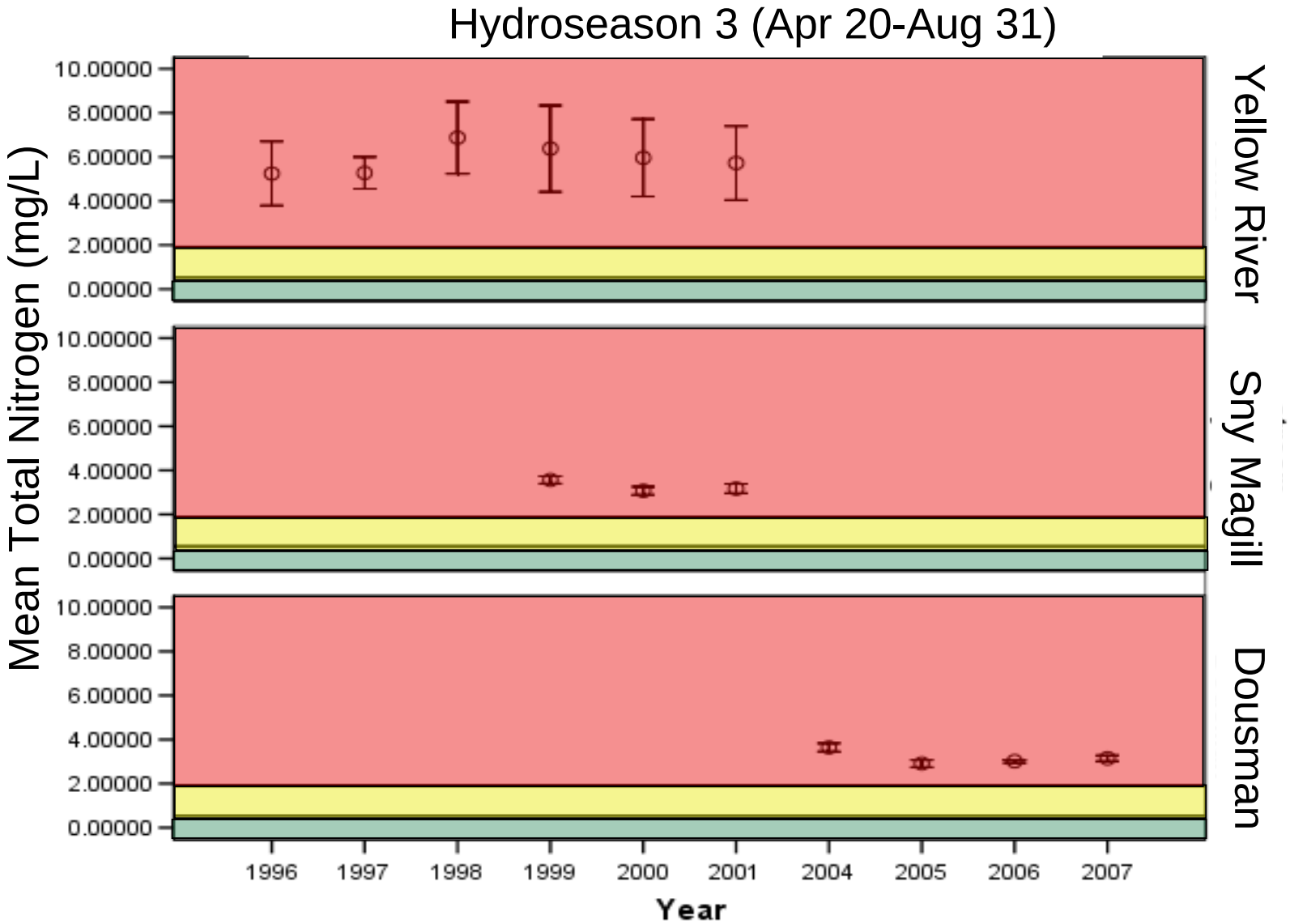
Parameters with Baseline Criteria

Parameter Group	Parameter	Storet Code	Units	ONSR Samples	Lower Criteria	Upper Criteria	EFMO Samples	Lower Criteria	Upper Criteria
	Total Nitrogen	00600	mg/L	1702		0.38A to 1.03B	300		0.54G to 1.88G
	Total Kjeldahl Nitrogen	00625	mg/L	1195		0.05A	73		0.15G
	Ammonia	00610	mg/L	544		Varies by pH and Temp	322		Varies by pH and Temp
Nutrients	Nitrate	00620	mg/L	362		10C	46		10F
	Nitrite	00615	mg/L	527		1C	25		1F
	Total Phosphorous	00665	mg/L	2696		0.06 to 0.1A	383		0.03G to 0.07G
	Total Orthophosphorous	00660	mg/L	16		?	71		?
	Dissolved Phosphorous	00666	mg/L	366		?	0		?
	Lead	01051	mg/L	534		See Table ?	3		See Table ?
	Nickel	01067	mg/L	26		See Table ?	1		See Table ?
Metals	Zinc	01092	mg/L	540		See Table ?	3		See Table ?
	Cadmium	01027	mg/L	522		See Table ?	3		See Table ?
	Copper	01042	mg/L	42		See Table ?	3		See Table ?
	Mercury	71890	mg/L	71		See Table ?	0		See Table ?
Sediments	Total suspended solids	70300	mg/L	220		25 to 80E	54		25 to 80E
	Turbidity	00070	NTU	84		1.4A to 10.4B	359		3.38G
Bacteria	Fecal coliform	31616	#/100 mL	2956		200D	251		200F
	E. Coli	31633	#/100 mL	809		126-548D	81		126-548F
	Temperature	00010	ºC	4180		20ºC/Cold, 28.9/warm	364		20ºC/Cold, 32/warm
	Dissolved Oxygen	00300	mg/L	2149	6D/Cold, 5D/warm		315	5F	
Other	pH	00400	SU	4482	6.5C	9C	0	6.5C	9C
	Specific Conductance	00094	UMHOS/CM @ 25 ºC	1002		2.0-6.0B	280		
	Chloride	00941	mg/L	282		230C	62		250F to 860H
Primary Productivity	Sestonic Chl	32217	mg/L	1381		0.9A or 6.0B	0		2.32G

Sources	
A	EPA 2000 Ambient nutrient quality criteria nutrient region 11
B	Huggins 2005
C	See Appendix D in Huggins 2005
D	Missouri water quality criteria: whole body contact: only pertains to April 1- Oct 31 window
E	Alabaster and Lloyd 1982 (in Doisy and Rabeni 2004)
F	Iowa water quality criteria: whole body contact: only pertains to April 1- Oct 31 window
G	EPA 2000 Ambient nutrient criteria nutrient region 7

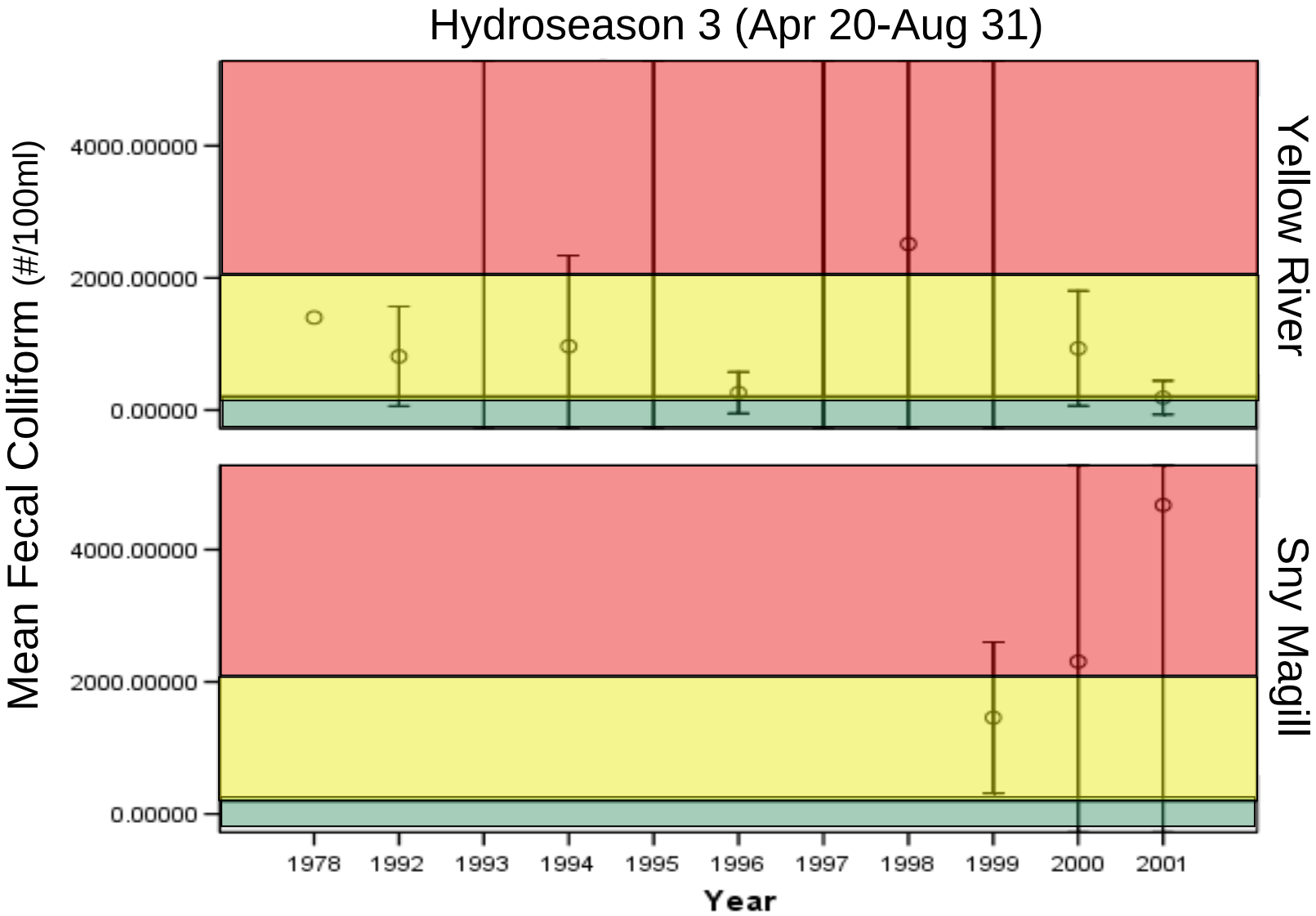
Chemical Properties: Water

EFMO Nutrients: Total Nitrogen



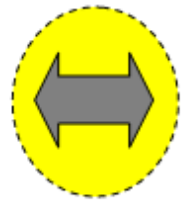
Chemical Properties: Water

EFMO Bacteria: Fecal Colliform



Chemical Properties: Water

Draft Scorecard Both Parks

	Nutrients	Metals	Sediments	Bacteria	Other	Productivity
ONSR						
EFMO						

Hydrology and Geomorphology

- **Reporting Categories**
  1. **Surface and Groundwater flows**
  2. **Dynamic Structural Characteristics**
  3. **Sediment Input and Transport**

- **Reporting Units**
  - **Parkwide, Mainstems and Tributaries**

- **Data Sources**
  - **Desired Conditions:** **Professional Judgment based on Literature**
  - **Current Conditions:** **Professional Judgment based on Literature**
  - **Trend Data:** **Professional Judgment based on Literature**
- **Measures/Indicators**
  1. **Fine sediment inputs**
  2. **Fine sediment transport**
  3. **Coarse sediment inputs**
  4. **Coarse sediment transport**

Hydrology and Geomorphology

ONSR Sediment Inputs & Transport

Sediment Inputs			Sediment Transport		
	Coarse	Fine		Coarse	Fine
Mainstem	↓	↔	Mainstem	↑	↔
Tributaries	↓	↔	Tributaries	↔	↔

Natural Disturbances

- **Reporting Categories**
  1. **Fire Regime**
  2. **Flow Regime (Flood and Drought Flows)**

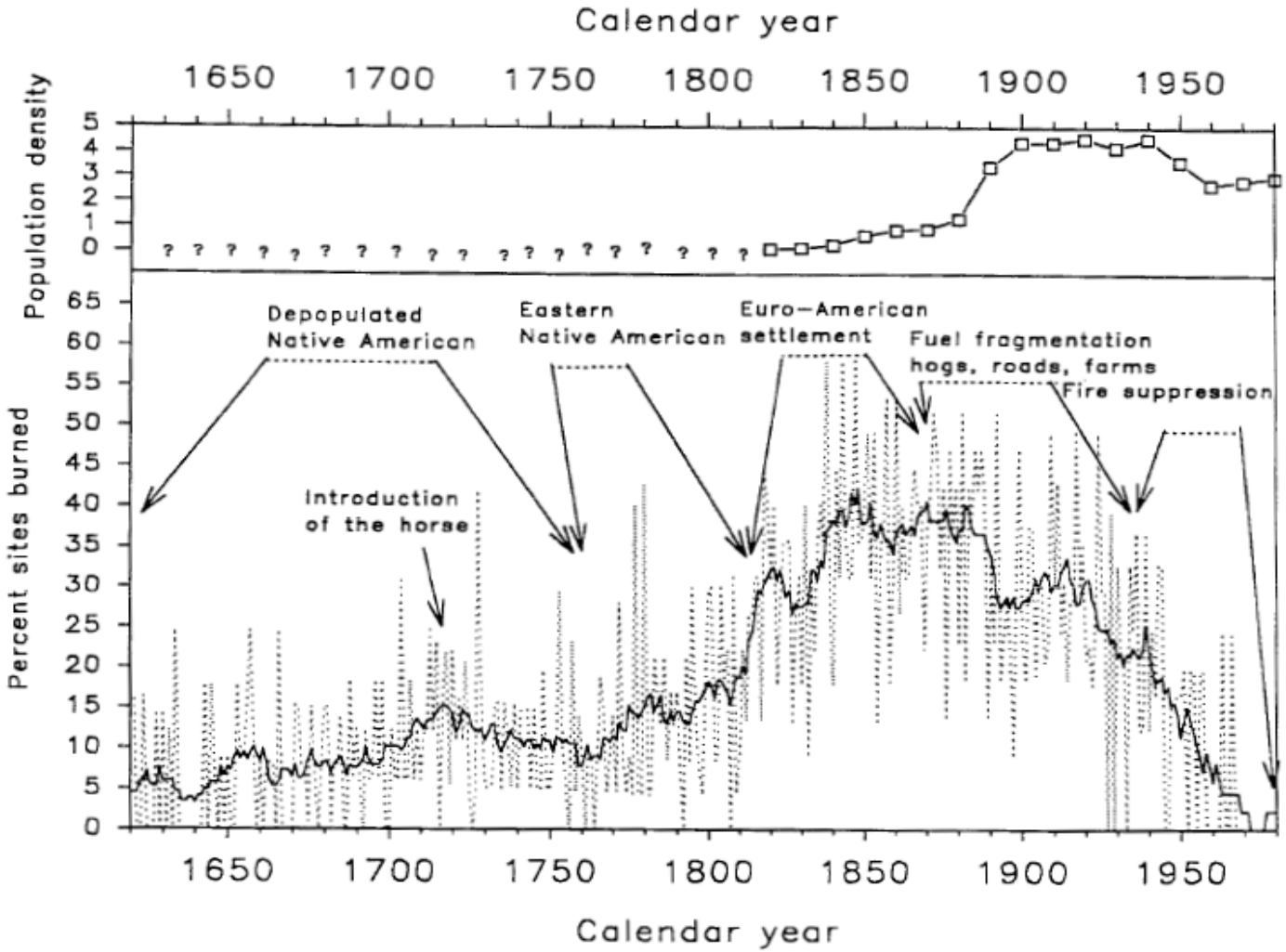
- **Reporting Units**
  - **Park Subunits and Parkwide**

- **Data Sources**
  - **Desired Conditions:** **R. Guyette Fire History Studies and PJ**
  - **Current Conditions:** **Park Fire Management Plan**
  - **Trend Data:** **R. Guyette Fire History Studies**

- **Measures/Indicators**
  1. **Frequency**
  2. **Spatial Extent**
  3. **Intensity**

Natural Disturbances

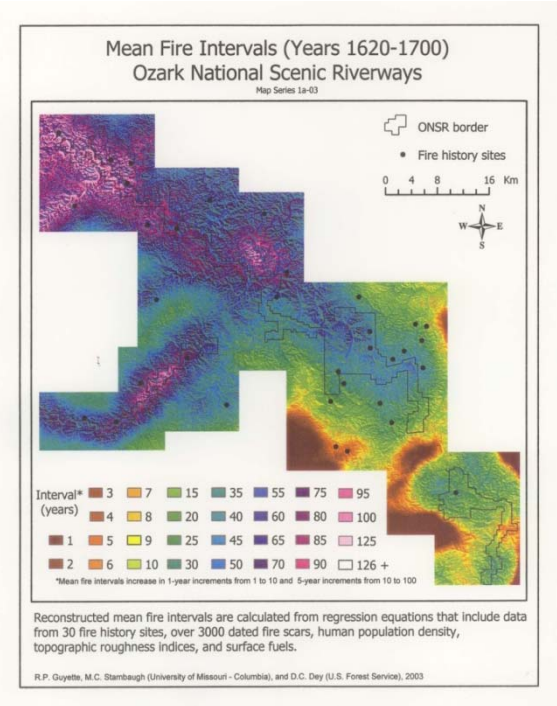
ONSR: Fire Extent

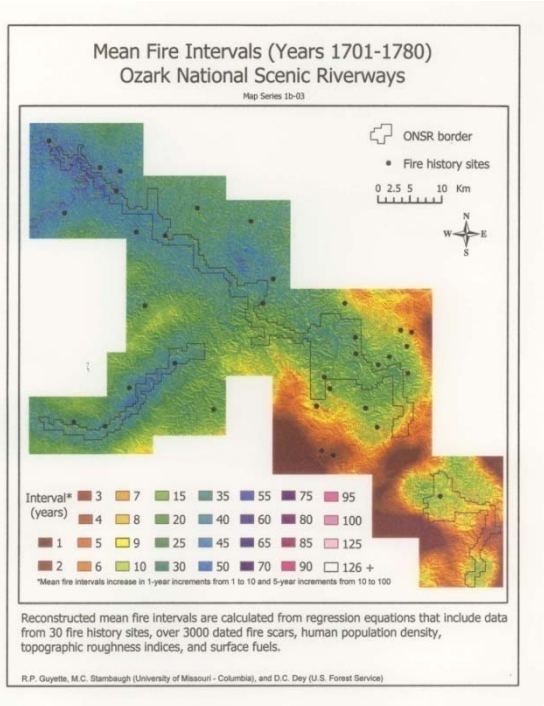


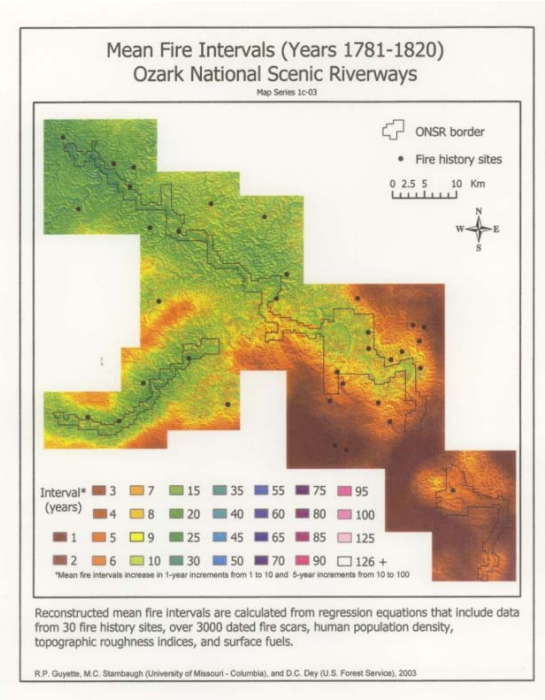
From: Guyette, R.P. and B.E. Cutter. 1997.

Natural Disturbances

ONSR: Fire Frequency



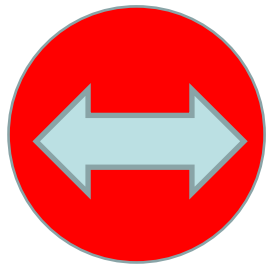
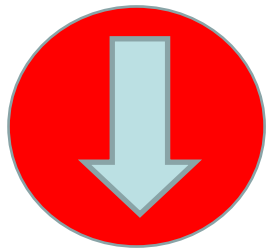
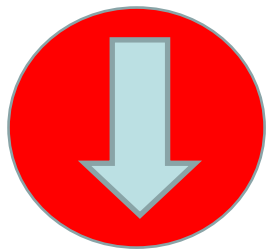




Type of MFI	Period 1620-1700	Period 1701-1780	Period 1781-1820
Mean riparian MFI (modeled)	39.9 (28.3)	19.9 (14.5)	8.9 (6.9)
Mean upland MFI (modeled)	28.1 (23.5)	13.9 (12.1)	6.1 (5.8)
Mean MFI (empirical)	21.6 (12.7)	12.4 (9.5)	7.1 (7.1)

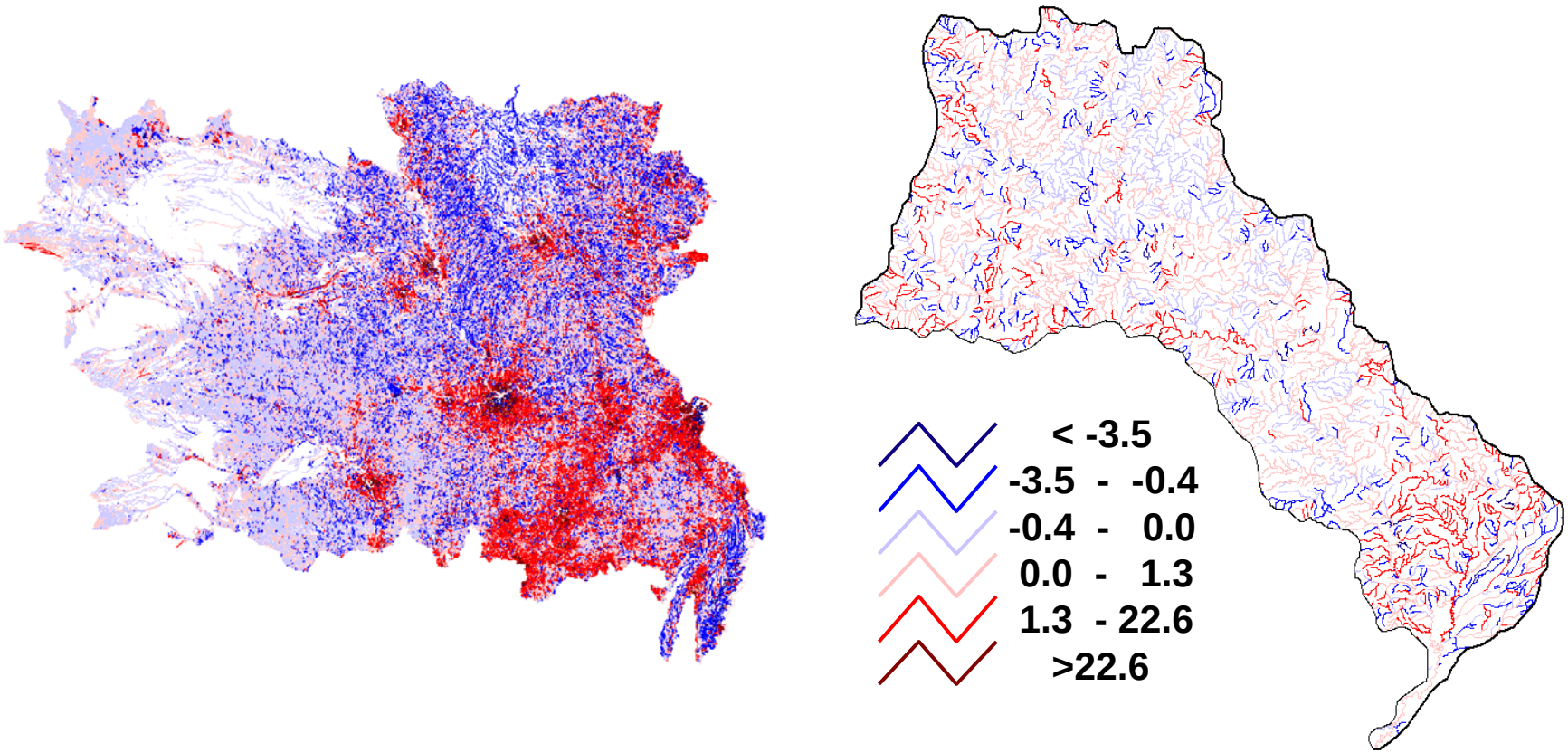
From: Guyette, R.P., M.C. Stambaugh, and D.C. Dey. 2003

Natural Disturbances
ONSR: Fire

- Fire Frequency 
- Fire Extent 
- Fire Intensity 

Quantifying Threats/Stressors Provides Critical Context

Population Change in Watershed (1990-2000)
#/km^2



Threats Quantified For Each Park

Agriculture:
- Cropland
- Pasture/rangeland
- Row crop chemicals
- Pasture chemicals
- CAFO

Stream alteration:
- Dams
- Major reservoirs
- Headwater impoundments
- Channelization
- Distance to reservoir
- Fragmentation

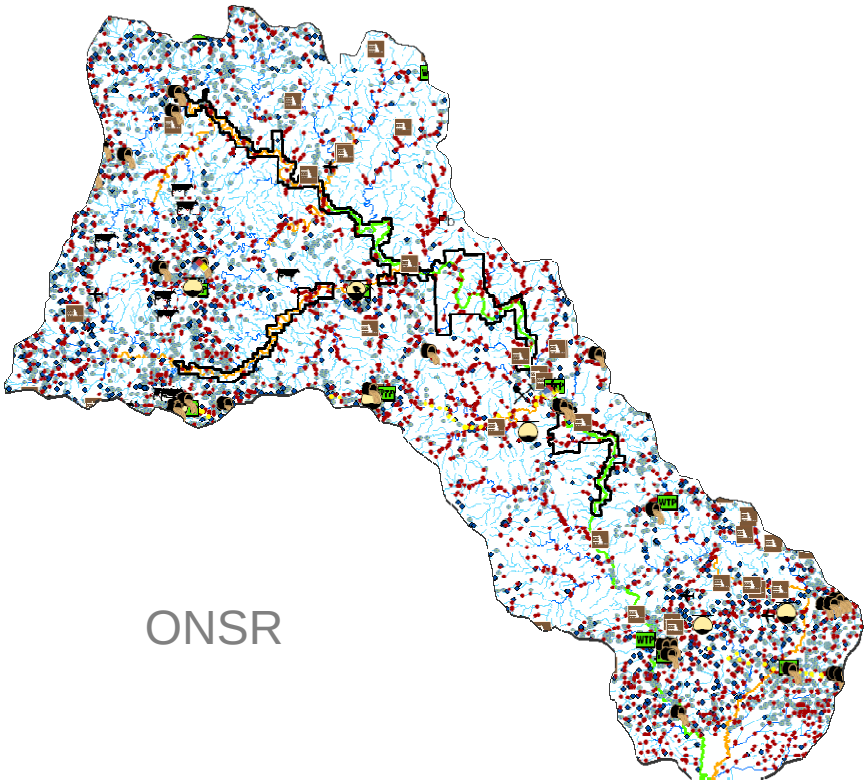
Transportation:
- Airports
- Length of road
- Road – stream crossings
- Length of Railroads
- Rail – stream crossings

Human infrastructure:
- Population change
- Power lines
- Pipelines
- Wells
- Military sites
- Impervious surface

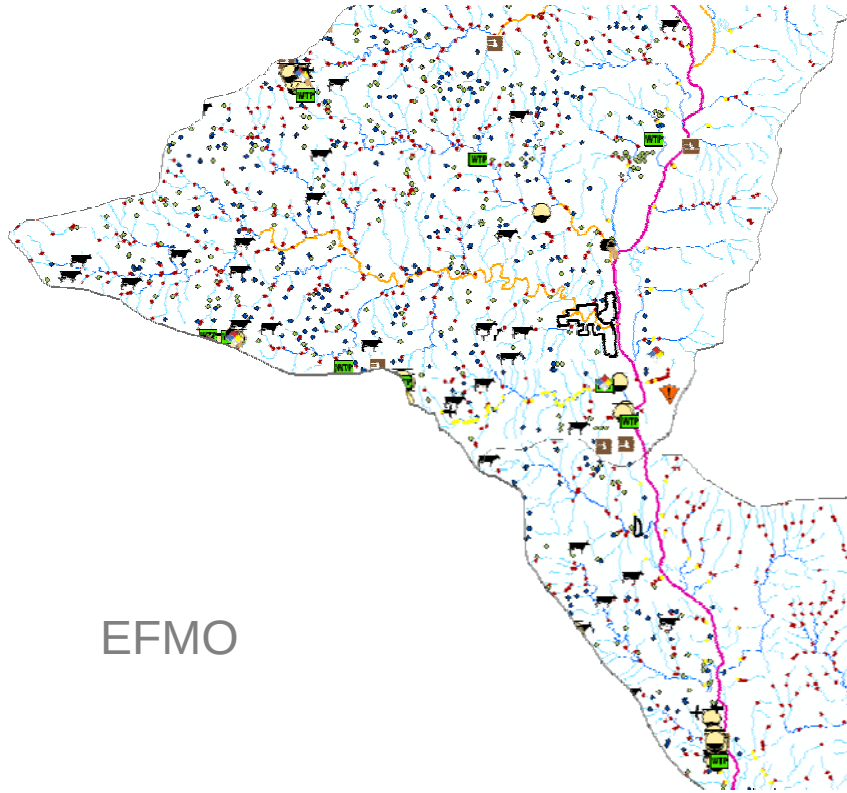
Discharge:
- LUST
- Superfund sites
- TRI
- NPDES
- Landfills
- Waste water treatment

Mining:
- Lead mines
- Coal mines
- Other mines
- Oil & gas wells

Threat Examples



ONSR



EFMO

Airports
Mines
Lead Mines
Coal Mines
Toxic Releases
Point Source Discharges
Leaking Underground Storage Tanks
Wastewater Treatment
Landfills
Confined Animal Operations
Dams

ONSR Boundary
Rail Stream Crossings
Road Stream Crossings
Headwater Impoundments
Certified Wells

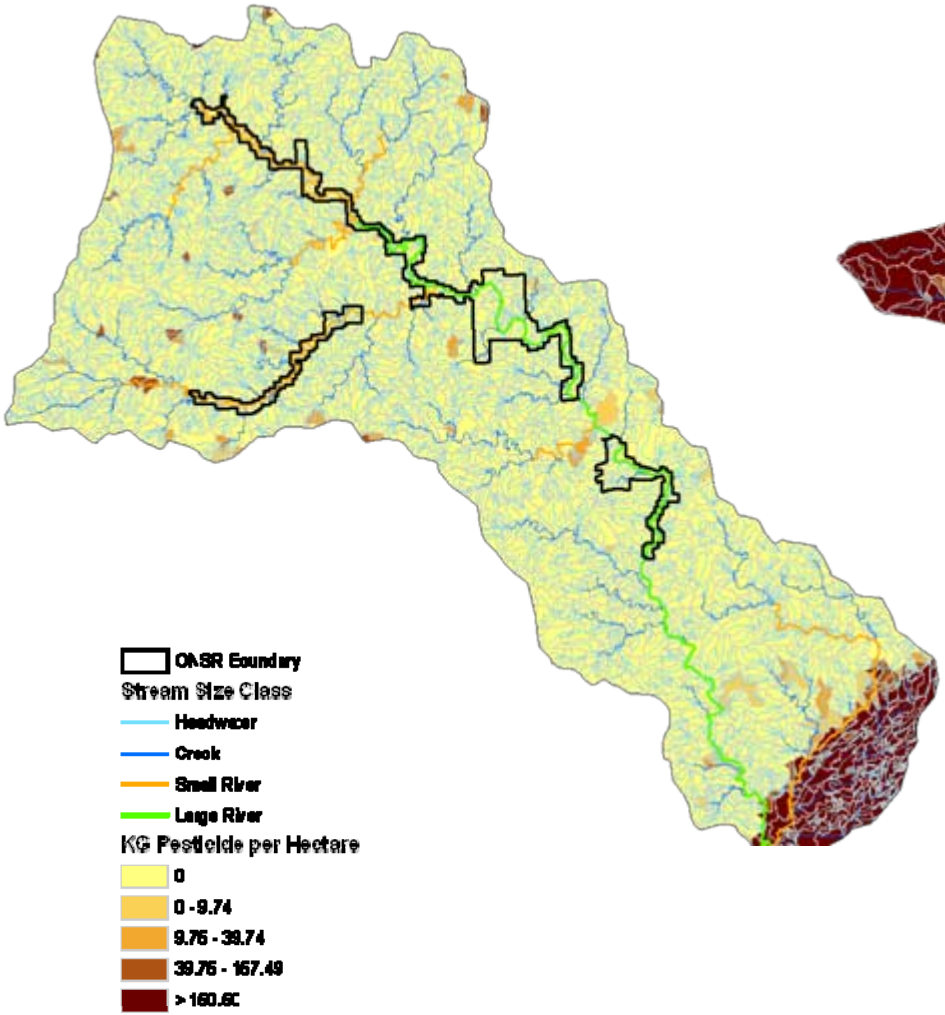
Stream Size Class
Headwater
Creek
Small River
Large River

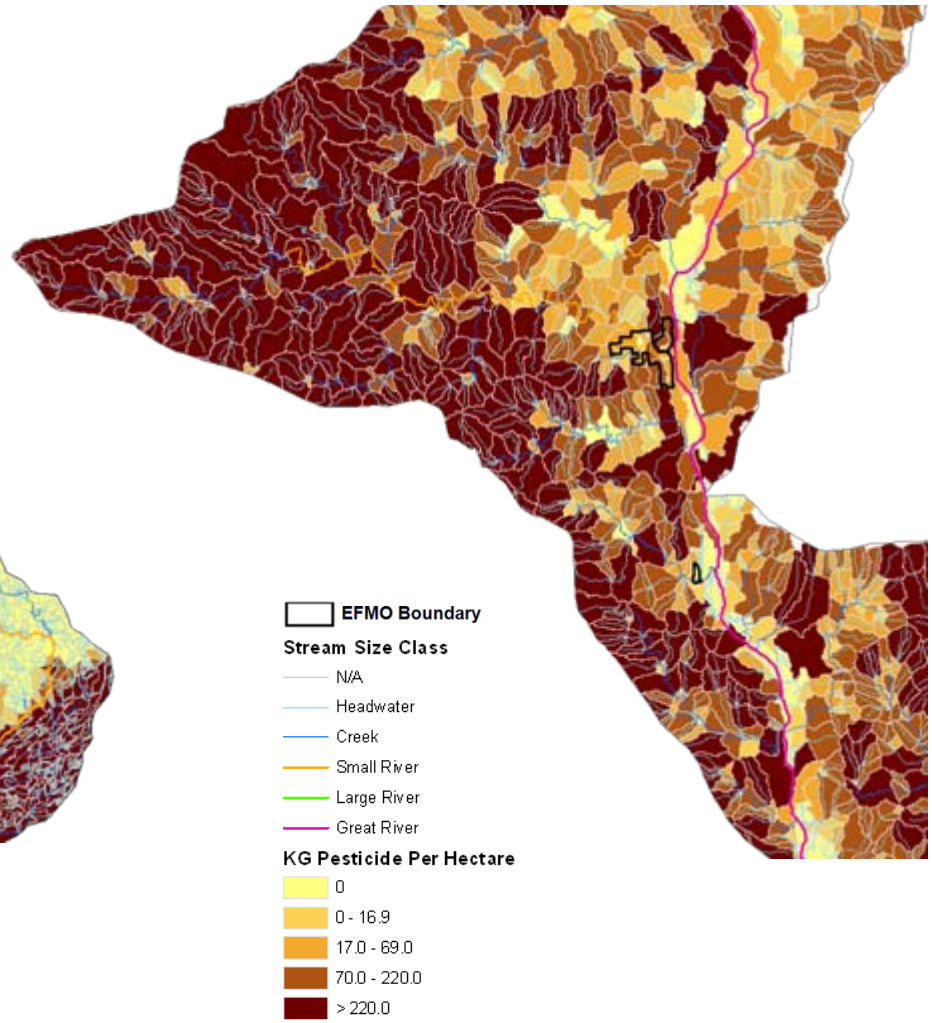
Airports
Toxic Releases
Point Source Discharges
Wastewater Treatment
Leaking Underground Storage Tanks
RCRA Sites
Confined Animal Operations
Dams
EFMO Boundary
Rail Stream Crossings

Road Stream Crossings
Headwater Impoundments
Certified Wells

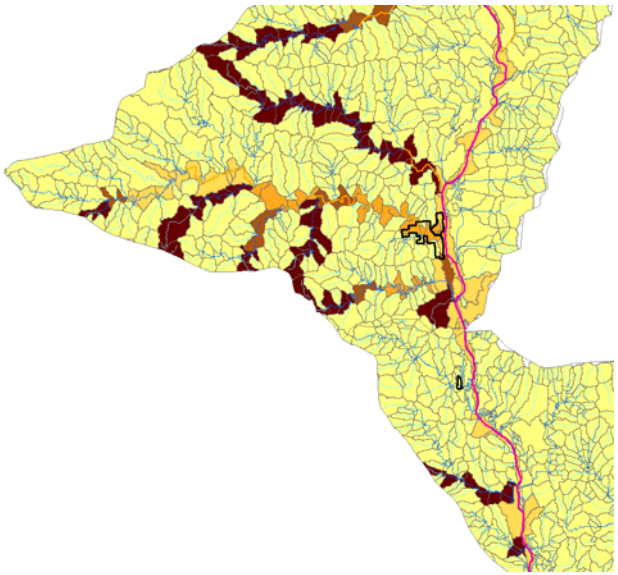
Stream Size Class
N/A
Headwater
Creek
Small River
Large River
Great River

Pesticide Applications





Other Threats: EFMO



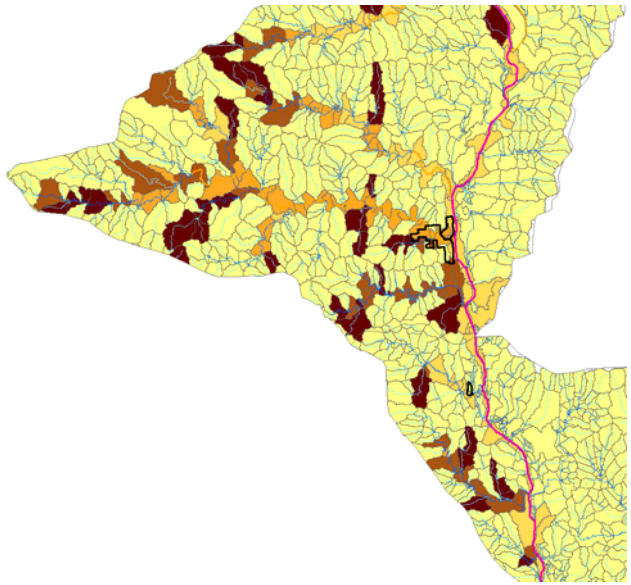
EFMO Boundary

Leaking Underground Tanks Per SKM

- 0
- 0 - 0.009
- 0.01 - 0.016
- 0.017 - 0.03
- 0.03 - 4

Stream Size Class

- N/A
- Headwater
- Creek
- Small River
- Large River
- Great River



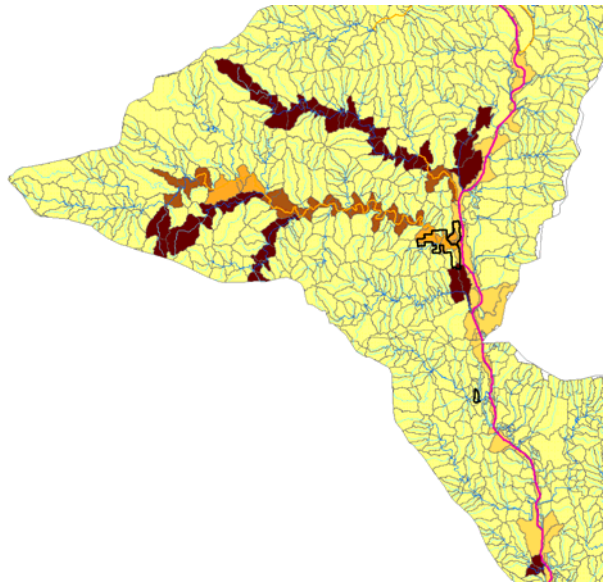
EFMO Boundary

Animal Feeding Operations Per SKM

- 0
- 0.00001 - 0.02134
- 0.02135 - 0.03669
- 0.03670 - 0.07014
- 0.07015 - 1.09254

Stream Size Class

- N/A
- Headwater
- Creek
- Small River
- Large River
- Great River



EFMO Boundary

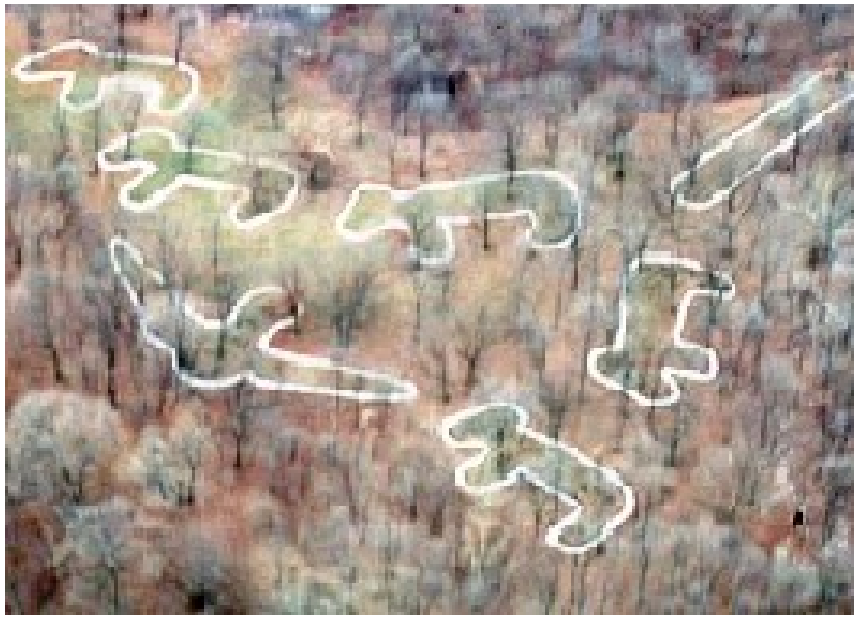
Waste Water Treatment Plants Per SKM

- 0
- 0.000001 - 0.002666
- 0.002667 - 0.005134
- 0.005135 - 0.009721
- 0.009722 - 0.667735

Stream Size Class

- N/A
- Headwater
- Creek
- Small River
- Large River
- Great River

Major Issues/Findings

- Ecosystem assessments are feasible
- Require broad range of expertise
- Must work closely with Park and I&M staff
- Many data limitations/gaps, particularly ecological processes
- Consolidating data and devising baseline/desired conditions can be a nightmare
- I&M data is critical
- Assessments will be significantly more informative in the future
- NPS needs a data entry, management, analysis, and reporting system

Questions?