



# ***NHDPlus as the Core for Significant Nexus Analysis***

**NWQMC Sixth National Monitoring Conference  
May 20-24, 2008  
Atlantic City, NJ**

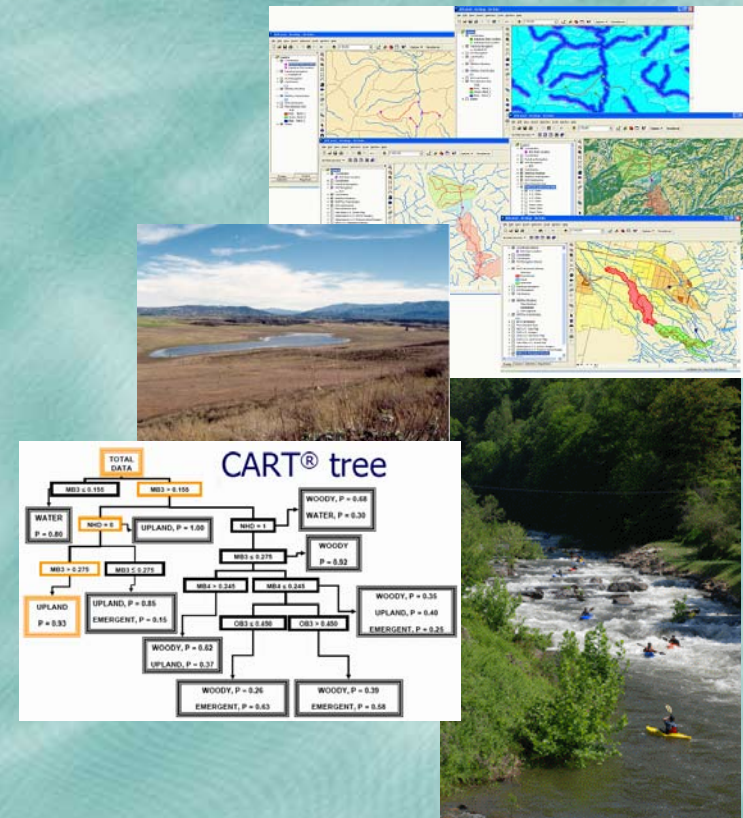
**Authors:**

**William Cooter, RTI International (presenter)  
Jay Rineer, RTI International  
Brandon Bergenroth, RTI International  
Shel Brannan, RTI International  
Kevin Pickren, RTI International  
David Cunningham, MDA Federal (EarthSat)**



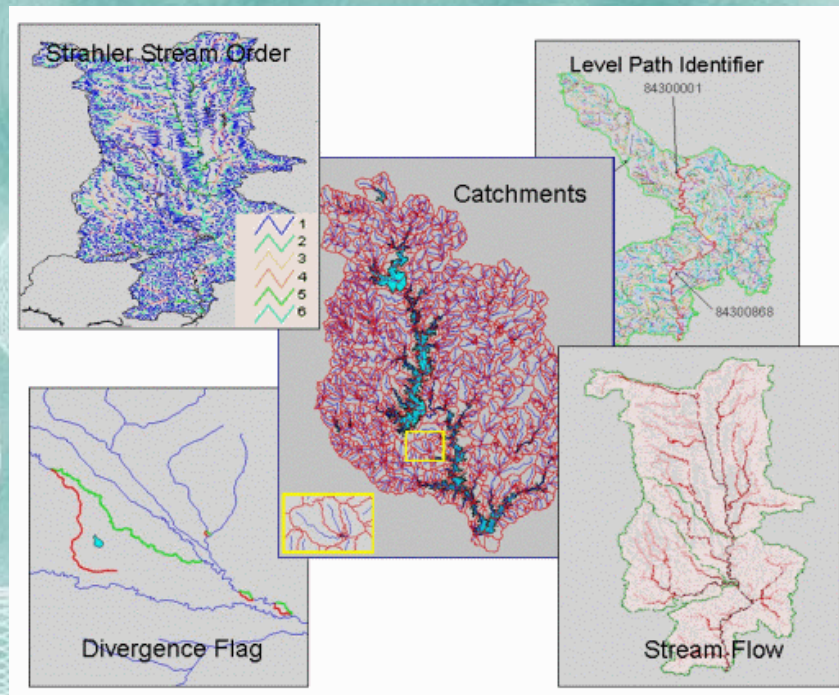
# Presentation Outline

- NHDPlus and the Significant Nexus Challenge
- Direct Approaches to Documenting Significant Nexus Status
- Near Field/Far field Frameworks using NHDPlus
- CART Analysis and “Training Datasets”



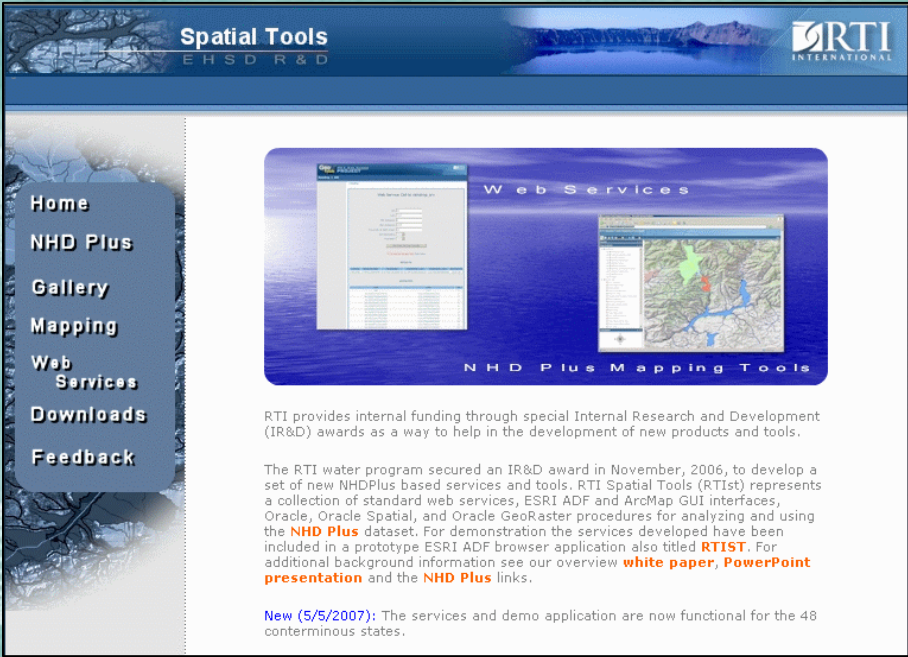


RTI has experience with the current NHDPlus – and all versions of the NHD and the EPA Reach Files (RF1, RF2, RF3, NHD “Initial Release”, NHD “Releveled”, and NHD High Resolution)





# RTI's Oracle Spatial GeoTools provide an ideal platform to create custom analysis frameworks using NPDPlus vector and raster data



The screenshot shows the RTI Spatial Tools web application. The header includes the title "Spatial Tools" with "EHSD R&D" below it, and the RTI International logo. A left sidebar contains a menu with links: Home, NHD Plus, Gallery, Mapping, Web Services, Downloads, and Feedback. The main content area features a "Web Services" section with two screenshots of the application interface. Below this, text describes the RTI water program's IR&D award and the development of NHDPlus-based services. A "New (5/5/2007)" announcement states that the services and demo application are now functional for the 48 conterminous states.

**Spatial Tools**  
EHSD R&D

RTI  
INTERNATIONAL

Home  
NHD Plus  
Gallery  
Mapping  
Web Services  
Downloads  
Feedback

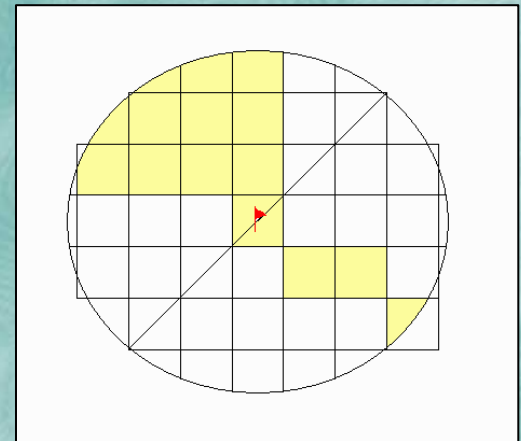
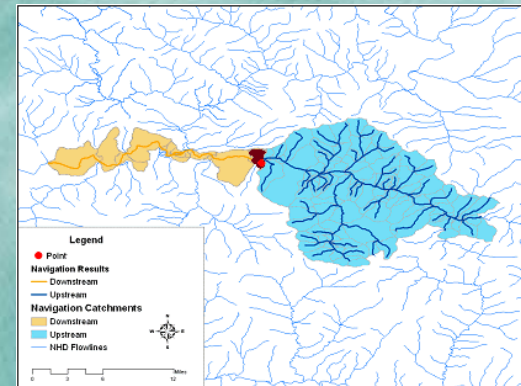
**Web Services**

NHD Plus Mapping Tools

RTI provides internal funding through special Internal Research and Development (IR&D) awards as a way to help in the development of new products and tools.

The RTI water program secured an IR&D award in November, 2006, to develop a set of new NHDPlus based services and tools. RTI Spatial Tools (RTIst) represents a collection of standard web services, ESRI ADF and ArcMap GUI interfaces, Oracle, Oracle Spatial, and Oracle GeoRaster procedures for analyzing and using the **NHD Plus** dataset. For demonstration the services developed have been included in a prototype ESRI ADF browser application also titled **RTIst**. For additional background information see our overview **white paper**, **PowerPoint presentation** and the **NHD Plus** links.

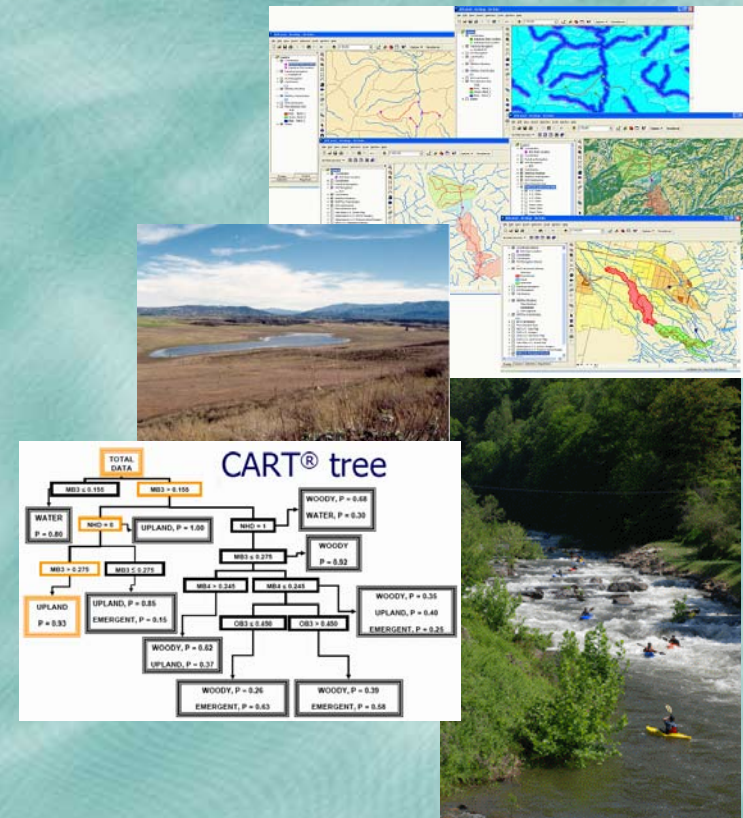
**New (5/5/2007):** The services and demo application are now functional for the 48 conterminous states.





# Presentation Outline

- NHDPlus and the Significant Nexus Challenge
- Direct Approaches to Documenting Significant Nexus Status
- Near Field/Far field Frameworks using NHDPlus
- CART Analysis and “Training Datasets”





# The Significant Nexus Challenge

Justice Kennedy rejected the “presence of a hydrologic connection” alone as being sufficient to establish significant nexus in all cases. He observed that “Absent some measure of the significance of the connection for downstream water quality, this standard is too uncertain.”

He further observed: “...(M)ere hydrologic connection should not suffice in all cases; the connection may be too insubstantial for the hydrologic linkage to establish the required nexus with navigable waters as traditionally understood.”

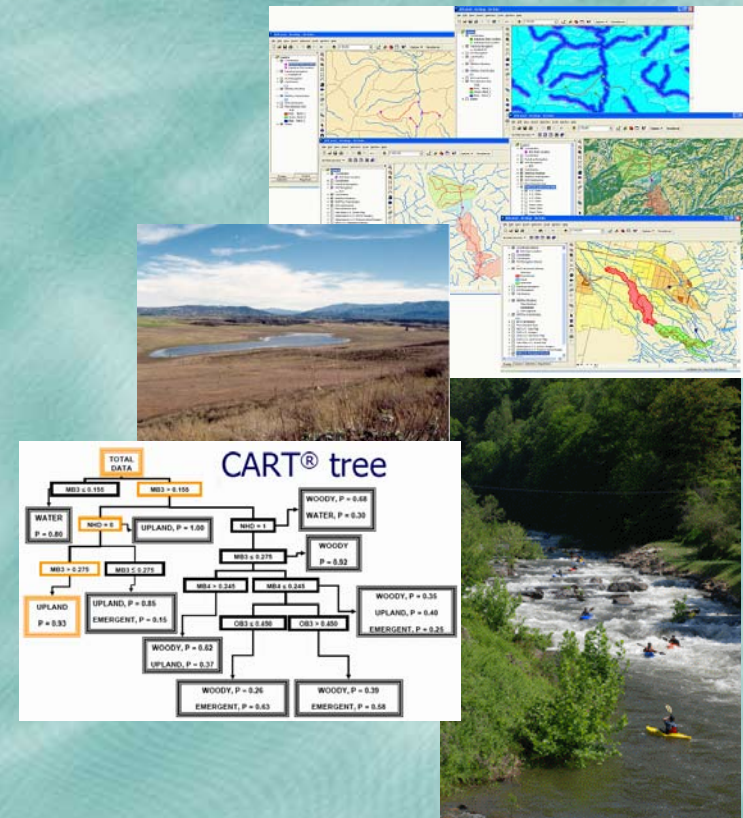
In other words:

Need information that goes beyond the presence of hydrologic network flowpaths to demonstrate that a specific waterbody or project area is protected under the Clean Water Act.



# Presentation Outline

- NHDPlus and the Significant Nexus Challenge
- Direct Approaches to Documenting Significant Nexus Status
- Near Field/Far field Frameworks using NHDPlus
- CART Analysis and “Training Datasets”

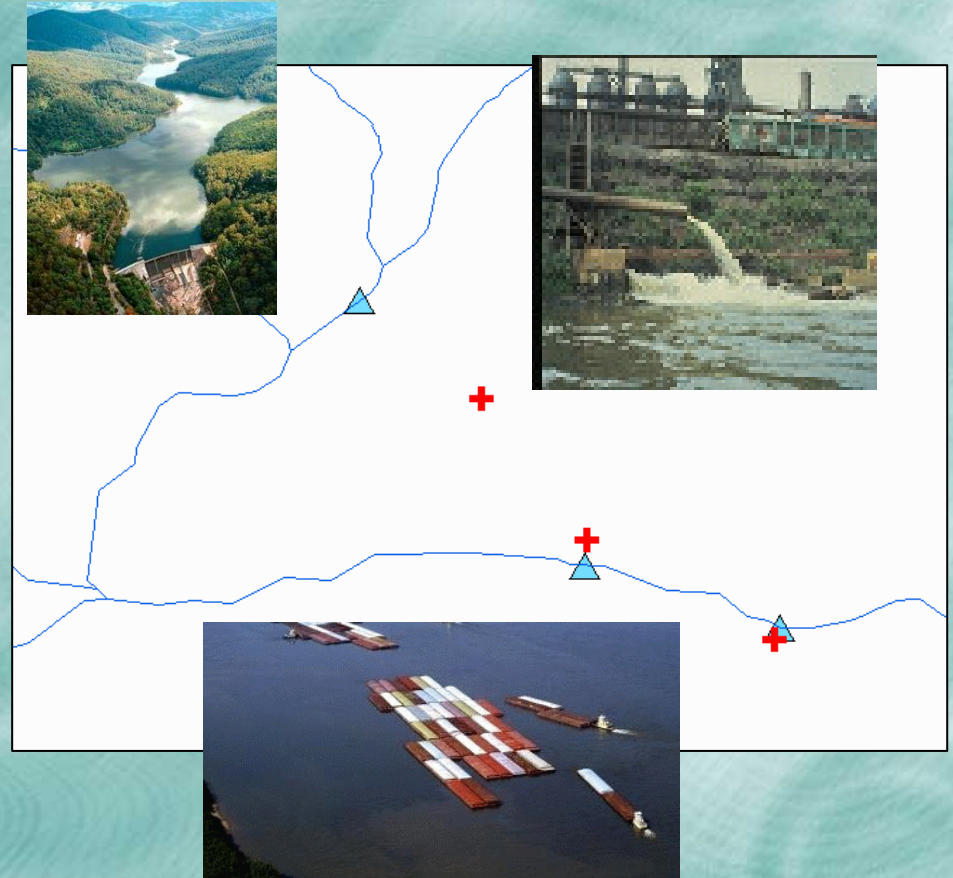




# There are Basic Ways to Document a Clean Water Act Significant Nexus

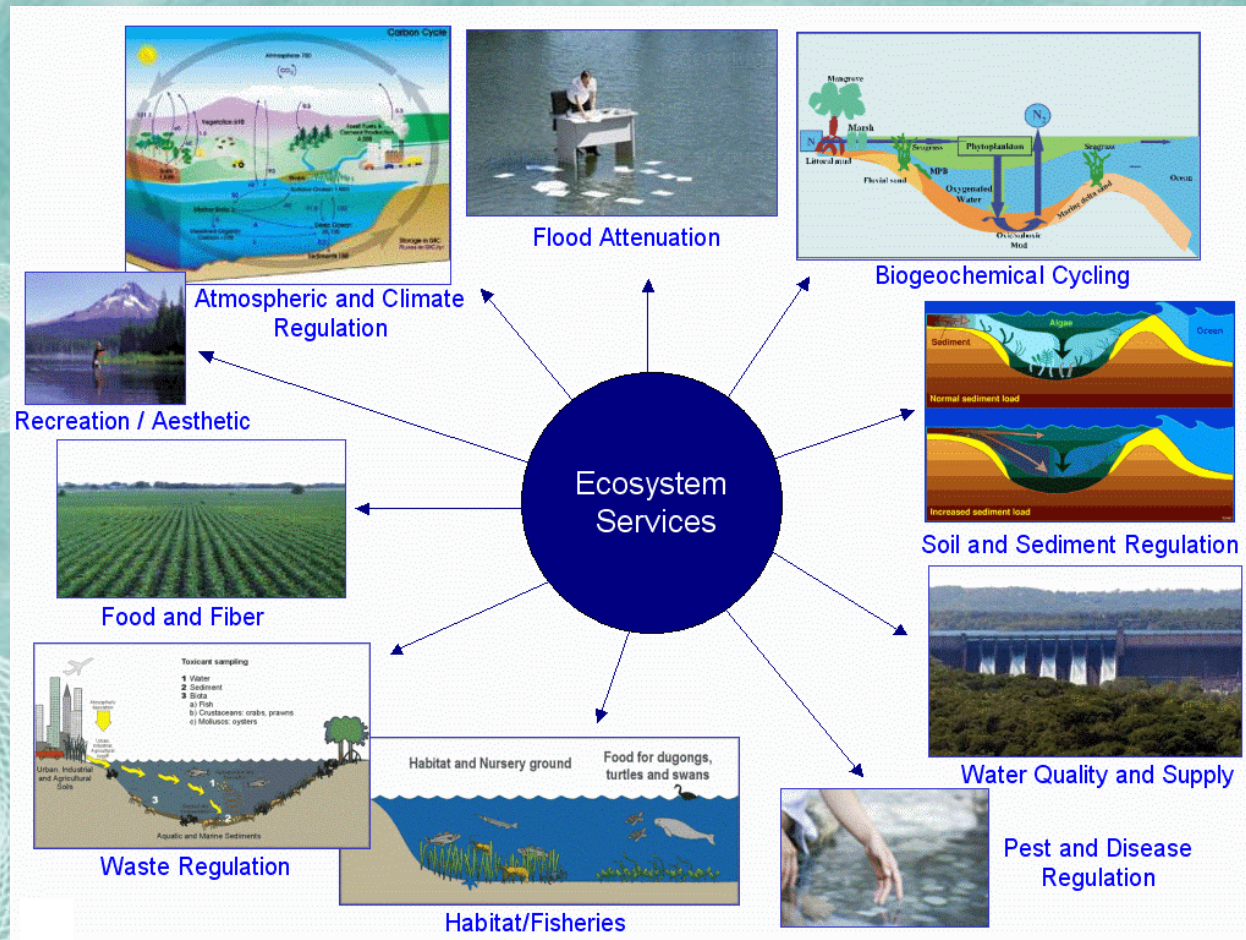
- Source of Drinking Water
- Assimilates Wastes
- Supports “Navigation”

Often these will correlate well with legal Jurisdictional Determination categories





**Ecosystem Services** is also a framework that helps document the value of waterbodies and project “Areas of Investigation”





# The NHDPlus provides the framework to document important Clean Water Act services

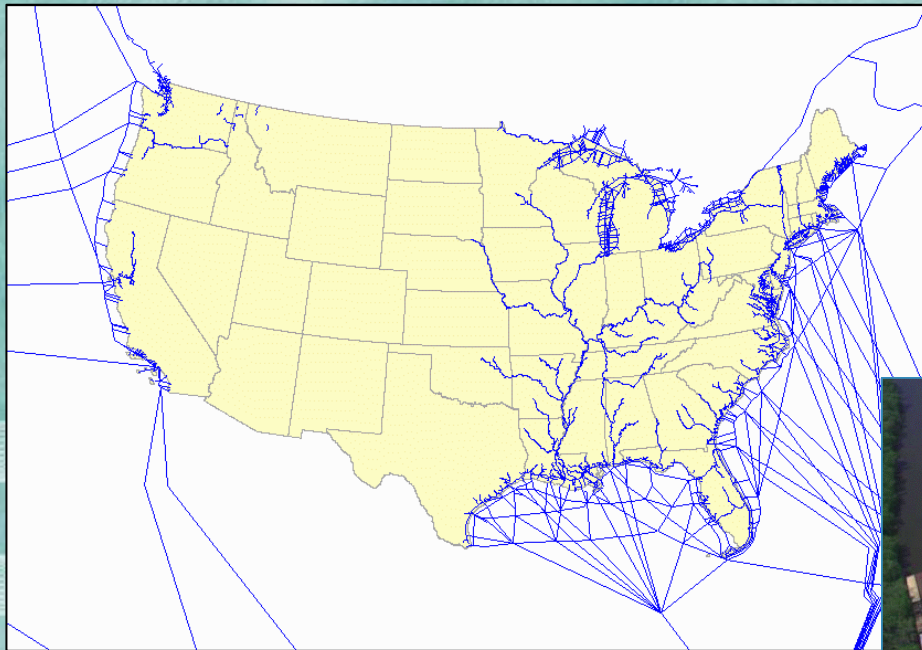


Each service becomes a “leg” to document valuable ecosystem services





# Traditional Navigable Waters (TNW)



The U.S. Army Corps of Engineers provides many GIS layers on waterways that qualify as Traditional Navigable Waters and can be georeferenced to the NHD

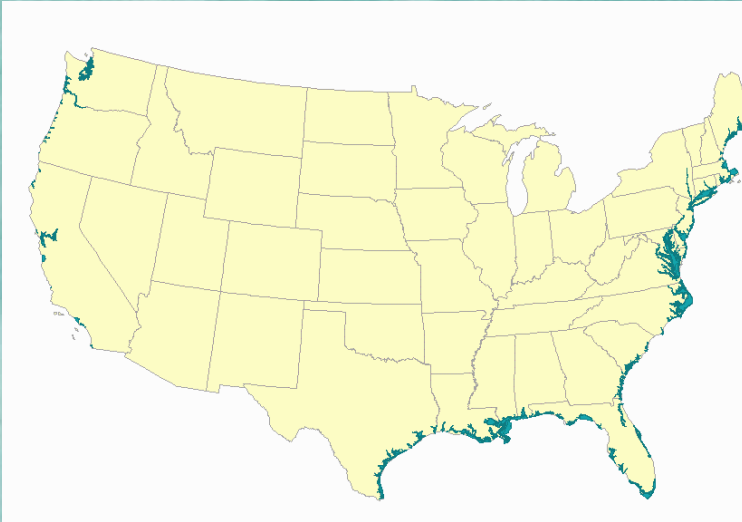
The Upper Midwest Environmental Sciences Center (USGS Science Center) provides a wealth of information for the Upper Mississippi River

<http://www.umesc.usgs.gov/>





# Coastal & Marine Public Trust & Navigable Waters



Clean Water Act protection for coastal areas, estuaries and areas subject to tidal effects usually easier to document than for inland fresh waters.

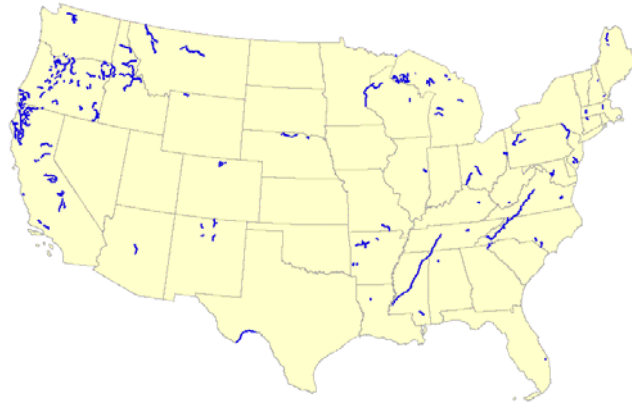




# Other “Navigable” Waters ???



Whitewater recreation can establish Public Trust rights & document services and value under the Clean Water Act



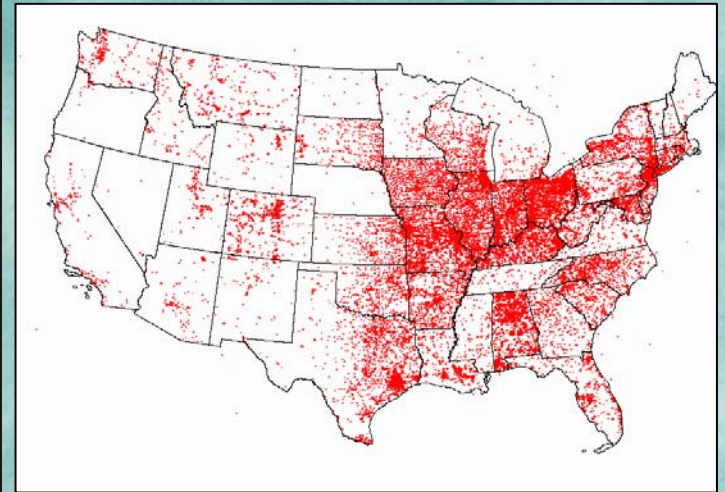
National Wild and Scenic Rivers



# TNW, Relatively Permanent Waters (RPW), and other perennial, intermittent or ephemeral streams

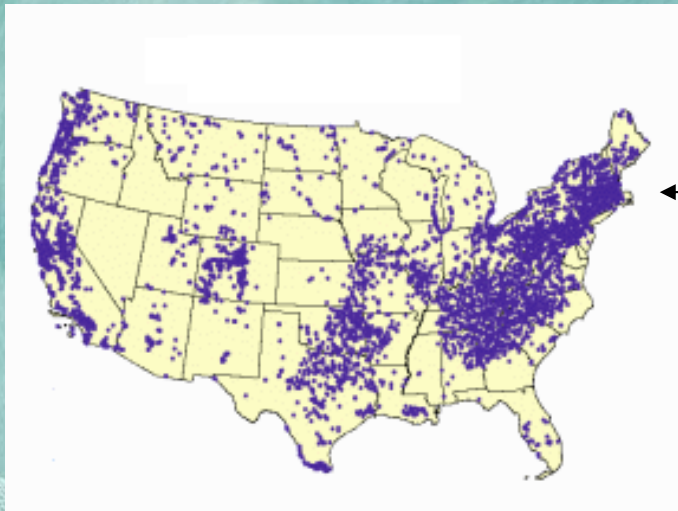


## Waste Assimilation

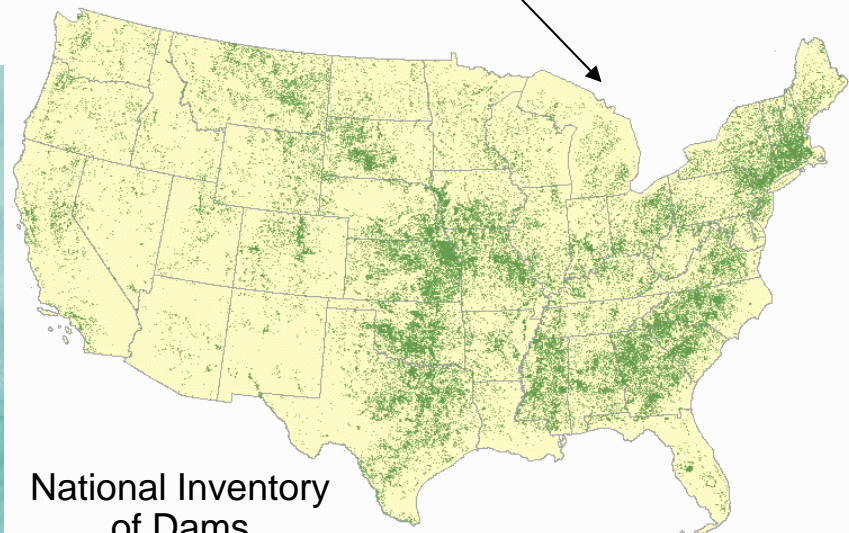




# TNW, Relatively Permanent Waters (RPW), and other perennial, intermittent or ephemeral waters



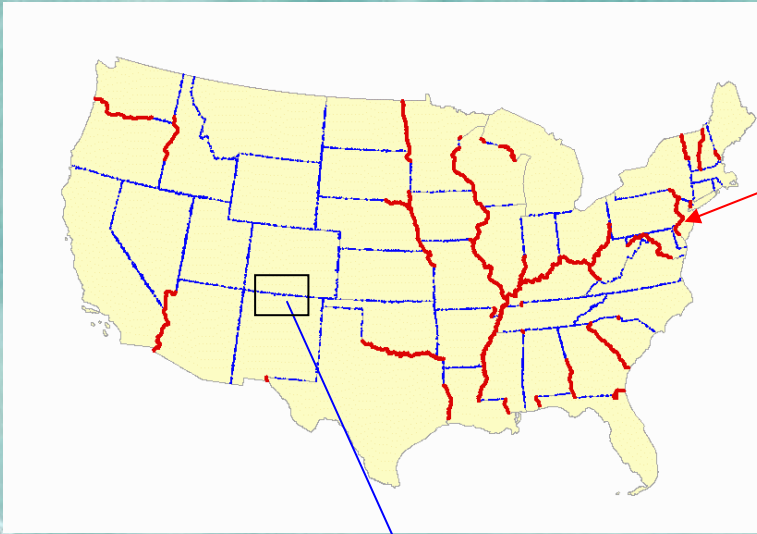
Drinking Water Intakes &  
Surface Impoundments



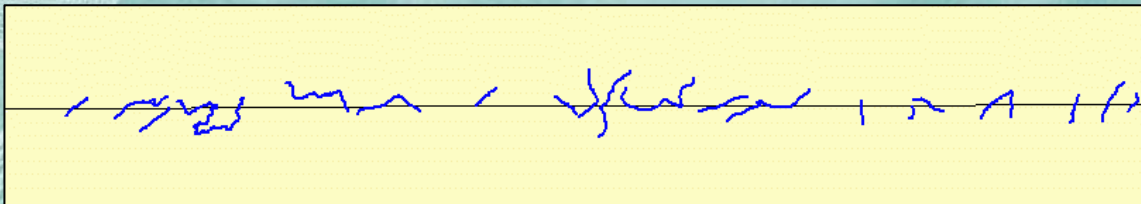
National Inventory  
of Dams



# Interstate Waters



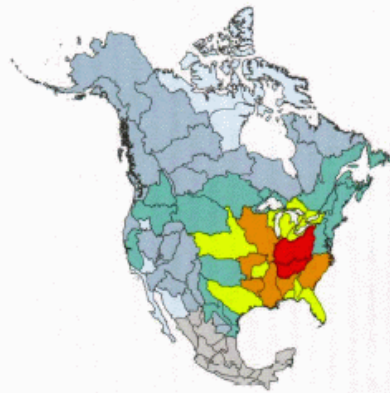
- Interstate (boundary) waters
- Also “across state line” interstate waters



Example of waters crossing state lines from the NHDPlus



# Valuable Information – Where Available



Distribution:  
Unionid species  
richness by  
ecoregion

Abell et al., 2000  
Freshwater ecoregions of  
North America: a  
conservation assessment.

LEGEND

|                 |                    |
|-----------------|--------------------|
| 100-125 species | 1-4 species        |
| 50-99 species   | No species present |
| 25-49 species   | No data            |
| 5-24 species    |                    |

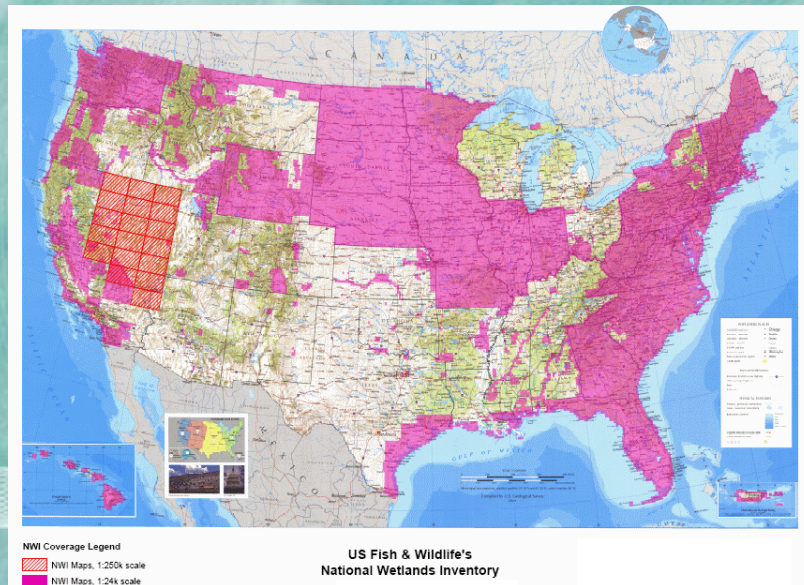
Figure 3.7a Unionid mussel richness.

Some public information from the  
Fish and Wildlife Service for  
Threatened & endangered aquatic  
species can be indexed to the NHD

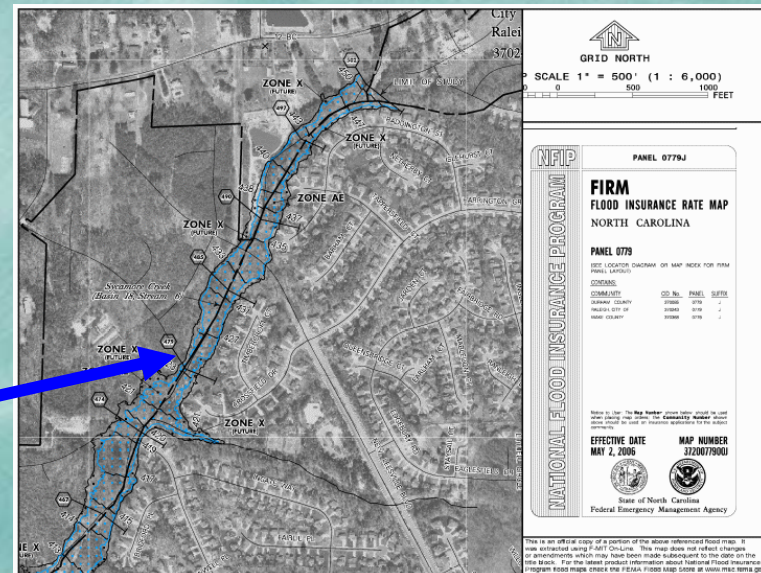




# Valuable Information – Where Available

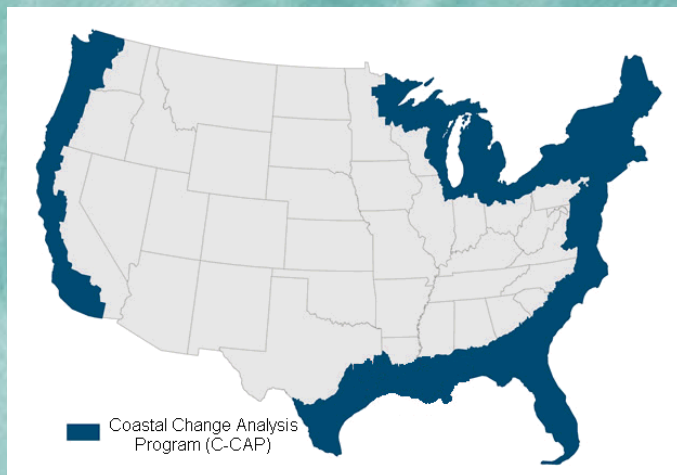


Digitized National Wetlands Inventory Data or Digital Flood Insurance Rate Maps (DFIRMs)

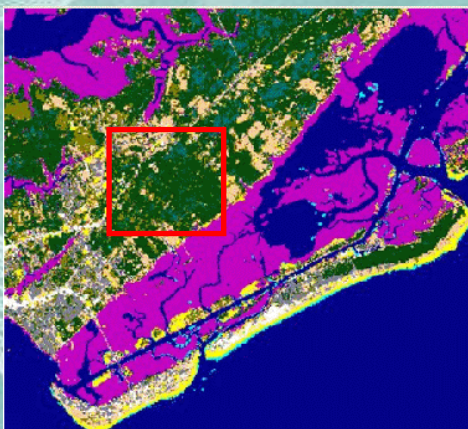




# Valuable Information – Where Available



Remote sensing-based documentation for trends in land use and land cover patterns (e.g., from NOAA's Coastal Change Analysis Program)



1972

Changes in  
Land use and  
Land Cover

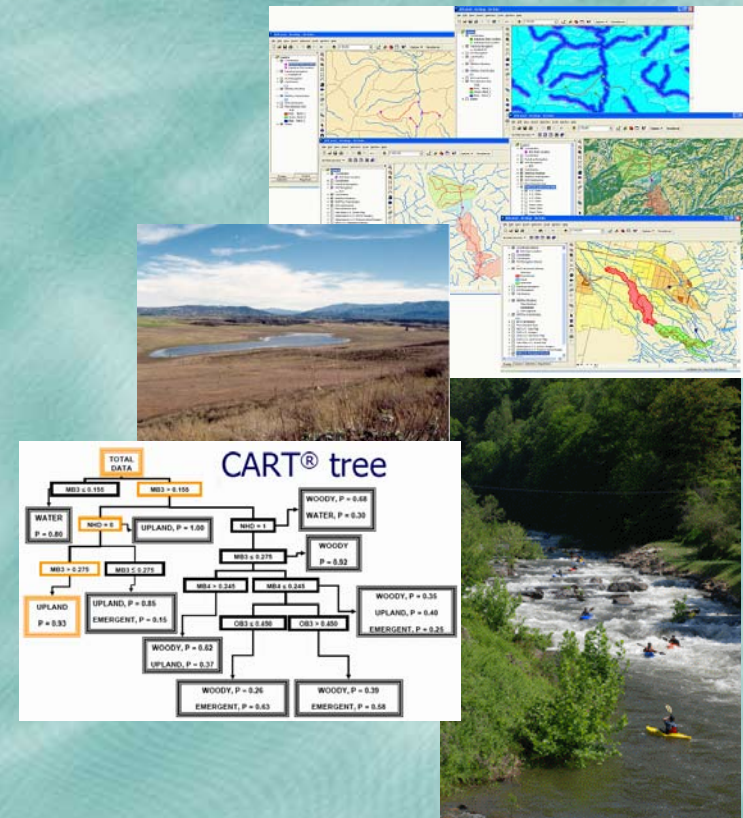


2000



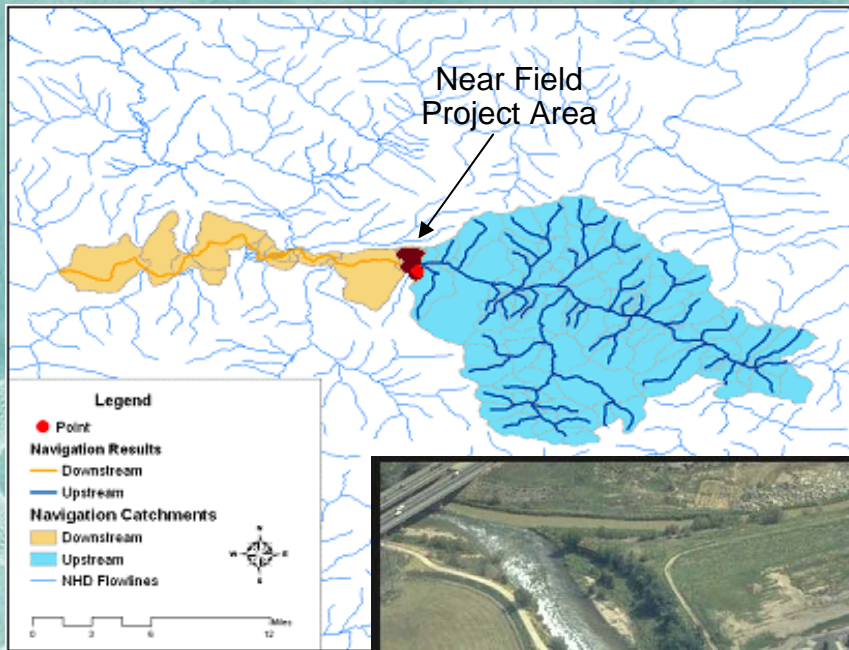
# Presentation Outline

- NHDPlus and the Significant Nexus Challenge
- Direct Approaches to Documenting Significant Nexus Status
- Near Field/Far field Frameworks using NHDPlus
- CART Analysis and “Training Datasets”





Documenting the services of a specific area of investigation encourages looking at both the “near field” and upstream and downstream “far field” areas



NHDPlus provides facilities for easy determination of flow paths and related catchments that fall, for instance, within a day's time of travel of a near field area of investigation



**Downstream waters**  
provide waste  
assimilation services

**Upstream waters**  
provide water  
storage/dilution services  
for downstream waste  
assimilation services



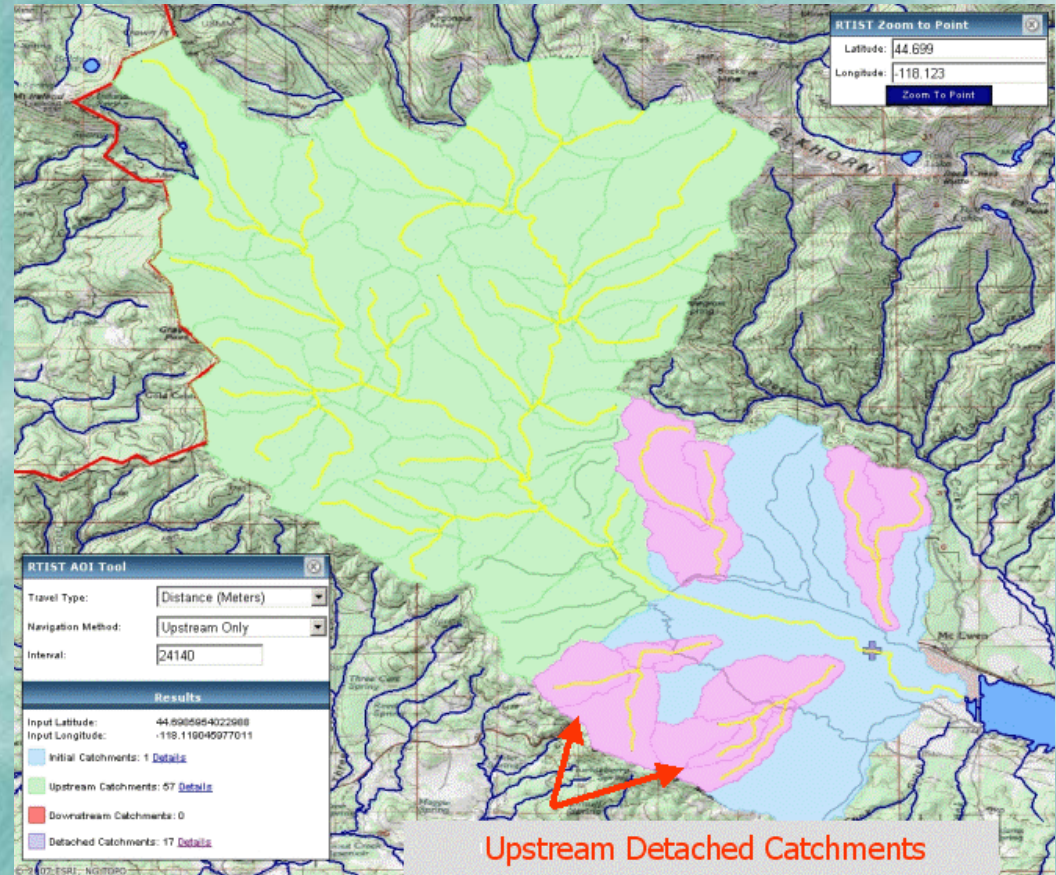
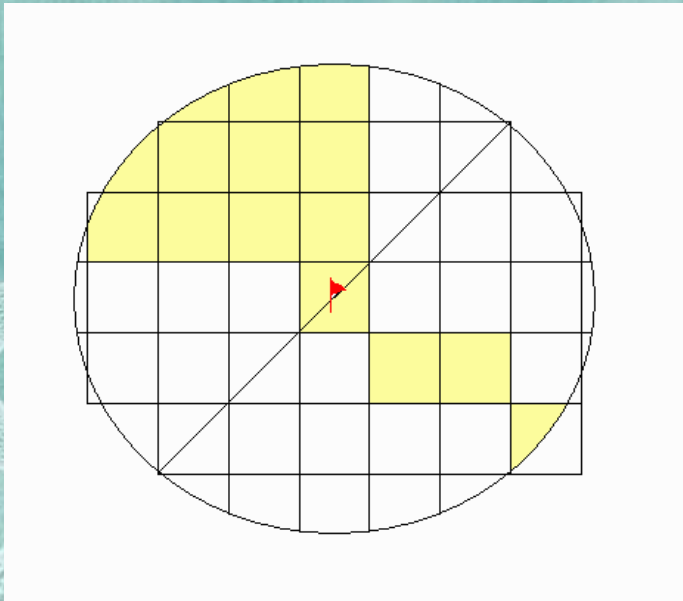
# Upstream “far field” areas of particular importance for drinking water source water protection areas



Analytical Source  
Protection Area for  
NHDPlus Catchments  
within One Day's Time  
of Travel Upstream from  
a Drinking Water Intake

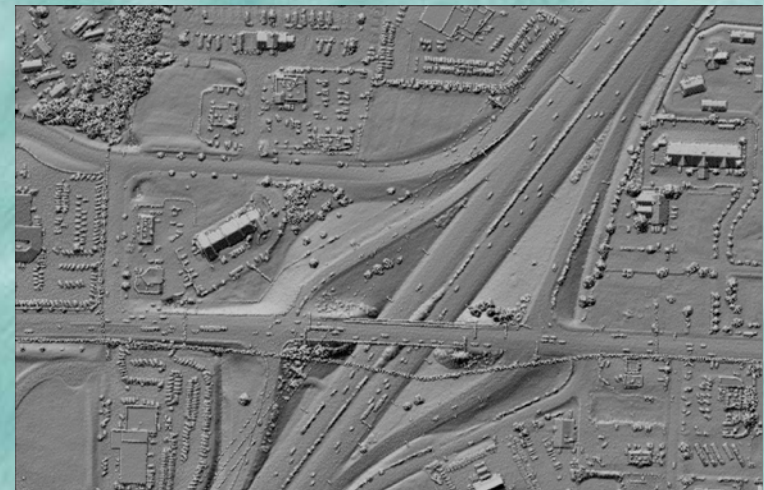
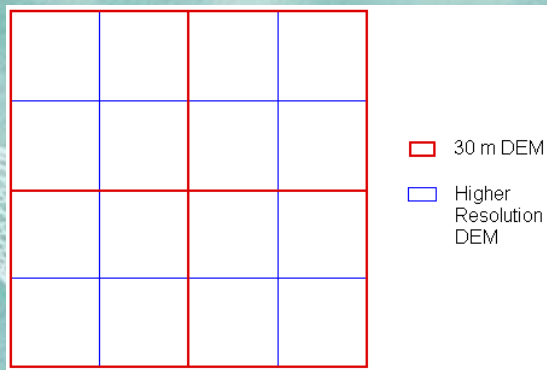
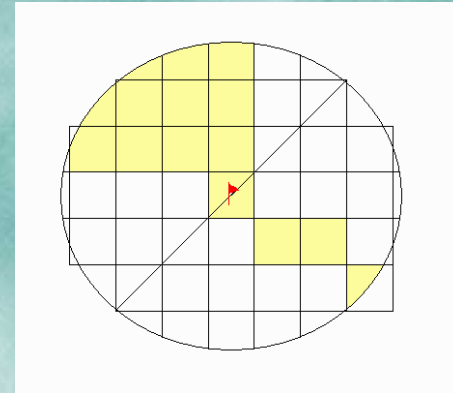


Near field/far field analysis frameworks can also be defined working from raster DEMs for areas of concern where line work in the medium resolution NHDPlus involves detached catchments or does not capture “missing streams”



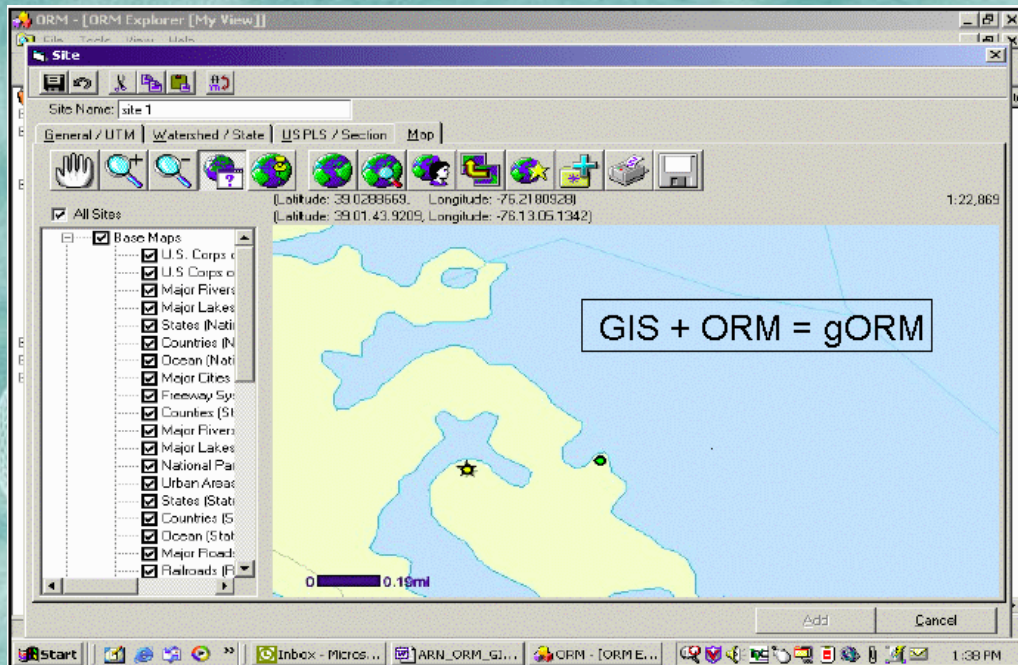


# Upstream/Downstream Frameworks using high resolution LIDAR can be used with the NHDPlus





# Finally: Share Information from CORPS Database and GIS Systems



- RAMS (and RAMSII)
- ORM
- gORM


Regulatory Analysis and Management System (**RAMS**)

Operations Management Business Information Link  
(**OMBIL**)

OMBIL Regulatory Module (**ORM**)

GIS combined with ORM (**gORM**)





# Framework

## ■ CART Analysis of Datasets

- [illegible]





Diagram illustrating the distribution of plant species across different habitats (Water, Upland, Emergent) based on their presence/absence (W, U, E) and associated probabilities (P).

- TOTAL DATA**
  - WATER** ( $P = 0.85$ )
    - W** ( $P = 0.85$ )
    - U** ( $P = 0.15$ )
  - UPLAND** ( $P = 0.15$ )
    - U** ( $P = 0.85$ )
    - E** ( $P = 0.15$ )

Further breakdown of species distribution:

- WATER** ( $P = 0.85$ )
  - W** ( $P = 0.85$ )
    - W** ( $P = 0.85$ )
    - U** ( $P = 0.15$ )
  - U** ( $P = 0.15$ )
    - U** ( $P = 0.85$ )
    - E** ( $P = 0.15$ )
- UPLAND** ( $P = 0.15$ )
  - U** ( $P = 0.85$ )
  - E** ( $P = 0.15$ )

Species distribution summary:

- WATER** ( $P = 0.85$ )
  - W** ( $P = 0.85$ )
  - U** ( $P = 0.15$ )
- UPLAND** ( $P = 0.15$ )
  - U** ( $P = 0.85$ )
  - E** ( $P = 0.15$ )

Diagram illustrating the distribution of plant species across different habitats (Water, Upland, Emergent) based on their presence/absence (W, U, E) and associated probabilities (P).

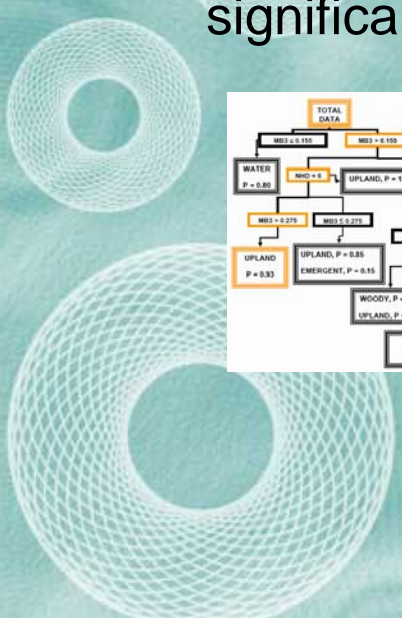
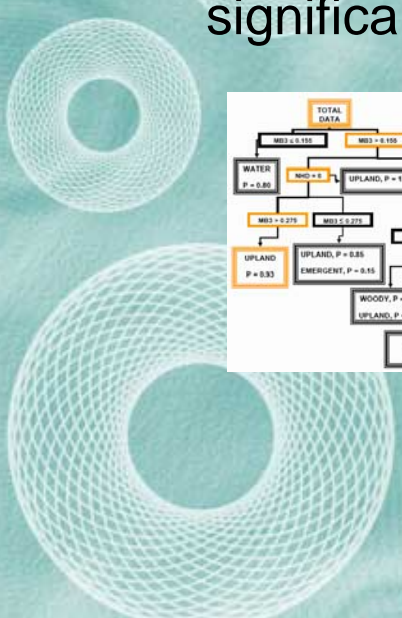
- TOTAL DATA**
  - WATER** ( $P = 0.85$ )
    - W** ( $P = 0.85$ )
    - U** ( $P = 0.15$ )
  - UPLAND** ( $P = 0.15$ )
    - U** ( $P = 0.85$ )
    - E** ( $P = 0.15$ )

Further breakdown of species distribution:

- WATER** ( $P = 0.85$ )
  - W** ( $P = 0.85$ )
    - W** ( $P = 0.85$ )
    - U** ( $P = 0.15$ )
  - U** ( $P = 0.15$ )
    - U** ( $P = 0.85$ )
    - E** ( $P = 0.15$ )
- UPLAND** ( $P = 0.15$ )
  - U** ( $P = 0.85$ )
  - E** ( $P = 0.15$ )

Species distribution summary:

- WATER** ( $P = 0.85$ )
  - W** ( $P = 0.85$ )
  - U** ( $P = 0.15$ )
- UPLAND** ( $P = 0.15$ )
  - U** ( $P = 0.85$ )
  - E** ( $P = 0.15$ )

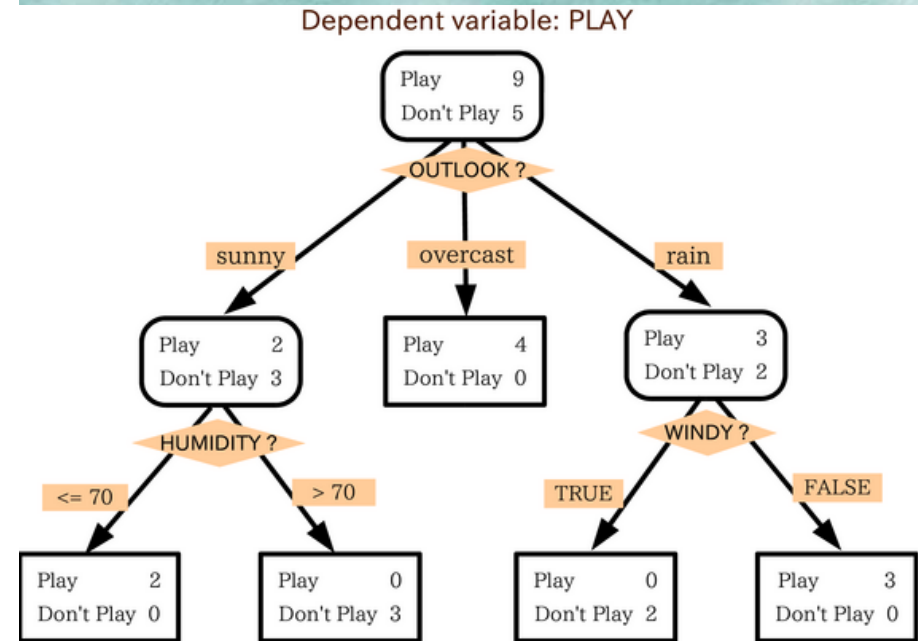




# CART is a decision tree data mining tool

Play golf dataset

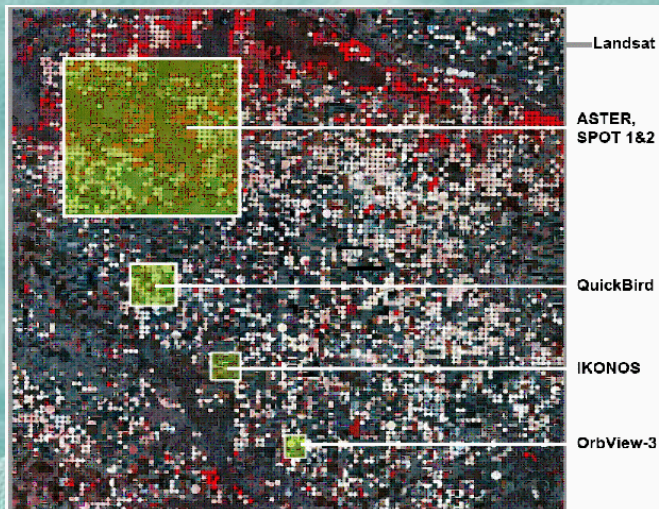
| Independent variables |             |          |       | Dep. var   |
|-----------------------|-------------|----------|-------|------------|
| OUTLOOK               | TEMPERATURE | HUMIDITY | WINDY | PLAY       |
| sunny                 | 85          | 85       | FALSE | Don't Play |
| sunny                 | 80          | 90       | TRUE  | Don't Play |
| overcast              | 83          | 78       | FALSE | Play       |
| rain                  | 70          | 96       | FALSE | Play       |
| rain                  | 68          | 80       | FALSE | Play       |
| rain                  | 65          | 70       | TRUE  | Don't Play |
| overcast              | 64          | 65       | TRUE  | Play       |
| sunny                 | 72          | 95       | FALSE | Don't Play |
| sunny                 | 69          | 70       | FALSE | Play       |
| rain                  | 75          | 80       | FALSE | Play       |
| sunny                 | 75          | 70       | TRUE  | Play       |
| overcast              | 72          | 90       | TRUE  | Play       |
| overcast              | 81          | 75       | FALSE | Play       |
| rain                  | 71          | 80       | TRUE  | Don't Play |



Simple decision tree using numeric, categorical and true/false data



MDA Federal has applied CART techniques to build the 2001 NLCD, to predict depths to groundwater, and in other analyses



### Decision Tree Model

If  $(x_1 < 5 \ \& \ x_2 > 3 \ \& \ x_3 < 12)$  then  $y =$

**Class 1**

If  $(x_1 > 8 \ \& \ x_2 > 5 \ \& \ x_3 < 14)$  then  $y =$

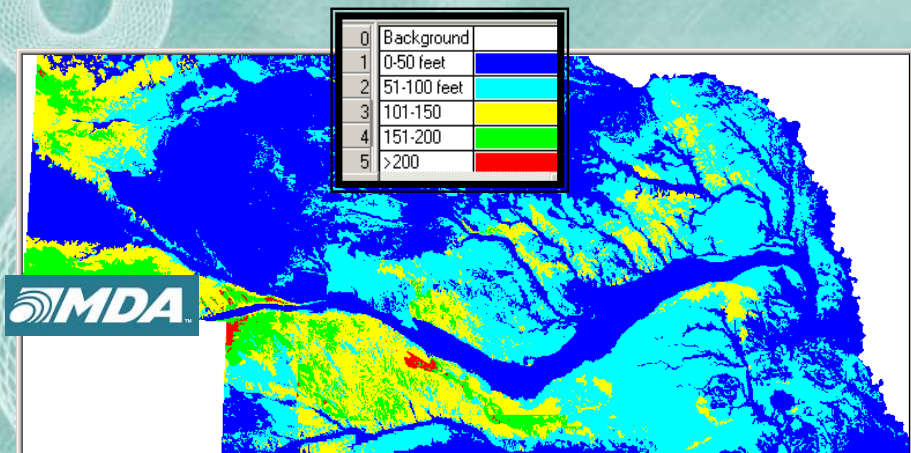
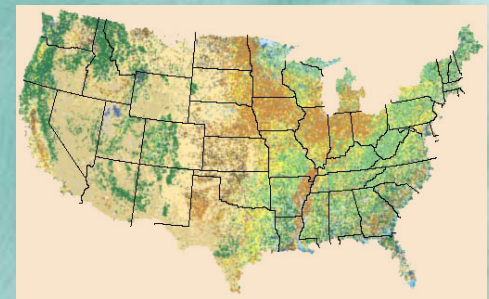
**Class 2**

If  $(x_1 > 9 \ \& \ x_2 > 3 \ \& \ x_3 < 11)$  then  $y =$

**Class 3**

If  $(x_1 < 3 \ \& \ x_2 > 6 \ \& \ x_3 < 10)$  then  $y =$

**Class 1**



### Regression Tree Model

If  $(x_1 < 5 \ \& \ x_2 > 3 \ \& \ x_3 < 12)$  then  $y = .5 \cdot x_1 + .4x_2 + .3x_3 + .8$

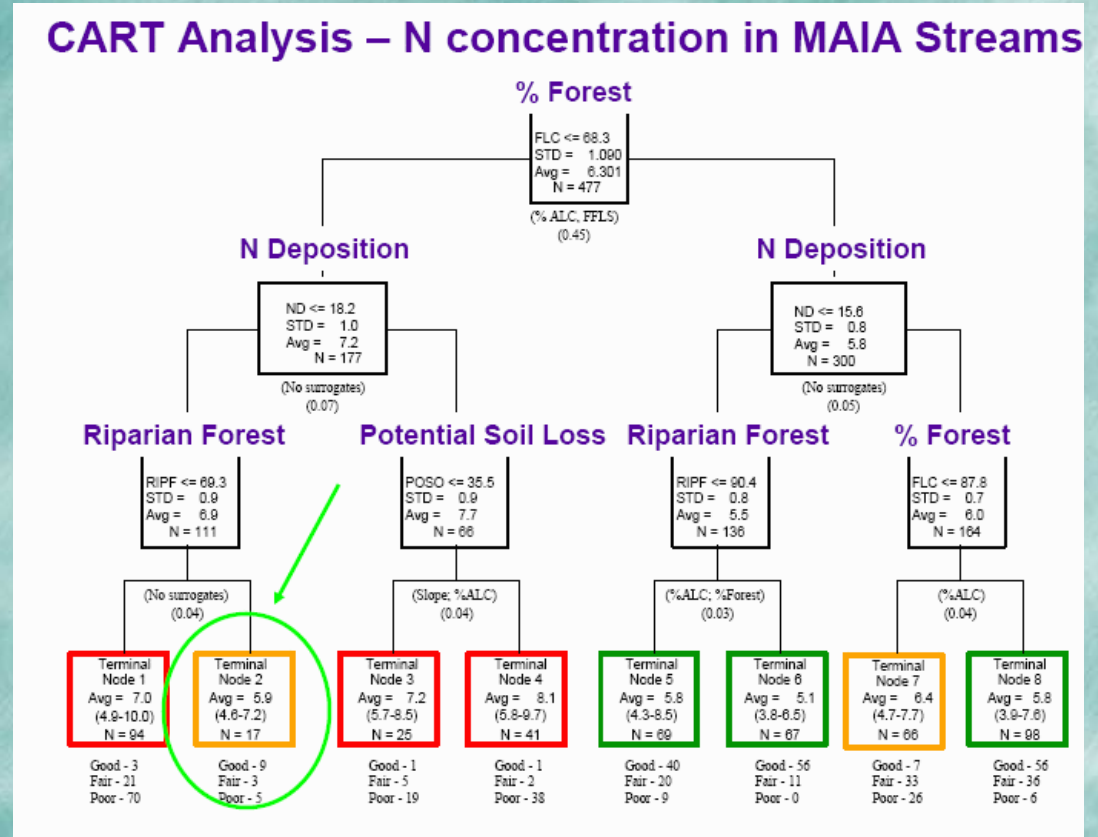
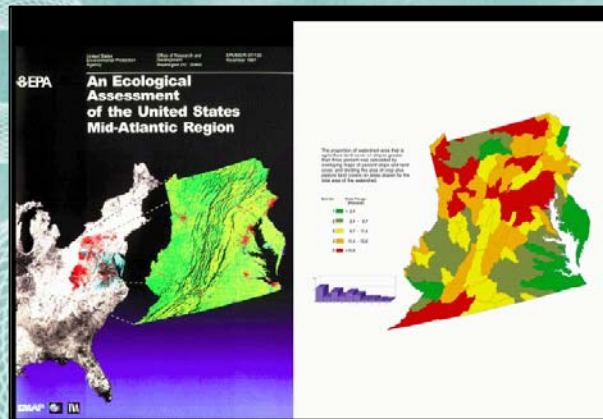
If  $(x_1 > 8 \ \& \ x_2 > 5 \ \& \ x_3 < 14)$  then  $y = .3 \cdot x_1 + .2x_2 + .4x_3 + .6$

If  $(x_1 > 9 \ \& \ x_2 > 3 \ \& \ x_3 < 11)$  then  $y = .4 \cdot x_1 + .6x_2 + .1x_3 + .3$

If  $(x_1 < 3 \ \& \ x_2 > 6 \ \& \ x_3 < 10)$  then  $y = .1 \cdot x_1 + .2x_2 + .6x_3 + .1$

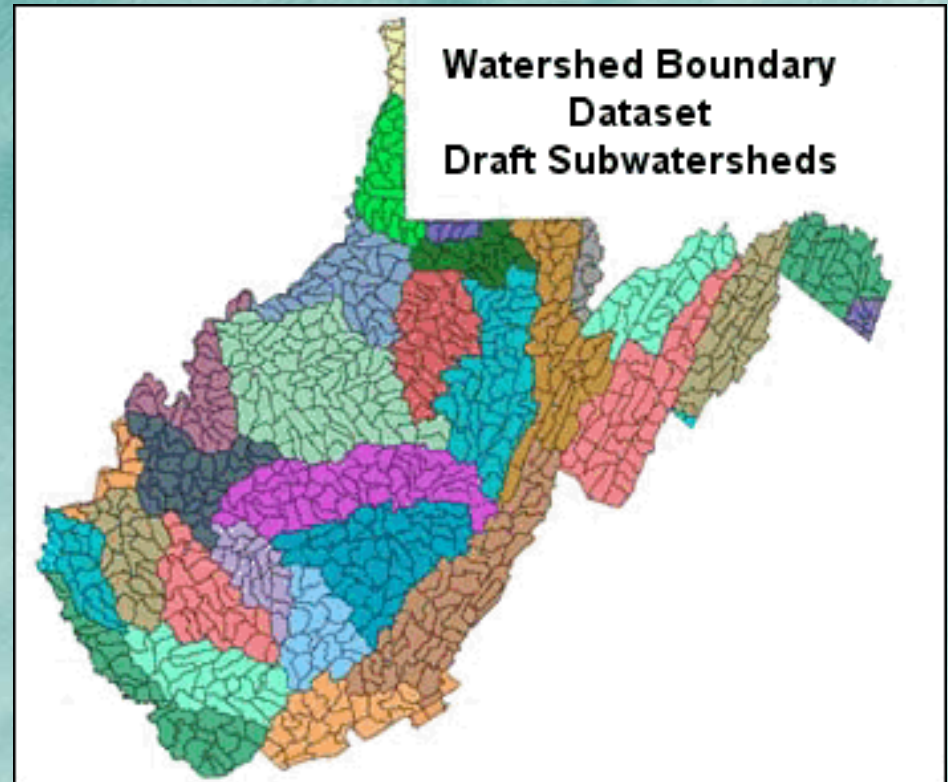
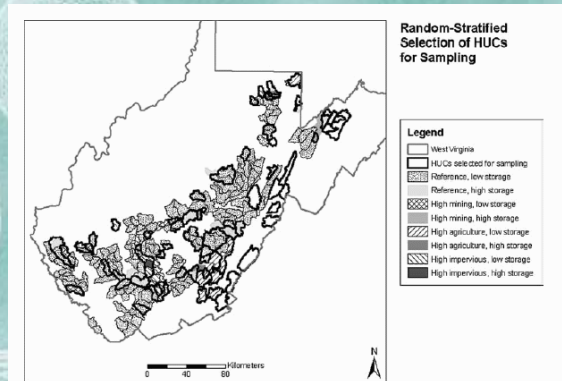
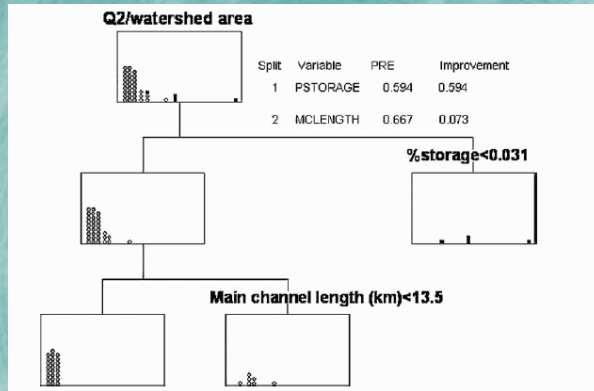


# CART analyses have related information for sites to information for HUC8s based on MAIA data





# CART analyses using HUC12s to anchor the “far field”



Detenbeck, Naomi, Dan Cincotta, Judith Denver, Susan Greenlee, Anthony Olsen, and and Pitchford. 2005. Watershed-based Survey Designs. Environmental Monitoring and Assessment (2005) 103: 59–81. DOI: 10.1007/s10661-005-4774-7.

Detenbeck, Naomi and Dan Cincotta. 2008. Comparability of a regional and state survey: effects on fish IBI assessment for West Virginia, U.S.A. Hydrobiologia. DOI 10.1007/s10750-008-9278-3.



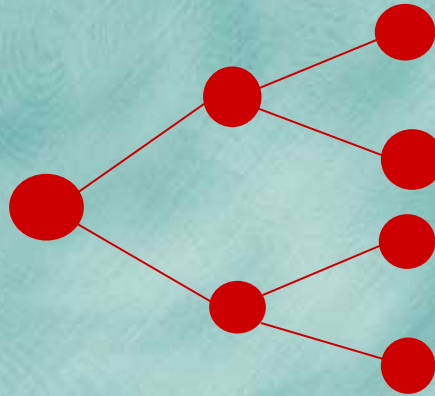
# CART packages are available in both commercial and open source implementations



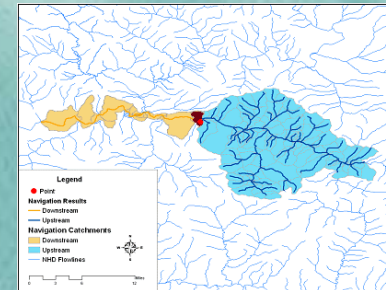
Leo Breiman



John Ross Quinlan



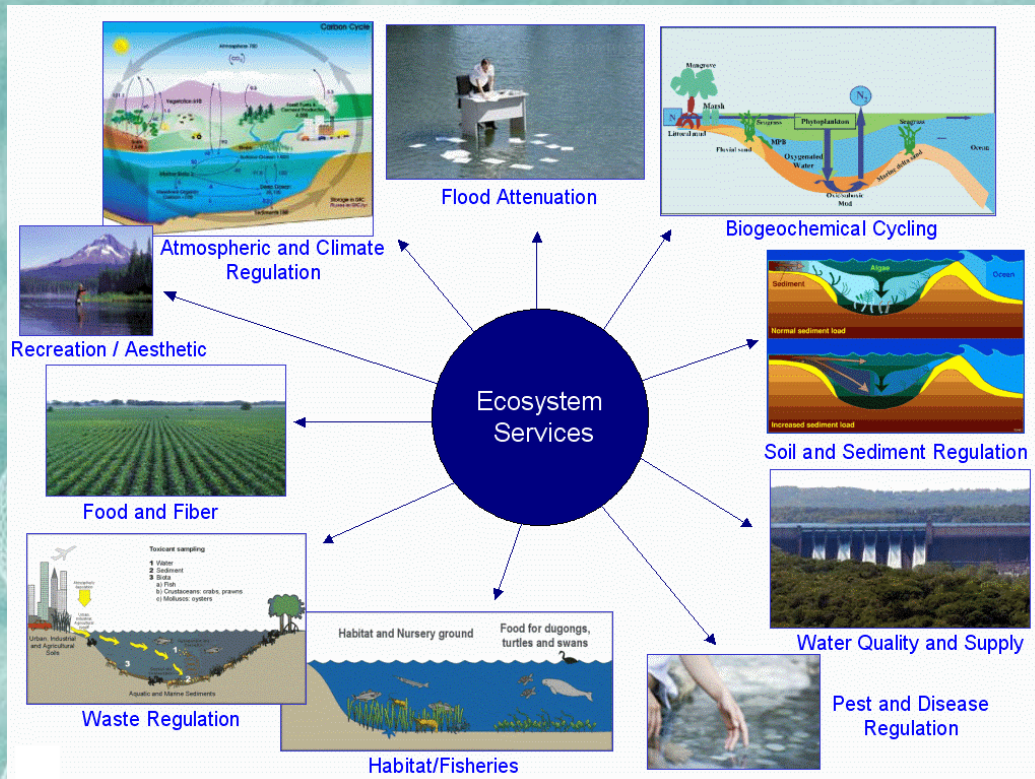
Implementing CART as a decision support tool requires selecting suitable TRAINING DATA SETS ...



With near field/far field spatial frameworks defined using analytical time of travel considerations using (wherever possible) the NHDplus catchments



# CART training datasets needed to document features suggesting the presence of important ecosystem services

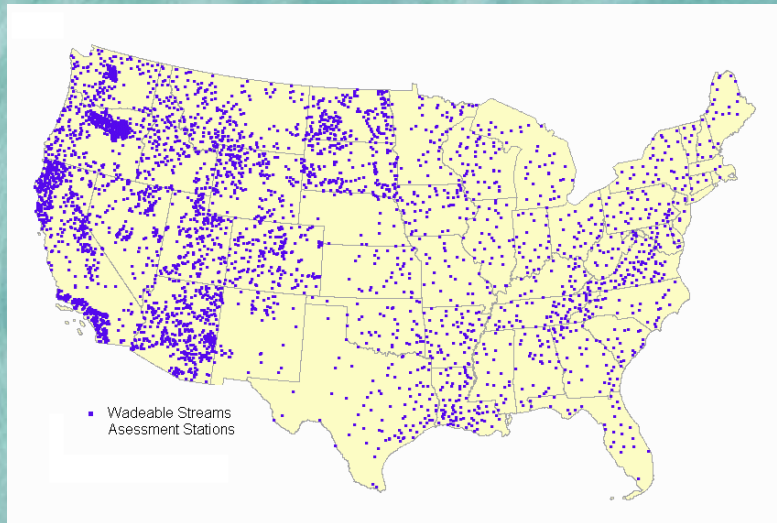


- information sources for river/stream areas of investigation
- will likely be different from the information sources for wetlands

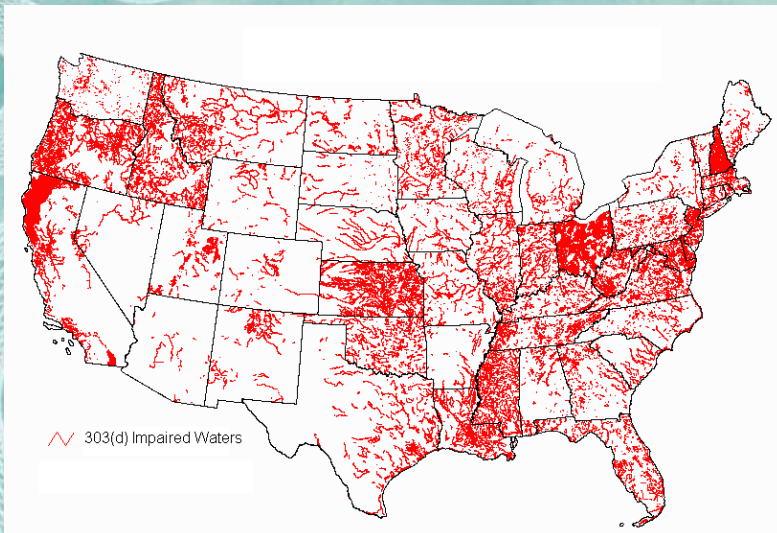




# CART training datasets for rivers/streams

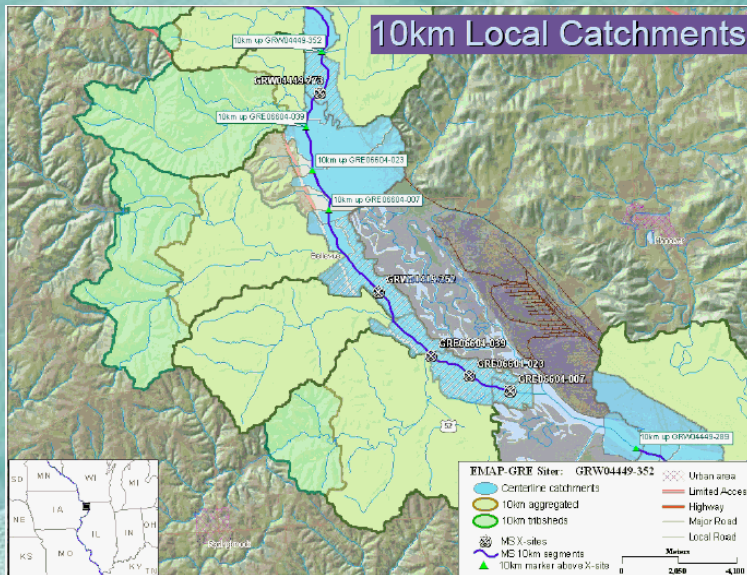


- Wadeable Streams Assessment
- Impaired Waters (Total Maximum Daily Loads)





# Wadeable Stream Assessment (WSA) and new Great Rivers Ecosystem (GRE) data



<http://www.epa.gov/emap/greatriver/grewkshp.html>

Indicators for the Assessment of Great River Ecosystems  
EMAP-GRE Workshop, October 24-26, 2006, Duluth, MN

Mary Moffett, US EPA, Duluth, MN, Landscape data

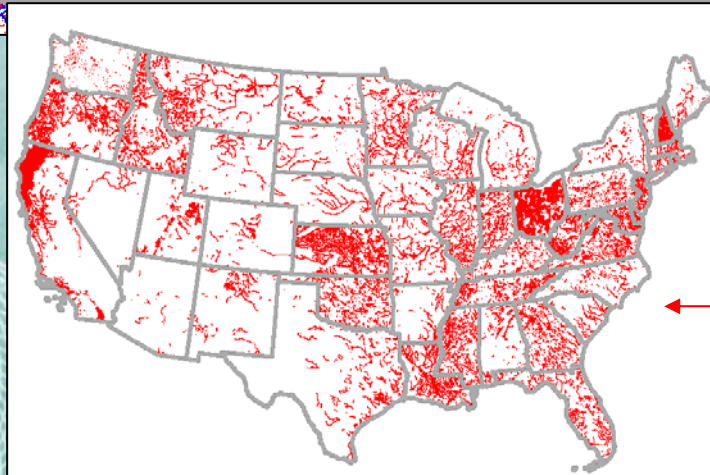
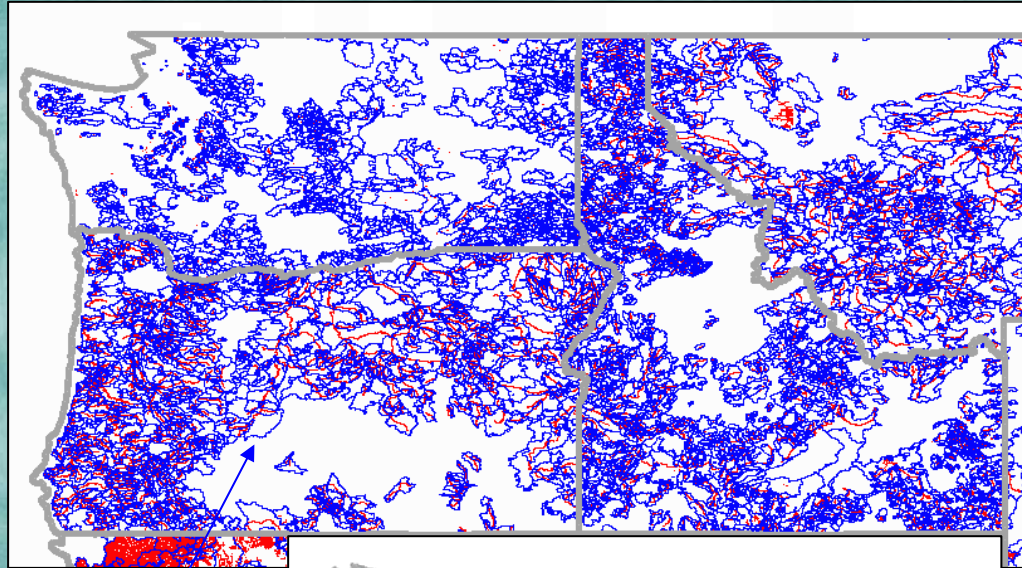
<http://epa.gov/emap/greatriver/indicator/MoffetLandscape.pdf>

- WSA provides unbiased station selection project design
- Includes data related to habitat, biological integrity and other ecosystem services
- New GRE information makes explicit use of analytical local and regional watersheds relative to monitoring station locations
- Upstream analytical watersheds based on NHDPlus catchments





# Total Maximum Daily Load (TMDL) Information



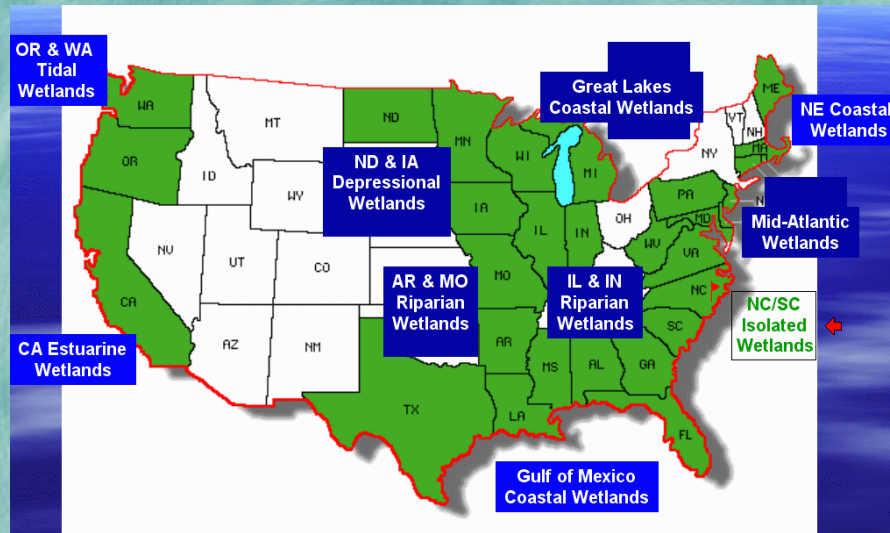
- A major water quality-based program for the EPA Office of Water
- Initial “impaired waters” georeferenced to the NHD
- Upstream (and downstream) watersheds can be defined based on NHDPlus catchments
- Information for “established” TMDLs can provide information related to ecological services

1 day time of  
travel upstream  
watersheds  
based on  
NHDPlus  
catchments

Impaired waters based  
on NHDPlus reaches



# CART training datasets for wetlands



EMAP-style probability surveys only at a pilot stage



- Use Corps datasets with GIS location information
- Use new National Wetland Inventory studies with “landform” information
- Avoid basing training data on manually abstracted information (e.g., from “JD Forms”)

**APPROVED JURISDICTIONAL DETERMINATION FORM**  
U.S. Army Corps of Engineers

This form should be completed by following the instructions provided in Section IV of the JD Form Instructional Guidebook.

**SECTION I: BACKGROUND INFORMATION**

**A. REPORT COMPLETION DATE FOR APPROVED JURISDICTIONAL DETERMINATION (JD):** [REDACTED]

**B. DISTRICT OFFICE, FILE NAME, AND NUMBER:**

**C. PROJECT LOCATION AND BACKGROUND INFORMATION:**  
 State: \_\_\_\_\_ County/parish/borough: \_\_\_\_\_ City: \_\_\_\_\_  
 Center coordinates of site (lat/long in degree decimal format): Lat. ° **Pick List**, Long. ° **Pick List**  
 Universal Transverse Mercator: \_\_\_\_\_  
 Name of nearest waterbody: \_\_\_\_\_  
 Name of nearest Traditional Navigable Water (TNW) into which the aquatic resource flows: \_\_\_\_\_  
 Name of watershed or Hydrologic Unit Code (HUC): \_\_\_\_\_  
☐ Check if map/diagram of review area and/or potential jurisdictional areas is/are available upon request.  
☐ Check if other sites (e.g., offsite mitigation sites, disposal sites, etc...) are associated with this action and are recorded on a different JD form.

**D. REVIEW PERFORMED FOR SITE EVALUATION (CHECK ALL THAT APPLY):**  
☐ Office (Desk) Determination. Date: \_\_\_\_\_  
☐ Field Determination. Date(s): \_\_\_\_\_

**SECTION II: SUMMARY OF FINDINGS**

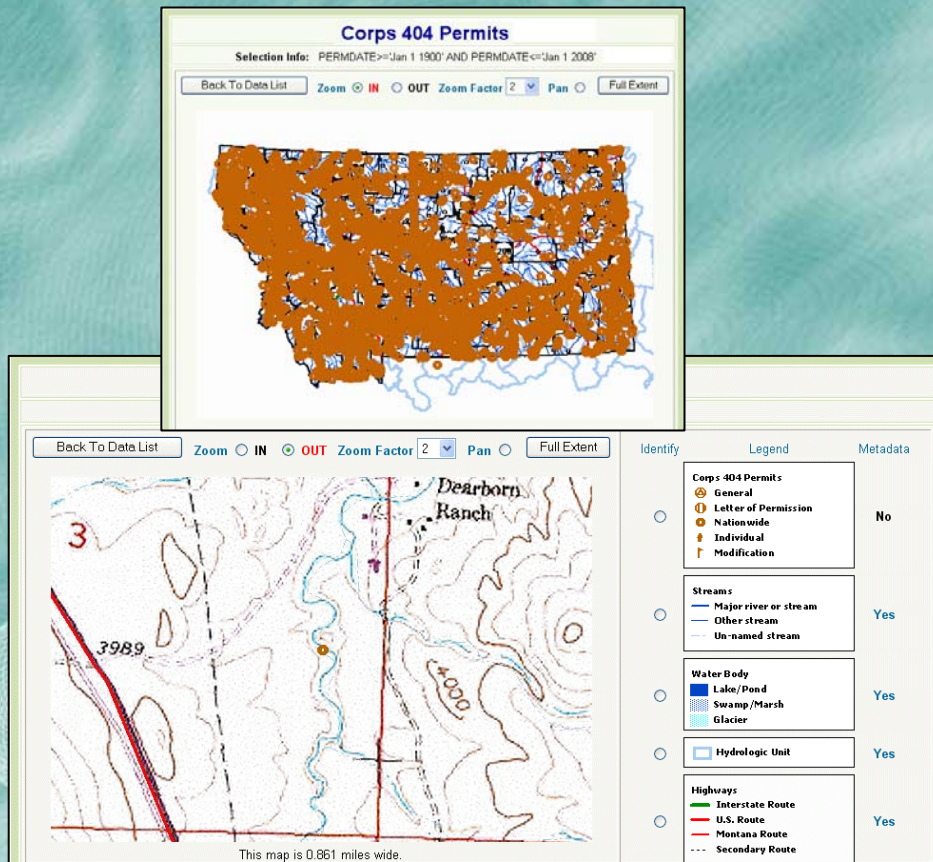
**A. RHA SECTION 10 DETERMINATION OF JURISDICTION.**

There **Pick List** “navigable waters of the U.S.” within Rivers and Harbors Act (RHA) jurisdiction (as defined by 33 CFR part 329) in the



# Wetlands Information from the CORPS

- Older RAMS systems (e.g., for Montana)
- New OMBIL Regulatory Module (ORM) data



Montana Natural Resource Information System

<http://nris.mt.gov/default.asp>

<http://maps2.nris.state.mt.us/mapper/>

Corps 404 Permit Query System (permit records through the year 2003)

<http://maps2.nris.mt.gov/mapper/Corp404/CorpMain.asp>

Impacts of the 404 Permit Program on Wetlands and Waterways in Montana

[http://mtaudubon.org/html/take\\_action\\_streams\\_and\\_marshes\\_404\\_report.htm](http://mtaudubon.org/html/take_action_streams_and_marshes_404_report.htm)



# New National Wetlands Inventory (NWI) Studies and C-CAP

## Expanding National Wetlands Inventory Data to Predict Wetland Functions for Watersheds

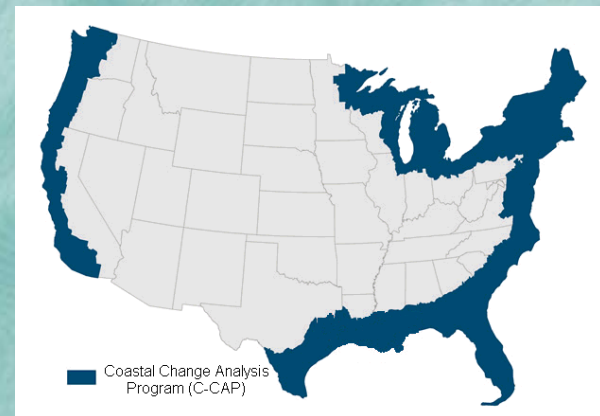
Ralph Tiner  
Wetland Ecologist  
U.S. Fish & Wildlife Service  
National Wetlands Inventory Program

<http://www.aswm.org/calendar/wetlands2007/tiner.pdf>

- Use new NWI studies applying “LLWW” Use new National Wetland Inventory studies with “landform” information
- Take advantage of time trend potential in coastal areas using NOAA’s **Coastal Change Analysis Program (C-CAP)** landcover data

### LLWW Descriptors

- Landscape Position - relationship between a wetland and an adjacent waterbody or not
- Landform - shape or physical form
- Water Flow Path - directional flow of water
- Waterbody Type – more specificity







# ***NHDPlus as the Core for Significant Nexus Analysis***

**NWQMC Sixth National Monitoring Conference  
May 20-24, 2008  
Atlantic City, NJ**

**Authors:**

**William Cooter, RTI International (presenter)  
Jay Rineer, RTI International  
Brandon Bergenroth, RTI International  
Shel Brannan, RTI International  
Kevin Pickren, RTI International  
David Cunningham, MDA Federal (EarthSat)**