The USGS Upper Delaware Decision Support System (DSS) for Ecological Flows

Kelly O. Maloney, Heather S. Galbraith, Jeffrey Cole, & Carrie Blakeslee *Northern Appalachian Research Lab, Wellsboro PA*

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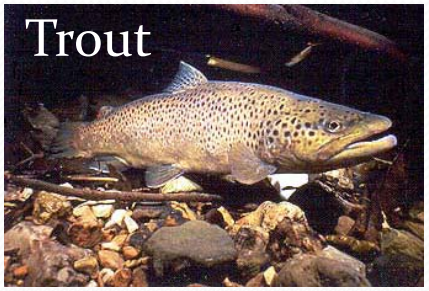
USGS

WaterSMART

Tool to Support Management

- Evaluate how different flow scenarios affect instream habitat for biota
- Incorporate a suite of taxa
- User-friendly, updateable, etc.

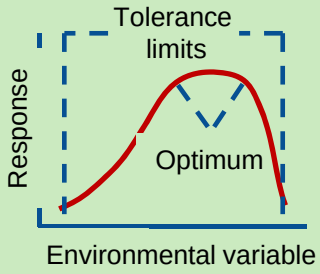
American eel



Tool to Support Management

Flow Release Model (OASIS)

Habitat Suitability Criteria (HSCs)

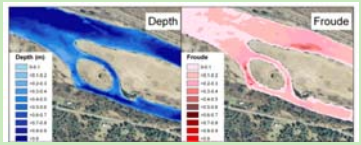


Synthesis Tool (DSS)

Temperature & Other Parameters

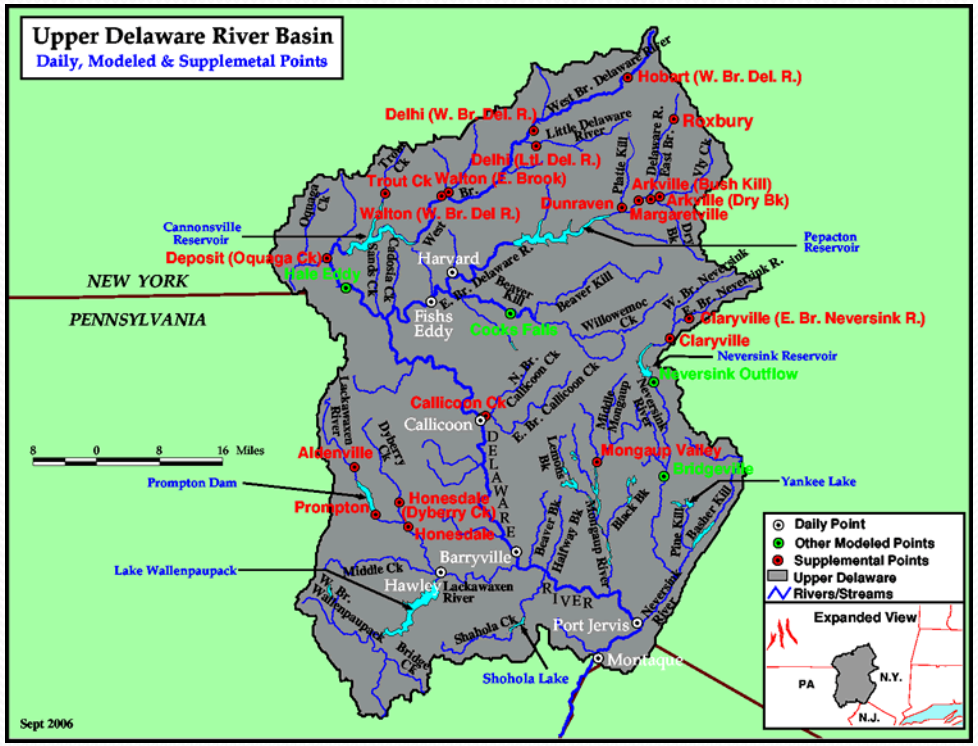
$$T_w = k + a_1 T_a + a_2 T_a^2 + a_3 H + a_4 W + a_5 S + a_6 Q_1 + a_7 (Q_2 - Q_1) + a_8 Y T_w$$

Flow-Specific Estimates of Habitat

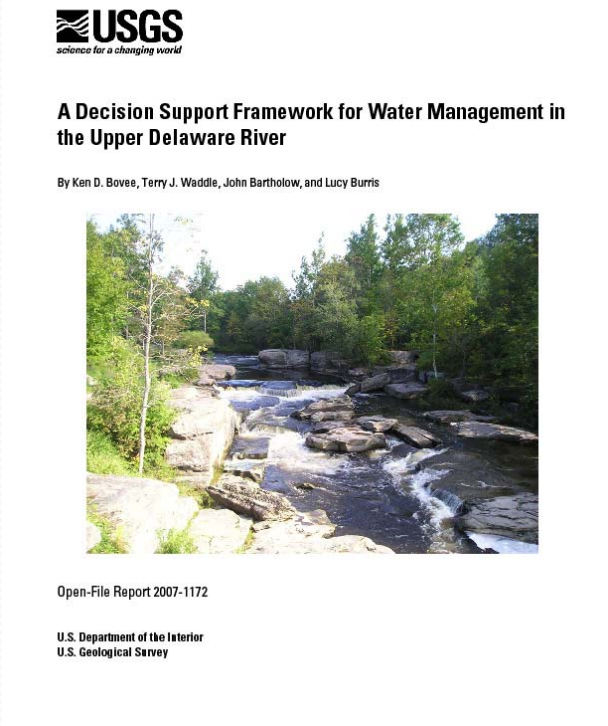


Current Decision Support System

Upper Delaware



Bovee et al. 2007



USGS
science for a changing world

A Decision Support Framework for Water Management in the Upper Delaware River

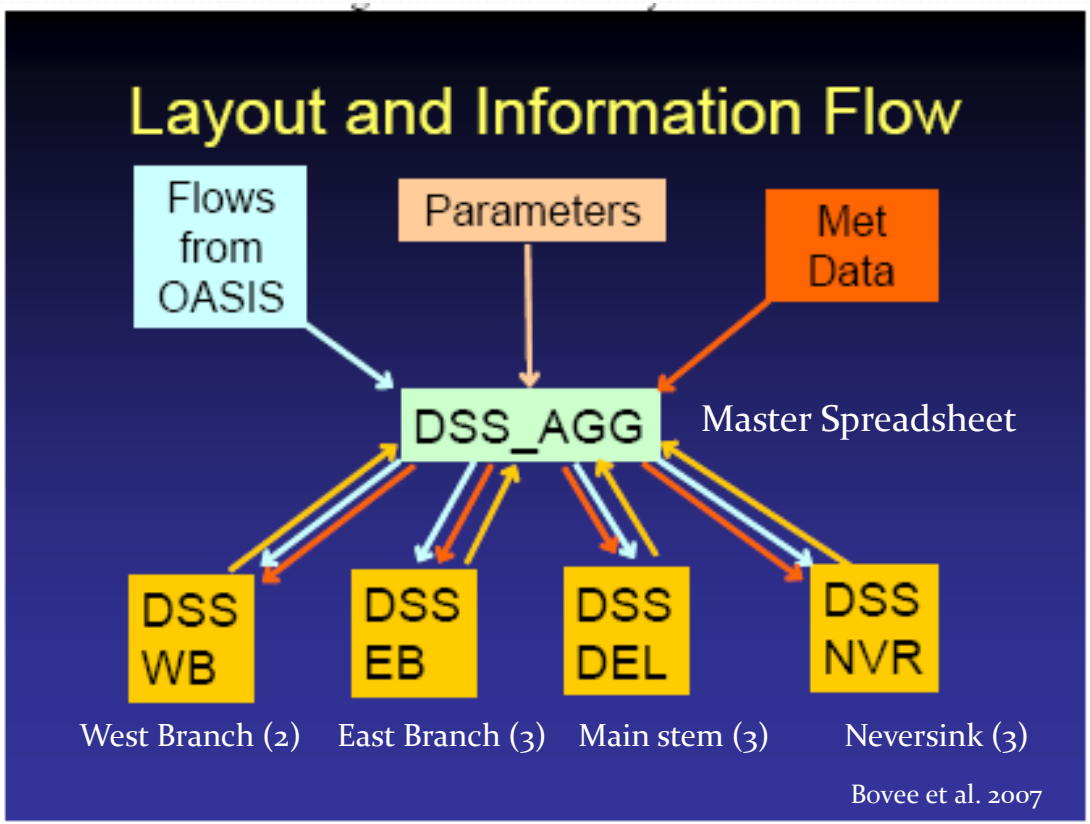
By Ken D. Bovee, Terry J. Waddle, John Bartholow, and Lucy Burris

Open-File Report 2007-1172

U.S. Department of the Interior
U.S. Geological Survey

Current Decision Support System

- 11 reaches
- 4 species
- 2 fish guilds
- Integrates:
  - OASIS estimates
  - Temperature
  - User defined parameters
  - Habitat curves



Current Decision Support System

- Platform: Excel
- Output:
  - Summary stats available by flow scenario

October - April 15

Resource	West Branch Pct Chg	West Branch Δ Hab	West Branch Pct Chg	West Branch ΔTCondHab	East Branch Pct Chg	East Branch Δ Hab	East Branch Pct Chg	East Branch ΔTCondHab
Trout Adult, ha	21%	13.50			8%	12.31		
Trout Spawning/Incu, ha	91%	2.39			3%	0.10		
SSCV, ha	8%	1.11			-9%	-2.64		
SFCV, ha	52%	2.44			41%	1.04		
Shad Juvenile, ha								
Shad Spawning, ha								
Dwarf Wedge Mussel, ha								
Spills, minor, count	-6%	-1.00			14%	1.00		
Spills, moderate, count	13%	2.00			15%	2.00		
Spills, major, count	-13%	-2.00			-14%	-4.00		

April 16 - June

Resource	West Branch Pct Chg	West Branch Δ Hab	West Branch Pct Chg	West Branch ΔTCondHab	East Branch Pct Chg	East Branch Δ Hab	East Branch Pct Chg	East Branch ΔTCondHab
Trout Adult, ha	16%	11.47	16%	11.41	4%	6.77	4%	6.84
Trout Spawning/Incu, ha								
SSCV, ha	2%	0.24	2%	0.24	-4%	-0.84	-3%	-0.77
SFCV, ha	11%	0.40	11%	0.40	8%	0.24	8%	0.24
Shad Juvenile, ha								
Shad Spawning, ha					16%	5.50	16%	5.50
Dwarf Wedge Mussel, ha								
Spills, minor, count	0%	0.00			14%	1.00		
Spills, moderate, count	0%	0.00			-21%	-8.00		
Spills, major, count	0%	0.00			-5%	-2.00		

Figure 11. Expanded view of the scoring summary page, showing details of the scores and metrics for biological resources and spills in the DRDSS.

Improving Management of Ecological Water Needs - **Objectives**

- Add 2010 hydrodynamic modeling data for three main stem reaches & extend time coverage
- Update habitat suitability criteria for biota and include additional species
- Extend meteorological data and test temperature model
- Develop an improved DSS platform
- Extend coverage – from dams to Trenton NJ

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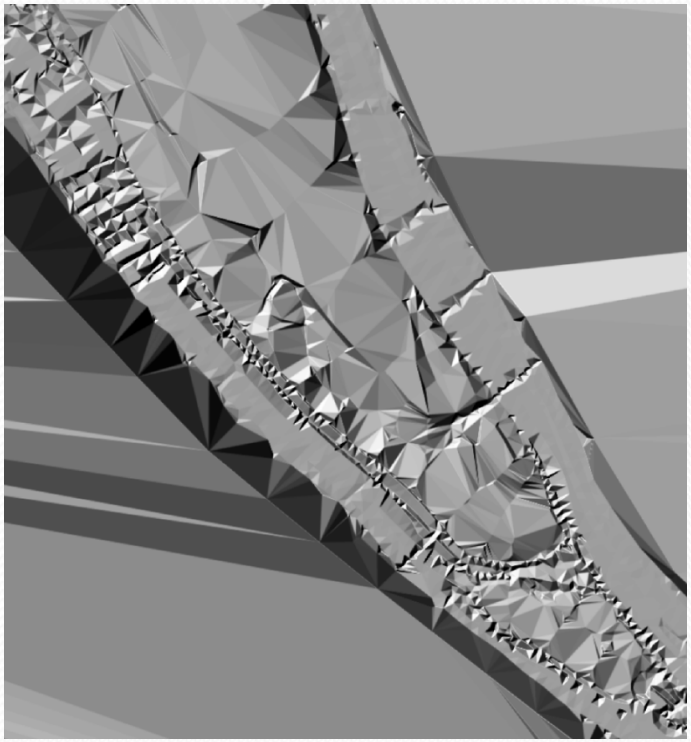
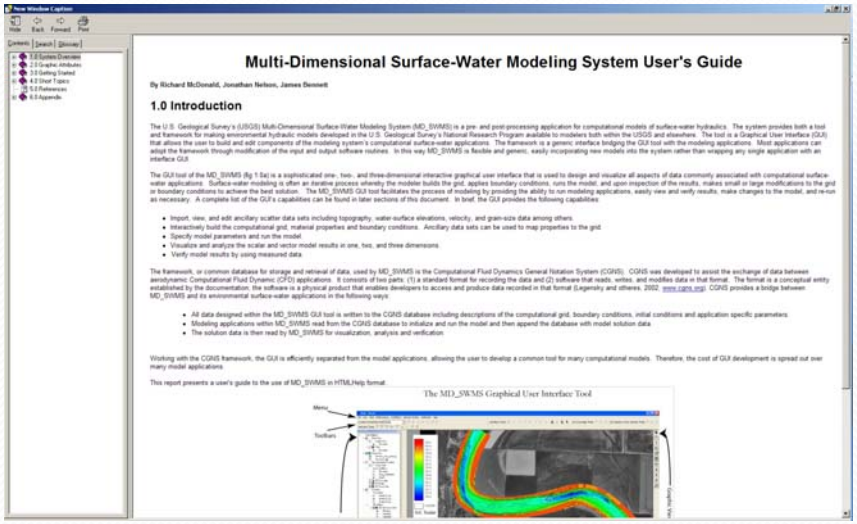
2010 data

- 2010 high resolution bathymetry – 3 main stem reaches

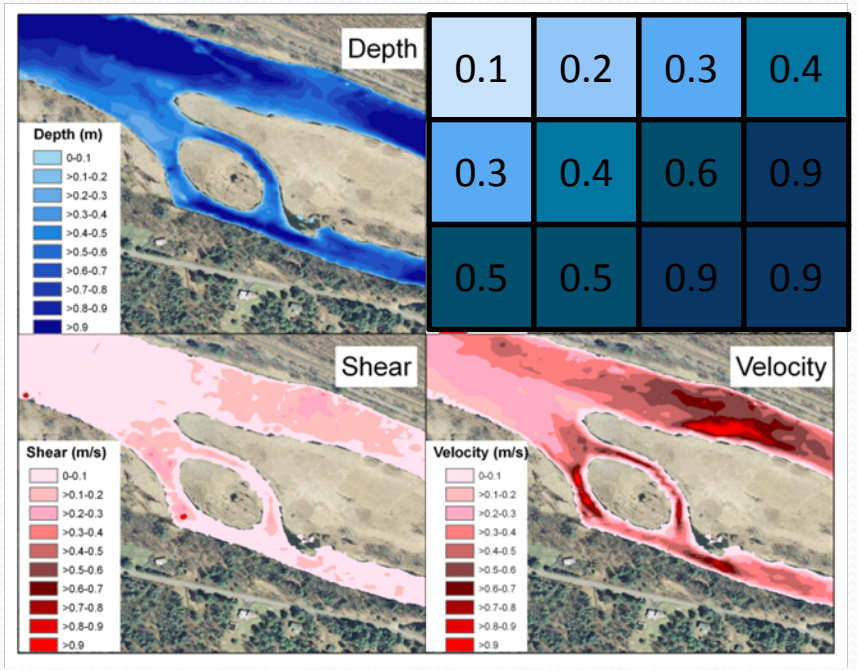


2010 data

2-D hydrodynamic models

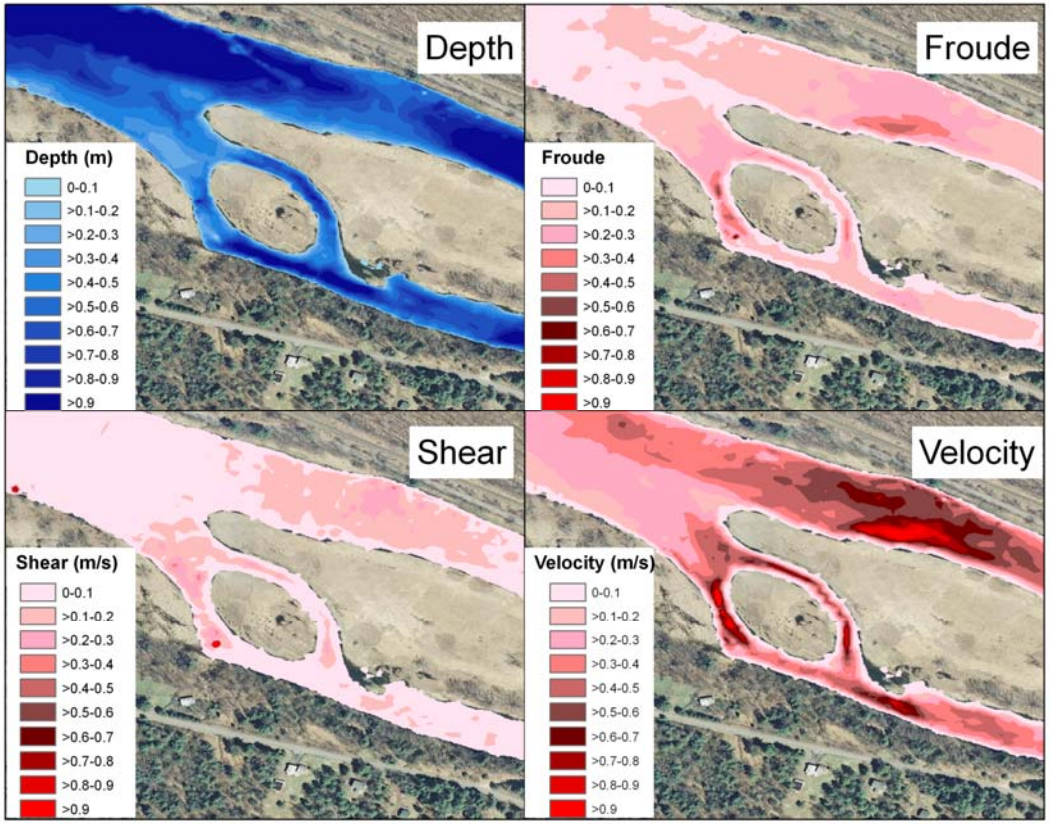


Pixel-scale output



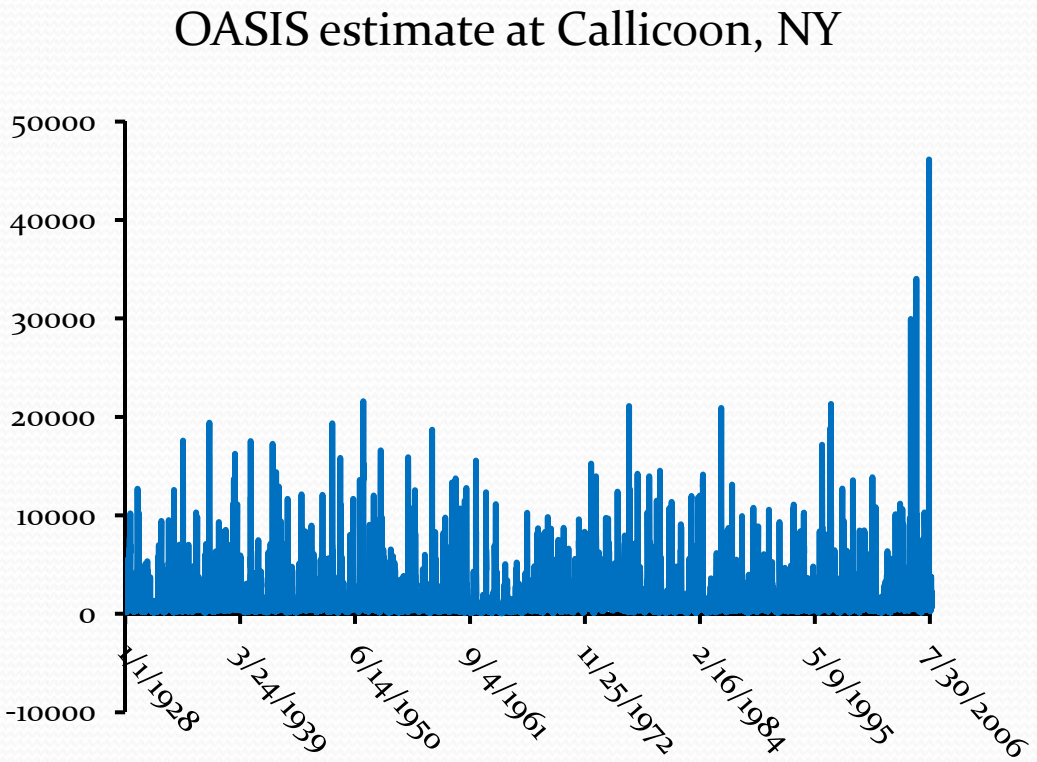
2010 data

- Better hydrodynamic model estimates for sedentary taxa/life stages



Extend time coverage of DSS

- Incorporate OASIS model outputs over range of time (1928 – 2006)
- Add FFMP



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Revised Habitat Suitability Curves (HSC)

- Bovee et al. 2007: Delphi technique
  - Questionnaire to experts

Suitable depth and velocity ranges for target organisms, as defined by the Delphi panel.

Target Organism	Depth Range (m)	Velocity Range (m/s)	Temperature
Brown trout adult	0.3–100[1]	0.0–1.0	
Brown trout juvenile	0.2–0.8	0.0–0.7	
Brown trout spawning	0.2–0.6	0.3–0.81	
Brown trout incubation	0.2–1.0	0.15–1.2	
Rainbow trout adult	0.3–100[1]	0.0–1.2	
Rainbow trout juvenile	0.2–1.0	0.0–0.8	
American shad spawning	0.3–3.0	0.2–0.7	
American shad juvenile	0.25–1.6	0.0–0.6	
Shallow-fast guild	0.05–0.3	0.3–1.2	
Shallow-slow guild[2]	0.05–0.3	0.0–0.3	

- USGS NARL approach: Literature review
  - Other species? (e.g., American eel, bridal shiner, sea lamprey, etc.)

Literature Review methods

- Use defined “key search terms” in several major search engines
  - *E.g.*, ISI Web of Knowledge, Google Scholar, USGS Digital Desktop Library
- Primary literature (no grey literature)
- Preference: articles reporting fish density AND environmental variables (depth, velocity, temperature)
- Second: articles reporting average environmental variables where fish present (no density data)

Example: Rainbow Trout

- Search Engine = Web of Knowledge
  - Topic = *Oncorhynchus mykiss*
  - Topic = Depth
    - 188 Results
      - Reviewed 56 Articles
      - Used ~20

1. Title: **Archival and acoustic tags reveal the post-spawning migrations, diving behavior, and thermal habitat of hatchery-origin Sacramento River steelhead kelts (Oncorhynchus mykiss)**
   Author(s): Teo, Steven L. H.; Sandstrom, Phil T.; Chapman, Eric D.; et al.
   Source: ENVIRONMENTAL BIOLOGY OF FISHES Volume: **96** Issue: **2-3** Pages: **175-187** DOI: **10.1007/s10641-011-9938-4** Published: **FEB 2013**
   Times Cited: **3** (from All Databases)
   Find It @ USGS [View abstract]

2. Title: **Deep RNA Sequencing of the Skeletal Muscle Transcriptome in Swimming Fish**
   Author(s): Palstra, Arjan P.; Beltran, Sergi; Burgerhout, Erik; et al.
   Source: PLOS ONE Volume: **8** Issue: **1** Article Number: **e53171** DOI: **10.1371/journal.pone.0053171** Published: **JAN 8 2013**
   Times Cited: **0** (from All Databases)
   Find It @ USGS [View abstract]

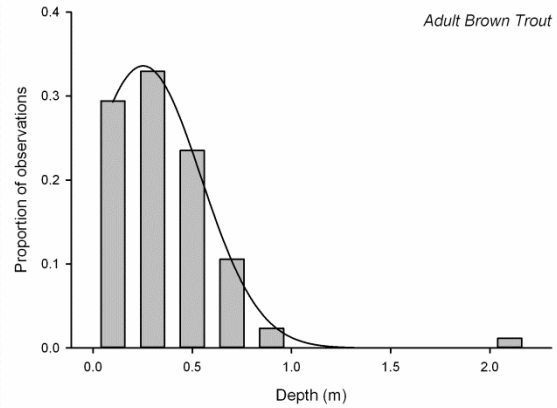
3. Title: **A hydrodynamic investigation of brown trout (Salmo trutta) and rainbow trout (Oncorhynchus mykiss) redd selection at the riffle scale**
   Author(s): Marchildon, M. A.; Annable, W. K.; Power, M.; et al.
   Source: RIVER RESEARCH AND APPLICATIONS Volume: **28** Issue: **5** Pages: **659-673** DOI: **10.1002/rra.1478** Published: **JUN 2012**
   Times Cited: **0** (from All Databases)
   Find It @ USGS [View abstract]

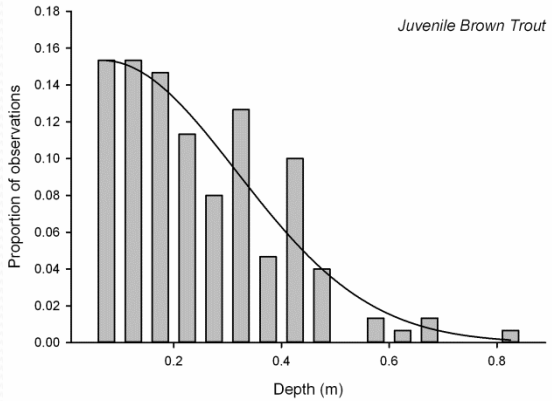
- Similar for each additional search engine
- Other search terms: habitat suitability, rainbow trout, flow, etc.

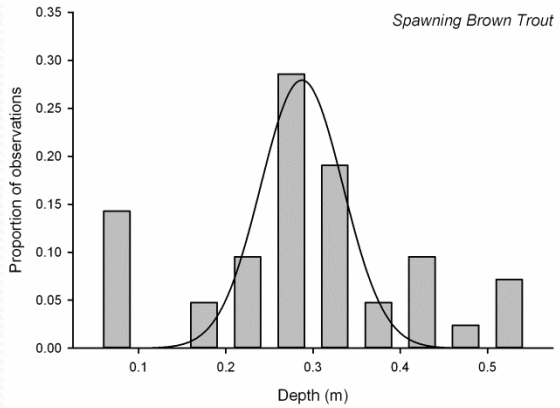
Current progress on trout

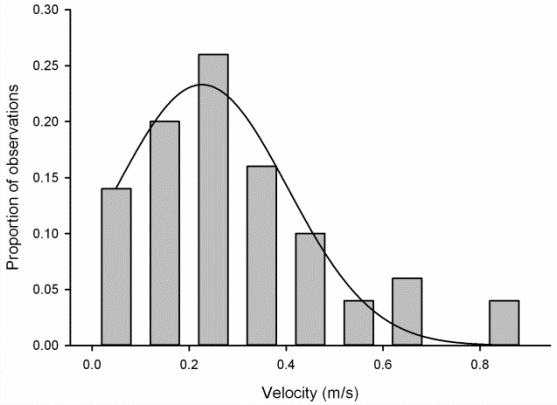
- Brown Trout (depth and velocity)
  - Adult, juvenile, spawning
  - Total Number of Articles = 33; 309 observations
    - 20 from Studies Conducted in Europe
    - 12 from Studies Conducted in North America
    - 1 from Studies Conducted in Australia
- Rainbow Trout (depth and velocity)
  - Adult, juvenile
  - Total Number of Articles = 29; 89 observations
    - 1 from Studies Conducted in Europe
    - 27 from Studies Conducted in North America
    - 1 from Studies Conducted in Asia

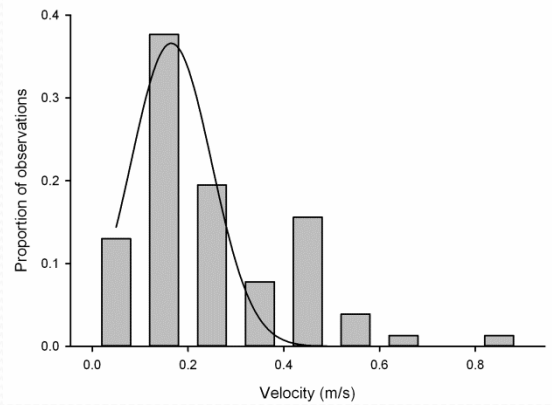
Brown trout HSC

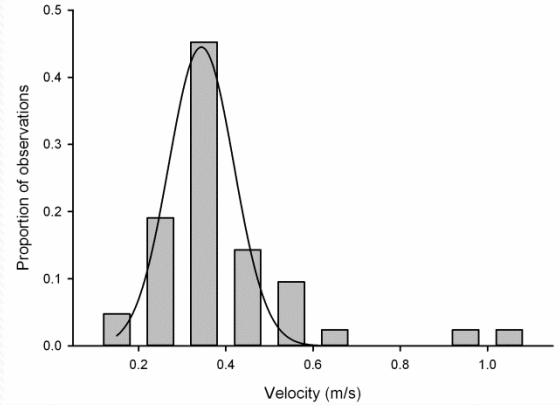




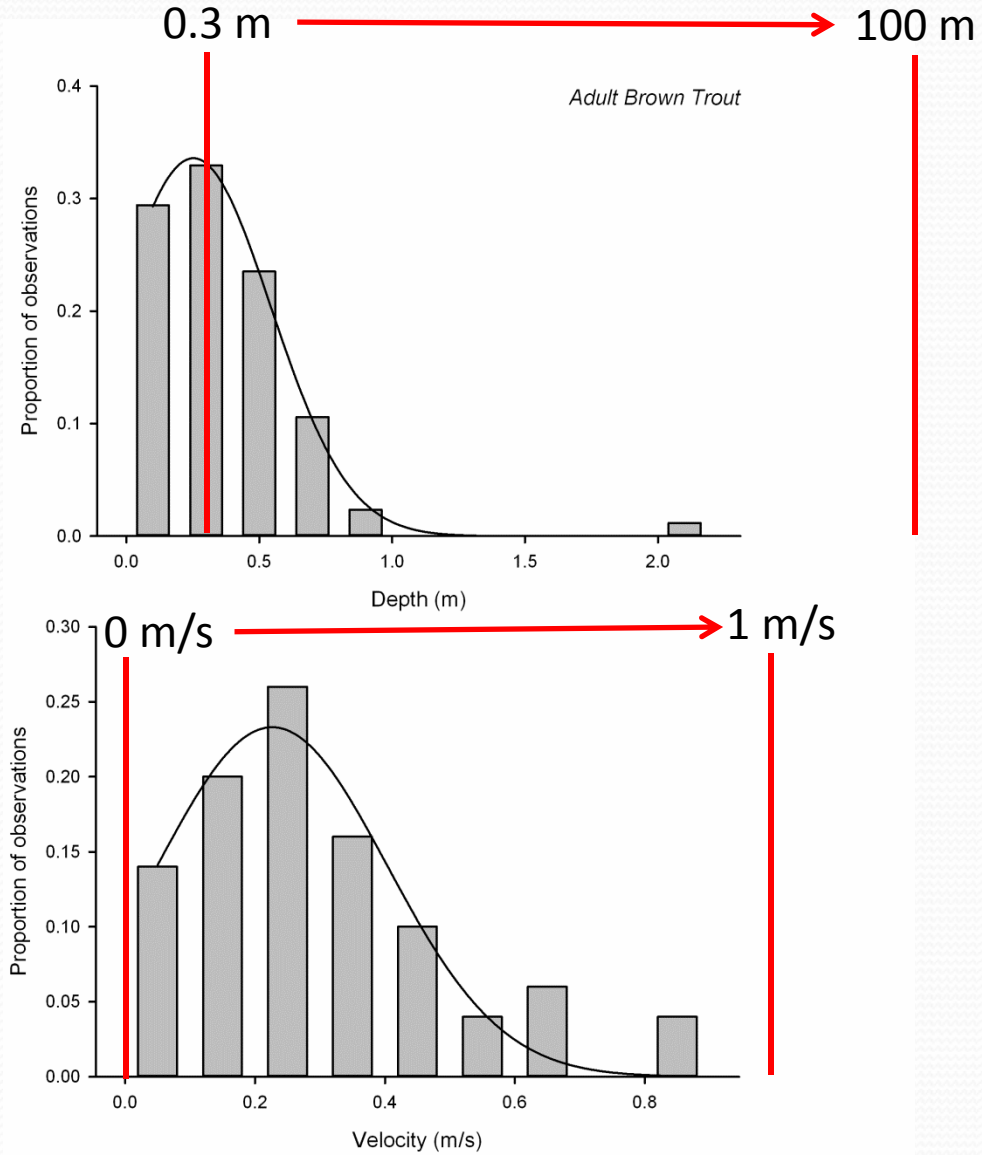








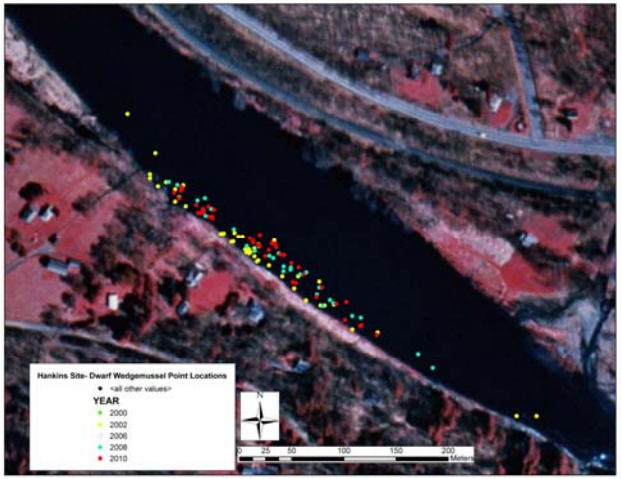
NARL curves vs. Bovee et al. 2007



Dwarf wedgemussel

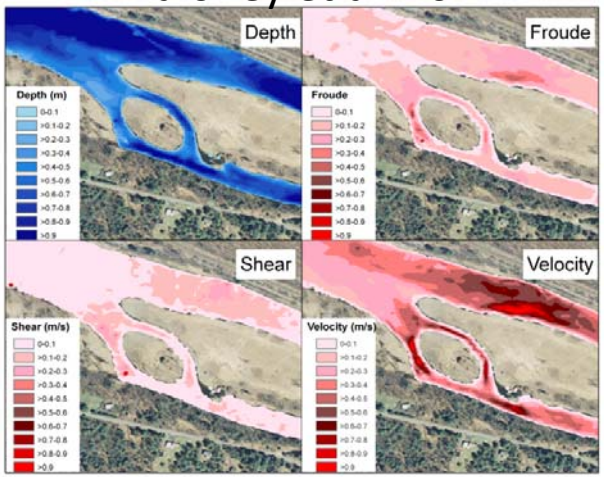
- Limited published literature on habitat use of mussels in general
- Used USGS NARL field, laboratory, and modeling data to build HSC – idea of **Persistent Habitat**

Field measurements
2007-2009
Delaware mainstem & tribs



Depth preference studies, NARL
2010-2011
Delaware tribs

Hydrodynamic modeling results
Maloney et al. 2012



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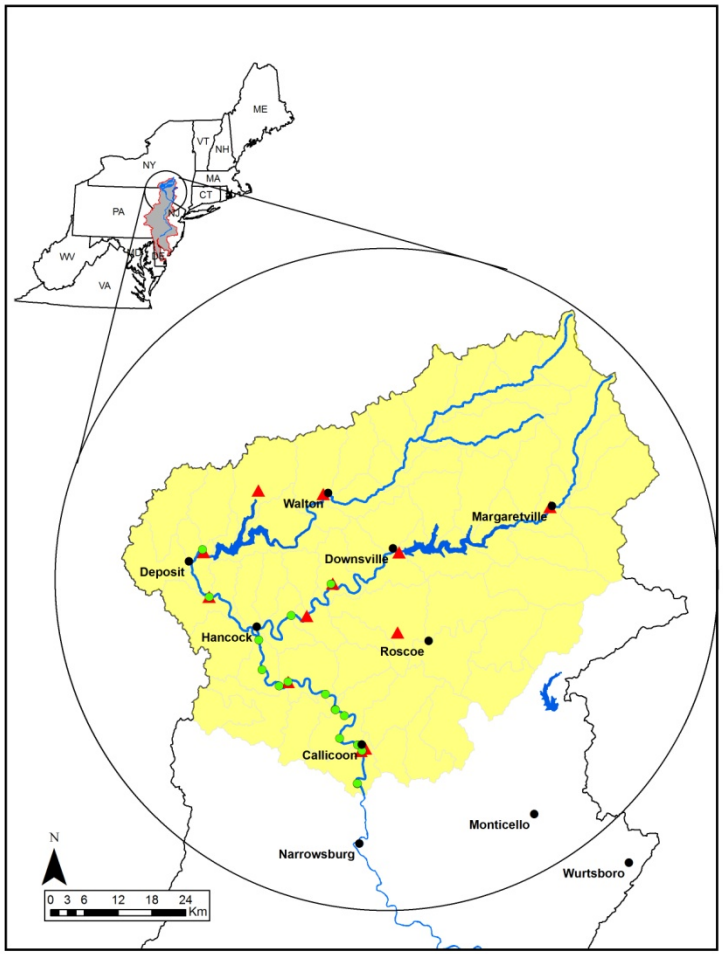
Climate Data &Temperature Model

- Extend meteorological data
  - Currently used station limited to 1994
  - Timeline to match OASIS
  - Use other stations to extend by proxy
- Test temperature model
  - SNTEMP and Multivariate models
  - Construct models with part of data, test with recent data
  - Deploy additional temp loggers
- NEED: Reservoir release amounts and temperatures, spillover estimates



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Improved DSS Platform - History

- Original Delaware DSS (Excel)

- SMART River (Trinity River)

- Yakima River DSS (hard coded)

- Revised Delaware DSS (User Friendly, spatially referenced GUI)

Improved DSS Platform

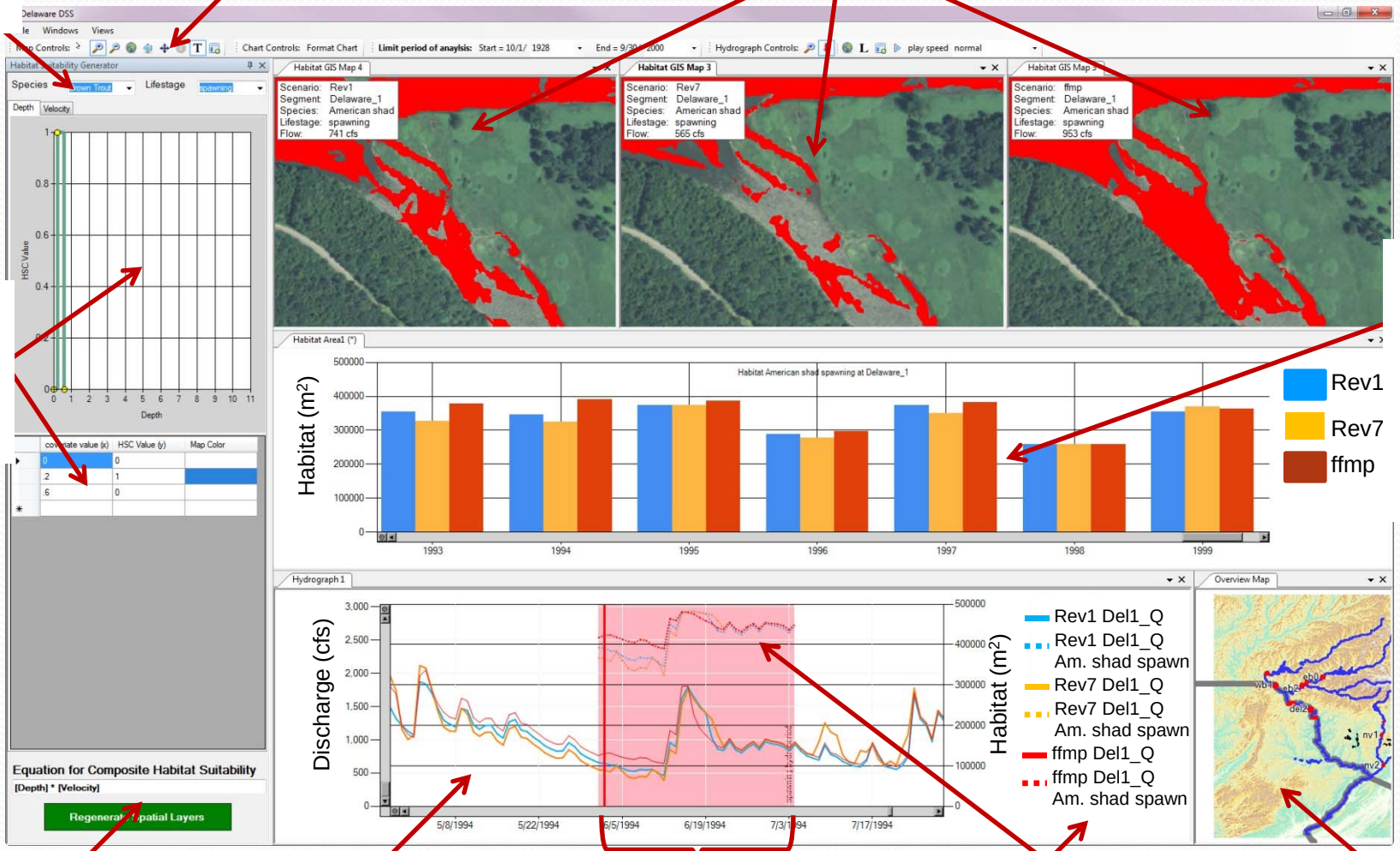
Key Features:

- User friendly, transferable GUI
- Enables user to manually modify the habitat suitability criteria/curves
- Spatial representation of input data (e.g., hydrodynamic variables) and calculated available habitat)
- Allows user to select time period of interest

Selection of key species

Geographic Information System (GIS) functionality

Color coded habitat maps for each scenario



Habitat suitability criteria can be modified

Daily average amount of available habitat over period of interest

Equation for displayed habitat suitability maps

Display of hydrograph for all scenarios

Hydroperiod of interest

Amount of available habitat by scenario by date

Map of site location

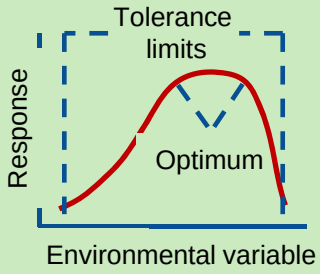
Putting it all Together

Flow Release Model (OASIS)

Temperature & Other Parameters

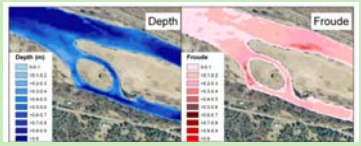
$$T_w = k + a_1 T_a + a_2 T_a^2 + a_3 H + a_4 W + a_5 S + a_6 Q_1 + a_7 (Q_2 - Q_1) + a_8 Y T_w$$

Habitat Suitability Criteria (HSCs)



Synthesis Tool (DSS)

Flow-Specific Estimates of Habitat



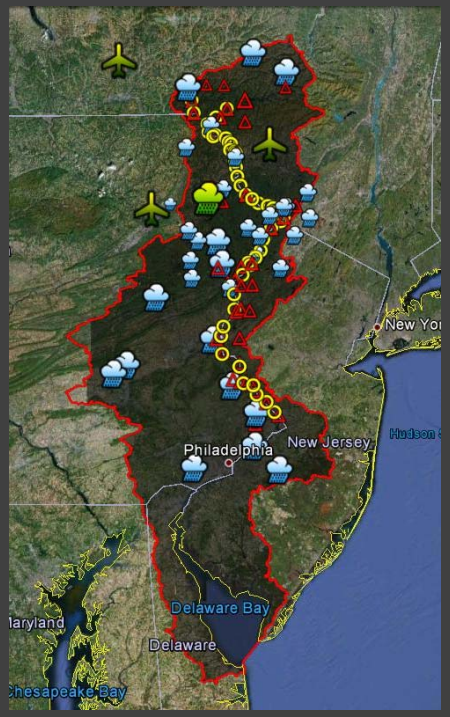
Where do we Stand?

- Automate data import from OASIS (2012)
- Extend temporal coverage of DSS and add 2010 hydrodynamic modeling data (2012)
- Develop a more user-friendly, transferable DSS platform (beta version Jan 2013)
- Revise and incorporate revised habitat suitability criteria (ongoing, 2013/14)
- Add persistent habitat metric to DSS (2013/14)
- Test temperature model and add to DSS (2013/14???)
- Workshop on DSS – mid-April in conjunction with SEF meeting

Extend Aerial Coverage – 2014 & beyond

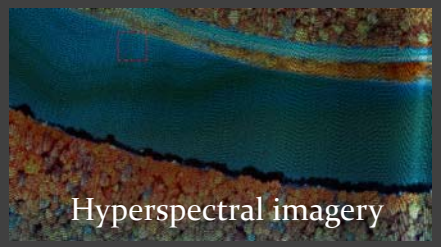
Temperature

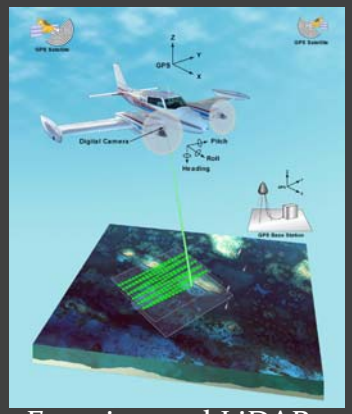
- 13 stations
- 37 stream gages
- Deployed 60 HOBO loggers



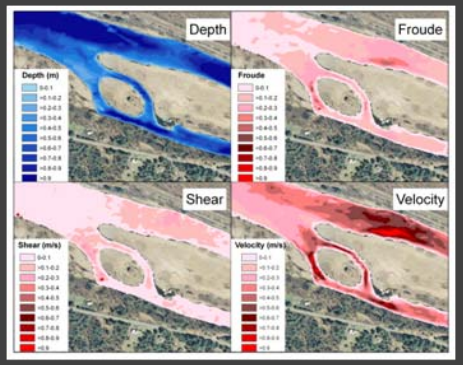
Bathymetry

RTK GPS &side-scan sonar

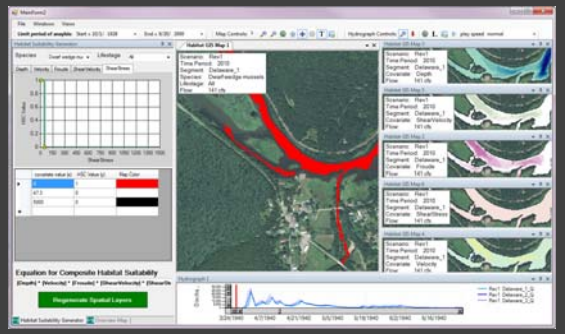

Hyperspectral imagery


Experimental LiDAR

2D Modeling



DSS



Thank you

Upcoming possible "hands on" demonstration of the DSS in 2013

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