



WFA8433-Natural Resource & Conservation Decision Making

Class 1
Introduction to decision making & ProACT



Class website

Course home Course information Module 1 Module 2 Module 3 Module 4 Module 5 Additional Resources

WFA8433 - Natural Resource & Conservation Decision Making

Announcements

- Welcome to WFA8433 Natural Resource And Conservation Decision Making

<https://mcolvin.github.io/WFA8433-Natural-Resource-Decision-Making>

Syllabus

Course home Course information Classes Additional Resources

WFA8433-- Natural Resource & Conservation Decision Making

WFA8433 - Syllabus

Contact

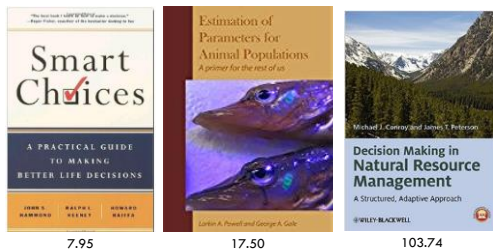
Instructor: Dr. Michael E. Colvin
Office: Thompson 215
Office phone: 962-325-3392
Email: michael.colvin@montana.edu
Office hours: By appointment
Lecture: TBD
Location: TBD

3:30-4:45
8-9:15

Catalog description

Three hours lecture. Natural resource and conservation decision making including rapid prototyping of decision problems, structuring objectives, structured decision making, adaptive management, and relevant case studies of successful natural resource decision making.

Textbooks...



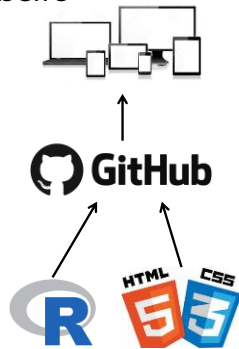
Class website

- <https://mcolvin.github.io/WFA8433-Natural-Resource-Decision-Making/>



Class website

- Transparent
- Versioning
- Reproducible
- Collaborative
- Documentation
- Stakeholders



About the class

- Analysis is important!
- Link statistics to management actions!
- Freely available



Course home Course information Classes Additional Resources

WFA8433 - Natural Resource & Conservation Decision making

WFA8433 - R tutorials and resources

A great course on R for Fish and Wildlife Grads put together by folks at Oregon State University. It is 20 or so pages on relevant bits of R and other useful information (e.g., databases) geared toward new R users.

- R for Fish and Wildlife Grad

Here are some nice YouTube video tutorials about using R from the folks at Google.

- R 1.1 - Initial Setup and Navigation
- R 1.2 - Calculations and Variables
- R 1.3 - Create and Work With Vectors
- R 1.4 - Character and Boolean Vectors
- R 1.5 - Vector Arithmetic
- R 1.6 - Building and Subsetting Matrices
- R 1.7 - Section 1 Review and Help Files
- R 2.1 - Loading Data and Working With Data Frames
- R 2.2 - Loading Data, Object Summaries, and Dates
- R 7.3 - R Graphics: Loading, Customizing, and the R Graphics Environment

all tech considered

20 Years Later, Humans Still No Match For Computers On The Chessboard

Listen · 7:17 Queue Download Transcript

October 24, 2016 · 5:56 PM ET
Heard on All Things Considered

ROBERT SIEGEL

A photograph showing two men, likely Magnus Carlsen and a human opponent, sitting at a chessboard during a match. The man on the left is looking down at the board, while the man on the right is looking up, possibly thinking or discussing a move.

Kasparov's confidence proved unjustified. In the years since, computers have built on Deep Blue's 1997 breakthrough to the point where the battle between humans and machines is not even close. Even chess grandmasters like author and columnist Andrew Soltis know this to be true.

"Right now, there's just no competition," Soltis says. "The computers are just much too good."

And as it turns out, some players prefer to stay away from computers as opponents, he says.

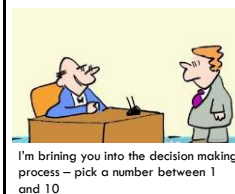
Murray Campbell of IBM was part of the Deep Blue project. As he says, chess computers *do* play differently. They make moves that sometimes make no sense to their human opponents.

"Computers don't have any sense of aesthetics or patterns that are standard the way people learn how to play chess," Campbell says. "They play what they think is the objectively best move in any position, even if it looks absurd, and they can play any move no matter how ugly it is."

Human chess players bring preconceptions to the board; computers are unbound by habit.

And, unlike people, computers love to retreat, Soltis says.

Decision makers & managers, scientists, & stakeholders oh my...



A smart guy

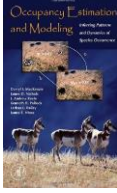
James Nichols
Senior Scientist, Palawan Wildlife Research Center, USGS
population ecology, conservation biology, wildlife management, biostatistics
Verified email at usgs.gov

Google Scholar

Citation Index: 4065
h-index: 55
i10-index: 309

Since 2012: 16755
208

Title	Cited by	Year
Analysis and management of animal populations D. Williams, J.D. Nichols, M.J. Conroy Academic Press	2523	2002
Estimating site occupancy rates when detection probabilities are less than one D. MacKenzie, J.D. Nichols, G.B. Lachman, S. Droege, J. Andrew Royle Ecology 83 (9), 2248-2255	2331	2002
Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence J.D. Nichols, J.D. Nichols, J.E. Hines, M.J. Conroy, A.B. Franklin Ecology 84 (9), 2209-2217	2138	2006
Statistical inference for capture-recapture experiments K.H. Pollock, J.D. Nichols, C. Brownie, J.C. Hoot Wildlife monographs, 3-57	1952	1990
Dispersion J. Gilbert, J.C. Eklund Ecology 82 (3), 2209-2217	1132	2001
Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly D. MacKenzie, J.D. Nichols, J.E. Hines, M.J. Conroy, A.B. Franklin Ecology 84 (9), 2209-2217	1012	2003
Estimation of tiger densities in India using photographic captures and recaptures K.J. Karanth, J.D. Nichols Ecology 79 (8), 2862-2882	958	1998



An interview with Jim Nichols

INNGE International Network of Next-Generation Ecologists

ABOUT NEWS ECOLOGISTS RECAPPER WWW MEMBERS JOIN US

Integrating science into conservation decision-making: an interview with Jim Nichols

published by harsidhar on Mon, 01/16/2016 - 10:45
Citation for this post: 60-504 (1995)

James D. Nichols has been a wildlife biologist with the US Geological Survey for more than 40 years and a long-time collaborator on conservation research projects in India. At the Student Conference on Conservation Science, Bangalore (SCCS) — Bangalore in September 2016, Dr. Nichols spoke about ways to integrate science into conservation decision-making, drawing upon his own experiences working with wildlife managers in North America. Hari Srinath spoke to Dr. Nichols after the talk, to find out more about his work.

Hari: In your talk at SCCS-Bangalore, you said that the way in which scientists usually engage with park managers and conservation decision-makers is inefficient. Why do you think so?

Jim Nichols: I guess the first thing I should say is that inefficiency is not a horrible crime. It is just that, in the conservation world today, our dollars and efforts are so limited. If we can do better within our limited means, why not do so?

I think the inefficiency comes via a lack of communication and a lack of a central programme within which everyone works. What often happens is that at least what I have seen in my world is a group of scientists interested in a particular system will get money for studying that particular system, claiming that what they learn will be useful to conservation folks. They will then go out and perform the study, learn something and then give...

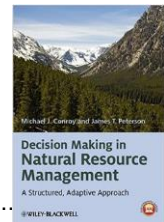
INNGE Blog
Ecobloggers
INNGE ecologist
Ecobloggers
INNGE Page
INNGE Group
INNGE Trailblazers
INNGE LinkedIn
INNGE Flickr
inng_e_ajpops
Google calendar
Submit an event
Email us

Themes...

- People & Natural Resources
 - Objectives
 - Interdisciplinary
 - Transparent
 - Repeatable
- **Process** for making decisions...

Practicing folks...

- Mike Conroy, UGA
- Jim Peterson, UGA, OSU
- Elise Irwin & Connor McGowan, Auburn
- Mike Runge, Larrissa Bailey, Katriona Shea, Sarah Converse, Drew Tyre...
- An incomplete list



Is this process used widely now?

JN: No, not at all. I am not even sure of a number. I am involved in I guess five different formal programmes right now. But I feel sure that the difficulty is you can't just convince people to change their way of making a presentation. There's a long way between that and getting it done. In each one of the five programmes I am involved in I have had to spend a lot of time and effort and basically be a part of that programme for a number of years. Otherwise, I am not sure what you will have with a small number of individuals who have done exactly that.

How did I drink the Cool Aid

- Tough to learn from a book....
- Apprenticeship?



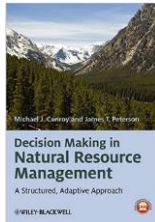
How did I drink the Cool Aid

- Tough to learn from a book....



How did I drink the Cool Aid

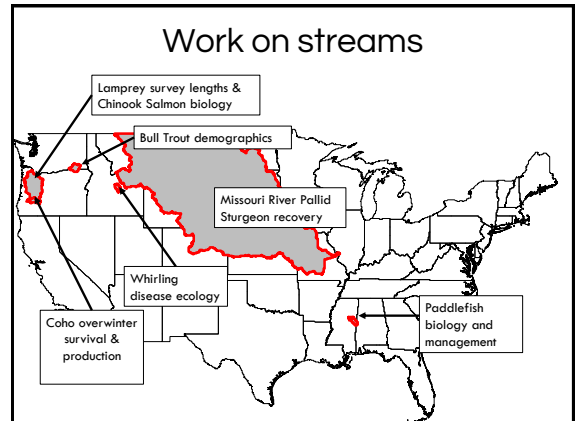
- Tough to learn from a book....



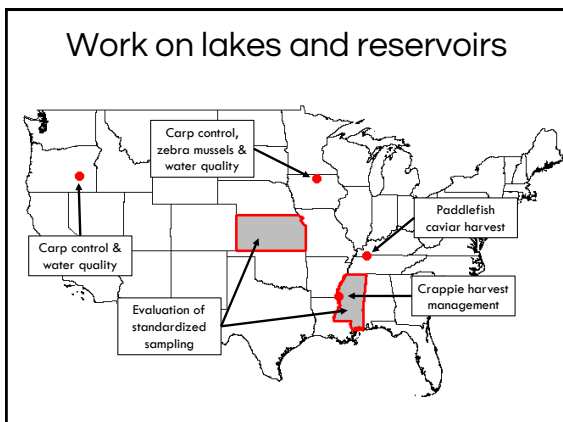
Folks...Stakeholders



Work on streams



Work on lakes and reservoirs



I am a bit fishy

- A decision making process
- Applies to all management problems
- Experiences Research, SDM & ARM

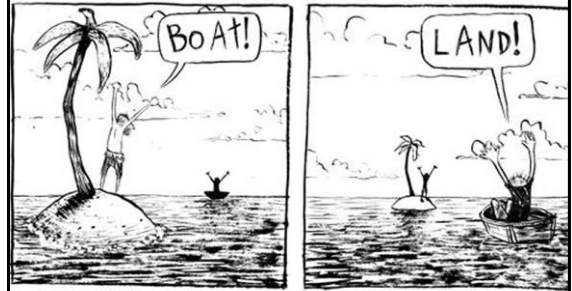


I am a bit fishy

- Experiences Research, SDM & ARM
- Critical for buy in (more later in semester)
- How to think about decision making and your science



Perspective & Buy in



Perspective...



CHALLENGES

Challenges

1. Communication
2. Stakeholder involvement
3. Data-too little, too much
4. Finite resources
5. No management alternatives

1. Communication



Integrating science into conservation decision-making: an interview with Jim Nichols

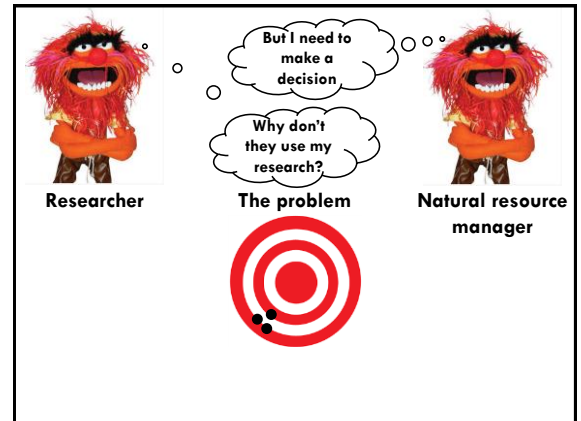
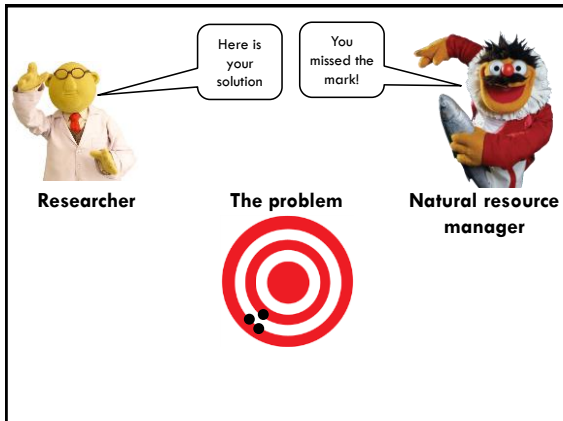
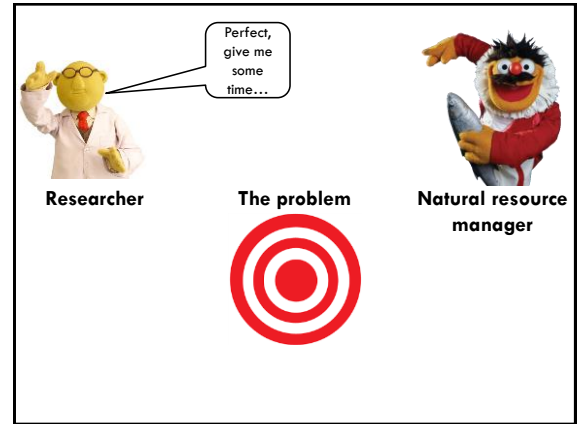
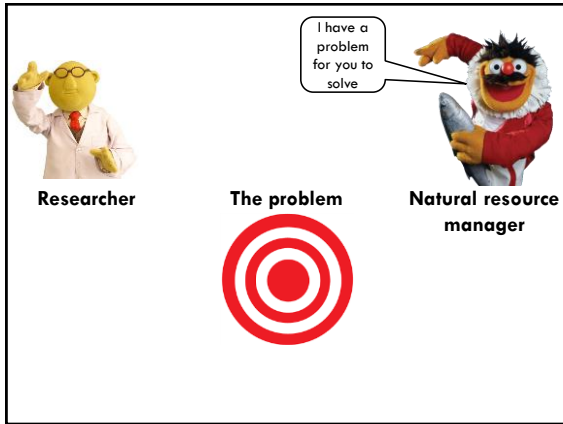
published by *bioRxiv* on Nov. 9/11/2016 - 10:45
Citation for this post: *BioRxiv* | 1016

James D. Nichols has been a wildlife biologist with the US Geological Survey for more than 40 years and a long-time collaborator with the USGS. He is currently a senior advisor to the USGS, focusing on integrating science into conservation decision-making.

"I think the inefficiency comes via a lack of communication and a lack of a central program within which everyone works." J. Nichols

Hari: In your talk, you mentioned that you have a lot of experience with park managers and conservationists. How do you think about the communication between them?

Jim Nichols: I go to a lot of meetings and I see a lot of people who are not doing so well. I think the inefficiency comes via a lack of communication and a lack of a central programme within which everyone works. What often happens - or at least what I have seen in my world - is a group of scientists interested in a particular system will get money for studying that particular system, claiming that what they learn will be useful to conservation folks. They will then go out and perform the study, learn something and then give that information to the manager or conservation guy who is actually on the ground doing things. I don't claim that what is learnt is never useful, but very frequently it doesn't hit the mark. In other words, what scientists learn is



Stakeholders Increasingly Interested & Judicious

IN THE UNITED STATES COURT OF FEDERAL CLAIMS

Lidker Farms, Inc.; Lynn and Elaine Binder; Todd and April Binder; and Tyler and Valerie Binder; Richard Binder; Dustin Binder; and Darwin Binder dba Midwest Grain Co.; Eldar Drewes; Robert W. Drewes Recoverable Trust; Rita K. Drewes Recoverable Trust and David Drewes, individually and dba Drewes Farms, Inc.; Patrick Newlon dba Newlon Farms, Inc.; David Newlon

Plaintiffs,

v.

UNITED STATES OF AMERICA,

Defendant.

COMPLAIN

NATURE OF THE

1. Plaintiffs bring their claims for a delinquent compensation, by means of a significant and delinquent Engineers ("the Corps" or "Corps") from its delinquent

Case No.:

Attorneys for Plaintiffs

UNITED STATES DISTRICT COURT FOR THE DISTRICT OF MONTANA, GREAT FALLS DIVISION

DEFENDERS OF WILDLIFE and NATURAL RESOURCES DEFENSE COUNCIL,

Plaintiffs,

v.

UNITED STATES ARMY CORPS OF ENGINEERS, UNITED STATES BUREAU OF RECLAMATION, and UNITED STATES FISH AND WILDLIFE SERVICE,

Defendants.

Case No.:

COMPLAINT FOR DECLARATORY AND INJUNCTIVE RELIEF

Stakeholder visibility

MoldyChum (Small form only)

SEE EVERY COLOR VINTAGE

DEFENDERS OF WILDLIFE

UNITE NOW

Home | Press Release | Plan for Yellowstone Dam and Fish Bypass "Won't Pass" for Pallid Sturgeon

New Regulations a "Slap in the Face"

PLAN FOR YELLOWSTONE DAM AND FISH BYPASS "WON'T PASS" FOR PALLID STURGEON

FOR IMMEDIATE RELEASE
October 14, 2016

MEDIA CONTACT:
Jennifer Witherspoon, Defenders of Wildlife, (202) 772-6208, jwitherspoon@defenders.org

Plan for Yellowstone Dam and Fish Bypass "Won't Pass" for Pallid Sturgeon

DEFENDERS OF WILDLIFE expressed strong opposition to the action proposed in the Army Corps of Engineers Corps and the Bureau of Reclamation's (collectively "the Corps") latest Yellowstone State Sturgeon Dam Fish Passage Project Environmental Impact Statement (EIS), which calls for construction of a larger, more permanent dam and without fish bypass near Gardiner, Montana, on the Yellowstone River.

Numerous independent, state and federal agency scientists criticized the Corps and Reclamation's approach, saying the efficacy of a fish bypass to get the pallid sturgeon around the dam is unproven.

Gillette News Record 30°

NEWS SPORTS PHOTOS OPINIONS COLUMN BIZCHES CLASSIFIEDS MONTPLACE CALENDAR SPECIAL SECTIONS RESOURCES

Stash Your Cash Christmas Club!

New Yellowstone dam challenged over sturgeon worries

By MATT TREND @TRENDERS Associated Press Jan 11, 2017

The proposed new dam on the Yellowstone River, a vital tributary to the state's water supply, has been challenged by environmental groups. The dam would be built near Gardiner, Mont., and would be the largest dam in the state. It would be the largest dam in the state. It would be the largest dam in the state.

Jet Go Long! iFlyGillette.com

LATEST NEWS

Things to do in the area. Things to do in the area. Things to do in the area.

MISSOURI RIVER RECOVERY PROGRAM

FRP Management Plan Effects Analysis Policy/Strategy/Action FRPIC Initial Action Explorer

MISSOURI RIVER RECOVERY IMPLEMENTATION COMMITTEE (MRRIC)

Overview

The Missouri River drains one-third of the United States, encompassing over 520,000 square miles. The river flows 2,900 miles through seven states. The basin is also home to 28 American Indian Tribes. There are many diverse non-governmental stakeholders with lives and livelihoods linked to the river (e.g., farmers, waterway industries, hydro and thermal power, and outdoor recreationists, and many more).

The Committee is chaired by Michael Mac.

For more information on the committee and its work, visit www.mrric.org.

What's New

- Draft EIS for Lower Yellowstone
- 2017 MRRIC Annual Report
- First EIS for Lower Yellowstone
- 2016 MRRIC Meeting
- Draft MRRIC Management Plan and EIS available

Managers need to make decisions that are transparent & repeatable

BOZEMAN DAILY CHRONICLE

Groups sue to save endangered pallid sturgeon

By LAURA LUNDQUIST Chronicle Staff Writer
Posted: Monday, February 2, 2015 9:50 am

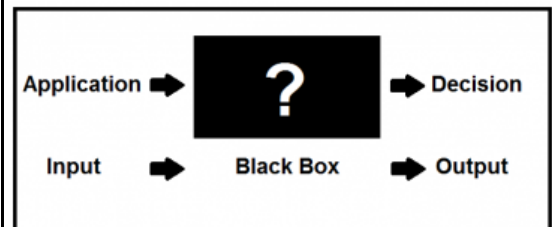
Environmental groups are suing federal agencies after Bozeman researchers provided additional evidence that Missouri River dams continue to endanger the pallid sturgeon.

On Monday, the Defenders of Wildlife and the Natural Resources Defense Council sued the U.S. Army Corps of Engineers, the Bureau of Reclamation and the Fish and Wildlife Service in a Great Falls federal district court for operating dams on the Yellowstone and Missouri rivers in such a way that endangers the pallid sturgeon.

The environmental groups are asking the judge to rule that the agencies violated the Endangered Species Act and order them to make immediate changes on two Montana dams — the Fort Peck and Intake Diversion dams — to save the upper Missouri population of pallid sturgeon.

Fort Peck Intake Dam Lake Sakakawea Upper Missouri River

Black box management



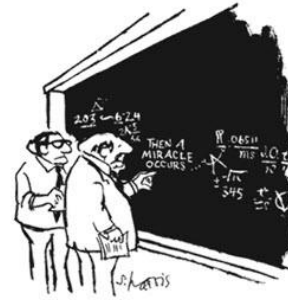
Managers have a model, even if they don't realize it

Mental models

- Increase habitat & population will increase
- Increase harvest & population will compensate



Unstated assumptions



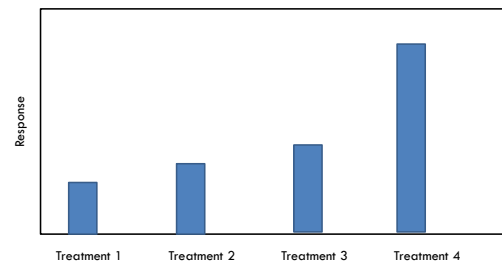
"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

3. Data limitations

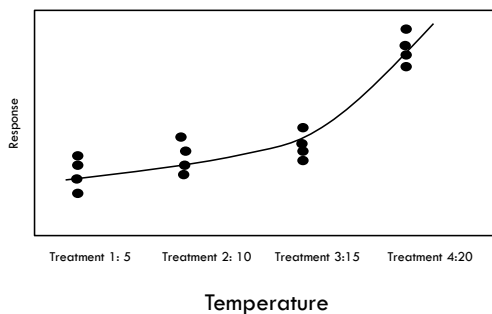
Fisheries biologist never complain about collecting too much data—Dr. Joe Bonneau

- What do we do with the data?
- Is it collected to meet objectives?
- How is it incorporated into management?

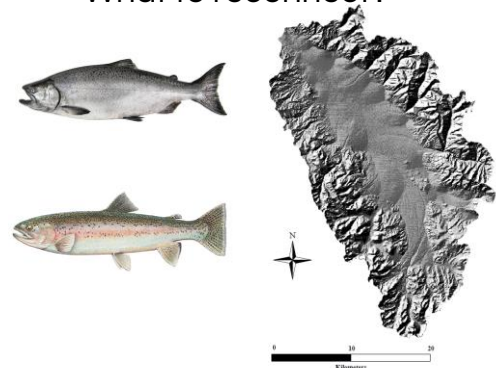
Effects versus prediction



Effects versus prediction

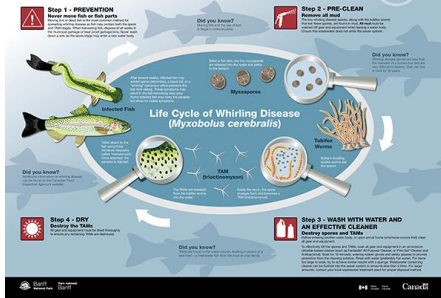


What to reconnect?



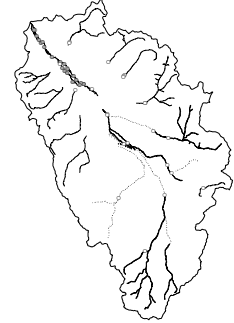
Whirling disease

How You Can Help Prevent the Spread of
Whirling Disease



Many times data are not collected in a way that can be used to make a decision

"sites were statistically different"



Monitoring & Current System State

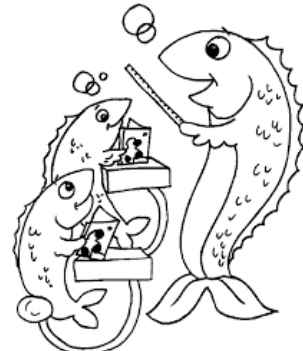
- Data represents "System state"
- Infected or not
- Objective: Minimize risk in tribs
- Cost



Estimating system state

- Monitoring
- State dependent decisions
 - Decision depends on whether downstream is infected (binary)
 - Decision depends on how infected downstream reaches are (continuous)

Formalize learning from data collected & monitoring?



Make smarter decisions...

4. Finite resources

How do we prioritize monitoring?

How do we prioritize research?

If something has to be cut what should it be?

Will it impact decision making & management?

Managers need to do more with less & prioritize monitoring & research in a way that contributes to management decisions

National Park Service prepares for sequester cuts

Chuck Russell, USA TODAY 5:27 pm EDT March 11, 2013

Natural park supervisors are preparing to open roads later, close visitor centers, furlough park police and fire, hire seasonal workers to meet the 2% sequestration budget cuts mandated by Congress and President Obama.

National Park Service spokesman says the agency is preparing for sequester cuts. "We're looking at a number of options, including hiring seasonal workers, to meet the 2% sequestration budget cuts mandated by Congress and President Obama."

La. Department of Natural Resources announces hiring freeze savings and mid-year budget cuts

Friday, December 16, 2011

The state Department of Natural Resources (DNR) announced today its cost savings measure associated with Gov. JB Pritzker's Executive Order 82 (2011-12). The savings will help address the state's mid-year budget shortfall.

The agency's Office of Conservation reduced spending by \$61,857 to its FY 11-12 budget by eliminating an engineering position for that office. DNR will additionally cut \$758,111 from its general fund budget and \$1,028,563 from its statutory dedication budget.

Managers need to figure out how to best allocate finite resources

July 21 - 25, 2008 Structured Decision Making Workshop

Optimal Budget Allocation for American Shad Conservation

A Case Study from the Structured Decision Making Workshop

July 21-25, 2008

National Conservation Training Center, Shepherdstown, WV, USA

11 Million allocated to Pallid Sturgeon research...
How to allocate it?



5. Consider management alternatives

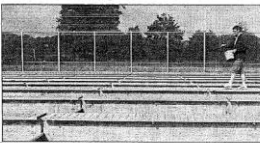
Court orders agencies to consider fewer hatchery fish for the Elwha

By Cassandra Proffitt

SEASIDE

PORTLAND — A judge has ordered federal agencies to reconsider the number of planned hatchery fish releases into the Elwha River on Washington Olympic Peninsula. As crews finish the largest dam removal in history on the Elwha, managers are working to restore fish runs above the dam sites. Their plan includes releasing more than 7 million hatchery salmon and steelhead into the river.

That plan has been controversial.



KATIE CAMPBELL / SEASIDE

In this 2011 photo, Lower Elwha Hatchery Manager Larry Ward feeds the steelhead and coho that are raised in a hatchery for introduction to the Elwha.

In his opinion, the judge wrote that "the court is concerned with the spring coho and steelhead releases," and as the agencies consider options for releasing fewer hatchery fish, those proposed numbers "would be a good starting point for an agreement."

The National Marine Fisheries Service released a statement in response to the decision noting that the judge upheld the overall hatchery plan for the Elwha River.

"Numerous reviews and a broad consensus of scientists

Solutions

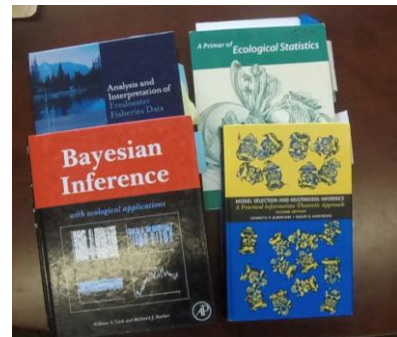
All MacGyver needed was a ball point pen and a paper clip



Biologists & ecologists spend time reading biology & ecology books



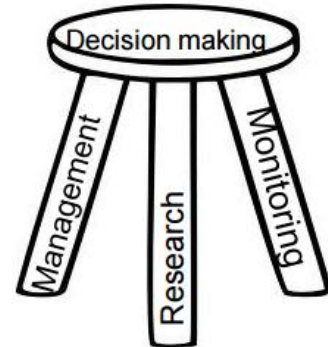
Biologists & ecologists spend time reading methods & statistics books



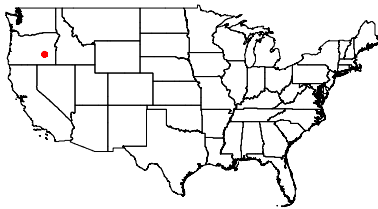
We do not read books about
decision making & analysis



A Central Program



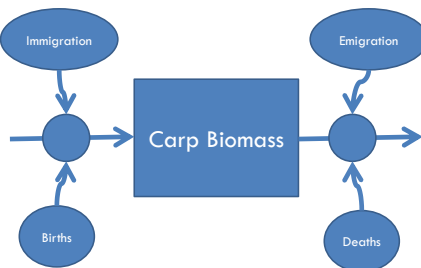
MALHEUR CARP MANAGEMENT



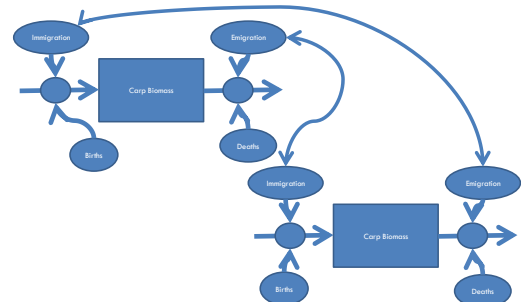
This \$6*# is complicated & dynamic!



Conceptualizing population
dynamics



Coupling populations



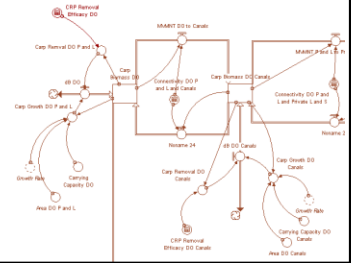
Strategies

- Reduce connectivity
 - Refuges
 - Movement
- Reduce biomass

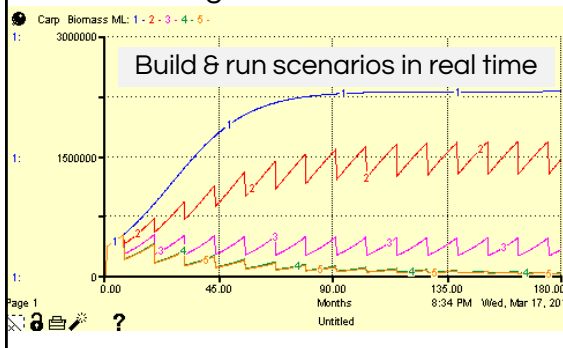


To A Simulation Model

- Spatial representation
- Logistic population model
- Allows movement



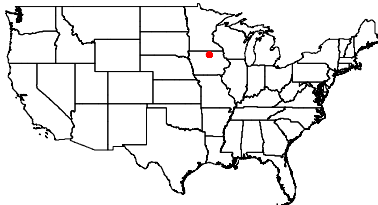
Powerful tool for communicating with managers and stakeholders



Outcomes

- Clear objectives
- Identified alternatives
- Explicit assumptions
- System understanding
- Stakeholder involved in process

CLEAR LAKE ECOSYSTEM MANAGEMENT



Clear Lake is valuable

Visitors spend an average **\$43.36 million** annually

\$1-3 million USD recreational fishery



Lake restoration in Iowa

State Legislation HF2782 (2006)

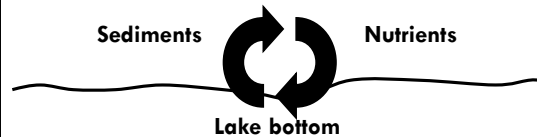
- 1.4 m Secchi disc transparency 50% of the time
- Water quality and public use benefits sustained at least 50 years.



Water quality: internal processes



Water column

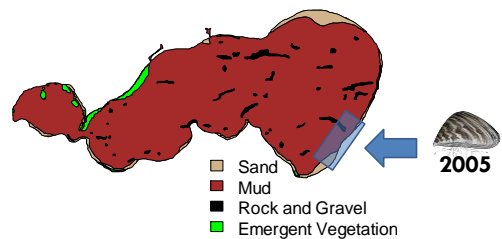


Managing carp biomass

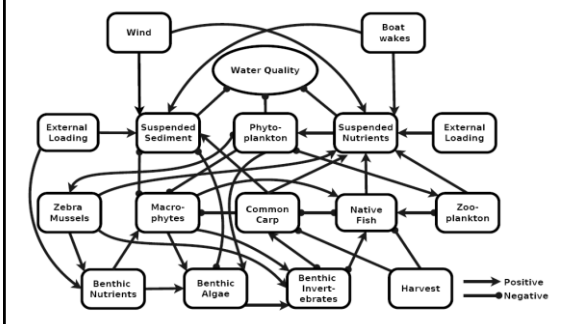
- Pulsed intense removals over a short period
 - Large removals
 - Short duration
 - Spring and fall



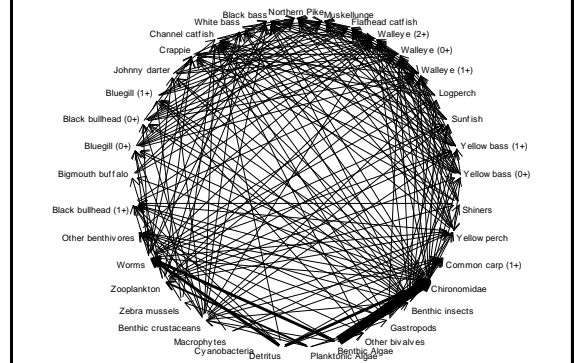
Zebra Mussels



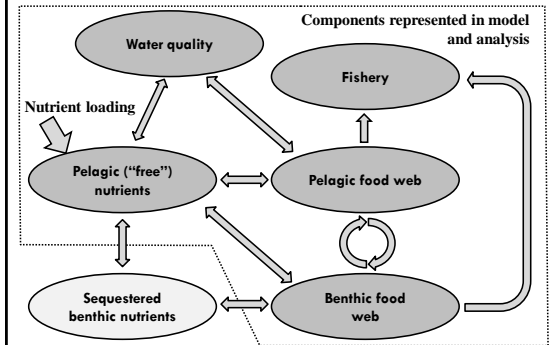
Clear Lake: a complex system



The Clear Lake Food Web



The Clear Lake Ecosystem Model (CLESM)



Lots of equations nobody will use...
or ever look at

$$\frac{dBiomass_{juv,i}}{dt} = Production_{juv,i} + B Stocked_{juv,i} + Migration_{juv,i} + B Recruited_{juv,i} - B Graduated_{juv,i} - B Predation_{juv,i} - B Other mortality_{juv,i}$$

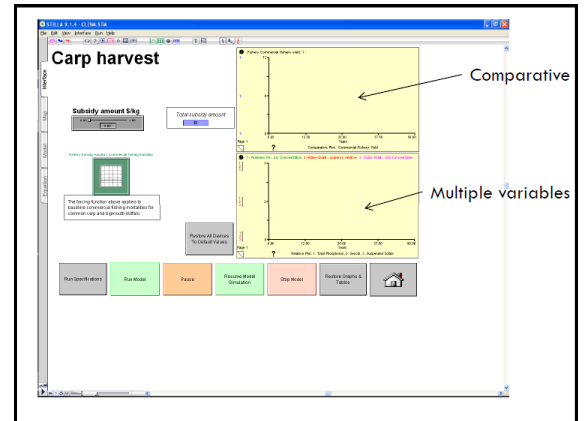
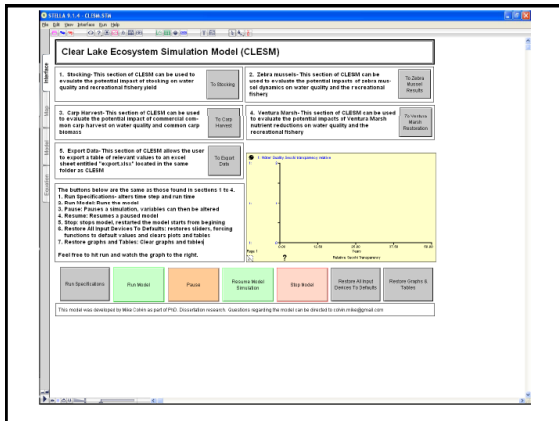
$$\frac{dN_{juv,i}}{dt} = N Recruited_{ad,i} + N Stocked_{juv,i} - N Loss_{juv,i}$$

$$\frac{dBiomass_{ad,i}}{dt} = Production_{ad,i} + B Migration_{ad,i} + B Graduated_{juv,i} - B Recruited_{juv,i} - B Harvest_{ad,i} - B Predation_{ad,i} - B Other mortality_{ad,i}$$

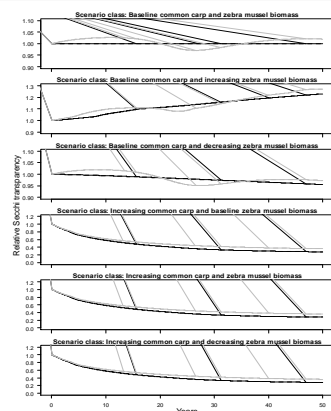
$$\frac{dN_{ad,i}}{dt} = N Graduated_{juv,i} - N Loss_{ad,i}$$

$$\frac{dBiomass_i}{dt} = Production_i + Stocking_i + Migration_i - Harvest_i - Predation_i - Other mortality_i$$

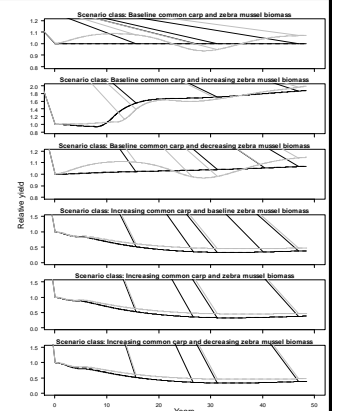
$$Production_i = \begin{cases} \text{Primary production, } i = \text{producer} \\ \text{Consumption, } i = \text{consumer} \end{cases}$$



Water quality



Recreational fishery yield



Outcomes

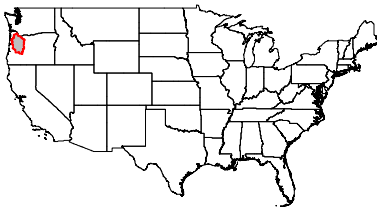
- Finite resources-where to target restoration efforts
- Transparency
- Explicit assumptions
- Communication with stakeholders & managers

Better, but....

- Clear objectives
- Model of dynamics
- Monitoring and system state
- Predict effect of management actions
- NO UNCERTAINTY..



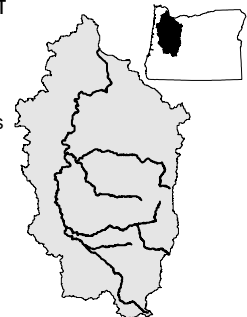
SPRING CHINOOK SALMON RECOVERY



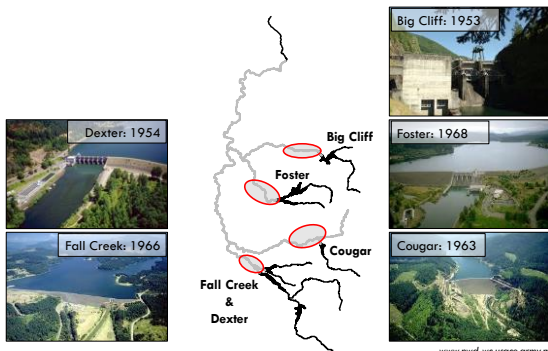
Willamette basin spring Chinook

Anadromous species of conservation need

- Threatened status 1999
- Anthropogenic modifications



Limited natural reproduction

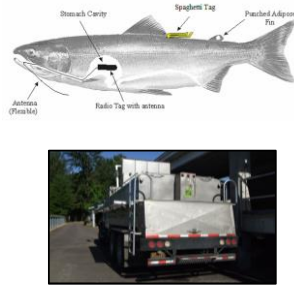


Just to die before spawning

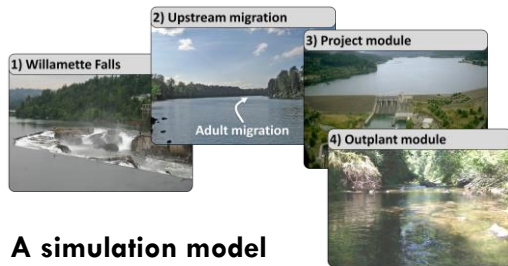
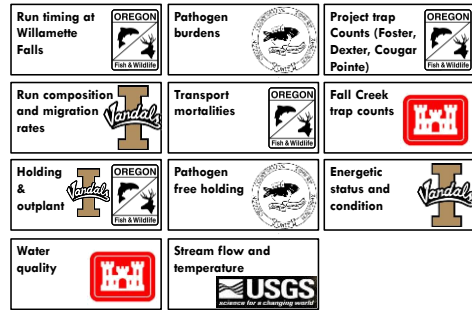


Lots of money in Chinook Recovery

- Tagging
 - Transporting
 - Monitoring
- 30+million a year



Data & sources

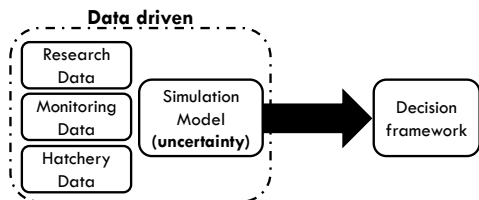


A simulation model to assimilate all the information

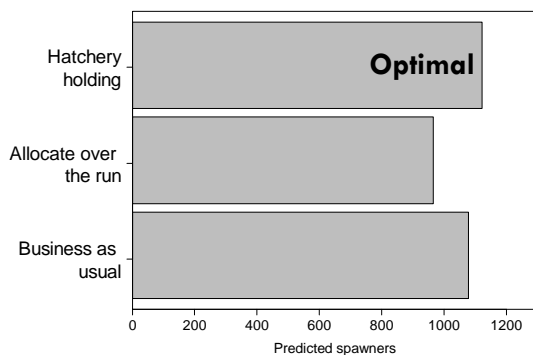
A decision framework

Structured decision making approach

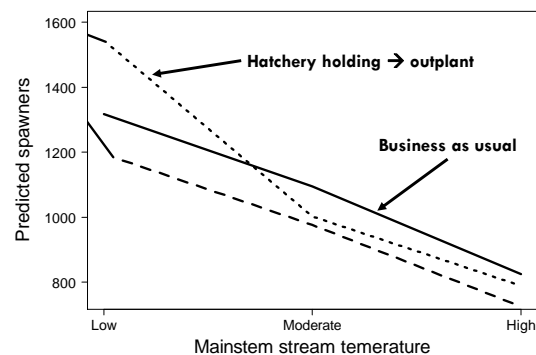
1. Simulation model
2. Decision model



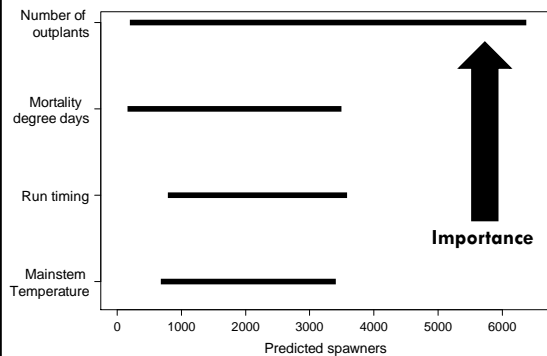
What is the optimal decision?



Mainstem temperature



Informing research and monitoring

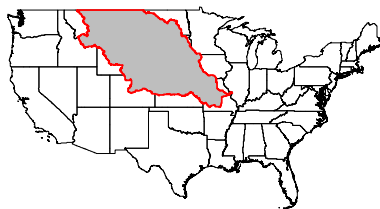


Outcomes

- Finite resources-where to target restoration & monitoring
- Transparency
- Explicit assumptions
- Communication with stakeholders and managers
- Using monitoring to learn



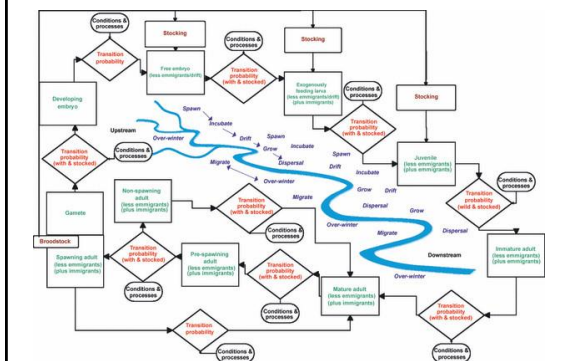
PALLID STURGEON RECOVERY



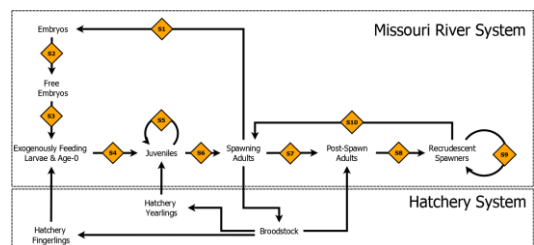
Ongoing over several decades

- 53+ Million annually recovery
- Active stakeholder group-MRRIC
- Multi attribute decisions
 - Human considerations
 - Recovery
 - Terns & Plovers
- 700 million over 10 years

Complicated life history



Stage based model

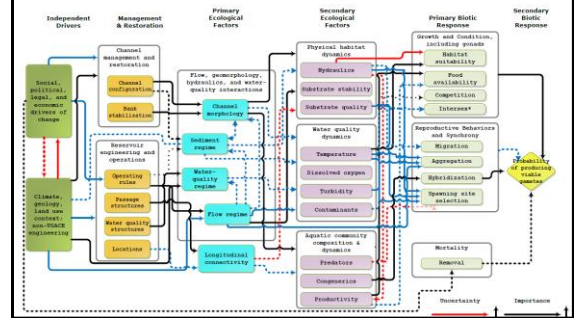


Collaborative model

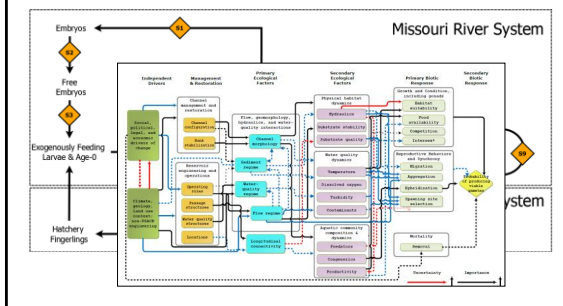
- Build on existing work-stage based matrix type
- Collaborative
- Flexible
- Fits within Effects Analysis



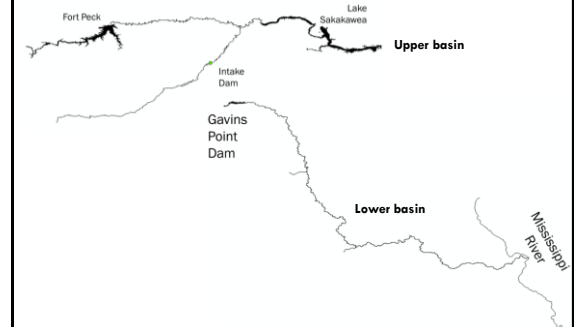
Conceptual Ecological Models



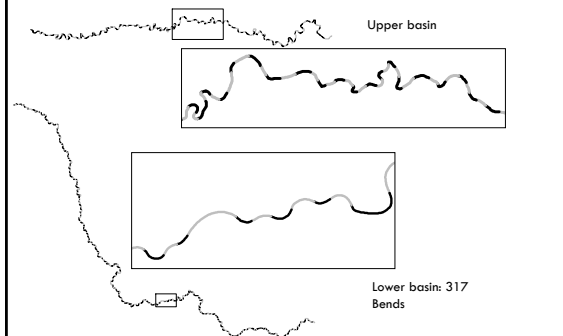
Linking CEMs



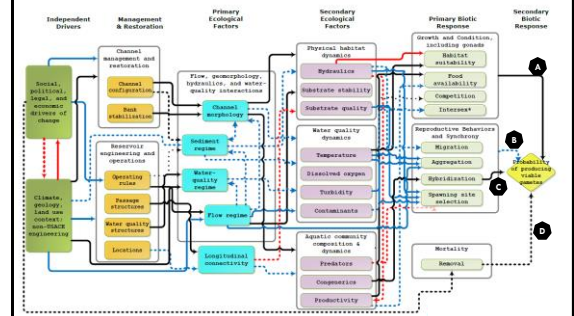
Spatial extent



Spatial grain



Linking management & science



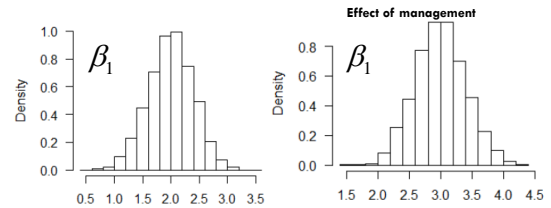
Effects function

$$A) Y = \beta_0 + \beta_1 \cdot A_1 + \beta_2 \cdot B_2 + \beta_3 \cdot C_3 + \beta_4 \cdot D_4$$

$$B) \Pr_{\text{viable gametes}} = \exp(Y) / (1 + \exp(Y))$$

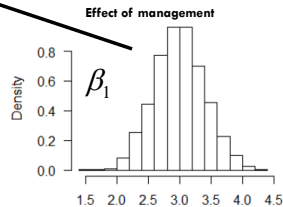
Can estimate parameters by capture-recapture (monitoring), field experiments, or expert elicitation

Linking Information

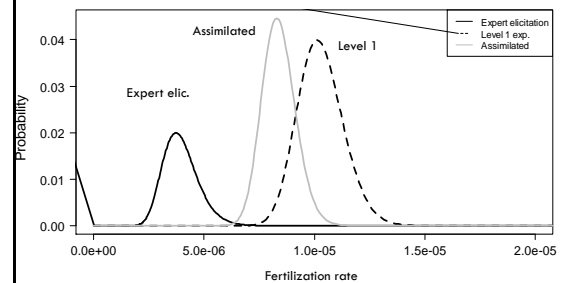


Effects function

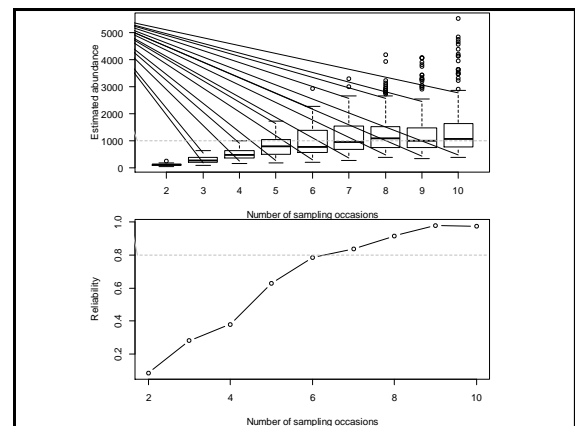
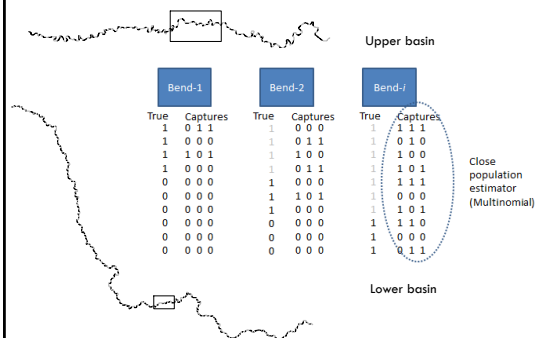
$$A) Y = \beta_0 + \beta_1 \cdot A_1 + \beta_2 \cdot B_2 + \beta_3 \cdot C_3 + \beta_4 \cdot D_4$$



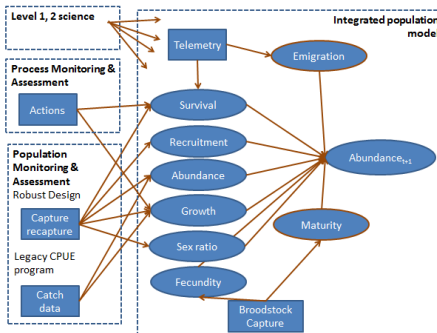
Formalize learning...



Population monitoring



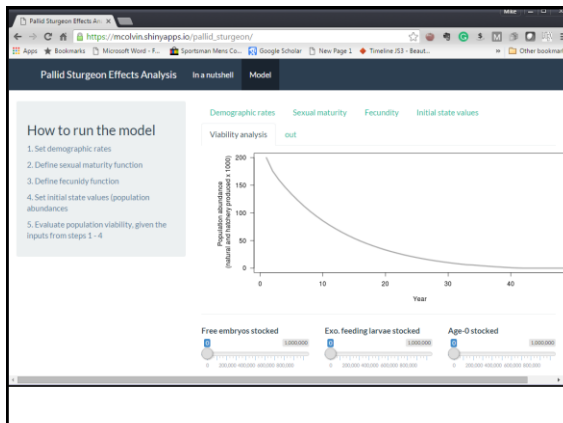
Integrated population model



The screenshot shows the 'Pallid Sturgeon Effects Analysis' website. The main heading is 'PLEASE READ'. Below it, a paragraph states: 'THIS MODEL VERSION SHOULD NOT BE USED FOR ANY TYPE OF ANALYSIS. THIS VERSION IS INTENDED TO DEMONSTRATE HOW THE POPULATION MODEL AND BACKGROUND INFORMATION MAY BE PACKAGED AND AVAILABLE TO STAKEHOLDERS.' The 'Background' section mentions that the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service recently initiated an effects analysis (EA) for the Missouri River Recovery Program (MRRP). The EA was strongly encouraged by the Missouri River Recovery Implementation Committee (MRIC) and the MRIC Independent Science Advisory Committee (ISAP) as a means to:

- Collection of reliable scientific information;
- Critical assessment and synthesis of available data and analysis;
- Analysis of the effects of actions on listed species and their habitats.

The last step needs to be as quantitative as possible in order to forecast expected ecological costs and benefits of an action, and to evaluate trade-offs with socio-economic costs and benefits. The output of an EA provides a useful framework for ongoing assimilation of data from hypothesis-driven monitoring and research, if sufficiently quantitative, can be used to



Outcomes

- Finite resources-where to target restoration & monitoring
- Transparency
- Explicit assumptions
- Communication with stakeholders and managers
- Using monitoring & science to learn



A Central Program

