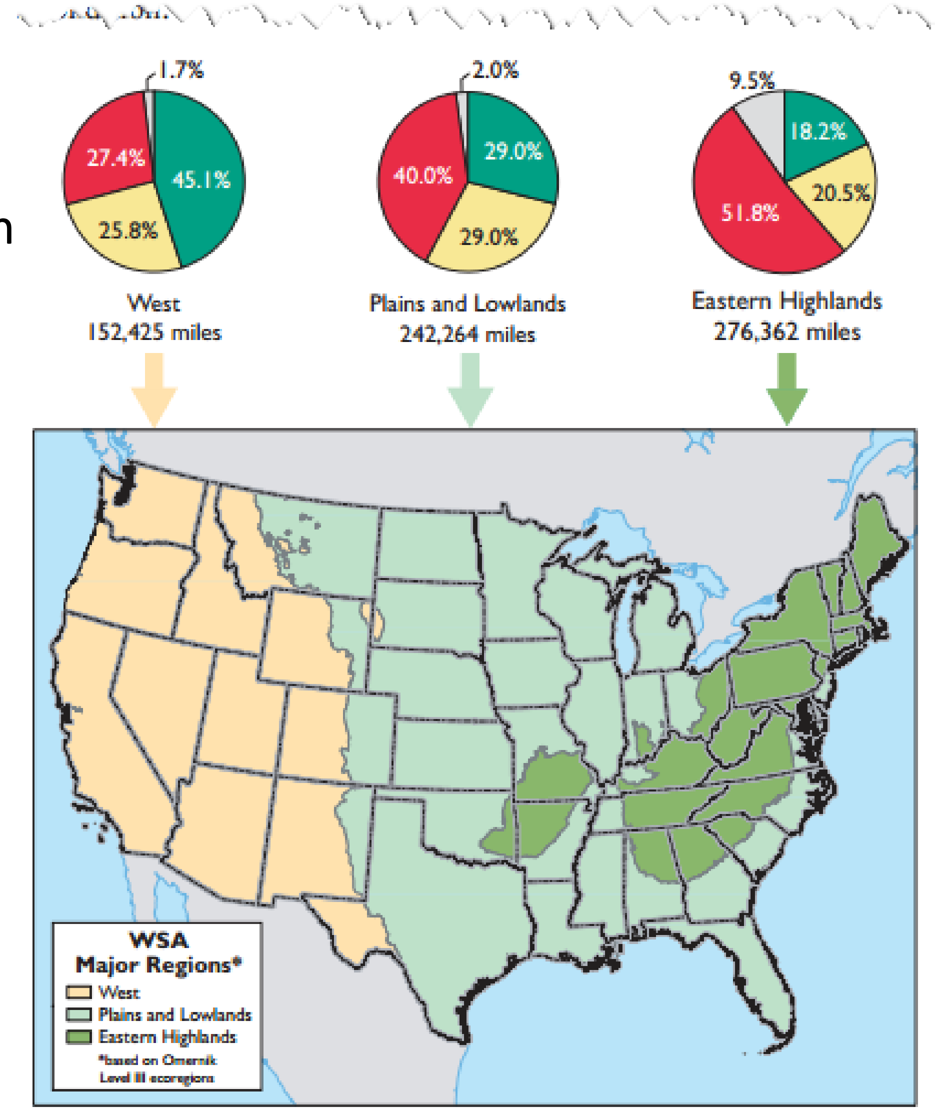
Adaptive Management of
Low-Tech Process-Based Restoration of Riverscapes
WATS 5625

Module 1
Nick Bouwes

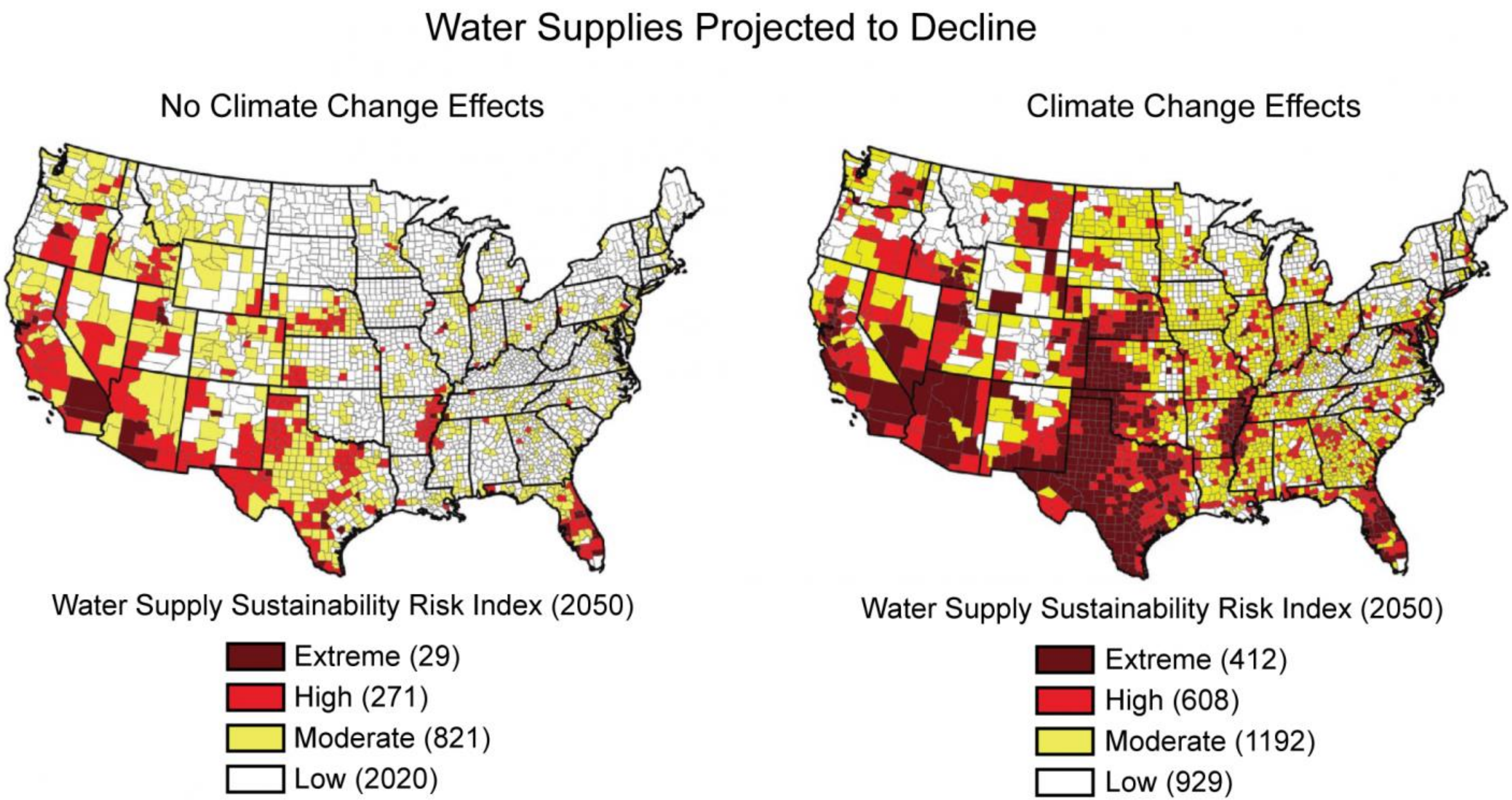
Biological condition of streams in west

- 53% of Western wadeable streams are in fair or poor condition
- 76,000 miles of degraded streams
- Wadeable streams make up ~90% of the stream length in a given watershed



USEPA, 2006. Wadeable Streams Assessment, Office of Research & Development, Office of Water, United States Environmental Protection agency, Washington D.C., pp. 113.

2050 Predicted Water Supply Impacts



Roy et al. (2010) Tetra Tech

http://www.global-warming-forecasts.com/water-supply-shortage-water-scarcity-climate.php

Why always Tonka toys?

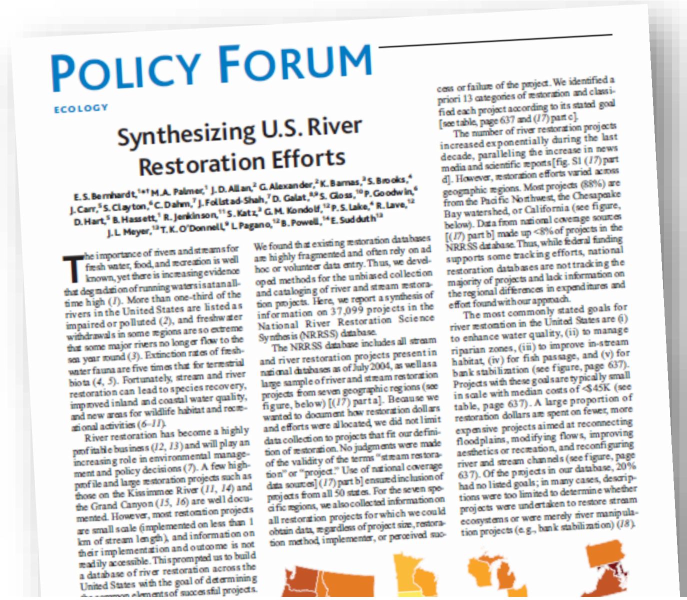
- If you do a google search for restoration, the first images that come up are of Tonka toys in streams



Common restoration approach

Investments in Stream Restoration

- The over-cited Bernhardt et al. (2005) paper
  - 38,000 projects
  - At least $15 billion spent since 1990-2003
- Gross Under-Estimate
  - 42,000 projects alone in PNW


POLICY FORUM

ECOLOGY

Synthesizing U.S. River Restoration Efforts

E. S. Bernhardt,[1*†] M. A. Palmer,[1] J. D. Allan,[2] G. Alexander,[2] K. Barnas,[3] S. Brooks,[4] J. Carr,[5] S. Clayton,[6] C. Dahm,[7] J. Follstad-Shah,[7] D. Galat,[8,9] S. Gloss,[10] P. Goodwin,[6] D. Hart,[5] B. Hassett,[1] R. Jenkinson,[11] S. Katz,[3] G. M. Kondolf,[12] P. S. Lake,[4] R. Lave,[12] J. L. Meyer,[13] T. K. O'Donnell,[9] L. Pagano,[12] B. Powell,[14] E. Sudduth[13]

The importance of rivers and streams for fresh water, food, and recreation is well known, yet there is increasing evidence that degradation of running waters is at an all-time high (1). More than one-third of the rivers in the United States are listed as impaired or polluted (2), and freshwater withdrawals in some regions are so extreme that some major rivers no longer flow to the sea year round (3). Extinction rates of fresh-water fauna are five times that for terrestrial biota (4, 5). Fortunately, stream and river restoration can lead to species recovery, improved inland and coastal water quality, and new areas for wildlife habitat and recreational activities (6–11).

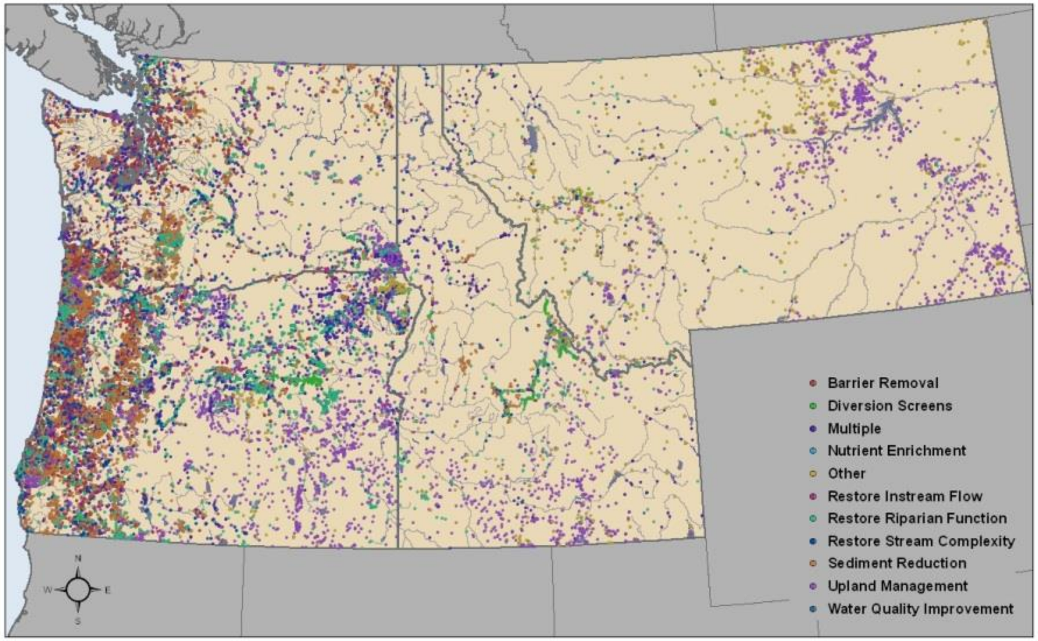
River restoration has become a highly profitable business (12, 13) and will play an increasing role in environmental management and policy decisions (7). A few high-profile and large restoration projects such as those on the Kissimmee River (11, 14) and the Grand Canyon (15, 16) are well documented. However, most restoration projects are small scale (implemented on less than 1 km of stream length), and information on their implementation and outcome is not readily accessible. This prompted us to build a database of river restoration across the United States with the goal of determining the common elements of successful projects.

We found that existing restoration databases are highly fragmented and often rely on ad hoc or volunteer data entry. Thus, we developed methods for the unbiased collection and cataloging of river and stream restoration projects. Here, we report a synthesis of information on 37,099 projects in the National River Restoration Science Synthesis (NRRSS) database.

The NRRSS database includes all stream and river restoration projects present in national databases as of July 2004, as well as a large sample of river and stream restoration projects from seven geographic regions (see figure, below) [(17) part a]. Because we wanted to document how restoration dollars and efforts were allocated, we did not limit data collection to projects that fit our definition of restoration. No judgments were made of the validity of the terms "stream restoration" or "project." Use of national coverage data sources] (17) part b] ensured inclusion of projects from all 50 states. For the seven specific regions, we also collected information on all restoration projects for which we could obtain data, regardless of project size, restoration method, implementer, or perceived success or failure of the project. We identified a priori 13 categories of restoration and classified each project according to its stated goal [see table, page 637 and (17) part c].

The number of river restoration projects increased exponentially during the last decade, paralleling the increase in news media and scientific reports [fig. S1 (17) part d]. However, restoration efforts varied across geographic regions. Most projects (88%) are from the Pacific Northwest, the Chesapeake Bay watershed, or California (see figure, below). Data from national coverage sources [(17) part b] made up <8% of projects in the NRRSS database. Thus, while federal funding supports some tracking efforts, national restoration databases are not tracking the majority of projects and lack information on the regional differences in expenditures and effort found with our approach.

The most commonly stated goals for river restoration in the United States are (i) to enhance water quality, (ii) to manage riparian zones, (iii) to improve in-stream habitat, (iv) for fish passage, and (v) for bank stabilization (see figure, page 637). Projects with these goals are typically small in scale with median costs of <$45K (see table, page 637). A large proportion of restoration dollars are spent on fewer, more expensive projects aimed at reconnecting floodplains, modifying flows, improving aesthetics or recreation, and reconfiguring river and stream channels (see figure, page 637). Of the projects in our database, 20% had no listed goals; in many cases, descriptions were too limited to determine whether projects were undertaken to restore stream ecosystems or were merely river manipulation projects (e.g., bank stabilization) (18).



Problem is simple to state…

Scope of riverscape degradation is massive

- ~ $10 Billion spent annually, but barely scratching surface
- We spend disproportionate $$$$ on too few miles of streams and rivers
- Leaving millions of miles neglected…

Agricultural Stream Ecosystem (PDF)

Urban Stream Ecosystem (PDF)

USGS

Does it Work?

Stream Restoration and Enhancement Projects: Is Anyone Monitoring?

JEFFREY S. BASH
Yamhill Basin Council
Yamhill Soil and Water Conservation District
McMinnville, Oregon 97128, USA

CLARE M. RYAN*
Universit...

of biological, physic... chemical, or other water quality measur... ...ects. Of those who reported collec- ... only 18% indicated that monitoring ...nts were also asked to rank the ...ject goals on a Likert scale. ...jects focusing on "engineering" ...zation) were less likely than other ... baseline monitoring data. ...cts focusing on "restoration/ ...s were more likely than other ...onitoring measures. Although

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"piecemeal" information currently available. We found that only 10% of project records indicated that any form of assessment or monitoring occurred. Most of these

Does it Work?

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Synthesizing U.S. River Restoration Efforts

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JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION

JAWRA

Vol. 48, No. 3 AMERICAN WATER RESOURCES ASSOCIATION June 2012

COMPENSATORY MITIGATION FOR STREAMS UNDER THE CLEAN WATER ACT: REASSESSING SCIENCE AND REDIRECTING POLICY[1]

Martin W. Doyle and F. Douglas Shields[2]

"ABSTRACT: Current stream restoration science is not adequate to assume high rates of success in recovering ecosystem functional integrity. The physical scale of most stream restoration projects is insufficient because"

"scape context. Physical habitat variables are often the basis for indicating success, but are now increasingly seen as poor surrogates for actual biological function; the assumption "if you build it they will come" lacks support of"

Does it Work?

FORUM

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number of river restoration projects ...entially during the last ...increase in news ...(17) part

Ecological Applications, 21(6), 2011, pp. 1950–1961

Twenty years of stream restoration in Finland: little response by benthic macroinvertebrate communities

Pauliina Louhi,[1,6] Heikki Mykrä,[2] Riku Paavola,[3] Ari Huusko,[4] Teppo Vehanen,[5] Aki M... and Timo Muotka[1,2]

...lity ...collec- ...onitoring ...k the ...le. ...eering" ...an other ...a. ...ion/ ...other ...ough

doi:10.1111/j.1365-2427.2009.02372.x

Freshwater Biology (2009), **55** (Suppl. 1), 1–18

River restoration, habitat heterogeneity and biodiversity: a failure of theory or practice?

Margaret A. Palmer*,†, Holly L. Menninger‡ and Emily Bernhardt§

3. We found habitat and macroinvertebrate data for 78 independent stream or river restoration projects described by 18 different author groups in which invertebrate taxa richness data in response to the restoration treatment were available. Most projects were successful in enhancing physical HH; however, only two showed statistically significant increases in biodiversity rendering them more similar to reference reaches or sites.

Does it Work?

Ecological Applications, 16(2), 2006, pp. 784–796

DID THE PRE-1980 USE OF IN-STREAM STRUCTURES IMPROVE STREAMS? A REANALYSIS OF HISTORICAL DATA

DOUGLAS M. THOMPSON[1]

" beneficial to aquatic organisms. A review of the literature reveals that, despite published claims to the contrary, little evidence of the successful use of in-stream structures to improve fish populations exists prior to 1980. A total of 79 publications were checked, and 215 statistical analyses were performed. Only seven analyses provide evidence for a benefit of structures on fish populations, and five of these analyses are suspect because …

River restoration, habitat heterog…

Ecological Applications, 19(4), 2009, pp. 931–941

Effectiveness of engineered in-stream structure mitigation measures to increase salmonid abundance: a systematic review

GAVIN B. STEWART,[1] HELEN R. BAYLISS,[2] DAVID A. SHOWLER,[3] WILLIAM J. SUTHERLAND,[4] AND ANDREW S. PULLIN[1,5]

"… rendering them more similar to reference reaches … to stream width, with in-stream devices being less effective in larger streams. Consequently, widespread use of in-stream structures for restoration, particularly in larger streams, is not supported by the current scientific evidence base. "

Does

Ecological Applications, 21(6), 2011, pp. 1926–1931

... or failure of the project. We identified a ... of restoration and classi-

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River restoration: the fuzzy logic of repairing reaches to reverse catchment scale degradation

Emily S. Bernhardt[1,4] and Margaret A. Palmer[2,3]

Restoring Rivers One Reach at a Time: Results from a Survey of U.S. River Restoration Practitioners

Emily S. Bernhardt,[1,2,3] Elizabeth B. Sudduth,[1,4] Margaret A. Palmer,[3,5] J. David Allan,[6] Judy L. Meyer,[4] Gretchen Alexander,[5] Jennifer Follastad-Shah,[1,7] Brooke Hassett,[1,3] Robin Jenkinson,[8] Rebecca Lave,[9] Jeanne Rumps,[10] and Laura Pagano[9]

...easures

Effective...
to increa...

Gavin B. Stewart,[1] Helen R. Bayliss,

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...cessful use of in-stream stru...

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"...to stream width, with in-stream devices being ... widespread use of in-stream structures for restoratio... supported by the current scientific evidence base."

Doe

Ecological Applications, 21(6), 2011, pp. 1926–1931
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... or failure of the project. We identified a
... of restoration and classi-

River restoration: the fuzzy logic of repairing reaches to reverse catchment scale degradation

Restoring Rivers One ...
a Survey of U.S. ...

Emily ...

River Restoration in the Twenty-First Century: Data and Experiential Knowledge to Inform Future Efforts

Margaret Palmer,[1,2] J. David Allan,[3] Judy Meyer,[4] and Emily S. Bernhardt[5]

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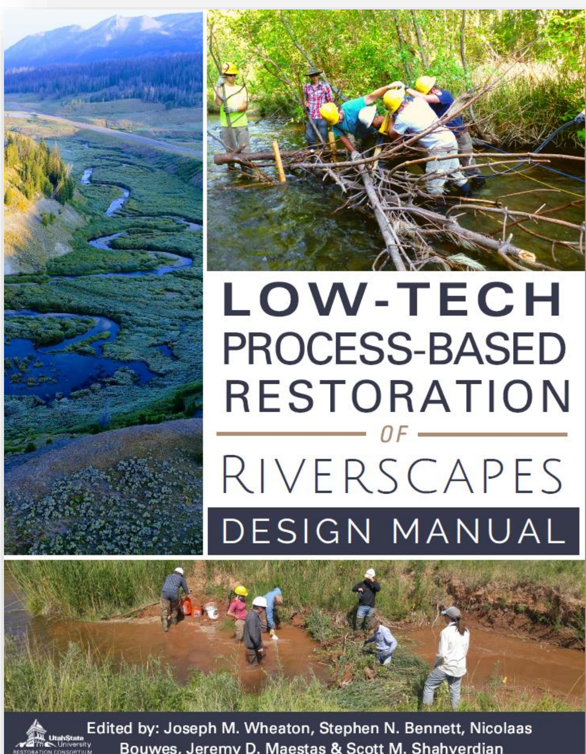
Gavin B. Stewart,[1] Helen R. Bayliss,[2] David ...

... enhancing physical HH; however, only two ...

"...to stream width, with in-stream devices being less effective in larger ... widespread use of in-stream structures for restoration, particularly in lar... supported by the current scientific evidence base."

Low-tech Processed-Based Restoration

- Simple, cost-effective
- Efficiently scaled up to scope of degradation
- Structures can be hand-built, natural materials
- Relies on the system/beaver to do the work



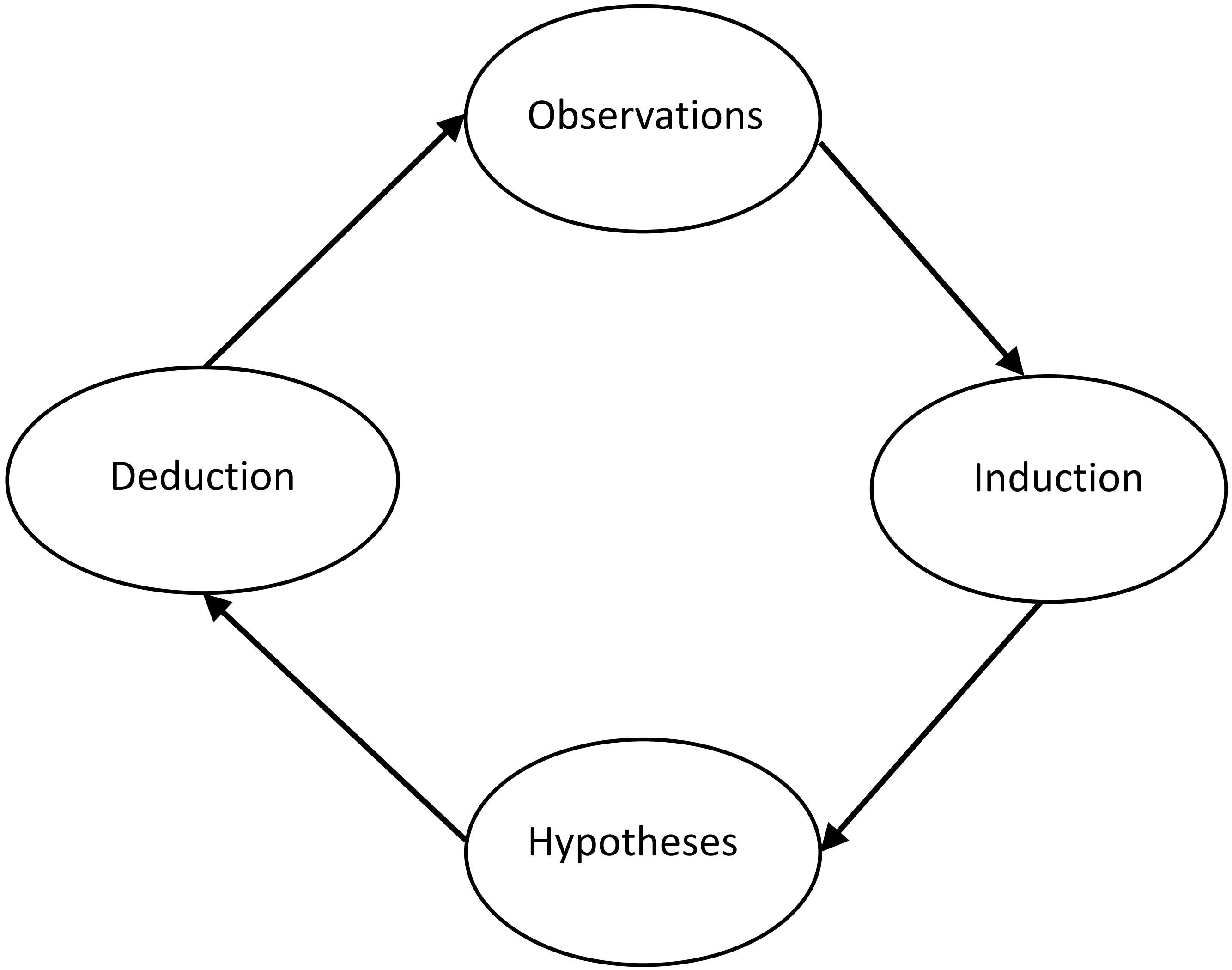
Process Based Restoration LOW-TECH

…but does it work?

What is Adaptive Management?

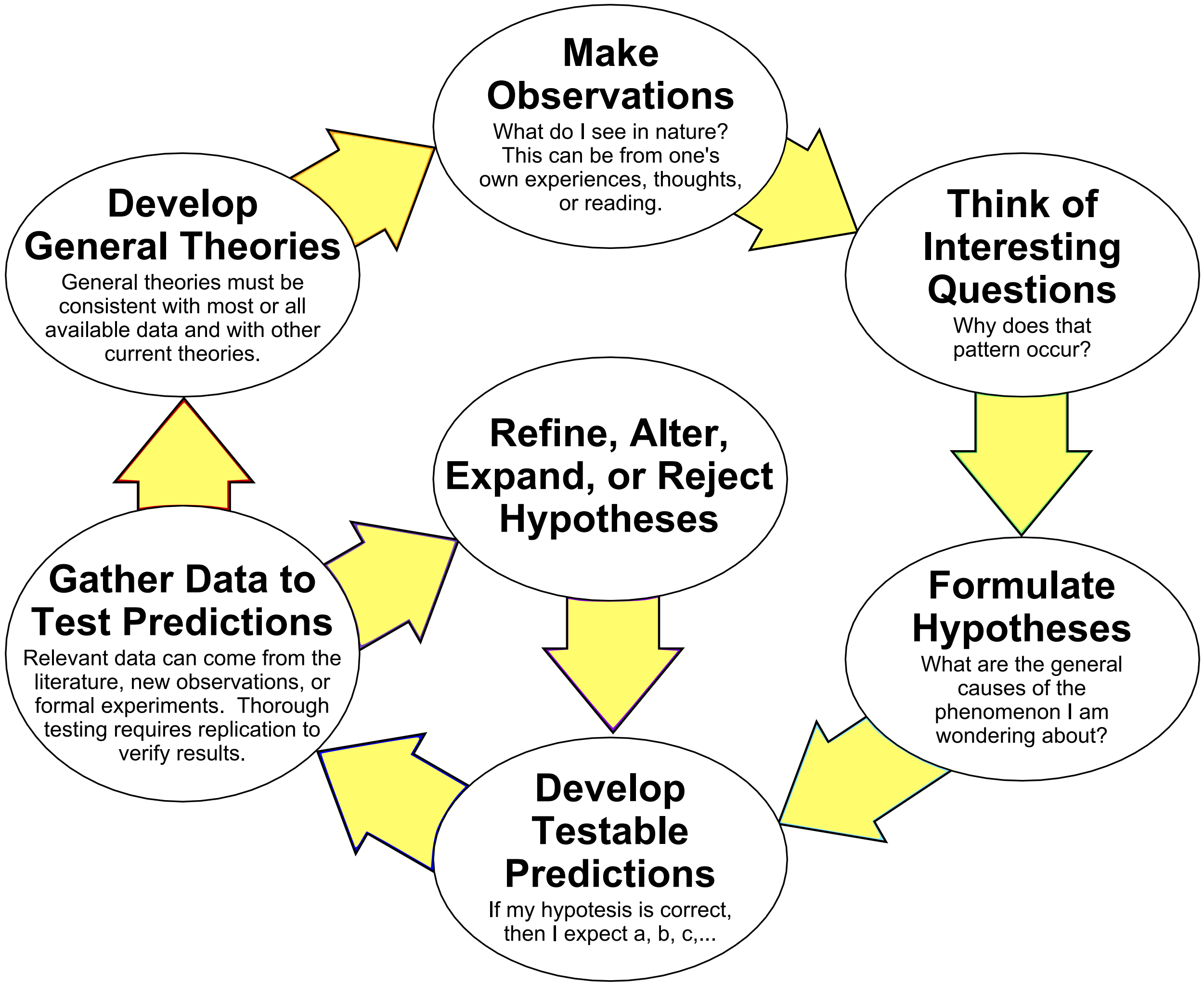
The Scientific Method

Specific



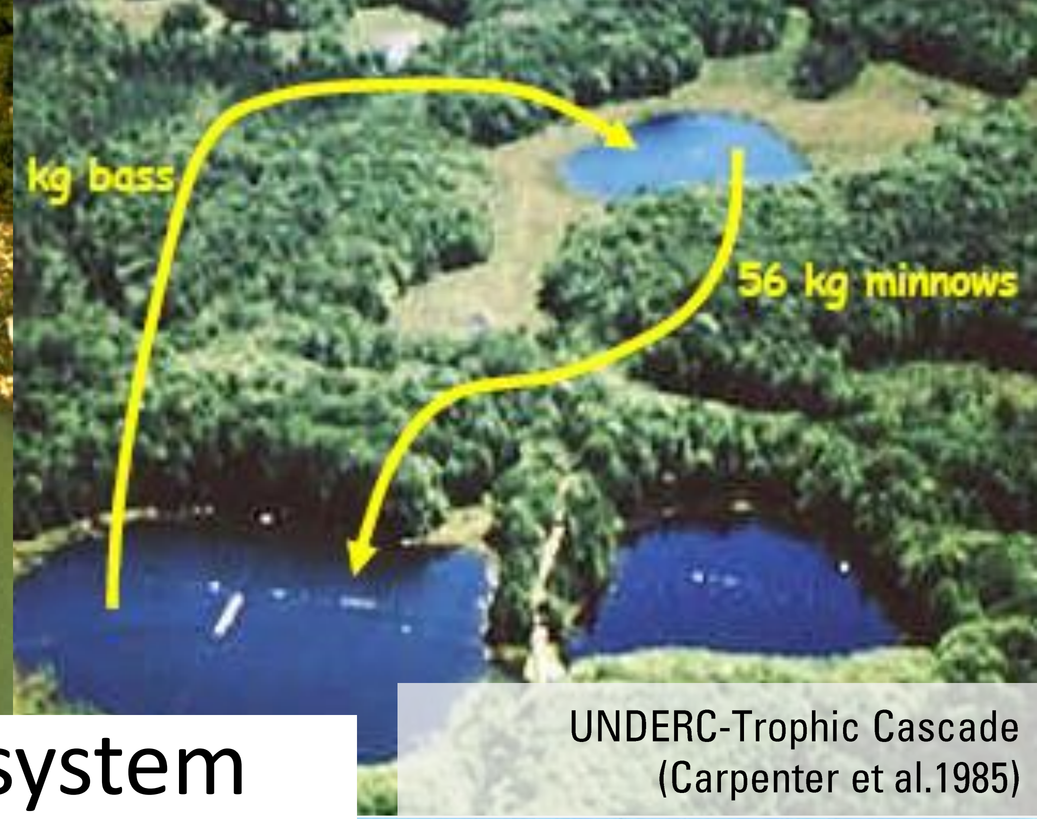
General

The Scientific Method as an Ongoing Process



Ecosystem Experiments

Experimental Lakes Area
(Schindler et al. 1975)



UNDERC-Trophic Cascade
(Carpenter et al.1985)

Carnation Creek
(Hartman et al. (1996)

Hubbard Brook
(Likens et al. 1970)

Historical Management (from Walters 1986)

- Up until 1900s, resources assumed to be limitless- little to no long-term management
- Dramatic shift in limits of sustainable harvest, monitoring systems to document this, and conservation movements
- 1950s fisheries, forestry, and wildlife management developed into scientific disciplines. Discovery would lead to management decisions
- 1960s skeptism whether resource sciences were making progress (e.g. collapse of the Peruvian anchovies)

Traditional approaches for making management decisions for natural resources (Johnson 1999)

- political/social
- conventional–wisdom
- best–current–data
- monitor–and–modify

Problem with some management approaches

- Often has been driven by expert opinion
- Often decisions not made with multiple stakeholders
- Not flexible to deal with changing conditions
- Threshold effects- not considering resilience
- Narrow focus/single species
    - Try to keep a population stable while allowing the system to change
- Social and ecological components may not align
- Lack of understanding
- Lack of data
- Large uncertainties
- Risk-averse
- Search for certainty smoothers opportunities

Expert opinion in management

Source of information	Number	%
Common sense	55	32.4
Personal experience	37	21.8
Speaking to other managers in region	34	20.0
Other managers outside region	4	2.4
Expert advisers	17	10.0
Secondary publications	19	11.2
Primary scientific literature	4	2.4

ELSEVIER Opinion *TRENDS in Ecology and Evolution* Vol.19 No.6 June 2004
Full text provided by www.sciencedirect.com
SCIENCE DIRECT

The need for evidence-based conservation

William J. Sutherland[1], Andrew S. Pullin[2], Paul M. Dolman[3] and Teri M. Knight[4]

[1]Centre for Ecology, Evolution and Conservation, School of Biological Sciences, University of East Anglia, Norwich, UK, NR4 7TJ

Origins of adaptive management

- Fredrick Taylor (1910)- Scientific Management
- Beverton-Holt (1957)– Population Dynamics modeling- comparison of different models and parameters to manage for optimal stock size.
- Holling (1973)-Resilience and stability of ecological systems
- Holling (1978) – Adaptive Environmental Assessment and Management
- Walters (1986) – Adaptive Management of Renewable Resources

Scientific Management

the scientific method of management

Emphasized: analysis; synthesis; logic; rationality; empiricism; work ethic; efficiency; best practices; mass production; and knowledge transfer

Frederick Taylor (1856–1915)

- Select methods backed by science
- Assign workers to jobs that match their aptitude
- Monitor worker performance
- Divide the workload between management and staff
- Use pay as incentive for workers and profit for the business

Beverton-Holt (1957)

- Develop methods of comparing detailed fish population models to estimate optimal harvest rates

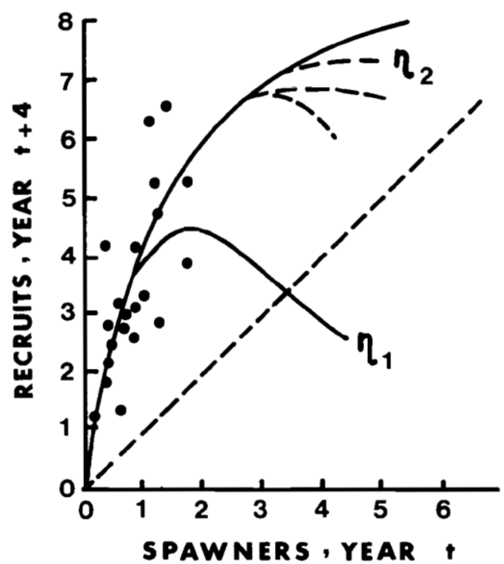
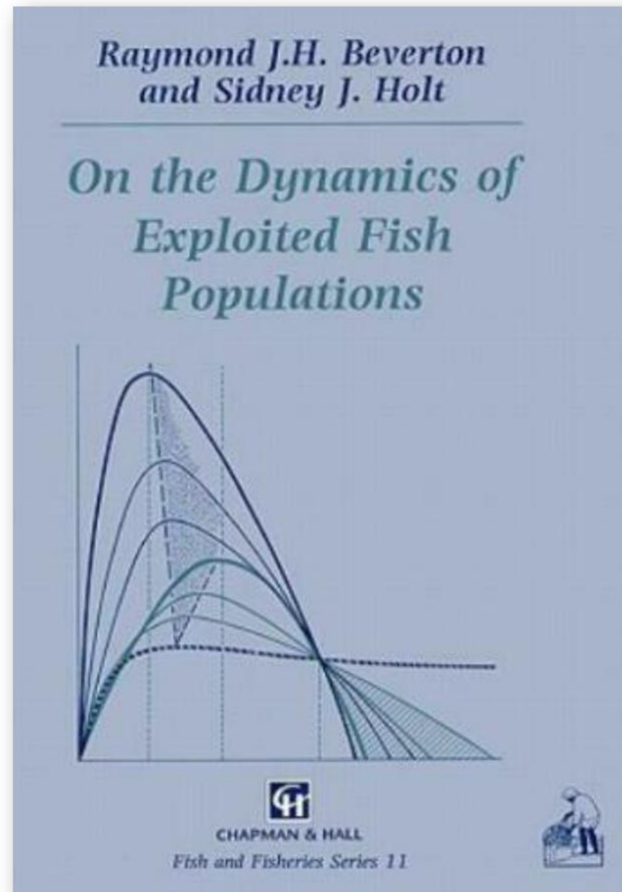
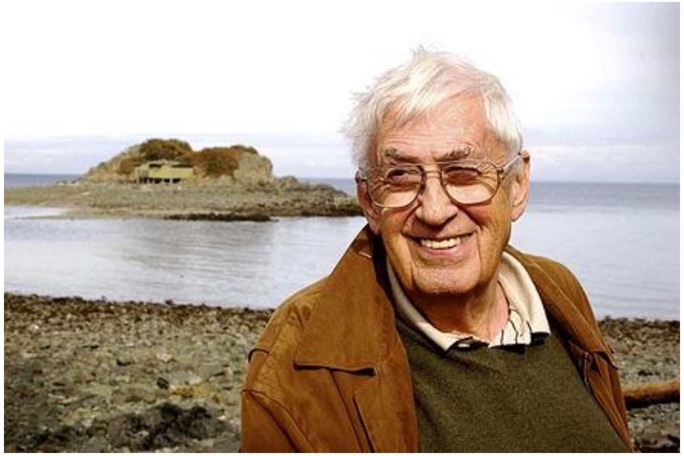


FIGURE 12.14 Alternative stock-recruitment models for Fraser River sockeye salmon, off-cycle years. Data shown are for 1939–1973, omitting every fourth or cycle year beginning in 1942. η_1, least-squares fit to Ricker model; η_2, visual fit to Beverton–Holt (1957) model. Graph axes in millions of fish. After Walters and Hilborn (1976).



CJ Holling (1973)

“Resilience is the ability of a system to experience disturbances, to be changed thereby and then to re-organize and still retain the same basic structure and ways of functioning. It includes the ability to learn from disturbance. Flexibility and break points are at its heart. The precepts of adaptive management were developed as a response to defining an ecosystem in terms of resilience.” Holling & Sundstrom (2015)

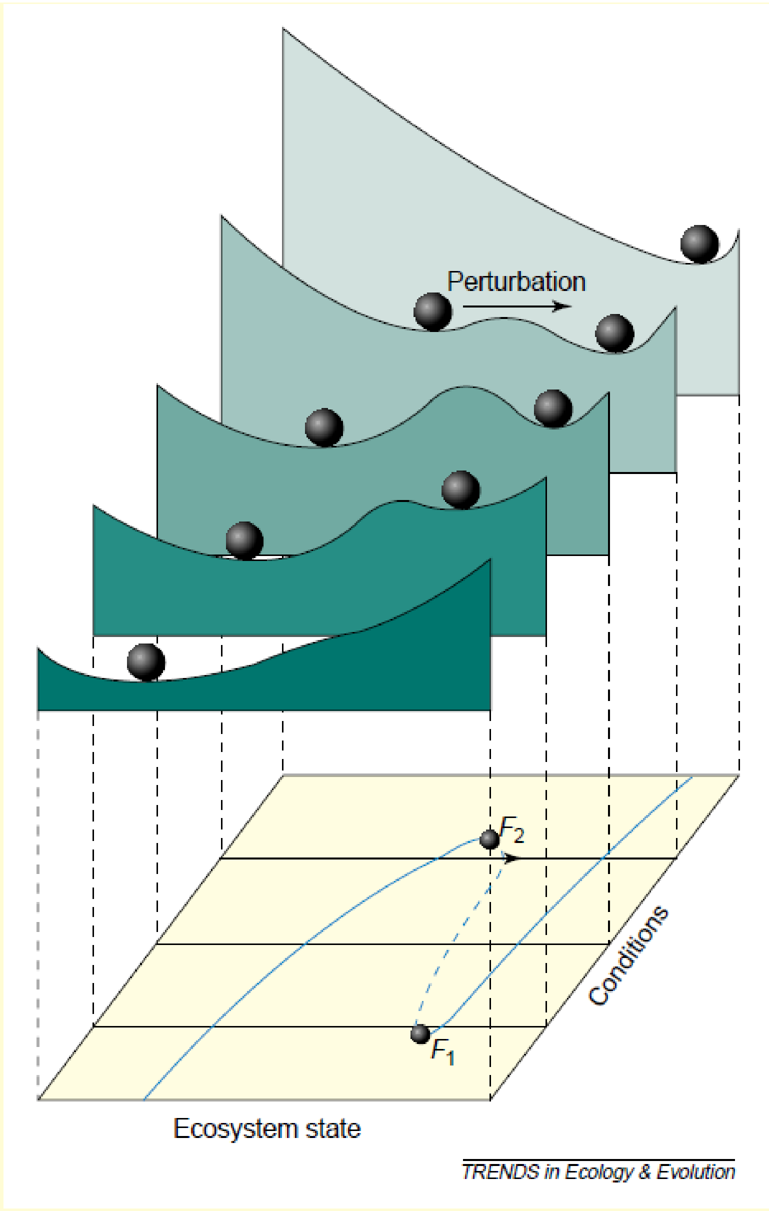


RESILIENCE AND STABILITY OF ECOLOGICAL SYSTEMS

C. S. Holling
Institute of Resource Ecology, University of British Columbia, Vancouver, Canada

Annu. Rev. Ecol. Syst. 1973.4:1-23.

Importance of resilience



648 Review TRENDS in Ecology and Evolution Vol.18 No.12 December 2003

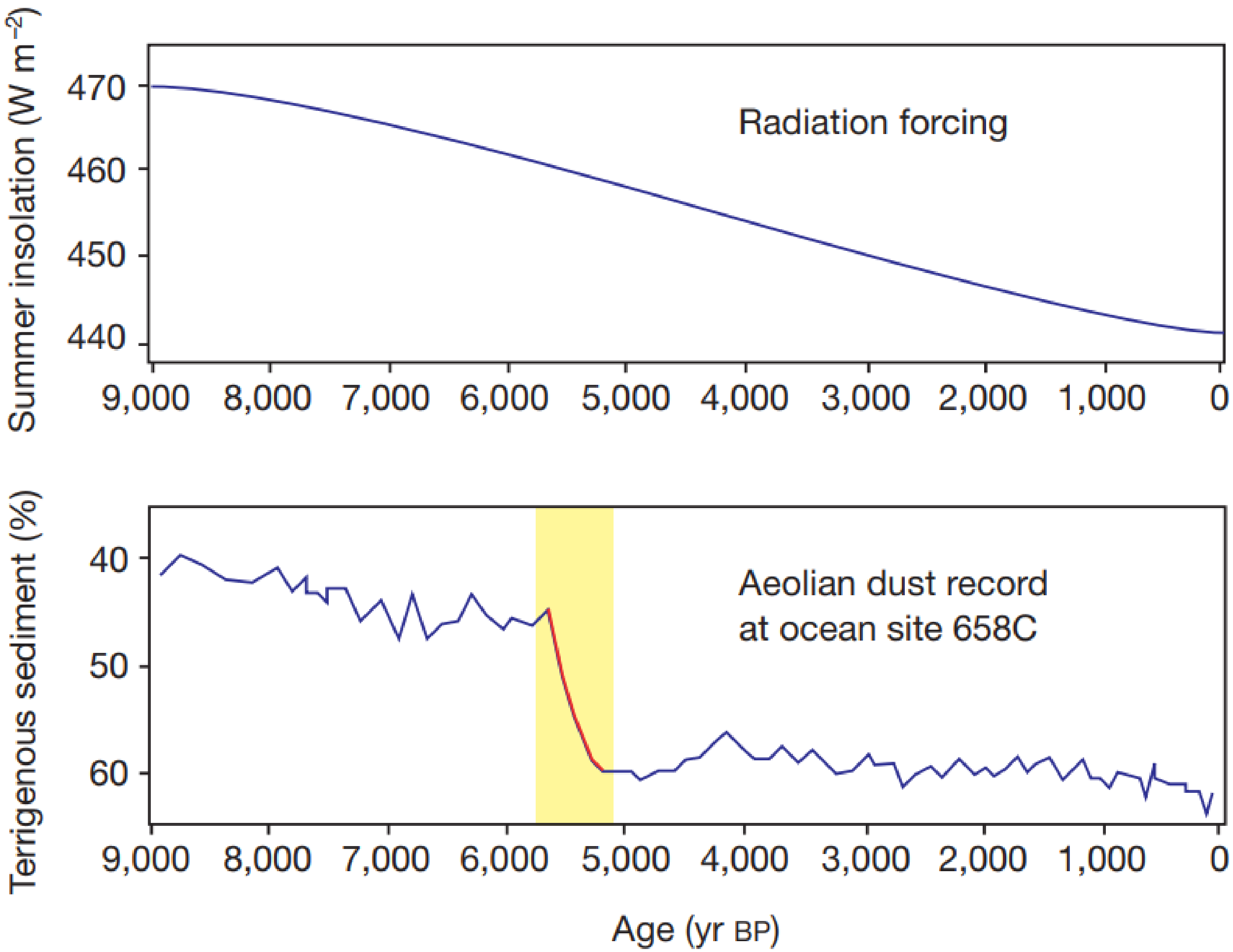
ELSEVIER

Catastrophic regime shifts in ecosystems: linking theory to observation

Marten Scheffer[1] and Stephen R. Carpenter[2]

[1]Department of Aquatic Ecology and Water Quality Management, Wageningen University, PO Box 8080, 6700 DD Wageningen,

Abrupt shift in climate and vegetation cover over the Sahara

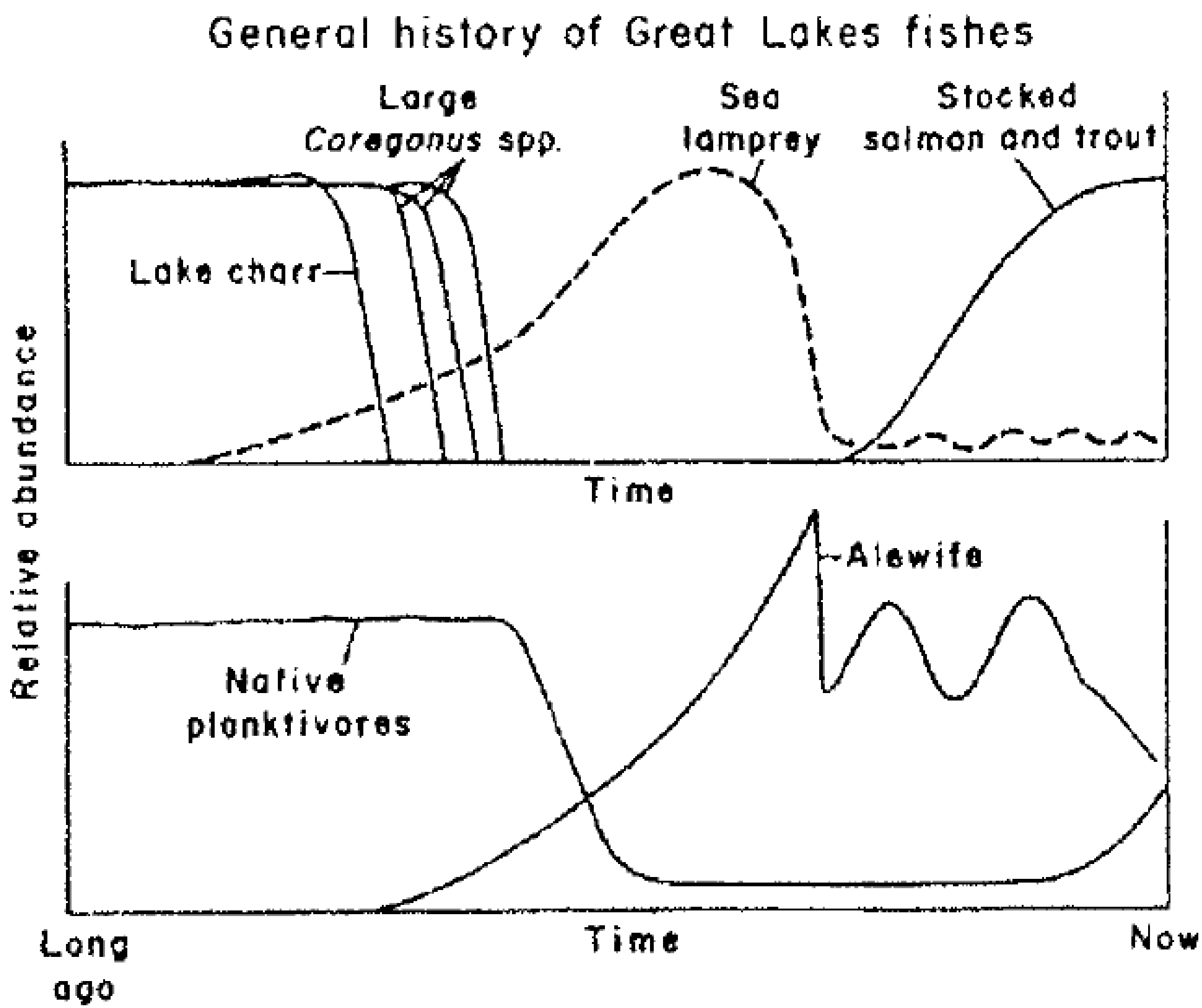



review article

NATURE | VOL 413 | 11 OCTOBER 2001

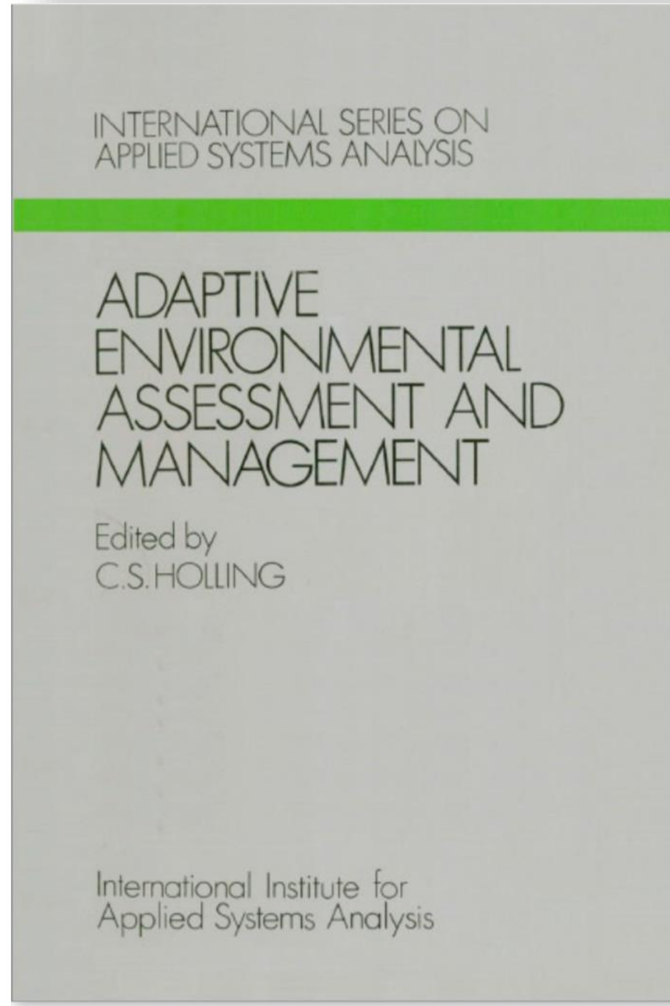
Catastrophic shifts in ecosystems

Marten Scheffer*, Steve Carpenter†, Jonathan A. Foley‡, Carl Folke§ & Brian Walker||


General history of Great Lakes fishes
Large
Coregonus spp.
Sea
lamprey
Stocked
salmon and trout
Lake charr
Time
Alewife
Native
planktivores
Relative abundance
Long
ago
Time
Now

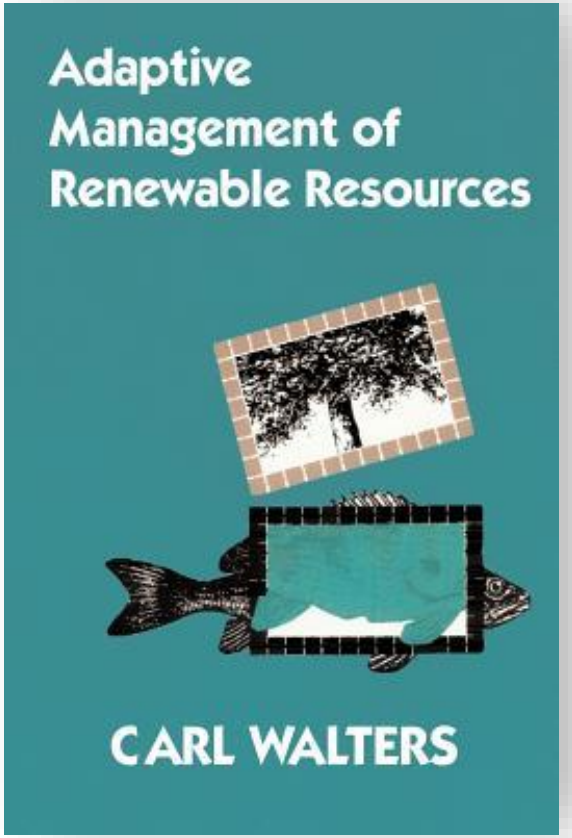
Holling + 11 coauthors (1978) – Adaptive Environmental Assessment and Management

- Resilience research led group engaged in several large-scale management issues.
- Allowed for comparative studies leading to theoretical foundations of ecosystem behavior and ecological, social and economic ecosystem management
- Lesson learned and case studies were the subjects of the book



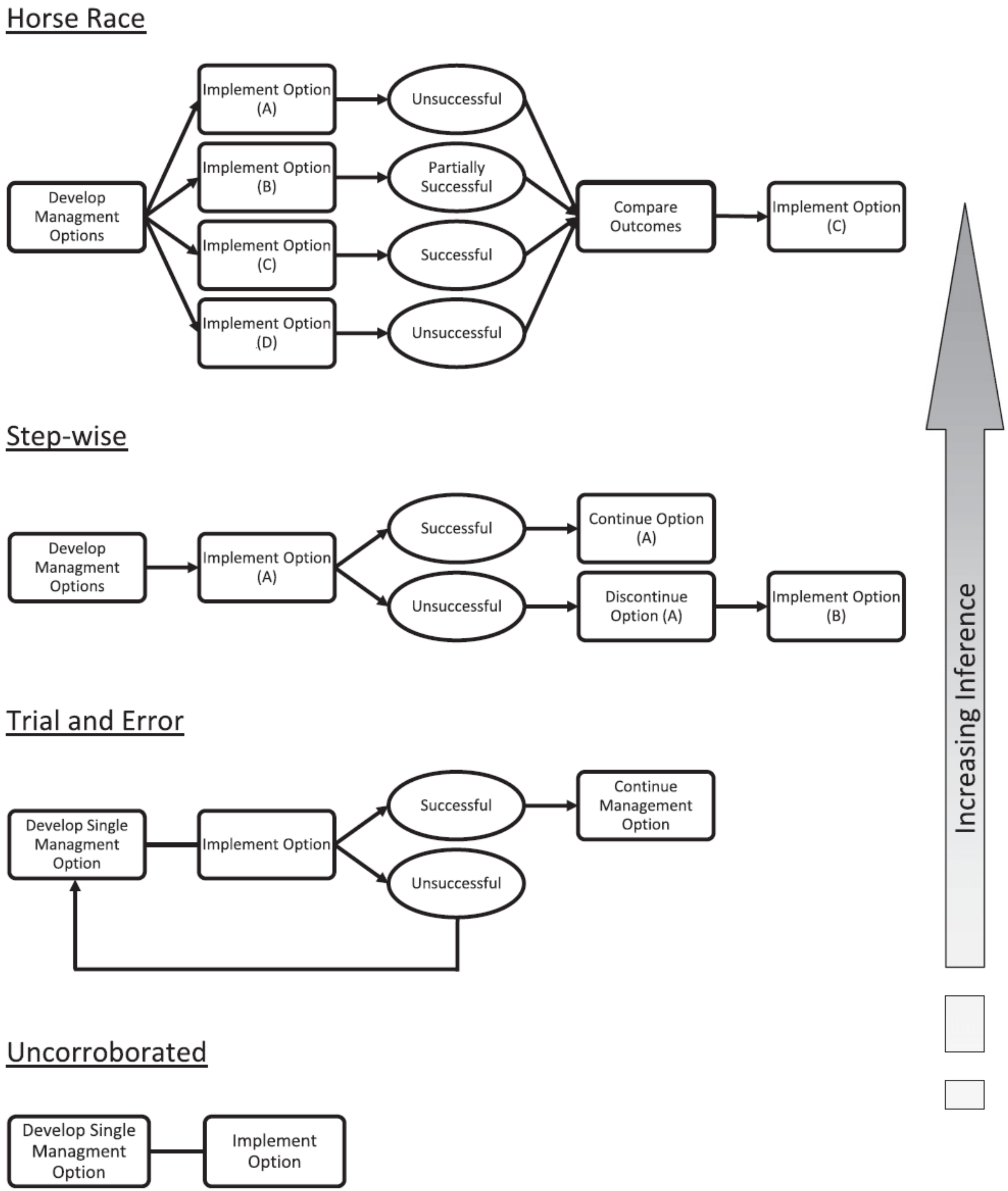
Walters (1986) – Adaptive Management of Renewable Resources

- Treat management as an adaptive learning process where management activities are the primary experiments
- The best way to evaluate complex systems (vs aggregating small directed research)
- The book provides a collection of tools for adaptive policy analyst



Structured management as an adaptive process (Walters 1986)

- Evolutionary or “trial and error” in which early choices are haphazard, while later choices are made from a subset that gives better results
- Passive adaptive, where available data each time (iterative) are used to construct a single best choice (assumes the model is correct)
- Active adaptive where available data each time (iterative) are used to structure a range of alternative response models and a policy choice is made that reflects a trade-off between short-term performance and long-term value of knowing which model is correct.


Horse Race
Develop Managment Options
Implement Option (A)
Implement Option (B)
Implement Option (C)
Implement Option (D)
Unsuccessful
Partially Successful
Successful
Unsuccessful
Compare Outcomes
Implement Option (C)
Step-wise
Develop Managment Options
Implement Option (A)
Successful
Unsuccessful
Continue Option (A)
Discontinue Option (A)
Implement Option (B)
Trial and Error
Develop Single Managment Option
Implement Option
Successful
Unsuccessful
Continue Management Option
Uncorroborated
Develop Single Managment Option
Implement Option
Increasing Inference

Embrace uncertainty- management decision still need to be made and we will never know everything

Uncertainty in resource management

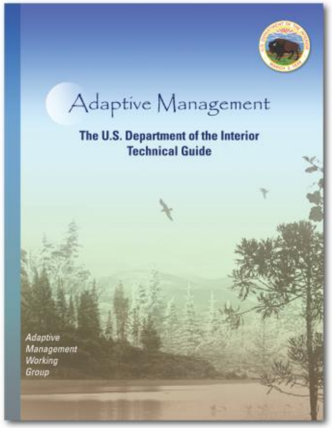
- Environmental variation
- Partial observability
- Partial controllability
- Structural or process uncertainty

What is Adaptive Management

- learning through management, with management adjustments as understanding improves (Williams 2011)

What is Adaptive Management?

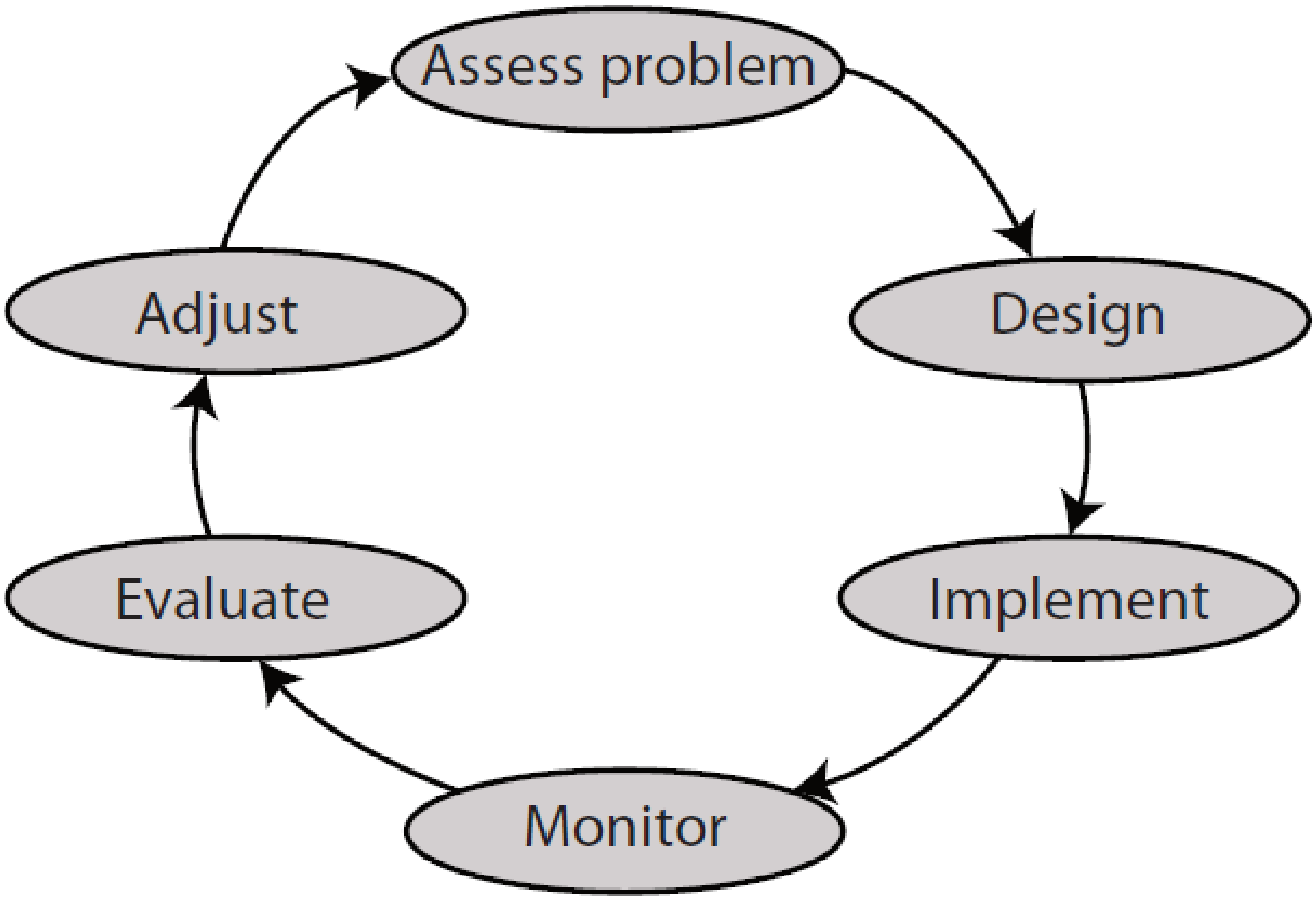
- Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders. (Williams et al. 2009)

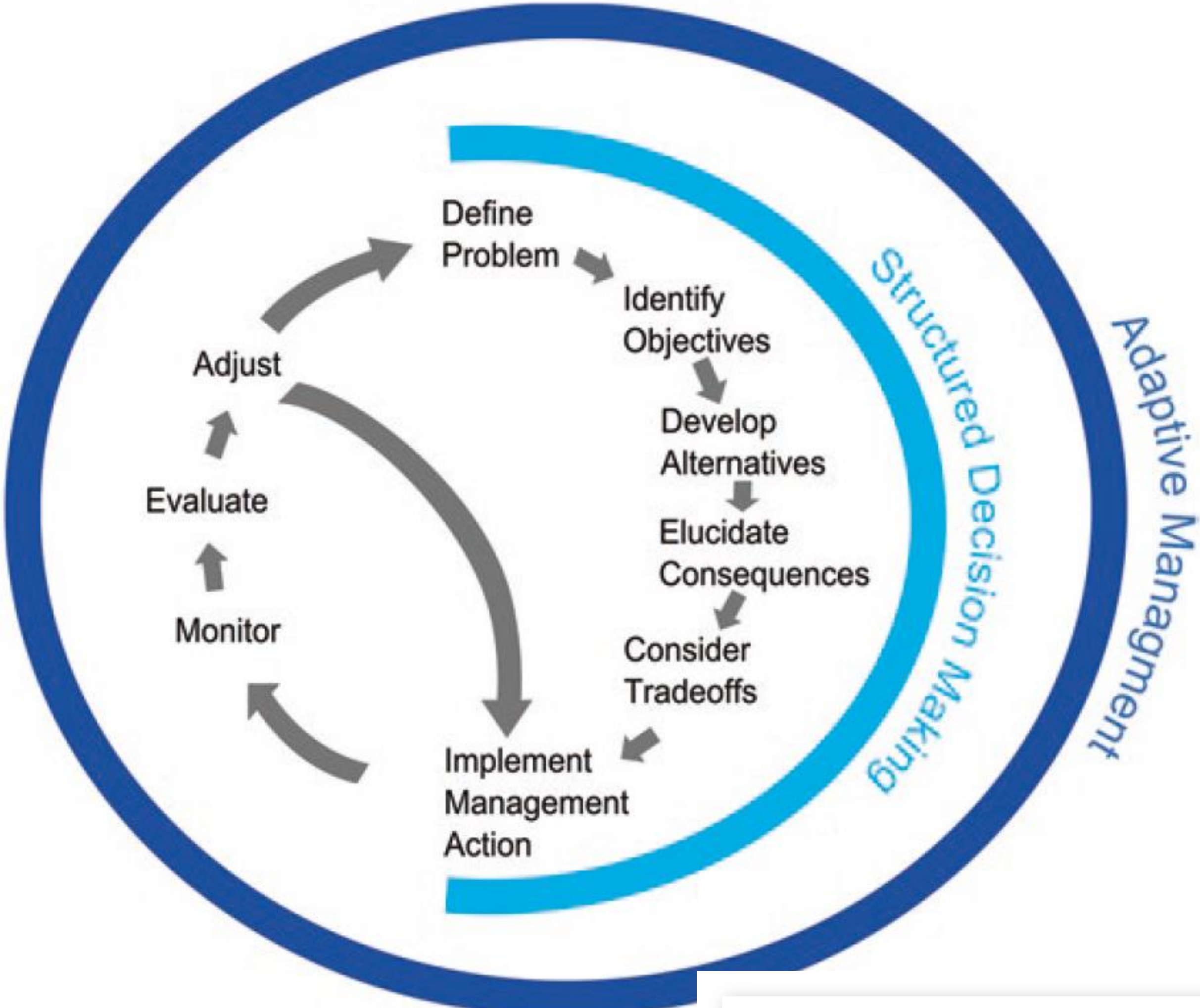


Conditions that Warrant an Adaptive Management Approach (Williams et al 2009)

- action must be taken in the face of uncertainty
- institutional capacity and commitment to undertake and sustain an adaptive program
- consequential decisions to be made
- an opportunity to apply learning exists
- objectives of management are clear
- the value of reducing uncertainty is high
- uncertainty can be expressed as a set of competing, testable hypothesis
- a monitoring system can be put in place with a reasonable expectation of reducing uncertainty

The process of Adaptive Management





Process of Adaptive Management

Chapter 11
Adaptive Management of Rangeland Systems

Craig R. Allen, David G. Angeler, Joseph J. Fontaine, Ahjond S. Garmestani, Noelle M. Hart, Kevin L. Pope, and Dirac Twidwell

"Adaptive Management of Rangeland Systems" (2017). *Nebraska Cooperative Fish & Wildlife Research Unit – Staff Publications*. 231.

Process of Adaptive Management

- Define the problem
- Identify objectives
- Develop alternatives
- Exploring consequences
- Consider trade-offs
- Implement management action
- Monitoring
- Evaluation
- Adjustment

Steps of Structured Decision Making

- Define the problem
- Identify objectives
- Develop alternatives
- Exploring consequences
- Consider trade-offs
- Implement management action

Define the Problem- What’s broken

- What decision(s) have to be made?
- What is the scope of the decision?
- Will the decision be iterated over time?
- What are the constraints within which the decision will be made?
- What stakeholders should be involved in the decision process and what are their respective roles?

Steps of Structured Decision Making

- Define the problem
- Identify objectives
- Develop alternatives
- Exploring consequences
- Consider trade-offs
- Implement management action

Identify objectives

- Define "why do care"?
- State desired direction and quantity of change that can measured
- Define key trade-offs and uncertainties so decision makers can create alternatives
- SMART
- Fundamental objectives (goals)
- Means objectives (ways of achieving an end)

Steps of Structured Decision Making

- Define the problem
- Identify objectives
- Develop alternatives
- Exploring consequences
- Consider trade-offs
- Implement management action

Develop alternatives

- Designed to address the outlined objectives
- Built on best known practices
- Comprehensive enough to include the technical understanding for implementation
- Expose trade-offs between the decision process by having mutually exclusive strategies
- Achieve the maximum benefit for the stakeholders involved

Steps of Structured Decision Making

- Define the problem
- Identify objectives
- Develop alternatives
- Exploring consequences
- Consider trade-offs
- Implement management action

Steps of Structured Decision Making

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Steps of Structured Decision Making

- Define the problem
- Identify objectives
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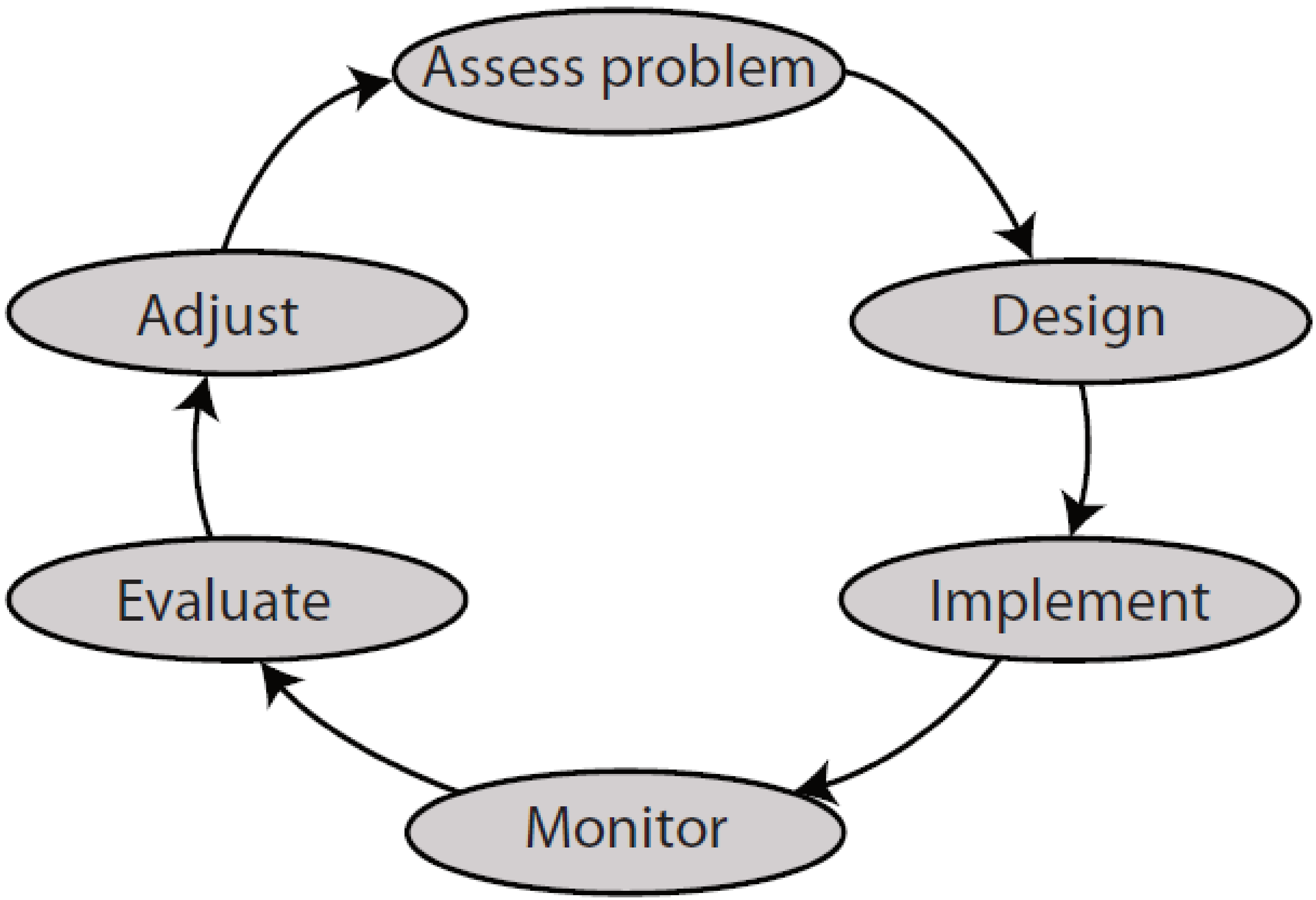
Process of Adaptive Management

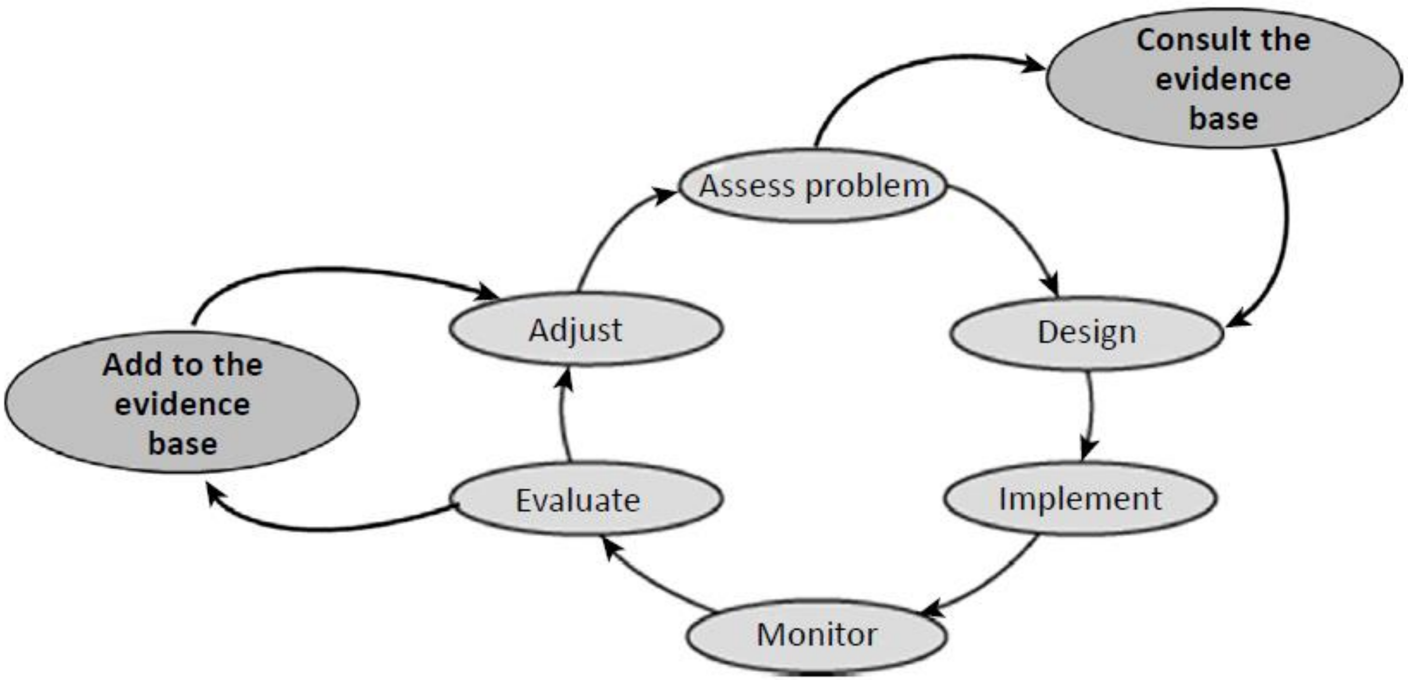
- Define the problem
- Identify objectives
- Develop alternatives
- Exploring consequences
- Consider trade-offs
- Implement management action
- Monitoring
- Evaluation
- Adjustment

Process of Adaptive Management

- Define the problem
- Identify objectives
- Develop monitoring design
- Develop alternatives
- Exploring consequences
- Consider trade-offs
- Implement management action
- Monitoring
- Evaluation
- Adjustment


Assess problem
Design
Implement
Monitor
Evaluate
Adjust

Combining evidence based conservation to adaptive management



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