



Synthesis:  
Nutrient Effects  
on Springs Biota

Synthesis: Springs Management and Research  
Needs



# Synthesis:

## Springs Management and Research Needs

### Our Driving Questions

- What are the most important unknowns?
- What are the most important management issues related to nutrients & springs?
- How might these management issues be addressed?
- What are the most important springs research initiatives?

# Synthesis:

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### Important Unknowns:

- Impacts on spring biota of exotic & nuisance species control
- Effects of combinations of N& P on spring biota
- Nutrient dynamics within algal mat communities
- The coupled nature of nutrient and trace metal cycles in spring systems
- The fate of N within the spring systems
- The function of sediments for storage and cycling of nutrients
- Population dynamics of higher level consumers and top down controls on spring community organization
- The implications of changing O<sub>2</sub> and C concentrations on spring community organization
- The interaction of nutrients, changes in consumer populations, O<sub>2</sub>, C, salts, flow and disturbance on spring community organization
- The age dynamics of spring water



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### Important management issues related to nutrients & springs.

- Management of exotic and nuisance species and impacts on ecosystem dynamics
- Cumulative interactions - Uncertainties associated with management of interactions nutrients, salts, flow regime, disturbance and how best to manage.
- Top-down/ bottom-up control - management alternatives quite different
- Responsiveness of pollutants to management - Uncertainties related to springsheds and flow paths - Sources, sinks and transformations of nutrients
- Human carrying capacity - how to manage effectively

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### How might these management issues be addressed?

In all cases an adaptive management strategy is warranted

- Exotic/nuisance species - eradication or manage?
- Cumulative effects - divide and conquer? Auto - Cross-correlation?
- Top-down/ bottom-up - exclusion / inclusion ?
- Responsiveness to management - test management - monitor at fine resolution
- Carrying capacity - limit human use?

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### The most important springs research initiatives

- Whole spring run N budgets
- Characterize temporal dynamics of water age estimates.
- Characterize temporal dynamics of nutrient, O<sub>2</sub>, salts, and flow at fine enough resolution to elucidate variability
- *in situ* top-down and bottom up experiments
- Elucidate the multi-causal nature of anthropogenic changes in spring ecosystems using cross-scale cross-system comparative studies
- Spatial modeling of springshed nutrient dynamics - coupled with research to better measure flow regime and water age



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### Potentials for management...

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#### Components of an Adaptive Basin-management Action Plans (A B-MAPS)

- Identify the problem (s)
- consider a variety of plausible hypotheses about why;
- consider a variety of possible strategies to fix the problem;
- model the problem and select actions
- favor actions that are robust to uncertainties ;  
informative and reversible;
- probe and experiment...collect data
- update assessments.



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### The Bold Experiment....

#### Adaptive Environmental Assessment and Management (AM)

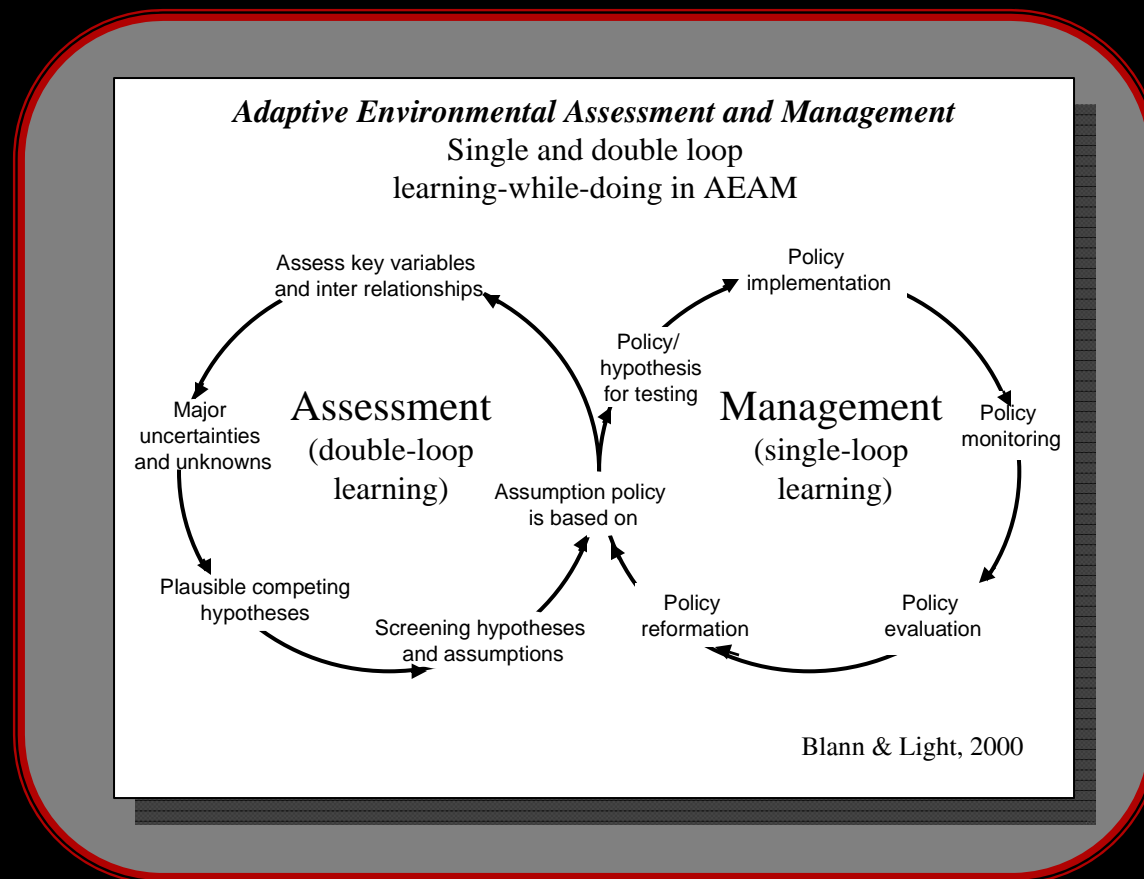
#### Several (6-10?) carefully chosen spring systems

1. Assess the potentials & pitfalls of AM
2. Assess the causality of spring system declines
  - Restore flow
  - Restore O<sub>2</sub> levels
  - Control N inputs
  - Control disturbance



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# Synthesis:

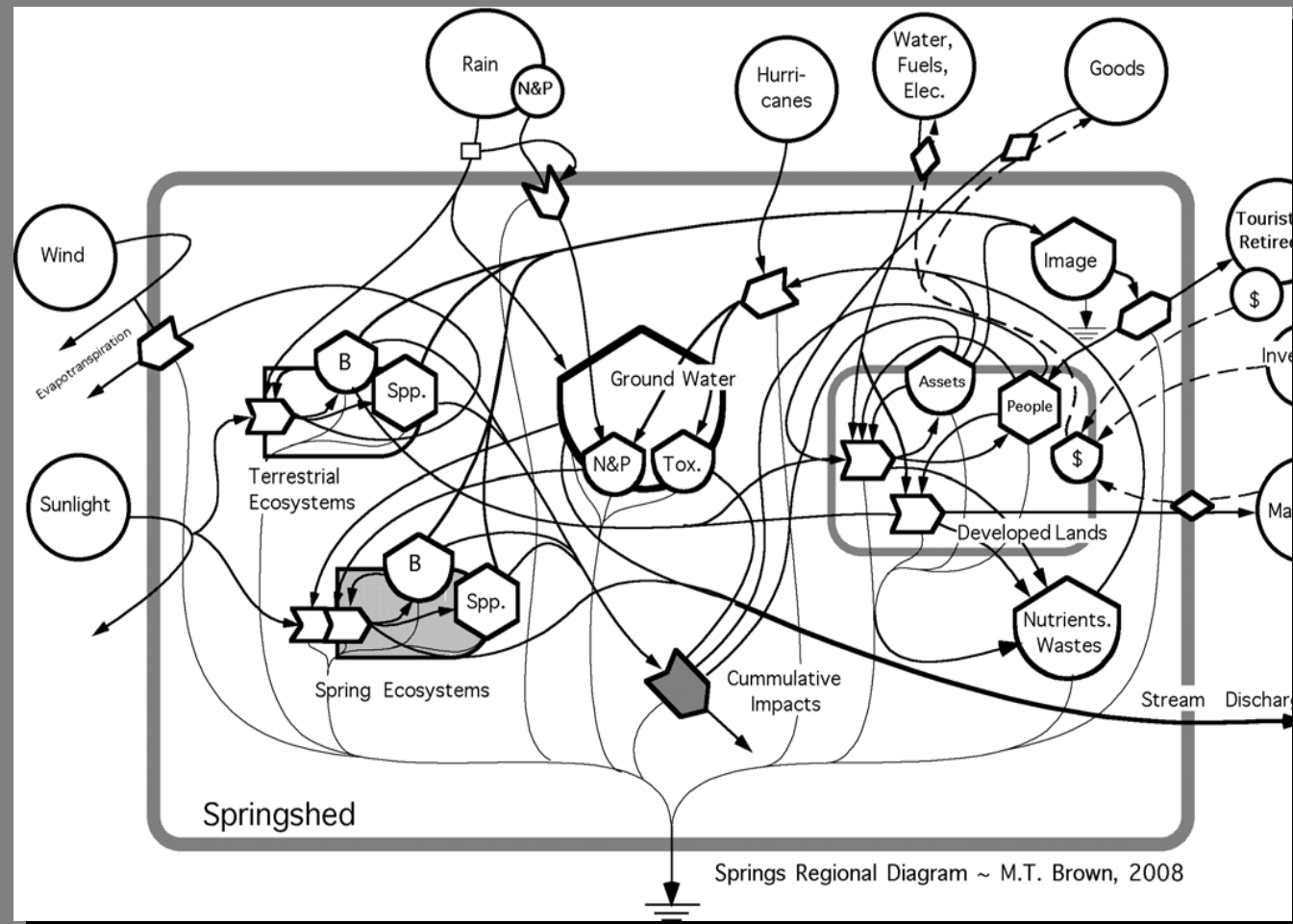
## Springs Management and Research Needs

### 1. ASSESS the PROBLEM

- 1.1 Define scope of management problem.
- 1.2 Define measurable management objectives and list potential management actions.
- 1.3 Identify key indicators for each objective.
- 1.4 Explore effects of alternative actions on indicators. (MODEL)
- 1.5 Make explicit forecasts about response of indicators to alternative management actions.
- 1.6 Identify and assess key gaps in understanding (key uncertainties).

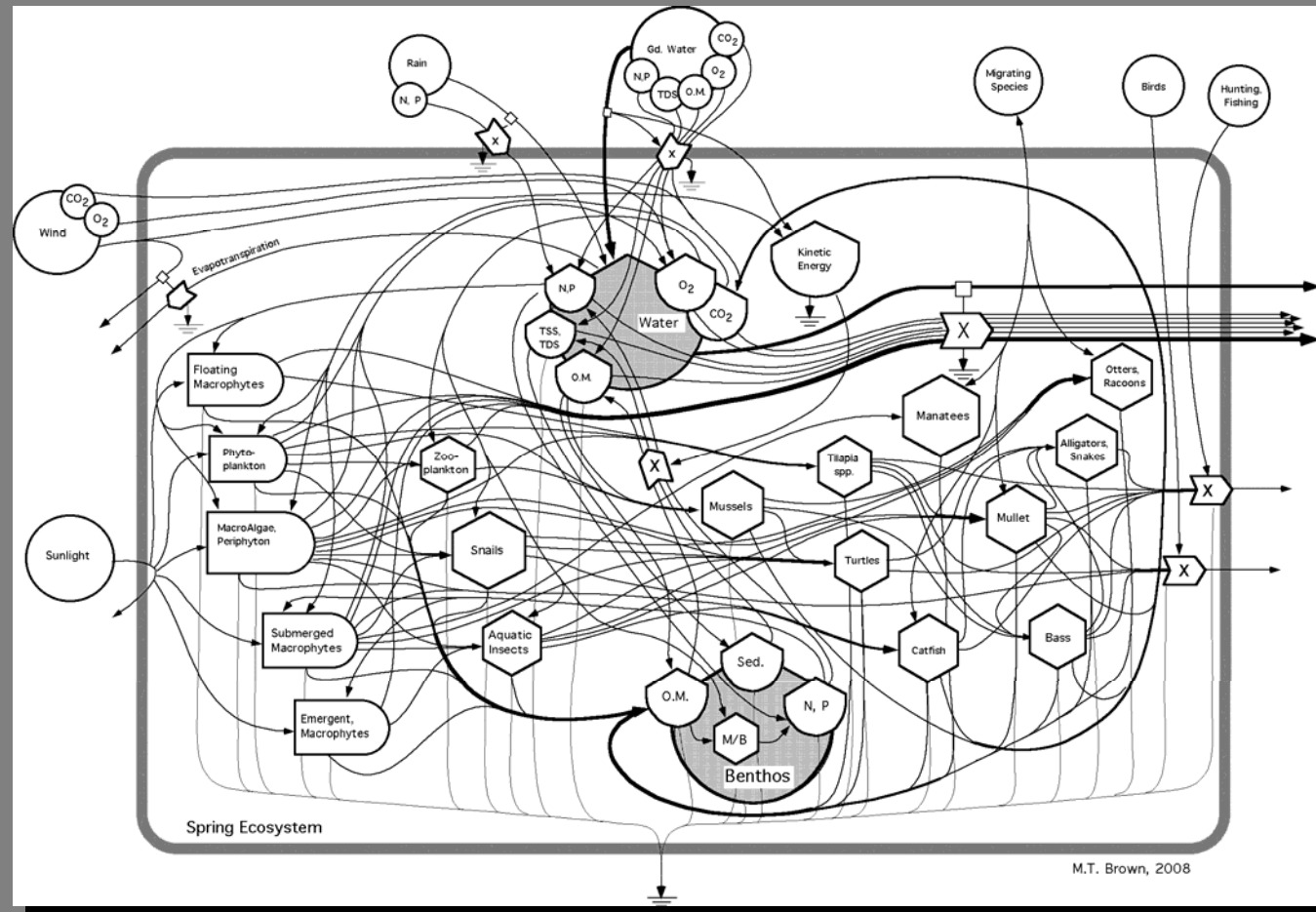
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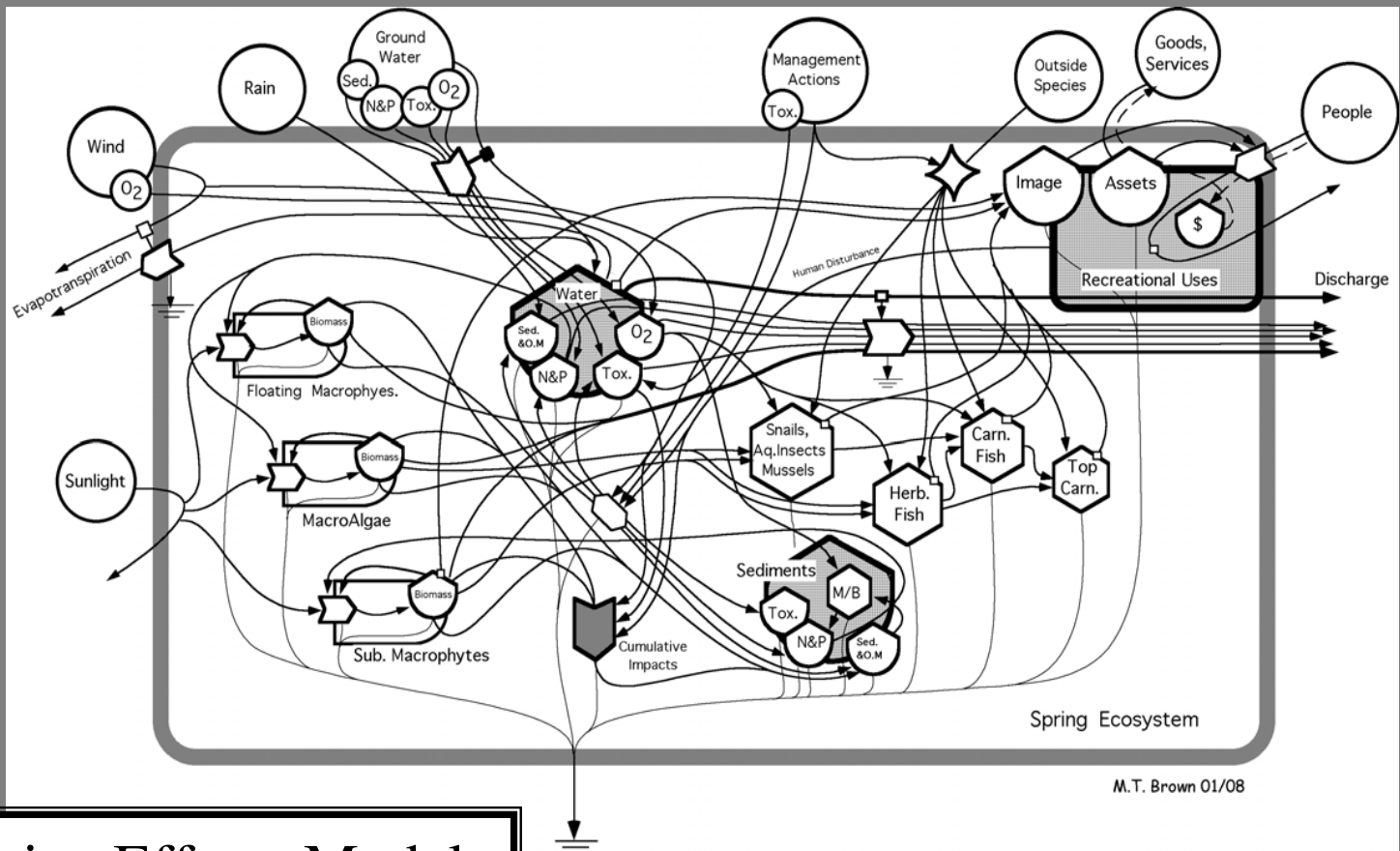


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# Synthesis: Springs Management and Research Needs



Cumulative Effects Model



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### 2. DESIGN the MANAGEMENT PLAN

- 2.1 Design management plan and monitoring program.
- 2.2 Evaluate management options/alternative designs, and choose options to implement.
- 2.3 Design monitoring protocol.
- 2.4 Plan data management and analysis.
- 2.5 State how management actions or objectives will be adjusted.
- 2.6 Set up system to communicate results and information.

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### 3. IMPLEMENT the MANAGEMENT PLAN

3.1 Follow the plan

3.2 Monitor implementation and document any deviations  
from plan.



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### 4. MONITOR the RESULTS

- 4.1 Monitor for compliance, effectiveness and validation of hypotheses:
- 4.2 Follow the monitoring protocol designed in Step 2.





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### 5. EVALUATE the OUTCOMES

5.1 Compare actual outcomes to forecasts and hypotheses.

5.2 Document results and communicate them to others within the management frame.



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### 6. ADJUST the DIRECTIONS / INTERVENTIONS

- 6.1 Identify where uncertainties have been reduced, and where they remain unresolved.
- 6.2 Adjust the model used to forecast outcomes so that it reflects the hypothesis supported by results.
- 6.3 Adjust subsequent management decisions and policies, and reevaluate objectives, as necessary.
- 6.4 Make new predictions, design new management experiments, test new options.



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Thank You...Questions?