Enabling Adaptive Management in a Noisy and Complex World: What Does It Take?

Clint Alexander*, Marc Nelitz, David Marmorek, Carol Murray & Cedar Morton

Canadian Studies Program, UC Berkeley, May 9, 2019
Adaptive Management is....

a rigorous approach for designing and implementing management actions to maximize learning about critical uncertainties that affect recurrent decisions while simultaneously striving to meet multiple management objectives.
Robust AM strives to balance learning and doing

**LEARNING** (Enabled by **Technical** Factors)

**DOING** (Enabled by **Institutional** Factors)

Adapted from Duitz and Galaz 2008
Robust AM strives to balance learning and doing

LEARNING (Enabled by Technical Factors)

DOING (Enabled by Institutional Factors)

“Autopilot”

Adapted from Duitz and Galaz 2008
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**DOING** (Enabled by Institutional Factors)

**LEARNING** (Enabled by Technical Factors)

GAMBLING

ON MY HUNCH

“Autopilot”

Adapted from Duitz and Galaz 2008
Robust AM strives to balance learning and doing

LEARNING (Enabled by Technical Factors)

DOING (Enabled by Institutional Factors)

HIGH

LOW

LEARNING

SCIENCE PROGRAM

HIGH

LOW

GAMBLING

ON MY HUNCH

“Autopilot”

Adapted from Duitz and Galaz 2008
Robust AM strives to balance learning and doing

LEARNING (Enabled by Technical Factors)

DOING (Enabled by Institutional Factors)

GAMBLING ON MY HUNCH

HIGH

LOW

ROBUST AM

SCIENCE PROGRAM

"Autopilot"

HIGH

LOW

Adapted from Duitz and Galaz 2008
We’ve learned it takes...

- Good governance to enable good science
- A common transboundary framework
- Acceleration using real-time tools & “turn taking”
- Integration of climate change adaptation
Key message 1: Focus first on institutional requirements; technical aspects will follow
# Two wheels, multiple gears

<table>
<thead>
<tr>
<th>Technical Gears</th>
<th>Institutional Gears</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigorous AM science</td>
<td>Executive Direction / Authority</td>
</tr>
<tr>
<td>• Thorough experimental design</td>
<td>Strong Communication within agencies &amp; with stakeholders</td>
</tr>
<tr>
<td>• Strong contrasts, replication</td>
<td>Effective Governance Arrangements</td>
</tr>
<tr>
<td>• Targeted monitoring &amp; rapid evaluation</td>
<td>Trust</td>
</tr>
</tbody>
</table>

**Science boiled down for decision makers**

**Leadership**
Missouri River: Many interests, many voices

- Navigation
- Irrigation
- Flood control
- Fish and wildlife
- Recreation
- Water quality
- Water supply
- Agriculture
- Conservation districts
- Waterway industries
- Major tributaries
- Thermal power
- Hydro power
- At large / other interests (cultural and historic preservation)
- Local government
- Environmental / conservation organizations

Missouri River Basin

- 15 federal government agencies
- 8 state agencies
- 29 stakeholder members representing 16 stakeholder interests x 2 reps / interest
- 29 Tribes
Governance

MRRIC
Agency Leadership (Oversight)

Agency Management Team
Corps/USFWS

Implementation Level

Bird Team
- Corps/USFWS Implementation Staff
- MRRIC Bird WG

Fish Team
- Corps/USFWS Implementation Staff
- Fish PM Water Mgt. Rep.
- MRRIC Fish WG

HC Team
- Corps/USFWS Technical Staff
- MRRIC HC WG

Technical Team

Independent Panel

Integrate Science Program
Governance

Agency Management Team
Corps/USFWS

Implementation Level

Bird Team
- Corps/USFWS Implementation Staff
- Bird PM
- MRRIC Bird WG

Fish Team
- Corps/USFWS Implementation Staff
- Fish PM
- MRRIC Fish WG

HC Team
- Corps/USFWS Technical Staff
- MRRIC PM
- MRRIC HC WG

Independent Panel

Stakeholders

Integrated Science Program

Managers

Technical - Implementers

Technical - Scientists

Independent Science Reviewers
Key Contributions Enabling AM...

1. Robust governance powers technical underpinnings of AM
   - Technical gears don’t turn efficiently (or at all) with ad hoc leadership structures

2. Clarity and separation of major roles with choreographed interactions enhances effectiveness
Key messages 2 & 3: Develop a common transboundary framework for describing problems

Then

Accelerate balanced trade-off decisions using real-time tools and “turn-taking”
What Does a Common Transboundary AM Framework Look Like?

- **Common** input datasets and tools (powering indicator generation)
- **Collaborative** trade-off evaluation
- **Basin-wide** perspective, technical and institutional *flexibility*
Why? Important to AM because...

Dueling science

Effect!

No effect!

Government
Industry

Academics
Indigenous
Nations
eNGOs
Common “Core” (Specific) Performance Measures

DIAGNOSTIC MEASURES → Candidate Performance Measures
Common “Core” (Specific) Performance Measures

DIAGNOSTIC MEASURES → Candidate Performance Measures

VITAL SIGNS → Core Performance Measures

- heart rate
- skin/core body temperature
- SpO2 (oxygen saturation)
- respiratory rate
- blood pressure

CT and MRI
- radionuclide bone scan
- PET scan
- cardiac catheterization and angiogram
- at-home blood glucose testing
- genotyping
- sputum culture
- cystoscopy
Business as Usual
“What if” Tooling

The “view” downstream

*Today’s Menu*
- **Take it** or
- **Leave it**

Input ➔ **BLACK BOX** ➔ Output

1-WAY SEQUENCE

- **Scenario Generation**
- **Operations Model**
- **Multiple Subsystem Models/Rules, Performance Indicators**
- **Multi-objective Tradeoff Summary**
Coupled Modeling: Deep Learning Optimization/Feedback Loop

Focused trade-off evaluation on more robust set of scenarios from 1000s of trial simulations
Key Contributions Enabling AM...

1. Clear **specific** core performance indicators
   - specific includes agreeing on performance that is “good enough” or “acceptable”

2. Common science foundation (models & tools) allows focus on hard trade-off decisions (values)

3. Can explore **thousands** of scenarios to find robust solutions
Success Story: Okanagan River Sockeye

- **Context:** Wells dam operators responsible to mitigate dam related fish losses (Douglas County Public Utility District)
- **Challenges:** Competing demands, changing climate, extreme events, Columbia River dam operations
- **AM:** Recover Okanagan sockeye by flow management, re-introduction to Skaha Lake

Columbia River sub-basins historically accessible to sockeye

Columbia River sub-basins with present day viable sockeye populations

<table>
<thead>
<tr>
<th>COLUMBIA RIVER DAM SITES</th>
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</thead>
<tbody>
<tr>
<td>1 Bonneville</td>
</tr>
<tr>
<td>2 The Dalles</td>
</tr>
<tr>
<td>3 John Day</td>
</tr>
<tr>
<td>4 McNary</td>
</tr>
<tr>
<td>5 Priest Rapids</td>
</tr>
<tr>
<td>6 Wanapum</td>
</tr>
<tr>
<td>7 Rock Island</td>
</tr>
<tr>
<td>8 Rocky Reach</td>
</tr>
<tr>
<td>9 Wells</td>
</tr>
<tr>
<td>10 Chief Joseph</td>
</tr>
<tr>
<td>11 Grand Coulee</td>
</tr>
<tr>
<td>12 Zosel</td>
</tr>
<tr>
<td>13 McIntyre</td>
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</table>
Success Story: Okanagan River Sockeye

March 23, 2010 – 24

Challenges:
- Competing demands
- Changing climate
- Extreme events
- Columbia River dam operations

AM:
- Recover Okanagan sockeye by flow management
- Re-introduction to Skaha Lake

Context:
Wells dam operators responsible to mitigate dam-related fish losses (Douglas County Public Utility District)

Okanagan Wenatchee ARROW LAKES
Columbia River sub-basins historically accessible to sockeye
Columbia River sub-basins with present day viable sockeye populations

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Return Year

 FWMT & Skaha Re-intro projects begin in 2002.
Coupled Subsystem Models & Real-Time Decision Making

- Flood control
- Agriculture water intake
- Navigation (docks)
- Kokanee survival
- Domestic water intake
- Navigation (boats)
- Ridged mussel
Need Earlier Warnings of Extreme Events

Estimated Property Damage

- > $20M
- $1.5-20M
- << $.5M
The snow pillow data for Mission Creek is currently above the 91st percentile which is rare for the week of Feb 26. Our analysis shows this may lead to a very wet year.
4. **Coupled**, *real-time* models accelerate shared understanding

- Less information lost than if relying on paper ‘master manuals’
- Operators and planners brought *together*

5. Automated forecasts & early warnings allow for more proactive adjustments
Improving Multi-Objective Ecological Flow Management with Flexible Priorities and Turn-Taking: A Case Study from the Sacramento River and Sacramento–San Joaquin Delta

Clint A. D. Alexander*,1, Frank Poulsen1, Donald C. E. Robinson1, Brian O. Ma1, and Ryan A. Luster2

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Jagger's Law
You can't always get what you want
But if you try sometimes, well you just might find
You get what you need
—Jagger and Richards, 1969

What Does Turn-Taking Look Like?

Turn-Taking Optimization vs Business As Usual

Year

1 2 3 4 5 6 7 8 9 10 11
Flow Adjustments

Management Priority

Species Status

Year

Delta Smelt
Chinook Salmon
Steelhead
Fremont Cottonwood

Business as Usual

Turn Taking Optimization
Key Contributions Enabling AM...

6. Turn-taking expands solution space when confronted with multitude of objectives

- Don’t have to pick “winners and losers”
- Responsive to natural (climate) conditions
- Ready-made for operational (not just planning) context
**Key message 4:** Blend principles / practices of adaptive management (AM) and climate change adaptation (CCA)
Recent river basin AM projects facing extreme climate events

- Extreme runoff and flow events (Floods)
- Decreasing precipitation leading to longer Drought

Map showing river basins with symbols indicating extreme conditions.
Recent river basin AM projects facing extreme climate events

- **Extreme runoff and flow events (Floods)**
- **Decreasing precipitation leading to longer Drought**
Recent river basin AM projects facing extreme climate events

**Extreme runoff and flow events (Floods)**

Decreasing precipitation leading to longer Drought

- Platte River
- Okanagan
- Missouri River
- Trinity River
- Russian River
Recent river basin AM projects facing extreme climate events

**Extreme runoff and flow events** (Floods)

Decreasing precipitation leading to longer Drought
Recent river basin AM projects facing extreme climate events

- Extreme runoff and flow events (Floods)
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Recent river basin AM projects facing extreme climate events. Extreme runoff and flow events (floods) and decreasing precipitation leading to longer drought.
Recent river basin AM projects facing extreme climate events

- Extreme runoff and flow events (Floods)
- Decreasing precipitation leading to longer Drought

Okanagan
Trinity River
Platte River
Russian River
Missouri River
Recent river projects facing extreme climate events. Extreme runoff and flow events (Floods). Decreasing precipitation leading to longer drought.

H: 5,000 to 8,000 cfs will build sandbars.
Climate change adaptation strategies can benefit AM projects

1. Use variability in flow to test flow-habitat hypotheses
2. Develop real-time systems for anomaly detection and flood forecasting from weather
3. Leverage storage (dams, groundwater, wetlands, ponds) to reduce impacts of drought
4. Rethink and re-design habitat restoration for greater resilience during droughts and floods
5. Implement actions to reduce water demand
6. Revise basin-wide water management strategies to meet species’ needs and accommodate increased variability in flows
Climate change adaptation strategies can benefit AM projects

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In Review, American Water Resource Association

Adaptive Management and Climate Change Adaptation: Two Mutually Beneficial Areas of Practice

David Marmorek, Marc Nelitz, Jimena Eyzaguirre, Carol Murray and Clint Alexander

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Research Impact Statement: Adaptive Management (a rigorous approach to learning while doing) and Climate Change Adaptation (a way to reduce risks from climate change) are mutually beneficial and supportive fields of practice.

Abstract: Adaptive management (AM) is a rigorous approach to implementing, monitoring and evaluating actions, so as to learn and adjust those actions. Existing AM projects are at risk from climate change, and current AM guidance does not provide adequate methods to deal with this risk. Climate change adaptation (CCA) is an approach to plan and implement actions to reduce...
In Summary!

Front ‘governance’ gears first
rear ‘technical’ gears will follow

Establish common transboundary framework & tools

Accelerate using real-time tools & “turn taking”

Integrate climate change adaptation
Thank you!

https://essa.com/approach/
http://essa.com/services/adaptive-management/


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