

Records of Engagement and Decisions for Science and Management of Coupled Human-Natural Systems

Pierre Glynn
USGS, NWQMC Workshop, Nov. 6, 2018

With additions from Patricia McKay (MSU),
Nicole Herman-Mercer, Michael Rosen, Carl Shapiro (USGS),
Alexey Voinov (UTS, Australia), and
Paul White (GNS, New Zealand)

Indian Peaks Wilderness, CO, July 2015

Some Takeaways

- Humans increasingly affect living and natural systems.
- Anticipation and planning is essential to managing human futures.
- Recognizing sources of human judgments, and role of biases, beliefs, heuristics, values (BBHV) in decision-making is critical.
- Adaptive management is essential, but requires follow-through.
- Stakeholder/public engagement is essential.
- So is trust and attention to social values.
- Creating Records of Engagement and decision-making (RoE) is needed, but will require new approaches and tools.
- RoE can potentially help address water quality issues.

Outline

1. Human Evolution: Communications & Thinking
2. BBHV* & CHN** Systems
3. RoE***: Rationale & Principles
4. Technology to the Rescue?
5. RoE and water quality: example cases

*BBHV: Biases, Beliefs, Heuristics, Values

**CHN: Coupled Human-Natural

***RoE: Records of Engagement and decision-making

Evolution in Consciousness...

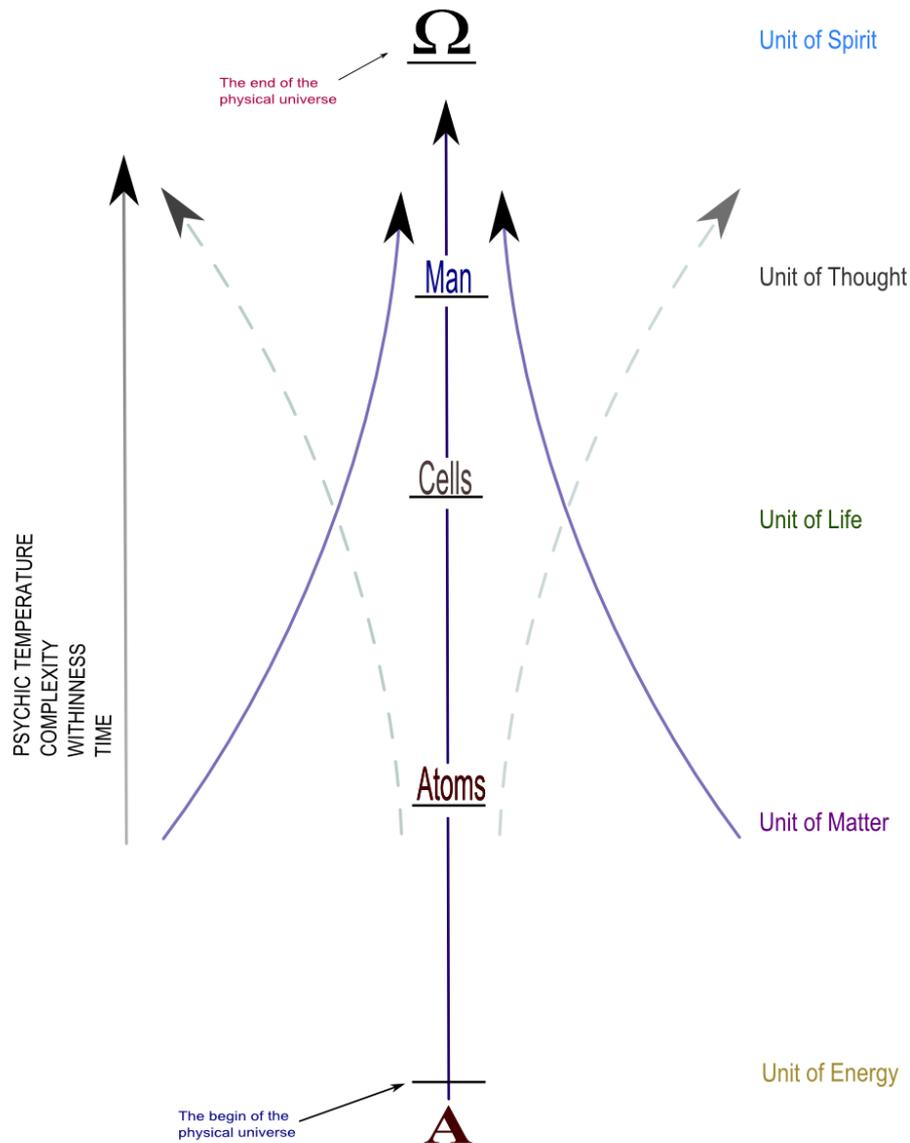
The Noosphere Concept

“A postulated sphere or stage of evolutionary development dominated by consciousness, the mind, and interpersonal relationships“.

Vladimir Vernadsky
(1863-1945; geochemist)

Edouard Le Roy
(1870-1954; philosopher & mathematician)

Pierre Teilhard de Chardin
French philosopher, paleontologist, Jesuit
priest (1881-1955). (image: Wikipedia, 8/6/2016; Archives des
Jesuites de France)



The Cosmos
The Process of convergence and divergence

~17000 years old RoE: animals, humans, abstract symbols



Great Hall of the Bulls, Lascaux Cave, France

Re-discovered RoEs, New RoE Synthesis

Philosophy Causality Governance

Gutenberg's
printing press
(1439)

The School
Of Athens,
Raphael,
1509-1511
(Wikipedia)

Luther's
German Bible
(1522-1534)





Information in the Internet Age

Memes

(short, simple, potentially viral, mutate, evolve...)

Innate **history**

Missing contexts?

Chopped humanity reflects technology dominance?

Decrease in literacy and thinking?
Move back to orality (Ong, 1982)?
Increase in visuality & sociality.

La jeune fille à l'intrigant
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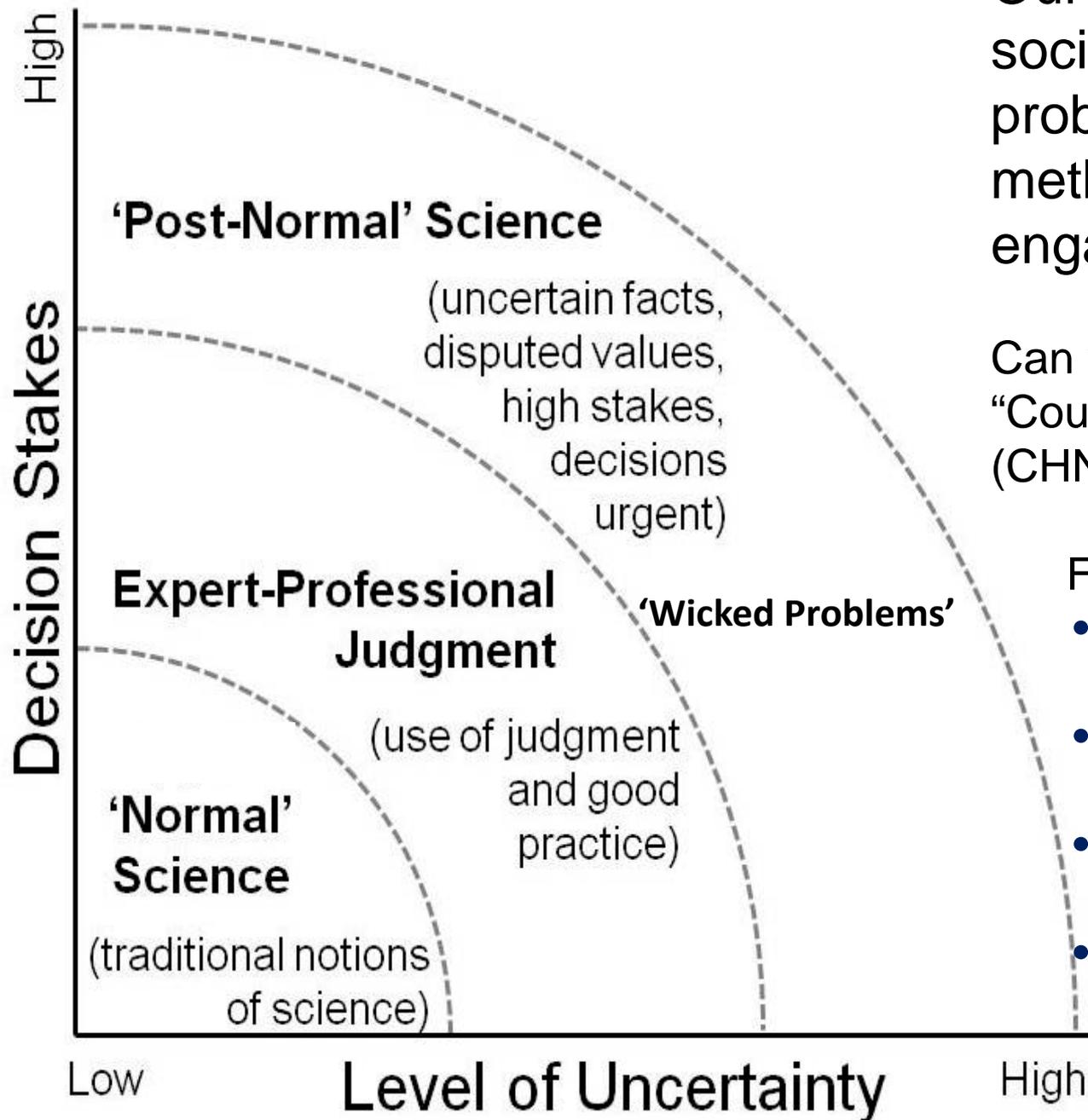
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Our most important societal issues and problems require new methods and public engagement!

Can we better manage our “Coupled Human-Natural” (CHN) Systems?

Four ingredients:

- Anticipatory Adaptive Management
- Critical thinking, Systems thinking
- Stakeholder/public engagement
- Establishing Trust

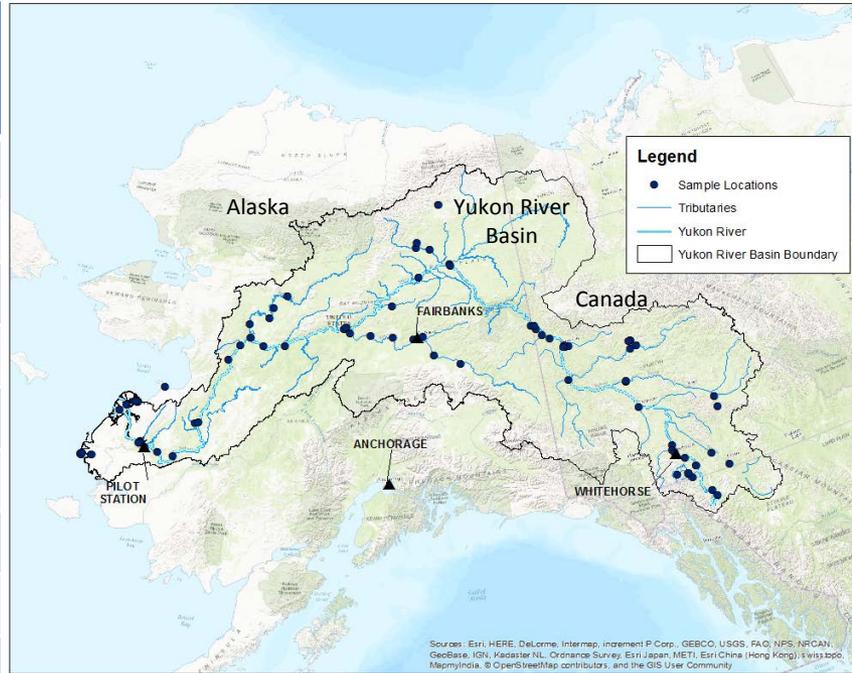
Timescales for Anticipatory Management?

Action	Short-Term < 1 yr	Near-Term ~2 – 20 yrs	Long-Term ~ Decades
Predict & manage outbreaks of water- or vector-borne disease	✓		
Plan recreation intensity to minimize resource damage	✓	✓	
Implement control treatments on invasive species	✓	✓	
Manage water discharge/storage (dams & reservoirs)	✓	✓	✓
Design infrastructure to mitigate climate extremes and natural hazards (and possibly land-use change).		sometimes	✓
Acquire new land, develop easements to sustain ecological habitats & connectivity		sometimes	✓

Indigenous Observation Network: Water-Quality Monitoring (Concerns: climate change, landfills, mining)



Year	Number of Sites	Number of Samples
2006	19	86
2007	27	135
2008	35	183
2009	31	178
2010	33	193
2011	41	139
2012	43	200
2013	38	287
2014	54	239
2015	24	39
2016	34	58
2017	27	51

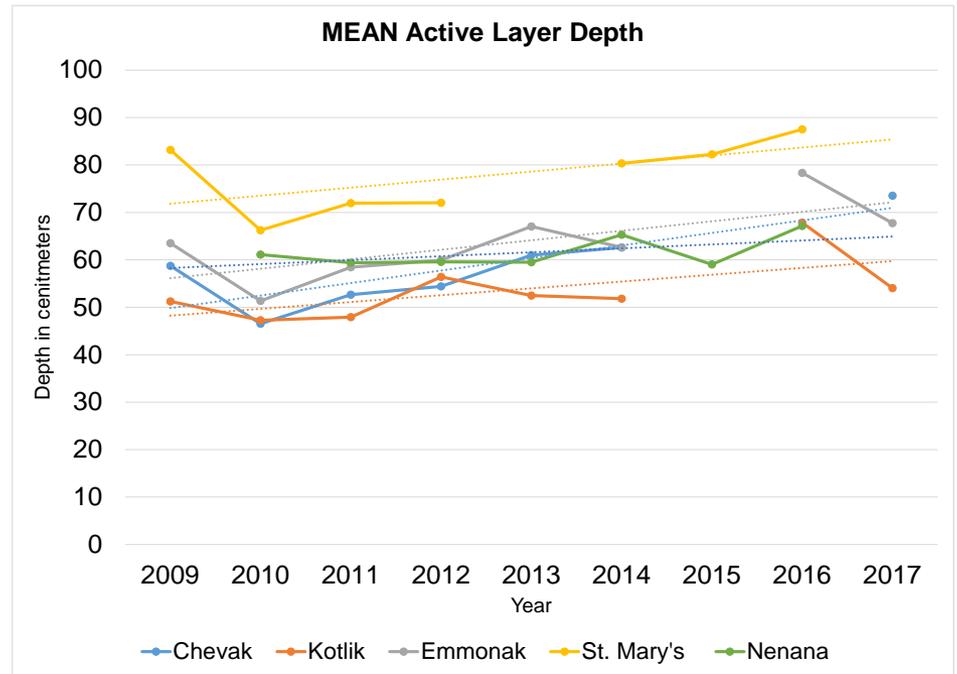
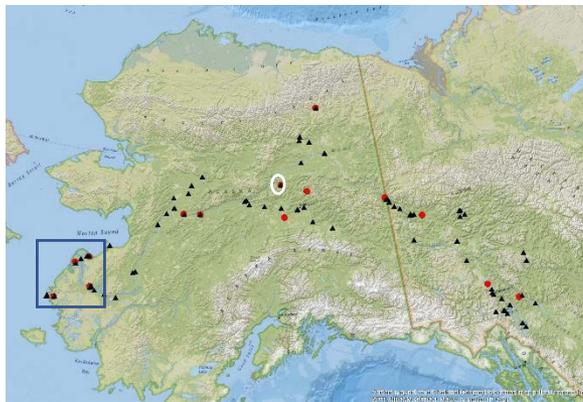


NSF funding for coordinators ran out in 2015.

Sampling focus: baseline data (rather than documentation of point-source contamination.)

Herman-Mercer et al. (2018): “Our results suggest that Indigenous Observation Network data are of high quality, and with consistent protocols and participant training, community based monitoring projects can collect data that are accurate, precise, and reliable.”

ION: Community-based active layer monitoring



Active layer depth increasing with time.
Result: increasing major ion concentrations
in streams and rivers.

What is Participatory Modeling?

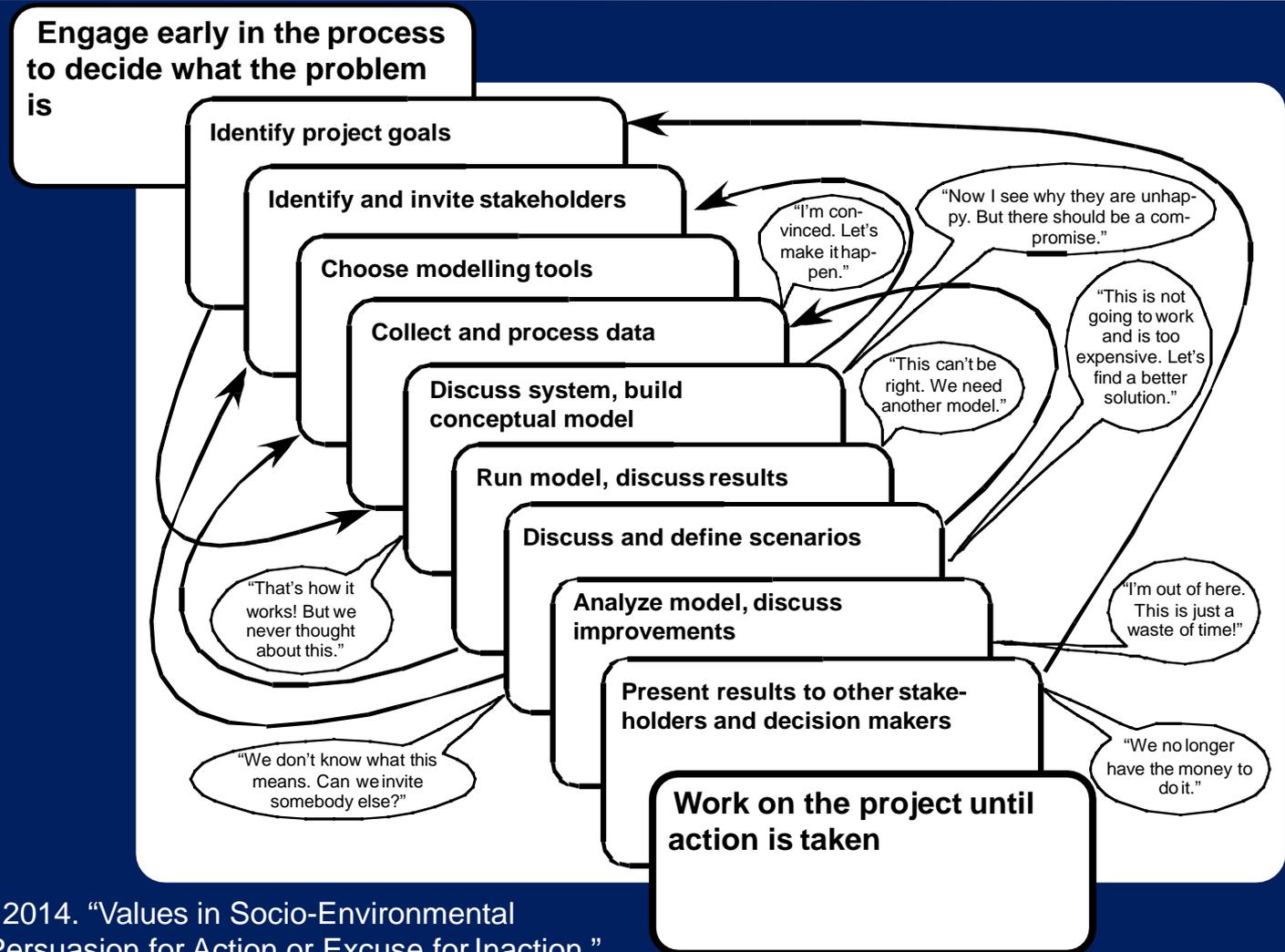
A *purposeful* learning process for action that *engages* the implicit and explicit knowledge of stakeholders to *create* formalized and shared representations of reality.

In the process, the participants *co-create* the problem statement, and *use modeling practices* to define the descriptions, “solutions”, and *decision-making actions* of the group.

<https://www.participatorymodeling.org/>

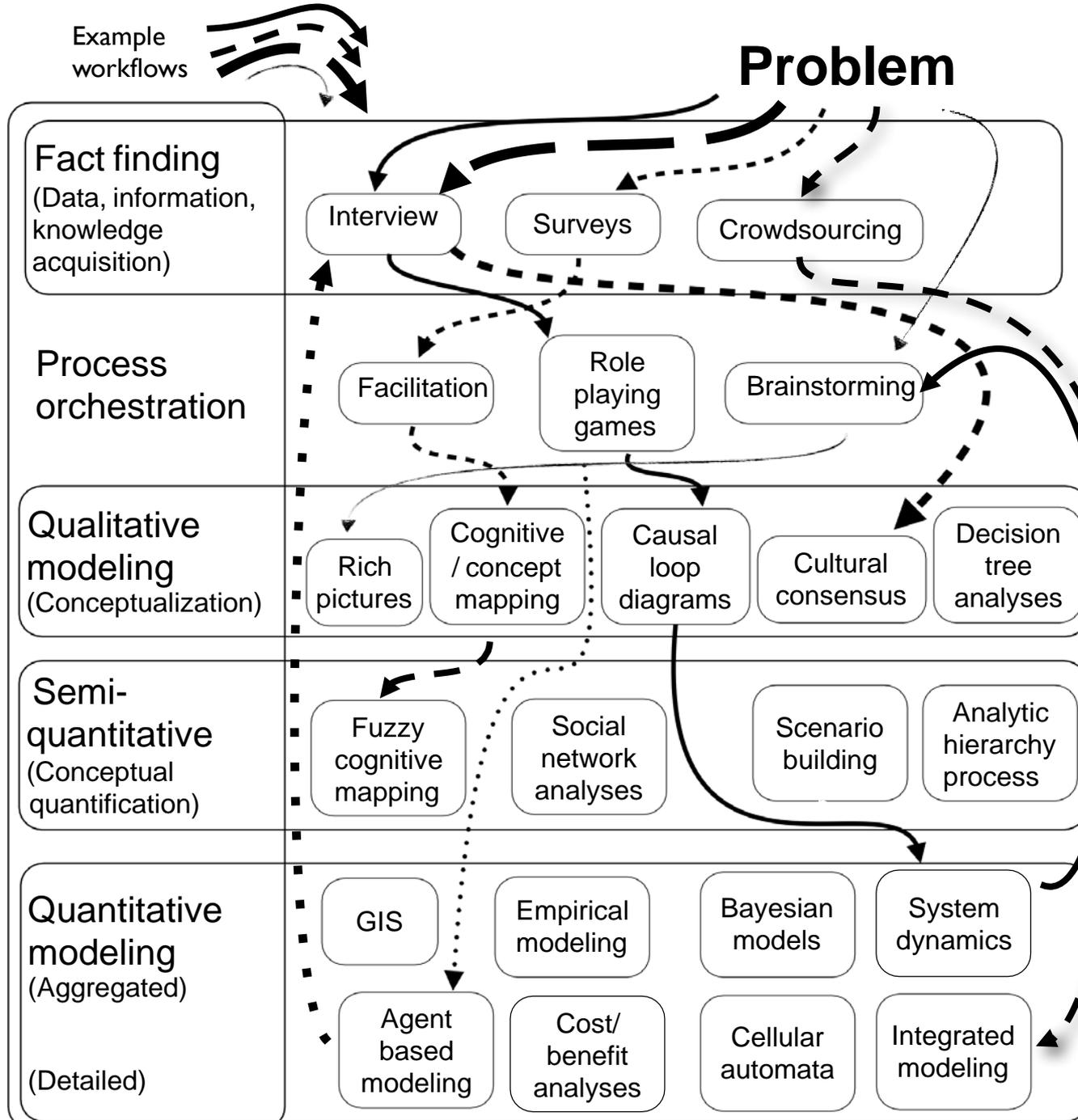
(Voinov et al., 2018, 2016; Jordan et al., 2018)

Modeling with Stakeholders



Voinov, A, et al. 2014. "Values in Socio-Environmental Modelling: Persuasion for Action or Excuse for Inaction." *Environmental Modelling & Software* 53: 207–212.





A Need for Critical Thinking

Choices & BBHV Affect Science:

- Data and Observations
- Process “truths” (e.g. causality relations)
- Conceptual/numerical models or other syntheses of information and assumptions
- Study design & implementation for wicked problems
- Informed **expert judgment** or expert opinions

~ Increasing Subjectivity
~ Usefulness for Decisions ~

BBHV affect all judgments and decisions.

Integrity and critical thinking require BBHV recognition

All decisions are affected by BBHV

BBHV are efficiencies from:

- 1) Our evolutionary **past**
- 2) Adapted social structures, interactions
- 3) Individual learning & experiences

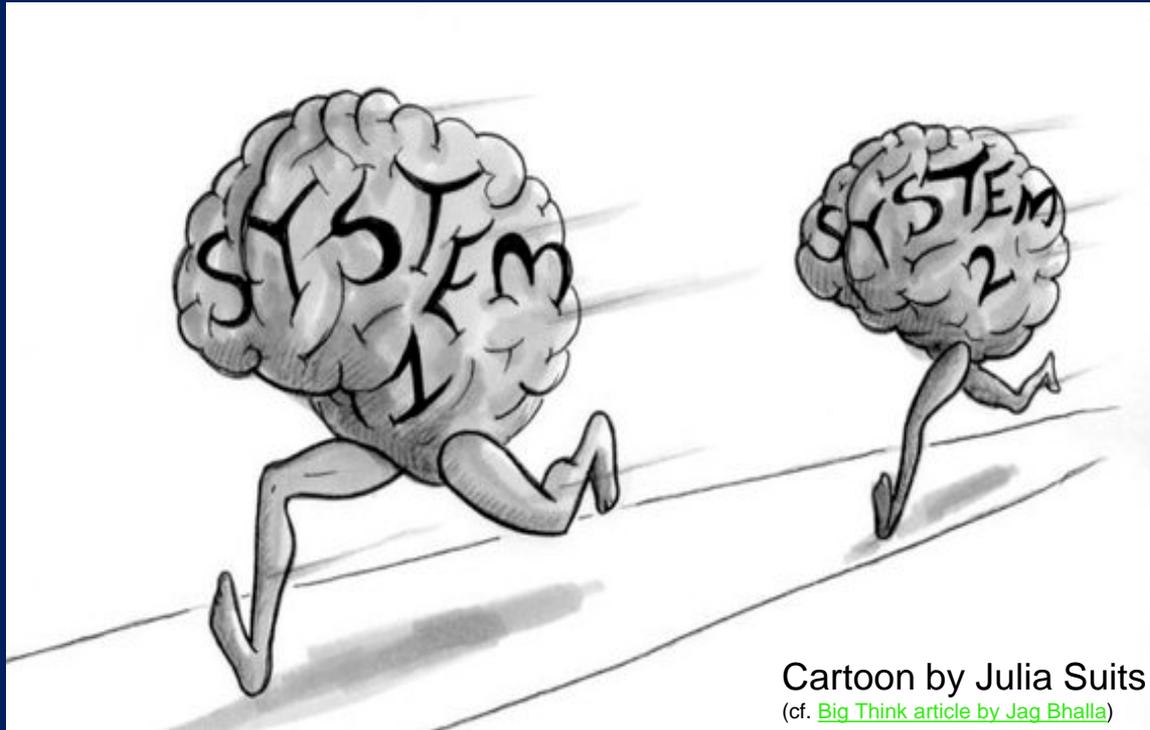
Humans	Needs	Time	Places	Biota	Resources
Myself, my Kids	Safety	The Now	Created by Me	Food, Pets	Air, Water
My Family	Love, Sex	The Near Future	Created by my tribe	Dangerous Creatures	Land, Energy
My Tribe	Esteem	The Next Generation(s)	My Carrying Landscape	Charismatic Biota	Minerals
Other People	Actualization	The Past, the Distant Future	Other Living Places	Other Biota	Environmental Carrying Capacity

[Glynn et al.. \(Earth's Future, 2018, 2017\)](#)

Do individual (or group) wants equal actual needs?

Are the issues of today and of our future those of our past?

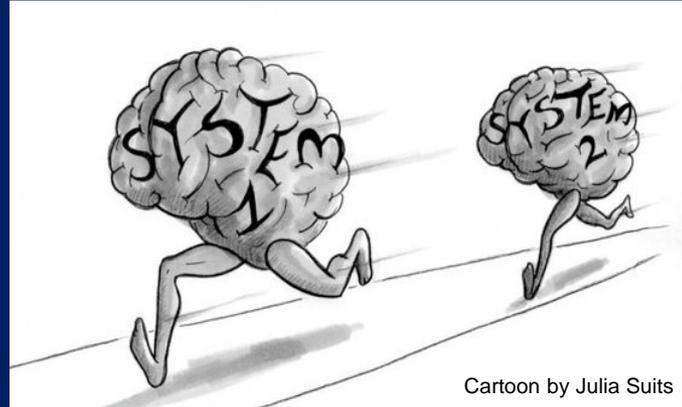
Innate (System 1) vs. Conscious (System 2) Thinking



Behavioral Economics (Kahneman, Tversky, Thaler)

System 1 thinking (& our BBHV) is faster, multi-tasking, and energy-efficient. Typically dominates judgements and decisions (cf. Kahneman, 2011).

System 1 and System 2 Communications and Records



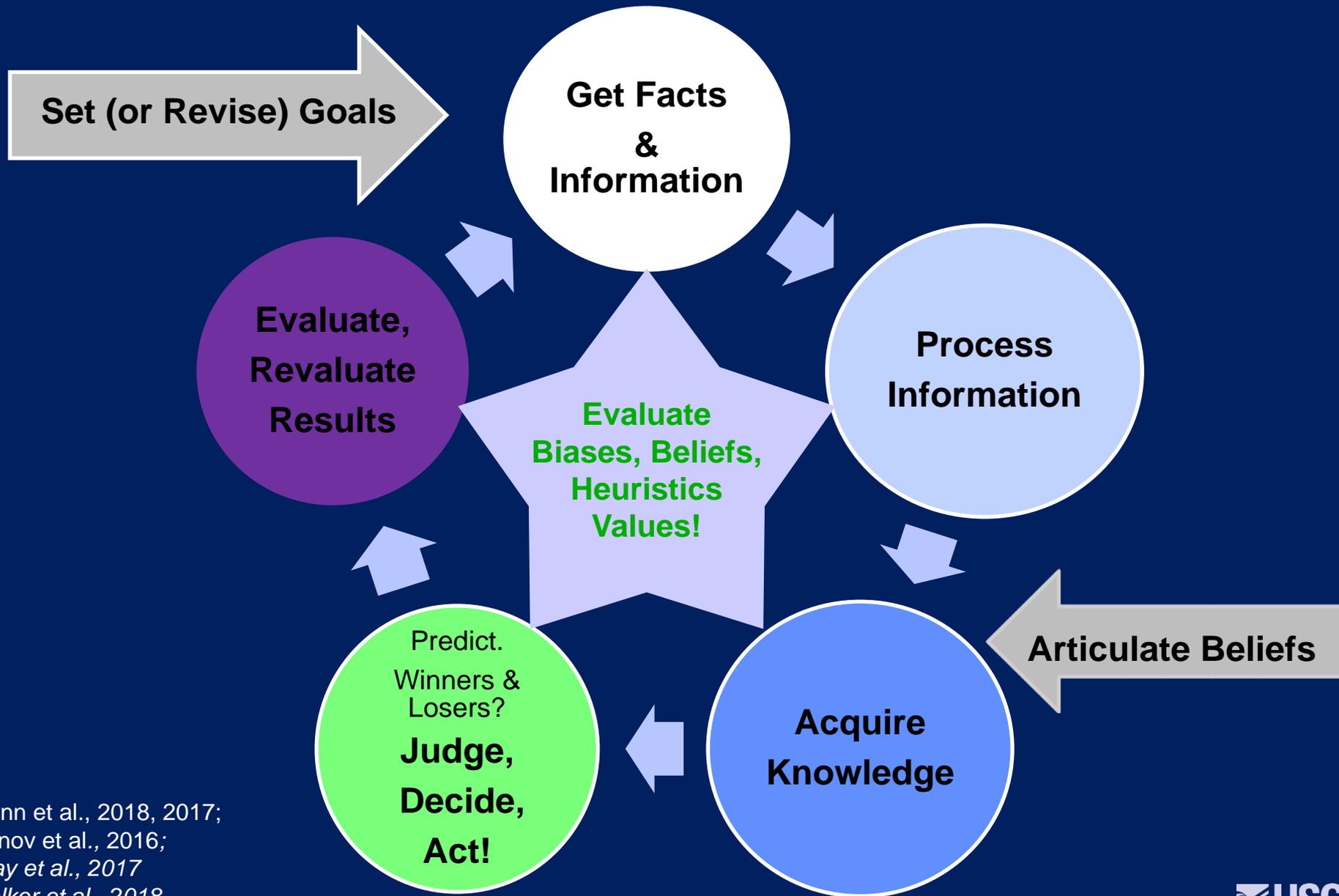
S1:
Memos

Memos have structure
(S2 thinking input?)
but solicit S1 responses

Is conscious
recognition,
differentiation
possible?

S2: Lines of reasoning,
deductive, evidence-
based

Science-Infused Adaptive Governance



Glynn et al., 2018, 2017;
Voinov et al., 2016;
Gray et al., 2017
Walker et al., 2018

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Records of Engagement and decision-making (RoE)

RoE describe (Glynn et al., 2018; IEEE):

- participatory processes,
- stakeholder perspectives,
- group dynamics,
- emotions expressed,
- lines of argumentation,
- scientific evidence
- all other “engagement” aspects...

that together combine into decisions made to manage coupled human-natural (CHN) systems.



Key Principles

- **No *a priori* principles**, except as agreed by participating constituencies (and possibly enablers).
- **Emotions and BBHV** (S1 manifestations) recognized, respected, recorded.
- **Evidence and lines of argumentation** (S2 thinking) recognized, respected, recorded.

RoE Rationale

- 1) **Creates tangible reward system** for engagement
- 2) **Modulates behavior** of participating constituencies. Reduces power asymmetries between constituencies
- 3) **Allows information transfer** to benefit understanding in the future or at a different place
- 4) **Facilitates *follow-up*** beyond the timescales and capabilities of individuals (e.g. adaptive management/governance)

Glynn et a. (2018, IEEE)

RoE Characteristics

Information construct (e.g. web site, social media interface, RDF, Business Intelligence 2.0, RMarkdown, Semantic Web, science-base, NZ Govt web Toolkit, MindMixer...)

Hierarchical (or Efficiently Usable)

Accessible, Flexible, Adaptable

Seeks transparency (documentation, creation, use)

Persistent, Suitably Controlled

Credible

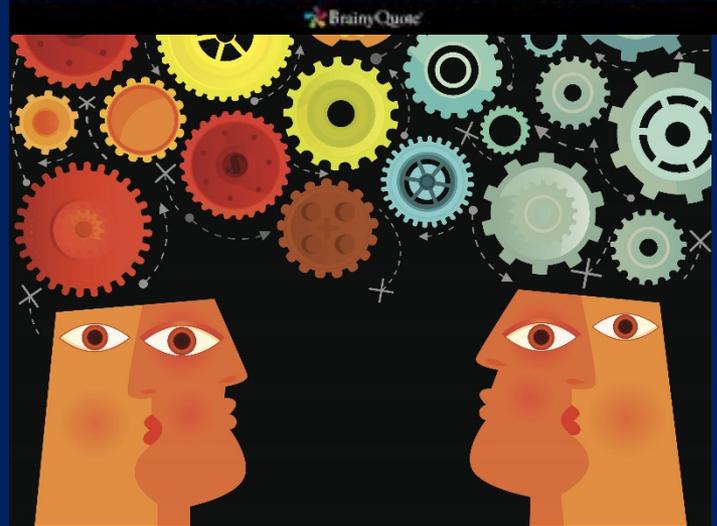
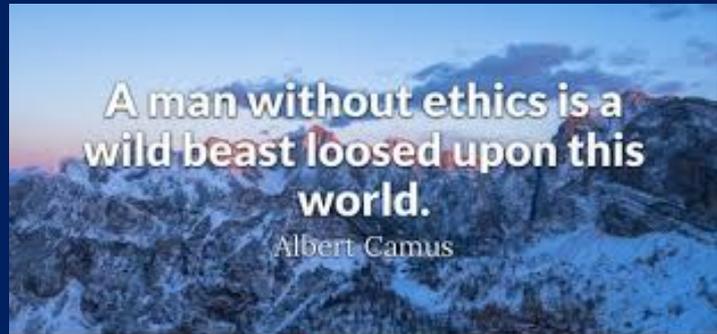
Considers S1 and S2 Thinking and BBHV

Principles: Ethics & Governance

Early Decisions Essential

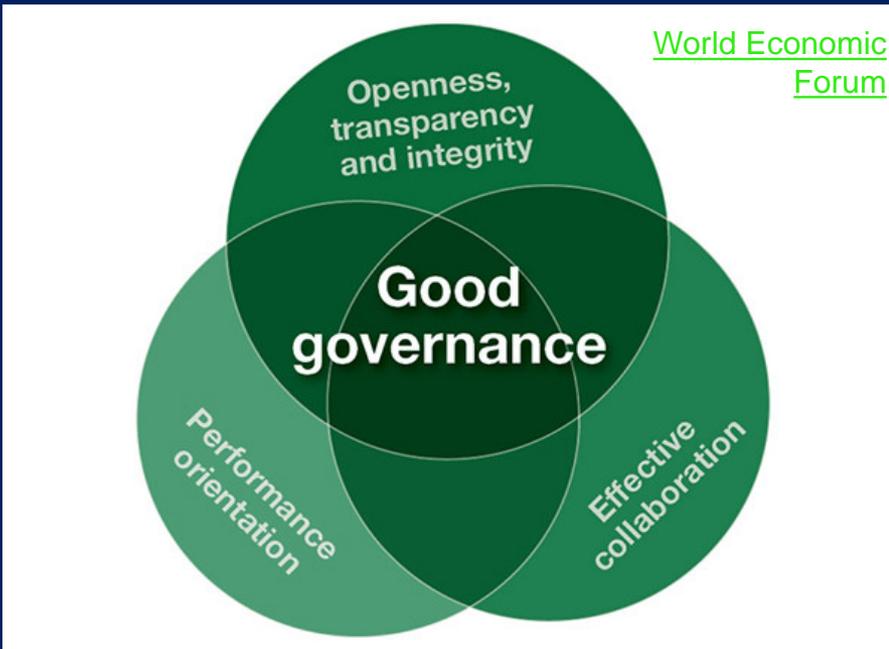
Who (or What), When, Where, How, How Much? Points of Responsibility?

Input Providers? Facilitators? Recorders? RoE keepers? RoE users?



Haidt's (2012) 6 moral foundations:
Care/Harm, Fairness/Cheating, Loyalty/Betrayal, Authority/Subversion, Liberty/Oppression, Sanctity/Degradation

Privacy?
Proprietary Rights?
Security?
Sacred values?
Other rights (& for whom)?



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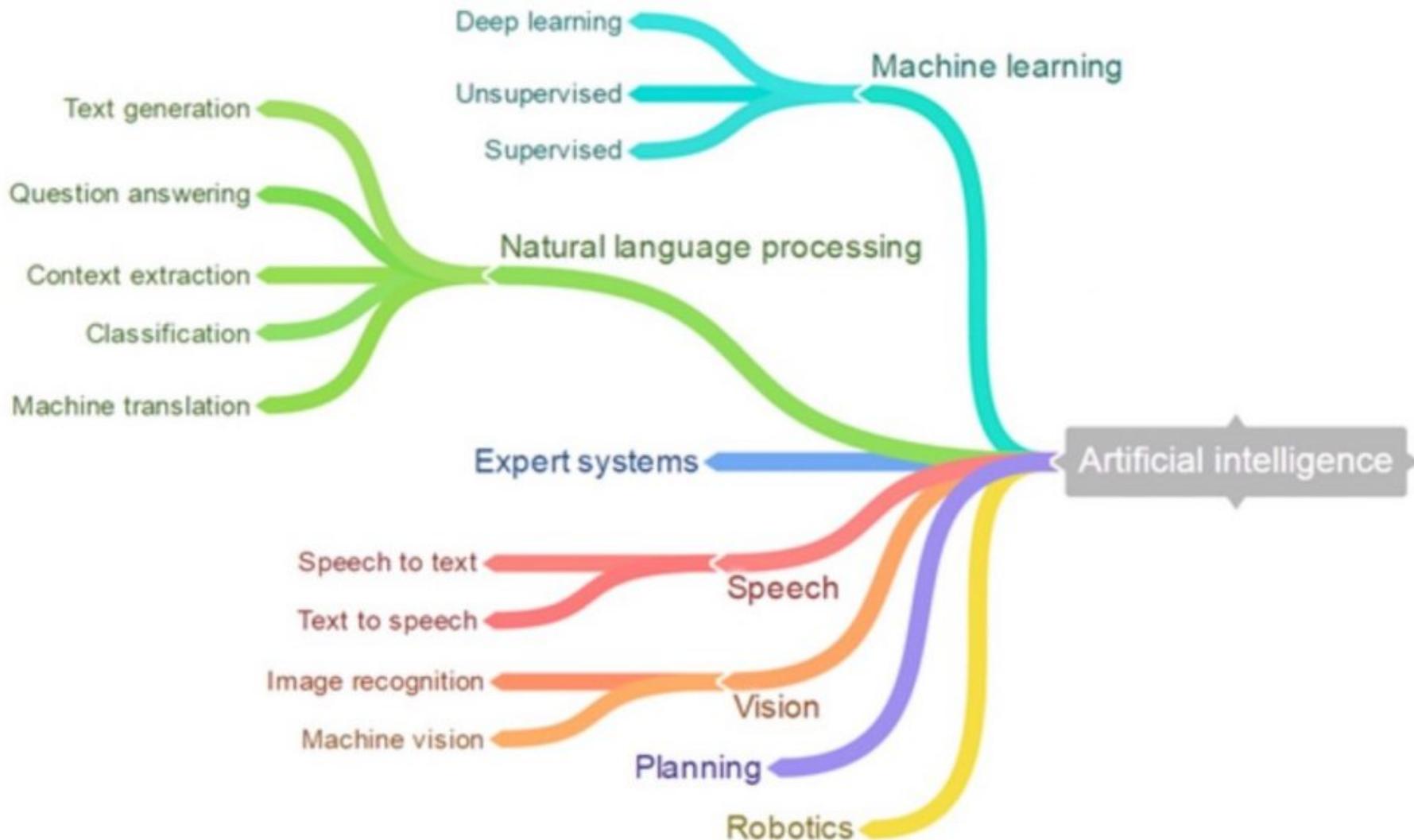
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Technologies to the Rescue?



Technology and Engagement Methods

Reasoning

Mental Modeling
Participatory Modeling
Gamification
Visualization
Scientific Analysis

Recognition & Elicitation

Machine Perception, Cognitive Robotics
Sentiment Analysis
Systems Intelligence
Critical Systems Heuristics
Value-Focused Thinking
Philosophical Dialogue Toolbox

Human Engagement

Contact Theory
Soft Systems Methodology
Rich Pictures
Embodied Cognition
Dance

Art

Recording & RoE Creation

Artificial Intelligence, Natural
Language Processing
Multi-media recording,
transcription
Blockchain



A painting's RoE analogy,
representing:

Structure

Our humanity and dreams

Two response/thinking modes

Turbulence and emergence

Memes, ideas, logic lines

Drivers for S2 thinking...

Stability is death

Will technology:

Deaden us?

Enhance our humanity?

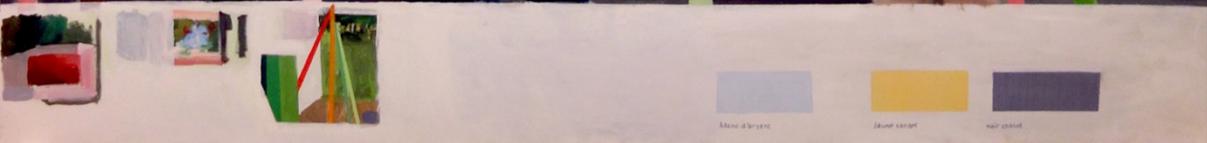
Enable us to control ourselves
and our BBHV?

Help us manage our future?

Cibles et Flocons 1

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Water Quality and RoE

- Yukon River Inter-Tribal Watershed Council and ION:
 - Spatially distributed monitoring of water quality, climate change impacts (thawing permafrost, berry collection...).
 - Integrates, to some extent, Traditional Ecological Knowledge (TEK) and “western science”.
 - Not contentious (locally), except sometimes in selection of sampling sites.
- Lake Taupo (NZ), an analog to Lake Tahoe (NV), threatened by nutrient inputs.
- Michigan environmental stakeholder initiative: socio-ecological systems studies (aka CHN systems); and Flint lead-in-water issue.



Lake Taupo Protection Project

“Nitrogen inflow has increased in all measured streams by between 50% to 300% since the 1970s.” (Petch et al., 2003)

Michael Rosen (now USGS, NV): groundwater contributes a large load of nitrogen to Lake Taupo, previously ignored by surface water budgets (Rosen et al. ,1998a, 1998b).

Poor wastewater treatment plant performance (Rosen & Chagué-Goff, 2000).

Multiple Constituencies:

- Lakes and Waterways Action Group (prime-mover community group operating since Oct. 1997)
- Taupo District Council, the local council (~10,000 domestic and rural land owners)
- Waikato Regional Council, the catchment authority (~130,000 regional land owners)
- Ministry for the Environment, national government
- Tuwharetoa Maori Authority
- Lake Taupo Protection Trust, a council-controlled organization tasked with removing nitrogen from the catchment

...Individual farmers, other stakeholders

Lake Taupo Protection Project milestones (2000 - 2018):

- 1970s – retirement of some agricultural land in the immediate vicinity of streams: aim to reduce P outflow to the lake
- 1998 – initiation of the “2020 Taupo-nui-a-Tia” project;
- 2001 – the farming community and Waikato Regional Council (WRC) began to work together (Yerex, 2009);
- 2003 - consultative document entitled “Strategy to Protect Lake Taupo” was launched publicly;
- 2004 - the 2020 Taupo-nui-a-Tia Action Plan was launched (Ministerial Press Release. 30 July, 2004) including funding (sourced from central, regional and local government) to protect Lake Taupo's water quality by contributing to land use change in the rural environment;
- 2005 - Variation 5 was notified publicly (Waikato Regional Council);
- 2005 – a Waikato Regional Council hearing on Variation 5;
- 2007 - the Lake Taupo Protection Trust was formed to administer the \$81.5 million fund that aims to remove 20% of the “manageable” nitrogen from the catchment.
- 2008 (approx.) TDC completes major capital works to improve wastewater treatment at Turangi
- 2008 - an Environment Court Appeal in in May 2008 with the eventual approval of Variation 5 (Environment Court, 2011);
- 2011 - approval of Variation 5 (Environment Court, 2011) and incorporation of Variation 5 within the Waikato Regional Council policy;
- **2017 – the Lake Taupo Protection Trust completes contracts to remove 20% of the “manageable” nitrogen from the catchment.**

(See references & description by Paul White in Glynn et al., 2017)

Some Key Enablers and Critical Elements:

- 1) Doug Gartner of the Taupo District Council
- 2) Unbiased community survey (Rosen and 2 others): turning point for WRC and TDC action
- 3) Lakes and Waterways Action Group (LWAG), incl. key contributors Gartner, Rosen, Robinson, Green, White, Penton...

4) Large information base provided by LWAG and other groups.

- Since inception, LWAG has held ~ 11 monthly meetings per year
- LWAG has minutes from ~ 200 monthly meetings. Includes the many debates (often strident) and individuals (commonly very opinionated) that have followed the Lake Taupo Protection Project.
- LWAG has also made many submissions to district, regional and national government (approx. 100) in regards of Lake Taupo Protection.
- Together, minutes and submissions, represent a large information base.

LWAG and RoE

- LWAG starting (2018) to develop an RoE from its large information base. Aim to use Glynn et al. (2018, IEEE) as a guide.
- Lake Taupo RoE will detail:
 - Context
 - Participatory activities, discussions, and intermediate results
 - All relevant information (facts)
 - Tools and methods
 - Final results
- Lake Taupo RoE information is not currently available on a web site. To what extent will emotions and social values and BBHV be represented?
- A symptom of cognitive discounting? Groundwater N inputs were initially ignored in N budget calculations.



PATRICIA MCKAY (MSU):

IMPROVING SOCIO-ECOLOGICAL SYSTEM (SES*) OUTCOMES IN MICHIGAN

Government Reinvention
(including state's cleanup and
redevelopment program)

From: Hierarchical Governance**



To: Participatory and Network-
Based Governance



Used:

- Collaborative Stakeholders Initiative
- Diagnostic Capacity Tool

*SES are also known as CHN systems

**Three basic types of governance: market, hierarchical, network

THE COLLABORATIVE STAKEHOLDERS INITIATIVE

- A series of facilitated internal regulatory stewards and external stakeholder program practitioner meetings, followed by workgroup sessions.
- Focused on resolution of 7 complex program problem areas that resulted in long term human health and environmental exposures.
 - Program changes
 - Regulatory framework changes (e.g. rule changes)
- Diagnostic tool revealed significant improved program outcomes (2013 and 2014 data).

McKay, P.A., Vogt, C.A. & Olabisi, L.S. Environ Syst Decis (2017) 37: 156.
<https://doi.org/10.1007/s10669-016-9611-8>





BENEFITS AND ATTRIBUTES OF PARTICIPATORY AND NETWORK-BASED SYSTEMS DECISION MANAGEMENT

Participatory systems analysis

- Polycentric/Social learning
- Co-generation/leveraging of knowledge
- Shared understanding and goal setting
- Transparency
- Evidence based analysis of system behavior

Network-based approaches utilize:

- Trust
- Reciprocity
- Diplomacy



CONSISTENT WITH THE LITERATURE, THE
DIAGNOSTIC TOOL REVEALS A
CORRELATION BETWEEN TRUST,
PROCEDURAL FAIRNESS, AND
DIVERSITY AND UNIQUENESS IN
PARTICIPANTS, IN IMPROVED SES
OUTCOMES

This case study used a very transparent process and record of decision. On the other hand, the agency's involvement in the Flint Water Crisis has resulted in a lack of trust and threat rigidity.

CONCURRENTLY THE STATE'S WATER PROGRAM BECOMES EMBROILED IN FLINT'S WATER CRISIS

- On the other hand, the states' **hierarchical** involvement in the Flint Water Crisis, resulted in accusations, and....
 - A lack of
 - Systems thinking
 - Transparency
 - A loss of trust
 - Resulting in threat rigidity





PAT'S KEY REASONS FOR A MEANINGFUL RECORD OF DECISION:

Trust

- Ability
- Integrity
- Benevolence

Procedural Fairness

- Participants are more accepting of a fair process than one that provides a more desirable outcome.

...Can Result in Improved SES Outcomes

Summary

- Communication and information modes evolve & reflect & affect thinking, beliefs, and management of personal & community “worlds”.
- BBHV are adaptations created from *past* experiences. Do they suit *present* or *future* issues or systems?
- Improving management of CHN systems requires recognizing, recording BBHV, emotions, lines of reasoning, evidence.
- Group reasoning requires shared emotions, understanding, memes.
- Trust, integrity, accountability, attention to social values required!
- CHN systems are complex, dynamic, and require management follow-through.
- RoE's need to be created for engagement and follow-through.



Four Needs of CHN or SES systems:

- Anticipatory Adaptive Management
- Critical Thinking, Systems Thinking
- Stakeholder and Public Engagement
- Establishing Trust:
 - Transparency, integrity, accountability in science and policy/management
 - Attention to social values (e.g. 6 moral foundations; Haidt, 2012)



Ann Schonlau Photo, RMNP: "Crows on the Continental Divide"

Acknowledgments

- SESYNC Pursuit on [Participatory Modeling](#)
- SESYNC/Powell Center Pursuit on [Natural Capital Accounting](#)
- USGS Science and Decisions Center
- USGS Water Mission Area (Earth Systems Processes Division)

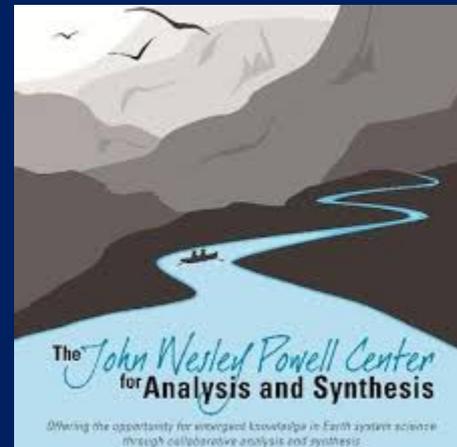
- Many Wonderful Colleagues in Universities and Government Agencies!



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[Interagency Collaborative
for Environmental Modeling
and Monitoring](#)



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