Citizen Science for the Management of Natural Resources and Environments: a Conceptual Framework

&

Volunteer Watershed Monitoring: Current Characteristics & Impacts

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(with help from many other folks!)

Sept. 16, 2014
Engaging Society

North American Breeding Bird Survey (USGS)
Outline

Part I: A Conceptual Framework (Glynn)
1) Why Citizen Science?
2) Some Needed Elements
3) Benefits & Challenges
4) Some Implementation Principles

Part II: Volunteer Watershed Monitoring (Stepenuck)
Why Citizen Science?
A personal story

• My talks on ecosystem connections at Rocky Mountain National Park... Our increasing disconnection from the observation of Nature...

• Importance of science education in avoiding “The Tragedy of the Commons”...(Hardin & Oström)

• Maintaining long-term research & monitoring of complex, dynamic systems (e.g. USGS WEBB program)

• Engaging citizens in Integrated Environmental Modeling (IEM)
‘Post-Normal’ Science
(uncertain facts, disputed values, high stakes, decisions urgent)

Expert-Professional Judgment
(use of judgment and good practice)

‘Normal’ Science
(traditional notions of science)

High

Decision Stakes

Level of Uncertainty

Low

WE ARE HERE

Provided by Daniel Sarewitz, adapted from: Funtowicz and Ravetz, 1993
Managing the Commons: Top-Down does NOT suffice

1987 Global Perspective

2013 National Perspective

Effective chlorine & Montreal Protocol

United Nations

Report of the World Commission on Environment and Development

Our Common Future

United Nations
1987

SUSTAINABILITY FOR THE NATION
Resource Connections and Governance Linkages
Understanding and managing complex dynamic ecosystems for the long term

• Simplification, by itself, is not an answer
• Neither is increasing the knowledge divide between professional expertise and the public

• Increasing engagement & knowledge base of the broader public is critical.

• Also essential:
  – Seeking primary information and “objectivity”
  – Open, transparent, models to increase our global knowledge base
  – Expanding our human perspectives
  – Improved adaptations to our failures
We Need a New Science to Manage Our “Commons”, that Reinvents Discovery & Syntheses of Knowledge

Mental Models Matter!

Oil on canvas, 29 1/8 x 21 x 5/8" (73.9 x 54.9 cm). Gift of Mrs. Werner E. Josten in memory of her husband. The Museum of Modern Art, New York, NY, U.S.A. Digital Image © The Museum of Modern Art/Licensed by SCALA/Art Resource, NY
My Definition of Citizen Science

• An engagement from members of the public, often in collaboration with credentialed technical experts, to observe, analyze, and/or understand natural resources and environments for the benefit of science and society.

• The members of the public are usually, but not always, volunteers.

• The engagement has a scientific basis: participants seek honest pursuit of greater knowledge.
Some Needed Elements for Citizen Science

- Broader demographics
- More & better partnerships
- Multidisciplinarity... Avenues for fuller scientific engagement of volunteers into all aspects of science...
- Interdisciplinary linkages, including w/ built environments
- Knowledge transfer to different scales and systems
- Long-term perspectives and temporal contexts
- More coordination, broader scope, resilience...
- Translation to societal actions!
Informed Societal Action
(Eight Core Principles)

Honest, Structured, Traceable
Represents the Community Partners for Resilience
Full Science Engagement
Cross-Disciplinary Processes
Cross-Spatial Knowledge
Temporal Awareness
Knowledge into Action
Science Needs for Societal Action

- **Increased Benefits:**
  - Learning,
  - Knowledge
  - Generation,
  - Applicability,
  - Scaleability,
  - Transferability.

- **Temporal Assessments & Forecasts**

- **Larger Scale Assessments**

- **Local Short-Term Assessments**

- **Research and Understanding**

- **Observations and Monitoring**

- **Increased Costs:**
  - Educational & Informatic Needs,
  - Uncertainties,
  - Human & Community Biases.
Existing Citizen Science Activities

Observations and Monitoring

Temporary Assessments & Forecasts

Larger Scale Assessments

Local Short-Term Assessments

Research and Understanding

Social Action groups
Watershed Monitoring
Storm/Weather Watching

Joint-Fact Finding & Mediated Modeling
Participatory Mapping

Biota monitoring
Sample collecting
Photography
Citizen Sensors
Benefits

- **Science** (monitoring, research, assessments, modeling)
  - More science and better accessibility
  - More sharing of results (& cross-system use)
  - Better sharing of science resources

- **Education**
  - Better connects people to their resources & environments
  - Challenges people & formal & informal educational systems

- **Policy**
  - Translation of scientific knowledge into improved societal actions
  - More engaging & inclusive
  - Considers an individual’s view of the “here & the now”, but seeks the benefit of entire communities, for the larger scale & the longer term.
Maslow’s Pyramid of Human Needs (revised in the 1990’s)

- **Transcendence**: helping others to self-actualize
- **Self-Actualization**: personal fulfillment
- **Aesthetic**: beauty, balance, patterns
- **Cognitive**: Intellectual curiosity, self-awareness
- **Esteem**: achievement, reputation
- **Belongingness & Love**: relationships, family, work groups
- **Security**: protection, stability
- **Biological & Physiological**
"For any man of good will, there is work to be done here, effective, virtuous, satisfying work which can give rich meaning to one's own life and to others"

Abraham Maslow quoted in Gould (2008)
Challenges

- Quality & Consistency, Archival & Access
- Study design, scientific method, assessment tests, audits, followups…
- Credibility…
- Human biases & cognitive limitations…
- Legal constraints and ethical considerations
- Costs & organizational constraints
- Recruitment & retention
Initial thoughts on implementation (1)

• Professionals (including scientists and engineers) need to engage:
  ➢ Step off the pedestals!
  ➢ Professional engagement needs to be rewarded
  ➢ Professional (and volunteer) development & education needs to be encouraged

• Recruitment/retention of professionals and volunteers needs to be based on an understanding of basic human motivations

• Engage with the Social Sciences to understand our human biases and drivers!
Initial thoughts on implementation (2)

- Science, education, and policy aspects should not be divorced from each other
  
  - Formal education systems need to participate
  
  - Regulatory/management agencies need to participate
  
  - “Honest advocacy” needs to be present
  
  - Credible science and policy brokers are needed
Initial thoughts on implementation (3)

• Volunteers must be rewarded (and have access to development & educational opportunities).

• Lessons must be obtained by examining past and current social systems, accomplishments and failures.

• New and evolving technologies and new paradigms of understanding must be put to appropriate use (and experimentation).

• Ethical and legal considerations are important.
Concluding thoughts

• Integrative Organizations are Essential

• So is Taking Cognizance of Human Motivational Drivers, Biases and Heuristics.

• We Need a New Area of Science: “the Behavioural Biogeosciences” (Glynn, 2014, IEMSs)

➢ Managing our “Commons” Requires Public Engagement and Transdisciplinary, Trans-Institutional, Science & Education.

➢ We Need Depth, Breadth & Persistence in our Science!
Volunteer Watershed Monitoring

• Volunteer watershed Monitoring (VM) serves as one of the best models for broad scope, integrative, Citizen Science.

• VM already provides significant benefits to communities and states

• There are opportunities to enhance and strengthen existing VM efforts (and other Citizen Science)!!
Conceptual Frameworks (& mental models) are important!

There is always more than one perceived reality.
Characterizing Volunteer Water Monitoring Programs & Assessing Their Impacts on Natural Resource Policy & Management
National Survey - 2013

- Surveyed 345 program coordinators
- 86% responded
- Represent 1675 programs in US
Type of Waterbody Monitored

Most monitor rivers/streams and lakes

- Streams: 86%
- Lakes: 43%
- Estuary/Marine: 24%
- Wetlands: 20%
- Beaches: 13%
- Wells: 4%

Images: Kris Stepenuck, Joanna Griffin, Wisconsin Wetlands Association, WI DNR
What is Monitored

- Chemical
- Physical
- Biological
Examples of What is Monitored

Dissolved oxygen
Streamflow
Aquatic macroinvertebrates

Water clarity
Temperature
Habitat
Examples of What is Monitored

Dissolved oxygen

Continuous temperature

Nutrients (lab)

pH

Bacteria

Specific conductance
Geographic scope

Most operate in a single watershed

- **Local waterbody or single watershed**: 41%
- **Multi-watershed**: 18%
- **Multi-state or Regional**: 7%
- **Statewide**: 4%
- **National**: 1%
- **Other**: 1%
Annual program budgets

- Less than $5000: 25%
- $5,000 to $25,000: 31%
- $25,001 to $125,000: 30%
- More than $125,000: 14%

n = 271
Sponsored by

Percent of programs

Nonprofit: 60%
State govt: 40%
Municipality: 20%
University: 10%
Business: 10%
K-12: 5%
Tribe: 5%
Other: 30%
Quality assurance

Percent of programs

- EPA-approved QAPP: 25
- State-approved QAPP: 41
- Written methods: 68
- No formal QA plan: 20
How Are Program Characteristics Related To Outcomes?

- School-based
- Budget
- Political Climate
- Volunteer roles
- Type of Quality Assurance
- Natural Resource Policy & Mgt
  - Objective to Address an Environmental Crisis
  - Program age
  - Level of external support by decision makers

Natural Resource Policy & Mgt Outcomes
Types of Outcomes

Direct Outcomes on Policy & Mgt Decisions

Civic Engagement

Waterbody Restoration & Protection

Organizational
Examples of Reported Outcomes

• More common:
  – Identified and controlled illicit bacterial discharges
  – Streams given upgraded protection status
  – Best Management Practices installed

• More unique:
  – National Wild and Scenic River status obtained
  – Data used to gain gear restrictions for creek fishing
  – Presentation to Congress to obtain Superfund site status
How are Characteristics Related to Outcomes?

Impact Indices:
- Assigned 1 point for every type of outcome reported
Significant Characteristics

• Address an environmental crisis

• Perceived level of external support from decision makers

• EPA or state-approved QAPP

• Entirely school-based program

• Larger budget

• Volunteer roles (select sites, communicate results, analyze data)
### Equal Weight Index

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So What?

• Volunteer monitoring programs are achieving natural resource policy and management successes
  – Volunteer civic engagement
  – Especially at the local and state levels
  – Identification of when and where standards are being met

• Programs that coalesce and focus on addressing a crisis have more successes

• There is a distinction between educationally-focused school efforts and other volunteer monitoring efforts

• Having an EPA or state-approved QAPP is important

• Budget often matters
Questions?
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Resources


• Stepenuck dissertation: Search the Proquest Dissertation Database or: https://uwmadison.box.com/s/ye362pocnlju7g6fzewet

• List and description of water monitoring apps used by VM programs: http://www.usawaterquality.org/volunteer/Special/EPAListserv/ElectronicForms.html (See Discussion #6 for a table and links)


• National map of volunteer water monitoring programs (and other resources): http://acwi.gov/monitoring/vm/programs/vm_map.html