Regional Assessments of Ecological Integrity: Sensitivity of Inferences to Data Sources, Scoring and Aggregation

Scott Miller\textsuperscript{1,2}, Christian Perry\textsuperscript{1}, Chuck Hawkins\textsuperscript{1,2,3}
\textsuperscript{1}BLM/USU National Aquatic Monitoring Center,
\textsuperscript{2}Department of Watershed Sciences, Utah State University
\textsuperscript{3}Utah State University Ecology Center
Common watershed management questions

- Where to prioritize conservation, restoration or development actions?
- Where do problems exist?
- How does one watershed compare to another?
- What is the vulnerability of watersheds to development, climate change or drought?
Traditional approaches to stream assessment

• Reach-based assessments

• Application of survey-based statistics to scale results
Regional assessments defined

- Geospatial analyses to *infer* ecological integrity from readily available measurements of land uses and surface disturbances
Regional assessments: Assessment & planning

- Need for spatially contiguous maps of resource condition
- Some attributes not easily measured at the reach-scale
- Vulnerability and causal assessments
- Cost is right
Regional assessments: Assessment & planning

- Need for spatially contiguous maps of resource condition
- Some attributes not easily measured at the reach-scale
- Vulnerability and causal assessments
- Cost is right
Regional assessments: Rising popularity

- Increasing use of regional assessments

- Know very little about how they work and merit as assessment and planning tool

Trends in types of indicators to assess ecological integrity (Kuehne et al. 2017)
Study objectives

• Review regional assessments of ecological integrity – focus on streams and rivers

• Use case studies to compare how differences in data types, methods of scoring and aggregation affect assessment results

• Suggest best practices for the evolution and application of these tools
Methods

- Conducted literature review of regional assessments
- Rubric for comparing regional assessments
  1. Stated objectives, geographic scope & reporting units
  2. Types of input datasets
  3. Methods of data scoring and aggregation
Case studies: 3 regional assessments

- BLM’s Rapid Ecoregional Assessment (REA) – Strittholt et al 2012

- Trout Unlimited Conservation success Index (CSI) – Williams et al 2007

- Anthropogenic Threat Index (ATI) – Whittier and Sievert 2014
Watershed integrity: the capacity of a watershed to support and maintain the full range of ecological processes and functions (Flotemersch et al. 2015)

Aquatic Intactness: absence of anthropogenic activities that influence key ecological processes, functions and services

Case study assessment objectives

Hydrologic intactness
Case study spatial extent and reporting units

**Geographic extent:**
- Upper Colorado River Basin
- Level III ecoregions

**Reporting units:**
- NHD segment catchments
- HUC12
- HUC10
Case study data inputs

- **Land use**: % ag, density of mines, timber harvest
- **Connectivity**: road density, dam density
- **Water quality**: NPDES, 303(d) streams
- **Hydrologic regime**: artificial flow paths, dam density
- **Biological condition**: invasive riparian vegetation, macroinvertebrate condition
Data scoring and aggregation: ATI

Simplest of the approaches
  - Raw data scoring: Presence / absence
  - Data aggregation: summation
Data scoring and aggregation: TU-CSI

Middle of the road complexity

- Raw data scoring: ranked frequency (1 – 5) based on density of threat
- Data aggregation: summation
Data scoring and aggregation: BLM-REA

Most complex of the approaches

- Raw data scoring: re-scaling (-1 to +1) based on density of threat. Consider mix of proportional and threshold responses

- Data aggregation: various operators (e.g., sum, min, max)
Low degree of comparability among three case studies

On average: ATI > CSI > REA
Validation of case study results

Do assessment scores correlate with direct measures of aquatic intactness?

• Condition measure: macroinvertebrate O/E index

• 123 HUC12s (~10%) had O/E scores

Expected

Observed

O/E = 0.5
Validation of case study results

Poor correlations between regional assessment scores and macroinvertebrate biological condition.
What have we learned so far

• Large diversity of regional assessment approaches; many share common objectives and data inputs

• Low degree of comparability among assessment scores

• Weak correlations with measured biological condition

• No measures of uncertainty included in assessment results
Recommendations: Back to ecological basics

Rationale for a given data scoring and aggregation schema
Rationale for a given data scoring and aggregation schema

- Threat – response relationships
  - Type of response curves - empirical support

Recommendations: Back to ecological basics
Rationale for a given data scoring and aggregation schema

- Threat – response relationships
  - Continuity of threat – response relationships
  - Context dependencies

Craig et al. 2017

Recommendations: Back to ecological basics
Recommendations: Back to ecological basics

Rationale for a given data scoring and aggregation schema
• Ecosystem responses to multiple, co-occurring stressors
  ▪ Individual versus net effects
Recommendations: Empirical modeling

Model calibration and validation
  • Kitchen sink syndrome: Effect of correlated variables on model performance
  • Optimal data scoring and aggregation approaches
  • Issues of scale and context dependency
  • Including measures of uncertainty
Recommendations: Empirical modeling

**STEP 1:** Gather all available field data from reference and altered sites. Build and test models using calibration and validation subsets. Report model accuracies.

**STEP 2a:** Compute spatially-explicit ‘reference-state’ predictions for region of interest.

**STEP 2b:** Compute spatially-explicit ‘altered-state’ predictions for region of interest.

**STEP 3:** Determine spatially-explicit departures of actual-state from reference-state. Rank sites as good, fair, or poor.

Ecological integrity

- Temperature
- Flow
- Connectivity
- Water Chemistry
- Density
- Sedimentation
- All
Conclusions

- Regional assessments playing an increasingly important role in watershed planning and assessment
- Importance of looking beyond the reach-scale
- Beware of pretty maps - devil is in the details
- Quantify and reduce uncertainty and bias in regional assessments