Indicator: Streambed Stability in Wadeable Streams (342)

Streams and rivers adjust their channel shape and particle size in response to the supply of water and sediments from their drainage areas. Excess fine sediments can destabilize streambeds when the supply of sediments from the landscape exceeds the ability of the stream to move them downstream. This imbalance results from numerous human uses of the landscape, including agriculture, road building, construction, and grazing. Lower than expected streambed stability causes stressful ecological conditions (by filling in the habitat spaces between stream cobbles and boulders), and may result either from high inputs of fine sediments (from erosion) or increases in flood magnitude or frequency (hydrologic alteration). This instability can lead to channel incision and arroyo formation, and can negatively affect benthic invertebrate communities and fish spawning (Kaufmann et al., 1999). Streams that have *higher than expected* streambed stability also can be considered stressed—very high bed stability is typified by hard, armored streambeds, such as those often found below dams where fine sediment flows are interrupted, or within channels where banks are highly altered.

One measure of this interplay between sediment supply and transport is relative streambed stability (RBS). Relative Streambed Stability is calculated as the logarithm of the ratio of observed mean streambed particle diameter to the "critical diameter," the largest particle size the stream can move as bedload during stormflows. RBS is calculated from field measurements of the size, slope and other physical characteristics of the stream channel (Kaufmann et al., 1999). Expected values of the index are based on the statistical distribution of values observed in minimally disturbed reference sites. Values of the RBS Index either substantially lower (finer, more unstable streambeds) or higher (coarser, more stable streambeds) than those expected based on the range found in reference sites are considered to be indicators of ecological stress.

This indicator is based on data collected for the U.S. EPA's Wadeable Streams Assessment (WSA) (in draft). Wadeable streams are streams, creeks and small rivers that are shallow enough to be sampled using methods that involve wading into the water. They typically include waters classified as 1st through 4th order in the Strahler Stream Order classification system (based on the number of tributaries upstream). The WSA is a based on a probability design, so the results from representative sample sites can be used to make a statistically valid statement about the condition of the nation's waters. Using standardized methods, crews sampled 748 sites, including reference and repeat visits, in the eastern and central U.S. Between 1999 and 2004, 839 sites were sampled in the western U.S. using the same methods. All samples were collected between late April and mid- November. At each site, measurements related to stream morphology, large woody debris, riparian structure, and sediment characteristics are taken at or between eleven equally spaced transects within the sample reach. Detailed field methodologies and project information can be found at ttp://www.epa.gov/owow/monitoring/wsa/index.html.

What the Data Show

Relative streambed stability in wadeable streams in the U.S. was found to vary over six orders of magnitude, with negative values more common than higher values (indicating that stream bed material in most streams is fine enough to be moved readily by flood flows) (Figure 342-1). The percentage of wadeable stream miles for any particular index score can be read off the left hand y axis, and the total wadeable stream miles off the right hand y axis. The cumulative frequency distribution in the figure represents the national distribution of the data. Thresholds indicating favorable or unfavorable- amounts of fine sediments relative to the ability of streams to transport these sediments vary from one part of the country to another.

Indicator Limitations

- Samples were taken one time from each sampling location during the index period (June – October). Although the probability sampling design results in ~~an~~ unbiased estimates for relative streambed stability in wadeable streams during the study period, values of the index may be different during other seasons and years because of variations in hydrology.
- Reference levels for the relative streambed stability in streams (i.e., levels that would allow streams to be classified as to least disturbed, moderately disturbed, and most disturbed based on regional reference sites) vary from region to region; these reference levels will be available from the WSA to provide such a classification of streams nationally, but they are not available at this time.
- This is the first time that a survey on this broad scale has been conducted. The data will serve as a baseline for future surveys, but the sampling design for the current WSA design does not allow trends to be calculated over the period 1999-2004.

Data Sources

Data for this indicator were collected for the Environmental Protection Agency's (EPA) Wadeable Streams Assessment (WSA) in 2004 for the central and eastern states and from 1999-2004 for the western states. Information about the WSA can be found at http://www.epa.gov/owow/monitoring/wsa/index.html.

References

Barbour, M.T., J Gerritson, B.D. Snyder, J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water. Washington D.C.

Karr, J.R., and D.R. Dudley. 1981. Ecological Perspective on water quality goals. Environmental Management 5:55-68.

Kaufmann, P. R., Levine, P., Robinson, E.G., Seeliger, C. and Peck, D. 1999. Quantifying Physical Habitat in Wadeable Streams. EPA 620/R-99/003. U.S. Environmental Protection Agency, Washington D.C.

Peck, D.V., Lazorchak, J.M. and Klemm, D.J. In Press. Western Pilot Study Field Operation Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA. 2004. Wadeable Streams Assessment: Field Operations Manual. U.S. Environmental Protection Agency; Office of Water, Washington D.C. EPA841-B-04-005.

Graphics

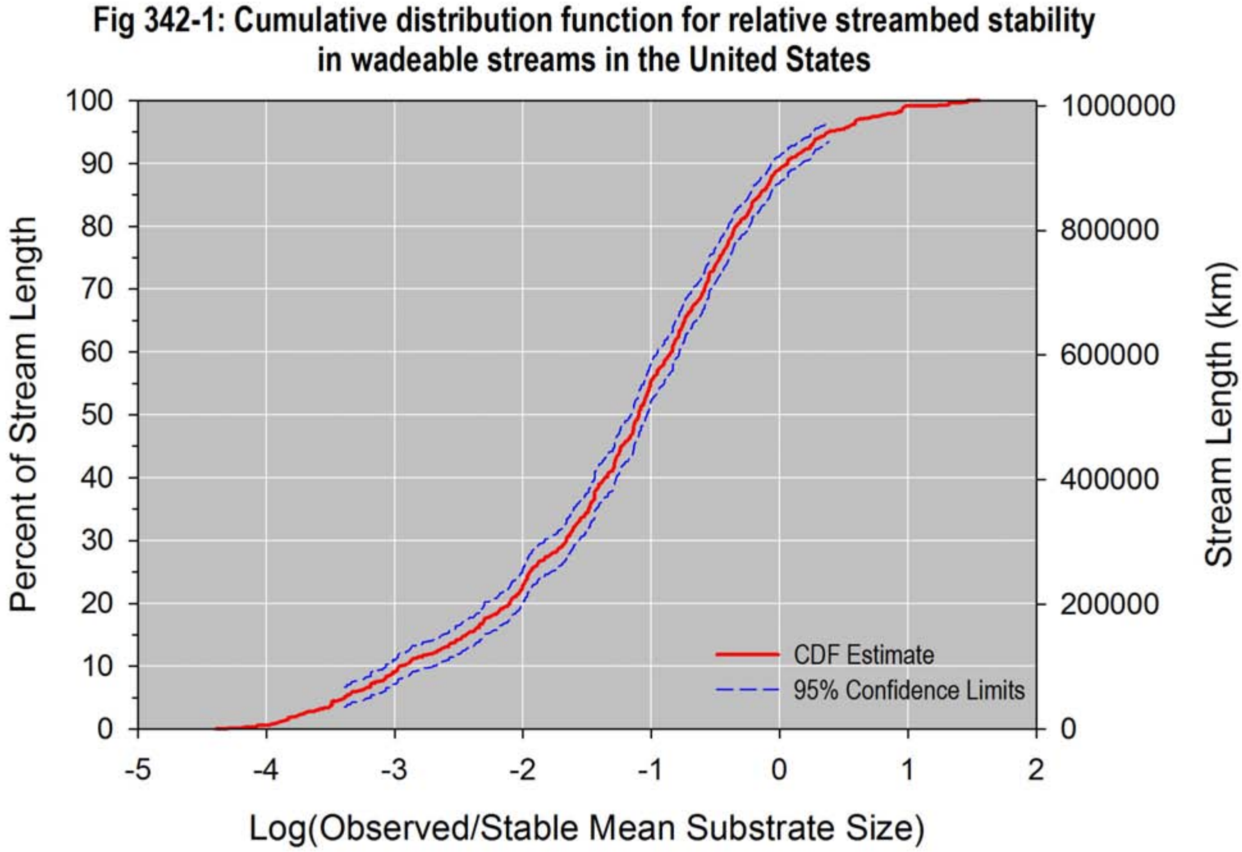
Fig 342-1: Cumulative distribution function for relative streambed stability in wadeable streams in the United States
Percent of Stream Length
Stream Length (km)
Log(Observed/Stable Mean Substrate Size)
CDF Estimate
95% Confidence Limits
100
90
80
70
60
50
40
30
20
10
0
1000000
800000
600000
400000
200000
-5
-4
-3
-2
-1
0
1
2

R.O.E. Indicator QA/QC

Data Set Name: STREAMBED STABILITY IN WADEABLE STREAMS
Indicator Number: 342 (89190)
Data Set Source:
Data Collection Date: UNKNOWN
Data Collection Frequency:
Data Set Description: Streambed Stability in Wadeable Streams
Primary ROE Question: What are the trends in extent and condition of fresh surface waters?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The field methods used to collect the streambed stability data were published in the Wadeable Streams Assessment (WSA) Field Operations Manual (2004 EPA841-B-04-008) in 2004. The protocols used were initially established and published in the Environmental Assessment and Monitoring Program (EMAP). They outline the collection technique, equipment, and field processing for all samples. Trained field crews collected a single water sample from each site following the detailed methodologies laid out in the Field Operations Manual. Crews used a standardized set of field equipment provided by the EPA, and followed protocols for collecting the physical habitat data. Streambed stability is commonly used as an indicator of stream health. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Field Operations Manual. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-004.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The indicator is based on data collected by the EPA's Wadeable Streams Assessment (WSA). The WSA is based on a probabilistic survey design used to make a statically valid statement about the ecological condition of the wadeable streams through the United States. Standardized field protocols were used to collect data from streams Strahler Order 1-5. Between 1999-2004 1500 sites were sampled in the western states, and in 2004 748 sites were sampled in the eastern and central states. Information about the probabilistic survey design and implementation can be found on the U.S. EPA website http://www.epa.gov/nheerl/arm/index.html Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. 1996. EMAP Statistical Methods Manual. EPA620-R-96-002, US Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Stevens, D.L., Jr, and Olsen, A.R. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agriculture, Biological and Environmental Statistics, 4, 415-28. Herlihy, A. T., D.P. Larsen, S. G. Paulsen, N.S. Urquhart, and B.J. Rosenbaum. 200. Designing a spatially balanced, randomized site selection process for regional stream surveys: The EMAP Mid-Atlantic Pilot Study. Environmental Monitoring and Assessment 63:95-113. Stevens Jr., D. L. 1997. Variable density grid-based sampling designs for continuous spatial populations. Environmetrics 8:167-195.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The concept of relative streambed stability is well-established in the scientific literature, though its application to synoptic survey data is relatively recent, and is described by Kaufmann et al. (1999). Relative streambed stability is calculated as the ratio of observed streambed particle size to the size of particles the stream is able to move as bedload during storms. Expectations for streambed stability will be ecoregion or stream-class specific, and will be based on values observed in minimally disturbed reference sites. Though deviations from reference condition are usually negative and due to excess sediment supply, additional data besides that contained in the index itself is necessary to interpret the whether low streambed stability relative to reference sites may be the result of the accumulation of fine sediments ("excess fines") from land erosion or from increases in the erosive power of stream channels (hydrologic alteration). Kaufmann, P. R., Levine, P., Robinson, E.G., Seeliger, C. and Peck, D. 1999. Quantifying Physical Habitat in Wadeable Streams U.S. Environmental Protection Agency, Washington D.C.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The spatial and temporal aspects of this indicator are appropriate for reporting on the suspended sediment stressor on the nation's freshwater stream resource. Data used to generate this indicator comes from the U.S. EPA's Wadeable Streams Assessment (WSA). The WSA is a statistically valid survey designed to make an ecological assessment if streams through the U.S. based on physical, biological and chemical features. Between 1999-2004, 1500 sites were sampled in the western states. In 2004, 748 sites were sampled in the eastern and central states. These sites were distributed evenly, with approximately 50 sites sampled per ecoregion. These sites represent a diverse selection of streams that vary in size, flow and type of disturbance. Because of the statistical approach to selecting these sites, the aggregated results can be extrapolated to make a statement about the target population, stream Strahler Order 1-4. Field crews collected water chemistry samples before conducting any sampling to minimize stream disturbance. A map depicting the location of the sampling sites can be found in the Graphics section.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The statistically valid survey ensures spatial dispersion within the target population. All types of natural streams, and associated ecosystem characteristics, have a known probability of being included in the sample. Highly sensitive or unique ecosystems have a lower probability of being sampled due to the sparse nature of there location and the broad geographic scale of the sampling design.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Selection of reference sites was a key aspect to the analysis of the WSA data. Approximately 20 reference sites per ecoregions were selected a priori to be sampled with the same methods as the randomized sites. States and cooperators were asked to contribute their 10 best reference sites for inclusion in this pool. Additionally, the U.S Geological Survey North American Water Quality Assessment (NAQWA) identified a number of predefined reference sites from their Status and Trends Program and Hydrologic Benchmark Network to be sampled with WSA methods for this survey. Additional reference sites were contributed by the Chuck Hawkins in his STAR grant program for the Western states.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

All sampling methodologies can be found in the U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Field Operations Manual. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-004 Detailed analytical procedures can be found in the Data Analysis Plan accompanying the Wadeable Streams Assessment Final Report. Documents are available on the web at http://www.epa.gov/owow/monitoring/wsa/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

All data, including metadata, from the Wadeable Streams Assessment will be available for the public through the Storage and Retrieval (STORET) System. Information on STORET, including data downloads, can be found at http://www.epa.gov/storet/.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The description of the study design, methods to select and sample sites, and the laboratory analysis are all fully documented and available for the public (http://www.epa.gov/owow/monitoring/wsa/index.html) (http://www.epa.gov/nheerl/arm/index.html). Following these documents and associated references, the study design could be replicated. Analytical methods used to examine the data are also fully documented and will be available in the final report. Using the data publicly available on the STORET warehouse, analytical procedures could also be replicated.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

An extensive Quality Assurance/Quality Control procedure was an integral part of the WSA. Full documentation of the QA/QC procedures can be found in U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-005. The QAPP was reviewed by an independent EPA team with members from ORD, OW and OEI. It is available to the public on the EPA's website. http://www.epa.gov/owow/monitoring/wsa/QAPP-August18.pdf. In the field QA/QC included training all crew members in WSA methods, conducting a thorough field audit of all crews, and extensive chain of custody documentation. All information on the field audits and training sessions are currently housed at the U.S. EPA's Office of Water in the Monitoring Branch and can be distributed on request.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The WSA is based on a probability sampling design where the results from the sampled population can be used to make a statistically valid statement about the entire population. Details about the statistical design and implementation of this approach can be found the EPA website dedicated to this topic. http://www.epa.gov/nheerl/arm/index.htm

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Measurements of uncertainty are associated with the dataset and can be found in the WSA Report (in draft). Actions were taken throughout the study to reduce the level of uncertainty throughout the dataset. The Quality Assurance Project Plan (QAPP) for the WSA has Measurement Quality Objectives (MQOs) and Data Quality Objectives (DQOs) specified for each indicator. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-005.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The conclusions are not impacted by variability around the indicator. Actions were taken throughout the study to reduce the level of uncertainty and increase repeatability throughout the dataset. The extensive QA procedures employed reduce the variability of the dataset. Field crews used standardized protocols and equipment to further reduce uncertainty. Information about all the QA procedures can be found at http://www.epa.gov/owow/monitoring/wsa/QAPP-August18.pdf.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

This is the first time a national, statistically valid survey has been conducted. Results from this survey will serve as a baseline to compare future surveys. Trends over time using this indicator cannot be assessed at this time.