RESOURCE NOTES

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HYDROLOGY

Indicators of Hydrologic Alteration

By Steve Swanson, River Modeling Specialist, BLM, National Science and Technology Center

Hydrologists of the Bureau of Land Management have long been challenged to identify and record anthropogenic effects on the natural flow regimes of streams and rivers on public lands. Increased public concern and legislation over the past 20–30 years have resulted in heightened scrutiny of the consequences of human-caused alterations to these natural systems.

The historical tools available to answer the question "How much hydrologic alteration is too much for a riverine system?" have not been adequate. Historical methods may focus on specific portions of the ecosystem, such as aquatic biology or riparian functionality, rather than the system as a whole. Another limitation involves the fundamental differences in language and analytical methods that exist between hydrologists and ecologists or biologists. Hydrologists tend to be concerned with the statistics of monthly and annual averages and the frequencies of floods and flows. Ecologists and biologists are often concerned with flow durations, low-flow extremes, and the rates at which water levels rise and fall.

Hydrologic Parameters Indicate Anthropogenic Effects

The Nature Conservancy has developed an approach, led by Brian Richter, in which the gaps in communication and methods are bridged. This approach, termed Indicators of Hydrologic Alteration (IHA), is a suite of 33 hydrologic parameters that are ecologically meaningful and serve as sensitive indicators of anthropogenic effects on riverine systems. These parameters and their potential influences are shown in the Table.

Some of these parameters are difficult or impossible to calculate by using standard spreadsheet or statistical software. The National Science and Technology Center (NSTC), Denver, Colorado, uses an IHA software package (Smythe Scientific Software) that calculates the entire suite of parameters by using daily streamflow data obtained from the U.S. Geological Survey. The program also plots the results and provides two types of statistical analysis and three methods of parameter analysis and interpretation:

Statistical Analysis

- Nonparametric Statistics: The highly skewed nature of most hydrological data sets dictates this method in many situations. The software uses the median as a measure of central tendency for the IHA parameters
- Parametric Statistics: This type of analysis assumes a normal distribution, with the mean as a measure of central tendency for IHA parameters.

Parameter Analysis

- IHA Analysis: This analysis provides a pre-impact versus post-impact comparison. A "scorecard" table and graphs of each IHA parameter are produced to quantify changes in each parameter between the pre- and post-impact flow regimes.
- Range of Variability Analysis: In this analysis, the user defines three categories that divide the range of pre-impact data values. Delineation into three equal categories, for example, would result in parameters less than or equal to the 33rd percentile, parameters between the 33rd and 67th percentile, and parameters greater than or equal to the the 67th percentile. The program then calculates the expected frequency at which the post-impact values should occur in each category. A comparison of these two data sets provides a pre- and post-impact measure of the hydrologic alteration between flow regimes.
- Trend Analysis: A complete graphical historical analysis of the IHA parameters is produced, together with a linear regression analysis of the data.

Staff of the NSTC are presently using the Indicators of Hydrologic Alteration approach on a project in southern Arizona. This approach also has significant application to other locations within the Bureau.

Contact

Steve Swanson, National Science and Technology Center,
Denver Federal Center,
Building 50, P.O. Box 25047
Denver, CO 80225-0047
phone: 303-236-8693
fax: 303-236-3508
email: Steve_Swanson@blm.gov

Table. Indicators of Hydrologic Alteration.

IHA group	Hydrologic parameters	Ecosystem influences
Magnitude of monthly water conditions	Mean value for each calendar month (12 parameters)	1. Availability of habitat for aquatic organisms 2. Availability of soil moisture for plants 3. Availability of water 4. Reliability of water supplies for wildlife 5. Effects of water temperature and dissolved oxygen
Magnitude and duration of annual extreme water conditions (mean daily flow)	1. Annual 1-day minima 2. Annual 3-day minima 3. Annual 7-day minima 4. Annual 30-day minima 5. Annual 90-day minima 6. Annual 1-day maxima 7. Annual 3-day maxima 8. Annual 7-day maxima 9. Annual 30-day maxima 10. Annual 90-day maxima 11. Number of zero-flow days 12. 7-day minima/mean for year	1. Balance of competitive and stress-tolerant organisms 2. Creation of sites for plant colonization 3. Structure of river channel morphology and physical habitat conditions 4. Soil moisture stress in plants 5. Dehydration in wildlife 6. Duration of stressful conditions 7. Distribution of plant communities
Timing of annual extreme water conditions	1. Julian date of each annual 1-day maxima 2. Julian date of each annual 1-day minima	1. Predictability and avoidability of stress for organisms 2. Spawning cues for migratory fish
Frequency and duration of high and low pulses	1. Number of low pulses within each year 2. Mean duration of low pulses each year 3. Number of high pulses within each year 4. Mean duration of high pulses each year	1. Frequency and magnitude of soil moisture stress for plants 2. Availability of floodplain habitat for aquatic organisms 3. Effects of bedload transport and channel sediment distribution, and duration of substrate disturbance
Rate and frequency of water condition changes	1. Means of all positive differences between consecutive daily values 2. Means of all negative differences between consecutive daily values 3. Number of hydrologic reversals	1. Drought stress on plants 2. Desiccation stress on low-mobility streamedge organisms

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Technical Editor - Deborah Harris (Debbie_Harris@blm.gov)
Science Editor - Brian St. George (Brian_St_George@blm.gov)
Graphic Designer - Ethel Coontz (Ethel_Coontz@blm.gov)

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