40 Geoindicators: a tool for monitoring the ecosystem and understanding the resources

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"Geoindicators" is a coined term for a class of geologic environmental indicators recently developed as a tool to assess rapid change in the environment and provide some measure of ecological health by examining the abiotic component of ecosystems. Twenty-seven indicators examine the near-surface geologic, hydrologic, and atmospheric parameters that are likely to change in the period of a human life span. Geoindicators look at both human and natural components of change in the ecosystem, identifying critical areas and measuring them independently. The International Union of Geological Sciences developed the geoindicators concept for environmental planning in the mid-1990s through its geoindicators working group (Antony Berger, chairperson).

The National Park Service (NPS) has adopted the geoindicators tool to implement portions of its strategic plan and provide improved science-based information to park managers. In recent decades, increasing pressures on park resources have created a need for active management of park ecosystems. In 1997, Richard Sellars' book *Preserving Nature in the National Parks*, along with earlier reviews by the Park Service and external organizations, showed that often this work was being done with ambivalence about the role of science in park management and decision making (Sellars 1997). The Park Service now recognizes that active management requires scientific knowledge and understanding of natural systems.

However, most parks, even those with significant geologic resources, don't have geologists on staff or in their regional offices to call on for expertise. The geoindicators checklist was designed to enable planning teams make science-based assessments of geologic conditions. Geologists designed geoindicators for non-geologists and geologists alike.

As a land manager, NPS is interested in environmental assessments, particularly those that can identify rapidly changing conditions. Most park resource managers are familiar with the indicators and monitoring methods used to determine change in the biological components of the ecosystem. With geoindicators, park managers will now have access to the same criteria that geologists would use to help determine the health of the ecosystem and guide management decisions.

The geoindicators tool begins with a checklist that enables parks to identify geologic and hydrologic processes important for evaluating the state of the environment, ecosystem change, and how humans are affecting natural systems. The easy-to-use checklist includes twenty-seven indicators selected for their ecological importance:

1. Coral chemistry and growth patterns
2. Desert surface crusts and fissures
3. Dune formation and reactivation
4. Dust storm magnitude, duration, and frequency
5. Frozen ground activity

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

6. Glacier fluctuations
7. Groundwater quality
8. Groundwater chemistry in the unsaturated zone
9. Groundwater level
10. Karst activity
11. Lake levels and salinity
12. Relative sea level
13. Sediment sequence and composition
14. Seismicity
15. Shoreline position (Figure 40.1)
16. Slope failure (landslides; Figure 40.1)
17. Soil and sediment erosion
18. Soil quality
19. Streamflow
20. Stream channel morphology (Figure 40.2)
21. Stream sediment storage and load
22. Subsurface temperature regime
23. Surface displacement
24. Surface water quality
25. Volcanic unrest
26. Wetlands extent, structure, and hydrology (Figure 40.2)
27. Wind erosion

The geoindicators tool goes well beyond identifying topical areas in geology; it provides sufficient information to assess each indicator based on ten separate criteria. With the tool, the user can determine the significance of each indicator for specific park ecosystems. In addition, the criteria help define parameters for monitoring each indicator.

1. *Significance.* Why is it important to monitor this indicator?
2. *Human-caused or natural change?* Can this geoindicator be used to distinguish natural from human-caused change, and, if so, how?
3. *Environment where applicable.* In what general landscape settings would this geoindicator be used?
4. *Spatial scale.* At what scale would this geoindicator normally be monitored in the field?
5. *Types of monitoring sites.* Where specifically should the geoindicator be measured?
6. *Method of measurement.* How is this indicator measured in the field?
7. *Frequency of measurement.* How often should this geoindicator be measured so as to establish a time series and baseline trend?
8. *Limitations of data and monitoring.* What important difficulties are there in acquiring field and laboratory data?
9. *Application to past and future.* How can this geoindicator be applied to paleoenvironmental analysis?
10. *Possible thresholds.* What thresholds and limits cannot be exceeded without drastic environmental change or threats to human health and biodiversity?

The geoindicators help answer NPS resource management questions about what is happening to the environment, why it is happening, and whether it is significant. They can also be used to establish baseline conditions and trends so that human-induced changes can be identified.

A resource management team can begin to use the geoindicator checklist by implementing the simplified approach described below. It is recommended that a geologist, hydrologist, or soils scientist is included as a part of the park team.

Figure 40.1. Some geoindicators. Top: Shoreline position: offset shoreline due to human-made jetties. Bottom: Slope failure: environmental factors exceeding surface material strength.

Figure 40.2. Some further geoindicators. Top: Stream morphology: dynamics of the river channels. Bottom: Wetlands extent, structure, and hydrology.

Step 1. Use the checklist of 27 indicators to identify all geologic processes that occur in park ecosystems.

Step 2. Screen the list further to identify those indicators which are of greatest importance—those serving as drivers in ecosystem function—and those being influenced by human activity.

Step 3. Apply the ten assessment criteria for each of the indicators selected in Step 2.

After going through this process, the assessment team can make recommendations for research, identify gaps in the data, recommend a monitoring plan, and identify preliminary monitoring protocols.

The geoindicator checklist can help to focus our thinking about landscape management. However, it only reaches its full potential when used in concert with other scientific disciplines. Geology and the other physical sciences contribute important information to our understanding of ecosystem function, but information from social and biological sciences is also needed. The triangular diagram (Figure 40.3) illustrates conceptually how the basic sciences of ecosystem study contribute to our understanding and development of an ecosystem model.

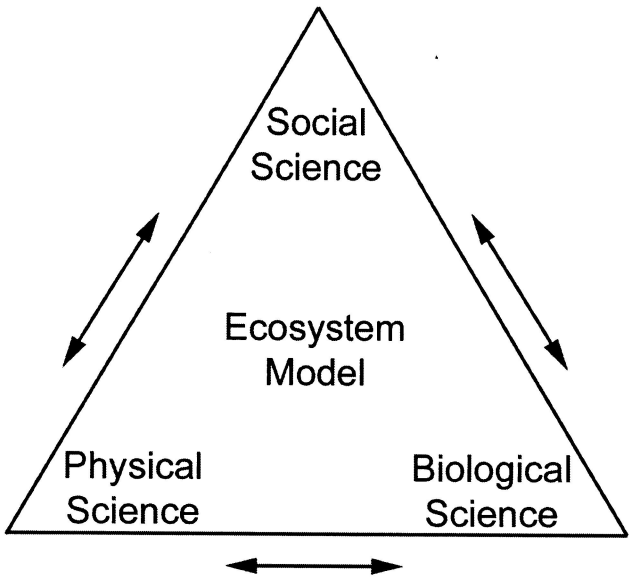

Figure 40.3. The basis of an ecosystem model.

Understanding ecosystems requires not only knowledge of the component parts and their interactions, but their natural cycles and variability as well. In the last few decades, we have come to realize that change in an ecosystem is normal, naturally occurring, and desirable. Steady-state conditions over time are not generally the norm. This concept is important for our understanding of the interaction of human influences and natural processes. We perceive that the human component of change in the ecosystem is expanding disproportionately and often at the expense of abiotic and other biotic components. But measuring stress at the interface between humans and the environment requires scientific tools that can resolve naturally occurring

change from human-induced change. The geoindicators tool can contribute to sustainable park management by providing information on both natural conditions and the effects of human actions.

In the NPS, geoindicators have been integrated into several projects to provide science-based information for resource management. The year 2000 was the pilot year for the NPS Strategic Plan Goal Ib4, the identification of human influences on geologic processes. This knowledge-based goal uses the combined expertise of park personnel and geologists to identify natural earth-system processes that are being influenced by humans. In September 2000, the first scoping meeting for this goal was conducted at Craters of the Moon National Monument involving staff from the park, the NPS Geologic Resources Division, and the U.S. Geological Survey. The geoindicator checklist was a focal point of the scoping meeting, which identified critical geological components of the park ecosystem for long-term ecological monitoring and research. Over the next five years, parks throughout the National Park System will be using geoindicators to conduct ecological assessments, evaluate monitoring needs, and meet strategic goals.

Geoindicators are also being integrated into the Vital Signs Monitoring Program for NPS Strategic Plan Goal Ib3 to identify geologic "vital signs" of ecosystem condition in the 32 monitoring networks and in individual park units. In April 2000, the concept was introduced as an assessment tool at the Northeast Barrier Network's vital signs scoping meeting. The checklist and criteria were used during the meeting to evaluate options for monitoring, and shoreline position was selected as a critical ecological indicator.

Recently, the long-term monitoring program of NPS initiated development of a handbook for natural resource monitoring. The NPS Geologic Resources Division drafted a chapter on geologic resource monitoring that includes the geoindicator concept (NPS 2001).

In addition to the existing applications for geoindicators, we believe the checklist can provide other benefits to the Park Service. The NPS planning process in general may benefit by considering geoindicators, but the General Management Plan (GMP) process and, specifically, the visitor experience and resource protection element, need geoindicators. Geologic information is important to consider for evaluations of visitor experience, safety, and protection. Since the geoindicator concept addresses human-induced change to geologic processes and features, its use can make it easy for parks and planning teams to consider the effects of development and visitor use on natural systems. The geoindicators checklist could also be adapted to help in identifying resource management needs and providing information for new funding proposals.

Ever since we first viewed Earth from space in the late 1960s, we have had a clear image of the boundaries of our ecosystems. Since then, there has been an increasing public expectation, nationally and internationally, that scientists would eventually gain an understanding our global ecology and provide for the preservation of the environment in which we live. There are further expectations that national parks protect the best examples of pristine conditions and therefore, may provide a baseline for ecosystem comparisons. By gathering long-term data on geoindicators in parks, we hope to gain a better understanding of geology's role in the ecosystem and provide information that will contribute to the preservation of healthy ecosystems.

References

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