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COMMENT AND REPLY

Comment on D. Welch's "Geoindicators for Monitoring Canada's National Park System" published in Geoscience Canada v. 30 (1), 2003

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As David Welch, senior scientist with Parks Canada, rightly points out in a recent issue of Geoscience Canada (Welch, 2003), species, ecosystems and landscapes are not static, and information about the ways they change is essential to long-term environmental management, particularly in protected areas. To assist in this endeavour, he proposes a set of geological indicators for Canada's national parks (see Welch 2002 for further details). This combines many of the geoindicator set defined by IUGS (Berger and Iams 1996, Berger 2002, and see www.geoindicator.org), some of those developed by Canada's Ecological Monitoring and Assessment Network, and several new parameters discussed at a 2001 workshop on tracking geological change in protected areas (Berger and Liverman, 2002). If the progress towards monitoring geological change in US national parks is anything to go by (see Ozaki and Higgins in Berger and Liverman op.cit.), Welch's efforts should assist in the efforts of the Canadian government to monitor and report on the state of its national parks. Nevertheless, there are some real difficulties with his proposals.

First, ecological monitoring by Parks Canada involves "structure", "functions" and "stresses", reminiscent of the familiar pressure-state-response (PSR) framework followed by the UN and many countries, states and even cities in their State-of-the-Environment reporting. Thus, Welch groups dunes and lakes as "structures," whereas the related IUGS geoindicators are dune formation and remobilization, and lake levels and salinity. In contrast he places groundwater level and frozen ground activity (a collective grouping of all rapidly changeable permafrost phenomena) under "processes". Why a surface (level) in one case is regarded as a structure and in another as a process is not clear. Neither is it apparent why changes in dunes are not in the same category as he puts changes in frozen ground.

Perhaps the crux of the problem concerns the category of "stresses." From this Welch excludes mass movements, and glacier fluctuations, both of which can certainly stress (force, exert pressure on) nearby biota. Moreover, the only "candidate geoindicator" in this category according to Welch is the "built environment". Obviously, roads, dams, hiking trails, and golf courses can affect local ecosystems, but I do not see how they can be regarded as "geological". The problem is that stresses in the Parks Canada approach, as in many other applications of the PSR framework, are generally defined as human-induced (Berger and Hodge, 1998). Yet, pressures, stresses, and forces or one sort or another within the natural environment existed long before the advent of humans and, indeed, set the background for evolution. I applaud Welch's efforts to fit geoindicators, both his and those of IUGS, into the ecosystem-based framework that Parks Canada is using, but the result is a playing field with some rather square pegs in round holes – the fit is at best artificial, at worst, nonsensical.

Second, Welch includes "extreme events" in his "blended list of geoindicators," Since avalanches and landslides, dust storms, seismicity and volcanism, and some other IUGS geoindicators are all associated with extreme events, and on occasion regarded as natural disasters, it is not easy to see the rationale of setting out a separate category of extreme events.

Third, lurking in the background of monitoring park environments is the legislated concept of maintaining ecological integrity (Welch, 2002). This is defined in the National Parks Act as "a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communicates, rates of change and supporting processes." Confused and unwieldy wording apart, the salient feature of this definition is the emphasis on no change, as if nature and ecosystems were static. Vary the rates of change, the processes, biodiversity and the abiotic (including water, soils, and landforms) and ecological integrity is diminished. Since evolution has always been driven, at least in part, by geological change, this seems a strange requirement, and more so in the face of landscape change associated with climate warming - retreat of mountain glaciers, fluctuations of sea levels and coastal zones, and increased instability of steep slopes. An earlier definition (Woodley, 1996) used by Parks Canada states that ecological integrity is "achieved when ecosystem structures and functions remain unimpaired by human-caused stresses and native species are present at viable population levels." The implication here seems to be that there is no loss of integrity when natural stresses impair ecosystems. In both definitions, there is

the difficult problem of reconciling the reality of short- and long-term change with the management goal of continuity, even allowing for limited change within system boundaries (Berger, 2002). There can be little integrity remaining in a tropical island ecosystem drowned by rising sea level, or in a savannah overrun by migrating sand dunes.

At the heart of the matter lies the challenge of dealing with, managing, and regulating environmental components and systems against am autonomous natural background that is changeable in ways and directions that are not necessarily predictable. There is some way to go yet before a satisfactory conceptual framework for assessing causes of environmental change is available.

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Reply to Antony Berger's comment on "Geoindicators for Monitoring Canada's National Park System" by David Welch in Geoscience Canada, v. 30 (1), 2003

Antony Berger has been a leading proponent of the use of geological indicators in environmental monitoring, as attested by the 1996 book he edited with Bill Iams and the 2001 international workshop he organized with David Liverman. It was this workshop that led to my report on geoindicators as an adjunct to ecological integrity monitoring in national parks and to the article published in this journal (references in Berger's comment). His comments are welcome, as there is room for more thinking on this subject. For example, have the IUGS, Ecological Monitoring and Assessment Network, and Gros Morne workshop participants covered the field? Are there other geoindicators yet to be identified? Within finite budgets, how should one set priorities between indicators?

The definition of ecological integrity enshrined in law hinges on the phrase "... characteristic of its natural region and likely to persist ..." The remainder of the definition elaborates on what ingredients might be considered in that characterization, and explicitly includes "... rates of change and supporting processes." In both the legislated and earlier definitions of ecological integrity to which Berger refers, there is no loss of ecological integrity when natural processes change ecosystems, whereas there is a loss of ecological integrity when anthropogenic processes move ecosystems away from a natural state. Regardless of our disagreement over interpretation of a definition that may be "confused and unwieldy," Berger is right to emphasize the challenge of managing ecosystems in the face of both naturally and anthropogenically driven changes.

To assist in this challenge, Parks Canada has adopted a monitoring framework that distinguishes structures (*e.g.* features, arrangements, patterns), functions (e.g. processes, mass and energy budgets) and stresses, the latter considered to be anthropogenic factors that perturb the features, structural arrangements and processes of otherwise natural systems. Of my short list of ten geoindicators, nine are essentially measures of structure and function. Between these two there is bound to be overlap between the measure of a structure and the measure of a manifestation of a function. I recognize this in my paper when I write "These are not exclusive tiers, merely practical devices to ensure a balance in choosing indicators for monitoring natural systems" (p.14). My practical device is to broadly distinguish geoindicators related to 1) features that can be readily appreciated and adequately photographed and mapped by ecosystem managers, consultants and graduate students in various disciplines, using common field and remote sensing tools, from 2) phenomena that require instruments installed in the field and/or laboratory methods to measure non-visible, relatively fine or rapidly variable effects.

The segregation of anthropogenic stressors is central to the world view of parks and protected areas. For research, planning, management, monitoring and communication, we try to distinguish natural change from human-induced change. I am very far from the being the first person to recognize humans as a leading agent of geological change. Either in terms of landforms built or soil and rock moved, either intentionally or unintentionally, I propose to capture humans' role in changing the face of the Earth (Thomas, 1956). For this I propose an indicator that includes all direct and indirect modifications of the Earth's surface by human activity, and which I call the built environment. This is an area worthy of further thought. Is there a better name? Would it be useful to distinguish geoindicators of anthropogenic change into more categories such as structures (e.g. levees

or reservoirs), excavations (e.g. quarries), incidental earth movement (e.g. erosion from bare fields, clear cuts or building sites), incidental weathering (e.g. due to acid rain), or other?

In reviewing geoindicators for park monitoring, my intention was to cast a wide net and then look for an optimum subset. In my full report I recognized that an indicator of extreme events would require more consideration, and this is in part why my subset of geoindicators does not include it. Yes, all geoindicators exhibit outlier values. Nevertheless, catastrophic events may change in frequency (witness the October 2003 flood in Pemberton, British Columbia) and there may be measures, such as insurance claims or loss of life, common to different kinds of events.

A final word. Parks Canada employs working definitions in order to engage in land management. It also accepts the need for adaptive management and a culture of science. Both require ongoing re-evaluations of all its tools including definitions enshrined in legislation, monitoring frameworks, and the selection of indicators of environmental change. For the present, though, the definition of ecological integrity continues to be provisionally valid and it can be put to good use.

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