Denali National Park and Preserve, Long-Term Monitoring Program (LTEM)

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The strength of the Denali LTEM is that the existing structure of professional scientists that understand and that are concerned about the park. I was very impressed with the knowledge and abilities of the people that I met, and with the coverage of subject matter specialists that the park has to draw on. Most monitoring programs do not start from such strong base. On the flip side, the major disadvantages of the LTEM are the current park infrastructure (offices, etc..) and the shear size of the monitoring and assessment job required by such a large park.

I base my comments here on the stated purpose of the LTEM in the 1997 annual administrative report: (summarized) to develop an information system on status and trends in the structure and function of the park's ecosystem to:

1) Improve management decision-making on preservation concerns
2) Increase understanding of ecological dynamics
3) Enhance national and global monitoring networks

I draw my ideas and comparisons from experience with the national Environmental Monitoring and Assessment Program (EMAP) for which I have been working with for over five years. This program spent millions looking at monitoring and assessment and has lots to offer through both its successes and its failures. Given my limited exposure thus far to LTEM, my comments are offered only as "food for thought."

Overall Recommendation

My most important recommendation is to develop a plan for proceeding toward success; and to follow it. My suggestions for future steps are:

Step 1: *Conceptual Plan*
The first step is to develop goals and objectives and get long term buy in. There are already a set of goals and objectives. However, are they agreed upon by the appropriate decision makers?

- The first step in this section should be to determine who will decide what the park objectives should be. Potentially this could include the resources group, other park groups such as rangers, the superintendent, policy makers in Alaska, policy makers in the U.S., and citizens. Groups like the park rangers, for example, should be included since they share in the park's management and because they see how people use the park on a daily basis.

There are objective ways to be representative and to develop plans that are "approved" by the appropriate clientele groups. Most government agencies that are under intensive public scrutiny already go through these processes (like the Bureau of Land Management or Forest Service for example).

I recommend that you use a variety of ways to develop your objective plan. Looking at how other agencies deal with defining objectives for controversial issues would be a good place to start. The Analytical Hierarchy Process (AHP) method that I have been working on for environmental applications is a good way to map out these objectives once they are stated. I have enclosed some articles about AHP in appendix three. I included an example from Peterson et al with a park application, one on developing an environmental index, and one on AHP. I also have an EPA report that I could send you if you are interested in learning more about how we used AHP in North Carolina for an environmental issue. It is very comprehensive. The important point here is that before spending a lot of money on monitoring, it is a good idea to have a good, agreed upon, and publicized map of what you are monitoring and why.

- The second step should be to develop and publish the goals and objectives.

Step 2: *Implementation Plan*

The implementation plan would go through the difficult process of how to use limited resources at the park to address goals and objectives (like to track status and trends). This is the most difficult part of the project because it requires information and organization to make informed decisions. It will also require interpretation and modification of the original goals and objectives as information is brought to light.

- The first step here would be to determine a wish list of attributes that address goals and objectives. For example, if a park objective is to "maintain a healthy vegetation," then which variables would the park collect?
- The second step is to narrow the list by eliminating costly or difficult items that are unrealistic to accomplish. This would require some preliminary cost information, interviews with the potential data collectors, and some

forward thinking about what the statistical and research implications might be.

- The third step is develop a list of scenarios that could be followed to collect, store, assess, and report the information collected. All four of these parts need to be considered. For example, one scenario would be to use the grid approach suggested by the statisticians. A sub-scenario would be to eliminate hard to reach areas, or mountain tops, or to separate out rivers and streams into a different sampling program, etc. Other decisions will include timing, helicopter use, road access, equipment, and personnel.
- A forth step is to link the scenarios to the park objectives. This is where the AHP can be very useful. It can be used to map objectives to data collection, setting up the fifth step below.
- A fifth step is to identify pro's and con's , costs and benefits, to each scenario. This is the hardest step. It is also the step where the statistical consultants and the cost data from economics are most useful. AHP can be used in the end to actually weight each tradeoff. For example, a weight could be developed for each data type's contribution in a water quality index. If the budget were limited, the least important, most costly variables could be dropped. The weights are created as a group effort. AHP modelers have found that the discussion that leads to the group weights usually results in cooperation and agreement.
- The sixth step is to choose the plan
- The last step is to develop a hierarchical map of data collection to goals and objectives so that everyone understands what is being done and why

Step 3: *Implementation*
Going from a plan to implementation will require working out a lot of bugs. The format of the data must be conducive to computer storage, protocols might need to be adjusted and so forth.

Step 4: *Evaluation*
It would be easy to forget to create an evaluation program that helps determine where efforts have been on target and where they have failed. The evaluation program should be designed from the outset.

Detailed Observations and Recommendations

EMAP

I have included several reports from EMAP or about EMAP in appendix 2. I will not elaborate here since everything I want to say is contained in those reports. However, I will encourage you to read these reports above all else since they will basically say the same kinds of things that I am saying here. The EMAP experience is remarkably similar to the issues at hand here and these reports should be very helpful. The articles complement the EMAP reports by discussing what went wrong in more detail. ***Above all, the EMAP program "failed" because it was not able to report what data meant to the people that funded it in meaningful, simple terms. That is, they were not policy relevant, so they were considered irrelevant.*** In both of the articles I wrote, we detailed several studies that concluded that when assessment, that is putting data into more understandable terms, was omitted or downplayed, projects failed. Therefore, I recommend that assessment be an equal and important part of the monitoring and research program at Denali. The articles detail my case for this argument.

Goals and Objectives

1) The park already has an existing overall direction and objectives (see above) for monitoring and assessment, but staff are not organized around these goals and objectives

The LTEM does not have widespread buy in from with the resources group, or across the other park groups (rangers, etc.), with park overseers (superintendent, politicians), or with clientele groups

Recommendations:

- Determine who decides what park objectives are-- I highly recommend that you go through the pain that it will take to get a plan that you can convincingly say that your clientele group supports. Probably, the resource management group would oversee the plan and make final decisions. However, they need to be able to justify that they included clientele input to defuse any future attacks on choices made.
- Determine how to solicit their opinions-- There was some concern that asking the public might open a can of worms. However, one could easily have a set of user group meetings that worked to balance opinions. No one group could dominate because they are part of a larger process. For example, I recommend a few focus groups with ordinary citizens. Park officials can explain what they are trying to do; see how it resinates with the public. I would include a meeting with locals about hunting and fringe development. Then I would bring in all relevant park user groups (rangers, resource management, interpreters,..) in a single meeting. There is a good book on this subject called "dealing with an angry public: the mutual gains approach to resolving disputes" by Susskind and Field. There are probably a lot of others too. My limited reading confirms that it is best to get public and park buy in now.

- Determine how to monitor for those objectives-- This is the monitoring and assessment program described above. This step simply reminds us that the monitoring program has to match the objectives. I have seen many of these types of programs go through a lot trouble developing plans, then having no way to assure that scientists link their efforts to it.

- Develop an assessment program– This step assures that the monitoring program information is assessed to make statements about goals and objectives. For example, did water quality get better?

2) There seems to be little stability and continuity about LTEM goals and objectives.

Recommendations:

- Determine *core* objectives and *flex* objectives– The staff at Denali said that it is important to "establish a baseline and to determine the impact of future threats." I agree. A core set of information should be collected indefinitely to determine status and trends over time. No one knows what future threats will be (air pollution, climate, urban encroachment, etc.), but the threats won't be easily determined if a solid baseline is not established and continually monitored. The park should determine what the core information will be and institutionalize it so that it is hard to change. At the same time, there should be a set of flexible objectives that can change over time. For example, a core objective might be to monitor charismatic megafauna populations. A flex objective might be to monitor moose populations to determine hunting goals for the park. The trick will be how much of the park budget and effort is devoted to core objectives. These will usually be routine to park scientists and the hardest for them to recognize as important. Issues of the day are important, but come at the expense of neglecting long run objectives. The park should therefore have a solid, well communicated policy on the long term core objectives that must be done to avoid them being overlooked in the interest of current topics.

- Build institutional structure to preserve core and to provide continuity– Most scientists are so specialized in their disciplines that they have little desire or experience with integrating their knowledge into a larger, more political structure. A manager understands all too well why a scientist must show that their research is important. An institutional structure accomplishes two things. First, it preserves continuity over time, so that long-term trends can be determined, by eliminating programs and ideas coming in and out with new personnel, administrators or wavering public opinions. Second, it connects science with policy. Scientists can see where they fit in the big picture and why they are being asked to modify their efforts, in some cases, away from what might seem the most "scientifically" sound approach. Monitoring and assessment is the integration of science and policy to provide people with meaningful information. Both science and policy must make adjustments away from purely political or scientific motivations to make assessment happen.

Monitoring Resources

1) The park is too large to monitor everything given its resources. The watershed approach has been suggested.

Recommendations:

- Follow the statisticians' recommendations to create a grid for the entire park. Intensify the grid to get watershed or other level information when needed. This is the exact same recommendation EMAP makes.

2) There are no guidelines to help the park prioritize a monitoring program with limited resources.

Recommendations:

- The park needs a plan to match data collection to address policy relevant goals. They don't have the resources to measure everything everywhere so tough choices will have to be made. ***The decision will depend on cost, statistical validity, and values (goals).*** On the cost side, there are many confounding issues. For example, a hierarchy of information like that shown on the first page of appendix I could map data to policy relevant questions. Each piece of data maps into answering a question (higher up the hierarchy) that the park considers important. However, if say half of these had to be eliminated, it would be important to assure that the remaining variables still address needed information. For example, one could easily envision collecting a fraction of the information needed to address flora condition and a fraction needed comment on fauna, and a fraction needed to understand water quality, resulting in the inability to address any of these issues. A valid question then is whether it is better to get complete information on some things at the cost of knowing very little about another. The hierarchy helps map difficult tradeoffs.

- The park needs a hierarchical map of its monitoring program linking data to goals and objectives.

Research and Monitoring

1) There appears to be a lot of confusion over the term research as it pertains to monitoring.

Recommendations:

- Monitoring <u>cannot</u> be done outside of a research program. However, research can mean many different things and can draw a monitoring program away from its objectives. The monitoring program should be done to address goals and objectives. Monitoring research refers to the research that will accompany monitoring to address policy (or goal) relevant questions. Monitoring research in this case refers to the protocols that are applied to the attributes monitored (statistical reliability, accuracy of tests, etc.), the way that information is collected and stored, and the way it is aggregated, integrated and reported. In this case the monitoring program will probably be linked to a monitoring research program that assesses whether status and condition has changed. This requires effort to develop the statistical tools to determine whether the movement in a variable is a trend. It also requires research to determine how to aggregate, integrate and summarize data.

Aggregation and integration, for example, is a science in itself and can dramatically affect the information reported. I have included examples in appendix 1 of a hierarchy that aggregates and integrates monitoring data. Note on the right side of the first page (single resource/single region), I have inserted a slider bar that shows how monitoring is mostly science, but assessment progressively becomes more policy. It is monitoring research to determine how one uses several indicators to form a higher order indicator. On page 2 of the appendix, an index is conceptually shown at the top of the page. At the bottom of the page, the assumptions that must be made for a simple indicator like forest productivity are demonstrated. Monitoring collects information on three things: pine species crown condition, diameter at breast height, and density. These terms mean little to communicate whether the "park" has deteriorated to a non-trained scientist. Therefore, they are aggregated up to ultimately indicate whether flora gets "better" or "worse" over time. This requires assessment science, which is a part of the monitoring research program. There all ready three assumptions about which variables should be monitored to indicate flora condition; altogether, there are 9 assumptions about which variables to measure. In addition, the assumption is made that stand structure is made up of DBH and density. This requires an assumption about the weight each component has and the functional form (linear, nonlinear) that the relationship takes on. There are a total of 8 weights assumptions and 5 functional form assumptions. There may already be a scientific study that defines the relationship of measured variables to the desired index; and there may not be. But as data is moved up the hierarchy to answer the policy relevant question defined by the park (in this case, what is the forest productivity condition in the park), more and more assumptions have to be made. Altogether, there are 22 value judgements. Social scientists have devised many methods to make these assumptions objectively fit park decision maker goals and objectives. That is to move value judgements beyond just the hands of scientists that develop the index.

The last two pages of appendix 1 contain examples showing how important a simple thing like functional form can be. I put this in to indicate the importance of treating assessment as an important element of monitoring. Eclipsing shows where a two-variable index can understate risk, for example. In the example shown, the functional form for the index shown yields a score of 75 (under 100 is safe) with three different scores for each subindex (125:25, 25:125, and 75:75). Although all three indexes suggest safety, in two cases one of the components of the index is out of the safe range. Eclipsing shows how badly any particular functional form underestimates its components. In the water quality example on the same page, I show how different two "water quality" indexes can be, even with the same exact data. Finally, I gave a few more examples about hierarchy and indexes on the last page.

- My recommendation is that a monitoring and assessment program include a research component that clearly spells out that ***monitoring research*** is purely to determine appropriate monitoring and assessment techniques. ***Park research*** would be anything that occurs outside this program. For example, the monitoring and assessment program should address whether there is a trend up or down in park megafauna. The park research program might separately address what the cause of the trend is.

Personnel

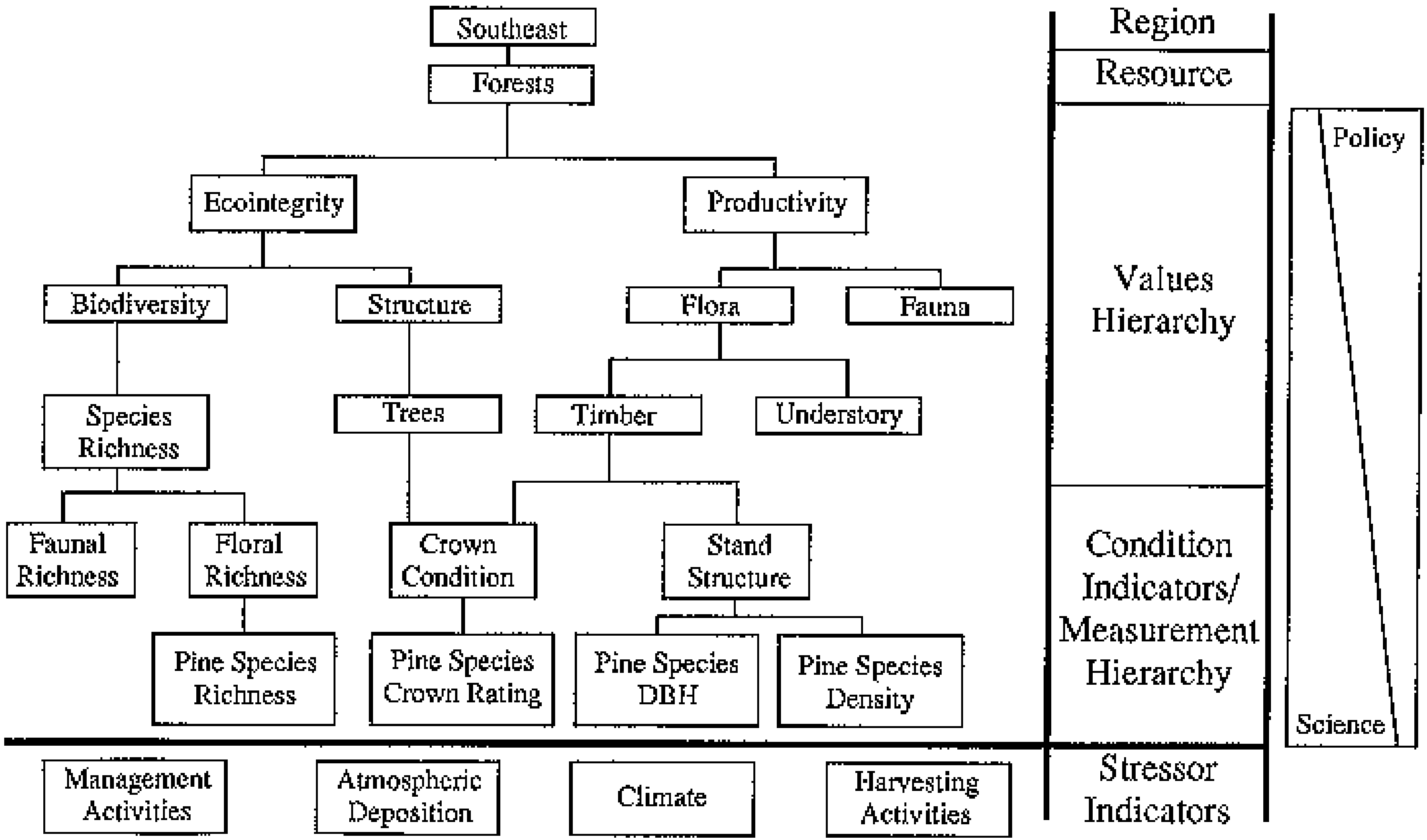
1) Personnel includes those from BRD, the resource staff and resource administration. A coordinator for LTEM will be hired.

Recommendations:

- The coordinator should not be a subject matter specialist. They should be trained in resource management or policy. They will have to understand many subjects, but their main function will be to organize and communicate between science and policy. The coordinator should also be energetic, a good writer and a good communicator. Duke University and many others have such programs. Also, resource economics programs would produce good fits for this type of position.

Appendix 1: Graphics

Single Resource/ Single Region Assessments



Appendix 2: EMAP Reports/Articles

The Exponential Nature of Value Judgements Within the Assessment Hierarchy

Number of Value Judgements	EMAP Activity
$21^{R \times E}$	Multiple Resources/ Multiple Regions
21^{E}	Multiple Resources/ Single Region
21^{R}	Single Resource/ Multiple Regions
21^{c}	Develop ecological status index (human dimension)
21	Develop objective/ value index
5	Develop Indicators
3	Monitoring

(R = Region, E = Environmental Resource)

Index Construction

- Linear $I = (w_i \times i_i) + (w_i \times i_i)$
- Non-linear
  - Multiplicative
  - Root-sum Power $I = \sqrt{w_i^2 \times i_i^2}$
  - Root-mean Power $I = \sqrt{(w_i^2 \times i_i^2)/2}$
  - Min (max) Operator I = best (worst) of i_i or i_i
- Increasing or decreasing scale

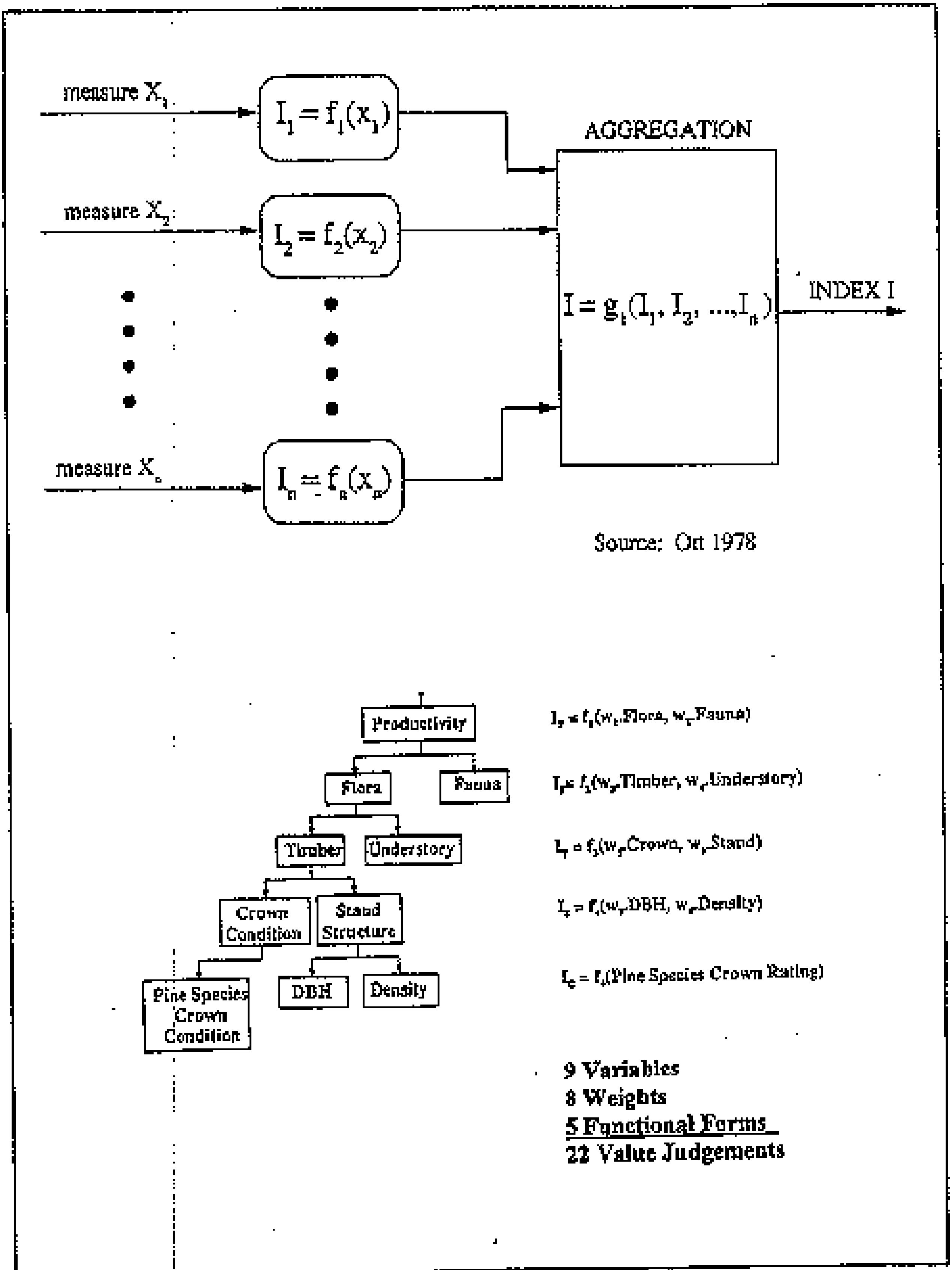


Figure . : Conceptual models of environmental indices and of an environmenal hierarchy.

Eclipsing Example: Linear Functional Form

- Equal Weighted: $I = (i_1 + i_2)/2$
- Bad: $I \geq 100$
- Three Ways to get Water Quality =75
  - Ozone = 125 , NOx = 25
  - Ozone = 25, NOx = 125
  - Ozone = 75, NOx = 75
- Eclipsing Problem
  - Index reports nominal even though subnominal conditions exist for a subindex
  - Potential under-reporting of ecological deterioration

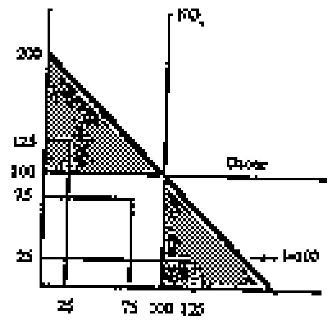


Illustration: Same Variables Can Have Different Weights

Table: Subindex Functions for Stoner's Public Water Supply Index

Variable	Subindex Function
Fecal Coliforms (no./100 ml)	[illegible]
Copper (mg/l)	[illegible]

Table: Subindex Functions for Stoner's Irrigation Index

Variable	Subindex Function
Fecal Coliforms (no./100 ml)	[illegible]
Copper (mg/l)	[illegible]