

Resource	Indicators	Existing Data	Data Needed
<p><b>Rangeland Resources</b></p>	<p><b>Definition:</b> 1. Presence/temporal variance of natural vegetation 2. Individual species of native vegetation varying with time since last disturbance, soils, and precipitation patterns 3. Absence/suppression of exotic species 4. Upward trend in ecological status over time 5. No accelerated soil erosion 6. Fire as a natural event 7. Concurrent profitable timber and/or livestock production 8. Provision for ecologically appropriate recreational activities 9. Appropriate employment rates in natural resource dependent rural communities</p>		
<p><b>Agriculture</b></p>	<p>1. Area of land in agricultural production 2. Trends in soil quality and erosion rates 3. Proportion of agricultural and rangeland managed with sustainable practices</p>	<p>1. Oregon Pesticide Use Database (OPUD) 2. USDA--NRCS Natural Resources Inventory (NRI) Program 3. Wypocki and Veseth, pers. comm., 1989 4. Western Regional Project W-84, 1984-1989 5. Kogan et al., 1999 6. OSU Agricultural Chemistry Extension Program, Jenkins, Buchwalter, and Thomson draft report 7. Wentze et al., 1988 8. Oregon DEQ</p>	<p>1. Monitor agriculture land type and conversion 2. More informative indicators of soil quality and health such as biochemical and microbial biodiversity measurements 3. Establish new measures of sustainable agricultural practices 4. Determining an appropriate balance in the reduction or removal of organophosphate pesticides under FQPA 5. Land use/land cover mapping at regular intervals</p>
<p><b>Urban Resources</b></p>	<p>1. Water quality: Temperature, Dissolved oxygen, Phosphorous, Nitrogen 2. Air quality: Carbon monoxide, sulfur dioxide, nitrogen oxides, lead, ozone, particulate matter, and hazardous air pollutants (HAPS), vehicle miles travelled (VMT), VMT per capita 3. Soil and groundwater contamination: Presence of potentially harmful chemicals in the soil, leakage from underground storage facilities, and the hazardous chemical sites inventory list</p>	<p>Oregon DEQ's Water Quality Index (WQI); US EPA Basins data; ODEQ raw water data  ODEQ Air Pollution Index (API); ODEQ Air Quality Data and Averages; US EPA Airs Data; US EPA Hazardous Air Pollutants (HAPs)  ODEQ Underground Storage Tank (UST) List; ODEQ Environmental Cleanup Site Information System (ECSIS); ODEQ Inventory of Hazardous Substances Sites (IHSS)</p>	<p>1. Examining the sediment, instream, or bank qualities as well as the water may be a more comprehensive part of an effective assessment 2. Greater number of possible water quality indicators and sampling stations 1. Greater number of air quality datasets 2. More monitoring of hydrocarbons are required 3. Development of an urban airshed model 4. More frequent monitoring of NO and VOCs</p> <p>1. Better assessment with increased number and type of monitoring devices for soil and groundwater contamination</p>

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Biodiversity	1. Conservation status of broad categories of habitat or vegetation and individual at-risk species 2. Sustainability of natural resource management practices across landscapes	Oregon Biodiversity Project (1996); Oregon Natural Heritage Program (1998, 1999) -- Oregon Gap Analysis Project;	1. Stronger public policy framework to address biodiversity at the habitat or ecological processes level 2. Assemble research collections into a statewide picture of how the state's biodiversity is distributed 3. Land use/land cover mapping at regular intervals.
Exotic Species	1. Number of exotic species 2. Geographic distribution of exotic species 3. Distribution of those exotic species with the potential for serious impact	1. "White" List for exotic species (Arnold and Anthony 1999) 2. "Red" List for problem exotic species 3. Oregon Dept. of Agriculture surveys and monitoring programs (e.g., Noxious Weed Control Program)	1. Tools to identify problem exotic species and predict their potential for establishment and spread, including better communication with agencies outside Oregon 2. Interaction among invading species -- communities of invaders 3. Statewide coordination and monitoring of exotic species

- 4) A frame of reference for gauging sustainability. This frame of reference might be the historical range of variability for the condition or outcome of interest (such as the historical range of old growth in the coast range), levels of habitat from research studies (such as the amount of large trees in streams with healthy fish stocks), or the properties of communities that survive and prosper (such as economic diversity). By comparing the level of the indicator in some plan or policy to the frame of reference, we can assess the amount of risk relative to providing sustainable levels of the condition or outcome of interest;
- 5) Rules for deciding whether sustainability has been achieved (sustainability check) for some outcome or condition of interest (a non-declining harvest volume over time, a level of old forest near the average of the historic range of variability, at least an 80% probability of providing habitat for a viable population of native species well distributed over the planning area). These rules connect the indicator to the framework and establish threshold levels of the indicator that will be considered sustainable. They have important political dimensions in establishing how much risk to take. They help answer the question: what level of the indicator is sufficient to be considered sustainable? They often become policy targets, constraints, or benchmarks;
- 6) A method for projecting the outcome of proposed management alternatives or policies (i.e. simulation using forest inventory and forest vegetation growth simulators, strategic forest planning models, trend analysis, expert opinion). These methods help us evaluate alternative management plans and assumptions relative to the condition or outcome of interest; and
- 7) A monitoring program to collect actual data on the amount and/or qualities of the conditions and outcomes to be sustained. This is a reality check for determining if an implemented plan or policy is in fact meeting sustainability standards.

Of the seven components listed above, establishing a framework for gauging sustainability (4), agreeing on the threshold levels of the indicators that will be considered sustainable (5), and developing a method for projecting the conditions of interest under alternative policies (6) can be especially difficult. In most cases, the state has not yet developed rules or information related to the sustainability check or models for projecting selected conditions to be sustained. Until and unless the state develops agreement over these issues and a systematic framework in which to implement the program, money may be spent to generate a great deal of data but Oregon may still not be in a position to assess environmental or economic sustainability.

Therefore, a group or consortium of local, state and federal

agencies should be charged with the responsibility of clarifying the overall purpose and goals and developing appropriate models and a strategy to gather and manage environmental data in Oregon. The long term goal should be to establish a state environmental data management system that is coherent, consistent, quality ensured and easy to access with minimum resources. A key challenge will be to find the right balance between statewide coordination and agency and program decentralization for strategy implementation.

A discussion memo was recently developed by staff from the Oregon Natural Heritage Program which may provide a starting point for resolving many of these issues (Overall Information Management Model in Oregon, J. Kagan, February 2000). Whatever strategy evolves should address these common components of environmental data management:

## The Strategic Assessment Model and Overall Framework

The strategic assessment model and overall purpose, goals and objectives for the use of environmental data in Oregon must be clarified. A clear conceptual framework is important to clarify what the state wants to learn from the data it gathers, to determine the type of data that should be gathered, how they will be used and who will use them, how the data will be organized and shared with the public and decision makers, and how the system will function over time. Clarity on these issues will lead to clarity on the “parameters” or objects to measure to assess the condition of the environment. Parameters are often called “environmental indicators.” The idea is to select the indicators which best describe the condition of the environment based on the overall goals and objectives established by the state.

### Key Points to Consider

- Oregonians need information on the effects of past human activities on the current status, trends and risks to the environment (for example, water and air quality data) which can be called “lag” indicators, *and*, on the activities occurring within society today that may eventually generate pressure on and effects within the environment (for example, the amount of fossil fuel use or waste water treatment discharged into streams) which can be called “lead” indicators.
- Consideration should be given to producing an update on the State of the Environment Reports every biennium and a full report every four years to provide the public and decision makers with information about their environment and how policies and programs are working.
- State of the Environment assessments should be developed at the ecoregion *and* watershed scales, as each provides different types of valuable information. The use

of one approach alone is certain to lead to unexpected problems in the future.

- All environmental data gathered should be usable in a strategic context (e.g. it must help identify trends, future risks, causes, consequences, priorities).
- Data content should reflect overall priorities of the state.
- Environmental data should support everyday work by agencies and activities and concerns of the public.
- All data work should be related to products and outputs (reports etc.) that provide a platform for improving data management, resource management, or policy development.
- The data gathered by the state should be related to the suite of indicators proposed by the Science Panel in this Report.

## Organization

Once the state’s strategic model and an overall framework for data management are determined, an internal organizational strategy is needed to clarify the roles, responsibilities and relationships between different agencies and personnel to meet the goals. The way that data should be gathered, secured and shared, resources distributed, and the way agencies and programs cooperate with other each other and external organizations must be spelled out.

### Key Points to Consider

- The most important step is to develop clear guidelines and procedures to ensure that similar concepts, approaches, methods and parameters are applied and used within all agencies and levels of government where appropriate.
- The development of clear goals, objectives and action plans are needed to achieve cooperation and data integration across departments, areas of work and between the public sector and external organizations.

## The Computer and Database Aspects

Once the conceptual framework and organizational aspects are clarified, the hardware and technical aspects of the system can be clarified. Developing environmental databases is a complicated process. Clarity must be achieved on the types of data to be gathered, how they will be gathered, and how they will be managed, displayed and integrated with other data.

### Key Point to Consider

- Consideration should be given to an environmental key data system to provide a computer based tool for combining, structuring and presenting environmental information. The system could combine map-based data and graphic presentations of data (pie-charts, etc.)

## Data Contents

The next step is to determine the exact contents (indicators to be used and data to gather) of the model and databases. The contents must help inform the overall assessment models chosen and meet the needs of the state and agency as a whole to be useful. This is not as simple as it might seem. The science panel has recommended a suite of indicators that it believes are relevant to assessing the degree to which we are maintaining naturally functioning landscapes, the productive capacity of the environment, and meeting environmental laws. These indicators should be considered a starting point for this process.

### Key Points to Consider

- Focusing on “products” when developing databases (i.e. defining the output in the form of reports or map-based presentations) is a way to make sure that data are used for practical purposes and not just collected because somebody thought it might be useful.
- Focusing on a few high-quality indicators and data sets is generally more important than large quantities of less important data.
- Consideration should be given to developing a hierarchy of data. Data should be gathered at different levels to make it easier to combine data and make better use of the existing data.
- Consideration should also be given to developing a computer based catalog of databases and a database of common data (data used in more than one data base and codified in a uniform way).

## Human and Financial Resources

Finally, once the other aspects of an environmental data strategy are clarified, an assessment can be completed of the human and financial resources needed to operate the system. There must be enough dedicated personnel with the knowledge, expertise, experience and software tools at hand to do the job. Skilled personnel are essential to make decisions regarding key issues such as what kinds of environmental data are relevant, how are they to be used etc. Sufficient financial resources must be provided to hire the staff and provide the on-going staff training needed.

### Key Points to Consider

- Responsibility for databases should be placed with the people working with the relevant data.
- Inventories of all data bases should be accessible to all staff-members.

2. Adopt Land Use/Land Cover as a Key Meta-Indicator of Environmental Health  
Data on changes in land use/land cover are one of the few

types of information that provides important information for a number of key indicators of ecological health. For this reason it can be considered a meta-indicator. More than one third of the indicators proposed by the Science Panel can be addressed by land use/land cover data, making it one of the more cost-effective and significant indicators the state could develop and maintain over the long term. The Science Panel therefore recommends that the state institute a program to generate land use/land cover data and track its change over time.

*Land use* refers to “man’s activities on land which are directly related to the land” (Clawson and Stewart, 1965, in Anderson et al., 1976:4); *land cover* describes “the vegetational and artificial constructions covering the land surface” (Burley, 1961, in Anderson et al., 1976:4). The two concepts are related in that on any one piece of land, there can be both a land use and a land cover; in some cases, these can be consistent in that one infers the other. For example, a land cover of “agricultural row crop” is consistent with a land use of “agriculture”. In other cases, land cover may not inform as to land use: a land cover of “70-90 year conifer forest” may occur in an area where land use is “recreation” and in another area where land use is “industrial forestry”, or even where land use is a mix of both. In urban areas, a “forest” land cover may be coincident with a land use of “low density residential” or with “civic open space”; a land cover of “urban built” may include a mix of commercial, industrial and residential land uses. To further complicate the picture, land use and land cover can be vertically differentiated, such as the right-of-way of an electric transmission line may overlay pastures used for grazing (two coincident land uses). Thus, it is clear that the classification, the types of data used in that classification, and the questions that the data are intended to answer can lead to emphasis on cover, on use, or on some mixture of the two.

Knowledge of land cover can be equally important as land use in environmental assessment. Land use/land cover information (primarily satellite-based), gathered systematically at regular intervals, can inform analyses of social concerns such as:

- The preservation of agriculture on prime soils
- Changes in vegetation and habitat for wildlife
- Changes in forest and rangeland vegetation cover
- Loss of wetlands
- Changes in riparian vegetation
- Penetration of rural residential development into productive forests
- Percentage of urban areas with impervious surfaces
- Road densities
- Other

Land use/land cover data have been used as an indicator to provide direct measurement of the status, change and trend of change in acreage of classes of land use/land cover. The value of this indicator increases with an increase in the resolution of the reporting unit. By knowing where changes are occurring, and the type of land conversions (e.g. agriculture converting to urban, or, fallow pastures converting to forest), management agencies can better target policies or monitoring plans.

For on-going State of the Environment Reports, a statewide land use/land cover database can be used to define the extent of most ecosystems of interest, excluding groundwater. Derivatives of land use/land cover are also useful as potential indicators of environmental quality. These indirect indicators are reported not in terms of land use or land cover, but in terms of other quantities that have direct relevance to analyses of resource quality or quantity. The use of land use/land cover in any model that aims to predict status and/or changes in quality/quantity requires scientifically researched and validated procedures. Complicating the use of land use/land cover in such analyses is the possible correlation of natural variables such as topography, climate, geology and soils with land use/land cover. Adequate time histories of land use/land cover however, may provide a dimension that can assist in isolating the effect of land use/land cover, or in ascertaining whether land use/land cover can act as a valid surrogate for other variables that are more difficult and/or expensive to obtain.

The spatial configuration of habitat across the landscape is an essential component of conservation strategies for wildlife, and indices of landscape pattern have been linked in many studies to ecological function (Schumaker, 1996). Given a land use/land cover data base of appropriate resolution and extent, metrics describing landscape patterns (patch size, shape, connectivity, distribution, interior size, and edge length, edge to area ratio, etc.) can be extracted (Turner, 1989). Land use/land cover changes can also have an effect on fish diversity and populations through contributions to changes in water temperature (loss of riparian cover), sedimentation (devegetation of susceptible soils; land use in sensitive areas), nutrient runoff (changes in agricultural land use and loss of riparian buffers; increased urbanization), etc. Land use/land cover data can also be used to target areas of potential concern for soil degradation. It also appears likely that land use/land cover can be useful as at least one of the components in predicting trends in air quality. Results from this program could therefore better define the relationships (or the lack of relationships) between land use/land cover, water resource quality and biological response in Oregon landscapes, a vital step in using land use/land cover as an indirect indicator.

In sum, land use/land cover data can offer a snapshot of the state of the land as influenced by human activities: it is integrative of decisions made by people and of the response of the land to these decisions. By examining a series of these snapshots over time, the changes that occur on the land and the trend of those changes become evident. There are linkages between land use/land cover changes and specific environmental, economic and social resource changes. Thus, land use/land cover can be viewed as a meta-indicator which, with adequate classification and spatial and temporal resolution, can track trends, not only in the state of the environment but also in the state of the State reporting.

Once such a data-gathering and analysis system is in place, it could serve as a low cost and efficient means of tracking over a third of the indicators proposed by the science panel and as an organizing framework for more detailed environmental information gathered in the field. It appears reasonable to expect that land use/land cover can be used to at least describe portions of the State as to their risk of degradation for certain resources. Broad statements may have to be employed, but defensible conclusions could be reached. Over time, given an appropriate framework and fieldwork, predictive relationships could be developed to link, within defined geographic sub-regions of the State, trends in land use/land cover with trends in the quality of ecosystem resources, and thus improve the ability to anticipate more precisely the effects of human activity.

It should be understood that land use/land cover data cannot answer all questions; its use, for example, can be limited in some areas where natural or human-made disconnects exist between biotic responses and the land cover (e.g. drain tiling of agricultural fields), or where local site conditions are unique and difficult to characterize at the spatial resolution of the land use/land cover data. However, land use/land cover data may prove to be as fundamental to the analysis of environmental interactions as are topography, geology and climate, and, as such, should serve as an essential component in environmental and socio-economic management.

The adoption of land use/land cover as a meta-indicator will require considerable upfront work within the community of scientists, managers, business leaders and policy makers of the State. Recurrent data acquisition, analysis, storage and access protocols will have to be resolved; scientific studies funded and undertaken; integration into planning and management strategies developed. However, this innovative effort will generate significant payoffs in the future as Oregon attempts to balance environmental quality, livability and economic productivity.

Note of caution. Satellite based land use/land cover data cannot be a substitute for ground based data. Both are needed. Land use/land cover data will not assess the composition, diversity or structure of vegetation types. This is vital information. Both types of information must be generated to provide a credible picture of the status, trends and risks to Oregon's environment.

### Conclusion

Through the development of a systematic environmental data management strategy which generates, manages, integrates and displays the type of environmental data which the science panel believes are needed to effectively measure environmental health over time, the public and decision makers can become better informed about the condition of their environment. This will provide a credible scientific platform for environmental policy analysis and development and support the work of the agencies, scientists and public that rely on environmental data in their daily work.

### References

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