Indicators of Basin Condition For the Oregon Plan for Salmon and Watersheds

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Acknowledgments

We would like to thank other major contributors to this report including Jay Nicholas and Ken Bierly with Oregon Watershed Enhancement Board, Rick Hafele and Greg Pettit with Oregon Department of Environmental Quality, Bob Hughes from Dynamic Consulting Firm, Phil Larsen with Environmental Protection Agency, and Jeff Rodgers with Oregon Department of Fish and Wildlife. Sarah Vickerman with Defenders of Wildlife, Jeff Tryens with the Oregon Progress Board, and Steve Lanigan with US Forest Service provided valuable feedback through out the development of the paper. These contributors along with other November 2003 workshop participants Bill Krueger, Bruce Crawford, Dan Hilburn, Doug Drake, Doug Terra, Janet Morlan, Jay Nicholas, John Bolte, Kevin Birch, Lori Hennings, Mack Berrington, Mike Furniss, Sharon Clarke, Tamzen Stringham, and Tracy Hilman (affiliation shown in appendix B) donated valuable time in shaping the content of and reviewing this document.

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Introduction

The Oregon Plan for Salmon and Watersheds (Oregon Plan), initiated in 1997, is a state-led effort to restore watersheds and recover fish populations to productive and sustainable levels in a manner that provides substantial environmental, cultural, and economic benefits (IMST 1999). Many of the fish populations of concern in 1995 became listed as threatened species during the late 1990s and early 2000s. The original plan focused on anadromous fish in the coast range, but the current Oregon Plan expands the original focus to recovery and conservation of all native fish and watershed health throughout Oregon. The strategy depends on landowner and community support and volunteer actions, regulatory programs, and monitoring and research to achieve its goals for watershed and native fish conditions.

The Oregon Watershed Enhancement Board (OWEB) has several key statutory responsibilities regarding implementation of the Oregon Plan, including a requirement to report to the Governor and the Legislative Assembly biennially on environmental trends. While a huge volume of data about the environment is available, much of it is so site-specific that it cannot be used collectively to assess the condition of broad geographic regions. Therefore, in the spirit of providing a forum to assess Oregon's collective restoration investments (state, federal, and private dollars), OWEB is leading an effort to develop and institutionalize a system of tracking a small set of environmental indicators throughout Oregon to be reported at a basin scale. Once defined and agreed upon, these indicators will allow Oregonians to answer the question – *What are the environmental conditions of Oregon's basins, and are they stable, declining or improving over time?* Ultimately, indicators of basin condition should support an understanding of resource management policies and management programs that will lead to more effective use, protection, and restoration of Oregon's natural resources.

Evaluating the Oregon Plan at Multiple Scales

In Oregon, decision-makers need intuitively meaningful information to understand if conditions are improving under the implementation of the Oregon Plan. To do this, we propose a set of indicators that can inform decision-makers on basin conditions. It is important to establish what indicator-monitoring can and cannot provide decision makers. Monitoring the proposed indicators at a basin scale provides a measure of the status or condition of a given value and when implemented over time can provide a measure of changes or trends in those conditions. This is different than establishing that a given action (e.g. The Oregon Plan or riparian restoration) caused a given condition. To answer the question: '*Do our actions result in improved environmental conditions?'* – we must successfully establish cause-and-effect relationships. This requires an approach that differs from broad-scale indicator monitoring. Therefore the state should invest in nested reach and watershed scale effectiveness studies to evaluate if restoration and management practices are contributing to desired basin conditions. In concert, indicator-monitoring, as discussed in this paper, and effectiveness studies would provide a complete picture of environmental conditions and if our actions are having the desired results.

Purpose of This Project

The OWEB commissioned the Institute for Natural Resources (INR) to specify a *small set of environmental indicators* and their measurement methodology that can quantitatively and consistently measure trends in basin conditions. Ideally, the environmental indicators of basin condition will be used to evaluate 15 Oregon Plan "basins" throughout the state (Figure 1) and will have the following characteristics:

- The indicators will *detect status and trends* in environmental resources over time.
- The indicators will be meaningful at the *basin scale* (*3rd field HUC)*
- The indicators will be *sensitive to management actions*.
- The indicators will *inform* policy and land management *decision makers* (e.g. boards and commissions, agency staff, legislature) regarding resource-related investments, rules, regulations, and management actions (i.e., Oregon Plan and other watershed and native fish conservation investments).

This project introduces a framework for specifying a broad set of sustainability indicators. We then focus on a subset of four environmental components of basin conditions: Aquatic and Riparian Ecosystems, Terrestrial Ecosystems, Estuarine Ecosystems, and Biodiversity.

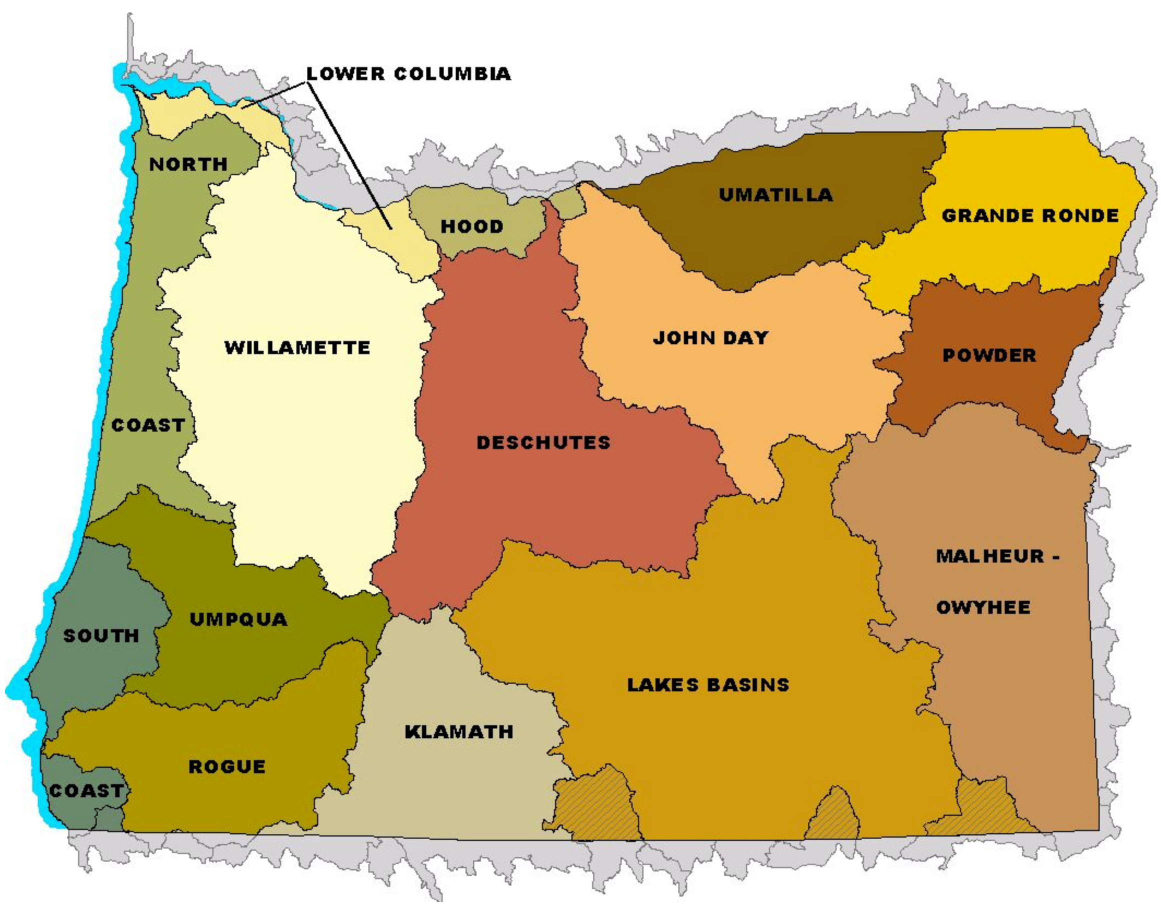

Figure 1. Fifteen Oregon Plan Basins. These are based on 3rd field hydrologic unit classifications (HUC), with modifications to provide more familiar names and to better represent physical and biological diversity in southwest Oregon. Note that some HUCs cross drainage boundaries (e.g. North and South Coast HUCs).

Background

Basin Condition

For the purpose of this project *basin* is defined as the land area, biological communities, and water bodies contained within a 3rd field hydrologic unit classification (HUC) as designated by the United States Geologic Survey. While this paper refers to these as "basins" they actually represent an aggregation of watersheds which may not drain to a common water body. Within a 3rd Field HUC there may be a mixture of land (terrestrial) habitats such as forested mountains and grassy plains. There may also be a combination of water (aquatic) habitats such as streams, lakes, reservoirs, freshwater wetlands, and estuarine wetlands. Vegetated transitional (riparian areas) habitats between terrestrial and aquatic habitats provide unique riparian habitats that may be comprised of meadows, low growing shrubs, hardwoods or confer trees. *Basin Condition* therefore is defined as the status of these terrestrial, aquatic and riparian habitats and the biological communities they support within the boundaries of a 3rd Field HUC.

Oregon ecosystems support a wide range of aquatic and terrestrial communities both shape and depend on basin characteristics to support their life histories. Hydrologic; geologic and soil processes; natural disturbance frequency and intensity; as well as the climatic and vegetative characteristics of a basin affect the character, quality, and quantity of terrestrial and aquatic habitats. The State of the Environment Report (SOER 2000) stated that the extent to which these processes and characteristics reflect natural ranges is considered the best long-term indicator of basin and aquatic ecosystem "health". This approach can be problematic and raises several challenges such as defining the temporal and spatial scales within which the range is considered, defining natural, and the human role within "natural". Natural is commonly defined as pre-European settlement conditions, a yard stick that represents ecological conditions prior to industrial human population. Within this definition the temporal and spatial scales of natural processes should incorporate a range of rates and extents of disturbances such as fire, flood, and debris flows characteristic to particular ecoregions or HUCs.

Indicators

This paper specifies a set of quantifiable indicators. Often times indicator, parameter or attribute are used interchangeably. The differences are important. For the purposes of this Oregon Plan project, an indicator provides an overarching quantifiable description while the data parameters or attributes describe specific data collected and used to support or calculate the value of the indicator. We employ a definition of *indicator* as articulated by Cairns et al (1993): "An indicator is a characteristic of the environment that, when measured, quantifies the magnitude of stress, habitat characteristics, degree of exposure to the stressor, or degree of ecological response to the exposure."

Why Establish Indicators?

There has been an abundance of valuable thinking and implementation on the topic of environmental, social and economic indicators particularly in recent years. Such work has taken place at the basin, state, regional, national, and international scales (Montreal Process 1999, EPA 2003, Heinz 2002, National Academy 2000, NRTEE 2003, SOER 2003, Salwasser and Fritzell 2002, Hillman 2003, Green Mountain 1998). All these efforts share common goals and face similar challenges:

- A goal to establish an accounting system to track the assets that sustain our social, economic and environmental values.
- An obligation to bridge the gap between policy and science by informing decision-making processes with scientifically credible information.

- A need to represent highly complex and interconnected environmental, social, and economic systems with simple, intuitively meaningful indicators.
- A constraint to obtain useful decision making information based on scientifically defensible data for the least cost.

The fundamental and common driver among the various processes for establishing indicators is to inform decision-makers (National Research Council 2000, Whitman and Hagan 2003, Heinz 2002, Montreal 1999). Whitman and Hagan eloquently describe the utility of indicators in the following excerpt:

> *"Good indicators will inform us about whether things we value are being maintained (or sustained), and warn us of an impending breach in a value or a group of values. Typically, the values we wish to maintain are highly complex (e.g., the economy, biodiversity) and we cannot afford to measure all the possible components of the system of concern. Indicators are specific components of these complex systems, that, when measured, tell us a great deal about the present or future condition of the large system"*

Indicator Development: Criteria and Framework

The process used to establish indicators can have a profound effect on the likelihood that the proposed indicators will shed light on the questions, will be supported by the collectors, users, and stewards of the data, and can successfully inform decision-makers. If the process bridges the gaps between scientific, social, and political stakeholders it is more likely to be successful. The integrity of the bridge depends on establishing clear goals, identifying the social values that form the basis of the goal, and seeking and implementing input into the process from representatives of the stakeholder communities in a way that keeps the focus on the values and goals of the project.

There are long-established "frameworks" or approaches designed to guide indicator development. Most efforts have established principles or qualities of an ideal indicator (Cairns et al. 1993, Heinz Center 2002, National Academy 2000, Salwasser and Fritzell 2002, Whitman and Hagan 2003). Authors commonly recommend using these principles as a screen by which to test candidate indicators and as such move towards a less biased more scientifically rigorous set of indicators. The lists can be quite long (35 criteria) but for this project we have focused on:

1. Quantifiable: The indicator can be described numerically and objectively.
2. Relevant: The indicator will be biologically and socially germane to the questions being asked.
3. Responsive: The indicator will be sensitive to the stressors of concern.
4. Understandable: The indicator can be summarized so as to be intuitively meaningful to a wide range of audiences and pertinent for decision makers.
5. Reliable: The indicators will be supported by science. Statistical properties will be well understood and have acceptable levels of accuracy, sensitivity, precision and robustness to serve the intended purposes.
6. Accessible: Existing data are available or there are feasible approaches to collect necessary data including cost, time, and skills.

Whitman and Hagan (2003) went beyond a list of criteria and adapted a long-standing conceptual framework based on four types of indicators: Pressure, Condition, Impact, and Policy Response Indicators. The inclusion of four types of indicators is compelling in that it provides different types of information on which to base decisions. Whitman and Hagan define the types of indicators as follows:

- **Pressure** indicators represent the level of stress related to human activity that affect a value of interest (e.g. area of timber harvest/yr)
- **Condition** indicators describe the current condition or status of a resource
- **Impact** indicate the change in a value of interest as a result of a pressure
- **Policy Response** indicates the level human action taken to reduce the pressure on a value of interest

The Pressure-Condition-Impact-Response framework offers a hierarchy by which to link indicators with values and goals. This framework acknowledges that our goals are, by definition, value driven. Once established, the process by which we evaluate if these goals are being met can be based on scientific monitoring. We have adapted the Whitman and Hagan framework to this Oregon Plan Indicators Project.

In the case of the Oregon Plan, the overall goal is to achieve basin and native fish sustainability (Figures 2-5). There are social, environmental, and economic components associated with this sustainability goal (discussed further in this paper under "Monitoring Sustainability"). Each component, in turn, has a set of values associated with it. For example, we define the Oregon Plan environmental component with a set of four environmental values: Aquatic and Riparian Ecosystems, Terrestrial Ecosystems, Estuarine Ecosystems, and Biodiversity. This combination of values will provide a complete framework for addressing basin and native fish sustainability. Our ecological understanding of basin sustainability is supported by what is learned from trends in ecological indicators.

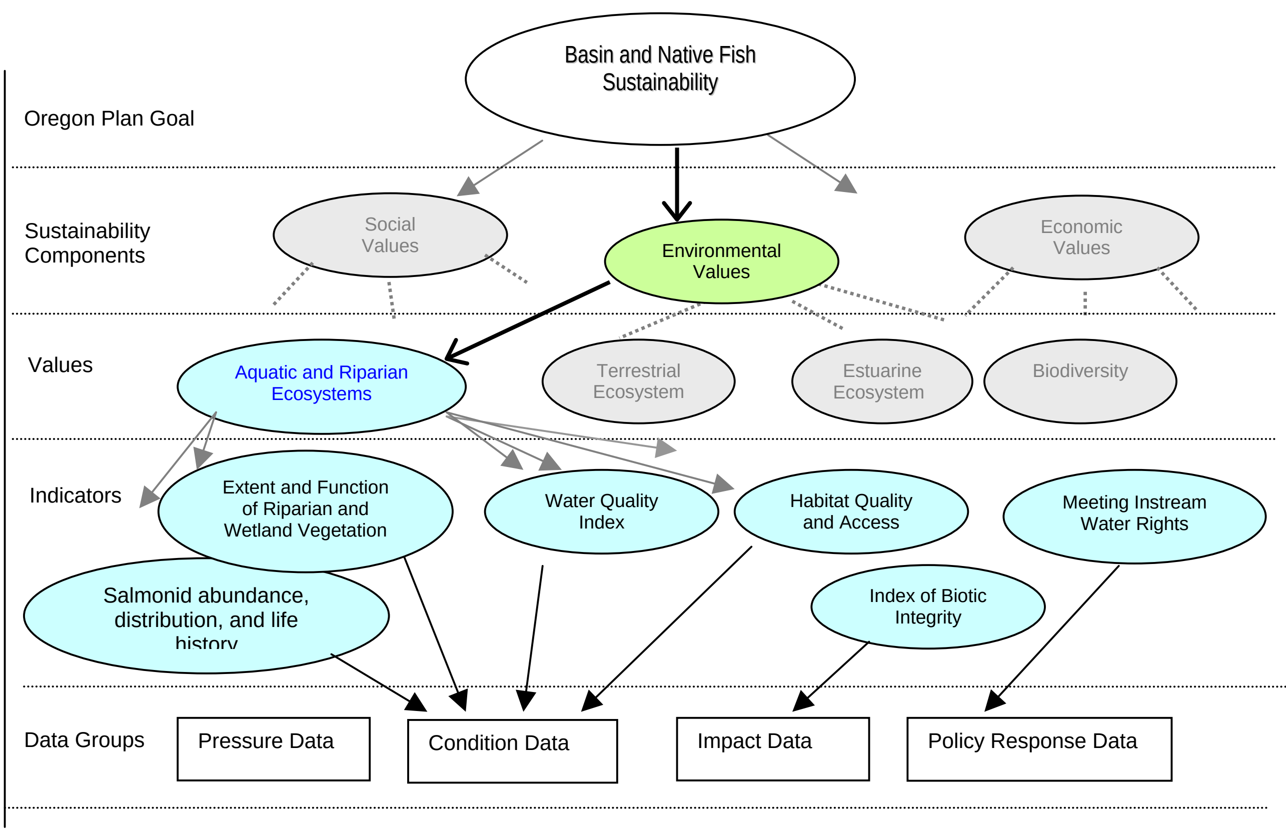

Figure 2. Schematic of how indicators of aquatic and riparian ecosystem conditions support an understanding of sustainable basins and native fish. (Adapted from Whitman and Hagan, 2003)

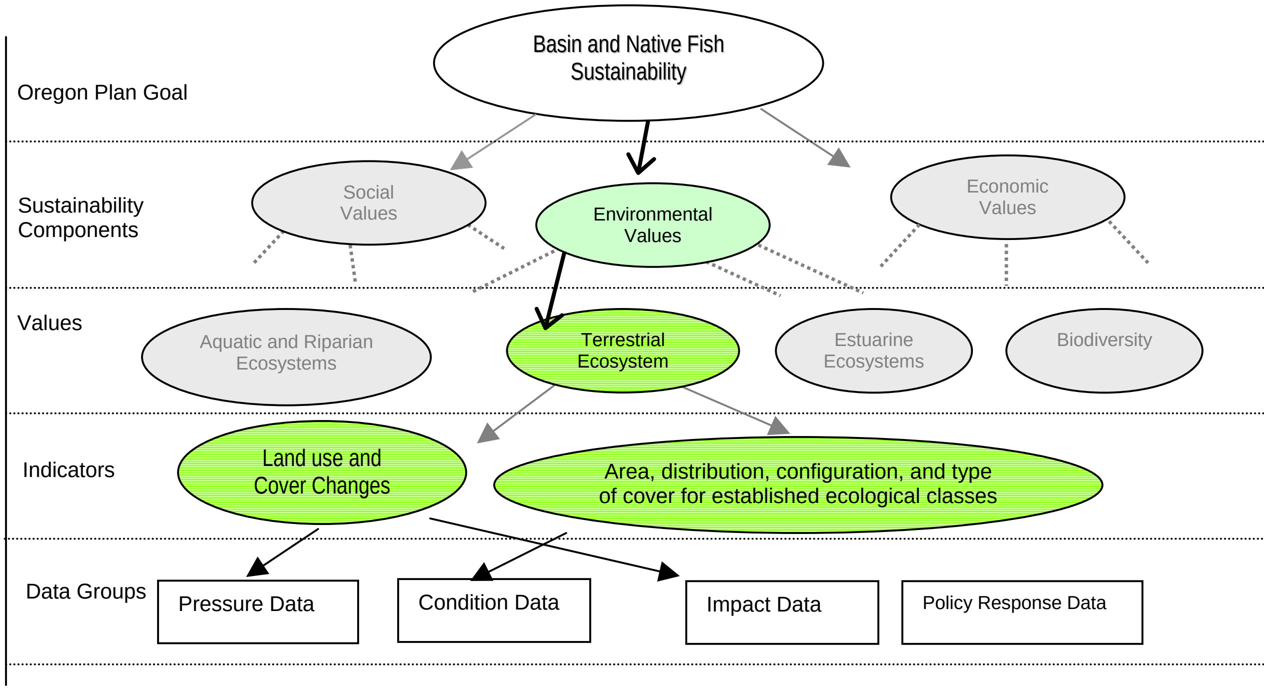

Figure 3. Schematic of how indicators of terrestrial ecosystem conditions support an understanding of sustainable basins and native fish. (Adapted from Whitman and Hagan, 2003)

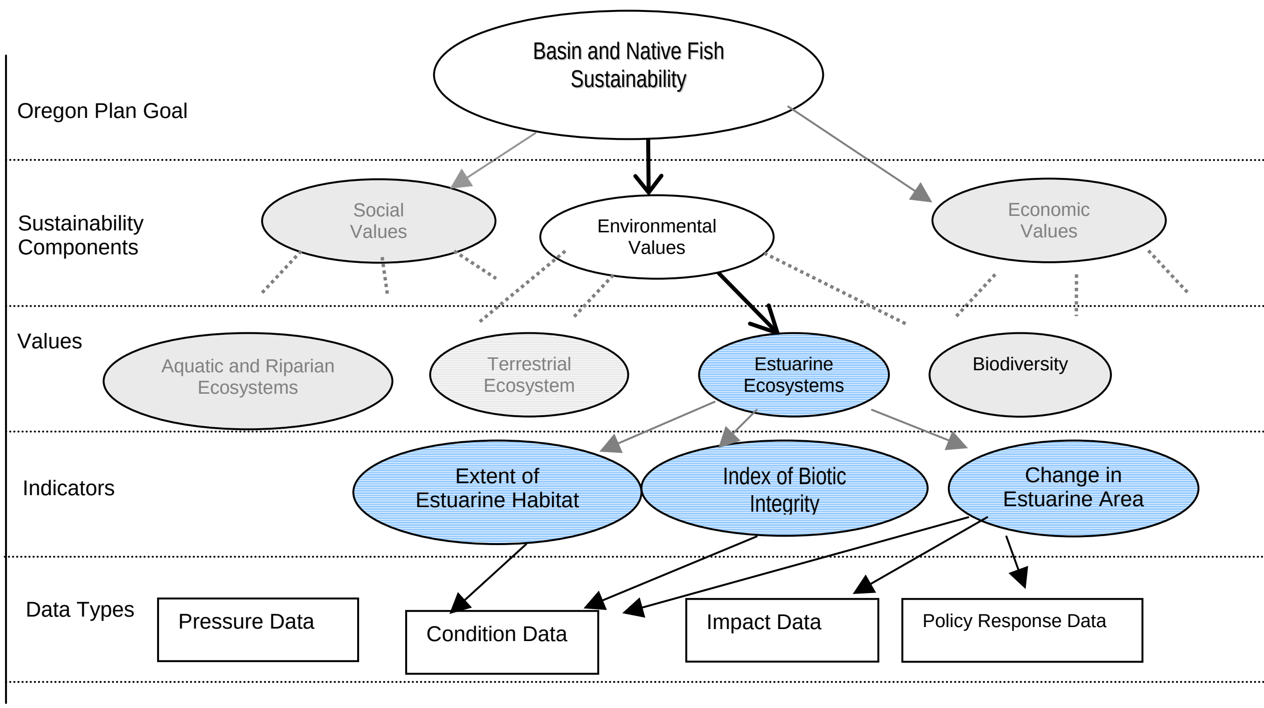

Figure 4. Schematic of how indicators of estuarine ecosystem conditions support an understanding of sustainable basins and native fish. (Adapted from Whitman and Hagan, 2003)

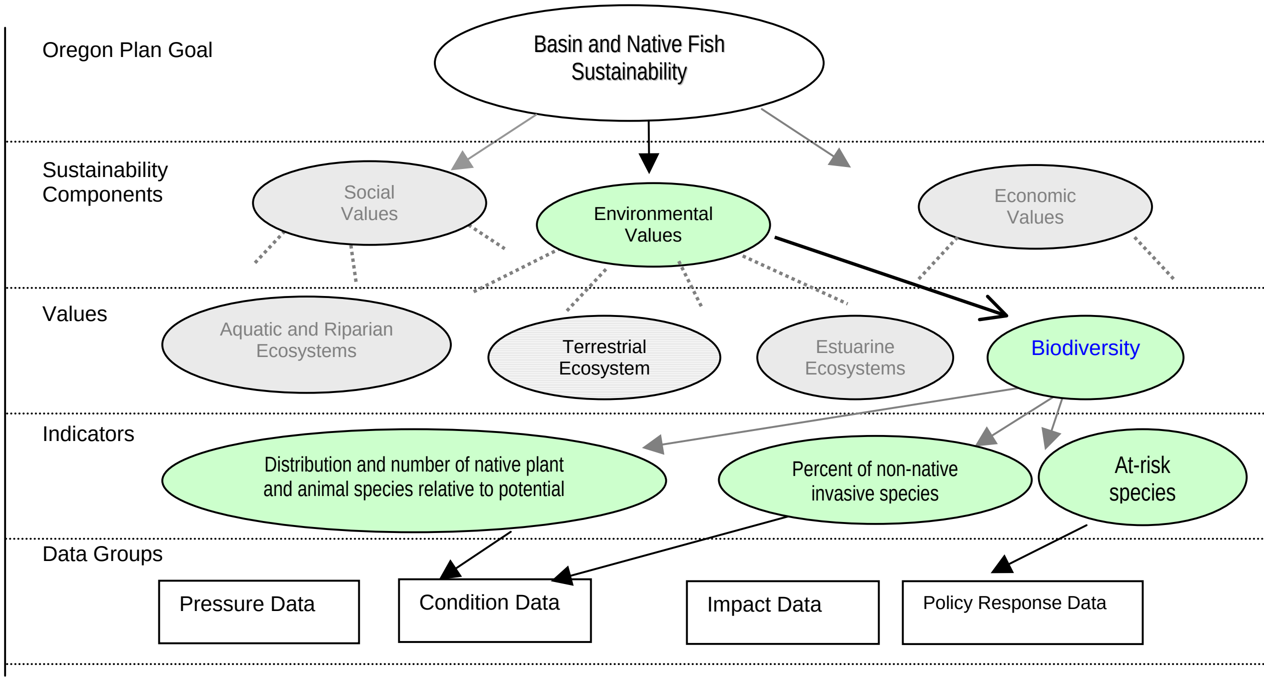

Figure 5. Schematic of how indicators of biodiversity support an understanding of sustainable basins and native fish. (Adapted from Whitman and Hagan, 2003)

Monitoring Sustainability

Through the Oregon Plan, Oregonians have established that we value environmental quality, not only for the use of natural resources which are a vital part of the state's economy and social values, but also for ecological sustainability. There are many practical definitions of sustainability most of which project a state of well being into the future maintained by a self-perpetuating process. Sustain literally means "to keep going, or keep in effect as an action or process". Oregon's Independent Multidisciplinary Science Team described the recovery of endangered or threatened salmon as the process by which "the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured" (IMST 1999). US Fish and Wildlife Service defined the goal of the recovery process as the maintenance of secure, self-sustaining wild populations achieved with the minimum necessary investment of resources (IMST 1999). The *OWEB Strategy for Achieving Healthy Watershed* (OWEB 2001) links healthy watersheds with thriving communities in the vision to "help create and maintain healthy watersheds and natural habitats that support thriving communities and strong economies".

Effective indicators of sustainability provide a balanced view of environmental, social, and economic conditions at the scale of interest (community, ecoregion, basin, county, etc.). This is particularly attractive when considering Oregon because of our social and economic success that stems from fertile agricultural valleys and productive forests, abundant fishery resources, and a diverse array of recreational opportunities (Oregon Blue Book 2003). The three sustainability components and examples of related values are listed below.

- Environmental Values:
  - Aquatic Communities
  - Aquatic and Riparian Ecosystems
  - Terrestrial Ecosystems
  - Estuarine Ecosystems
  - Biodiversity

- Social Values:
  - Land Stewardship:
  - Land Management and Policies
  - Fish Management: Harvest and Hatcheries
  - Education

- Economic Values:
  - Sustainable Economies
  - Poverty and Employment Rates

The Oregon Progress Board has developed a strategy for monitoring sustainability in Oregon "based on the assumption that the social and economic well being of Oregonians depends on the inter-connectedness of quality of jobs, a sustainable environment, and caring communities" (Oregon Progress Board 2003). This approach emphasizes the three components of sustainability (social, environmental, and economic) and that the three components must be considered simultaneously to effectively monitor sustainability.

The environmental indicators presented in this paper relate to a subset of the environmental benchmarks described in the Oregon Progress Board's 2003 Benchmark Performance Report. Progress board environmental benchmarks, numbered 75-89, have undergone significant review and revision. For a description of the current Progress Board Environmental Benchmarks, see the Oregon Progress Board Web site: http://www.econ.state.or.us/opb/0305obm s/Environ.pdf . The relationship between the Oregon Plan Indicators and Progress Board Benchmarks are illustrated in Appendix A, along with other environmental indicators specified in regional and national reports.

Proposing Environmental Indicators for the Oregon Plan

While we support the need for a balanced sustainability monitoring approach to the Oregon Plan, the focus of this paper is on *environmental indicators of basin (3rd Field HUCs) condition*. Decision-makers need intuitively meaningful information to understand if environmental conditions are improving under the implementation of the Oregon Plan. The INR hosted a workshop in November 2003 in which technical staff from state and federal agencies, local governments, and non-governmental organizations worked to specify 15 environmental indicator or indicator groups of basin condition (Table 1). Of these 15, five were identified by the group as an immediate priority. They are:

- Anadromous fish abundance, distribution and life histories
- Index of Water Quality
- Index of Biotic Integrity

- Area, distribution, and type of riparian and wetland vegetation
- Land cover and land use change

The authors performed a preliminary ranking of the proposed indicators against the six principles of a suitable indicator discussed on page 8. The results are illustrated in Appendix A. In total each of the proposed indicators ranked well against this small set of principles, but none were without limitations or challenges.

The reporting time frame will vary depending on the indicator and sample design. A reporting timeframe of 5 – 10 years would allow for ecosystems to evolve and change both in response to management activities and policies as well as natural disturbance regimes. Shorter reporting periods are likely to reveal very little change and yet increase costs.

Table 1. Proposed Environmental Condition Indicators.

Environmental Indicators of Basin Condition * = ranked as an immediate priority at the November 2003 Workshop	
Aquatic and Riparian Ecosystems	1. *Anadromous fish abundance, distribution and life histories
	2. *Cold water Index of Biotic Integrity for fish and for macroinvertebrates. (Also, with these same data we can report native and non-native species numbers and distributions for Indicator #15)
	3. *Water Quality Index (WQI) (miles or % of streams with rating of poor, fair, or good WQI)
	4. *Area, distribution, and types, of riparian and wetland vegetation
	5. Riparian function index based on vegetation and site capability (e.g. large wood recruitment, shade, and nutrient input) and Wetland function index based on hydrogeomorphic (HGM) typing
	6. Condition of physical aquatic habitat and estuarine habitat
	7. Access to freshwater and estuarine habitat (Miles of habitat accessible or limited-further analyze by habitat quality)
	8. Frequency with which instream water rights are being met
Terrestrial Ecosystems	9. Area, distribution, configuration, and types of cover for established ecological classes
	10. *Change in land use and land cover
Estuarine Ecosystems	11. Area, distribution, type, and change in area of tidal and submerged wetlands
	12. Index of Biotic Integrity for estuaries
Ecosystem Biodiversity	13. Number of native plant and animal species and distribution over time (departure from potential)
	14. At-risk species (aquatic, estuarine, and terrestrial; plant and animal)
	15. Percent of non-native invasive species (focus on subset of known species)

Priority Environmental Indicators

It will be important to eventually track a component of each of the four proposed environmental indicator groups and combine the environmental findings with findings from social and economic indicators to provide a balanced picture of environmental trends and sustainability in Oregon. However, the state is likely not able to pursue all the proposed environmental indicators simultaneously. What follows in the discussions below, and in tables 2-4, is a more detailed evaluation of the immediate priority indicators as identified during the November workshop.

I. Aquatic and Riparian Ecosystems

Basin condition indicators were selected to answer the following questions:
What are the conditions of native salmonids and aquatic organisms and how do they change over time?
What are the conditions of aquatic and riparian ecosystems and how do they change over time?

Status and trends in aquatic and riparian conditions are comprised of 8 of indicators:

Indicator 1: Native Fish Abundance, Distribution, and Life Histories (condition)
Indicator 2: Index of Biological Integrity (condition)
Indicator 3: Water Quality Index (condition)
Indicator 4: Area, Distribution, Type, and Of Riparian And Wetland Vegetation (condition)
Indicator 5: Riparian and Wetland Vegetation Function (condition)
Indicator 6: Condition of Aquatic Habitat (condition)
Indicator 7: Access to Aquatic Habitat (condition)
Indicator 8: Meeting Instream Water Rights (condition)

Of these 8 indicators 4 were identified as a high priority during the November 2003 workshop and are discussed below: native fish abundance, distribution, and life histories; index of biotic integrity; water quality index; and area, distribution, and type of riparian and wetland vegetation. Examples of available data are provided in Table 2.

<u>Anadromous Fish Indicators</u>
Indicators of abundance and distribution of native fish are singled out from other species because of the focused goal of the Oregon Plan to recover threatened fish populations. Life history trends (e.g. size, age and weight of fish combined with their migration timing) in native fish are also critical to understand how management decisions may be influencing population vigor. There are challenges to monitoring life history trends so we typically retreat to a reliance on fish numbers to inform our management decisions, but such an approach is incomplete. There are a few examples around the state where life history studies can provide some data to examine run timings, sizes, weights, and ages of fish and answer questions such as: Are fish maturing faster and coming back smaller? While life history monitoring was identified as a high priority we provide limited discussion in this report because Oregon Department Of Fish And Wildlife (ODF&W) is in the process of formulating species conservation plans as directed by it's Native Fish Conservation Policy. These plans will contain information on life history monitoring needs.

<u>Index of Biotic Integrity</u>
Anadromous fish indicators provide a narrow focus of aquatic communities and are responsive to multiple pressures and conditions that challenge interpretations. Therefore, we recommend the use of an Index of Biotic Integrity (IBI) to broaden our understanding of aquatic ecosystems. The use of an IBI provides a

more comprehensive index of aquatic organisms including native fish and incorporates the use of reference conditions as a measure of the relative "health" of the aquatic environment. IBI combines measures of multiple biological indicators such as species richness, relative abundance of specific organisms, and health of the organisms to rate the condition of the system (Hughes et al. in press, Hughes et al. 1998, Mebane et al. 2003, Karr and Chu 1999). The data can also be used to evaluate pressures from introduced species.

Water Quality

Trends in water quality conditions are proposed as an indicator because of the relative sensitivity to management, the availability of data, and the importance of water quality to basin condition and native fish. Multiple parameters are tracked and used to calculate one water quality index.

Riparian

Undoubtedly one of the greatest needs for the state of Oregon is to understand riparian conditions at broad landscape scales (State of the Oregon Environment Report, 2000). This need has been articulated by the IMST, the Core Team for the Oregon Plan, multiple natural resource agencies, non-governmental organizations, and researchers. The value of riparian data for Oregon Plan indicators is the sensitivity of riparian vegetation to management and the linkages with water quality, aquatic, and terrestrial habitat and communities. Additionally, protection, maintenance or improvement of riparian areas represent key management approaches to conservation of aquatic species currently considered at risk. Therefore, improving Oregon's ability to report on riparian conditions could vastly improve the likelihood of understanding environmental changes over time that are both sensitive to management and restoration investments, and that have well-understood linkages to the health of basins and native fish.

In March 2003, an interagency team wrote a workplan to develop riparian landscape condition assessments (State Interagency Work Group 2003). The report established the need for interagency efforts to collect riparian data at multiple scales using three types of data (satellite imagery, aerial photography, and field plots) and a structure by which the work could be implemented. This workplan is valuable because if implemented it would meet the needs of multiple agencies for evaluating their policies and programs and provide basic information on the condition of riparian areas regardless of the policies in place to manage or regulate the management of riparian vegetation and soils. The indicators recommended in this paper could be acquired in a subset of basins through the implementation of pilot study described in the Interagency Workplan.

The proposed riparian condition indicators are area, distribution, and type of riparian vegetation and function. Riparian functions include stream shading, nutrient input and uptake, erosion control, and fish and wildlife habitat. The definition of function is in part dependent on the management goals. A consistent definition focused on a subset of functions is required for this indicator to be further developed.

Freshwater Wetlands

Freshwater wetlands provide unique and diverse functions with regard to aquatic and basin health. These functions vary by ecosystem (e.g. Klamath Basin versus Cascades or Willamette Valley) but commonly include water storage to delay flood runoff, fish and wildlife habitat, and improved water quality. Indicators are proposed that are significant to ecological condition and are sensitive to detecting change.

Table 2. Summary of priority aquatic and riparian ecosystem indicators, data needs, sample design, and examples of currently available data.

Indicators	Aquatic Biota Data Needs	Sample Design	Currently Available Data	Scale of Available Data
Native Fish Abundance, distribution, and life histories	Native fish adult abundance	Spatially balanced random sampling	Coastal streams since 1998; John Day Lower Columbia River Tribs. 2003 ODF&W started in early 1990s using stratified random sampling.	4th field HUC
	Juvenile abundance: Fish/m^2 and pool occupancy	Spatially balanced random sampling	Coastal streams since 1998	3rd field HUC
	Coho smolt abundance: total number of migrants	Life Cycle Basins[1]	Various streams and start/end dates	Small scattered streams
	Dam counts		Winchester Dam: N.Umpqua Columbia Willamette Falls	
Coldwater Index of Biotic Integrity	-Species richness & relative abundance of Fish and other aquatic organisms, and health of the organisms -Need to develop index based on reference conditions for some HUCs	Spatially balanced random sampling; reference sites	Coastal streams since 1998, Willamette, John Day and Deschutes	3rd field HUC
Water Quality Index	• Temperature • Dissolved Oxygen • Bacteria • Turbidity • pH • Phosphorus Nitrogen, Nitrate, and Ammonia Nitrate • Macroinvertebrates • BOD • Total Solids	Spatially balanced random sampling	Coastal streams since 1998; ambient sites statewide since 1960	3rd field HUC; subwatersheds for ambient data
Area, distribution, and types of riparian and freshwater wetland vegetation.	-Acreage/miles of stream with vegetative cover in one of the following categories: hardwood, softwood, hardwood/softwood mix, shrub, grassland, shrub/grassland mix, row crops, pasture, impervious area, bare ground. -Acreage & location of wetlands by hydrogeomorphic (HGM) type	Field: Spatially balanced random, and/or augment current FIA plots for value at the 3rd field HUC Remote: Use 1:100K hydro layer as a guide to select scenes then use: Gradient and Nearest neighbor - 35 m remote sensed[2] - 5 m remote sensed - 0.5 m aerial photos	Field-FIA plots, state AREMP Remote-Low level air photos (DOA) certain watersheds; DEQ-TMDL data satellite:field plot comparisons for select watersheds Clams Willamette ICEBA EPA, USF&WS, DSL and OWEB: Change in wetland acreage below 100 neters. Timeframe: between 1984 and 1999-available in 2004	FIA: State Remote: Select watersheds Ground-based plots: reach Interagency Workplan: Combine all at 3rd-4th field HUC

[1] These sites could be considered for watershed scale effectiveness studies and possibilities to replicate the approach to other basins should be evaluated. May need to place adult traps where the smolt traps are located. Look for opportunities to link with or build on other watershed scale studies in the region (Bilby et al, Hinkle Creek, etc).
[2] Consider dropping 35m satellite imagery from the riparian project. It has been well demonstrated that this scale is inadequate for riparian area characterization.

II. Status and Trends in Terrestrial Ecosystems

What are the conditions of terrestrial ecosystems and how do they change over time? Status and trends in terrestrial conditions are comprised of 2 indicators:

Indicator 9: Area, distribution, configuration, and type of cover described by established terrestrial ecosystem classes (condition)

Indicator 10: Land use and land cover Changes (policy response or pressure)

Land Use and Land Cover Changes

Indicator 10, Land Use and Land Cover Changes, was identified as an immediate priority for Oregon at the November 2003 workshop. Land use change analyses are currently available from 1973 to 2000 for the entire state (reference). The data were compiled from aerial photographs and US Forest Service Forest Inventory and Analysis (FIA) plot data. Land cover change analyses will require further refinement of cover classifications for terrestrial ecosystems.

Terrestrial ecosystems encompass a broad range of values and characteristics. Various data sources and analyses are available to characterize the area, distribution, configuration, and type of cover for terrestrial ecosystems (Indicator 9). Perhaps the greatest challenge is to establish the number of cover classes to report on and the associated accuracy and precision with which they can be quantified. Some examples of available vegetation data are provided in Table 3. An index of road density relative to proximity to stream and location on steep slopes should be considered as a data parameter for Indicator 9.

Both Indicators 9 and 10 are relevant and sensitive to management. They can be used to quantify pressure and conditions. Currently underway is an effort to establish a conservation plan for Oregon that includes a biodiversity assessment. Also, the Oregon Plan is being assessed to determine if the goals are being met and if effectiveness can be measured. The terrestrial indicators of basin conditions should reflect the recommendations of these processes.

III. Estuarine Ecosystems

What are the conditions of estuarine ecosystems and how do they change over time?
Status and trends in estuarine conditions are tracked with two indicators:

Indicator 11: Area, distribution, and type of tidal and submerged wetlands (condition)

Indicator 12: IBI for estuaries (condition)

Estuaries are important both for our social and economic needs but also from an ecological perspective. Oregon's twenty-two estuaries provide unique ecological functions because they are transitions zones that integrate the basins they drain with the marine environment. Estuaries are ecological "hot spots' boasting exceptionally high biological productivity and providing habitat that serves critical life stages of a wide variety of marine and anadromous species. *(Source:* DSL Chapter III of Health of Natural Systems and Resources*, State of the Environment Report.)*. The proposed indicators were selected because of their ecological importance and sensitivity to environmental change. While the estuarine indicators were not identified as an immediate priority, and will not be discussed further in this paper, existing data are available that can provide a synoptic report on various estuarine qualities (EPA 1999). A cooperative effort between Environmental Protection Agency (EPA), United States Fish and wildlife Service (USF&WS), Oregon Department of State Lands (DSL) and OWEB will result in wetland change data for all of Oregon coastal wetlands below the 100 meter elevation. This data will be available for the change between 1984 and 1999 for the entire coast by the end of the summer 2004.

Table 3. Summary of terrestrial ecosystem indicators, data needs, sample design, and currently available data.

Terrestrial Indicators	Terrestrial Data Needs*	Sample Design	Currently Available Data	Scale of Available Data
Area, distribution, configuration, and type of cover for established ecosystem and cover classes	Need an agreed upon classification system. Could include those used by the USGS in the NLCD layer grouped to align with broad land use categories: Water ❑ Open Water ❑ Perennial Ice/Snow Urban ❑ Low Intensity Residential ❑ High Intensity Residential ❑ Commercial/Industrial/ Transportation Bare/Mining ❑ Bare Rock/Sand/Clay ❑ Quarries/Strip Mines/Gravel Pits Forest ❑ Transitional ❑ Deciduous Forest ❑ Evergreen Forest ❑ Mixed Forest Shrubland ❑ Shrubland Farmland and Grazing ❑ Orchards/Vineyards/Other ❑ Grasslands/Herbaceous ❑ Pasture/Hay ❑ Row Crops ❑ Small Grains ❑ Fallow ❑ Urban/Recreational Grasses Wetlands ❑ Woody Wetlands ❑ Emergent Herbaceous Wetlands Consider reporting, impervious area and road density separately from the Urban Class. Sub-classes might include: total density, density within 100' of streams, and density on steep slopes	-Combination of plot data and remote sensing data -Statewide -Report every 10 years	USGS National Land Cover data-most recent is 1990. **Available Forest Condition Analyses** Forest Type(C) by structural stage -FIA plots combined with satellite imagery – Fire Condition Class (C)- USFS (Missoula) and FIA or satellite – Forest Management Trends (P): Land use boundaries within various management classes – The Nature Conservancy (TNC): remote, cascades not complete yet, also part of ODF&W Conservation Plan **Available Farmland and Grazing Data** NRCS-NRI: Soil and vegetation condition compared to potential natural community, plot data TNC: Remote, cascades not complete yet, also part of ODF&W Conservation Plan **Available Urban** Sprawl: Northwest Environmental Watch Portland Metro: Area providing intact riparian	State wide Statewide; EO is a mix of years and sources Statewide and national; current Statewide; 1960 – current, Statewide, by ecoregion, every 10 years Statewide-every 5 years until 2004 then every year. Doesn't revisit sites. Statewide by ecoregion, Report every 10 years, Portland area, and will for Eugene, Portland metro has riparian data
Land Use and Land Cover Changes	Conversions from farming or forestry or grasslands to urban or rural residential and back again, conversions to conservation use, and urban sprawl.	Air photos and FIA plot data	ODF and TNC studies	1973 to 2000, statewide

* (C) = condition data, (P) = pressure data, (PR) = policy response data

IV. Ecosystem Biodiversity

The need to understand the biodiversity of ecosystems is common to the other 4 environmental values identified in the framework- aquatic and riparian, terrestrial, and estuarine ecosytems. Biodiversity has been described as the variety and variability of living organisms. It includes the diversity of ecosystems, as well as the diversity between and within species. Protecting, maintaining, and restoring native biological diversity at both local and landscape scales is important for sustaining the biological systems humans depend on – their web of life and the ecological processes that all species need to survive (Salwasser and Fritzell 2002). Three indicators are recommended to track the biodiversity of ecosystems:

Indicator 13: Number of native plant and animal species and distribution over time (Percent departure from range of potential natural communities)

Indicator 14: At-risk species (aquatic, estuarine, and terrestrial)

Indicator 15: Percent of non-native invasive species

While the biodiversity indicators were not identified as an immediate priority for this project, and will not be discussed further in this paper, existing data are available that can provide a synoptic report on various biodiversity qualities. It is also important to note the state of Oregon is undertaking a statewide conservation plan and biodiversity assessment. The final Oregon Plan indicators should be synonymous with those identified in the statewide conservation plan and assessment.

Data Management and Information Systems

It will be critical to select an appropriate data management tool that facilitates the sharing of data between partners. This is especially important because it is likely that the information will be collected by multiple sources. An interagency project, funded by OWEB, initiated a data library in 2003. This system provides a data-clearing house for the Oregon Plan Assessment, also initiated in 2003. Eventually, the data library may be sued for both housing and distributing natural resource data.

Draft Study Approach for a Subset of Indicators: Water Quality Index, Index of Biotic Integrity, Riparian Condition, and Fish Distribution & Abundance

The overarching questions articulated in the introduction: *What are the condition of Oregon's basins, and are they stable, declining or improving over time? Do our actions result in improved environmental conditions?*- are combined into one general question for this study design:

> *Are restoration projects and land management practices protecting and or improving aquatic communities, aquatic ecosystems, and riparian ecosystems?*

We propose collecting data for a Water Quality Index (WQI), Index of Biotic Integrity (IBI), Riparian Characteristics, and Fish Abundance & Distribution within the same sampling scheme (e.g. at the same places and with the same strata or classes). Some of the challenges to this approach include the need for multiple visits in one year to one site to get an accurate measure of water quality. Also, capturing accurate measures of fish distribution and abundance may require an increased density of sites in areas known to be populated by specific species of interest. However, we propose an approach that can answer some specific questions and specify the indicators that could be used to answer the questions (Table 5).

Indicator Definitions

WQI = Water Quality Index. A suite of measured parameters is compared to values as established through reference conditions or standards by the Oregon Department of Environmental Quality. Multiple parameters are combined into one index.

IBI = Index of Biotic Integrity. Separate indices for Invertebrates and Vertebrates. In each case the observed species, abundance, size, and anomalies are identified. Measured observations are compared with those observed in reference reaches. RIVPACS (a multivariate model) will be used to evaluate invertebrates and a vertebrate multi-metric model will be used to evaluate fish and aquatic amphibians. RIVPACS and vertebrate models have been developed and are available for use. The current RIVPACS model applies to Western Oregon only. Periphyton should also be considered as an indicator because it is relatively inexpensive to collect and analyze and is not constrained by a permitting process as fish sampling is. It is also sensitive to management and can be used to detect various anthropogenic disturbances and stresses.

Riparian Condition = Measures of streamside vegetation and land use characteristics. Understory and overstory vegetative species, size, cover and distribution; land use categories; and cover over the stream are measured. An index for riparian condition still needs to be developed or agreed upon. EPA's EMAP has developed riparian disturbance index that incorporates these variables. We may also consider using site capability as described by ODA and used in collaboration with some TMDL's. Also incorporate functional aspects that vary by ecosystem (e.g. meadow, shrub, forest) and goals. These alternatives need to be evaluated for precision, accuracy, and responsiveness.

Fish Distribution & Abundance = Numbers and distributions of salmonids except white fish. The value of this grouping is that it includes "canary-in-the-coalmine" species as well as fish that are listed and vulnerable to listing. It also tracks the distribution of species throughout the measurement unit and the numbers of species. While life history monitoring was identified as a high priority it is not further addressed in this report because ODF&W is in the process of formulating species conservation plans as directed by it's Native Fish Conservation Policy. These plans will contain information on life history monitoring needs.

Table 4. Monitoring questions and indicators that can be used to answer specific questions. The questions are posed to address conditions at the "basin" scale, in this case the #3rd Field HUC. The sample design can be adapted to other scales, for example "provinces" or ecoregions in which case basin would be replaced with "province" or ecoregion.

Monitoring Questions	Indicators
What are the most commonly occurring fish and amphibians in the basin? - How is this changing over time? - How does this vary within land classifications of interest (stream size, land use, etc.)?	IBI
What are the most commonly occurring aquatic and riparian non-native invasive species? - How is this changing over time? - How does this vary within land classifications of interest (stream size, land use	IBI, Riparian Area, Distribution, & Cover (also develop riparian index)
What percent of stream miles are in good, fair, and poor condition for aquatic biota, water quality and riparian condition? - How is this changing over time? - How does this vary within land classifications of interest (stream size, land use, etc.)?	IBI, WQI, Riparian Area, Distribution, & Cover (also develop riparian index)
What is the most commonly occurring streamside vegetation in the basin? - How is this changing over time? - How does this vary within land classifications of interest (stream size, land use, etc.)?	Riparian Area, Distribution, & Cover (also develop riparian index)
What are the main stressors (e.g. sediment, temperature, nutrients) in the basin? - How is this changing over time? - How does this vary within land classifications of interest (stream size, land use, etc.)?	IBI, WQI, Riparian Area, Distribution, & Cover (also develop riparian index)
What is the salmonid abundance in the basin? - How is this changing over time? - How does this vary within land classifications of interest (stream size, land use, etc.)?	Fish Distribution & Abundance *plus* spawner surveys
What is the distribution of salmonids in the basin? - How is this changing over time? - How does this vary within land classifications of interest (stream size, land use, etc.)?	Fish Distribution & Abundance, Habitat Quality
What targets/benchmarks represent attainment of biotic, water quality, and riparian condition or function?	IBI, WQI, Riparian Area, Distribution, & Cover (also develop riparian index) , Habitat Quality

Parameters

Indicators will be quantified through data collection of the following parameters listed after each indicator.

Vertebrate IBI: Fish and aquatic amphibians: Species, abundances, size, anomalies (diseases, deformities, tumors, lesions)

Invertebrate IBI: Species and abundances

WQI: Temperature, pH, bacteria, phosphate, Nitrate, Nitrogen, Ammonia Nitrate, dissolved Oxygen, BOD, Total Solids (revisits will be necessary on a subset to understand seasonal trends)

Fish Distribution and Abundance: Species, age, count (snorkeling and electro-fishing). Adults will have to be addressed with a separate sample.

Riparian: use existing methods (e.g. EMAP, DEQ, FIA, PIBO, AREMP, ODF&W, ODF, ODA, Greenline): Data parameters typically include but are not limited to: species, size (diameter and/or height), cover over the stream and within the riparian area, and distribution relative to the stream of trees, snags, shrubs, and herbs. Dominant landuse categories (forestry, agriculture, range, urban, rural residential, open space) stubble height, vegetative buffer width.

Sampling Design

Random probabilistic: We propose an EMAP (random probabilistic) sampling design with a 5 year rotating panel. A similar design has been implemented in the state for various projects including EMAP and Oregon Plan monitoring by EPA, DEQ, ODF&W.

Sample size and precision: We propose 50 sites per classification unit (e.g. 3rd Field HUC, province, or ecoregion) plus 50 additional reference sites. This equals 300 sites for five provinces or 800 sites for fifteen basins. In general, as sample size increases and variability decrease the precision in estimating conditions increases. The expected precision of an estimate of the average "condition" for a given sample size is provided in Table 6 (below) for each parameter.

Table 5. Indicator and expected precision with 50 sites per classification unit.

Indicator	*Precision with 50 sites/classification unit (basin, province, etc.)
IBI	12-15%
WQI	12-15%
Riparian Characteristics	5-40% (depends on indicator)
Fish Abundance	20-40%
Fish Distribution	20-40%

Five-year Rotating Panel: This approach involves visiting a subset of sites each year until desired sample size is attained after 5 years. For example, visit 60 sites every year for five years (300 sites) for province-level sampling. If the desirable scale is the basin scale, then visit 160 every year for 5 years (800 sites). There will be a need to return to a sub-set of sites every year, as well as a subset of sites multiple times a year to adequately characterize some components of water quality index.

The advantages to this approach include:

- Sample size increases after 1st five years because we would start a new set of 300 (five provinces) or 800 (15 basins) sites.
- We can report a preliminary statewide picture every year with increasing precision over time.
- After first five years we can report on the classification unit of interest (e.g. provinces or 3rd Field HUC), and every year after that begin reporting on trends.

Sampling Frame: The sampling frame currently available is the 1:100,000-stream layer. If the 1:24,000 stream layer is available when this project is implemented that will provide a superior sampling frame.

Classifications: The goal of this project was to describe indicators that could describe ecological conditions for fifteen 3rd Field HUCs throughout Oregon. An additional goal was to propose a cost effective study design for collecting data on those indicators. The necessary sample size for an acceptable precision (<15-20%) increases with increasing number of classifications (e.g. five provinces as compared to fifteen basins). Therefore, we offer alternatives to the fifteen Oregon Plan Basins and associated budget estimates.

1. Landscape Classes. The greatest limitations to implementation of this program are costs. By creating fewer classifications the costs can be reduced. Each of the following classifications is desirable for the reasons described.
   - *15 Oregon Plan Basins*: OWEB has defined 15, 3rd Field HUC, reporting basins presented on page 2 (Figure 1). Sampling schemes will allow inferences for each of the 15 3rd Field HUCs.
   - *5 DEQ Provinces* (Draft): DEQ is considering 5 provinces that would meet the agencies programmatic needs (Statewide monitoring that addresses TMDLs and permitting programs) and is cost-effective to implement. Use of provinces would increase collaborative and cost-reduction opportunities.
   - *9 Ecoregions Level III*: Ecoregions stratify the environment into areas with generally similar type, quality, and quantity of environmental resources. EPA Ecoregions were specifically designed through an interagency effort to develop a common framework on which to base ecological research and monitoring (EPA 2003, Thorston et al. 2003). A roman numeral, hierarchical scheme has been adopted for different levels of ecological regions. The EPA has defined 9 level III and 65 level IV ecoregions within the state of Oregon. This project can be designed to characterize the environment for Level III Ecoregions.
   - *7 ODF Georegions*: Oregon Department of Forestry rules vary regionally and provide a scaled down version of the ecoregions into 7 georegions. Results would align with ODF policy and program questions.
   - *8 Fishery Basins*: The above delineations may not align with fish populations and distributions. The following combinations may provide a better strata when considering fish abundance and distribution:
     - Umatilla, Grand Ronde and John Day
     - Lake Owyhee and Powder
     - Hood and Lower Columbia and Willamette
     - North Coast, Umpqua, South Coast to Cape Blanco
     - South Coast
     - Rogue
     - Deschutes
     - Klamath
2. Stream size: An additional stream size subclass should be considered for each landscape class as defined by stream order: Headwater (1st order), Wadeable (2nd – 4th order), and Boatable (> 4th order). If stream flow is modeled and mapped for the whole state at the time this is project is implemented that would be a superior sampling subclass than stream order.

Post Stratification: There are intrinsic characteristics of the environment that will influence the observed spatial and temporal trends of indicators such as water quality, index of biotic integrity, and vegetation. The data will be "post-stratified" so that indicators can be reported in the context of this natural variability. Possible strata include:

- Geology: Geology can be considered categorically.
- Gradient: Gradient can be considered on a continuum or categorically.
- Landform. Same as above.

- Valley Width: Same as above.
- Stream Size: Same as above. If it is not a sample classification then it should be addressed with post-stratification.
- Elevation: Same as above.
- Natural disturbance and cycles: Natural disturbance agents and cycles that have broad scale influence on the priority indicators will be accounted for in the analyses. These include fires, floods, droughts, windstorms, and ocean conditions.
- Land Use Classes: It will be useful to describe the results for various political and land use boundaries when making management and policy decisions. These may include land use classes such as urban, rural residential, agriculture, range, and forestry.

Assessing Trends

The indicators are designed to provide a measure of condition but when tracked over time they can also provide an index of change over time. To answer the question: Is there a difference between years? - we will use a step-trend (Box and whisker plots) analysis. To answer the question: Is the trend improving, degrading or staying the same?- we will use a monotonic (regression) analysis. Trend analyses can be reported after 5 years and every 5 years thereafter.

Estimated Costs

Establishment of a statewide coordinated effort may be able to leverage other funds especially if it is linked to programmatic interests and national efforts such as the EPA EMAP program. There may also be opportunities to build on existing state and federal programs and program budgets.

The estimated cost for collecting, processing, managing, and analyzing data is about $8,126/site with a design of 50 sites for five provinces plus 50 reference sites. See tables 6 and 7 for a summary and breakdown of costs. The costs/site varies depending on the design because some expenditures do not change with increasing sample size. For example, two data managers and analysts are recommended regardless of sample size (Table 8). Total costs over a 5 year period are estimated at 5.8 million dollars to report on 15 Oregon Plan Basins. Costs range from 2.5 million to 12.9 million depending on study design decisions.

Table 6. Number of samples and total estimated costs as it varies by classification system.

Classification System	Number of Trend and Reference Sites over 5 Years (and per year)	Estimated Annual Costs	Estimated 5-year Rotating Panel Costs
5 DEQ Provinces	300 (60 per year)	$487,564	2.5 million
8 Fishery Basins	450 (90 per year)	$693,346	3.5 million
15 OWEB Basins	800 (160 per year)	$1,154,192	5.8 million
*5 DEQ Provinces with 3 subclasses	900 (180 per year)	$1,265,724	6.3 million
*8 Fishery Basins with 3 subclasses	1350 (270 per year)	$1,570,038	7.9 million
*15 OWEB Basins with 3 subclasses	2400 (480 sites per year)	$2,574,512	12.9 million

* = 150 reference sites rather than 50, due to 3 sub-classes within each landscape class.

Table 7. Estimated annual and five-year costs for 5 provinces without subclasses. Assumes 60 sites per year for a total of 50 sites per province and 50 reference sites after 5 years.

Expenditure	Annual Costs for 60 sites per year	5-year Estimated Cost for 300 sites
2 crews of 3-@5000/mo for 4 months to do 60 sites	$120,000	$600,000
Travel ($85/night-commercial) 5 nights for 3 months for 6 people	$24,480	$122,400
Project Coordinator	$110,000	$550,000
Data Manager and Analyzer (@95K/year) step 3	$95,000	$475,000
Data Manager and Analyzer (@105K/year) step 4	$105,000	$525,000
Vehicles-2@$1000/mo for 3 months with travel plus 9 months "parked"	$12,000	$60,000
Overtime-(10 hours/week) 22/hour	$1,584	$7,920
WQ Data/lab Processing-@125/site	$7,500	$37,500
I-IBI Data/lab processing @ 150/site	$9,000	$45,000
V-IBI Data/lab processing @ 50/site	$3,000	$15,000
TOTAL	$487,564	$2,437,820
Per Site Estimate	$8,126	

Next Steps

1. The INR recommends that OWEB embark on a process to gain understanding, acceptance and support from state, federal, and local governments, and non-governmental organizations on the proposed indicators and priorities.

2. The proposal to integrate monitoring programs at the data collection level presents a number of organizational and budgetary challenges that will require strong partnerships. OWEB should undertake a process to gain understanding on the level of support for integrated monitoring from state, federal, and local partners.

3. The proposed study design, while building on current Oregon Plan monitoring approaches will need further refinement to ensure that it is adapted to partner programs such as state conservation plans. Prior to embarking on a state-wide, integrated, data-collection process it would be valuable to implement a pilot study to identify areas for improvement and increase the likelihood for longer term success.

4. Work with partners to further refine and define how the remaining indicators will be quantified, associated study designs, and costs for collecting data (those not addressed in this paper's study design section).

Table 8. Annual Costs for various classification schemes.

Classification System →	**8 Fisheries basins**	**15 basins**	**5 provinces with 3 subclasses**	**8 fisheries basins with three subclasses**	**15 basins with 3 subclasses**
5-year Sample Size: 50/unit plus 50 reference reaches (no subclass) **or** 150/unit plus 150 reference reaches (3 subclasses) →	450 Reaches	800 Reaches	900 Reaches	1350 Reaches	2400 Reaches
Explanation of Costs ↓	Number of Crews and Expenditures ↓				
	3 crews	**6 crews**	**7 crews**	**9 crews**	**16 crews**
Each crew has 3 people-@5000/mo, including OPE, for 4 months to do 30 sites	$180,000	$360,000	$420,000	$540,000	$960,000
Travel ($85/night-commercial) 5 nights for 3 months for each crew member	$36,720	$73,440	$85,680	$110,160	$195,840
Project Coordinator: (1 for 2-3 crews, 2 for 6-9 crews, 3 for 16 crews); including OPE	$110,000	$220,000	$220,000	$220,000	$330,000
Data Manager and Analyzer (@95K/year including OPE) step 3 (Same regardless of sample size)	$95,000	$95,000	$95,000	$95,000	$95,000
Data Manager and Analyzer (@105K/year including OPE) step 4 (Same regardless of sample size)	$105,000	$105,000	$105,000	$105,000	$105,000
Vehicles-2@$1000/mo for 3 months with travel plus 9 months "parked"	$18,000	$36,000	$42,000	$54,000	$96,000
Overtime-(10 hours/week) 22/hour	$2,376	$4,752	$5,544	$7,128	$12,672
WQ Data/lab Processing-@125/site	$56,250	$100,000	$112,500	$168,750	$300,000
I-IBI Data/lab processing @150	$67,500	$120,000	$135,000	$202,500	$360,000
V-IBI Data/lab processing @ 50/site	$22,500	$40,000	$45,000	$67,500	$120,000
Annual Total:	**$693,346**	**$1,154,192**	**$1,265,724**	**$1,570,038**	**$2,574,512**
5-year Total:	**$3,466,730**	**$5,770,960**	**$6,328,620**	**$7,850,190**	**$12,872,560**

List of References

Cairns John Jr., Paul V. McCormick, and B.R. Neiderlehner. 1993. *A proposed framework for developing indicators of ecosystem health.* Hydrobiologia 263: 1-44. Kluwer Academic Publishers. Printed in Belgium.

EPA. 2003. *EPA's draft report on the environment 2003*. Web site: http://www.epa.gov/indicators/ 5 Chapters and 2 Appendices.

EPA 1999. *EMAP Western Pilot Coastal Waters*. For further information, please contact Terry Fleming at (415) 744-1939 or fleming.terrence@epa.gov. General information on the U.S. EPA EMAP is available at http://www.epa.gov/emap.* Information found on the following web site: http://www.epa.gov/region09/water/wemap/coastal.html

Green Mountain Institute for Environmental Democracy. 1998. *Moving toward "a small, but powerful" set of regional salmon habitat indicators for the Pacific Northwest.* Prepared for the Pacific Northwest Salmon Habitat Work Group: Alaska Department of Environmental Conservation; British Columbia Ministry of Environment, Lands, and Parks; Environment Canada, Pacific and Yukon Region; Idaho Division of environmental Quality; Oregon Department of Environmental Quality; Washington Department of Ecology; U.S. Environmental Protection Agency, Region 10. 16 pages. 104 East State Street, Montpelier, Vermont 05602, (802) 229-6070, gmied@gmiedorg

Hart, Maureen. 2000. *Sustainable Measures*. P.O. Box 361. North Andover, MA 01845. http://www.sustainablemeasures.com/

Heinz Center. 2002. *The state of the nation's ecosystems: measuring the lands, waters, and living resources of the United States.* The H. John III Heinz Center for Science, Economics and the Environment. Press Syndicate of the University of Cambridge. 40 West 20th stree, New Your, NY 10011-4211, USA. www.heinzctr.org/ecosystems

Hillman, T. W. 2003. *Monitoring strategy for the Upper Columbia Basin. Draft Report.* BioAnalysts, Inc., Eagle, ID. Prepared for the Upper Columbia Regional Technical Team, Upper Columbia Salmon Recovery Board, Wenatchee, WA. Web Page: http://www.efw.bpa.gov/cgi-bin/FW/welcome.cgi.

Hughes Robert, Philip R. Kaufmann, Alan T. Herlihy, Thomas M. Kincaid, Lou Reynolds, and David P. Larsen. 1998. *A process for developing and evaluating indices of fish assemblage integrity.* Canadian Journal of Fisheries and Aquatic Science. Volume 55

Hughes Robert, Shay Howlin, Philip F. Kaufmann. Accepted. *A biointegrity index for coldwater streams of Western Oregon and Washington.*

Institute for Environmental Research and Education and Defenders of Wildlife. 2002. *Biodiversity and land use indicators. Washington DC Workshop, DRAFT (6-11-02) report.* www.biodiversitypartners.org/im/05.html

IMST (Independent Multidisciplinary Science Team). 1999. *Defining and Evaluating Recovery of OCN Coho Salmon Stocks: Implications for rebuilding stocks under the Oregon Plan for Salmonids and Watersheds*. Technical Report 1999-2 to the Oregon Plan for Salmon and Watersheds. Governor's Natural Resources Office. Salem, Oregon. http://www.fsl.orst.edu/imst/

Institute for Environmental Research and Education. October 2003. *Measuring Success: Biodiversity and Habitat Indicators at Multiple Scales. June 2002 Workshop Report.* *http://www.biodiversitypartners.org/im/Report01.html*

Institute for Natural Resources, Heinz Center for Science, Economics, and the Environment, Oregon Progress Board, The Food Alliance, Institute for Environmental Research and Education, Metro, and Defenders of wildlife. 2002. *Measuring success: Biodiversity and habitat indicators at multiple scales. Final draft workshop report, October 2002*. Oregon State University. http://www.biodiversitypartners.org/im/Report03.html

Karr, J. R. and E.W. Chu. 1999. *Restoring life in running waters: better biological monitoring.* Washington, DC: Island Press.

Kershner J.L., E. Coles-Ritchie, E. Cowley, R.C. Henderson, K. Kratz, C. Quimby, D.M. Turner, L.C. Ulmer, M.R. Vinson. 2004. *A plan to monitor the aquatic and riparian resources in the area of PACFISh/INFISH and the Biological Opinion for Bull Trout, Salmon, and steelhead.* Interagency Regional Monitoring Program in the Pacific Northwest. 104 pages. http://www.fs.fed.us/biology/resources/pubs/feu/pibo_final_011003.pdf

Mebane Christopher A., Terry R. Maret, and Robert M. Hughes. 2003. *An index of biological integrity (IBI) for Pacific Northwest Rivers.* Transactions of the American Fisheries Society. 132: 239-261

Mobrand Biometrics. 2003. *Guidelines for rating Level 2 Environmental Attributes*. http://www.mobrand.com/MBI/pdfs/Attribute_Rating.pdf

Montreal Process. 1999. *Criteria and indicators for the conservation and sustainable management of temperate and boreal forests (second edition)*. http://www.mpci.org/meetings_e.html#publications

National Academy Press. 2000. *Ecological Indicators for the Nation.* Committee to Evaluate Indicators for Monitoring Aquatic and Terrestrial environments; Board on Environmental Studies and Toxicology, Water Science and Technology Board; Commission on Geosciences, Environment, and Resources; National research Council.

Northwest Environmental Watch. 2002. *Sprawl and smart growth in metropolitan Portland, Comparing Portland Oregon with Vancouver Washington in the 1990s.* 9 pages. http://northwestwatch.org/press/portlandgrowth.pdf

NRTEE & TRNEE. 2003. *Environment and Sustainable Development Indicators for Canada.* National round table on the Environment and the Economy. 54 pages. Telephone: (613) 992-7189. web: http://www.ntree-trnee.ca Renoug Publishing Co. Ltd.

ODF. 2003. *Assessing forest sustainability in Oregon: Forest assessment project study plan to assess the condition and trends of Oregon's' forests February 2003 DRAFT.* Oregon Department of Forestry, Forest Resources Planning Program. 2100 State Street. Salem, Oregon. 97310

Oregon Progress Board. 2003. *2003 Benchmark Performance Report to the 2003 Legislative Assembly*. Oregon Progress Board. 775 Summer St. NE. Salem, OR 97301-1283. USA. http://www.econ.state.or.us/opb/2003report/2003BPR.htm

OWEB. 2001. *Willamette Restoration Strategy-Recommendations for the Willamette Basin supplement to the Oregon Plan for Salmon and Watersheds.* Oregon Watershed Enhancement

Board, 775 Summer Street NE, Ste 360, Salem Or, 97301-1290. 503.986.0178. 10 Chapters, Glossary, and 1 Appendix.

OWEB. 2001. *Monitoring Strategy for the Oregon Plan for Salmon and watersheds.* Oregon Watershed Enhancement Board, 775 Summer Street NE, Ste 360, Salem Or, 97301-1290. 503.986.0178. web site:

Pacific Coastal Salmon Recovery Fund Workshop. 2002*. Breakout session summary: monitoring and evaluation protocols, December 12, 2002.* Facilitated by Phil Roni, NOAA Fisheries.

PNAMP. *2004 DRAFT Recommendations for coordinating state, federal, and tribal watershed and salmon monitoring programs in the Pacific Northwest*. Pacific Northwest Aquatic Monitoring Partnership.

Reeves H. Gordon, David B. Hohler, David P. Larsen, David E. Busch, Kim Kratz, Keith Reynolds, Karl F. Stein, Thomas Atzet, Polly Hays, and Michael Tehan. 2001. *Aquatic and riparian effectiveness monitoring program, regional interagency monitoring for the Northwest Forest Plan.* http://www.reo.gov/monitoring/watershed/cover-aremp-report.htm

Salwasser Hal and Fritzell Erik. 2002. *Building a Biodiversity Assessment for Oregon-Progress Report of the Biodiversity Assessment Working Group.* Institute for Natural Resources, Oregon State University.

SOER Science Panel, Paul Risser, chair. 2000. *Oregon State of the Environment Report*. Oregon Progress Board. 775 Summer Street, NE, Salem, Oregon. 97310. (503) 986-0039 www.econ.state.or.us/opb

State Interagency Workgroup. 2003. *Interagency workplan for developing riparian landscape condition assessments: A riparian prototype that involves multiple digital imagery automated image interpretation, and ground-based measurements (3/19/03).*

Walter, Gerald R. 2002. *Economics, ecology-based communities, and sustainability*. Ecological Economics Volume 42, Issues 1-2, Pages 81-87

Whitman, Andrew A. and John M. Hagan. 2003. *Final report to the National Commission on Science for Sustainable Forestry. A8: Biodiversity indicators for sustainable forestry.* Manomet Center for Conservation Sciences 14 Maine St., Brunswick, ME 04011. Ph: (207)-721-9040 Fax: (207)721-9144 website: www.manometmaine.org

Appendix A: Summary Tables

A-1: Proposed Oregon Plan Environmental Indicators Compared to Indicators for the State and Nation

A-2: Preliminary Ranking of Proposed Oregon Plan Indicators Against Principles of a Suitable Indicator

Table A-2. Aquatic and riparian (Numbers 1-8), Terrestrial (9 and 10), Estuarine (11 and 12), and Biodiveristy (13-15) Indicators and indicator criteria discussed on page seven. Indicators have be preliminarily ranked on a scale from 1 – 3 on likelihood to meet the criteria. 1 = likely to meet, 2 = likely to meet with some known challenges, 3 = unknown certainty or unlikely to meet the criteria.

Environmental Indicators of Basin Condition * = identified as an immediate priority at the November 2003 Workshop	1. Quantifiable	2. Relevant	3. Responsive	4. Understandable	5. Reliable	6. Accessible	^Total (6 = best; 18 = worst)
1. *Anadromous fish abundance, distribution and life histories	1	1	2= Responsive to multiple stressors	1	2= Challenges with precision for trend detection due to natural variability	1	8
2. *Cold water Index of Biotic Integrity for fish and for macroinvertebrates. (Also, with these same data we can report native and non-native species numbers and distributions for Indicator #15)	1	1	1	2=Requires some technical explanation	1	1	7
3. *Water Quality Index(WQI) (miles or % of streams with rating of poor, fair, or good WQI)	1	1	1	1	2 Challenges with seasonal variability not being captured	1	7
4. *Area, distribution, and types, of riparian and wetland vegetation	1	1	1	1	1	3= Remote data is of limited value	8
5. Riparian function based on vegetation and site capability (e.g. large wood recruitment, shade, and nutrient input) and wetland function based on hydrogeomorphic (HGM) typing	2= Need agreed upon index of "function"	1	1	2=Depends on index of function	1	3= Remote data is of limited value	10
6. Condition of physical aquatic habitat and estuarine habitat	1	1	2: Response may be overshadowed large disturbance events	1	2: Natural variability may dampen precision	1	8
7. Access to freshwater and estuarine habitat (Miles of habitat accessible or limited-further analyze by habitat quality)	1	1	1	1	1	2: Challenge to obtain complete census	7
8. Frequency with which instream water rights are being met	1	2: Depends on how the rights were established	2: Response may be overshadowed by natural variability in flow and complex hydrologic processes	1	2: Reliability may be limited by natural variability in flow and complex hydrologic processes	1: Modeled approach currently being used for 2003-2004 Oregon Plan Assessment.	9
9. Area, distribution, configuration, and types of cover for established ecological classes	1	1	1	1	2: Challenges with precision to evaluate trends	1	7
10. *Change in land use and land cover	1	1	1	1	2: same as above	1	7
11. Area, distribution, type, and change in area of tidal and submerged wetlands	2: Challenges with establishing baseline	1	1	1	1	1	7
12. Index of Biotic Integrity for estuaries	2: IBI not established yet	1	1	2: Requires some technical explanation	1	3: Need to develop IBI	10
13. Number of native plant and animal species and distribution over time (departure from potential)	2: Challenges with establishing potential	1	1	1	2: Challenges with precision to evaluate trends	1	8
14. At-risk species (aquatic, estuarine, and terrestrial; plant and animal)	1	1	1: Although may also simply reflect policy shifts	1	1	1	6
15. Percent of non-native invasive species (focus on subset of known species)	2=need manageable subset of species to focus on	1	1	1	1	2: No systematic evaluation	8

^ = Note: Data needed for most of these indicators are not currently available statewide (Criteria #6). A rating of "1" therefore reflects an assessment of the ability to acquire given data collection costs and available technology.

Appendix B: List of November 2003 Workshop Participants

November 2003 Oregon Plan Indicator Workshop Participants

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