Table on Criterion 4 Refinements

This table shows recommendations for refinements to the Montreal Process indicators, the rationales for the indicators, and in selected cases, approaches to measurement. These recommendations were reached through discussion and general agreement at three technical workshops coordinated by the USDA Forest Service and the Roundtable on Sustainable Forests in April 2005 to obtain high-quality input from a diverse set of forest stakeholders. Column 1 shows the location of the text in the *Draft Document: Excerpts from the Montreal Process Technical Notes Modified for the Series of C&I Refinement Technical Workshops*. Column 2 presents the original language with any deleted text underlined and struck out; column 3 presents the refined text with any additional text underlined. Column 4 includes any comments made on the refinement.

Summary of Refinements
Additions to the introduction explain the reorganization into three new subcriteria: Protected Areas, Soil Productive Capacity, and Aquatic Productivity (Water Quantity and Quality). (Note: Criteria therefore are no longer arranged in numerical order.) Two new indicators are added, and Indicator 23 includes additions to its rationale and approaches to measurement. Indicators 18–25 are modified.
Other Cross-cutting Refinements
Under Criterion 1, Indicators 6, 7, 8, and 9 (1.2.a and b and 1.3.a and b), and any other indicators regarding forest-dependent species, diversity should specifically mention that diversity and distribution of aquatic species is addressed in Criterion 4, Indicator 23.
New Definition: Reference Condition
The range of spatial, structural, compositional, and temporal variation of ecosystem elements (i.e., plants, soils, animals) specified to represent reference or baseline conditions (e.g., historic period).
New Definition: Significant
Change of sufficient magnitude to affect ecological processes or the flow of goods and services.

Breakout Group: Criterion 4 - Indicators 18 - 25:

Participants: Michael Amacher, USDA Forest Service; Randy Davis, USDA Forest Service; Susan Fox, USDA Forest Service, Southern Research Station; John Greis, USDA Forest Service; Theodore Heintz, White House Council on Environmental Quality; David Heller, USDA Forest Service, Pacific Northwest Region; Robert Hendricks, USDA Forest Service; Theresa Heyer, USDA Forest Service; Chris Knopp, USDA Forest Service; Susan Morre, Department of Forest Resources, Oregon State University; Milo Pyne, NatureServe
Criterion Lead: Kenneth Stolte, USDA Forest Service, Southern Research Station
Facilitator: Christy Pereira, Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture

Text in the Montreal Process Technical Notes	Original Language with Recommended Deletions Underlined and Struck Out	Refined Language with Recommended Additions Underlined	Comments on Recommended Change
Criterion 4 Introduction		The indicators for Criterion 4 were organized into three subcriteria: Protected Areas (Indicator 19), Soil Productive Capacity (Indicators 18, 21, 22, 25, and new Soil Biota–Indicator Y), and Aquatic Productive Capacity and Quality (Indicators 20, 23, 24, and new Physical Indicator YY). This organization is an ecologically meaningful grouping similar to the subcriteria approach of Criterion 1. It produces a reporting framework for a broader group of stakeholders (e.g., forest landowners, policy makers, decision makers, formal and nonformal educators, practitioners, and managers) that facilitates the interpretation of results.	This organization is an ecologically meaningful grouping similar to the subcriteria approach of Criterion 1. It produces a reporting framework for a broader group of stakeholders—including forest landowners, policy makers, decision makers, formal and nonformal educators, practitioners, and managers—that facilitates the interpretation of results.
Protected Area Subcriterion		The Protected Area subcriterion is an overarching indicator that addresses the degree to which soil and water resources on forested lands are protected in legally designated areas. Additionally, it includes areas successfully managed for protection of these resources, but not legally designated as protected areas. The latter implies current best management practices are implemented and working to protect soil and water resources.	
Indicator 19 (4.b) Title	Area and percent of forest land ~~managed primarily for protection functions~~ (e.g., watersheds, flood protection, avalanche protection, riparian zones)	Area and percent of forest land whose management focus or designation is the protection of soil and water resources (e.g., municipal watersheds, flood protection areas, avalanche protection areas, riparian zones, etc.)	

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Indicator 19 (4.b) Rationale	This indicator provides a measure of the area and proportion of forest land managed primarily for ~~protective functions. In harvested forests, it is important that measures are implemented that give protection to water courses, if soil erosion is to be reduced and water quality maintained~~. Recording how much land is specifically allocated to soil and water quality protection provides an indication of the extent to which these elements are specifically considered in forest management.	This indicator provides a measure of the area and proportion of forest land managed or designated for the protection of soil and water resources. Recording how much land is specifically allocated to soil and water quality protection provides an indication of the extent to which these elements are specifically considered in forest management.	
Soil Productive Capacity Subcriterion		Soil productivity addresses the capacity of the key physical, chemical, and biological properties of soil systems to maintaining forest productivity, health, and sustainability, including associated aquatic systems. This subcriterion is composed of indicators 18, 21, 22, and 25, and includes the new soil biota indicator (Indicator Y).	These indicators were grouped together because they are the important attributes of forest soils relative to the productivity and viability of the terrestrial part of forest ecosystems and associated aquatic systems. Soil biota was added because it is, like aquatic biota, the ultimate indicator of whether the existing combinations of 18, 21, 22, and 25 produce a soil environment that is conducive to a healthy soil biota. Therefore, soil biota are analogous to biotic indicators of aquatic viability such as IBI indices or component ENT benthic larval indicators.
Indicator 18 (4.a) Title	Area and per cent of forest land with significant soil erosion	Area and percent of forest land with significant soil erosion	The wording for the indicator was unchanged. [The word 'per cent' was changed to 'percent' here and elsewhere in the document.]

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Indicator 18 (4.a) Rationale	This indicator aims to measure the extent of soil erosion ~~(from water and wind)~~ in forest areas that is of sufficient magnitude to lower soil ~~fertility~~ or ~~cause significant sediment delivery to streams~~.	This indicator aims to measure the extent of soil erosion in forest areas that is of sufficient magnitude to lower soil productivity or degrade aquatic systems.	This indicator language was defined so that "significant" is considered to be levels of erosion above normal natural, undisturbed-by-humans, erosion levels that are increased to a point at which productivity of terrestrial systems is affected or the health of aquatic systems is negatively affected and measurable.
Indicator 21 (4.d) Title	Area and per cent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties	Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties	The wording for the indicator was unchanged.

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Indicator 21 (4.d) Rationale	This indicator measures changes in chemical properties that affect soil ~~fertility~~. Soil organic matter contributes to the physical, chemical, and biological properties of soil, which affect many important ecological processes. ~~It is important to establish baselines of soil organic matter, or other soil physical properties, for each forest ecosystem.~~ The management objective for most forest types is to maintain soil organic matter levels over the long term. Absolute values of organic matter will vary with forest types, as will the degree of change. Changes in soil organic matter following non-catastrophic natural disturbance may be used as a baseline for estimating acceptable levels of change or natural fluctuation. Where natural fluctuations are found to be large, then some understanding of the potential impact of those changes on the resulting ecosystem would help interpret what may be acceptable levels of change. Soil organic matter can change following some forest operations/management. The level of soil organic matter is a characteristic of each forest ecosystem, and should be maintained because of its links to nutrient and carbon storage, effect on soil physical and hydrological properties, and role in providing substrates for soil biota.	This indicator measures changes in chemical properties that affect soil productivity (e.g., C, N, Al, pH, CEC, nutrients). Soil organic matter contributes to the physical, chemical, and biological properties of soil, which affect many important ecological processes. The management objective for most forest types is to maintain soil organic matter levels over the long term. Absolute values of organic matter will vary with forest types, as will the degree of change. Changes in soil organic matter following non-catastrophic natural disturbance may be used as a baseline for estimating acceptable levels of change or natural fluctuation. Where natural fluctuations are found to be large, then some understanding of the potential impact of those changes on the resulting ecosystem would help interpret what may be acceptable levels of change. Soil organic matter can change following some forest operations/management. The level of soil organic matter is a characteristic of each forest ecosystem, and should be maintained because of its links to nutrient and carbon storage, effect on soil physical and hydrological properties, and role in providing substrates for soil biota.	Soil organic matter is left here, even though it is a physical property more then a chemical property, because of its close association with soil nutrients and thus, soil productivity.

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Indicator 22 (4.e) Title	Area and percent of forest land with significant ~~compaction or~~ change in soil physical properties ~~resulting from human activities~~	Area and percent of forest land with significant change in soil physical properties	
Indicator 22 (4.e) Rationale	This indicator measures the extent of ~~physical soil~~ change ~~induced by human activities~~ that might affect soil productivity and hydrology and other ecosystem processes. Soil compaction from the use of heavy equipment in the harvesting of forest products, or from vehicle access, is a major cause of changes in soil bulk density. Management practices that control and limit compaction are desirable.	This indicator measures the extent of change in soil physical properties (e.g., soil compaction, bulk density, porosity, infiltration, etc.) that might affect soil productivity and hydrology and other ecosystem processes. Soil compaction from the use of heavy equipment in the harvesting of forest products, or from vehicle access, is a major cause of changes in soil bulk density. Management practices that control and limit compaction are desirable.	The indicator language was modified because all of these indicators are about the effects of "human activities" on a resource. "Significant" is defined as those soil properties that affect productivity or associated aquatic systems.
Indicator 25 (4.h) Title	Area and percent of forest land ~~experiencing an~~ accumulation of ~~persistent~~ toxic substances	Area and percent of forest land with a significant accumulation of toxic substances	
Indicator 25 (4.h) Rationale	This indicator measures the degree to which pollutants and environmentally damaging chemicals might be affecting forest ~~land. Toxic substances have adversely affected extensive areas of some forests~~.	This indicator measures the degree to which pollutants and environmentally damaging chemicals might be affecting forest resources and human safety.	The indicator language was modified to reflect that we are concerned (1) when toxic substances accumulate to a "significant" level, i.e., to a point at which they affect forest resources or human safety, and (2) about all toxic substances, not just those that are deemed persistent.
Indicator Y Title		Area and percent of forest land with significantly diminished soil biota and/or soil biological properties	Soil biota contribute to the physical, chemical, and biological properties of soil, which affect forest health and ecological processes (e.g., tree growth, water infiltration, recovery from disturbance, nutrient cycling, soil stability, and detoxification).

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Indicator Y Rationale		This indicator measures changes in soil biota and/or soil biological properties that affect soil productivity. Soil biota contribute to and reflect the physical, chemical, and biological properties of soil, which affect forest health and ecological processes (e.g., tree growth, water infiltration, recovery from disturbance, nutrient cycling, soil stability, and detoxification).	The role of soil biota is recognized as essential to the complete soil system, and as an overall integrator of the physical and chemical properties of the soil.
Indicator Y Approaches to Measurement		Soil biota change following some forest operations/management. Where natural fluctuations are found to be large, some understanding of the potential impact of those changes on the resulting ecosystem would help interpret what may be acceptable levels of change. A management objective for most forests is to maintain a healthy soil environment that is based on an active soil biological system. Absolute values of soil biota will vary with forest types, as will the degree of change. Changes in soil biota following noncatastrophic natural disturbance may be used as a baseline for estimating acceptable levels of change or natural fluctuation.	

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Aquatic Productivity (Water Quantity and Quality) Subcriterion		This subcriterion is composed of indicators 20, 23, 24, and the new Aquatic Habitat indicator (Indicator YY). This subcriterion addresses the physical, chemical, and biological properties of aquatic systems that are important indicators of forest health and ecosystem sustainability. These indicators measure water quantity and quality, which address ecological services (e.g., habitat) and human benefits (e.g., drinking water quality, safe aquatic recreational areas, and irrigation).	This subcriterion is created to be parallel with the approach in Criterion 1–Soil and Biodiversity. It includes all the attributes of what constitutes healthy and sustainable forest aquatic systems.
Indicator 20 (4.c) Title	Percent ~~of~~ stream ~~kilometers in forested catchments~~ in which stream flow and timing ~~has significantly deviated from the historic range of variation~~	Length and percent of streams in which significant changes in flow and/or timing have occurred in relation to reference condition	Length is added to make this indicator parallel with all indicators. Percent without an amount is meaningless, just as amount without a percent is meaningless. This change drops kilometers because the United States does not use the metric scale. "Significant" is retained but "historic range of variation" is changed to the generic "reference condition" because of the lack of information on historic data.
Indicator 20 (4.c) Rationale	This indicator measures ~~the effects of forest management and other factors on~~ water flow and ~~variation in flow~~. Management ~~of the forest~~ can result in changed water flow regimes~~, such as either increased or decreased runoff related to changes in interception and transpiration by vegetation. These factors have~~ implications ~~both~~ for stream health, life and property~~, and water supply for human use~~.	This indicator measures significant changes in water flow and timing. Management activities, diversions, impoundments, and other factors can result in changed water flow regimes. This indicator has implications for stream health, human life and property. It also has implications for biological, economic, and recreational values.	

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Indicator 23 (4.f) Title	Per cent of water bodies ~~in forest areas (e.g., stream kilometers, lake hectares)~~ with significant ~~variance of biological~~ diversity from ~~the historic range of variability~~	Area and percent of water bodies with significant changes in diversity and distribution of aquatic biota from reference condition	Area is added to make this indicator parallel with all indicators. Percent without an amount is meaningless, just as amount without a percent is meaningless. Distribution brings in the concept of relating to aquatic habitat. "Significant" is retained but "historic range of variation" is changed to the generic "reference condition" because of the lack of information on historic data.
Indicator 23 (4.f) Rationale	This indicator measures the diversity ~~of a sample of in-stream~~ flora and fauna ~~as~~ a reflection of the quality of habitat and water.	This indicator measures the diversity and distribution of aquatic flora and fauna in streams, lakes, and other water bodies (natural and artificial). This is one measure of aquatic health and serves as an integrator of terrestrial activities. Aquatic resources contribute to a range of biological, economic, and recreational values. The significant loss of aquatic diversity indicates an impaired ecosystem. This indicator is a reflection of the quantity and quality of habitat and water.	Note: Under Criterion 1, Indicators 6, 7, 8, and 9 (1.2.a and b and 1.3.a and b), and any other indicators regarding forest-dependent species, diversity should specifically mention that diversity and distribution of aquatic species is addressed in Criterion 4, Indicator 23.
Indicator 23 (4.f) Approaches to Measurement	Data for this indicator may include the following: • The diversity of aquatic macro-invertebrate fauna at a selected number of monitoring sites, but diversity of other aquatic groups may also be used • Where sufficient studies have occurred, it may be possible to predict the composition of undisturbed macro-invertebrate fauna at each site, based on river health models (e.g., the Australian Monitoring River Health	Data for this indicator may include the following: • The diversity of aquatic macro-invertebrate fauna at a selected number of monitoring sites, but diversity of other aquatic groups may also be used • Where sufficient studies have occurred, it may be possible to predict the composition of undisturbed macro-invertebrate fauna at each site, based on river health	

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	Initiative (MRHI)) • Where historical variability is unavailable for this indicator, the current fauna at reference or undisturbed sites can be used to establish baselines for water flow, water quality, and habitat with reference to forest management practices • Statistical analysis may be used to model the relationship between the observed fauna and the predicted (or expected) fauna for any monitoring site. Reporting would be in the form of a percentage of sites with fauna significantly different from the reference condition.	models (e.g., the Australian Monitoring River Health Initiative (MRHI)) • Where historical variability is unavailable for this indicator, the current fauna at reference or undisturbed sites can be used to establish baselines for water flow, water quality, and habitat with reference to forest management practices • Statistical analysis may be used to model the relationship between the observed fauna and the predicted (or expected) fauna for any monitoring site. Reporting would be in the form of a percentage of sites with fauna significantly different from the reference condition. Artificial lakes represent a fundamental change in habitat and diversity from the original stream reference condition. Establishment of an impoundment also represents a new reference condition against which additional change can be measured.	

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Indicator 24 (4.g) Title	Percent of water bodies in forest areas ~~(e.g., stream kilometers, lake hectares)~~ with significant ~~variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change~~	Area and percent of water bodies in forest areas with significant change in water chemistry from reference conditions	Area is added to make this indicator parallel with all indicators. Percent without an amount is meaningless, just as amount without a percent is meaningless. The indicator is now limited to chemical properties, with sediment moved to physical properties under new Indicator YY. The indicator is more parallel with soils and how different components of an aquatic system interact with each other and components of soil systems (see Conceptual Model).
Indicator 24 (4.g) Rationale	This indicator measures aspects of the ~~health of the~~ aquatic environment and the quality of water for ~~human use (drinking, irrigation, recreation, etc.), by measuring physical and chemical variables~~. Records of these variables ~~can, over time,~~ show trends that may indicate whether current or past management practices are positively or adversely affecting water quality. ~~Management practices can then be adjusted, to maintain or improve water quality.~~	This indicator measures important chemical aspects of the aquatic environment (e.g., pH, dissolved oxygen, nutrients, and other dissolved constituents) and the quality of water for biological, economic, and recreational values. Records of these variables over time can show trends that may indicate whether current or past management practices are positively or adversely affecting water quality.	
Indicator YY Title		Area and percent of water bodies or stream-length in forest areas with significant change in physical properties from reference conditions	This change moves sediment in with other physical attributes of aquatic systems that are important for aquatic biology and for human-use of aquatic systems. It makes aquatics more parallel with soils, and aids in presentation via Conceptual Models and interpretation by land managers, policy makers, etc.

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Indicator YY Rationale		This indicator measures important physical aspects of the aquatic environment (e.g., temperature, sediment, substrate, aquatic habitat, sinuosity, and pool depth) and the quality of water for biological, economic, and recreational values. Records of these variables over time can show trends that may indicate whether current or past management practices are positively or adversely affecting water quality.	