

## Appendix E: SAMPLE INDICATORS LIST - FOREST SUSTAINABILITY<sup>1</sup>

The sample indicators below can be used as a “starter set” for a community thinking about how to develop sustainable forest indicators using the Montreal Process Criteria and Indicators in order to raise awareness, make better decisions and monitor progress toward its goals and vision. The purpose of the list is not to dictate what indicators a community should use, rather to provide a starting point for discussion about what is valued and therefore needs to be measured, monitored and cared for. The indicators are categorized by the Montreal Process Criteria and Subcriteria and possible data sources are listed, along with an explanation of the indicator and its significance.

#	Montreal Process Indicator	Explanation/ Significance	Detailed Measure	Data Source
<b>Criterion 1. Conservation of biological diversity</b>				
<b>Subcriterion 1.1 Ecosystem diversity</b>				
1	Extent of area by forest type relative to total forest area	Each forest type supports different mixtures of species, so maintaining the ratio is important for biodiversity conservation.	<ul style="list-style-type: none"> <li>• % of forest area by forest type</li> </ul>	USDA FS, FIA & ECOMAP
2	Extent of area by forest type and by age class or successional stage	Each state of succession supports different communities of plants and animals; maintaining adequate area is important for species retention. It is important to look at forest land relative to the entire community land as well as forest land only.	<ul style="list-style-type: none"> <li>• Acres of forest area by forest type (SAF forest types);</li> <li>• Size class by forest type (acres by size class)</li> <li>• Age class by forest type (acres by years).</li> </ul>	USDA FS, FIA & ECOMAP
3	Extent of area by forest type in protected area categories as defined by IUCN or other classification systems	The World Conservation Union (IUCN) has developed an approach for classifying reserves based on the level of protection; this provides a useful and credible basis for tracking reserve areas.	<ul style="list-style-type: none"> <li>• Acres of forest in protected area categories.</li> <li>• % of forest in protected area categories as defined by IUCN or other classification system.</li> </ul>	

<sup>1</sup> This appendix contains information from the following sources: (1) Montreal Process Criteria and Indicators, The Santiago Declaration; (2) The Great Lakes Forest Alliance “Assessing progress in Sustainable Forest Management: Proposed Criteria and Indicators for the Upper Great Lakes Region”, June 1998; (3) Northeastern Forest Resource Planners Association – “Sourcebook on Criteria and Indicators of Forest Sustainability in the Northeastern Area, July 13, 2001.

#	Montreal Process Indicator	Explanation/ Significance	Detailed Measure	Data Source
4	Extent of areas by forest type in protected areas defined by age class or succession stage.	Protected areas are of high significance with their biodiversity. Each state of succession or age class support different mixtures of species.	<ul style="list-style-type: none"> <li>• Acres of forest in protected areas by age class.</li> <li>• % of forest in protected area by age class.</li> </ul>	
5	Fragmentation of forest types.	Forest fragmentation may be assessed from average patch size, road density, or other indices. Less fragmented forest provides opportunities for species and wildlife movement and interchange, and thus is more resilient over time.	<ul style="list-style-type: none"> <li>• Average patch size in acres.</li> <li>• Fragmentation index</li> <li>• Connectivity index</li> <li>• Road density</li> </ul>	GIS (geographic information system) (remotely-sensed analysis)
<b>Subcriterion 1.2 Species diversity</b>				
6	The number of forest dependent species.	Forest dependent species are at a greater risk of extinction with reduced quantity or quality of forests. Thus their number provides a measure of risk of biodiversity loss.	<ul style="list-style-type: none"> <li>• Number of forest dependent species.</li> <li>• Forest dependent species as % of all species.</li> </ul>	Threatened and endangered species lists from state agencies
7	The status (threatened, rare, vulnerable, endangered, or extinct) of forest dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment.	Species, which are classified as rare, threatened or endangered are at some relatively significant risk of extinction and the status of such species provides a measure of risk of loss of biodiversity.	<ul style="list-style-type: none"> <li>• % of forest species that are classified as threatened, rare, vulnerable, endangered or extinct.</li> <li>• Health of sensitive species (use a scale to evaluate it based on mortality, fecundity, and population structure).</li> <li>• Acres/% of habitat enhancement.</li> </ul>	State T and E species lists
<b>Subcriterion 1.3 Genetic diversity</b>				
8	Number of forest dependent species that occupy a small portion of their former range.	Species whose range is shrinking are likely to have less within-species genetic variation.	<ul style="list-style-type: none"> <li>• % or number of forest dependent species that occupy a smaller forest area than they used to.</li> </ul>	
9	Population levels of representative species from diverse habitats monitored across their range.	The number of representative species needs to be considered in the light of what a viable population is.	<ul style="list-style-type: none"> <li>• Number of members of representative species.</li> </ul>	

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<b>Criterion 2. Maintenance of productive capacity of forest ecosystems</b>				
10	Area of forest land and net area of forest land available for timber production.	This indicator is a measure of human pressures on forests.	<ul style="list-style-type: none"> <li>• Acres of timberland area</li> </ul>	USDA FS, FIA
11	Total growing stock of both merchantable and non-merchantable tree species on forest land available for timber production	Growing mixed species makes a forest more resilient to different outside pressures (diseases, storms, fires, etc.)	<ul style="list-style-type: none"> <li>• Percent or acres of forest area with merchantable and non-merchantable tree species for timber production.</li> </ul>	
12	The area and growing stock of plantations of native and exotic species.	Native ecosystems can be disrupted by exotic species. The disruptive effects may include the local extirpation of species, which are outcompeted or preyed on by the exotic species, and a shift in the distribution of remaining species.	<ul style="list-style-type: none"> <li>• Ratio of number of exotic species to native species</li> <li>• Acres/% of area for growing native vs. exotic species.</li> </ul>	
13	Annual removal of wood products compared to the volume determined to be sustainable.	Maintaining a sustainable ratio of removal to growth ensures the long-term health of a forest and its ability to provide future generations with all necessary resources, including timber.	<ul style="list-style-type: none"> <li>• Ratio of net growth to removal for wood products.</li> </ul>	
14	Annual removal of non-timber forest products (e.g. fur bearers, berries, mushrooms, game), compared to the level determined to be sustainable.	Higher rate of removal than the regeneration for non-timber species would compromise the long-term health and resource availability.	<ul style="list-style-type: none"> <li>• Ratio of net growth to removal for non-timber forest products.</li> </ul>	
<b>Criterion 3. Maintenance of forest ecosystem health and vitality</b>				
15	Area and percent of forest affected by processes or agents beyond the range of historic variation, e.g. by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinisation, and domestic animals.	This indicator measures the extent of each main type of natural and human disturbance. In some cases, such as insect infestation, a further breakdown by severity class is required to provide a measure of the stress faced by the forest.	<ul style="list-style-type: none"> <li>• Acres/percent of forest affected by insects and diseases (including exotics).</li> <li>• Rate of mortality (per acre)</li> <li>• Acres/percent of forest burned in fires.</li> <li>• Acres or % of forest damaged by storms, animal browsing, drought/flooding.</li> </ul>	USDA FS, FHM, FIA, National Interagency Fire Management Integrated Database (NIFMID)

#	Montreal Process Indicator	Explanation/ Significance	Detailed Measure	Data Source
16	Area and percent of forest land subjected to levels of specific air pollutants (e.g. sulfates, nitrate, ozone) or ultraviolet light that may cause negative impacts on the forest ecosystem.	This indicator measures the impacts of human development and air pollution on the health of forests.	<ul style="list-style-type: none"> <li>Acres or percent of forest damaged by acid rain.</li> </ul>	
17	Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g. soil nutrient cycling, seed dispersion, pollination) and/or ecological continuity (monitoring of functionally important species such as fungi, arboreal epiphytes, nematodes, beetles, wasps, etc)	This indicator measures forest health as result of human or natural disturbance.	<ul style="list-style-type: none"> <li>Acres or percent of forest with diminished beetles populations.</li> </ul>	
<b>Criterion 4. Conservation and maintenance of soil and water resources</b>				
18	Area and percent of forest land with significant soil erosion.	Soil condition is directly linked to forest health.	<ul style="list-style-type: none"> <li>Acres or % of forest area affected by significant soil erosion.</li> </ul>	USDA FS
19	Area and percent of forest land managed primarily for protective functions, e.g. watersheds, flood protection, avalanche protection, riparian zones.			
20	Percent of stream kilometers in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation.	This indicator attempts to report on the extent to which water flow relations have been disrupted; flow and timing exercise a strong influence on the habitat characteristics of streams.	<ul style="list-style-type: none"> <li>Kilometers (or %) of forested catchments, where stream flow and timing has significantly changed over time.</li> </ul>	
21	Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties.	Soil health is directly linked to the health of the forest ecosystem.	<ul style="list-style-type: none"> <li>Acres or % of forest area with diminished soil organic matter and/or change in other soil chemical properties.</li> </ul>	USDA FS, FHM

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			<ul style="list-style-type: none"> <li>Acres or % of forest with soil pH that has diverted significantly from the normal value.</li> </ul>	
22	Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities.	Compaction, puddling and loss of organic matter are key causes of soil degradation and productivity losses.	<ul style="list-style-type: none"> <li>Acres or % of forest area with significant compaction and/or change in other soil physical properties, resulting from human activities.</li> </ul>	
23	Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variance of biological diversity from the historic range of variability.	This indicator measures disturbances of the water bodies in a forest area over time.	<ul style="list-style-type: none"> <li>Index of Watershed Indicators (IWI)</li> </ul>	U.S. EPA, Office of Water Resources
24	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.	Water conductivity is one of the single best measures of overall water quality. Dissolved oxygen, pH, temperature are additional indicators. For example, the growth of organic matter reduces dissolved oxygen and thus – the ability of a water body to support life. Removal of tree cover over streams and other water bodies contributes to higher water temperatures, which affects growth rates and habitat – cool water species are particularly vulnerable to spikes in water t°.	<ul style="list-style-type: none"> <li>% of water bodies with low dissolved oxygen</li> <li>% of water bodies with deviation in pH level</li> <li>% of water bodies with higher temperature than normal.</li> <li>Average daily discharge of dioxins and furans from selected pulp and paper mills.</li> <li>Phosphorous levels.</li> </ul>	
25	Area and percent of forest land experiencing an accumulation of persistent toxic substances.	Persistent toxic substances usually have both acute and chronic effects. They can bioaccumulate in fish and then through the food chain can reach humans and lead to serious diseases such as mental retardation, cancer, etc.	<ul style="list-style-type: none"> <li>Area and % of forest land that has higher levels of mercury, lead or other persistent, bioaccumulative and toxic chemicals.</li> </ul>	

#	Montreal Process Indicator	Explanation/ Significance	Detailed Measure	Data Source
<b>Criterion 5. Maintenance of forest contribution to global carbon cycles</b>				
26	Total forest ecosystem biomass and carbon pool, and if appropriate, by forest type, age class, and successional stages.		<ul style="list-style-type: none"> <li>Tons of ecosystem biomass</li> <li>Metric tons of carbon pool</li> </ul>	USDA FS, U.S., Global Change Research Program
27	Contribution of forest ecosystems to the total global carbon budget, including absorption and release of carbon (standing biomass, coarse woody debris, peat and soil carbon).	Sequestering of carbon mitigates carbon emissions into the atmosphere.	<ul style="list-style-type: none"> <li>Metric tons of carbon flux per year</li> </ul>	USDA FS, U.S., Global Change Research Program
28	Contribution of forest products to the global carbon budget.	Burning wood releases carbon into the atmosphere and human fuel use may be an important contributor to atmospheric carbon in some areas.	<ul style="list-style-type: none"> <li>Tons of CO2 released as result of burning wood.</li> </ul>	USDA FS, U.S., Global Change Research Program
<b>Criterion 6. Maintenance and enhancement of long-term multiple socioeconomic benefits to meet the needs of societies</b>				
<b>Subcriterion 6.1 Production and Consumption</b>				
29	Value and volume of wood and wood products production, including value added through downstream processing.	The choice of products, and to a lesser extent, the efficiency of manufacturing indicate how much value a firm can add to the inputs during the manufacturing process.	<ul style="list-style-type: none"> <li>Value and volume by industry of wood production and products value added.</li> <li>Value and volume of imports and exports.</li> </ul>	
30	Value and quantities of production of non-wood forest products.	A measure that helps determine sustainability of production of other forest products, such as berries, furs, and mushrooms.	<ul style="list-style-type: none"> <li>Value and tons of other forest products – mushrooms, berries, furs.</li> </ul>	
31	Supply and consumption of wood and wood products, including consumption per capita.		<ul style="list-style-type: none"> <li>Value and volume of wood products consumed.</li> </ul>	RPA Assessment (USDA FS, FIA)
32	Value of wood and non-wood products production as percentage of GDP.	Proportion of GDP generated by forest products is a measure of their importance, and, indirectly, their competitiveness.	<ul style="list-style-type: none"> <li>% of GDP coming from forest-related products.</li> </ul>	

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33	Degree of recycling of forest products.	This is a measure of sustainable resource use. Use of recycled wood will reduce the demand for virgin wood.	<ul style="list-style-type: none"> <li>% of forest products that are recycled.</li> </ul>	
34	Supply and consumption/use of non-wood products.	This is a measure of the importance of forests in meeting other needs than wood consumption.	<ul style="list-style-type: none"> <li>Amount and % of income from supply/consumption of non-wood products.</li> </ul>	
<b>Subcriterion 6.2 Recreation and tourism</b>				
35	Area and percent of forest land managed for general recreation and tourism, in relation to the total area of forest land.	Recreation usage, and its value, is a complement to timber harvest revenues. It's also an important element of quality of life.	<ul style="list-style-type: none"> <li>% or area of forest land managed for recreation and tourism.</li> </ul>	
36	Number and type of facilities available for general re-creation and tourism, in relation to population and forest area.	Recreation and tourism are important forest services that contribute to both GDP and quality of life of people.	<ul style="list-style-type: none"> <li>Miles of trails by type</li> <li>Number of campgrounds</li> <li>Number of visitors trips/days</li> </ul>	USDIF & WS, National Survey of Fishing, Hunting and Wildlife Associated Recreation,; USDA FS NFS or Other Existing Recreation Data
37	Number of visitor days attributed to recreation and tourism, in relation to population and forest area.	Recreation and tourism are important forest services that contribute to both GDP and quality of life of people.	<ul style="list-style-type: none"> <li>Number of visitor days per acre per year.</li> </ul>	
<b>Subcriterion 6.3 Investment in forest sectors</b>				
38	Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism.	Investment in such activities is the key to long-term sustainability and profitability of forest-related industries.	<ul style="list-style-type: none"> <li>Dollar value of manufacturing/processing investment (lumber, wood products, paper products)</li> <li>Dollar value of forestry program budgets.</li> </ul>	AF&PA, U.S. Census, NASF State Data
39	Level of expenditure on research and development, and education.	This is another measure of industry competitiveness.	<ul style="list-style-type: none"> <li>% of forest-related income that goes for R&amp;D and education.</li> </ul>	
40	Extension and use of new and improved technologies.	Such technologies may reduce waste and thus lower the demand of virgin products.	<ul style="list-style-type: none"> <li>% of forest-related income invested in new and improved technologies.</li> </ul>	

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41	Rates of return on investment.	Some private landowners view their holdings as investments. For those who do, rate of return is a critical measure of the attractiveness of the investment, as well as of the affordability of land.	<ul style="list-style-type: none"> <li>• Rate of return on investment in timber industries</li> <li>• Rate of return on investment in tourism and recreation.</li> </ul>	
<b>Subcriterion 6.4 Cultural, social and spiritual needs and values</b>				
42	Area and percent of forest land managed in relation to the total area of forest land to protect the range of cultural, social and spiritual needs and values	Measurement of the area with special cultural, social and spiritual needs and values is the first step in promoting its proper management.	<ul style="list-style-type: none"> <li>• Percent of forest that is considered historically valuable.</li> <li>• Acres or % of forest land which have cultural value to community.</li> </ul>	
43	Non-consumptive use forest values.	These include tourism and recreation, education, and others and are important for achieving higher quality of life.	<ul style="list-style-type: none"> <li>• Number or % of local people who rank non-consumptive uses of forest as critical for achieving personal and spiritual development.</li> </ul>	
<b>Subcriterion 6.5 Employment and community needs</b>				
44	Direct and indirect employment in the forest sector and forest sector employment as a proportion of total employment.	Providing employment for local people is critical for the long-term sustainability of a community.	<ul style="list-style-type: none"> <li>• % of local residents employed in forest-related industries.</li> <li>• Direct employment in the forest sector, measured as % of people working in such industries.</li> <li>• Indirect employment in the forest sector, measured as % of people working in retail, insurance, transportation, and other related industries.</li> </ul>	
45	Average wage rates and injury rates in major employment categories within the forest sector.	People tend to move where wages are higher. The average can also be compared to economy-wide averages to gain a sense of the relative prosperity of a region. Rates of injuries in the forest sector are indicator of the relative safety of these kinds of jobs.	<ul style="list-style-type: none"> <li>• Average wage rate in major employment categories in the forest sector.</li> <li>• Ratio of average wage rate in the forest sector versus average wage rate in the area (state, county, etc.).</li> </ul>	U.S. Census Bureau USDA FS (IMI) IMPLAN NASF Forestry Statistics Bureau of Labor Statistics (BLS)

#	Montreal Process Indicator	Explanation/ Significance	Detailed Measure	Data Source
			<ul style="list-style-type: none"> <li>Lost workday injuries and illness rate (LWDII)</li> </ul>	
46	Viability and adaptability to changing economic conditions, of forest dependent communities, including indigenous communities.	This indicator measures the ability of forest dependent communities to adjust to quickly changing economic conditions that lead to reduced/increased demand for forest products and thus affect employment and income.	<ul style="list-style-type: none"> <li>% change in forest-related employment over the past several years.</li> </ul>	
47	Area and percent of forest land used for subsistence purposes.	Poverty (subsistence uses of forest resources) can exert high pressures on forest resources and lead to their fast depletion and degradation.	<ul style="list-style-type: none"> <li>Area or % of forest land significantly degraded as result of subsistence uses.</li> </ul>	
<b>Criterion 7. Legal, institutional and economic framework for forest conservation and sustainable management</b>				
<b>Subcriterion 7.1 Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests, including the extent to which it:</b>				
48	Clarifies property rights, provides for appropriate land tenure arrangements, recognizes customary and traditional rights of indigenous people, and provides means of resolving property disputes by due process.			
49	Provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including coordination with relevant sectors.			
50	Provides opportunities for public participation in public policy and decision making related to forests and public access to information.			
51	Encourages best practice codes for forest management.			

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52	Provides for the management of forests to conserve special environmental, cultural, social and/or scientific values.			
<b>Subcriterion 7.2 Extent to which the institutional framework supports the conservation and sustainable management of forests, including the capacity to:</b>				
53	Provide for public involvement activities and public education, awareness and extension programs, and make available forest-related information.			
54	Undertake and implement periodic forest-related planning, assessment, and policy review including cross-sectoral planning and coordination.			
55	Develop and maintain human resource skills across relevant disciplines.			
56	Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management.			
57	Enforce laws, regulations and guidelines.			
<b>Subcriterion 7.3 Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests through:</b>				
58	Investment and taxation policies and a regulatory environment which recognize the long-term nature of investments and permit the flow of capital in and out of the forest sector in response to market signals, non-market economic valuations, and public			

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	policy decisions in order to meet long-term demands for forest products and services.			
59	Nondiscriminatory trade policies for forest products.			
<b>Subcriterion 7.4 Capacity to measure and monitor changes in the conservation and sustainable management of forests, including:</b>				
60	Availability and extent of up-to-date data, statistics and other information important to measuring or describing indicators associated with criteria 1-7.			
61	Scope, frequency and statistical reliability of forest inventories, assessments, monitoring and other relevant information.			
62	Compatibility with other countries in measuring, monitoring and reporting on indicators.			
<b>Subcriterion 7.5 Capacity to conduct and apply research and development aimed at improving forest management and delivery of forest goods and services, including:</b>				
63	Development of scientific understanding of forest ecosystem characteristics and functions.			
64	Development of methodologies to measure and integrate environmental and social costs and benefits into markets and public policies, and to reflect forest-related resource depletion or replenishment in national accounting systems.			

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65	New technologies and the capacity to assess the socioeconomic consequences associated with the introduction of new technologies.			
66	Enhancement of ability to predict impacts of human intervention on forests.			
67	Ability to predict impacts on forests of possible climate change.			