Criterion 6, Indicator 40—Extension and Use of New and Improved Technologies

Ken Skog
USDA Forest Service
Forest Products Laboratory
One Gifford Pinchot Dr.
Madison, WI 53711
608-231-9360
kskog@fs.fed.us

The purpose of this report is to provide information on the rationale and data provided for Indicator 40 for the U.S. *National Report on Sustainable Forests—2003.* Information on the rationale for the indicator and recommended data to be developed are taken from the report of the Technical Advisory Committee of the Montreal Process[1] and from reports from the technical workshops of the U.S. Roundtable on Sustainable Forests Criteria and Indicators. Data that have been developed are displayed and sources are provided. The data are summarized in the *National Report on Sustainable Forests—2003*.[2]

A. Rationale for use of the indicator

1. Rationale from Technical Advisor Committee (TAC)

The indicator measures continuous improvement in forest management and forest products industries. This indicator is based on the assumption that improvements in forest management are related to the level of effort in seeking out and implementing better technologies in production, processing, and use. See Section F for more about indicators that show influences on seeking out and implementing technologies.

Approaches to measurement—Data for this indicator are likely to be in the form of a narrative listing of specific technologies indicating their expected contribution to improved forest management. These technologies are used to conserve, manage, or obtain goods and services from a forest.

Measurement of this indicator may involve collection and analysis of quantitative and qualitative data obtained from government, non-government, and industry sources.

2. Interpretation of the indicator as proposed by TAC

Adoption of new technologies can lead to more capabilities, options for efficient resource use, and better management of forests. Factors contributing to the adoption of new and improved technologies might include or result in changes in the type of forests being harvested, new

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[1] See http://www.mpci.org/tac/mexico/tn1-6_e.html
[2] See http://www.fs.fed.us/research/sustain/

industry standards, economic factors, increased environmental controls, and changes in demand for forest products.

The indicator does not distinguish how technologies contribute to sustainability. Determining how new technology affects sustainability involves monitoring the other indicators (see Section F).

3. U.S. Clarification from Roundtable Workshops

This indicator might include primarily qualitative data as well as applicable quantitative data. Technological innovation could be viewed to include the achievement of non-economic objectives as well as the goal of cost reduction (e.g., environmental controls may reduce impacts on the environment but may not reduce the direct cost of operation). The term “innovative” should be defined as the implementation of previously unused or undefined technology. The techniques identified in the First Approximation Report (FAR) should be used while augmenting this data for other resources.

B. Data provided to quantify the indicator

This indicator seeks to measure continuous improvement in forest management and forest products industries. It is based on the assumption that adoption of new technologies can lead to more capabilities, options for efficient resource use, and better management of forests.

We focus on technology change associated with wood-derived products and their substitutes. We do not attempt to outline the effect of technology changes related to recreation or other forest services on forest management. It is not clear if the indicator was to include technology change that may influence management for such services.

Many types of change in the technology related to timber and wood products can influence forest management. The rationale cites technology change in production, processing, and use of goods and services.

Technologies are adopted because they better meet existing demands for products and uses at lower costs or provide products in new end uses—primarily by substituting for existing products. Technologies may also be adopted in response to environmental regulations that decrease environmental impact—impact on forests, impacts of processing, or impacts of use.

The degree of adoption and effect of technologies on forests will be determined both by the advantages of adopting the technologies in the United States and by the advantages of applying technologies overseas. The technology will be adopted most where it gives the most competitive advantage for use in managing forests, producing products, or applications in end-uses. Competitive advantage is determined by a complex interaction of demands and institutions controlling resources, industries, and markets, including trade in various countries.

General technology changes in recent decades that have affected timber production, processing, and uses are as follow:

- Timber production—e.g., changes in genetic stock of trees, improvements in insect and disease treatments, improvements in fire treatments and protection, and improvements in silvicultural regimes, including establishment and fertilizers (For a discussion of genetic improvements and plantations, see Sedjo 1997)
- Harvesting—e.g., changes in harvesting systems for greatest yield of timber at lower cost and environmental impact for each type of forest condition (For a discussion of harvesting innovations, see Sedjo 1997)
- Processing to make existing solidwood and pulp & paper products—e.g., improvements in sawing allow changes in size of trees or species needed to make structural or appearance grade lumber, product per unit of wood input, costs, and emissions from processing; new grading regimes to identify wood with special qualities for high performance use such as machine stress rating for trusses; techniques to clean recycled paper and improve its stiffness and bonding, which increase paper recycling (e.g., For an analysis of changes in product output per unit of wood input for solid wood products industries, see Spelter 1998).
- New wood products—e.g., reconstituted panels, wood/plastic composites, laminated veneer lumber, wooden I-joints, and glulam beams, which call for changes in the wood (size, species of trees), wood residue, recycled wood, and nonwood (e.g., plastics) needed to make the products
- Use of wood for energy—e.g., use of pulping liquor for energy at pulp mills, higher efficiency stoves for residential wood burning, and use of wood for electric power production
- Changes in applications for solid wood and paper products—e.g., use of wood trusses in structures, substitution of wood composite panels for lumber and softwood plywood in structures, use of wood for housing basements, expanded use of paper for computer printers, and new uses of paperboard in packaging (For a discussion of the trends in wood panel production and use see Spelter et al. 1997 and McKeever 2003).
- Development of substitutes for solid-wood products and paper products in applications—e.g., vinyl and aluminum siding for buildings, light steel framing for residential structures, and electronic communication media for paper (For a discussion of substitution of nonwood materials for wood in housing, see Spelter 1996)
- Recycling of paper, mill residues, and solid-wood products—e.g., use of recycled paper for new paper and paperboard products, use of mill residues for composite panels and paper production, recycling of wooden pallets, and recycling of wood from deconstructed structures

One indicator of continuous improvement in wood processing and use that can affect forest management is roundwood input required per unit of wood and paper product output (Table 40–1). This is one broad indicator of technology-influenced improvement.

Most of this century's gains in industrial wood productivity have occurred since 1950 and have been the result of gains in the use of wood residues and paper recycling. These two developments have played sequential roles in industrial wood productivity gains. Large increases in wood residue use fostered improved wood productivity from the 1950s to the 1980s. (Chips, slabs, edgings, and planer shavings from sawmills and planer mills were used increasingly in the manufacture of woodpulp and particleboard, with a greater than tenfold increase in residue use from 1950 to 1985.) Since the mid-1980s, much of the further gains in wood productivity have occurred as a result of increased paper recycling. Overlapping trends reflect a correlation between the recovered paper utilization rate and industrial wood productivity (corresponding to a period when large gains were made in paper recycling, and coincidentally corresponding to a period when increases in residue use tapered off with nearly full utilization of available wood residues) (Ince 2000).

Technology innovations play a part in determining how low the cost will be for producing and using wood products in the United States and other countries, and consequently how much wood will be used from domestic forests versus imported wood products versus nonwood substitute products.

Given a need to provide wood and paper products from U.S. forests, technology innovations have supported at least five general trends that influence U.S. forest management: (1) a shift toward use of smaller diameter trees for lumber and panels, (2) a shift toward use of hardwoods versus softwoods in making paper, (3) an improvement in product performance per unit of wood fiber of a given quality, e.g., composite wood products, trusses in houses, improved paper and paperboard appearance and strength, (4) a shift toward use of recycled paper versus virgin fiber in paper production, and (5) a shift toward the production of an increasing proportion of softwoods on managed plantations primarily in the South and in the Northwest. (For a discussion of production shifts that are influencing management, see chapter 3 in Haynes (2003).)

C. Interpretation of data relative to rationale from TAC

The narrative information serves to indicate that technology change is occurring at every stage of wood production, processing, and use, as well as in the production and use of substitutes. These changes have an impact on what forest management is called on to produce in the way of amounts, species, and sizes of trees, and they have an impact on the associated locations and intensities of management in the United States and other countries.

D. Limitations of data

Only brief narratives have been provided that serve to indicate the range of technology innovations that are having an effect on forest management. We have made only brief mention of areas of technology change that have extensive and complex impact; in particular, the role of electronic media in increasing demand for some types of paper and paperboard and decreasing demand for other types.

It is not clear how much evidence of technology change is requested for this indicator since it is not the intent of the indicator to "….distinguish how technologies contribute to sustainability."

There could be more detailed narratives on scores of individual innovations (e.g., log scanning in sawmills; removing "stickies" from recovered paper). It seems the key information should be about the general effects of technologies on cost, amount, species, and size of wood (or nonwood materials) used; management practices supported; and locations of various types of management. Discussion of these effects does not directly "….distinguish how technologies contribute to sustainability."

The data do not indicate how innovations in wood and paper products may have an environmental impact beyond the impact on forest management—that is, the total life-cycle effects, in terms of energy costs and emissions, of alternative technologies to grow, harvest, process, use, reuse, and dispose of wood and paper.

E. Options available for remedy if current data are not adequate to measure the indicator

A detailed review of literature could be conducted if a more detailed listing of technology innovations and their effects is needed to clarify the way and extent to which individual innovations may influence forest management.

F. Cross-cutting issues/relationships with other indicators

The degree of effort in "seeking out and implementing improvements" can be influenced by the profitability of providing benefits, which in turn is influenced by institutional arrangements, including ownership, regulations, and support for research, and by interrelated market forces (supply and demand, trade and exchange rates). Indicators that may measure some aspects of "effort" include the level of expenditures on research (Indicator 39) and the capacity to conduct and apply research (Indicators 63–67).

Adoption of innovation may affect (1) the profitability of producing products (Indicators 29 and 30) or profitability of growing timber (Indicator 41); (2) the relative competitiveness between countries producing products, which would alter the amount of production capacity in different countries and the amount and kind of products imported and exported (Indicator 31); (3) the area retained in timberland versus other uses and rates of timber growth (Criterion 2); and (4) the kind, amount, location, and income from forest-based employment (Indicators 44 to 47).

The ability to discern the impact of technology change and to support targeted change is determined in part by the capacity to assess the socioeconomic consequences of using new technologies (Indicator 65).

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Table 40-1. Industrial roundwood productivity (product output per unit of roundwood input)

Year	Total industrial wood product production (thousand tons)	Roundwood input for production (million ft³)	Roundwood input for production (thousand short tons)	Industrial wood productivity (industrial wood product output per unit of roundwood input) (lb/ft³)	Industrial wood productivity (tons/ton)
1900	66,710	7,285	100,533	18.31	0.66
1901	69,933	7,580	104,604	18.45	0.67
1902	73,253	7,880	108,744	18.59	0.67
1903	76,820	8,215	113,367	18.70	0.68
1904	78,987	8,490	117,162	18.61	0.67
1905	80,439	8,625	119,025	18.65	0.68
1906	86,197	9,225	127,305	18.69	0.68
1907	91,497	9,555	131,859	19.15	0.69
1908	84,130	8,725	120,405	19.28	0.70
1909	89,189	9,275	127,995	19.23	0.70
1910	89,728	9,295	128,271	19.31	0.70
1911	87,183	9,020	124,476	19.33	0.70
1912	89,491	9,330	128,754	19.18	0.70
1913	88,128	9,170	126,546	19.22	0.70
1914	83,126	8,565	118,197	19.41	0.70
1915	78,217	8,020	110,676	19.51	0.71
1916	82,596	8,530	117,714	19.37	0.70
1917	77,640	7,940	109,572	19.56	0.71
1918	73,469	7,310	100,878	20.10	0.73
1919	76,701	7,725	106,605	19.86	0.72
1920	78,087	7,790	107,502	20.05	0.73
1921	66,263	6,580	90,804	20.14	0.73
1922	74,098	7,605	104,949	19.49	0.71
1923	81,991	8,545	117,921	19.19	0.70
1924	79,892	8,260	113,988	19.34	0.70
1925	79,724	8,380	115,644	19.03	0.69
1926	79,242	8,225	113,505	19.27	0.70
1927	75,924	7,805	107,709	19.46	0.70
1928	74,766	7,690	106,122	19.44	0.70
1929	78,295	8,050	111,090	19.45	0.70
1930	63,659	6,345	87,561	20.07	0.73
1931	48,444	4625	63,825	20.95	0.76
1932	37,424	3,395	46,851	22.05	0.80
1933	42,751	4,045	55,821	21.14	0.77
1934	45,361	4,355	60,099	20.83	0.75
1935	51,799	5,095	70,311	20.33	0.74
1936	59,991	5,990	82,662	20.03	0.73
1937	63,206	6,370	87,906	19.84	0.72
1938	55,346	5,570	76,866	19.87	0.72
1939	62,743	6,375	87,975	19.68	0.71
1940	66,300	6,975	96,255	19.01	0.69
1941	77,432	8,050	111,090	19.24	0.70
1942	76,567	8,085	111,573	18.94	0.69
1943	73,371	7,560	104,328	19.41	0.70
1944	72,213	7,455	102,879	19.37	0.70
1945	65,963	6,605	911,49	19.97	0.72
1946	75,422	7,705	106,329	19.58	0.71
1947	79,140	8,090	111,642	19.56	0.71
1948	80,181	8,365	115,437	19.17	0.69
1949	70,383	7,340	101,292	19.18	0.69
1950	82,814	8,520	117,605	19.44	0.70
1951	83,472	8,730	120,778	19.12	0.69
1952	81,464	8,765	120,813	18.59	0.67
1953	84,182	8,770	120,990	19.20	0.70
1954	83,469	8,730	120,451	19.12	0.69
1955	90,273	9,195	126,981	19.64	0.71

Table 40-1. Industrial roundwood productivity (product output per unit of roundwood input)

Year	Total industrial wood product production (thousand tons)	Roundwood input for production		Industrial wood productivity (industrial wood product output per unit of roundwood input)	
		(million ft^3)	(thousand short tons)	(lb/ft^3)	(tons/ton)
1956	91,858	9,590	132,534	19.16	0.69
1957	86,501	8,590	118,226	20.14	0.73
1958	87,827	8,500	116,969	20.67	0.75
1959	97,302	9,355	128,844	20.80	0.76
1960	88,651	8,875	122,557	19.98	0.72
1961	88,943	8,665	119,618	20.53	0.74
1962	92,674	8,950	123,646	20.71	0.75
1963	98,468	9,410	130,154	20.93	0.76
1964	104,539	10,000	138,341	20.91	0.76
1965	108,850	11,231	156,255	19.38	0.70
1966	113,172	11,520	160,458	19.65	0.71
1967	110,976	11,333	157,552	19.59	0.70
1968	115,986	11,784	163,238	19.69	0.71
1969	117,566	11,818	163,948	19.90	0.72
1970	115,751	11,851	163,875	19.53	0.71
1971	121,339	12,114	167,512	20.03	0.72
1972	128,690	12,456	172,226	20.66	0.75
1973	132,863	12,705	175,923	20.92	0.76
1974	125,754	12,031	167,125	20.91	0.75
1975	113,612	10,904	150,609	20.84	0.75
1976	128,193	12,103	167,084	21.18	0.77
1977	134,878	12,530	172,991	21.53	0.78
1978	139,249	12,930	178,889	21.54	0.78
1979	141,870	13,221	183,002	21.46	0.78
1980	134,030	12,081	167,959	22.19	0.80
1981	129,293	11,467	159,174	22.55	0.81
1982	124,165	11,328	157,621	21.92	0.79
1983	141,708	12,891	179,416	21.99	0.79
1984	149,916	13,368	186,574	22.43	0.80
1985	148,675	13,400	187,048	22.19	0.79
1986	160,650	14,644	204,535	21.94	0.79
1987	170,251	15,385	214,546	22.13	0.79
1988	174,510	15,618	218,165	22.35	0.80
1989	175,444	15,722	220,233	22.32	0.80
1990	176,164	15,577	218,500	22.62	0.81
1991	171,482	14,894	209,193	23.03	0.82
1992	180,125	15,280	214,946	23.58	0.84
1993	182,205	15,011	212,058	24.28	0.86
1994	188,569	15,306	216,293	24.64	0.87
1995	187,601	15,430	218,645	24.32	0.86
1996	189,362	15,258	216,092	24.82	0.88
1997	195,566	14,790	208,185	26.45	0.94
1998	196,569	14,899	210,217	26.39	0.94
1999	203,229	15,032	211,464	27.04	0.96

Sources: 1900–1994, Ince (2000); 1995–1999, Howard (2001).