Table FG.5 Ecosystems: Area, Population, and Protected Area

Sources: Various

	International Geosphere-Biosphere Programme (IGBP) Classification (000 km2)			Pilot Analysis of Global Ecosystems (PAGE) Classification		
	IGBP Land Area	Urban Area {a}	Agri-cultural Mosaic Area {b}	PAGE Area (000 km2) {c}	Population (000) {d}	Protected Area (000 km2) {e}
GRASSLANDS	**53,544**	**1,010**	**7,172**	**52,544**	**792,711**	**3,989**
Asia (Excl. Middle East)	9,033	141	1,281	8,892	249,495	586
Europe	7,072	116	189	6,956	20,491	248
Middle East & N. Africa	3,031	161	159	2,871	111,882	216
Sub-Saharan Africa	14,546	83	3,531	14,464	312,935	1,329
North America	6,816	238	518	6,583	6,032	791
C. America & Caribbean	1,130	82	24	1,048	30,533	56
South America	5,017	150	1,416	4,872	57,529	307
Oceania	6,898	40	54	6,859	3,814	457
FORESTS	**29,905**	**930**	**1,727**	**28,974**	**446,470**	**2,453**
Asia (Excl. Middle East)	3,812	91	192	3,721	231,782	302
Europe	6,957	226	338	6,731	43,713	155
Middle East & N. Africa	100	10	44	90	6,724	1
Sub-Saharan Africa	2,672	13	162	2,659	53,823	155
North America	7,564	449	965	7,115	30,764	711
C. America & Caribbean	997	59	1	939	33,940	88
South America	6,928	67	26	6,861	39,860	957
Oceania	874	17	0	857	5,864	84
AGRICULTURE	**27,890**	**2,407**	**X**	**36,234**	**2,790,582**	**1,594**
Asia (Excl. Middle East)	8,874	683	X	10,370	1,991,214	268
Europe	6,840	763	X	7,448	311,923	338
Middle East & N. Africa	1,025	136	X	1,230	99,662	11
Sub-Saharan Africa	2,141	38	X	5,837	204,901	476
North America	2,867	511	X	4,406	47,927	97
C. America & Caribbean	517	48	X	611	26,973	43
South America	4,991	216	X	5,642	105,083	317
Oceania	635	13	X	690	2,899	45
OTHER	**18,136**	**395**	**180**	**22,343**	**1,812,688**	**X**
ECOSYSTEM TOTALS {f}	**129,476**	**4,745**	**9,079**	**X**	**X**	**X**

Notes: {a} Area defined by the Nighttime Lights of the World database within each IGBP ecosystem category (i.e., grassland, forest, other).
{b} Area classified as 30-40% cropland within each IGBP ecosystem category (i.e., grasslands, forests, other).
{c} Boundaries for each PAGE ecosystem category are defined independently resulting in an overlap of agriculture ecosystem area with grassland and forest ecosystem area. Area estimates for grasslands and forests exclude urban areas as defined by the Nighttime Lights of the World database; area estimates for agriculture include urban areas.
{d} Estimates for grassland and forest ecosystems are based on boundaries of PAGE ecosystem categories; estimates for agriculture ecosystems are based on PAGE ecosystem area definition for agriculture minus the urban areas, as defined by the Nighttime Lights of the World database. See Technical Notes for population estimates of total PAGE agriculture ecosystem area.
{e} Estimates are based on boundaries of PAGE ecosystem categories.
{f} Global totals cannot be calculated for PAGE categories because the agriculture ecosystem area overlaps with the grassland and forest ecosystem areas.

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Sources: Landcover: Global Land Cover Characteristics Database Version 1.2 (T.R. Loveland, B.C. Reed, J.F. Brown, D.O. Ohlen, Z. Zhu, L. Yang, J. Merchant. 2000. "Development of Global Land Cover Characteristics Database and IGBP DISCover from 1 km AVHRR data." International Journal of Remote Sensing 21 [6]:1303–1330). Available online at: http://edcdaac.usgs.gov/glcc/glcc.html. U.S. Geological Survey (USGS) Earth Resources Observation Systems (EROS) Data Center (USGS/EDC) 1-km Land Cover Characterization Database, Revisions for Latin America (USGS/EDC, Sioux Falls, SD, 1999). Country boundaries: Environmental Systems Research Institute (ESRI), Digital Chart of the World CD-ROM (ESRI, Redlands, CA, 1993). Urban area: National Oceanographic and Atmospheric Administration—National Geophysical Data Center (NOAA/NGDC) Stable Lights and Radiance Calibrated Lights of the World CD-ROM (NOAA/NGDC, Boulder, CO. View Nighttime Lights of the World database online at: http://julius.ngdc.noaa.gov:8080 /production/html/BIOMASS/night.html. Population: Center for International Earth Science Information Network (CIESIN); Columbia University; International Food Policy Research Institute (IFPRI); and World Resources Institute (WRI) Gridded Population of the World, Version 2 alpha. (CIESIN, Columbia University, Palisades, NY, 2000). Available online at: http://sedac.ciesin.org/plue/gpw.

This table provides summary statistics for ecosystems used in Chapter 2 of World Resources 2000–2001. All area estimates use a common global land cover characteristics database, which was initiated by the IGBP and produced by the USGS and the University of Nebraska-Lincoln. The land cover regions in the database based on interpretation of advanced very-high-resolution radiometer (AVHRR) satellite imagery consolidated into monthly global composites for the period April 1992 to March 1993.

The global land cover characteristics database identifies between approximately 130 and 260 seasonal land cover regions (SLCRs) per continent (e.g., 167 for South America and 205 for North America). Each SLCR represents an area with similar land cover associations and distinctive patterns of biomass production such as the onset, peak, and duration of greenness. As part of a broader global land cover characterization process, seven different thematic global maps, each with a separate land cover legend, were produced by aggregating these detailed SLCR map units. These seven maps have corresponding customized legends to make them useful for specific global applications such as environmental modeling, land management, and monitoring. Pilot Analysis of Global Ecosystems (PAGE) researchers worked directly from the SLCR units to delineate the extent of agricultural ecosystems. They used two of the seven global legends to delineate forest and grassland boundaries and to calculate carbon storage: 1) the IGBP legend, developed to assist global change investigations, and 2) the Olson legend, produced for carbon cycle studies.

IBGP land area is based on the IGBP legend, with the exception of grasslands. The 17 separate IGBP land cover classes were aggregated to four broad categories: grasslands, forests, agriculture, and other. Grasslands consist of areas classified as open shrubland, closed shrubland, woody savanna, savanna, and grassland under the IGBP legend. It also includes an additional land cover type, tundra, which is not explicitly defined in the IGBP legend. This class is defined here by the Olson legend and typically overlaps with the IGBP shrubland, barren, and snow/ice classes. Forests include the IGBP categories for evergreen needleleaf forest, evergreen broadleaf forest, deciduous needleleaf forest, deciduous broadleaf forest, and mixed forest. Agriculture aggregates the IGBP categories for cropland and cropland/ natural vegetation mosaic. Other includes the IGBP categories for wetlands, snow/ice, urban areas, and barren land.

While the IGBP legend includes a specific category that depicts urban areas, summarized under the category "other" in the table, the data used to delineate urban areas (Digital Chart of the World) are out-of-date and underestimate urban extent. Thus, PAGE researchers used a different data set to delineate urban area. It is based on the Nighttime Lights of the World database, a 1-kilometer resolution map derived from nighttime imagery from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) of the United States. The data set contains the location of stable lights, including frequently observed light sources such as fires and lightning. The extent of "lit" area may be slightly overestimated due to the sensor's resolution and factors such as reflection from water and other surface features. It is a good indicator of the spatial distribution of settlements and infrastructure, but should not be interpreted as a measure of population density. The mean settlement size required to produce enough light to be detected is much greater in developing countries than in industrialized countries because of differences in energy consumption. The urban area estimates result from an overlay of IGBP land area, as

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defined in the first column of this table, with the Nighttime Lights of the World database. Area estimates are summarized by grasslands, forests, agriculture, and other, and are used to define PAGE extent.

Agricultural mosaic area represents the area of the 30–40 percent agriculture class within the IGBP grassland and forest extent as defined by the PAGE area for agriculture (see definition below). It provides an indication of the overlap between IGBP forest and grassland area and the PAGE area for agriculture.

Boundaries for PAGE area are defined independently using different legends for grassland, forest, and agriculture.

PAGE area for grassland and forest uses the IGBP and Olson legends. The extent for PAGE grassland and forest were calculated by subtracting a map of urban area, as defined in the second column of this table, from a map of IGBP grassland and forest extent, as defined in the first column of this table.

PAGE area for agriculture is based directly on the SLCR map units. The classification system used in the original SLCR map units allows for opportunities to improve the data interpretation for agricultural purposes, and improve upon the thematic maps generally presented at a global level that use the IGBP and Olson legends. These global land cover interpretations do not explicitly recognize all occurrences of agriculture occupying a less than dominant share (60 percent) of a SLCR class.

In consultation with the USGS/EDC, the potential agricultural content of all 961 SLCRs defined globally was reassessed. For example, an area interpreted as containing more than 60 percent forest and classified as "deciduous broad-leaf forest" cover using the IGBP classification scheme might, upon closer inspection of its naming convention, contain an agricultural subcomponent (i.e., its detailed classification might describe it as "deciduous broad-leaf forest with cropland"). The reassessment aimed to identify all such occurrences of agriculture, even when they occurred as minor cover components, although this was limited by the SLCR naming convention which did not identify an agricultural component if it occupied less than 30 percent of the SLCR region.

This reassessment resulted in a global map with three primary agricultural cover categories showing agricultural area intensity at 30–40, 40–60, and greater than 60 percent agriculture. PAGE area for agriculture thus adds up all 1-kilometer by 1-kilometer cells of the land cover characteristics database for which agricultural area intensity is more than 30 percent. Relative to the IGBP classification, the PAGE classification expands the geographic extent of agriculture by including areas where agriculture is not the dominant land cover. In addition to the IGBP agricultural area, it includes about 6 percent of the IGBP forest area and 13 percent of the IGBP grassland area as shown in the second column of this table. Furthermore, PAGE area for agriculture includes urban areas (with at least 30 percent agriculture) because no explicit urban class was assigned in the SLCR map units. This makes the PAGE agriculture area not directly comparable to the PAGE grassland and forest extent, which subtracted urban areas.

The reinterpretation to obtain agricultural extent, however, does not address some weaknesses in the original land cover characteristics database such as regional variations in the reliability of the satellite data interpretation, reflecting differences in the structure of land cover and in the availability of reliable groundtruthing data. Specific agricultural land-cover types whose interpretation is considered to be problematic include irrigated areas, permanently cropped areas (especially tree crops in forest margins), and extensive pastureland. Similarly, the adjustments made to obtain a better estimate for urban areas do not overcome the intrinsic limitations of the original land cover characteristics database, namely the coarse resolution and lack of auxiliary data to fine tune the satellite image interpretation for selected regions (e.g., in Africa). Therefore, all area estimates are most useful in depicting the relative size of broad ecosystem categories rather than providing an absolute estimate of the world's surface covered by trees, grasses, and other vegetation types.

Population data came from an inventory of national censuses, which were compiled by administrative units. These data were standardized to 1995 and translated into a global grid consisting of 4.6-kilometer by 4.6-kilometer cells, each cell accurately reflecting population counts in the respective administrative units intersecting with this cell. The map of PAGE extent was

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scaled to match the resolution of the population data, i.e., a generalization from 1-kilometer by 1-kilometer to 4.6-kilometer by 4.6-kilometer cells. To calculate population by ecosystem category, population was assigned to the majority ecosystem type. For example, population in cells that had 51 percent forest and 49 percent grassland were allocated to the forest category.

All population estimates in the table are based on the boundaries of the PAGE extent. Population for the PAGE area for agriculture, however, excludes urban areas, as defined by the Nightime Lights of the World database, to be comparable with grassland and forest population estimates. The population estimates for total PAGE agriculture area, which includes urban areas, are as follows (in thousands): Agriculture Total – 4,002,386; Asia (excluding the Middle East) – 2,608,216; Europe – 616,663; Middle East and North Africa – 148,576; Sub-Saharan Africa – 232,742; North America – 179,263; Central America and the Caribbean – 40,527; South America – 171,869; and Oceania – 4,530. Because of overlapping areas between PAGE categories, population estimates in this table for PAGE cannot be added to produce a global total.

Protected area represents the total area of each PAGE classification that falls within a protected area as designated by IUCN. A global map containing parks larger than 1,000 hectares and falling under IUCN management categories I–VI was produced for the analysis. For protected areas represented by points only, circular buffers corresponding to the size of the protected area were generated. This global map of protected areas was then intersected with the PAGE map and area estimates were summarized for each ecosystem category for all protected areas that had more than 50 percent in grassland, forest, and agriculture, respectively.