



ELSEVIER

Forest Ecology and Management 128 (2000) 3–10

Forest Ecology
and
Management

www.elsevier.com/locate/foreco

Omissions, commissions, and decisions: the need for integrated resource assessments

H. Gyde Lund^{a,*}, Susan Iremonger^b

^aForest Information Services, 8221 Thornwood Ct., Manassas, VA 20110-4627, USA

^b7 Leeson Park Avenue, Dublin 6, Ireland

Accepted 24 September 1999

Abstract

Agricultural lands are essential for providing food and forage for maintaining a healthy environment. Growing human populations are placing increasing demands for new lands for agricultural production. At the same time, there is a need to maintain or increase our forest cover for biodiversity and carbon sequestration. Unfortunately, our land base is limited. Consequently, there is strong competition between those lands will be used for forestry and those that will be used for agriculture. Current assessments of agriculture and forested lands are often carried out by separate entities. Often, there is duplication of data collection, information gaps, etc. The bottom line is that we do not really know how much land currently serves the needs of agriculture and forestry, which lands are best suited for conversion to alternate use, and where they are located. In order for decision makers to make more informed decisions, we need complete and up-to-date geo-referenced inventories. The purpose of this paper is to discuss the problems of separate resource inventories and to present ways to overcome these problems by integrated assessments. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Forest assessments; Agricultural censuses; Integrated assessments

1. Introduction

Agricultural or croplands, forestlands (includes lands classed as forests and woodlands), and other lands provide a variety of goods and services for humankind (e.g. food, fuel, construction material, biodiversity, soil protection, and nutrient cycle maintenance). They are essential for human survival. The

year 2000 CE will be a milestone on which mankind's management of the earth's resources will be judged. With increasing human populations, it is imperative then that agriculture and forest resource assessments be as complete and as accurate as possible to help decision makers develop long-term strategies for managing these resources. Due to of the competition among land uses and users, decision making will become more and more complex. Sound resource information, together with advanced technology, will make the job easier.

Effective resource and ecosystem management to meet the needs of future populations, whether it is at

* Corresponding author. Tel.: +1-703-368-7219; fax: +1-703-257-1419.

E-mail address: gklund@worldnet.att.net (H.G. Lund).

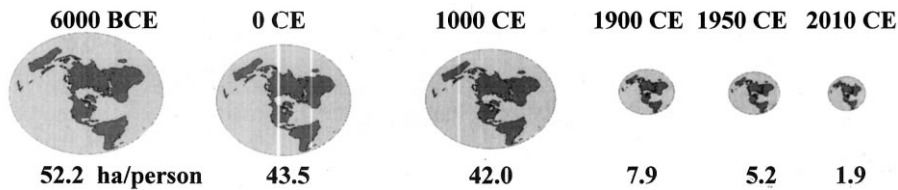


Fig. 1. Changing biosphere (land area) per person over time. Source: Lund, 1998a.

the local or global level, must be underpinned by a sound knowledge base. Resource inventories provide the information necessary to create a picture of the current resources, and from these, estimates of future supplies and shortages can be developed.

In many parts of the world, forests, aquifers, pasture lands and fisheries are being utilized faster than they can be replaced (Facing the Future Organization, 1997). The grazing needs of the world's herds of cattle and flocks of sheep and goats are outpacing the sustainable yield of grasslands. Forestlands are shrinking as the demand for new lands continues to grow. Estimates of species extinction rates vary from 5000 species per year (Goodland, 1993) to 104 (Facing the Future Organization, 1997).

Fig. 1 shows the change of living biosphere or land area per person for selected periods of time. With the reductions in 'living space', the competition for land and land use increases. With the increasing need for agricultural lands, accurate estimates of current land cover and land use, and the rate at which the areas are changing, are all-important. In order to plan for the living standards of the world's population in the future, we need to know:

- the area and geographical location of land used for agriculture,
- the area and geographical location of land used for forest goods and services,
- the current and forecasted ratio of each to the world's population (an estimate of the amount needed per person), and
- the rate of change and distribution of change patterns in the population, agricultural lands and forestlands.

The premise behind this is that if we can provide a picture of the future, given current rates of change and location scenarios, we will be in a much better position to plan for avoiding potential catastrophes. Currently,

because of different methods of reporting national statistics, different definitions and criteria, there is no clear idea of the accuracy of the available estimates (see discussion below). However, using the statistics available, it is possible to draw the trends that forecast forest disappearance concurrently with agricultural expansion and population increases. A recent study showed that by 2025, assuming the rate of global forest reduction remains steady, the ratio of forest-to-people will have decreased from a current 0.7 ha per person to 0.46 ha per person (Iremonger et al., 1997).

2. Needs

Fig. 2 shows the changes in land use from 6000 BCE to 2010 CE. Agricultural lands increase as human populations increase. Forests (including other wooded lands) and other lands (lands not qualifying as agricultural or forestlands) decrease as crop lands expand. The source of croplands is, of course, the conversion of forestlands and other lands.

Most of the forest disappearance will be attributable to expansion of agriculture, although forest degradation in particular is caused by fuelwood collection in many parts of the world. According to Kindall and Pimentel (1994) and FAO (1997f), over half of the additional agricultural lands will come from forested lands in the developing countries. The remaining will have to come from other lands. The Millennium Institute (1997) reports that the bulk of our food (98%) comes from the land. Approximately, 22% of the earth's land area is potentially arable. Most of the land (78%) is too wet, too poor, too cold, too dry, or too steep for cultivation. The potentially arable land is about 3.3 billion ha. Approximately, half of this (1.4 billion ha) is already used for crop production and the remainder is used for grazing.

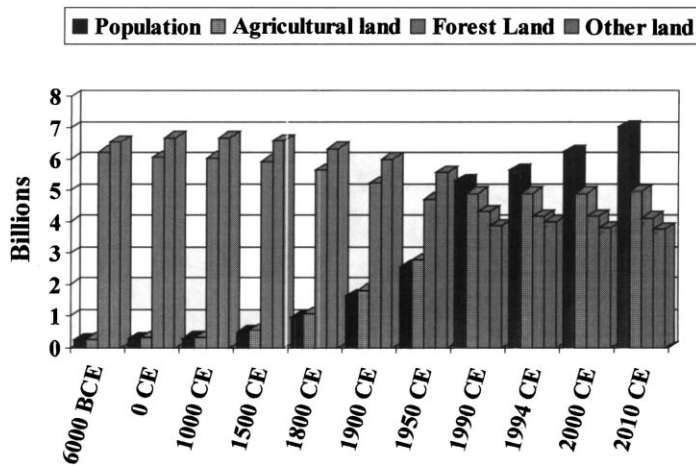


Fig. 2. Trends in land use with increasing population for selected periods in time (billions for people, ha for lands). Source: Lund, 1998a.

2.1. Agriculture needs

In 1994, FAO (1997c) estimated amount of area devoted to agriculture to be 4872 million ha worldwide. In 2010, FAO (1997f) estimates that 90 million ha more will be needed for agriculture (FAO, 1997f). This brings the total area needed for agriculture in 2010 to be about 4963 million ha. Current and calculated projected agricultural lands needs are shown in Fig. 2. There is a fixed amount of land, and every hectare cleared of forest for farming is one less hectare that can be used for timber production and biodiversity protection. The only ways to make up for this in terms of timber production is to increase

production from existing forestlands and establishing intensively managed plantations of genetically improved, fast growing species. This compromises biodiversity protection but this can be mitigated by the style of management and retaining some of the land in native forest.

2.2. Forest needs

Fig. 3 shows the current (1994) forestland area (forests and woodlands), probable forestland area (based on current estimates of deforestation and conversion to croplands) and needed forestland area (based on human population) to meet minimum sup-

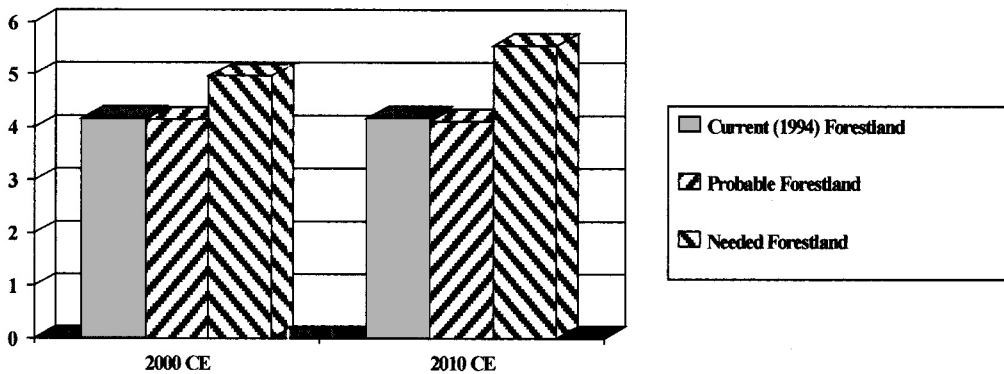


Fig. 3. Current (1994), probable, and needed forestland area (in billions of hectares) to meet the needs of increasing human population. Source: Lund, 1998a.

plies of wood, fuel, and fiber for the years 2000 and 2010 CE. Nilsson (1996) reports that all signs indicate that we do not have enough forestlands globally to fulfill the current and future demands. There may not be a physical shortage, but the different kinds of demands will be difficult to meet.

There are three primary uses of forest and woodlands that we must consider: biodiversity conservation, carbon sequestration, and forest and woodland products (fiber, wood, and fuel).

2.2.1. *Biodiversity conservation*

The World-Wide Fund for Nature (WWF, 1997) recommends that governments establish an ecologically representative network of protected areas, covering at least 10% of each of the world's forest-types by the year 2000, demonstrating a range of socially and ecologically appropriate models. In 1994, there were 4172 million ha of forest and woodland (FAO, 1997c). Ten percent of that would be 417 million ha. This land would also serve part of the carbon sequestration needs but would not provide the food, fiber and fuel-wood needs because the land is protected. Additional lands would be needed for these uses.

2.2.2. *Carbon sequestration*

The Noordwijk Declaration on Climate Change (1989) called for an annual net increase in global forest cover of 12 million ha by the year 2000 to mitigate carbon build-up. Given that about 17 million ha of tropical forestlands are lost each year, this implies an afforestation target of 30 million ha per year (Nilsson and Schopfhauser, 1995). Even if we assume that the current forest-to-people ratio is sufficient or carbon sequestration, we will need about 1 billion more hectares of forest by the year 2010 to maintain the ratio balance: a total of nearly 5 billion ha.

2.2.3. *Forest and woodland products*

Over the past four decades, per capita consumption of wood (both industrial wood and fuelwood) has changed little. Wood and wood products consumption is estimated to be 3.4 billion cubic meters per year or 0.6 m³ per person (Solberg, 1996). Sutton (1993) estimated the consumption to be 0.7 m³ per person per year. Using current forest area figures, an estimated 0.73 ha of forest and woodlands is needed for

wood and wood products. Assuming a constant demand per person, 5.13 billion ha of forest will be needed in 2010 due to population increase.

2.2.4. *Total forest and woodland needs*

The 5.13 billion ha we need for forest and wood products will also meet our predicted needs for carbon sequestration, since it is the larger of the two figures. It will also meet the needs for environmental protection. However, since the lands used for forest and woodland products will be managed, we will need the additional 417 million ha for preservation and maintaining biodiversity. Thus the total amount of forestlands we will need in 2010 is 5.55 billion ha. By these calculations we will be short of our needs by 1.38 billion ha by 2010, unless plans are implemented now to expand the forest base.

Note that the projections for agriculture and forestlands are based upon current needs estimates based upon existing international agreements and current technology. The bottom line is that at some point in time, those that administer agriculture and forestry programs, will be competing for land use at the global and perhaps national scales.

3. Omissions and commissions

The previous discussions assume first that we really know what we have, and secondly that our projections for the future are correct. Predicting the future always carries a degree of risk; however, we certainly should know what resources we currently have. But do we really know globally or even nationally?

FAO (1997b) reports that assembling and tabulating the mass of data in internationally comparable form presents many problems, mainly arising from differences found in countries' data as regards concepts, definitions, coverage and classifications. Definitions used by reporting countries vary considerably, and items classified under the same category often relate to greatly differing kinds of land. Ambiguous definitions and standards, indeterminate areas of responsibility and differences in data collection strategies lead to omission and commission problems for conducting global and national assessments. Table 1 shows some examples and differences between inventories conducted for forestry and agriculture. Other lands (shrub

Table 1
Example of national level data sources and characteristics

Inventory	Forest and woodland	Agricultural areas	Other lands
Responsibility	Ministry or Department of Forestry	Ministry or Department of Agriculture	varies or none
Focus	land cover	land use	land value
Primary interests	tree stocks	crops, livestock	land
Access	difficult	good	good to difficult
Rate of change	slow	rapid with season	varies
Sampling basis	statistical field samples	questionnaire/list frame	unknown

and grazing lands, agroforestry areas) are often 'no man's land.'

3.1. Omissions

Omissions are data gaps. Gaps at the global level may occur when nations do not or cannot provide the desired information. Nationally, gaps are frequently overlooked resources or lands. For example, national forest inventories often ignore forest fragments on non-forestlands, forests not on government land, trees outside the forest, lands suitable for conversion to forest and geo-referencing their information. Agricultural surveys may ignore the possibilities of lands not registered as agricultural, crops on forested land, trees on agricultural land and geo-referencing their information.

For global and national crop statistics, small holdings may be disregarded, especially, those outside of agricultural holdings, gardens and small plots. Crops grown in itinerant (shifting) agriculture are probably excluded from regular agricultural surveys. Some fruit crops are often grown outside agricultural holdings and commercial orchards to a greater degree than other crops, and they also may be excluded from national and global statistics. The production of crops and livestock whose main or exclusive use is subsistence of producers is seldom reported (FAO, 1997d). In sum, there may be too much information for certain commodities and too little for others.

Surprisingly, similar information on existing forest resources and how they could be utilized is also lacking. Much confusion exists over the way foresters and administrators estimate potential and economic wood supply. Non-wood demands (such as life-cycle approaches, biodiversity, environmental protection,

water, hunting, eco-tourism, and recreation) will continue to grow.

Finally, both agriculture and forest inventories usually overlook areas for possible expansion. This information becomes more critical for the decision maker as the population and its demands grow. Due to omission errors, we may have more resources than we think. Therefore, the resource situation may not be as dire as it may seem.

3.2. Commissions

There are two types of commission errors that we address: those that may provide duplicate information or duplicate coverage of the lands, and those of labelling or classification that limit interpretation of data. Duplicate reporting occurs when the areas of inventory/assessment responsibility are not clearly defined and not mutually exclusive, for example, in the case of the statistical division and the forestry division of the FAO, which separately collect data and report on areas of forest and woodland (Jansen, 1997, pers. com.). As definitions differ between the two departments, not only do national agencies have to report twice on the same subject to FAO, but they may also have to use different criteria by which to report. For example, the statistics division would not include forested recreation areas in their statistics, whereas FAO forestry division would. The statistical department treats rubberwood plantations as 'permanent' cropland land (FAO, 1997e), whereas the forestry division would include such plantations under 'forests' (ECE/FAO, 1997). Both the statistics and forestry divisions are now working to resolve their data collection and reporting responsibilities regarding forest and woodland. However, there are additional global assessments and conventions which require very simi-

lar data such as the World Agricultural Census, and the Desertification, Biodiversity, and Climate Change Conventions resulting from the 1992 United Nations Conference on Environment and Development (UNCED). Each requires data on land cover and most on forests (Lund and Boley, 1995). Each assessment and convention relies on national statistics often provided by different ministries or departments. Opportunities for commission errors increase with the number of organizations or groups to whom the ministers must report and the number of ministries or departments providing data.

Placing labels on various classes of land that tend to lead the decision maker to a biased conclusion is also a commission error. The use of terms like degraded forestland, wasteland, non-forest, and white areas on maps (displaying only forested areas or crop areas and little else) tend to bias the reader towards reaching some conclusion about how those lands should be managed. What may appear to be degraded forestland to one interpreter, may be improved agricultural land to another. The 'non' category tells the decision maker what the land is not but not what it is.

4. Decision needs

It should be clear from the above discussion that future land use decisions will require more complete information. Decision makers will need information on all resources on all lands along with demographic data.

To provide that information, inventory designers must take more holistic views of *all* resources and potential products to provide the more complete datasets to establish baselines for monitoring the environment. Traditionally, single-function inventories must give way to integrated and multiple resource data collection schemes in an effort to reduce costs and to get more information about the complete ecosystems that people manage. To help promote more consistent data and more comprehensive inventories, the International Union of Forestry Research Organizations developed a set of guidelines to assist countries in designing multipurpose resource inventories (Lund, 1998b).

There are two approaches one may use to develop national and global assessments. One is a bottom up

approach where data are obtained at the local level and aggregated into a broader assessment as is currently used in most UN assessments. The other is the top down approach. Here the program is carried out at a broader scale and the results and data are made available locally. Frequently discussed questions are (a) are data needed just at the broader scale or at the local scale as well, and (b) is it possible to get accurate results without involving the local reporters?

The answers seem to be that data are needed at a local scale for local planning exercises, but the local decision makers also need a broader perspective to see how their decisions relate to the surrounding lands around. Broad-scale surveys, particularly of land cover, can be drawn using the latest technology, but field-sampling and ground-truth exercises are needed to ensure an accurate product. Also, often the ancillary information (mentioned above) is only available at the local level. Additionally, there is the question of scale, and a global overview product, for example, will not be as detailed as a product with a regional or national focus.

5. Recommendations

Future assessments may be improved by expanding data collection and reporting beyond the forest and croplands, capitalizing more on the latest technologies and partnerships, and developing a firm base using integrated inventory approaches and GIS and then using remote sensing to monitor changes.

Nearly all natural resource issues, whether they are environmental, social, economic, ecological or political, are national as well as global issues. For these reasons, there is an increasing need for the inventory and monitoring of all lands and waters and the sharing of the resulting information with the international community especially through the UN. Current global and national assessments are sectorially oriented resulting in omissions and commission errors. The results of UNCED and the need to integrate our data collection and reporting should change the way we approach global assessments in the next century. Nearly every nation agreed to the documents resulting from UNCED. Therefore, they have some responsibility for gathering and providing the necessary data. Currently, however, there is no agreed system in place

that gives the necessary truly integrated picture of the world's resources. Without such a system, developing an effective strategy for planning for future needs is not possible.

Globally, the international community should develop joint assessment objectives by consolidating the Forest Resources Assessment, World Agricultural Census and the reports required by the UNCED Conventions on Desertification, Biodiversity and Global Climate change into one consolidated effort and database. To avoid commission errors, seek national input from one primary source for each country. To avoid omission errors, nations should cover all lands and resources. To avoid commission errors, program administrators should define clear, mutually exclusive areas of inventory responsibilities. Those responsible for national-level inventories should consider:

- Integrating data collection efforts to cover all lands and resources including demographic information at national and sub-national level
- Using remote sensing to map land cover according to an internationally acceptable scheme like that used in the United Nations' AFRICOVER project (FAO, 1997a)
- Using statistical sampling to determine vegetation and its condition and a sub-sample of field plots to determine land use
- Collecting and storing basic (un-interpreted) data according to international standards including
 - Name/address of land owner, location of tract, and site information
 - Vegetation species grown or present, height, and percent cover
 - Identification of person collecting data and date of collection
- Combining all data in a common GIS and using remote sensing to monitor changes in land cover
- To keep costs low, using latest technologies and sharing assets (imagery, personnel, equipment, facilities)
- Collecting and reporting figures in conformity with the guidelines and recommendations given by international bodies including timing, concepts, standards, definitions, and coverage of data.

Implementing a program for monitoring at a global scale is quite within the capabilities of modern technology. Global land cover maps have already been

made from satellite imagery. What is needed now is recognition of this by national governments and commitment to support and work with these efforts by verifying the remotely sensed data and by providing ancillary data. This will facilitate the creation of an integrated resource status database for the world. A database of this stature would enable everyone to have a much more accurate picture of the world's resources, and enable decision makers to better plan for the future.

References

- ECE/FAO, 1997. UN-ECE/FAO Temperate and Boreal Forest Resources Assessments 2000, Terms and Definitions, United Nations Economic Commission for Europe and Food and Agriculture Organization of the United Nations, Geneva, Switzerland, 13 pp.
- Facing the Future Organization, 1997. How Many People Can The Earth Support? Facing the Future—People and the Planet, <<http://www.facingthefuture.org/sustainable.html>>, 5 pp.
- FAO, 1997a. AFRICOVER Land Cover Classification, Food and Agriculture Organization of the United Nations, Sustainable Development Program Dept., Rome, Italy, 76 pp.
- FAO, 1997b. Crop Statistics, Food and Agriculture Organization of the United Nations, <<http://www.fao.org/WAICENT/FAOIN-FO/ECONOMIC/ESS/rmcrops.htm>>, Rome, Italy, 12 pp.
- FAO, 1997c. FAOSTAT Database, Food and Agriculture Organization of the United Nations, <[http://apps.fao.org/lim500/nph-wrap.pl?Land Use & Domain = LUI](http://apps.fao.org/lim500/nph-wrap.pl?Land%20Use%20Domain=LUI)>, Rome, Italy.
- FAO, 1997d. Problems of Compiling Internationally Comparable Agricultural Statistics and Estimation Of Missing Data, Food and Agriculture Organization of the United Nations, <<http://www.fao.org/WAICENT/FAOINFO/ECONOMIC/ESS/prob.htm>>, Rome, Italy, 4 pp.
- FAO, 1997e. FAO Production Yearbook, Food and Agriculture Organization of the United Nations, <<http://www.fao.org/waicent/faostat/agricult/landuse-e.htm>>, Rome, Italy, p. 3, 1997e.
- FAO, 1997f. State of the World's Forests, 1997, Food and Agriculture Organization of the United Nations, Rome, Italy, 200 pp.
- Goodland, Robert., 1993. Ecological limits. *Context* 36, 1–12.
- Iremonger, S., Ravilious, C., Quinton, T., 1997. A statistical analysis of global forest conservation, In: Iremonger, S., Ravilious, C., Quinton, T. (Eds.), *A Global Overview of Forest Conservation Including: GIS Files of Forests and Protected Areas*, version 2, CD-ROM. CIFOR and WCMC, Cambridge, UK, 1997.
- Kindall, Henry W., Pimentel, David, 1994. Constraints on the expansion of the global food supply. *Ambio* 23(3), 1–18.
- Lund, H. Gyde, 1998a. A comparison of multipurpose resource inventories (MRIS) throughout the world, Working Paper 14, European Forest Institute, Joensuu, Finland, 46 pp.

- Lund, H. Gyde (Ed.), 1998b. IUFRO Guidelines for designing multipurpose resource inventories, IUFRO World Series, Int. Union Forestry Res. Org., vol. 8, Vienna, Austria, 216 pp.
- Lund, H. Gyde, Boley, Margaret, 1995. National resource inventorying and monitoring needs: the said and unsaid from UNCED. *Schweizerische Zeitschrift für Forstwesen* 146(12), 953–964.
- Millennium Institute, 1997. Global 2000 Revisited, <http://www.labor.net.org/millennium/inds/bwsow.html>, 10 pp. 1997.
- Nilsson, Sten, 1996. Do we have enough forests? IUFRO Occasional Paper No. 5, Int. Union Forestry Res. Org., Vienna, Austria, 38 pp.
- Nilsson, Sten, Schopfhauser, Wolfgang, 1995. The carbon-sequestration potential of a global afforestation program. *Climate Change* 30, 267–293.
- Noordwijk Declaration on Climate Change, 1989, Atmospheric Pollution and Climate Change, Ministerial Conference, 6, 7 November 1989, Noordwijk, The Netherlands.
- Solberg, B. (Ed.), 1996. Long-term trends and prospects in world supply and demand for wood and implications for sustainable forest management, Research Report 6, European Forest Institute, Joensuu, Finland, 150 pp.
- Sutton, W.R.J., 1993. The World's Need for Wood. Paper Presented at the Conference on the Globalization of Wood: Supply Processes, Products and Markets, 1 November 1993, Forest Prod. Soc. Oregon Resour. Institute, Portland, OR, 1993.
- World-wide Fund for Nature (WWF) 1997. Target 1, Protected Areas, <http://www.panda.org/tda/forest/new/target1.html>, 1 pp.