Selected Satellite Images of Our Changing Environment

ISBN: 92-807-2272-5

United Nations Environment Programme
PO Box 30552, Nairobi, Kenya
Tel: +254 2 621234
Fax: +254 2 623943/44
http://www.unep.org
http://www.unep.net

United Nations Environment Programme
Division of Early Warning and Assessment-North America
47914 252nd Street, EROS Data Center, Sioux Falls, SD 57198-0001 USA
Tel: 1-605-594-6117
Fax: 1-605-594-6119
info@na.unep.net
www.na.unep.net
www.unep.org

For bibliographic and reference purposes this publication should be referred to as:

UNEP (2003), “Selected Satellite Images of Our Changing Environment”. UNEP/DEWA/RS.03-1
Division of Early Warning and Assessment (DEWA)
United Nations Environment Programme (UNEP)
P.O. Box 30552
Nairobi, Kenya

DISCLAIMER

Selected Satellite Images of Our Changing Environment

United Nations Environment Programme
2003

Acknowledgments

UNEP acknowledges the contributions made by many individuals and institutions in the preparation and publication of Selected Satellite Images of Our Changing Environment. A full list of names is included on page 124.

Production and Support Team

Ashbindu Singh
Kim Giese
Nazmul Hossain
Mark A. Ernste
Shingo Ikeda
Anil Raghavan
Sandra Prince
Michael Poppen
Rynn Lamb
Eugene Fosnight
Jane S. Smith
Elitsa Peneva
Pascal Peduzzi
Hassan Partow
Jesper Kofoed
Nicole Strub
Christian Lambrechts
Dominique Del Pietro

Editorial Review Team

Dr. Adrian Newton
Mr. S. K. Puri

To obtain a copy of the report, please contact:

Ashbindu Singh, Regional Coordinator
UNEP/GRID – Sioux Falls
USGS/EROS Data Center
47914 252nd St
Sioux Falls, SD 57198
Phone: (605) 594-6117
Fax: (605) 594-6119
E-mail: singh@usgs.gov

Table of Contents

Foreword

Scientifically valid environmental data and information are crucial to gain understanding of global change impacts and causes as well as to support enlightened decision-making. While collection and analysis of scientifically credible environmental information, particularly for developing regions, continues to be a major challenge, visualizing and communicating environmental changes through appropriate use of available information is also proving to be an equally arduous proposition. The latter can be particularly useful in understanding the outcome of human induced interference in natural systems, and in settings where the decision maker can explore alternative scenarios and develop a deeper knowledge of the context of decisions. It should be noted that even developed countries benefit from visualizing the complexities of environmental changes using satellite data, for example to detect changes in an ecosystem over time.

The overall objective of UNEP's Division of Early Warning and Assessment (DEWA) is to improve the knowledge of decision-makers at national and international levels with regard to global environmental trends, condition and emerging issues. To assist countries with their goal of sustainable development, UNEP provides these data sets on land cover changes to illustrate the impacts of existing policies on societal behaviors in land management and environmental protection.

UNEP has developed a deep understanding of the critical role of data in general, and satellite imagery in particular, in its endeavor to raise the profile of environmental issues across all levels of governments and societies. UNEP proposes to strengthen its links with relevant institutions in industrialized countries to enhance visualization of scientific information and encourage them to make such data accessible to developing countries. The identification, acquisition and dissemination of satellite imagery of critical ecosystems will help build capacity of national-level institutions to undertake their own environmental assessments and to report more effectively to satisfy their obligations under various conventions. Improved, integrated State of the Environment reporting at the national level is expected to enhance UNEP's ability for such reporting at the global level.

This publication *Selected Satellite Images of Our Changing Environment* uses satellite images to document environmental changes during the last thirty years in 50 selected sites around the world. I hope the information provided will not only be useful in the context of selected locales, but will also underscore the intrinsic value of harnessing, visualizing and communicating technologies to gain a deeper understanding of the dynamics of environmental changes.

Daniel Claasen
Acting Director
United Nations Environment Programme
Division of Early Warning and Assessment

Left: NASA Goddard Space Flight Center—Reto Stöckli, Robert Simmon
Right: USGS—Sundarban Reserve Forest, Landsat, 2000

Introduction

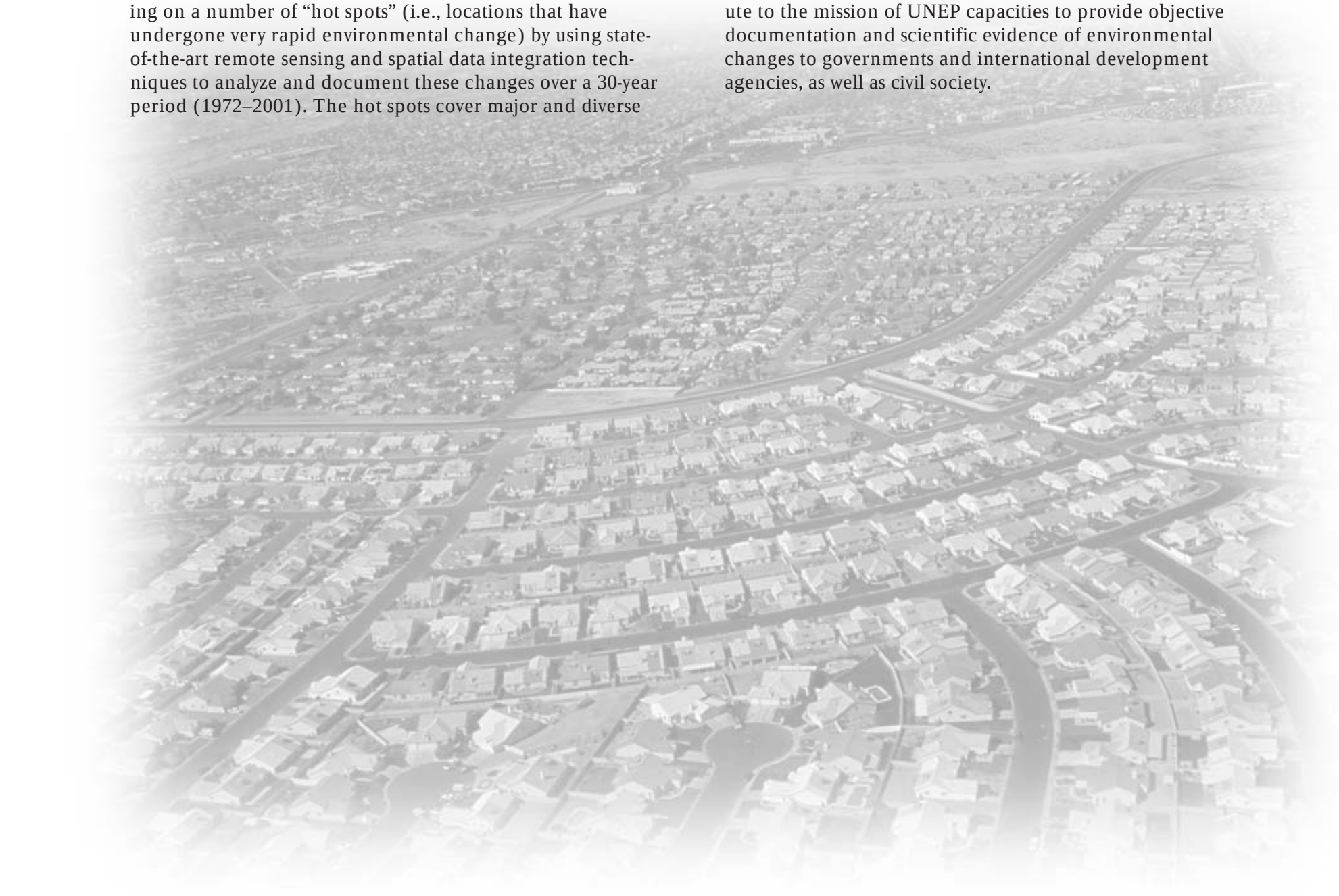
Many countries face multiple challenges arising from rapid degradation of critical natural resources, and many other environmental constraints. These constraints include inadequate rainfall and an unsustainable increase in the pressure on available resources owing to a rapidly burgeoning human population. These challenges underscore the critical and urgent need to properly manage and conserve the natural resource base. An effective management strategy must draw on a clear view of the current state of the environment, an understanding of local and regional trends and the factors driving those trends.

Increasing concern over how human activities interact and influence the global environment have led to the initiation and formulation of a number of environment assessment programs, treaties and agreements which call for increased, systematic observation of Earth systems. Such systematic observations require consistent, geographically referenced data that can be acquired over large areas repeatedly and at a reasonably low cost, using remote sensing technology. Since the launch of the first Meteorological Satellite in 1960, satellite remote sensing has emerged to be a cost-effective method for conducting time-series, large-scale observations of the Earth's systems. Satellite images can be used to map the entire world and to generate a number of global datasets needed for various thematic applications.

This publication directly addresses these issues by focusing on a number of “hot spots” (i.e., locations that have undergone very rapid environmental change) by using state-of-the-art remote sensing and spatial data integration techniques to analyze and document these changes over a 30-year period (1972–2001). The hot spots cover major and diverse themes across the world, ranging from forest cover change in Rondonia (South America), urban sprawl in Las Vegas (North America), drying of Lake Chad (Africa), demise of wetlands in Mesopotamia (West Asia), emerging urban growth centers in Asia, to the ice shelf collapse in Polar regions.

The primary data source for this project is the Landsat archive of digital satellite data housed at the USGS EROS Data Center, Sioux Falls, South Dakota. This unique archive is the longest running enterprise for the acquisition of satellite imagery of the Earth’s surface from space; it thus provides a periodic and immensely valuable record of the state of the global environment dating back to 1972. Landsat was the first Earth observation satellite developed by NASA. Landsat 1 was launched on July 23, 1972. Since then, six additional satellites have been launched, the latest in 1999. Landsat data are arguably the most extensively used satellite datasets in the world; their applications range from global change research to assessment of land use/land cover, forest fires, forestry, agriculture, hydrology, natural disasters, and also many other disciplines. These datasets are being used by international, regional and national institutions representing government, commercial, industrial, civilian, military, and educational communities worldwide.

The analyses made in this publication directly contribute to the mission of UNEP capacities to provide objective documentation and scientific evidence of environmental changes to governments and international development agencies, as well as civil society.

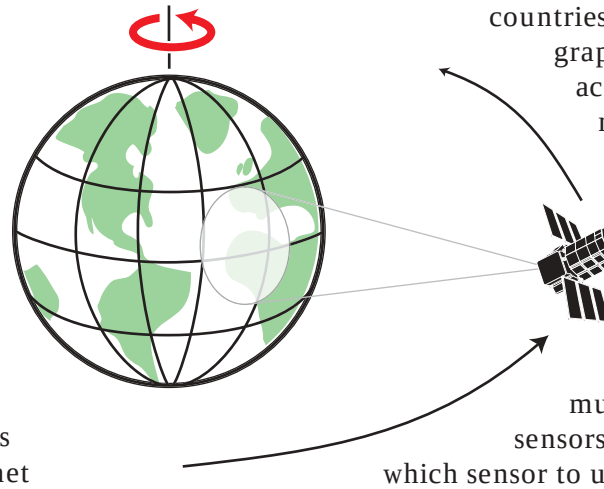


Overview of Satellite Imagery

Policy makers, managers, scientists and the public can view the changing environment using satellite images. More than 60 Earth observing satellites are collecting images of the Earth's surface. Remote sensing satellite systems for land cover assessment are operated by a growing number of countries including the United States, Japan, France, Canada, Russia and India.

The focus of this Atlas is satellite systems for land cover monitoring. The information presented will help assess the utility of remotely sensed images to meet the needs of decision-makers.

Remote sensing is the discipline of observing the Earth's surface without being directly in contact with it. It allows us to obtain information about our planet and the human activities that affect it from a distance. Remote sensing can reveal interesting features that may not be possible or affordable to assess from ground level. This gives a global perspective on changes and the interaction of our complex biosphere components.



The tools for remote sensing are sensors installed on aircrafts or satellites. Airborne sensors are typically photographic cameras. Although an important source of environmental information, airborne image collections often are poorly documented for small areas. In many countries the collection of airborne photographs is restricted. Satellite sensors acquire images of the Earth and transmit the data to ground receiving stations located throughout the world. Once these raw images are processed and analyzed, they can document changing environmental conditions like pollution, global climate change, natural resource management, urban growth, and much more. Even though many satellite sensors monitor the Earth, the choice of which sensor to use depends on the type of environmental information needed.

This *Selected Satellite Images of Our Changing Environment* atlas uses satellite images, particularly Landsat images to show changes in the global environment over the last 30 years.

Site Locator Map

The Earth at Night, Where We Live

This image shows the pattern of stable night-lights on the Earth's land surface. This pattern of night-lights intertwines two important variables related to human populations and the environment: population density and energy consumption. Cities and towns with greater populations tend to be brighter and larger. Societies that consume proportionally greater amounts of energy or which consume more land per capita tend to be brighter and larger than other cities with the same population.

Locally and regionally, night-lights show patterns of population concentrations. Within North America, the even distribution of population drops off quickly in arid, semi arid, mountainous, polar and tropical regions. Populations in arid and semi arid areas are concentrated in major urban centres, where water is often brought in from long distances or mined from fossil aquifers. In the north, the population density drops off quickly as the climate becomes too cold to support agriculture. In mountainous areas and in the tropics where arable lands are not evenly distributed, likewise the human populations are not evenly distributed. Transportation nets are visible as strings of lights. These patterns are equally strong on all the continents. Large

sparsely populated areas exist in South America, Africa and Central Asia where lights are few. Regionally this can be caused either by low population densities or low consumption of energy.

Regionally and globally, night-lights show patterns of energy consumption and economic development. Los Angeles, Paris, Buenos Aires, Shanghai, Cairo and Calcutta all have approximately the same population, but the area occupied by the cities and the amount of energy consumed vary considerably. Densely populated countries like China and India do not show the dense network of lights visible in Japan, Europe or the Eastern United States. A dramatic variation in energy consumed can be seen regional in areas such as the Korean Peninsula. Access to cheap power, such as in the Nile Valley below the Aswan Dam or along the Persian Gulf, create localized areas of high energy consumption that may not be typical of the more general society.

Threats to the environment are not simply a function of population growth. Equally important is the increasing trend in energy consumption per capita. Ultimately, stabilizing population growth may prove easier than stabilizing consumption. Not only do human populations continue to grow, but each person continues to make greater demands upon the environment. This trend toward a greater impact of people upon the environment is documented in the images that follow.

The Earth During the Day, the Environment We Live In

One quarter of the Earth's surface is covered by land. The darkest greens are in the boreal forests of the north and the rain forests of the tropics. The sparse boreal and coniferous forests of the polar zones sit on heavy organic soils that have accumulated organic matter for millennium through slow decomposition in damp, cold soils. Conversely, the dense tropical forests sit on leached soils with little organic matter; here the organic matter is held in the vegetation mass. The brighter greens are the grasslands during rainy seasons and agricultural areas under production. Deciduous temperate forests tend toward a medium green. The whites, tans, browns and reds are arid and semi-arid lands with many soil colors and mixtures of sparse vegetation. Transition zones between these colors are usually grasslands and woodlands at

various stages of development. Within lakes and seas the greens and blues show shallows, vegetation or suspended sediment. This image is lain over a shaded relief base, which emphasizes mountains and hilly landforms.

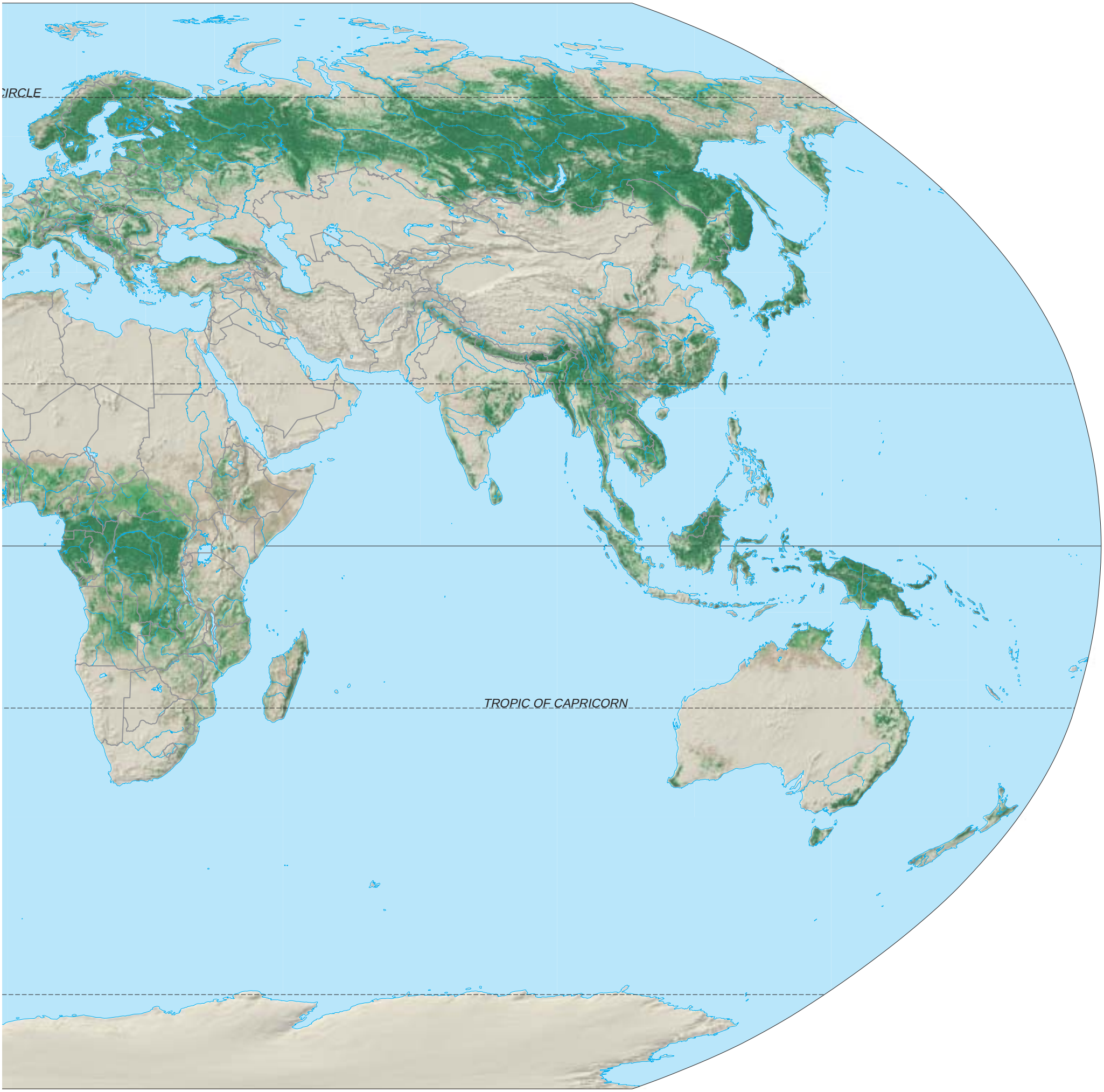
Water, temperature and fire set limits on what ecosystems can thrive. Lightening and people set the fires that promote fire tolerant species in many ecosystems. Immense fires have raced through the grasslands and boreal forests. In nearly all ecosystems, people have been the primary source of fire.

Until recently tropical fires were on a smaller scale. As people expand into tropical ecosystems, these too are being affected by fire. People are rapidly expanding into nearly all ecosystems. The protection of some of these ecosystems is necessary. The destruction and non-sustainable use of natural ecosystems impacts the capacity of the ecosystems to support people through food production, freshwater, protection from flooding, and forest products. People need to coexist with natural ecosystems to ensure the continued existence of all.

Our Forests

Forests are important elements for sustaining the ecological health of the Earth. The forest map of the world shows five major categories - closed forest (dark green); open and fragmented forest (light green); other wooded land (dark tan); other land cover (light tan); and water (blue). Forest cover maps can be used to monitor sustainability of forest ecosystems, and estimate forest biomass by country, ecological zone, climate region, and other terrestrial characteristics.

Forests, as is the case with all land cover, are manipulated by climate. In the cold regions of high latitudes exist Boreal Coniferous Forests. In the humid temperate zone are Broadleaved Deciduous Forests of eastern North America, Western Europe, and Eastern Asia. The Mediterranean climate's mild and humid winters and hot dry summers support the Sub-Tropical Dry Woodlands, which are scattered around the world in regional climatic zones. Tropical Dry Forest and Woodlands occur in tropical regions, most commonly in Africa, with pronounced dry seasons. Tropical Rainforests exist in the equatorial zones, where the climate is



hot and humid throughout the year. Mountain Forests often contain local endemic ecosystems that differ from the lowlands that surround them. Mangroves are highly productive coastal ecosystems along the tropical and subtropical coast. Forest plantations, a growing proportion of the forest area, provide forest products in an essentially monoculture ecosystem that helps to lessen logging in the natural forest.

Many of these forests are threatened. Among the most threatened are the Mangrove and Mountain Forests that exist as isolated and unique ecological systems that are not resilient to development. All forests are under threat of fragmentation and non-sustainable utilization of forest resources.