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***Selected Satellite
 Images of Our
 Changing Environment***

Selected Satellite Images of Our Changing Environment

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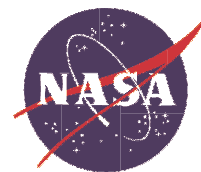
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We regret any errors or omissions that may have been unwittingly made.

Selected Satellite Images of Our Changing Environment



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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*



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.

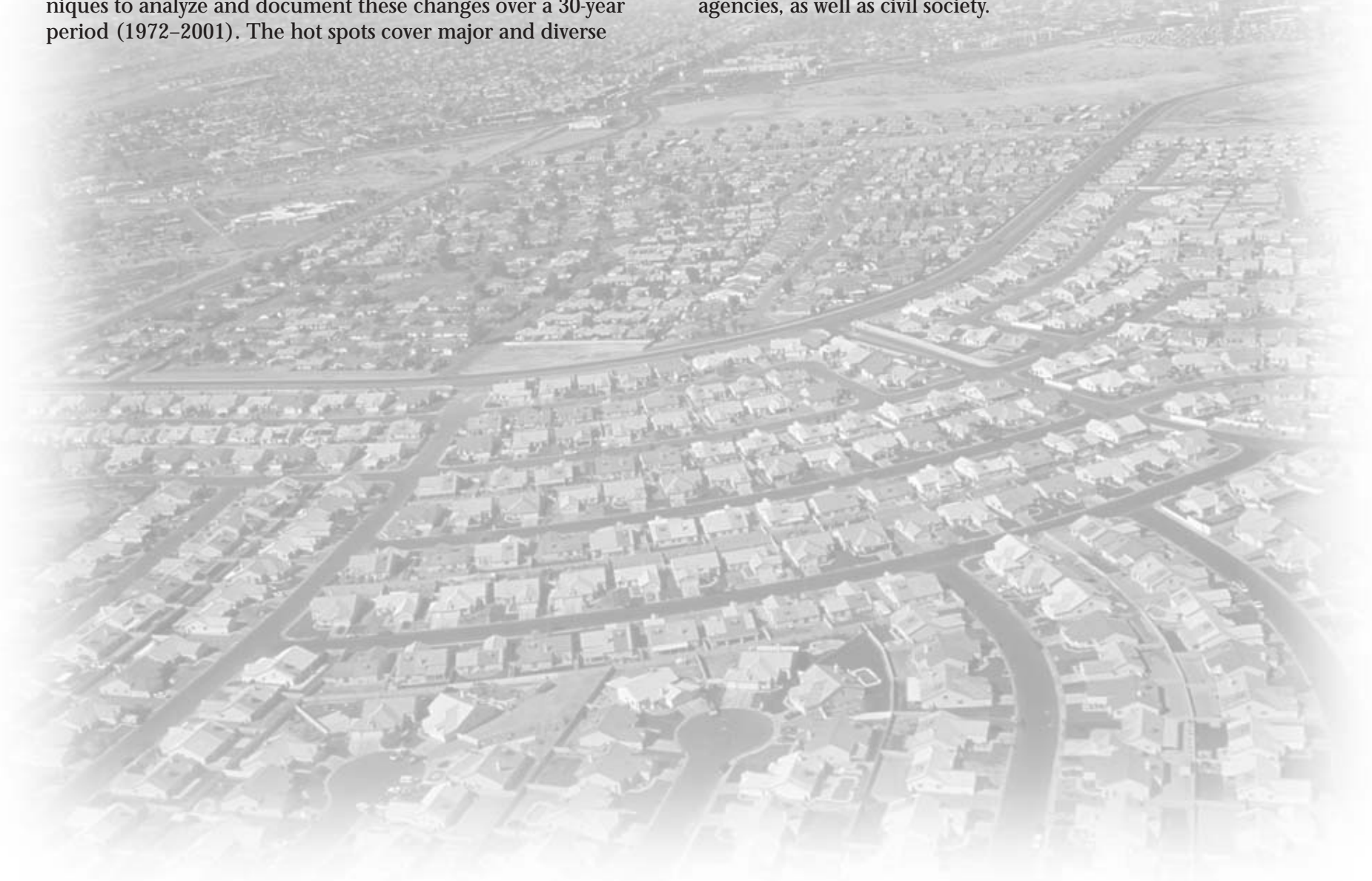
Increasing concern over how human activities interact and influence the global environment have led to the initiation and formulation of a number of environment assessment programs, treaties and agreements which call for increased, systematic observation of Earth systems. Such systematic observations 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.

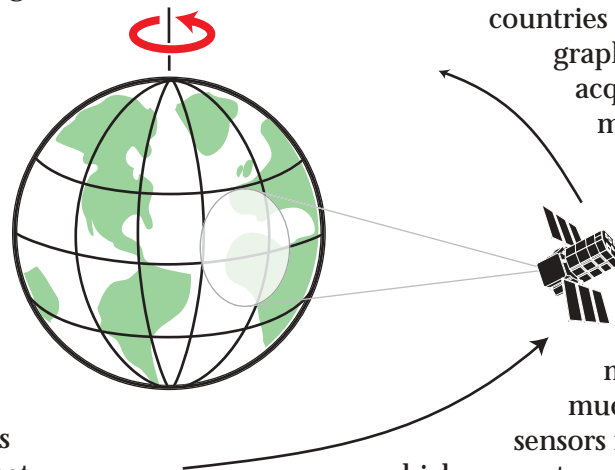


Overview of Satellite Imagery

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

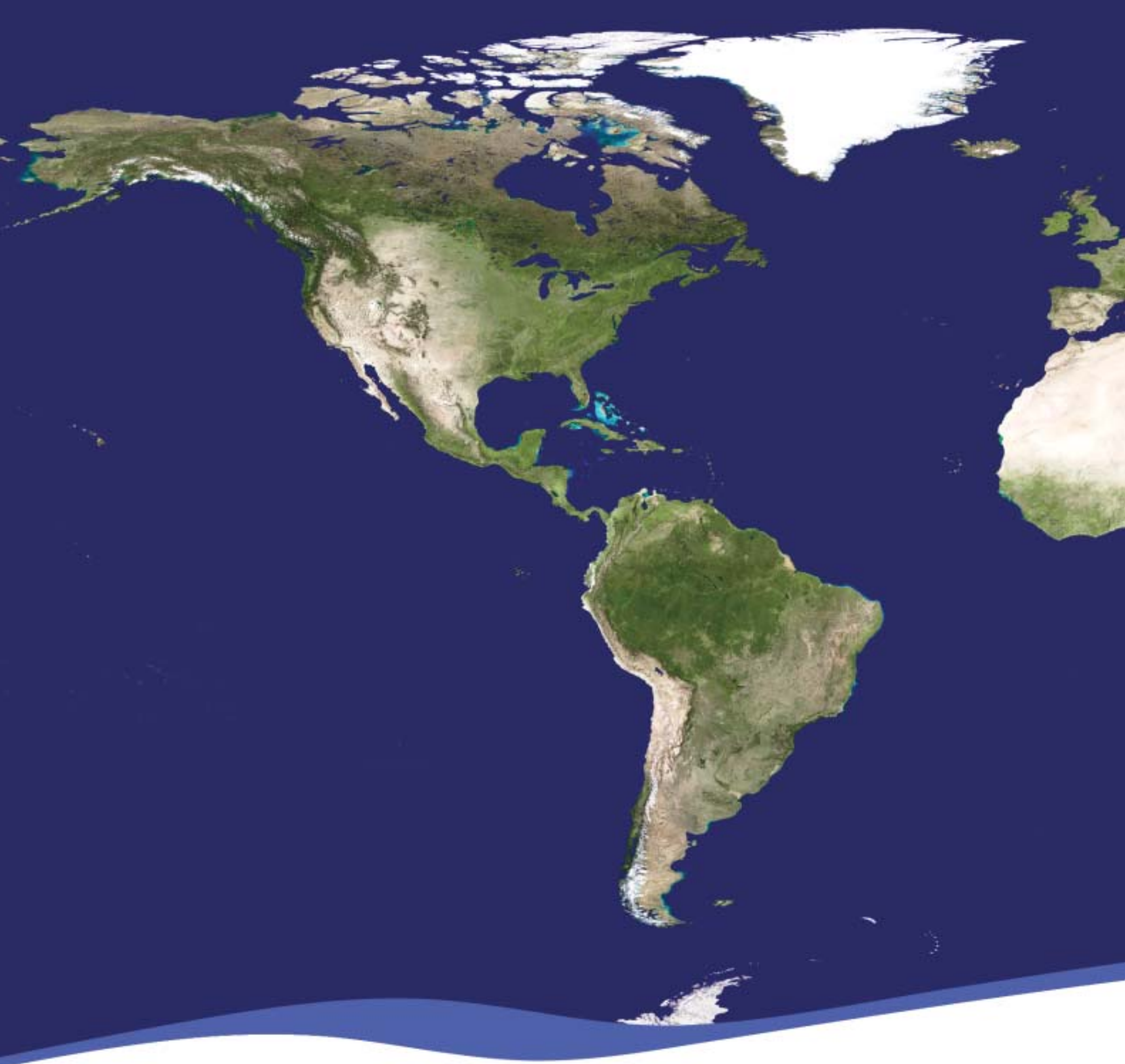


sparsely populated areas exist in South America, Africa and Central Asia where lights are few. Regionally this can be caused either by low population densities or low consumption of energy.

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.

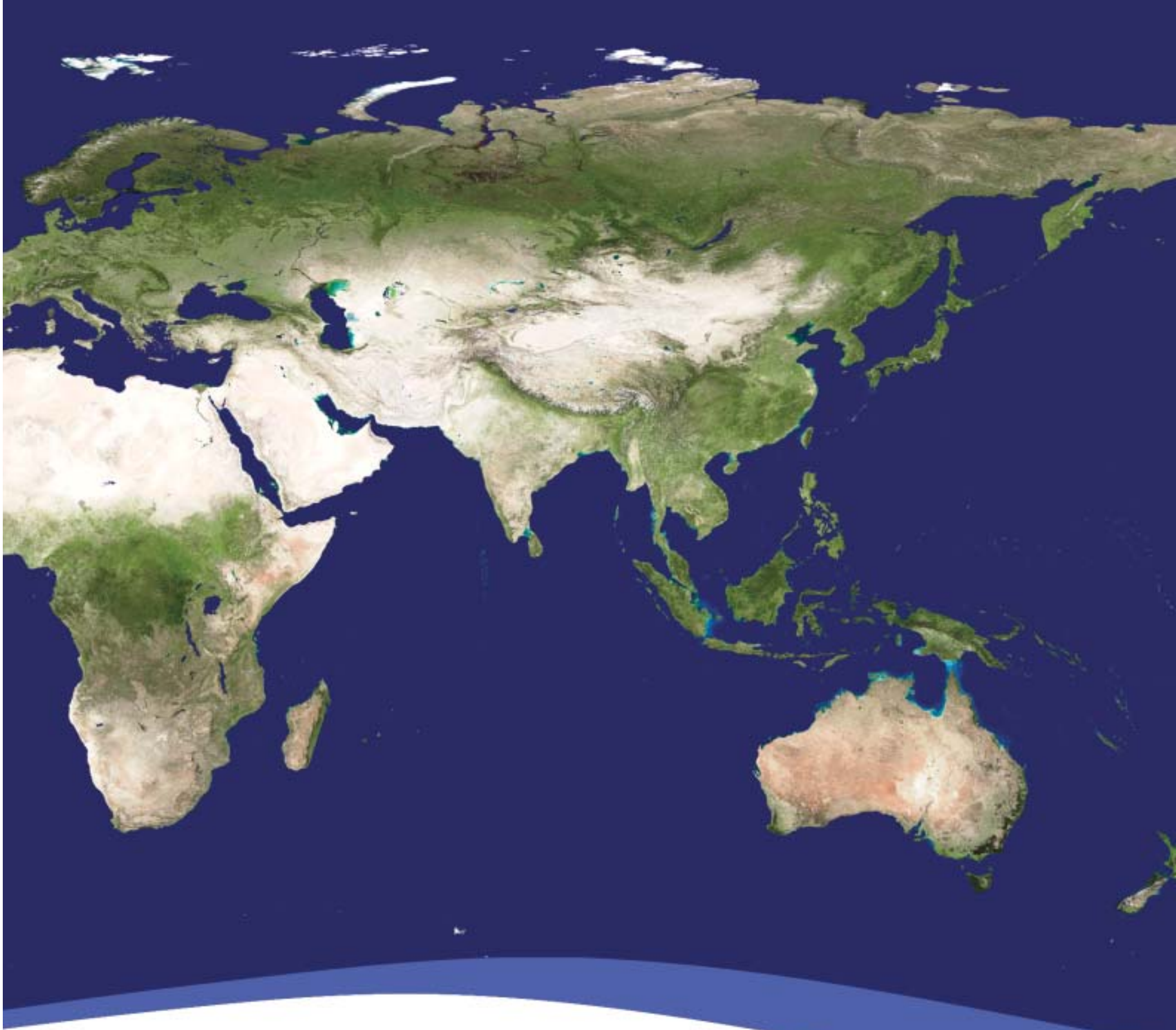
Threats to the environment are not simply a function of population growth. Equally important is the increasing trend in energy consumption per capita. Ultimately, stabilizing population growth may prove easier than stabilizing consumption. Not only do human populations continue to grow, but each person 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

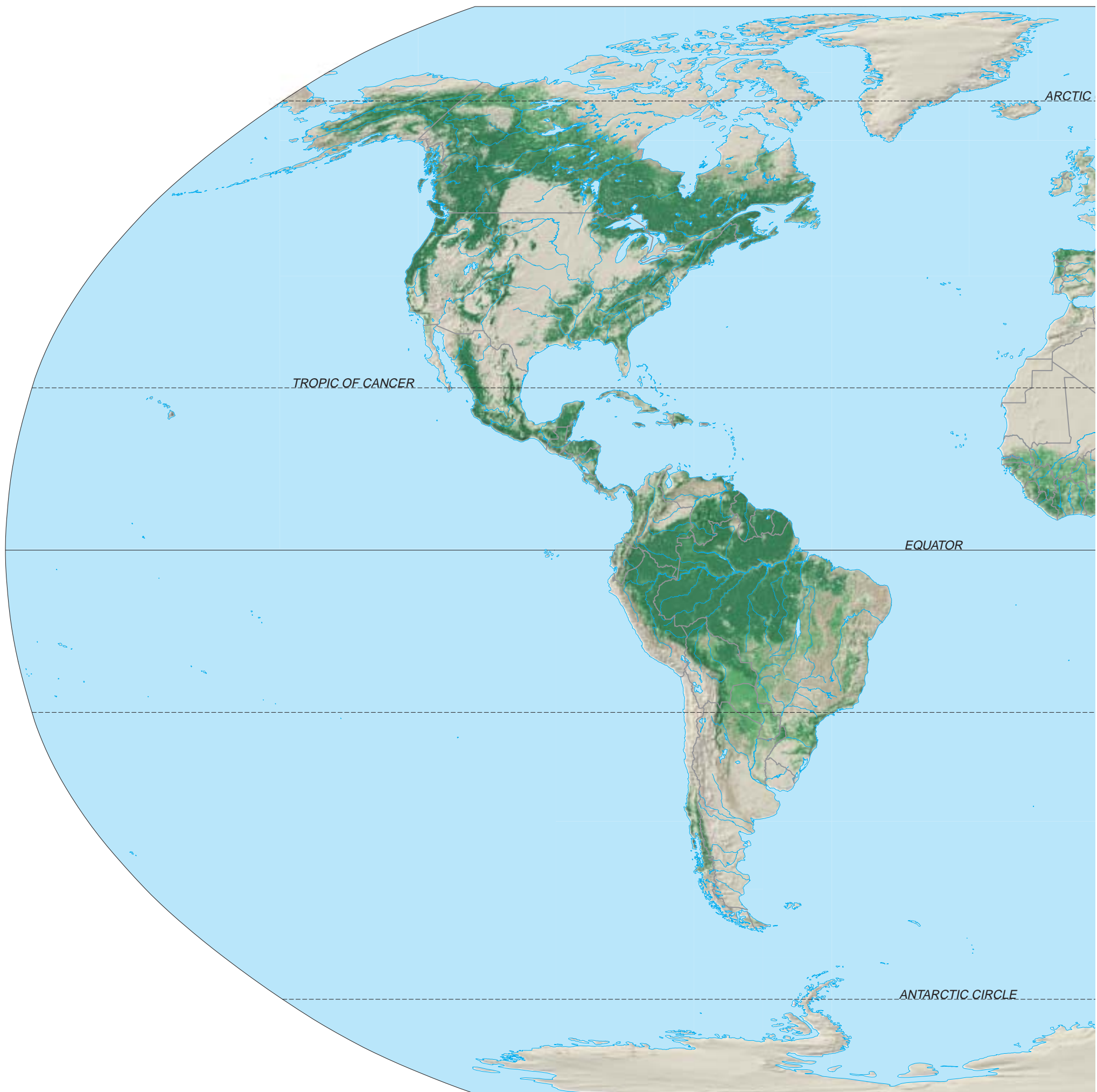


various stages of development. Within lakes and seas the greens and blues show shallows, vegetation or suspended sediment. This image is laid over a shaded relief base, which emphasizes mountains and hilly landforms.

Water, temperature and fire set limits on what ecosystems can thrive. Lightning 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.



Africa



At A Glance

Population: 812 million

Percent of World's Population: 13.2%

Land area: 30,065,000 sq km

Percent of Earth's Land: 20.2%

Key Environmental Issues:

Land degradation

Desertification

Deforestation

Habitat loss

Loss of biological resources

Water stress and scarcity

Deteriorating water quality

Wetland loss

Sites for Africa

Banjul Region, Gambia

Challawa Dam, Nigeria

Itampolo, Madagascar

Lake Chad, Chad

Lake Nakuru, Kenya

Lake Victoria, Uganda

Lesotho Highlands Dam, Lesotho

Midrand, South Africa

Mount Kilimanjaro, Tanzania

New Valley Project, Egypt



Banjul Region, Gambia

Urban Growth

Banjul, the capital city of Gambia, is located at the end of a peninsula. The Gambian population is increasing by about 4.2% annually. The satellite images of 1973 and 2001 indicate urban sprawl in the Banjul region during the past 27 years. Urbanization in Banjul has extended into surrounding areas, which now include several outlying districts such as Serekunde and Kanifing. The population of the greater Banjul area has more than tripled in the past 25 to 30 years.

The mangrove swamps that lie on the northeast border of Banjul have largely escaped destruction, as urban development has mostly progressed westward. Increasing population and human encroachment could be a threat to the swamps.



1973 (left)

The satellite image shows the extent of Banjul covering only a small area just at the bulge of West Africa.

2001 (right)

The satellite image shows the extent of Banjul extending far into the hinterlands (Serekunde and Karafining).





Challawa Gorge Dam, Nigeria

Land Degradation

Dam construction started in Kano, Nigeria, around 1969. There are currently 23 dams in the zone comprising the Hadejia-Jama'are River Basin. The Challawa Gorge Dam is the second largest of these dams. The Challawa Gorge Dam on the Challawa River has created a lake with a surface area of 101.17 sq. km, a storage capacity of 969 million cubic m, and a catchment area of 3,859 sq. km. The Challawa dam was completed in 1993. The Hadejia-Jama'are River Basin is part of the Komadougou Yobe River Basin and empties into Lake Chad.



1990 (left)

The image shows that the area affected by land degradation was approximately 3958.7 sq. km. This is an increase from approximately 842.18 sq. km. in 1975. Construction has just begun on the Ghallawa Gorge Dam in 1990. Many smaller dams are visible in the image.

2000 (right)

The image shows the Challawa Gorge Dam with degraded land trailing it in both the upstream and downstream reaches. The total area affected by land degradation increased to 6707.62 sq. km. The water in the Challawa Gorge Reservoir and in many of the other smaller reservoirs can be seen to be heavily sediment laden.





Itampolo, Madagascar

Deforestation

Madagascar, located in the South Indian Ocean off the southeast coast of Africa, is the world's fourth largest island, with an area of about 587,000 sq. km. The island has been described as an "alternative world" or "world apart" because of the uniqueness and rarity of many of its plants and animal species. Species diversity of both plants and animals exist primarily in the rain forests of eastern Madagascar. Madagascar was once covered almost completely by forests, but the practice of burning and cutting the forest to clear the land for dry rice cultivation, grazing, fuel, wood gathering, logging, cattle ranching, and mining has denuded most of the landscape, especially in the central highlands. Coffee production has changed forest diversity in some areas.

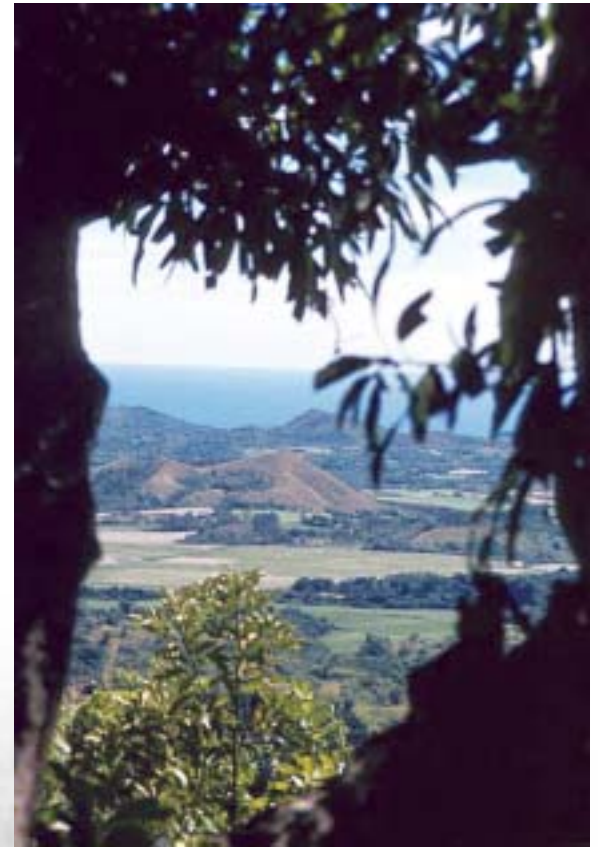


1973 (left)

The lake in the upper-left is Tsimanampetsota. The river flowing from the center to lower-center is the Fiherenana. The darker green areas are forested.

2000 (right)

Large portions of the center of the image were deforested between 1973 and 2000.





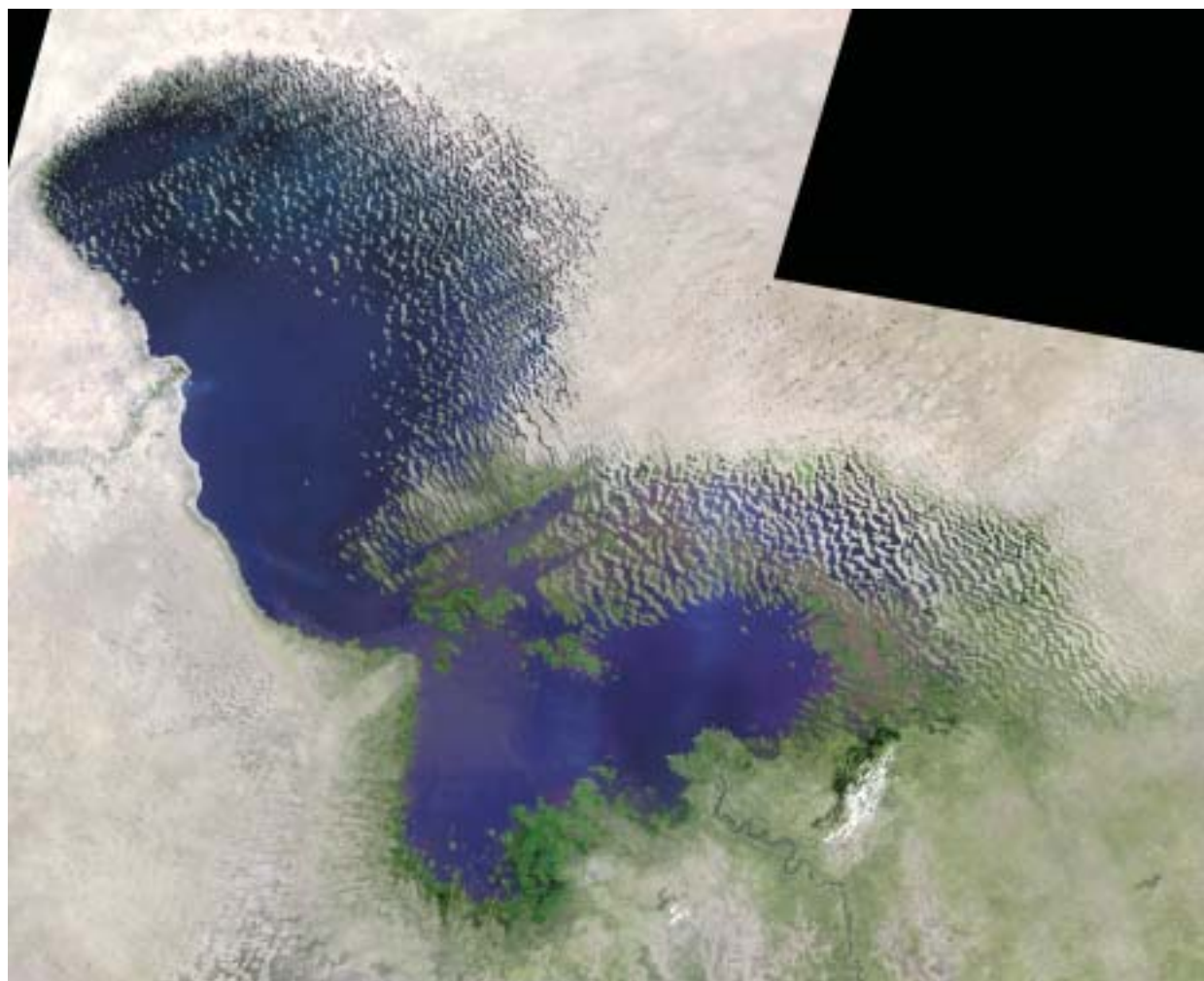
Lake Chad, Chad

Desertification/Landcover Change

Lake Chad is located at the junction of Nigeria, Niger, Chad, and Cameroon. Lake Chad was once the sixth-largest lake in the world, but persistent drought since the 1960s shrank it to about a tenth of its former size. Lake Chad has a large drainage basin (1.5 million sq. km.), but almost no water flows in from the dry north. The Komadougou-Yobe River, in the northwest quadrant of the Landsat images, now flows only in the rainy season. Ninety percent of Lake Chad's water flows in from the Chari River, at the southeast of the lake.

The lakebed is flat and shallow, so small changes in depth mean huge changes in area. Even in normal times, Lake Chad was no more than 5-8 meters deep. It may be more accurate to think of it as a deep wetland. Considered this way, Lake Chad was once the second largest wetland in Africa, highly productive, and supporting a diversity of wildlife.

Low-rainfall regions are usually also variable-rainfall regions. On the dry, northeast side of Lake Chad, at the town Bol, rainfall from 1954 to 1972 ranged from 125 to 565 mm (about 5-22 in), averaging 315 mm (about 12.5 in). The lake is very responsive to changes in rainfall. When rains fail, as in 1972, the lake drops rapidly because annual inflow is 20-85% of the lake's volume. In the 1950s the lake rose enough to flood out irrigation systems, peaking this century in 1962. Human diversion from the lake and from the Chari River may be significant at times of low flow, but rainfall is still the determining factor in lake level – the lake still affects irrigation more than vice-versa. Major irrigation systems have failed due to the lake level falling too low to supply water.



1963 (upper left)

The Lake Chad surface covered approximately 22,902 sq. km. The area shown in gray and white in the central portion of the image indicates the lake at different depths.

1973 (lower left)

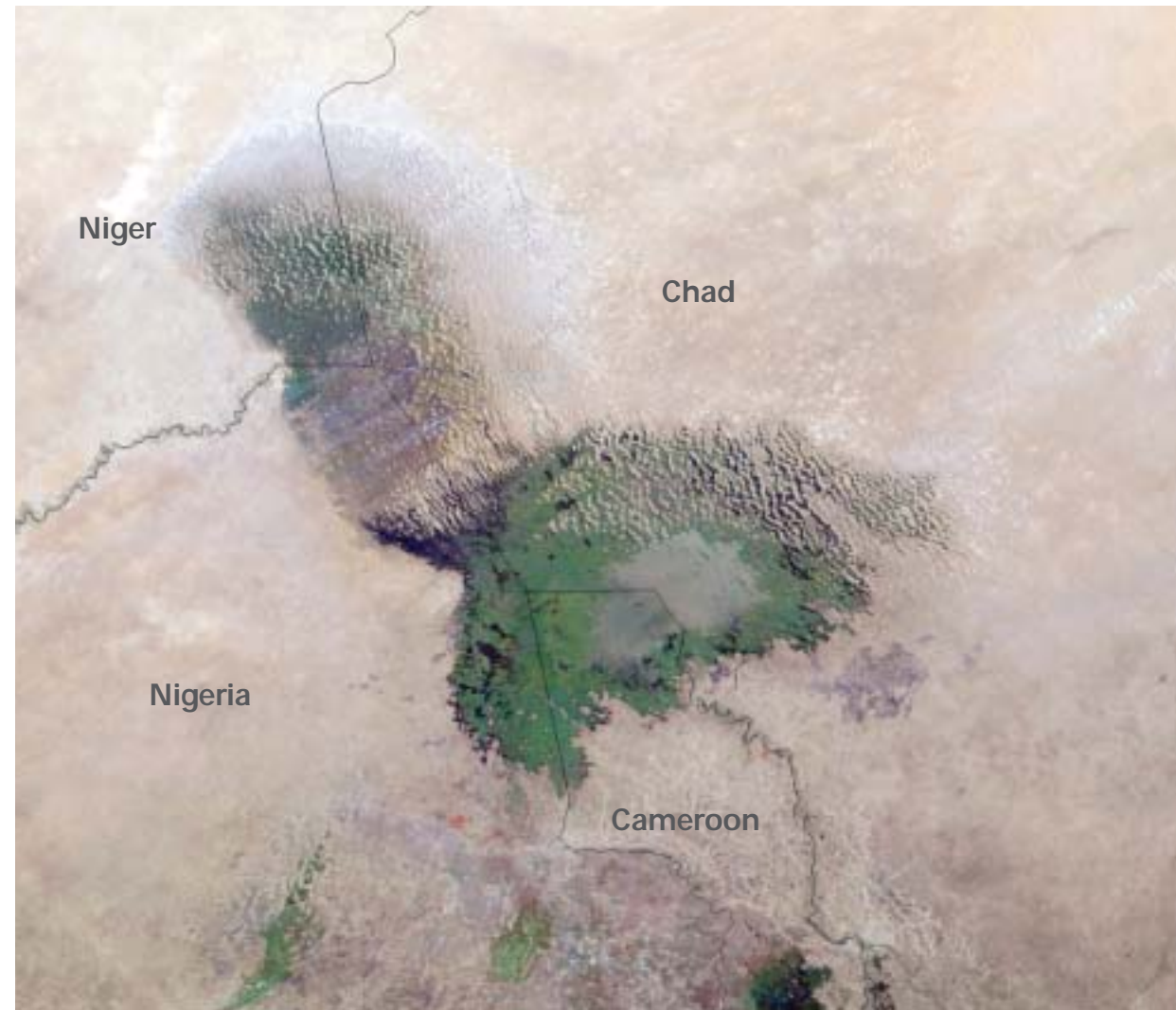
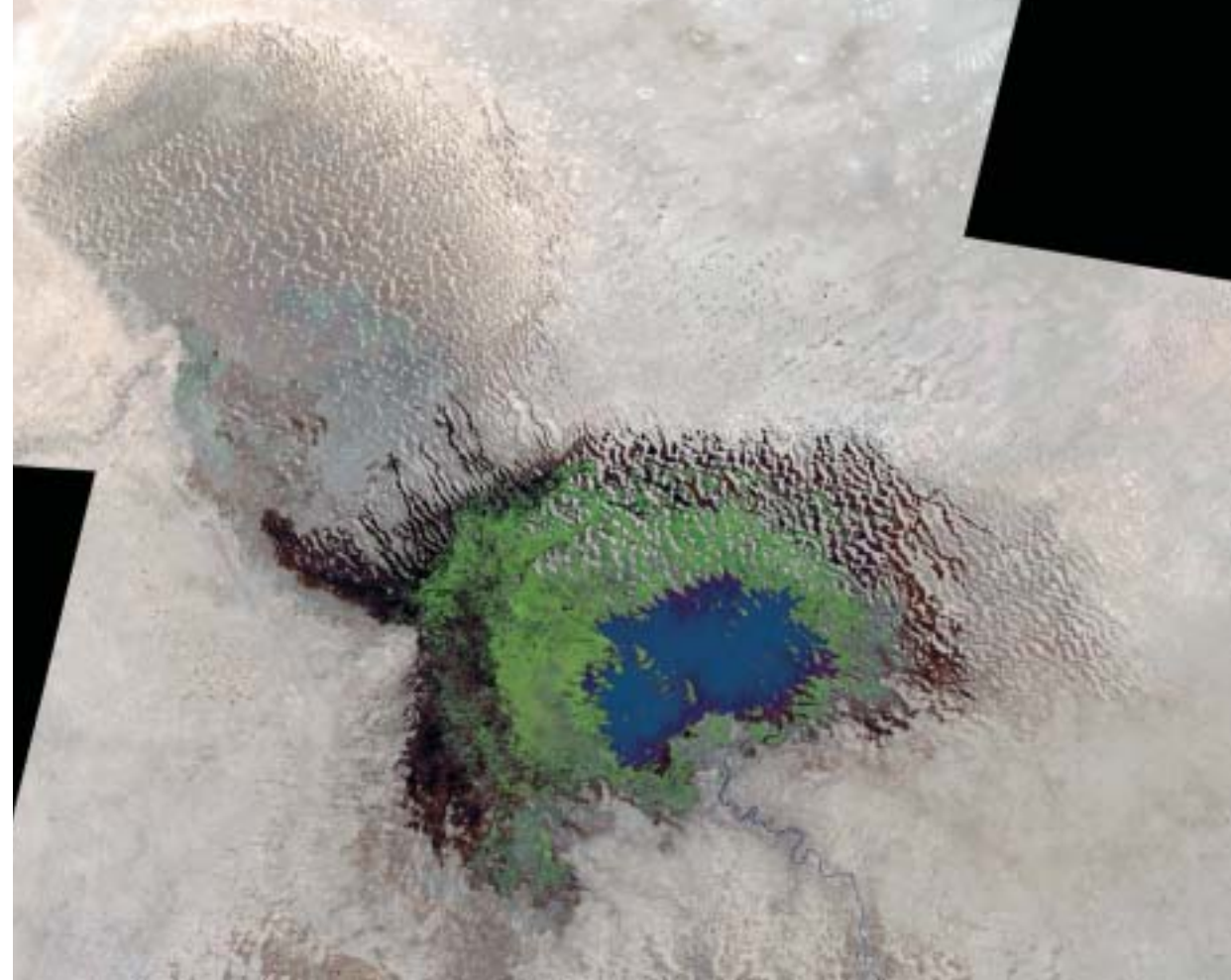
The Lake Chad water surface was reduced to about 16,884 sq. km. The area shown in red indicates the lake water while green indicates vegetation.

1999 (upper right)

The Lake Chad water surface was reduced to about 1,746 sq. km.

2001 (lower right)

The Lake Chad water surface was reduced to about 304 sq. km. The national boundaries can be seen in black.





Lake Nakuru, Kenya

Land Cover Change

Lake Nakuru is located southwest of the city of Nakuru, in the Eastern Rift Valley, southeast Kenya. Lake Nakuru National Park is the second most visited protected area in Kenya. It hosts the world's largest concentration of flamingos, as well many of the animal species that make Kenya a highly valued tourism destination, including lions, leopards, rhinoceros, and water buffalo. In its total area of 188 sq. km., there are over 450 bird species and 56 mammal species. Recognized as a wetland of international importance, Lake Nakuru was declared a Ramsar Site in 1990.

One of the most pressing threats to Lake Nakuru is the degradation of vegetation cover in its catchment, which is most likely to increase fluctuation in water flow and decrease water quality. The satellite images show the degradation of the vegetation cover in the catchment of Lake Nakuru between 1973 and 2001.



1973 (left)

The satellite image shows the status of Lake Nakuru and its catchment area containing about 754.67 sq. km. of vegetation cover.

2001 (right)

On 16 February 2001, the Government of Kenya announced its intention to excise 353.01 sq. km. of forest in the Eastern Mau Forest Reserve. As a result, most of the forest cover in the upper catchment of the main rivers that feed Lake Nakuru will disappear. About 50 per cent of the dense vegetation in the catchment has disappeared since 1973.



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Forestry Images—William Ceisla

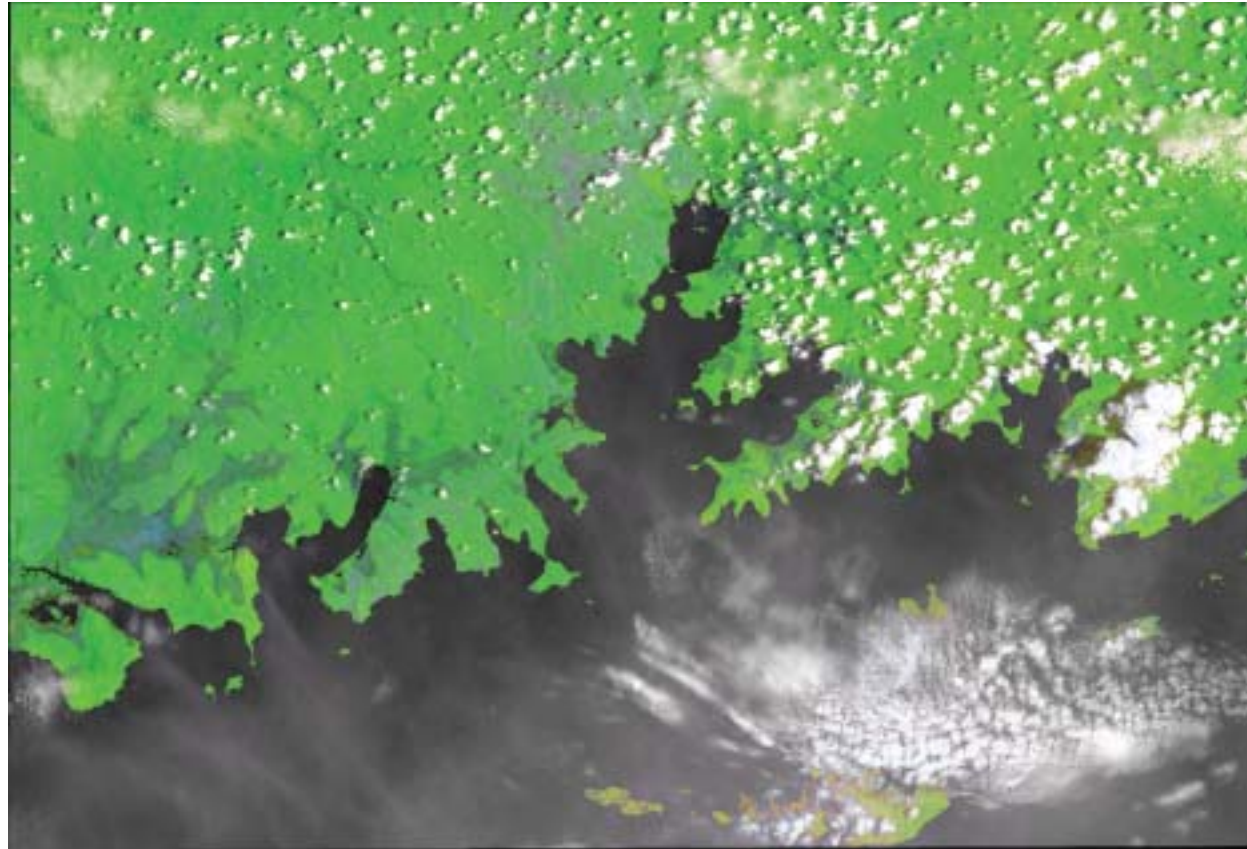


Lake Victoria, Uganda

Water Hyacinth Infestation

Lake Victoria is the second largest freshwater lake in the world in terms of surface area. It covers an area roughly the same size as the Central American country of Costa Rica. Bordered by Kenya, Tanzania, and Uganda, the lake serves as a valuable resource to the region providing food, potable water, hydroelectric power, and transportation. Although no one is sure exactly when or how the water hyacinth first entered the lake, reports suggest that it has been present on the lake since 1995. By 1998 it covered approximately 20,000 ha. Huge mats have paralyzed activities at the ports, villages, and bays, at times preventing even large boats from leaving their harbors. Fortunately, the amount of water hyacinth present on the lake in 2001 is considerably below its 1998 peak.

This menacing weed has particularly hit the Kenyan coastline and Port of Kisumu.



1995 (left)

This portion of a 1995 satellite image taken of Lake Victoria shows very few water hyacinth near the Kibanga Port of Kampala.

1999 (right)

This portion of a 1999 satellite image taken of Lake Victoria shows locations of the water hyacinth near Kibanga Port of Kampala. Water hyacinth are visible as bright green patches in protected embayments along the coast.





Lesotho Highlands Dam, Lesotho

Lesotho Highlands Water Project

Lesotho is a small land-locked country entirely surrounded by the Republic of South Africa. Most of the large rivers in the latter arise in the mountains of Lesotho. The Lesotho Highlands Water Project (LHWP) is designed to supply water to Gauteng Province in South Africa, and hydropower to Lesotho, otherwise dependent on its neighbour for energy, using some 40 per cent of the water in the Senqu (Orange) River system in Lesotho. With five large dams to be constructed, water will be diverted through 200 km of tunnels in the Maloti Mountains, to the Ash River in South Africa and ultimately the Vaal Dam south of Johannesburg. The LHWP is Africa's largest current infrastructure project and one of the largest in the world. With a contract between Lesotho and the apartheid government signed in 1986, the first dam (Katse) was closed in late 1995, and the second (Mohale) is nearing completion.

Lesotho depends almost entirely on South Africa for economic income, and many men are employed in South Africa's mines. With low returns from mining forecast in the late 1990s, the LHWP was a very welcome potential source of income, and further employment opportunities are anticipated if the project continues. Schools and clinics have been built, and other benefits introduced to the Lesotho highlands. Conversely, more than 20,000 people in the once remote highland communities have been affected by the first phase, losing either homes, communal grazing lands or farmland, and with only 9 percent of Lesotho's land regarded as arable, any loss is nationally significant. Communities have been separated by the Katse reservoir. At the same time, reportedly around 20,000 project workers and others have moved into the region, and AIDS is now a problem. Few grievances have been fully addressed.

Some water experts in South Africa believe that further dams could be postponed if demand-management measures are implemented in order to reduce wastage. There is fear that moving forward with the second dam will stall such measures and needlessly increase the cost of water at a time when the Government is trying to improve water services to millions of South Africans in the townships.



1986 (left)

The images show the Senqu River in northern Lesotho in its original condition.

2001 (right)

With the valley flooded over more than 30 sq. km. after closure of the Katse Dam, this water resource development will bring important benefits to many people. There are some adverse effects on displaced communities.





Midrand, South Africa

State of Environment

Midrand is strategically located approximately halfway between the major urban centres of Johannesburg and Pretoria. Midrand is 240 sq. km. in size and the current population estimate is 240,000, with about 84% living in Midrand east. Approximately 80% of the population lives in Ivory Park, which has the highest population density in Midrand. Sixty five percent of Midrand has been transformed for human settlements, crops, mining and industry. There are 232 hectares of wetlands and river areas. The dominant ecosystem is a transition of grassland that contains species that exist in both grasslands and in bushveld ecosystems.

In the future, the rapid growth of Midrand's economy is expected to continue with associated impacts on the environment. Current development trends and population indicate that if effective environmental management strategies are not adopted soon, within the next five years people could expect a significant deterioration in the quality of the environment.





1985 (left)

Midrand is divided into east and west by the N1 highway, which is the primary highway connecting Johannesburg and Pretoria. In the upper left (NE) are agricultural and rural residential lands with some suburbs, and in the lower left (SE) are low residential areas with some commercial. In the upper right is a mixture of vacant lands and commercial/industrial areas. In the centre right is a high-density residential area. Along and adjacent to the N1 is the central commercial district and medium density residential neighbourhood.

2001 (right)

The satellite image illustrates urban development throughout the image. Along the N1 is an extension of the commercial core. The high-density residential area has expanded into the neighbouring vacant lands. Evidence of development is visible in nearly all residential areas and is expanding into adjacent agricultural and vacant lands.





Mount Kilimanjaro, Tanzania

Diminishing Forests in Mountain Areas

Mt. Kilimanjaro, Africa's highest mountain, is located 300 km south of the equator in Tanzania. A forest belt ranging between 1,600 meters and 3,100 meters in altitude surrounds it. The forest has a rich diversity of vegetation types that result mainly from the large range in altitude and climate, with rainfall of about 700 to 3,000 mm/yr. It hosts a very large diversity of species, with about 140 mammal species and over 900 plant species. People have moved into the forest, creating dense settlements within the Forest Reserve. Some settlements have expanded and now are the size of towns. The satellite images of 1976 and 2000 show changes in forest areas in Kilimanjaro region.

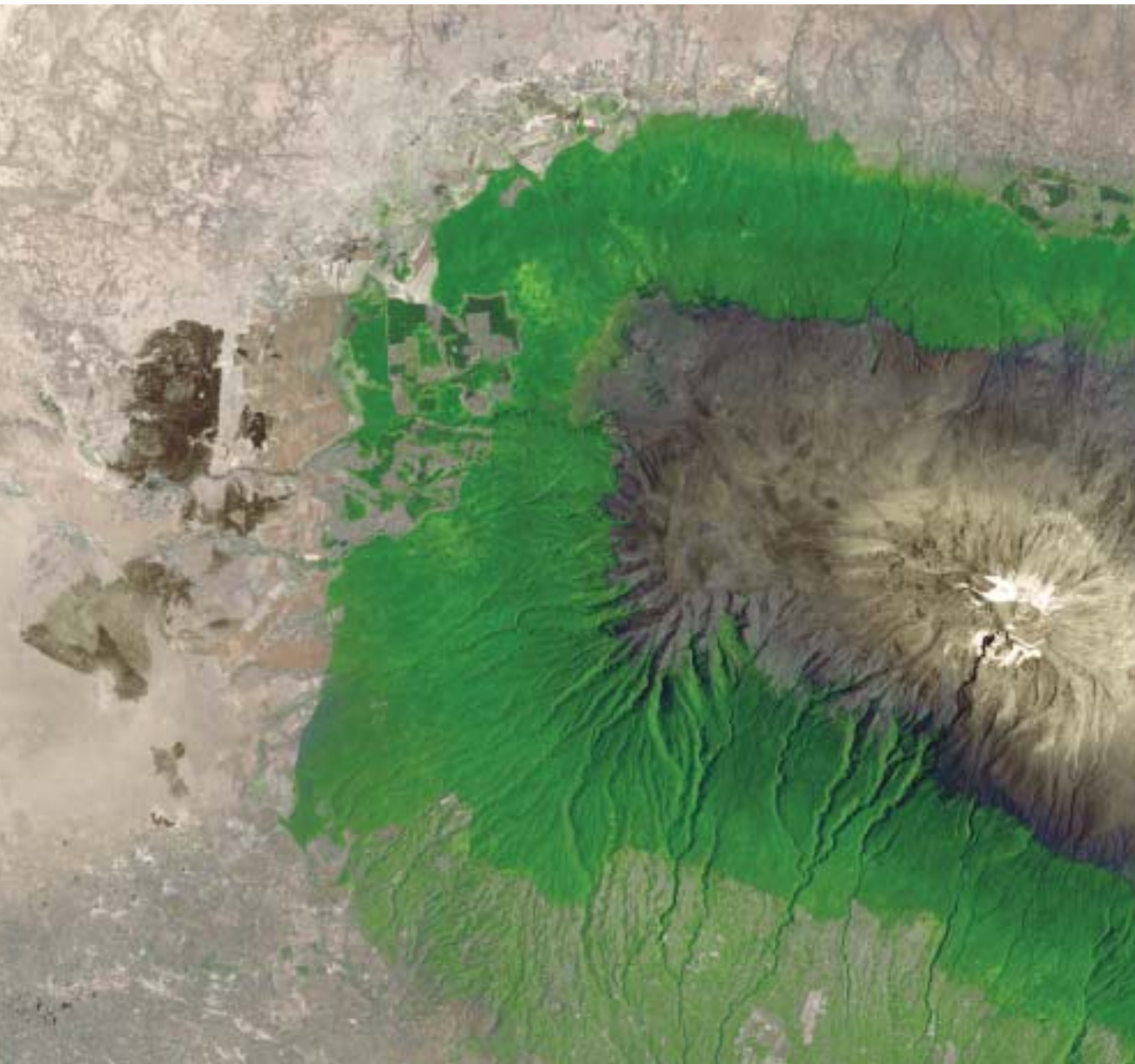


1976 (left)

A forest belt spans altitudes between 1,600 and 3,100 meters surrounding Mt. Kilimanjaro. In the image, green shows natural vegetation, and brown shows desert areas.

2000 (right)

This image shows large tracts of indigenous forest that have been converted into other land uses, representing about 12 percent of the Kilimanjaro Forest Reserve.





New Valley Project, Egypt

Agricultural Development in the Sahara

The scorched landscape of Egypt's southern desert suddenly merges into lush, neatly tended vegetable plots drip-fed with water and fertilizer. Seeking to relieve population congestion in the Nile Valley, the Egyptian government has embarked on large-scale horizontal expansion projects since the early 1980s. A comprehensive scheme for developing desert areas was put into motion to increase habitable land from the current 5 percent to 25 percent of land area.

The Toshka Project was officially launched on Jan. 9, 1997, 37 years after the inauguration of the Aswan High Dam. The Toshka Depression was connected to Lake Nasser by a new 310-km long canal, designed to take water from the Nile to new communities in the desert. The aim is to "go out from the Nile Valley," and to set up new agro-industrial population centers in the central Western Desert. The goal is to reclaim about 540 sq. km of land for farming, irrigated equally by groundwater and by canal-borne water from the Nile. The satellite images show dramatic change in the Toshka Depression between 1999 and 2001.



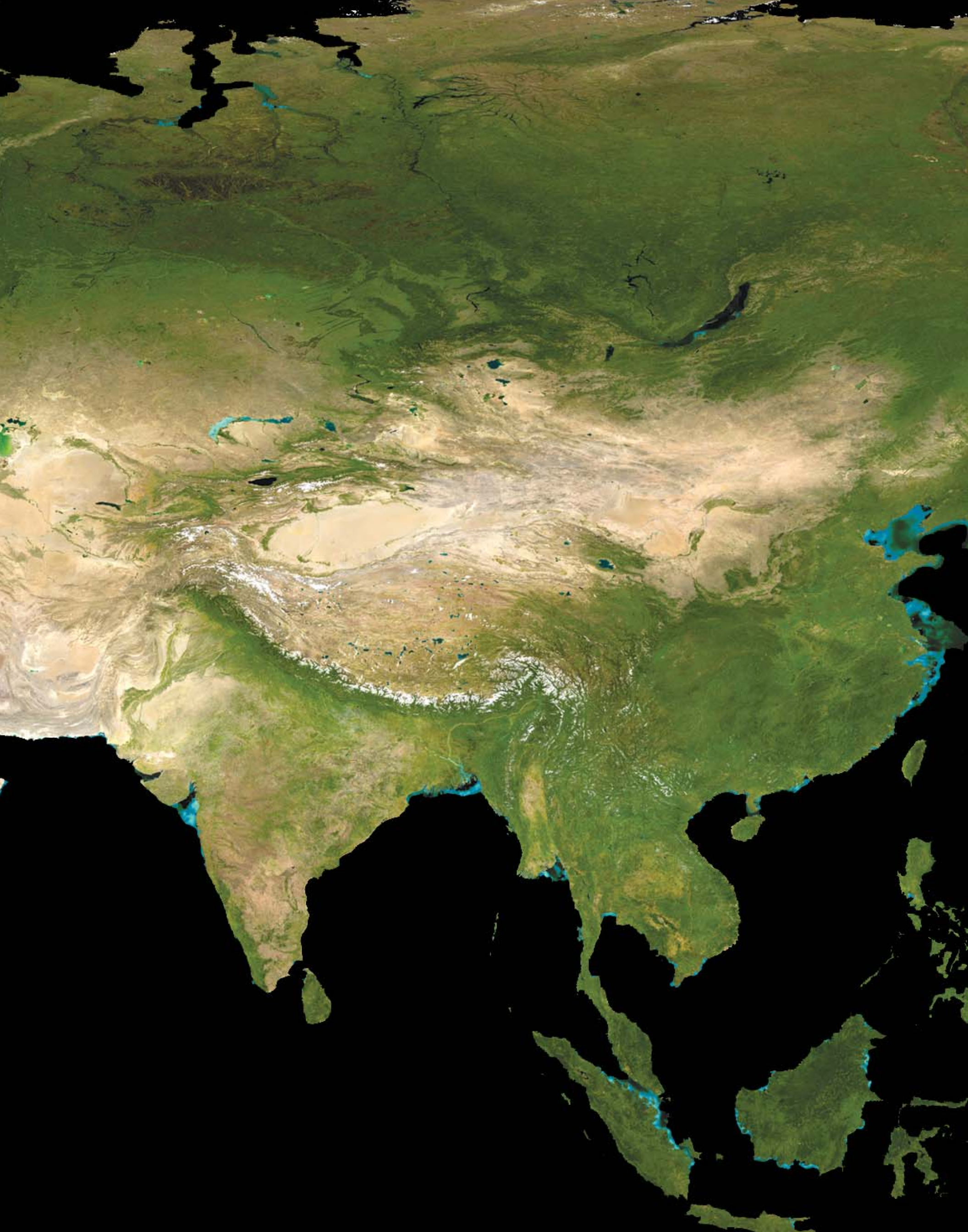
1999 (left)

The image of 1999 shows a portion of the first Tashka Lake not long after it was filled with water from Lake Nasser, but before the development of agriculture along its shore.

2001 (right)

The image of 2001 documents new flooding in the Toshka region, west of Lake Nasser, and the development of agriculture along the first Toshka Lake. The formation of Toshka Lakes in southern Egypt is part of Egypt's New Valley Project. The flooding of the region has been monitored since 1998, and continues to show rapid changes. Since September 2000, flooding has occurred over a large area at the western end of the Toshka Lakes stretching over 848 sq. km. The region will be used for large Egyptian agricultural developments to support millions of people.





Asia

At a Glance

Population: 3,721 million

Percent of World's Population: 60.66%

Land Area: 44,579,000 sq km

Percent of Earth's Land: 30%

Key Environmental Issues

Land use change

Desertification

Deforestation

Habitat loss

Forest loss and degradation

Water scarcity

Pollution of freshwater resources

Over population

*Expansion of aquaculture and
loss of mangrove areas*

Degradation of coastal and marine resource

Sites for Asia

Al Isawiyh, Saudi Arabia

Aral Sea, Kazakhstan

Atatürk Dam and the Harran Plain, Turkey

Beijing, China

Dhaka, Bangladesh

Oil Well Fires, Kuwait

Huang River Delta, China

Irian Jaya, Indonesia

Isahaya Bay Reclamation, Japan

Lake Hamun, Iran/Afganistan

Mesopotamian Wetlands, Iraq/Iran

New Delhi, India

Paektu San, Korea, DPR

Phnom Penh, Cambodia

Shenzhen, China

Sundarban, Bangladesh/India

Thailand Aquaculture, Thailand

Three Gorges Dam, China



Al Isawiyh, Saudi Arabia

Center Pivot Irrigation

Saudi Arabia, although rich with oil, is lacking a more vital natural resource: water. The kingdom has decided to diversify its economy and modernize its agricultural sector in order to become more self-supporting to meet the country's growing demand for wheat. As Saudi Arabia has severely limited water resources, the government decided to use the revenues from the oil industry to adopt the best technologies available for farming in arid and semi-arid environments.

Center pivot irrigation has been introduced in Wadi as Sirhan, a large alluvium-filled graben up to 300 meters below the surrounding plateau. Located in the extreme north along the border with Jordan, Wadi as Sirhan is a remnant of an ancient inland sea and is underlain by four aquifers, two of which contain fossil water more than 20,000 years old. The satellite images between 1986 and 2000 show the transformation of the desert to agriculture through center pivot irrigation.





1986 (left)

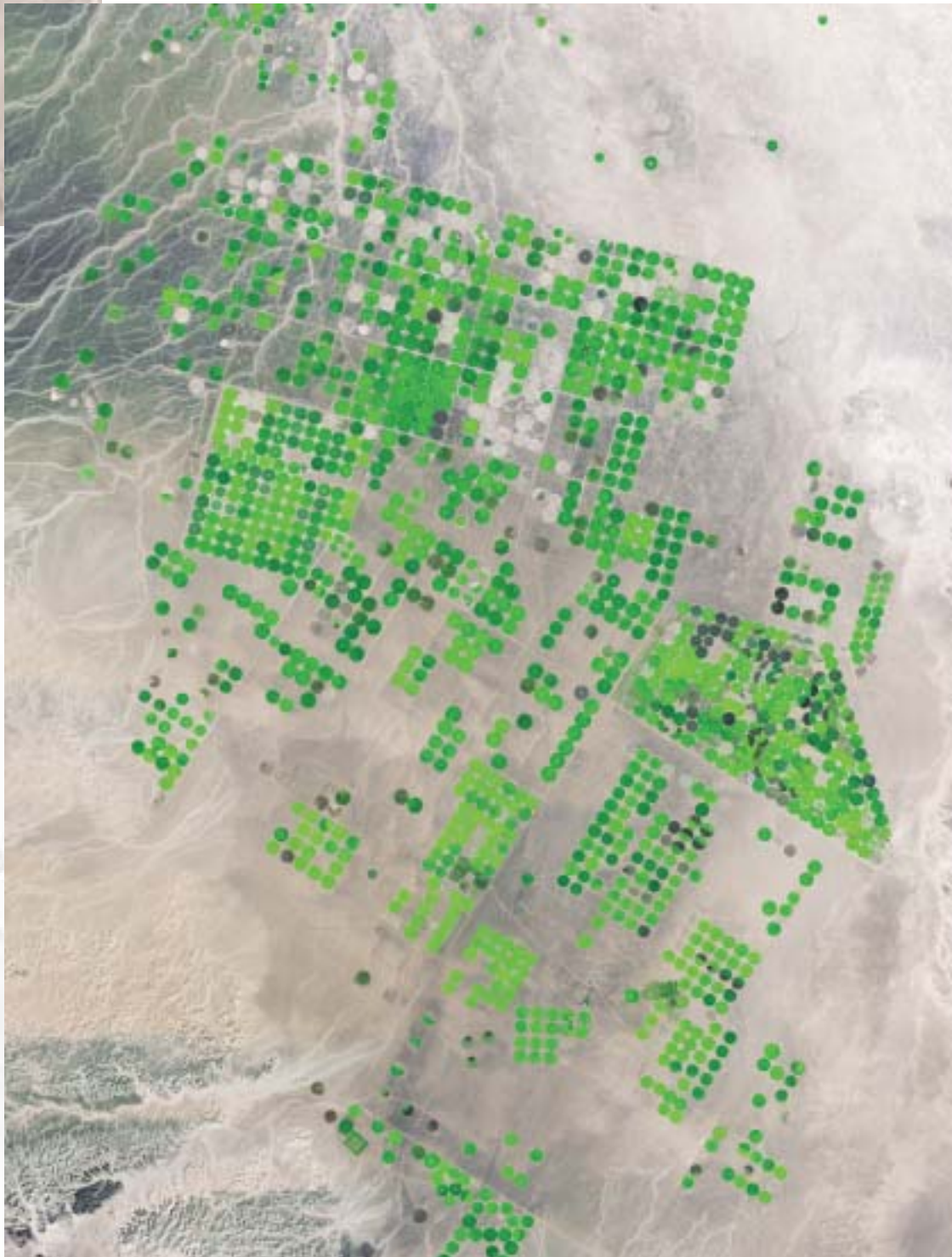
This image shows Wadi as Sirhan near the village of Al Isawiyah prior to the introduction of center pivot irrigation.

1991 (upper right)

This image shows the region shortly after the introduction of center pivot irrigation.

2000 (lower right)

Once established center pivot irrigation quickly spread throughout the region.





Aral Sea, Kazakhstan

A Sea in Peril

The Aral Sea, located in Central Asia, has undergone many changes in the recent past. The world's fourth largest lake before 1960, the Aral Sea has been progressively drying up. The Amu Darya and Syr Darya rivers, the sea's only inflow sources of water, no longer reach it. Some progress has been made since 1990. The total water withdrawal in the basin has now stabilized at about 110-120 cubic km/year.

The water crisis in the region continues even today. The gradual drying up of the Aral Sea will increase environmental degradation with huge adverse socio-economic effects. There are a variety of significant environmental problems, such as climate change, loss of biodiversity, water pollution and air pollution, in the Aral Sea Basin. The current trend is unsustainable but the poverty and export dependencies of the Central Asian states have prevented real action, and the sea continues to shrink.

The series of satellite images between 1972-2001 show continual shrinkage of the Aral Sea. More than 60 percent of the Aral Sea has already disappeared. It may completely disappear in coming decades. In the image, black shows water, brown shows desert areas and green shows vegetation.



1973

1987





1999



2002

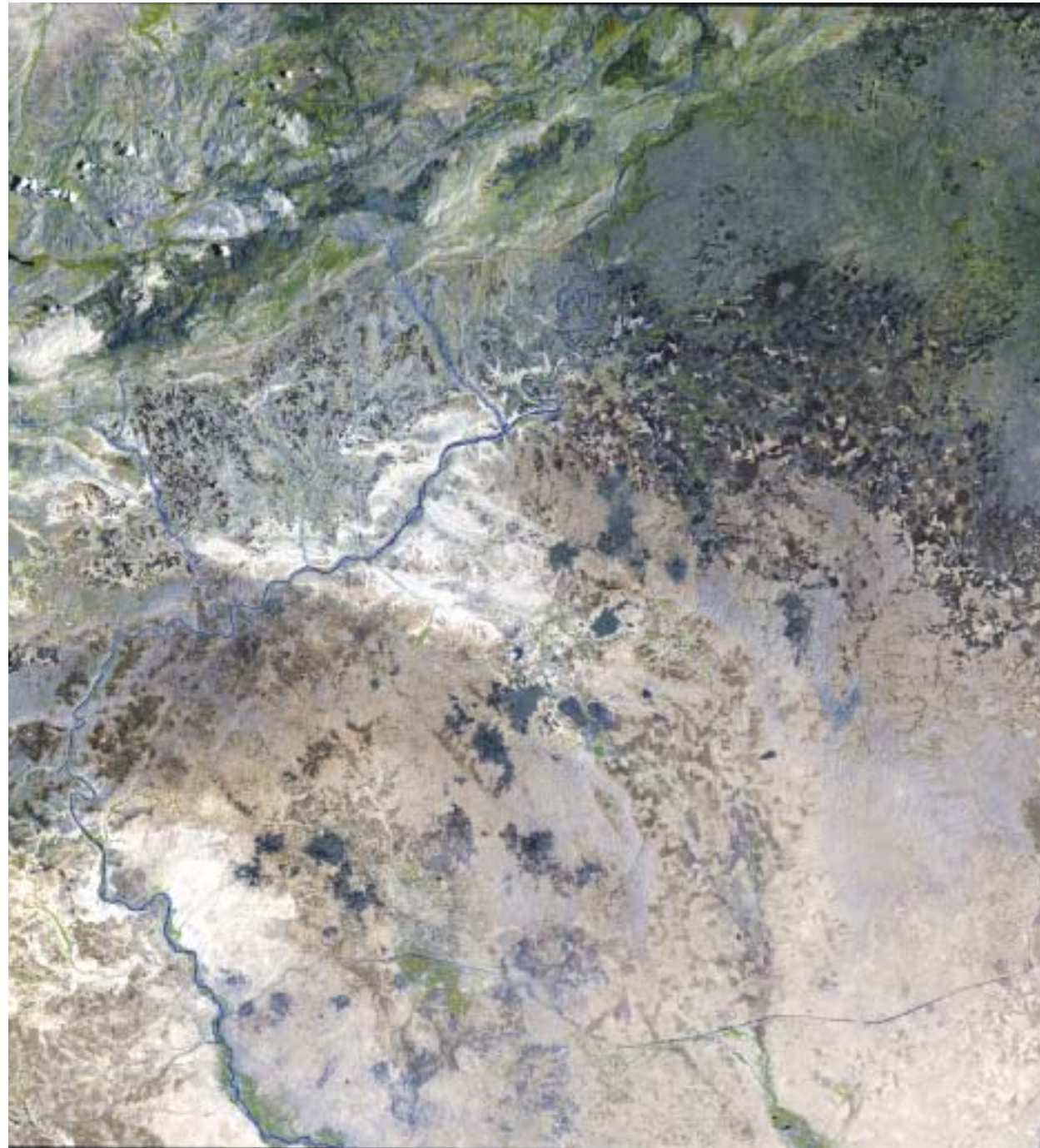




Atatürk Dam and Harran Plain, Turkey

Freshwater Resources and Dam

Atatürk Dam is the world's fourth largest dam, providing hydropower and irrigation for Sanliurfa and the Harran Plain of Turkey. The Atatürk Dam construction on the Euphrates River began in 1983 and was completed in 1990. By 1992 the reservoir had filled to capacity, and is now producing hydroelectric power and irrigation waters for Sanliurfa and the Harran Plain located southeast of the reservoir. The Euphrates River enters the image at the top through a gorge in the Taurus Mountains and exits the image at the bottom. On the Euphrates, just off the image bottom, is Lake Assad, a major Syrian reservoir. The Euphrates River is a major international river whose harnessing raises many environmental and water resources issues that need to be addressed by the countries sharing its waters. In the satellite images blue represents water, green represents natural vegetation and brown represents barren lands.





1975 (left)

Before the dam and reservoir were constructed, most of the agricultural lands produced seasonal, low water crops, such as barley and pistachio. This is a post harvest image, so the fields are either in fallow or were harvested in the spring. The primary agricultural areas are north and east of the river. They are visible mainly as dark harvested agricultural lands. The Harran Plain is in the southeast quadrant of the image.

1999 (right)

In 1999 the lands north and east of the reservoir were still dominated by seasonal agriculture. However, the Harran Plain, now provided a steady flow of water through the Sanliurfa irrigation tunnel, supports water-intensive cash crops, such as cotton, corn and soybeans. Urban and rural populations have grown in size since the introduction of the Atatürk Dam and Sanliurfa Tunnel. Official statistics shows that the population of Sanliurfa grew from 276,528 in 1990 to 410,762 in 1997, indicating a 49% increase largely supported by economic activity due to hydroelectric power provided by the dam.



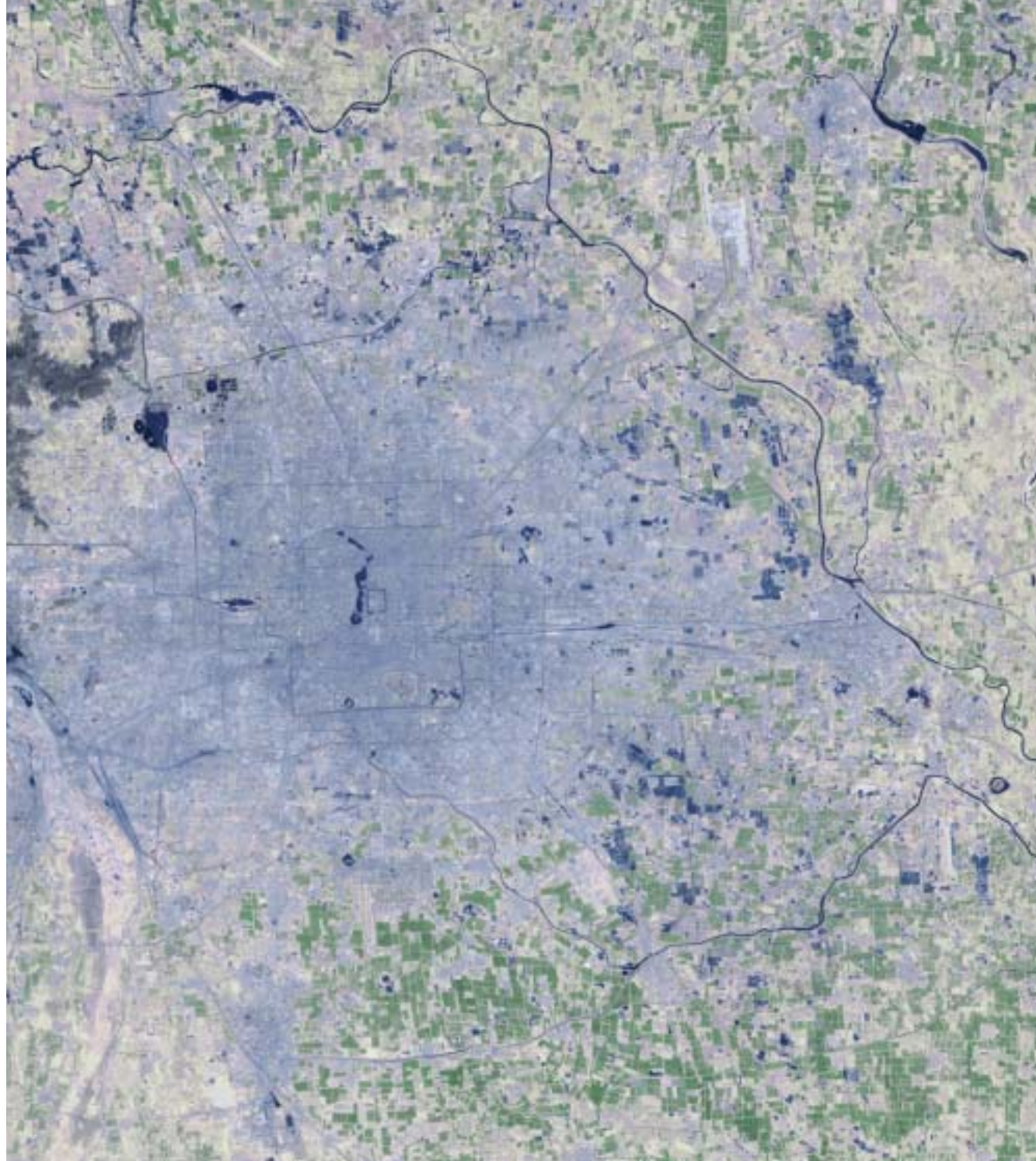


Beijing, China

Urban Population Growth

Beijing, the second largest city in China after Shanghai, is the cultural, political, and intellectual center of the country, as well as a major industrial and commercial metropolis. Beijing's extremely rapid industrial and commercial development is putting pressure on the city's historical and cultural landmarks, and causing significant loss of productive agricultural land. Like many other large cities, Beijing has also encountered serious pollution problems because of its growth. The Landsat images show the city's growth trends and remarkable changes during the "reform era" since 1979.





1978 (left)

The image shows the status of Beijing before the new economic reforms of 1979. The light blue area in the center shows Beijing, including the Forbidden City. The green hills west of the city are covered with deciduous forests. A mixture of rice, winter wheat and vegetables, represented in a range of colors depending upon the stage of their development, dominates the agricultural lands.

2000 (right)

This image shows urban growth expanded from the city center often along major transportation corridors and toward the airport. The estimated population was 11 million in 1992, with approximately 7 million living within the city boundaries. The suburbs grew rapidly as new construction of institutional, industrial, and residential buildings covered the landscape and resulted in the conversion of prime agricultural land to urban uses. The agricultural lands closest to the city center that historically been dominated by vegetable and rice production are among the most threatened by commercial and residential development. The population growth, mainly due to in-migration, increased to 13 million by the year 2000.





Dhaka, Bangladesh

Uncontrolled Urban Population Growth

Dhaka, the capital of Bangladesh, has achieved phenomenal growth since the country gained independence in 1971. In 1971, Dhaka had a population of almost two and a half million. Today it has a population more than ten million and occupies over 1500 sq. km. Dhaka is one of the poorest and most densely populated cities in the world having 6545 people per sq. km.

Dhaka is located on an alluvial floodplain between the Ganges/Brahmaputra rivers and the Meghna river. In a major flood event, about 71 of the 90 wards in the city will suffer severe damage and up to 25 percent of the country may be flooded. Seventy-five percent of the population of Bangladesh lives less than 10 meters above sea level. The monsoon rains cause repeated flooding and storm surges from cyclones devastate populations far inland from the coast. The green color in the images represent forest and agriculture, bright white spots represent planned areas for infrastructure and gray shows urban areas.



1977 (left)

Dhaka is visible in the top central portion of the image along the Turag River. Its seaport Narayangan is located 16 km to the southeast close to the confluence with the Meghna. The confluence of the Meghna and the Ganges can be seen further to the southeast. These two rivers dictate life in the region.

2000 (right)

The image reveals the conversion of low lands and agricultural areas to urban as Dhaka expands to the north. The very flat and broad nature of the floodplain can clearly be seen in the shifting channels of the major rivers.





Oil Well Fires, Kuwait

Environmental Pollution

The Persian Gulf war brought about some of the worst environmental pollution ever recorded as result of oil spills and oil fires. During the air and ground war of January–February 1991, 700 oil wells were damaged, of which more than 600 were set on fire. Ninety-five percent of the oil was removed and exported. Five percent continues to pollute the desert with a high risk of contaminating the ground water that is so limited in the region. The satellite images show the dramatic changes in Kuwait during the Gulf War. The blue shows water, green shows natural vegetation, light yellow shows desert areas and black shows pollution from oil spills and fire.



1990 (left)

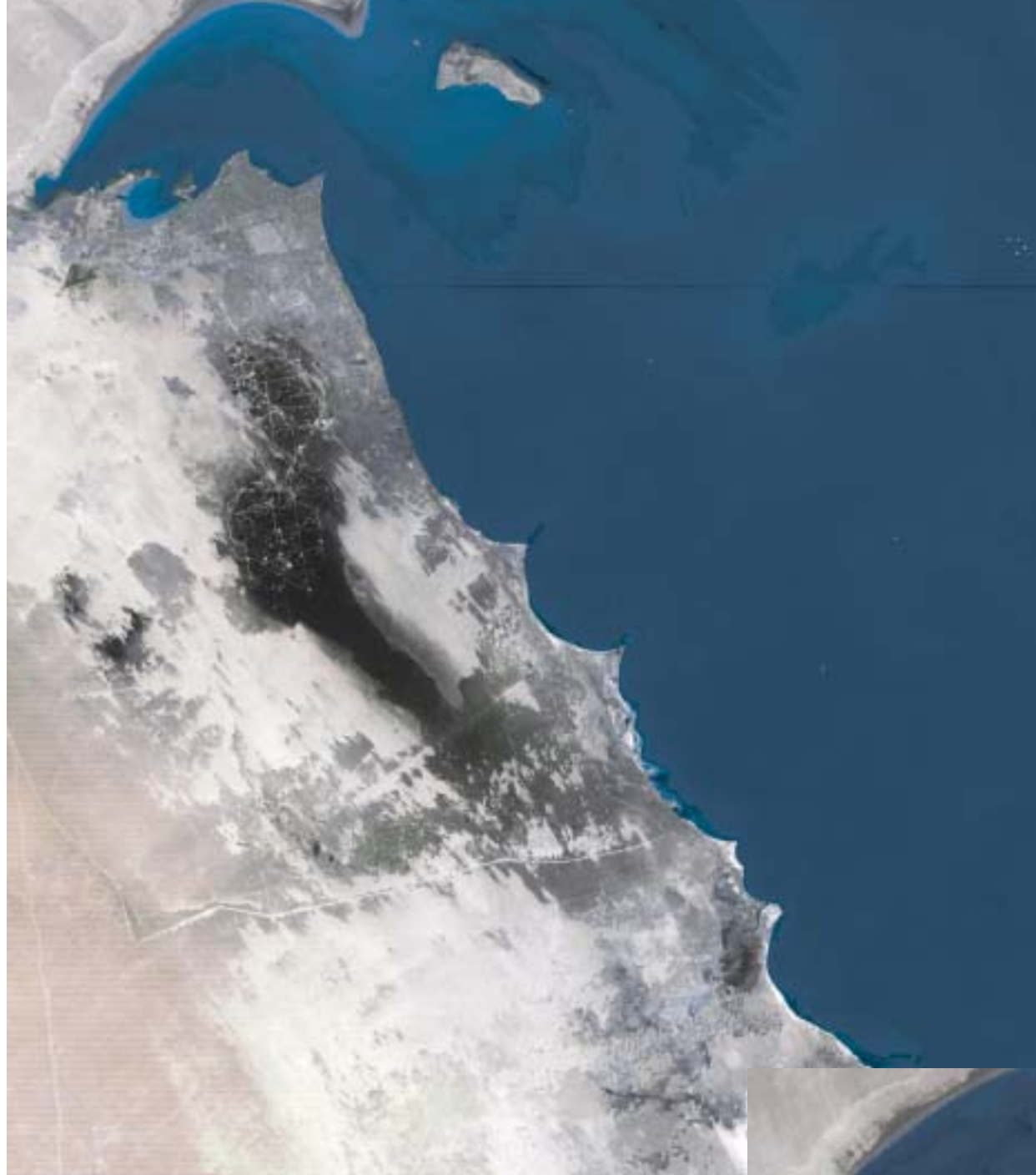
The August 1990 image (before the oil fire) shows the capital city of Kuwait in the upper part of the image.

1991 (upper right)

The November 1991 image was acquired after the fires had been extinguished. It shows the damage to the landscape and a number of newly formed oil lakes.

2000 (lower right)

The January 2000 image shows that the area is developing again but the soil quality has not yet been restored.





Huang He Delta, China

Environment Changes/Impacts of Land Use

The Huang He (Yellow River) is the muddiest river on Earth and is China's second longest river, running 5475 km (3,395 mi) from eastern Tibet to the Bohai Sea. The Huang He's yellow color is caused by a tremendous amount of mica, quartz, and feldspar in the sediment, most of which is accumulated as the river carves its way through the highly erodable loess plateau (wind-blown soil deposits) of north-central China, with substantial erosion taking place. As the river erodes the loess, it becomes a "river of mud" (Loessial soil is called *huang tu* or "yellow earth" in Chinese).

Between 1979 and 2000, satellite images show dramatic changes in the tip of the Yellow River delta. During this period, several hundred square kilometers have accreted to and been eroded from the coast.





1979 (left)

Agricultural lands were few until land reclamation efforts began in the 1950s. Only thirty years ago, this place was a vast expanse of saline-alkaline soil with limited agriculture.

2000 (right)

Between 1979 and 2000, the delta tip grew nearly 100 square km. Aquaculture has expanded along much of the coast and agriculture overall is better developed.





Irian Jaya, Indonesia

Loss of Traditional Lands

Irian Jaya is Indonesia's largest and most eastern province covering the western half of the New Guinea the world's second largest island.

Indonesia is the world's second largest producer of palm oil, after Malaysia. It currently has 3.2 million hectares of forest for oil palm plantations. Indonesia increased its production of palm oil by some 6.5 million tonnes last year. The drive to meet demand is causing many companies to jump into the market and convert forest areas into plantations.

Two major factors influencing deforestation in eastern Irian Jaya are the growth of the palm oil industry and the Indonesian government's policy of transmigration. A third concern is oil and gas exploration.

The result of the policies for Irian Jaya is a large and rapid increase in population that needs employment and infrastructure to accommodate them, while the palm oil industry finds an easy source of labor to work in newly created plantations. Numerous negative impacts are noted on the environment and on the local cultures and economies.





1990 (left)

The image shows tree canopy nearly untouched by development. Two rivers are visible, the smaller but more important of which is the Uvimmerah River to the northwest of the image. The other main river is along the border of Papua New Guinea. A transportation net is developing to connect the forest resources to a small river port.

2000 (upper right)

The image shows a large square area in the northwest quadrant where intervention in the forest shows its conversion into an oil palm plantation. The lighter green of the monoculture contrasts with the darker green of the old growth of the rest of the forest canopy. The reddish-brown areas have been cleared for planting, but have yet to be populated by palm trees. At the bend in the river near the affected forest area, a larger river port has been established to facilitate transportation of the palm oil.



2002 (lower right)

The intervention in the forest has expanded by 2002 and now reaches the Uvimmerah River in the northwest quadrant.





Isahaya Bay Reclamation, Japan

Tidal Flat Wetlands

This part of Japan has a mountainous interior filled with coastal plains, volcanoes, and hot springs. The Ariake Sea is a large bay almost equal in size to Tokyo Bay and Ise Bay. During low tide, a vast tideland appears, where over 15 species of valuable creatures live, such as mud skippers. The Isahaya Bay on the Ariake Sea is one of the largest and richest staging sites of migratory birds with an incredible amount of benthic and other organisms including mollusks and fishes. Tidal flat wetlands throughout Korea, China and Japan are among the most threatened by the need for increased food production and urbanization.

The Isahaya Bay Reclamation project separated approximately 30 sq. km. of tidal flats from the Ariake Sea in 1997. The intent of the project was to increase agricultural land and to decrease the risk of flooding. The land available per farmer for vegetable production will increase three-fold. The sea wall and its enclosed reservoir should provide a buffer to reduce the risk of flooding both from the river and from typhoon driven high tides.



1993 (left)

This image shows the Isahaya Bay some four years before the reclamation project that separated approximately 30 sq. km. of tidal flats from the Ariake Sea in 1997. Historically, the Ariake Sea has been little affected by red tide damage, thanks to the tideland's self-cleansing effects.

2000 (right)

On this image the seawall and the reservoir can be clearly seen. Future agricultural areas under development are on the white drying tidal flats. Walls to create and protect the future agricultural land can be seen as linear features on the old tidal flats. A few years ago, when the sluice gates around the bay's mud flats were closed, there were reports that the range of tide in the Ariake Sea had shrunk. The removal of one third of the bay will likely have some yet-to-be determined effects on the aquatic ecosystem, including a possible decline in seaweed aquaculture.



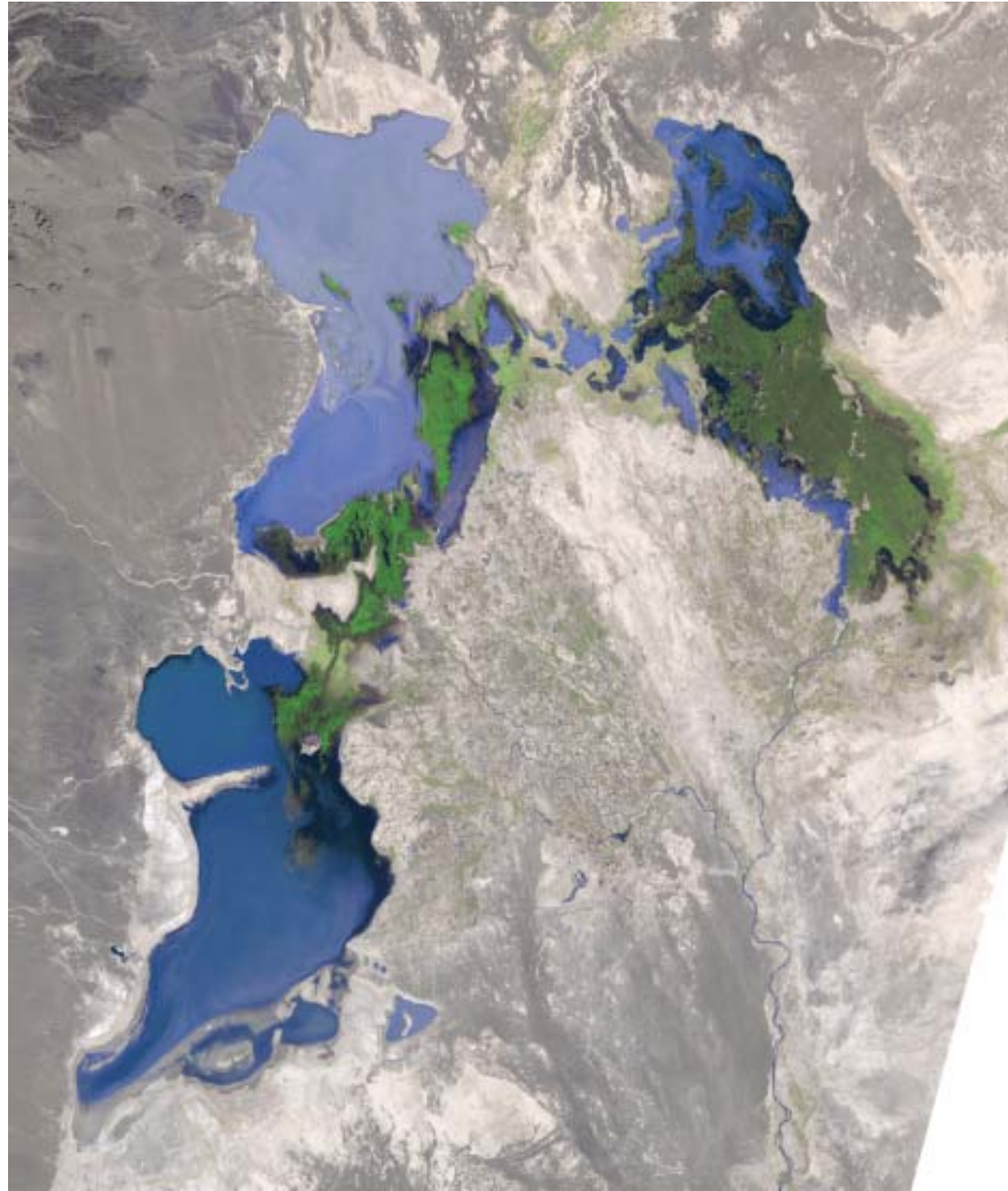


Lake Hamoun, Iran/Afghanistan

Sistan Oasis Parched By Drought

Sistan lies in a large depression located between Afghanistan and Iran. In the centre of this closed basin lies a historic riverine oasis nourished by the Helmand, one of Afghanistan's major rivers rising in the western Hindu Kush. By creating a distinct delta environment in a true desert setting, the Helmand has transformed one of the region's common salt flats into a cradle of life. Remarkably, although the river empties into an extremely arid evaporation pan, it sustains a vast and predominantly freshwater wetland complex, Lake Hamoun. Reaching their greatest extent with spring floods, these wetlands cover an area ranging from 2,000-4,000 sq. km. More than a third of the Iranian portion has been designated as an internationally protected area under the Ramsar Convention on Wetlands, but no land has been set aside for conservation in the Afghani portion.

Reflecting a dramatic decrease in precipitation and drought, satellite imagery shows the snow-covered area in the Helmand basin has decreased by almost two-thirds. By 2001, Iran and Afghanistan were experiencing for the third consecutive year an extreme drought so severe that Lake Hamoun dried out completely. However, drought is not the only reason for Lake Hamoun's disappearance. Sistan's environment has been also radically modified by human manipulation of water resources such as irrigation schemes, which siphon flows from the wetlands.



1976 (left)

Winding through the Margo desert, the Helmand forms a dendritic delta and dissipates in a series of lagoons or “hamouns.” Numerous seasonal rivers also converge in the closed basin. The image shows dense reed beds appearing as dark green, while tamarisk thickets fringing the margins of the upper lakes show up as light green. Bright green patches represent irrigated agriculture, mainly wheat and barley. The lakes flood to an average depth of half a meter denoted by lighter shades of blue, while dark blue to black indicates deeper waters not exceeding four meters.

2001 (right)

Hamoun wetlands vanished as Central and South Asia were hit between 1999 and 2001 by the largest persistent drought anywhere in the world. The only sign of water in this scorched landscape of extensive salt flats (white) is the Chah Nimeh reservoir in the center right of the image, which is now only used for drinking water.



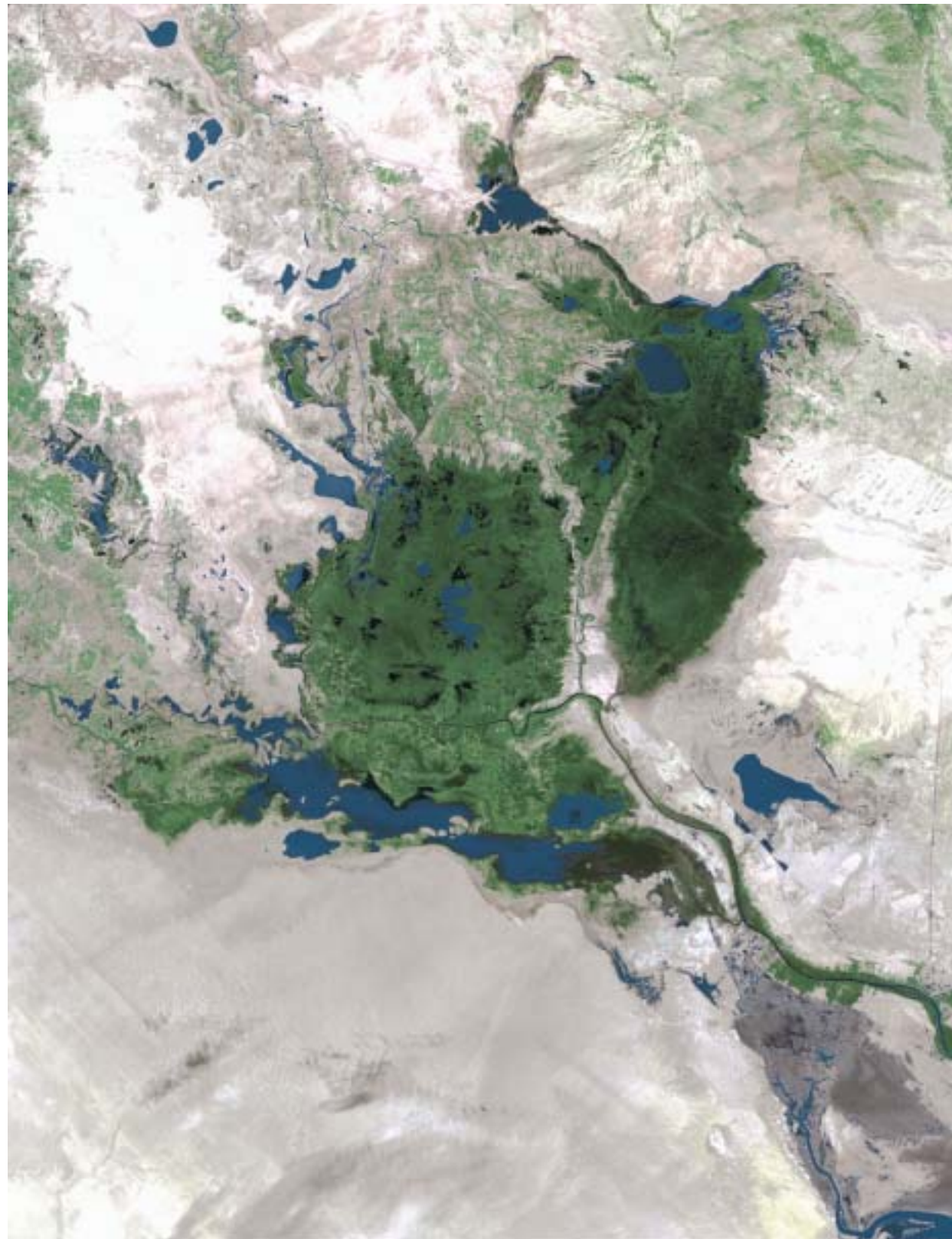


Mesopotamian Wetlands, Iraq/Iran

Disappearing Wetlands

The Mesopotamian marshlands are one of the world's great wetlands covering an estimated original area of 15,000 - 20,000 sq. km. The marshlands are an important center of biodiversity, play a vital role in the intercontinental migration of birds and have long supported unique human communities. Water reservoirs created by large dams upstream, as well as drainage activities in the marshlands themselves, have significantly reduced the quantity of water entering the marshes. Together these factors have led to the collapse of the ecosystem.

The satellite images taken in 1973, 1990 and 2000 provide a synoptic illustration of the great changes that have taken place in the Mesopotamian marshlands, located at the confluence of the Tigris and Euphrates rivers in southern Iraq and extending partially into Iran.



1973 – 1976 (left)

A mosaic of four images taken between 1973 and 1976 shows the status of Mesopotamia region. Permanent lakes appear in black and seasonal lakes are blue to very light blue. Dense marsh vegetation (mainly Phragmites) appears as dark green patches, while green elongated patches along riverbanks are date palms.

1990 (upper right)

Permanent lakes appear in black and seasonal lakes are blue to very light blue. Olive to grayish brown patches indicate low vegetation and dark green patches are dense marsh vegetation.

2000 (lower right)

The image from March 2000 shows that most of the wetlands have disappeared. Most of the marshland area appears as olive to grayish-brown patches indicating low vegetation on moist to dry ground. The very light to gray patches are bare areas with no vegetation and may actually be salt evaporates of former lakes.

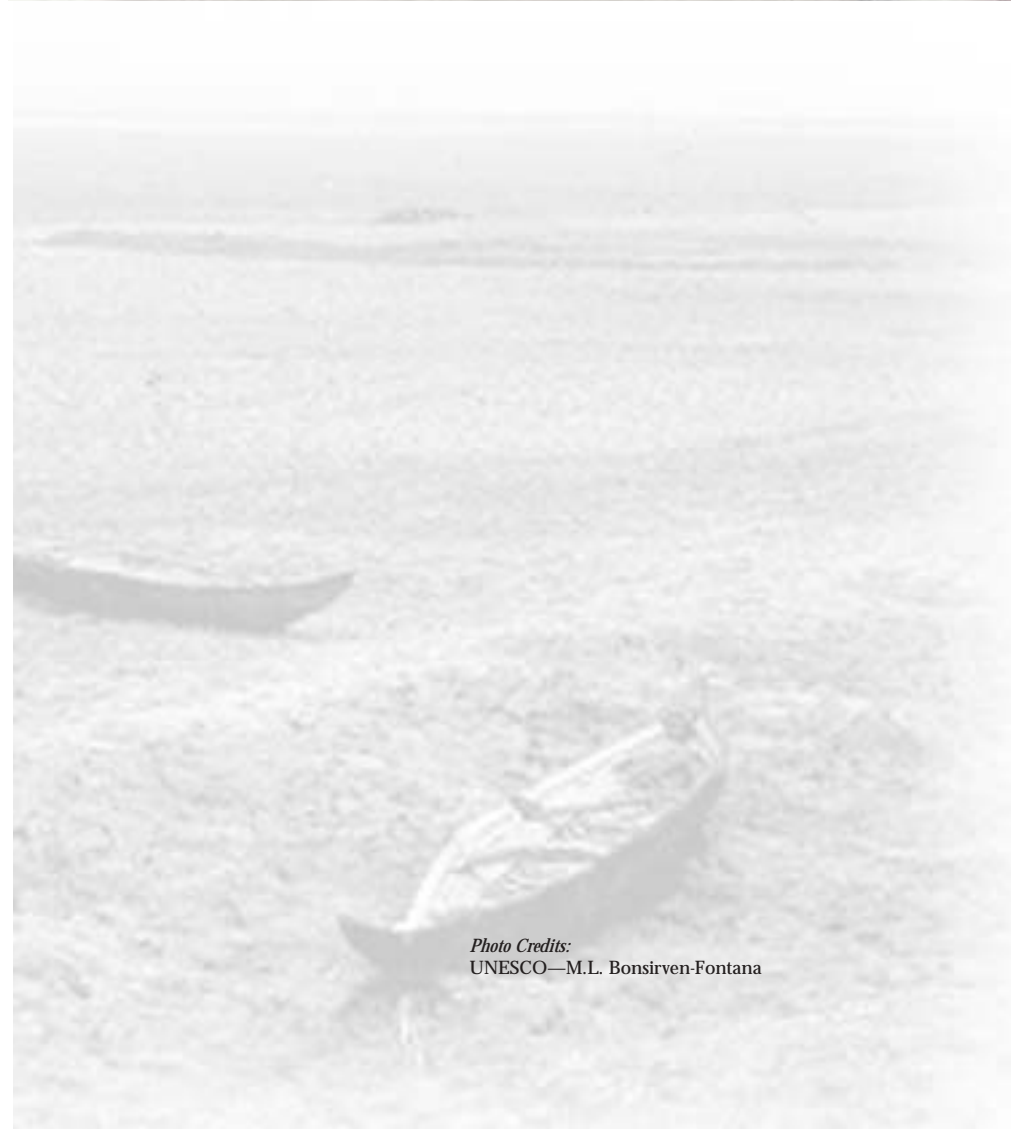
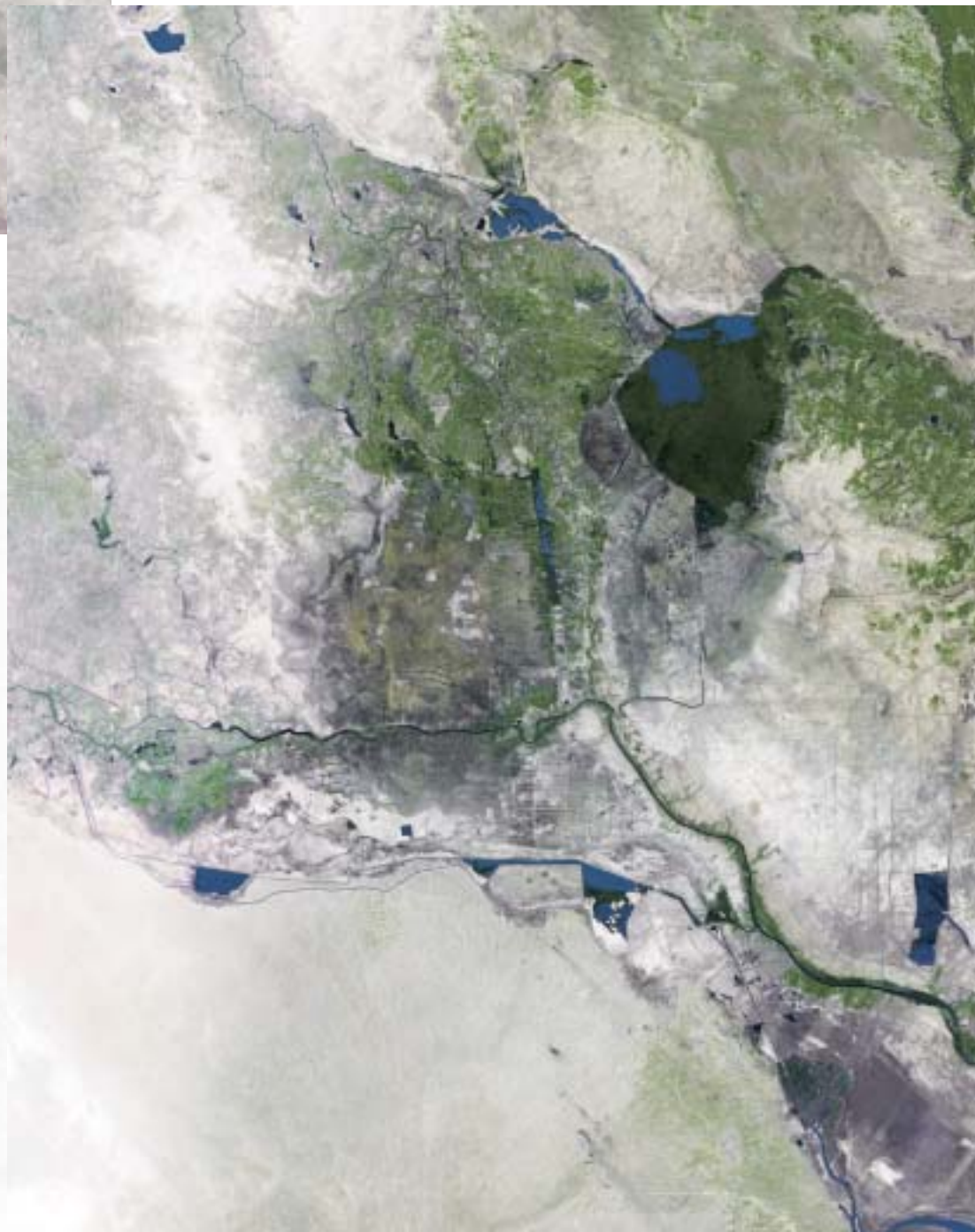
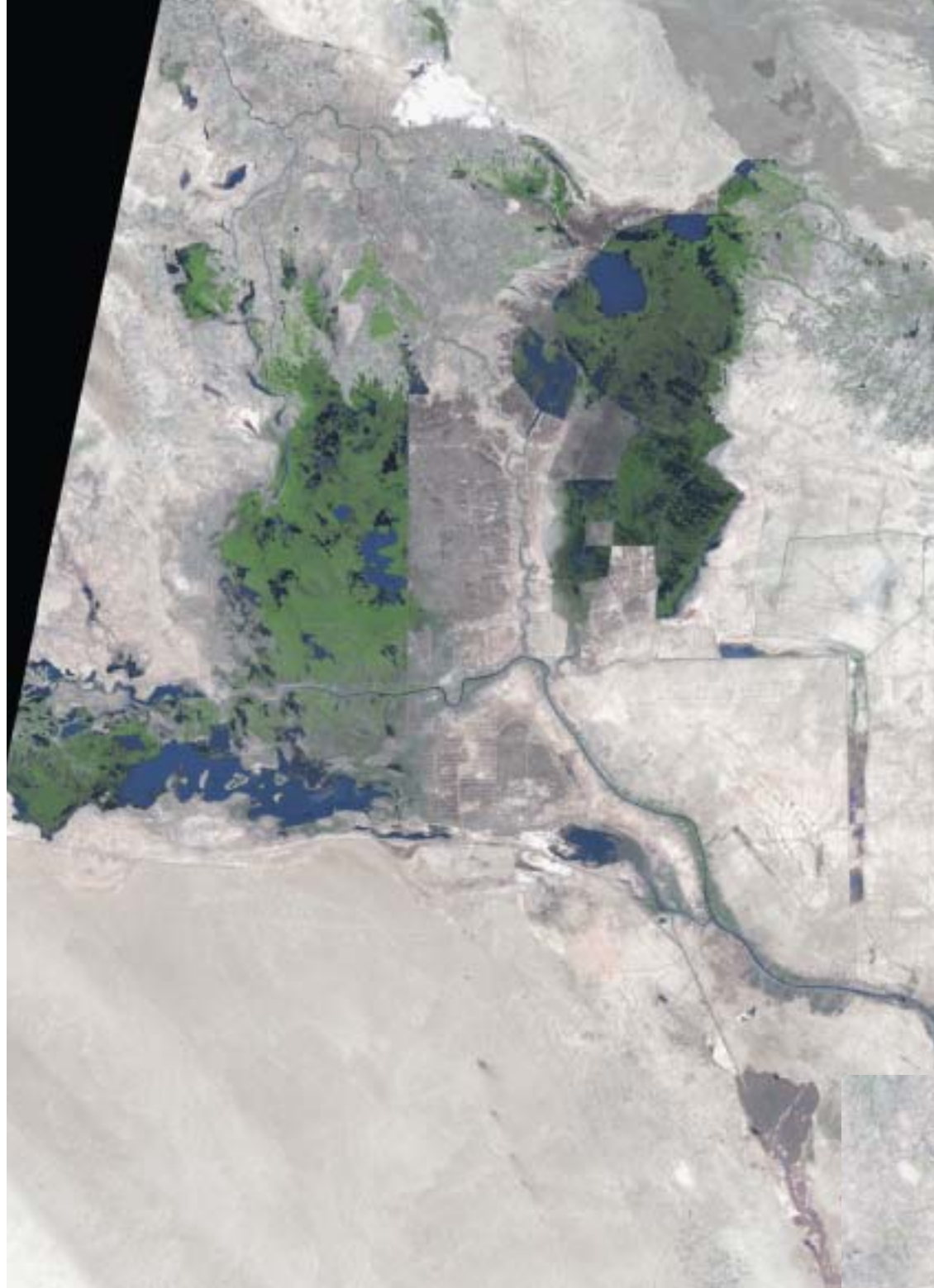


Photo Credits:
UNESCO—M.L. Bonsirven-Fontana



New Delhi, India

Urban Sprawl in a Megacity

New Delhi has experienced massive urban growth in recent decades, placing enormous pressure on the institutional and natural resources that support the city. The population of Delhi has increased from approximately 5 million in 1975 to about 12.2 million in 2000, and it is projected to continue to rise to over 22 million by 2021. Most of this growth is due to high migration rates associated with enhanced income and employment opportunities in New Delhi. The urban area has grown from 182 sq km in the 1970's to more than 750 sq km in 1999. This growth is primarily at the expense of productive farmland as well as loss of natural vegetation. At present, natural vegetation is 5.93% of the total area. The satellite images of 1977 and 1999 show the urban sprawl in New Delhi. In the image, green represents natural vegetation and dark blue represents urban areas.



1977 (left)

The 1977 image shows the status of New Delhi with a population of 5.3 million.

1999 (right)

The image shows dramatic expansion of urban areas in New Delhi with population increased to 12.2 million. As the population sharply rose by 46.31% during the 1990–1999 decade, more areas were converted to urban areas.





Paektu San Region, Korea DPR

Agricultural Expansion in Mountain Regions

Mt. Paektu is an ancestral mountain and the symbol of patriotism to the Korean people. It embodies the spirit of the nation. Volcanic soils and short, dry and relatively cool growing seasons make this high plateau suitable for agriculture. The satellite images document the changes in agricultural in this region. Here green shows natural vegetation, blue shows water and gray-brown shows bare agricultural soil prior to emergence of crops.



1980 (left)

Shortly prior to the collection of this image the dam was constructed on the volcanic shield of Paektu San. The newly filled reservoir can be seen in addition to some limited agriculture. Some of the existing agriculture appears to be related to recent burn scars.

1999 (right)

The area under cultivation on the plateau, west and north of the reservoir, is substantially greater in 1999 than in 1980.





Phnom Penh, Cambodia

The City and the River

Phnom Penh is the capital city of Cambodia. It is just west of the four-way river intersection, which is called the Chattomukh ("Four Faces"). From the northwest and northeast, respectively, flow the Tonle Sap and Mekong Rivers. These waters merge and split into the Basak River and the Mekong, which flow southeast to the South China Sea. The Mekong River is the 12th longest in the world, flowing from western China to the Mekong Delta in southern Vietnam. Phnom Penh is the Mekong River's largest city. Its population fluctuated wildly during the 1970s and 1980s; from an estimated 1.2 million in 1971 it swelled with war refugees to 2 million or more by 1975. By 1978 it was reduced to about 100,000 and then rebounded to over 1 million by 2000. The satellite images show Phnom Penh, the Mekong River, some irrigation works and the changes in landuse in this region.



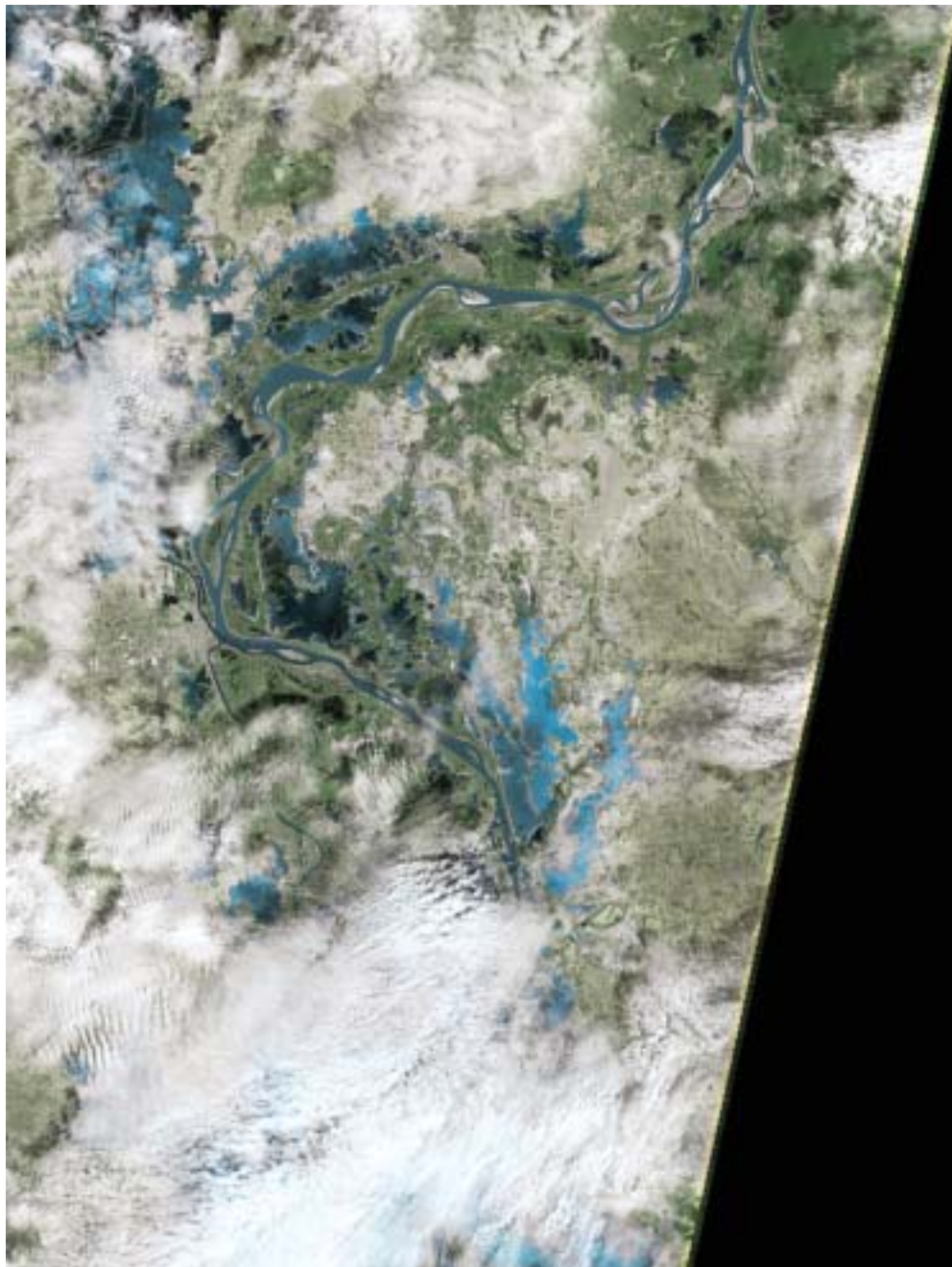


1973 (upper left)

The areas appearing as white or gray are areas that had been under cultivation. The Mekong River on the right is clearly larger than the tiny Tonle Sap River. This image is obviously not from the height of the rainy season and the 2 rivers are quite distinct from each other. Many lakes are visible in the image. These lakes are important to the local population that relies heavily on fish in their diet. Phnom Penh is barely visible as a slightly purple area just to the left of where the two rivers converge.

1985 (lower left)

This image does not show the yearly flooding either; instead the focus is on the irrigation systems set up under the Khmer Rouge. The irrigation canals are evident in a white grid pattern both in the Mekong basin and to the west of the Tonle Sap River. The light green scattered throughout the white grid show that the ground was somewhat newly under cultivation.



Sept. 2000 (upper right)

This image shows the region when the Mekong backs up and inundates the area. The Tonle Sap Lake covers about 270 sq. km in the dry season and about 1500 sq. km. during the rainy season. In the image the two rivers are virtually indistinguishable due to the flooding. Phnom Penh is just barely noticeable at the edge of the bend in the river.

Dec. 2000 (lower right)

Although cloudy, this image shows how much the waters recede in just a few months. The areas in light green are probably under early cultivation again. The remnants of the canals built under the Khmer Rouge regime are still in evidence to the northeast of Phnom Penh.



Photo Credits:
UNESCO—Daniel Riffet



Shenzhen, China

Urban Growth in an Economic Zone

The city of Shenzhen is located just across from Hong Kong and south-east of the Zhujiang (Pearl) River Delta Region in China. The city has been the focus of intense urbanization, known as Shenzhen Special Economic Zone (SSEZ). Comparison of these two satellite images shows the dramatic change in the landscape from 1986 to 2000, as thousands of high-rise buildings and factories have replaced previous agricultural and vegetated areas. The gray color in the image depicts urban areas, green represents natural vegetation and blue represents water.



1986 (left)

The 1986 image shows a concentrated area of development, which is primarily limited to the lower middle and adjoining coastal regions with less than 71,000 people.

2000 (right)

This satellite image shows that by 2000, the developed urban area has expanded to the north, northwest, and northeast and is home to more than 1 million people.

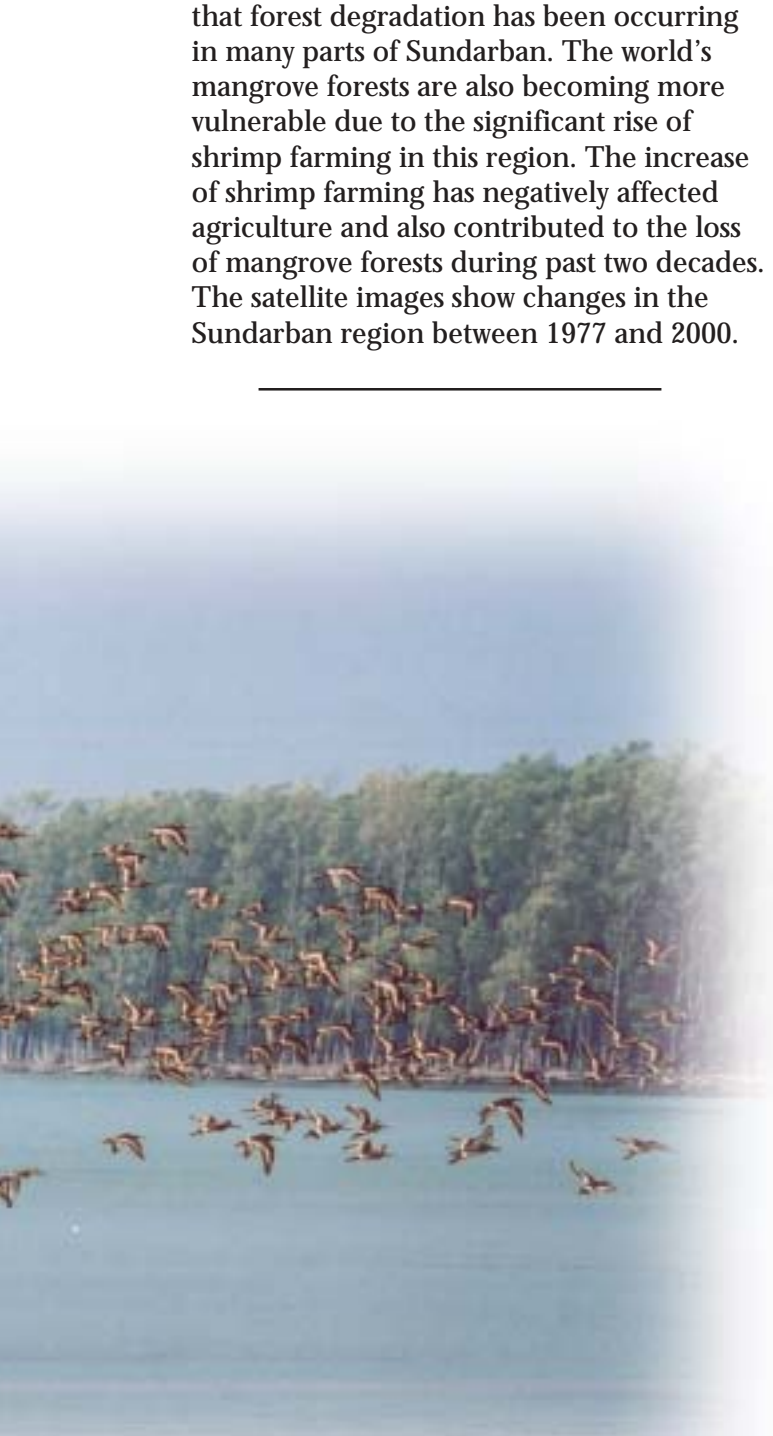




Sundarban, Bangladesh/India

World's Largest Mangrove Forest

Sundarban, the largest mangrove forest of the world, is situated in the southwestern part of Bangladesh and in the West Bengal of India, guarded by the Bay of Bengal. The total area of Sundarban is approximately 10,000 sq. km. Approximately 60% of the mangrove forests fall in Bangladesh and 40% in India. It was declared as a UNESCO's World Network of Man and Biosphere Reserve in 2001. Sunderban is an excellent example of the co-existence of human and terrestrial plant and animal life. Despite high population pressure and environmental hazards such as siltation, cyclone flooding and sea level rise, the aerial extent of the mangrove forest has not changed significantly in last the 25 years. In fact, with improved management, the tiger population has increased from a mere 350 in 1993 to 500-700 in 2000 and eco-tourism is progressing well. While sufficient data is not available, several reports suggest that forest degradation has been occurring in many parts of Sundarban. The world's mangrove forests are also becoming more vulnerable due to the significant rise of shrimp farming in this region. The increase of shrimp farming has negatively affected agriculture and also contributed to the loss of mangrove forests during past two decades. The satellite images show changes in the Sundarban region between 1977 and 2000.



1977 (left)

The closed vegetation canopy of Sundarban can clearly be seen as very dark green in the image, representing vigorously growing vegetation.

2000 (right)

This image is a mosaic of images from different times of the year. The agricultural lands in the west half of the image are pre-harvest, while the agricultural land in the east half are post-harvest. Local areas of shrimp farming show as light purple in previously dark green areas. Overall little change is visible. A closer look at the Sundarbans reveals a shifting composition of the wetland as water and soil quality changes.





Thailand Aquaculture, Thailand

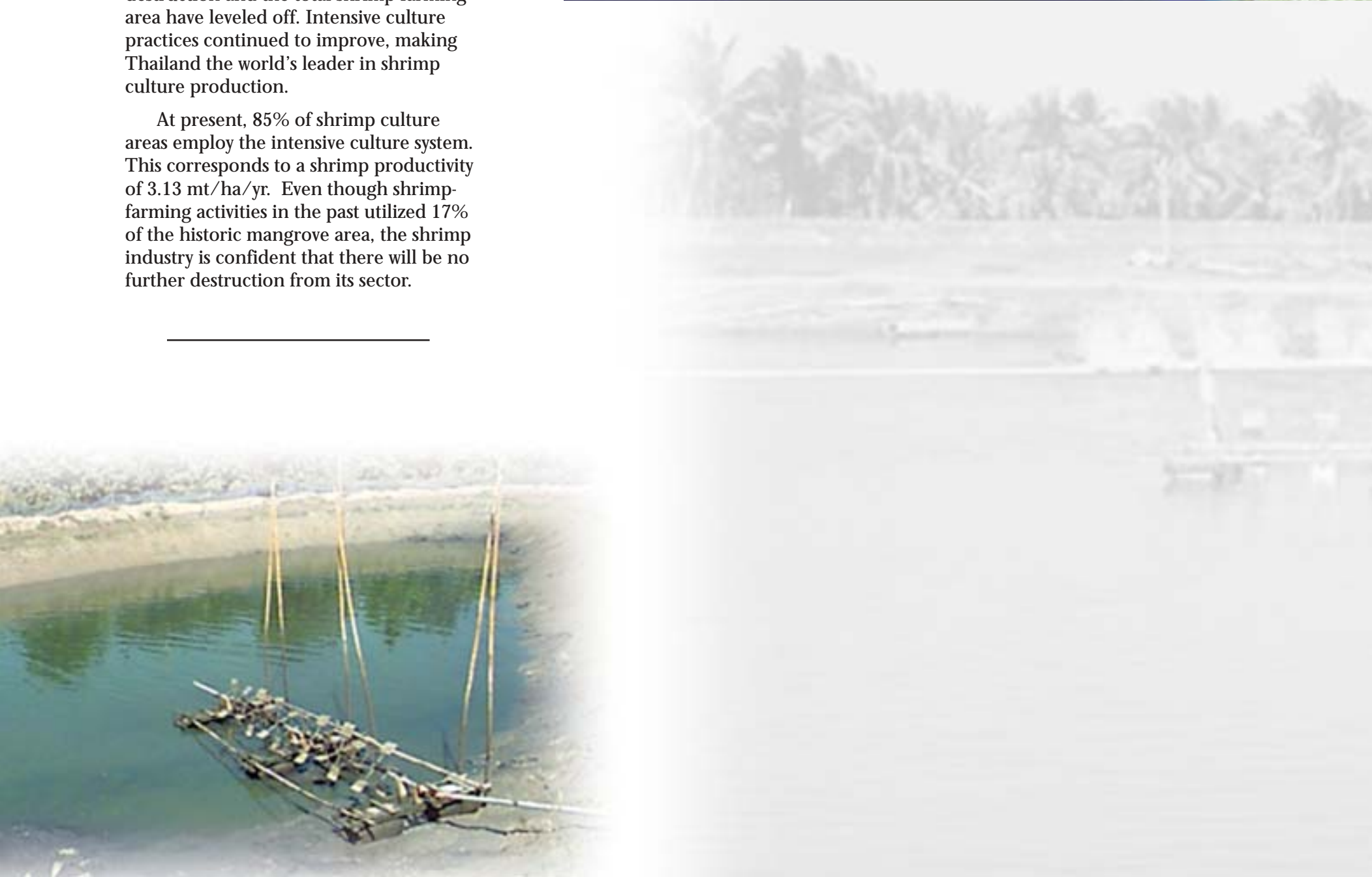
Aquaculture in Asia-Pacific

During the past three decades aquaculture has become the fastest growing food-producing sector and is an increasingly important contributor to national economic development and food security. The rapid population growth in Asia is widening the gap between supply and demand for fish, thereby threatening national food security in many countries.

In the coastal area of Thailand, about 54.7% (2037.65 sq. km) of mangrove was destroyed between 1961-1993 according to the Thai Royal Forestry Department. The highest rate of 129.81 sq. km./yr between 1979-1986 has declined since the introduction of the intensive aquaculture systems in 1987.

The most recent intensive culture system no longer requires mangroves. Since the intensive culture system was introduced in 1987, shrimp production has increased sharply, while mangrove destruction and the total shrimp farming area have leveled off. Intensive culture practices continued to improve, making Thailand the world's leader in shrimp culture production.

At present, 85% of shrimp culture areas employ the intensive culture system. This corresponds to a shrimp productivity of 3.13 mt/ha/yr. Even though shrimp-farming activities in the past utilized 17% of the historic mangrove area, the shrimp industry is confident that there will be no further destruction from its sector.



1973 (left)

The image of 1973 shows the coastal area of southern Thailand with mangrove areas.

2002 (right)

The 2002 image reveals a dramatic change in land use along the southern coast. Much of the coastal ecosystem has been converted to intensive shrimp cultivation, new infrastructure and construction of new dykes.





Three Gorges Dam, China

Man-made Landscapes

The Three Gorges Dam is located on the Yangtze River at Saduping in Hubei province in China. The Yangtze is the longest river in Asia and the third longest in the world, stretching nearly 6,500 km across China. The Three Gorges Dam will be the largest hydropower station and dam in the world, with a 600 km long and 160 metres deep reservoir. As planned, the capacity of Three Gorges dam, 17 million kilowatts, will top that of the largest dam currently operating by 40 percent. The dam may end up providing as much as one-ninth of the nation's electrical production: the energy of 15 nuclear power plants. In addition the dam will provide flood control for a river that has killed one million people in the last 100 years, and will allow shipping upstream to Chongqing for 10,000 tonne ships.

Many issues also exist. Up to 40 percent of the cost of the project will need to be spent on the vastly difficult task of relocating the over 1.2 million refugees displaced by the reservoir. The reservoir will partially or completely inundate 24,300 ha of farmland, 2 cities, 11 counties, 140 towns, 326 townships, and 1351 villages. In addition to commercial fish species, it will also affect endangered species, including the Yangtze dolphin, the Chinese Sturgeon, the Chinese Tiger, the Chinese Alligator, the Siberian Crane, and the Giant Panda. Esthetically, the Three Gorges are known throughout the world for their beauty. Many cultural remains will be submerged representing all of many cultures, including the Ba, who have lived in the valley.

The physiognomy of this region is foothills and the vegetation belongs to the evergreen and deciduous mixed forest of the sub-tropic climate zone. The two images are composed with a natural color composite where vegetation appears natural green. The images show dramatic changes between 1987 and 2000.





1987(left)

The dam site prior to the beginning of construction. The dam site is in the middle of eastern most of the three gorges, Xiling Gorge. Portions of the Xiling Gorge can be seen in the right-center and left-center of the image.

2000 (right)

Comparing the two images from 1987 and 2000, the diversion and navigation canals and the beginning construction of the 2 km concrete dam can easily be seen. An entire mountain was leveled to provide material for the dam and to make way for the navigation canal.





Australia/Oceania

At a Glance

Population: 31 million

Percent of World's Population: 0.5%

Land Area: 7,687,000 sq km

Percent of Earth's Land: 5.3%

Key Environmental Issues

Land degradation

Habitat loss

Greenhouse gas emissions and climate change

Degradation of coastal and marine environment

Sites for Australia/Oceania

Cape York Bauxite Mining, Australia

Wyperfeld National Park, Australia





Cape York Bauxite Mining, Australia

Land Degradation Due to Mining

Some of the world's largest open-cut bauxite mines are in operation in Cape York, Australia. Mining began at Weipa in 1963 and the operations currently produce 8.5 mt of ore annually. The total lease covers an area of approximately 2,590 sq. km. of which 68 sq. km. have been mined. Approximately 4 sq. km. of the mined land is revegetated each year, and over 50 sq. km. of land has been revegetated to date.

Under current mining practices, vegetation is cleared and the topsoil is removed and either stockpiled for later use or immediately replaced on previous mined areas. After topsoil removal, the bauxite is removed, resulting in a lowering of the entire landscape to a depth equivalent to the thickness of the orebody, often several meters. If the topsoil can be returned to a mined-out area after only a short time, it still contains most of the original soil fungi, bacteria and micro fauna. In addition, the seeds from the original community are more likely to be viable. On slopes, rigorous soil conservation measures are implemented, and the area is then normally planted with suitable native species so that it gradually reverts to bushland.

Some of the wealth generated through the mining operation is being placed in a trust for cultural protection, development and long-term investments to compensate for the disruption of the Aboriginal peoples lives and their environment.





1973 (left)

This 1973 satellite image shows an area that was largely native bushland with little or no interference outside of the initial mining operations. The native bushland of the Weipa region is adapted to a frequent fire regime. Fire scars can be seen throughout the images at various stages of regrowth.

2001 (right)

This image shows the disturbed land as a result of the extended mining operations, with areas of revegetation visible in the disturbed areas in the 1973 image. The mining activities at Weipa may be pushing the natural underground water level down into a saline level. Certainly the local drainage patterns will be impacted.

Unavoidably, the physical structure of the soil has been destroyed and in a semiarid environment will take generations to recover. Deeply rooted woody plants will be among the most seriously affected by changes in the deep soil structure and chemistry.





Wyperfeld National Park, Australia

Bush Fires in Australia

Wyperfeld National Park contains 3,237.49 sq. km. of fascinating mallee lands. Located in Victoria, 450 km. northwest of Melbourne, Wyperfeld lies in the flood plain of the Murray River. The park has water only when the river overflows. The park itself is native shrubland, what is often referred to as the Australian “bush.” Over 450 species of plants, 200 species of birds, and a variety of mammals and reptiles make the park their home. There are 2 lakes prominent in the southeast quadrant of the satellite images. They appear in blue. These lakes are Lake Albacutya to the north and Lake Hindmarsh to the south. This site features burn scars in the mallee forest area of Victoria. Fires have been used to maintain the Australian bush for thousands of years, but some modern practices are not sustainable as they are currently being implemented. Fires occur in the park and surrounding area almost every year, leaving huge fire scars.

Fire management in the bush is increasingly studied in Australia as they try to manage traditional lands and balance their need for large-scale agriculture to feed themselves and their livestock. The mallee, with its resistance to fire, its excellent regenerative abilities, and its unique leaf oil properties offers the best opportunity for bushfire control. The following satellite images show the fire scars and regeneration activity in Wyperfeld National Park.



1973 (left)

In the 1973 Landsat image the park area and environments are mostly a darker green with some areas of slightly lighter green, which are remnants of old burn areas that have mostly recovered their vegetation. Grazing land, in the southwest quadrant of the images, appears light green or gray; cropland to the southeast is a gray and brown rectangular patterned area.

1985 (upper right)

In the image from 1985, the park and the surrounding bush are a deep green with mottled patches of gray where the ground is bare after a burn. Two dense cloud masses are evident in white along the western edge of the image. Grazing land in the southwest quadrant of the images appears light green or gray; cropland to the southeast is a gray and brown rectangular patterned area. These areas are often threatened by the bushfires, but frequently escape the full force of the fires. As the mallee scrub thins out near the managed lands and with the largest source of fuel for the fires unavailable, they tend to die out.

2000 (lower right)

In the image from 2000, it is evident that the scars from 1985 show a tremendous amount of re-growth. The areas that were gray in the 1985 image are now a light green, showing the bush vegetation has regenerated itself to a large degree. However, several new burn patches are evident in gray. A large recent burn is evident to the northwest of Lake Hindmarsh. The lakes also show significant change during the 25 year period documented by the images.





Europe

At A Glance

Population: 726 million

Percent of World's Population: 11.83%

Land area: 9,938,000 sq km

Percent of Earth's Land: 6.7%

Key Environmental Issues:

Land degradation

Desertification

Loss of natural forest

Habitat loss

Rapid urbanization

Greenhouse gas emissions and climate change

Bio-invasion

Sites for Europe

Gabcikova, Slovakia/Hungary

IJsselmeer, Netherlands

Taiga Forest, Russia





Gabcikovo, Slovakia/Hungary

Damming The Danube River

Rising from the Black Forest of Germany and traveling 2,840 km to the Black Sea, the Danube River is a living ribbon between east and west Europe. In the middle of the 19th century, the Danube was a wide, branching river whose course was always changing and which had a year-round dynamic exchange with its floodplain. In 1977, The Gabcikovo Dam Project was started under the auspices of an international treaty between Hungary and the former Czechoslovakia to divert the Danube River. The goal was to dam the Danube all the way from Bratislava to Budapest, providing for a tremendous amount of clean hydroelectric energy.

Damming the river and the associated diversion of the water endangers 130 species of birds; 30 mammal species; 8 reptile species; 6 amphibian species and 28 species of fish. Many are endemic to this ecosystem. The lower water table resulting from the diversion threatens this complex wetland ecosystem and the largest drinking water supply in the region. The dam on the Danube River threatens the river's once-flourishing alluvial plains, floodplains, wetlands and its biodiversity.





1992 (left)

The satellite image shows the Gabčíkovo area before the construction of the dam and the Gabčíkovo hydroelectric project.

2000 (right)

Damming the Danube has dramatically altered the flow and volume of water in the old river channel, greatly disrupting the once dynamic ecosystem of Europe's largest river. Prior to Gabčíkovo, water flowed at an average annual discharge of 2,000m³/sec. After the project, the flow in the old river bed was reduced to less than 400m³/sec. The diversion of the navigational channel into Slovakia raises international navigation and trade issues.





IJsselmeer, Netherlands

Land Reclamation

These images show changes in the IJsselmeer, a lake on the coast of the Netherlands. Until 1932, this area was the Zuiderzee, a saltwater inlet of the North Sea. In 1932 the Dutch completed a dike across the mouth of the Zuiderzee to create the IJsselmeer. The freshwater from the IJssel River flushed out the saltwater creating a lake.

By 1968, the Dutch had transformed 1980 sq. km. of the Zuiderzee into five blocks of usable land, called polders. The land reclamation decreased the coastline by 300 km, reducing the impact of storm surges and flooding onto the mainland. The dikes bear the brunt of the storms, while the mainland urban areas benefit from the buffer provided by the dikes. The first of the five polders (Wieringermeer, off the image to the northwest) was actually diked directly from the sea, not from the IJsselmeer.





1964 (left)

Noordoost, top-right, was completed in 1942. East Flevoland, right-center, was completed in 1957. Both Noordoost and East Flevoland can be seen in the 1964 Argon satellite image to be cultivated. Southern Flevoland, the southernmost of the polders, can barely be seen in the 1964 image, diked but undrained.

1973 (uper right)

By 1973, Southern Flevoland had been drained and the soil was being cultivated to make it suitable for commercial agriculture. The dike separating Markerwaard from the rest of the IJsselmeer is partially completed in 1973 and appears as light-toned water.

2000 (lower left)

The 2000 image shows Southern Flevoland covered with active farming. The Markerwaard was completed, but was not drained. Markerwaard is used as a freshwater reservoir and a buffer against flood waters. The original plan was to drain the area as well, but the idea was abandoned due to lack of public support.

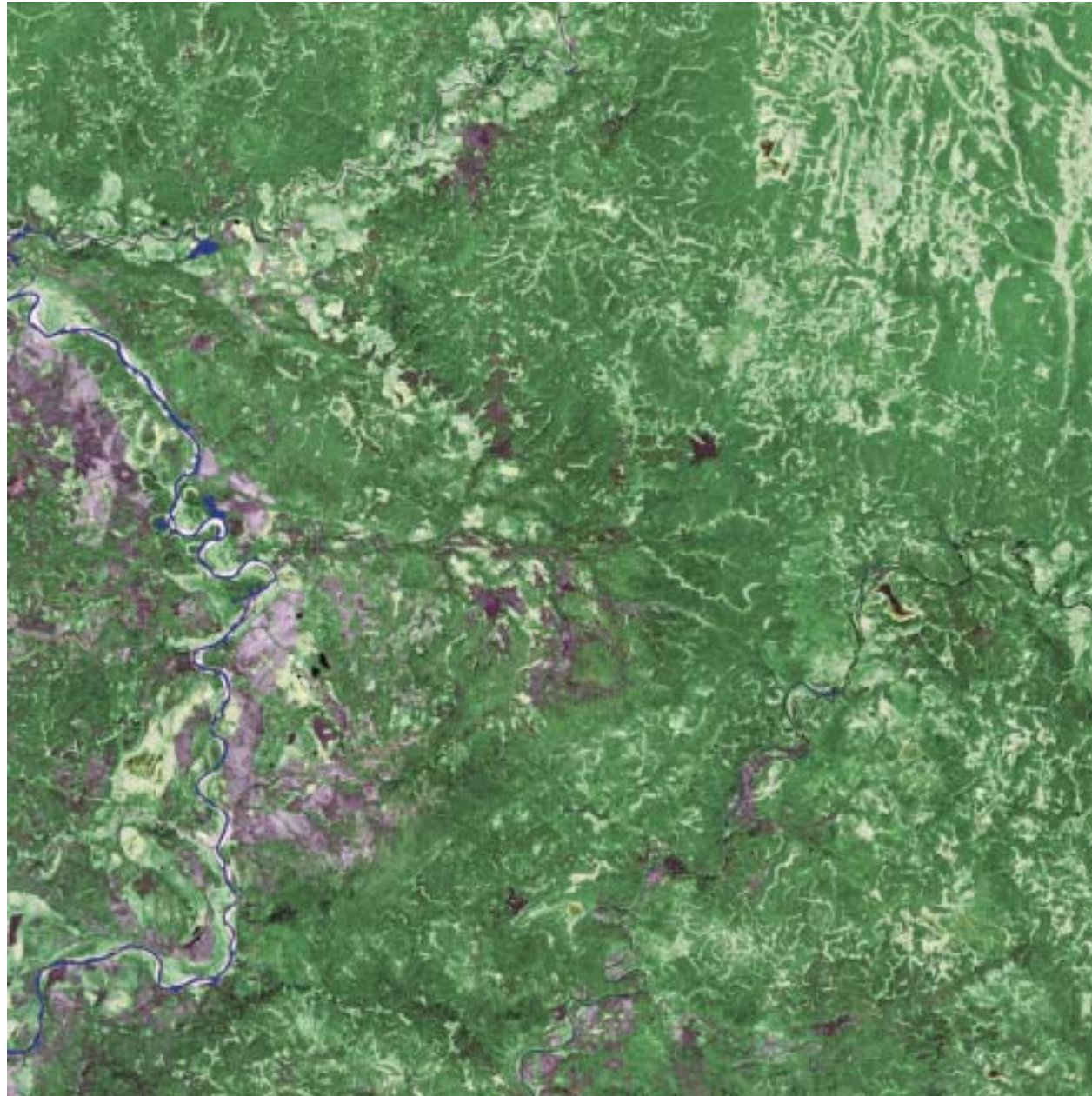




Taiga Forest, Russia

Deforestation in the Boreal Forest

Russia is home to more than 20% of the world's forests, which serve not only as a carbon sink but also as an important source of biological diversity. The Taiga forests of the Arkhangelsk region of Russia are old growth broad-leaf forests that have been a haven for a diversity of species. The satellite images show dramatic deforestation in this region. The dark green color in the images represents forest, light green represents low growth, grass and brush in clearcut areas, brown and tan areas represent bare ground and blue represents water.





1973 (left)

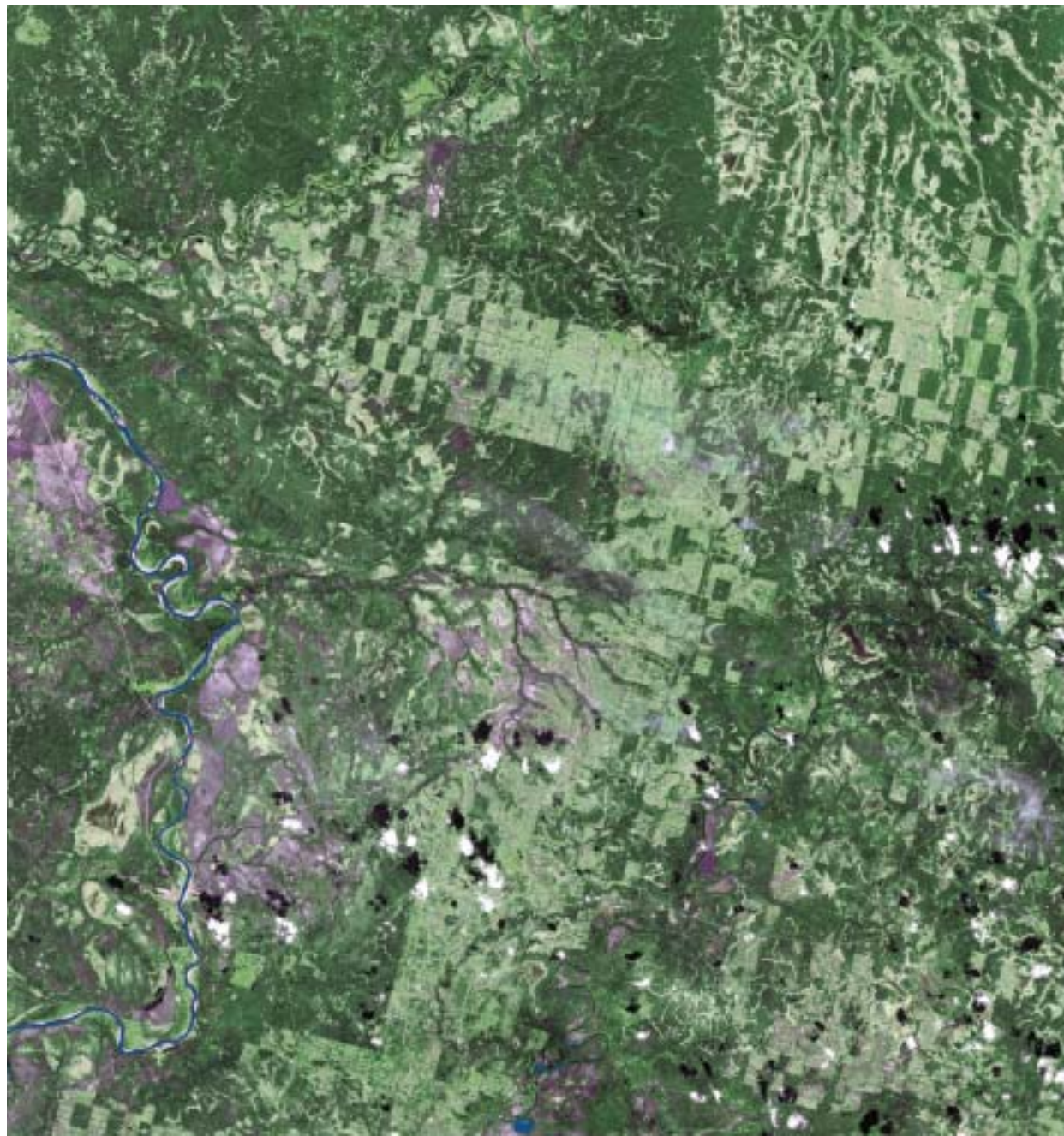
Only limited logging of the old growth forest is visible in the 1973 Landsat image.

1987 (upper right)

The 1987 Landsat image shows expansion of clear-cutting in these Siberian forests.

2000 (lower right)

The 2000 Landsat image shows continued deforestation of the old growth Taiga forest.





North and Central America

At A Glance

Population: 493 million

Percent of World's Population: 8.03%

Land Area: 24,474,000 sq km

Percent of Earth's Land: 16.5%

Key Environmental Issues:

Land degradation

Habitat loss

Conversion of fragile ecosystems

Greenhouse gas emissions and climate change

Exploitation of groundwater

Degradation of coastal and marine areas

Urban sprawl

Sites for North and Central America

Everglades, United States

Gulf of Fomesca, Honduras

Hayman Wildfires, United States

Las Vegas, United States

Mexico City, Mexico

Mount St. Helens, United States

Tensas River Basin, United States

Vancouver and Seattle, Canada/United States



Everglades, United States

Urban Encroachment into the Wetlands

Everglades National Park is situated on the southern tip of the Florida Peninsula, 16km from Florida City. The Everglades is the largest subtropical wetland in the United States with 6,100 sq. km. of area. Everglades National park was included on the list of World Heritage sites in 1993. The sawgrass marshes are the largest in the world and serve as a protected refuge for over 400 species of birds and some 800 species of land and water vertebrates. The threats to the region are evident, as urban growth, overpopulation, agricultural pollution from fertilizers, mercury poisoning of fish and wildlife and drought severely stress the system.

Escalating population is the single biggest threat to the Florida Everglades. Four-fifths of the historic boundaries of the Everglades lie outside the protected region of the park and are threatened by agricultural and urban conversion. The satellite images show that urban population growth has been particularly intense in the counties in the lower east coast rim of the Everglades, straining the natural buffer zone of mangrove forests and sawgrass marshes.





1973 (left)

In 1973, the population of Florida was 8,317,034 and had rather limited impact on Everglades.

2000 (right)

By 2000, the population had almost doubled to 15,774,603. The image shows encroachment along the edge of the everglades.





Gulf of Fomesca, Honduras

Hondurian Shrimp Farming

Honduras is second only to Ecuador in the production and export of cultured shrimp from Latin America. Shrimp aquaculture in Honduras began in the early 1970s and continued in the 1980s with the support of international financial organizations and the Honduran government. The private national and international enterprises converted vast areas of humid coastline into farms for the cultivation of shrimp. This industry boomed to become one of the top grossing industries of the country by the 1990s.

The increase in the production of shrimp is directly proportional to the requirement for land. This land is obtained through the conversion of highly productive coastal wetlands to shrimp farms. The rapid growth of aquaculture in Honduras has caused both environmental and social problems. Shrimp farmers are depriving fishermen, farmers and others access to mangroves, estuaries and seasonal lagoons. The destruction of mangrove ecosystems; alteration of the hydrology of the region; degradation of water quality; destruction of the habitats of other flora and fauna, which precipitates a decline in biodiversity, and the decline in Gulf fisheries through the indiscriminate capture of other species caught with the shrimp post larvae used to stock ponds degrade the overall well-being of local populations.



1987 (left)

This image shows the Gulf of Fonesca before the beginning of intensive shrimp cultivation.

2000 (right)

Over 250 sq. km. in the Gulf of Fonesca has been leased through concessions. The 2000 image documents the resulting conversion of wetlands. Estimates of mangrove loss due directly to the construction of shrimp farms range from about 20 to 40 sq. km. If conservation policies are not put in place, estimates suggest that all the mangroves will disappear within 20 years.





Hayman Wild Fires, United States

Wild Fires in the Western United States

The Hayman wild fire near Denver, Colorado caused the destruction of nearly 60,750 ha of forest. The fire forced about 6,000 people in the communities south and west of Denver to evacuate, and destroyed at least 115 homes and 10 commercial buildings. The cost of fighting the wildfire was \$3 million a day. Wildfire activity in 2002 was much higher than normal across the country with over 567,000 ha burned by June, nearly twice the 10-year average.



May 12, 2001 (left)

The satellite image shows healthy vegetation in various shades of green. In the pre-Hayman fire image, evergreen forests are generally dark green, while deciduous trees leafy plants are a lighter green color. Water and cloud shadows are black, and urban areas are gray.

July 2, 2001 (right)

The satellite image provides a view of the Hayman fire after it burned an estimated 4,600 ha. Recently burned areas appear black, some smoke plumes appear light blue or gray and clouds are white. The Hayman fire scar is clearly visible where older fires show shades of gray immediately north of the Hayman fire.



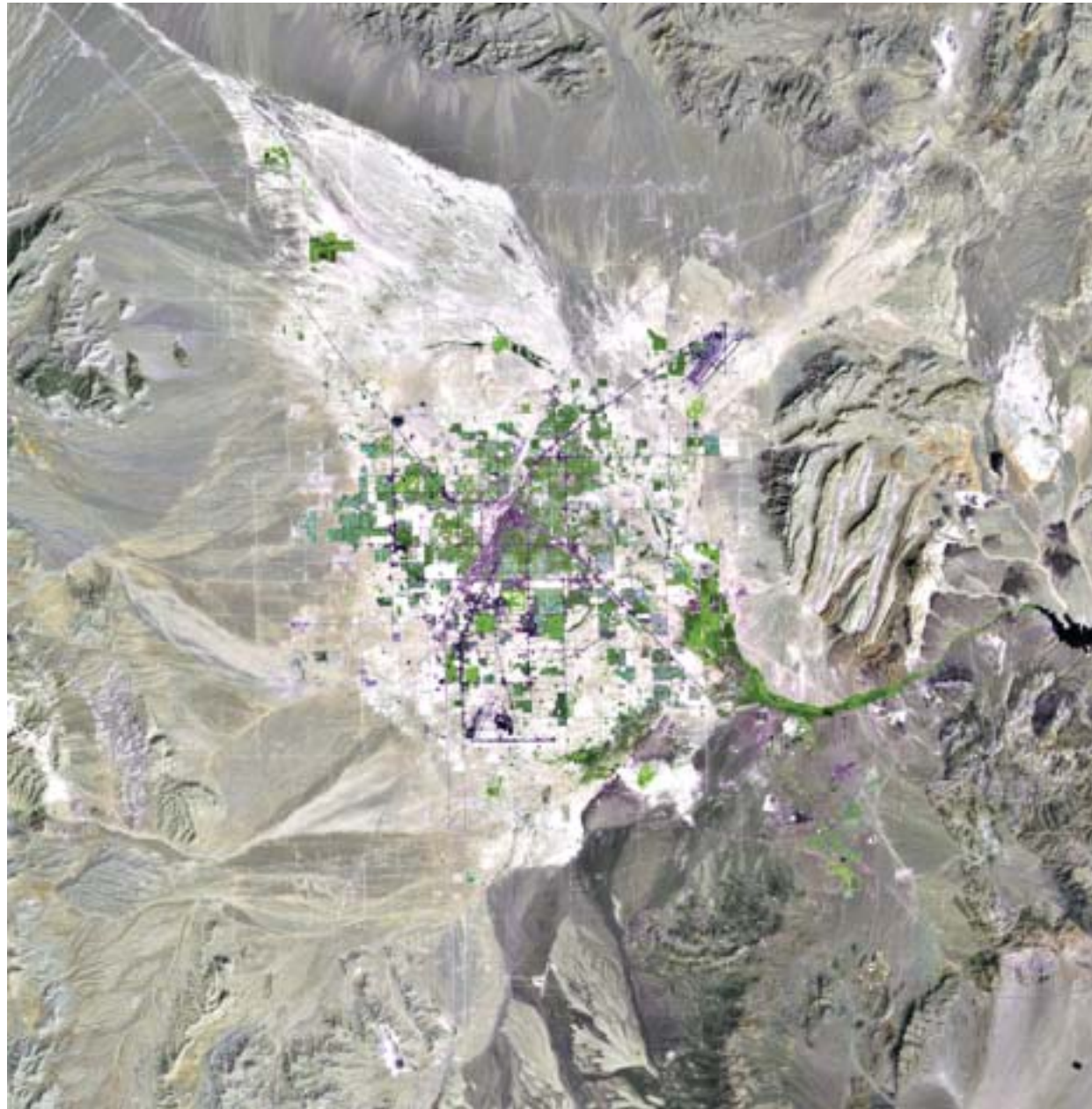


Las Vegas, United States

Urban Land Use Change

The built-up area data for Las Vegas provide a dramatic illustration of the spatial patterns and rates of change resulting from urban sprawl. Population growth in the Las Vegas Valley was fairly slow during the first half of this century, but as the gaming and tourism industry blossomed, population began to increase rapidly. For example, the population of Las Vegas in 1950 was 24,624 and in 1960, it increased to 64,405. By 1980, Las Vegas had a population of 164,674. Today, the Las Vegas Valley's population tops one million, and this does not include the tourist population. Las Vegas is the fastest growing metropolitan area in the USA. One estimate is that the population will double by 2015, causing the rate of conversion of the arable and forestlands to urban use to grow in the same proportion as the population.

The city of Las Vegas is shown in the central portion of the satellite images of 1973 and 1999. These show that modern urbanization in arid environments result in profound modifications to the landscape, specifically the proliferation of asphalt and concrete along with the displacement of the few vegetated lands, such as agricultural and forest lands.

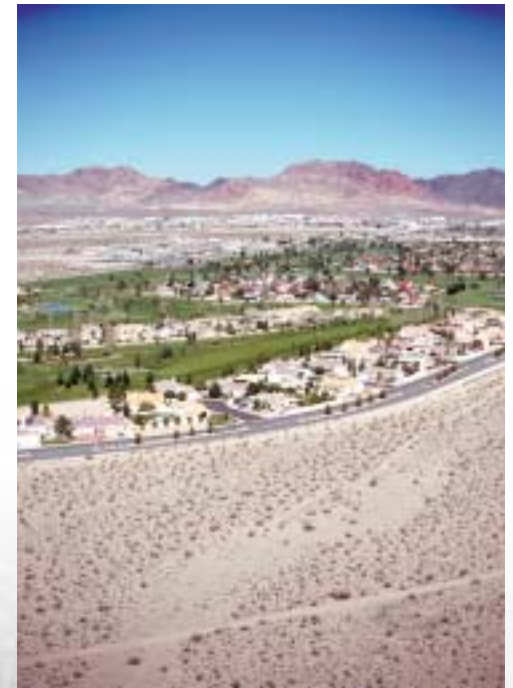
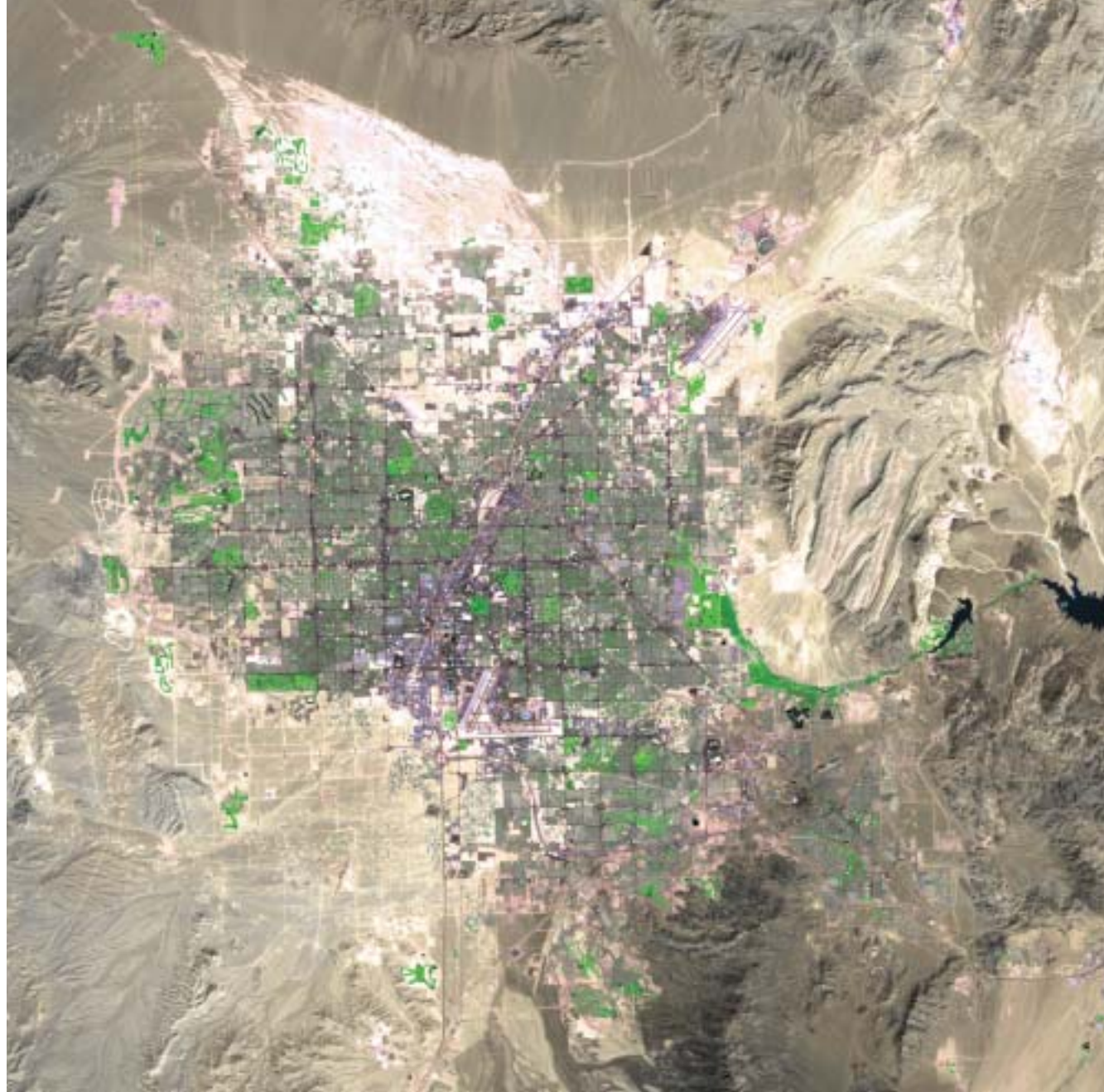


1972 (left)

This 1972 satellite image shows the status of Las Vegas in 1972. Las Vegas was just a stop along the railroad that passes through the town.

2000 (right)

By 2000, the town had grown and sprawled in almost all directions with emphases on the northwest and southeast directions. Several transportation networks emerged to serve the city.

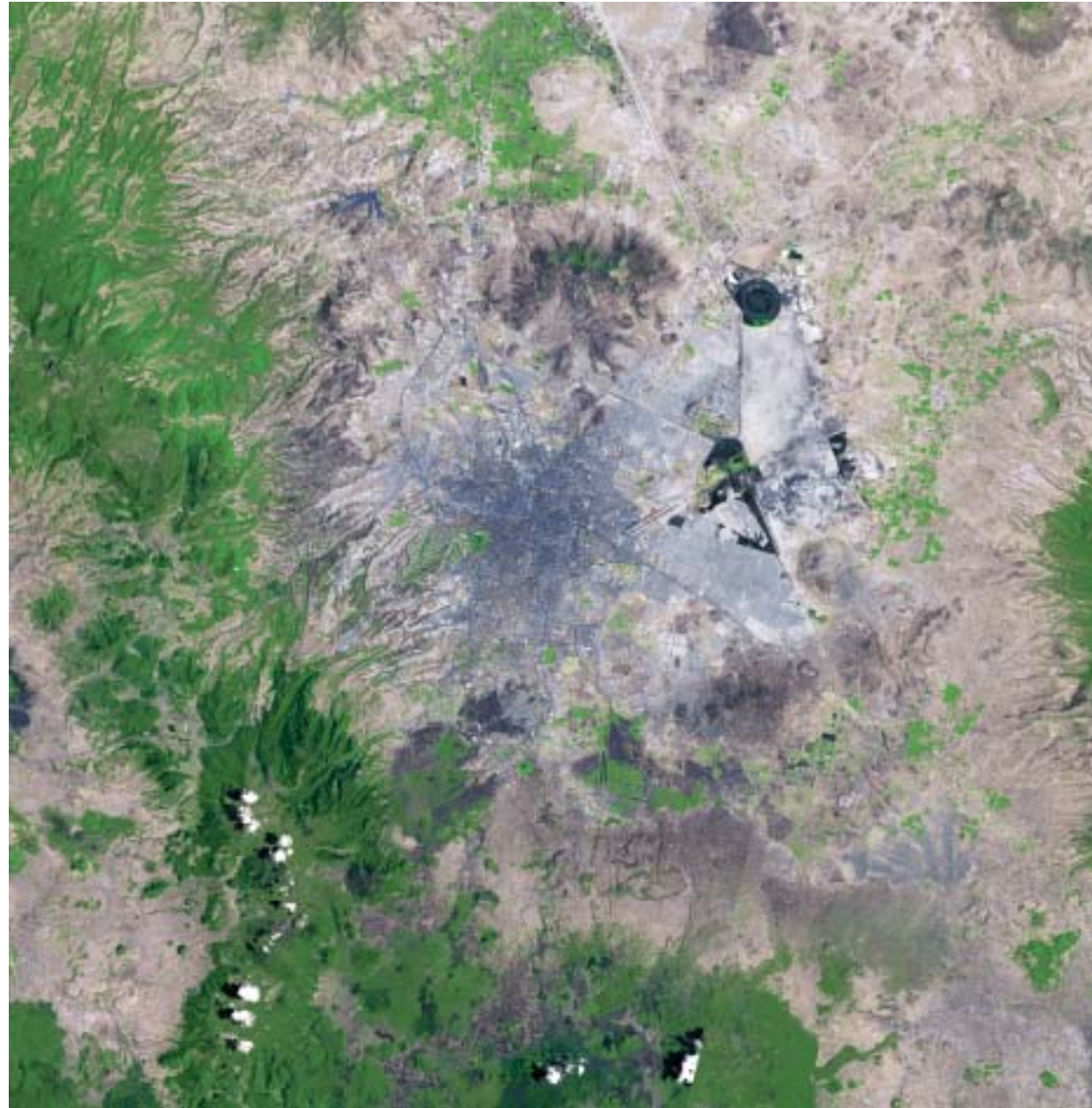




Mexico City, Mexico

Growth of a Megacity

Mexico City, Mexico had a population of 17.9 million in 1999 which makes it the second largest metropolitan area in the world behind Tokyo, Japan. The satellite images show dramatic urban growth in Mexico City between 1973 and 2000. The purple color shows urban infrastructure and green shows natural vegetation. The forests in the mountains west and south of the city have suffered significant deforestation.



1973 (left)

The satellite image of 1973 shows urban growth concentrated in the center of Mexico City, when the population was 9 million.

2000 (right)

The satellite image of 2000 shows dramatic urban expansion of the city into its surrounding areas. The mega city had a population of 14 million in 1986 and is heading for a population of 20 million within the next few years.

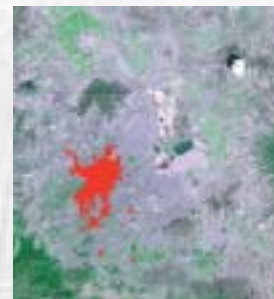
1910



1929



1941



1959



1970



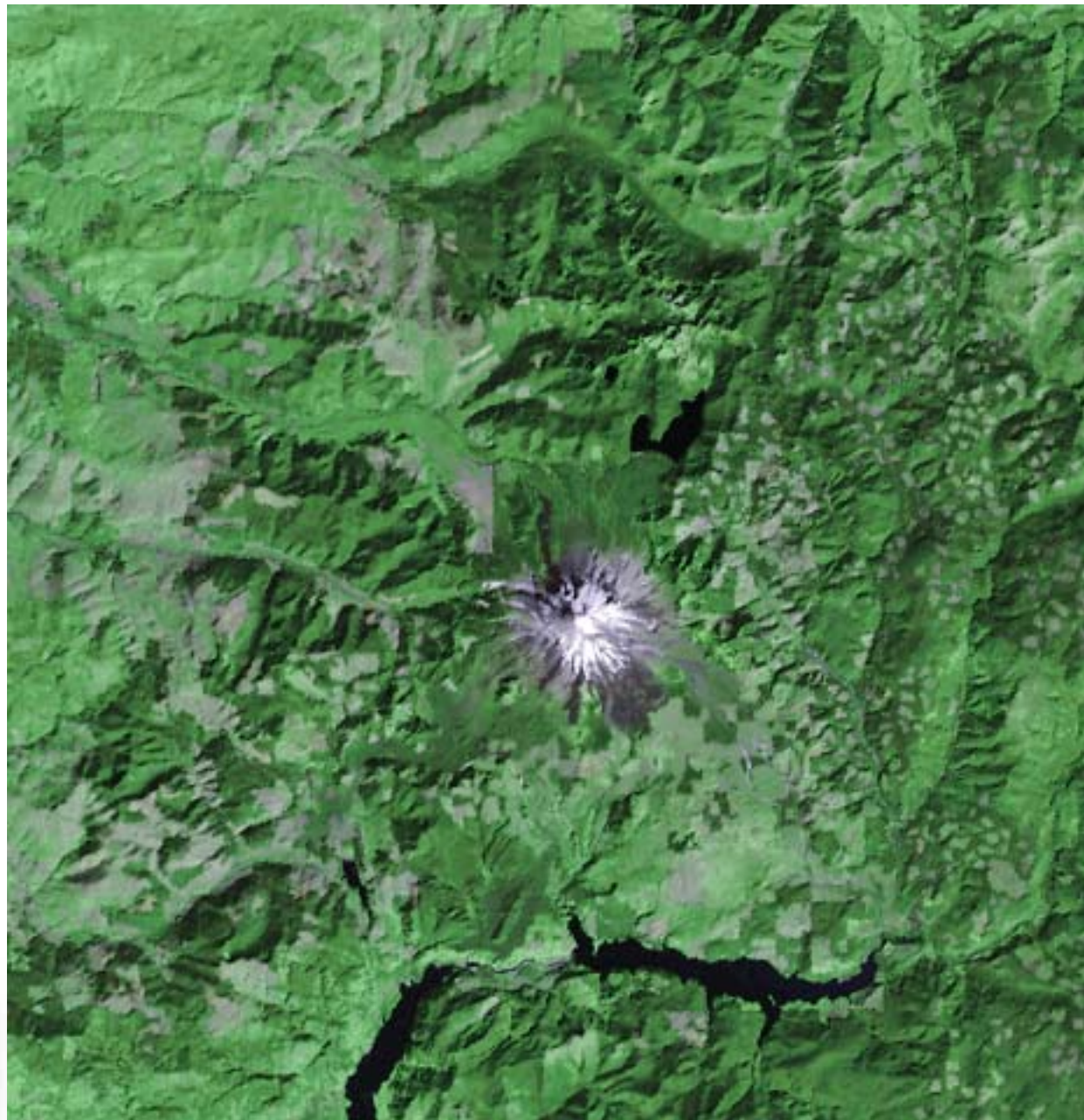


Mount St. Helens, United States

Change At Mount St. Helens

Before 1980, Mount St. Helens was a quiet mountain retreat and a popular location for skiing, hiking, camping, and fishing. However, in a matter of minutes on May 18, 1980, the landscape changed from dense forest to devastated moonscape. Following two months of unrest the volcano erupted catastrophically, resulting in a massive landslide into the Toutle River valley and devastating mudflows down several drainages. The eruption killed 57 people, flattened over 600 sq. km. of trees, and left the area barren and nearly devoid of life for some years. A vertical eruption column persisted for 9 hours, sending a stream of ash and pumice 15 miles into the atmosphere.

While the 1980 eruption of Mount St. Helens destroyed the landscape, it granted biologists an unprecedented view into the colonization and recovery of natural systems. Future eruptions of other volcanoes in the Cascade Range are inevitable, and lessons from Mount St. Helens will be invaluable to geologists and biologists for predicting such activity and anticipating their ecological impacts.



1973 (left)

In 1973 before the volcanic eruption in 1980, Mount St. Helens was a quiet mountain retreat and a popular location for skiing, hiking, camping, and fishing.

1983 (upper right)

This image shows Mount St. Helens after it erupted in May 1980 with the entire north flank of the mountain collapsed into the Toutle River. This reduced the height of its peak by 400 metres, and in the years that followed, a dome of viscous lava formed on the crater floor, eventually reaching a height of 300 metres when it stopped growing in 1986. In addition, two new lakes, Castle and Coldwater, formed where the landslide debris dammed tributaries of the Toutle River.

2000 (lower right)

By the year 2000, life had returned in areas affected by the eruption including the devastated blast zone. Seeds that were blown in by the wind took root in the avalanche deposit and soon shrubs and grasses began to grow. Elk, rodents, insects, and other animals followed the plants, and today, 22 years after the eruption, a thriving ecosystem is evolving.



Photo Credits:
 USGS/Cascades Volcano Observatory—Austin Post
 USGS/Cascades Volcano Observatory—Lyn Topinka
 USGS/Cascades Volcano Observatory—Harry Glicken



Tensas River Basin, United States

Conversion of Forest to Agriculture

The Tensas River Basin encompasses approximately 375,000 ha. of Mississippi River alluvial flood plain in Northeast Louisiana. Historically, most of the Basin was covered with bottomland hardwood forested wetlands. The bottomland hardwood wetlands of the Tensas River Basin have been described as some of the richest ecosystems in the United States in terms of diversity and productivity of plant and animal species. At the same time, the cleared lands are recognized as some of the country's most productive farmland for grain and fiber.

In past years, the freshwater marshes, stream banks, and bottomland swamps of the Tensas River Basin were under strong development pressures. Large portions of the forest near streams and in backwater swamps were converted to agriculture. In 1972 the amount of forest land in the Tensas River Basin was 126,298 hectares compared to 244,522 hectares for human use. These represent 33.6% and 65.1% of the total Tensas River Basin area. In 1991-1992 the amount of forest area was 80,807 hectares and human use was 290,336 hectares. These represent 21.5% and 77.3% of the total Tensas River Basin. The satellite images show the land use change in the basin.



1975 (left)

The image shows the distribution of forest and agricultural lands in the complex riparian ecosystem along the Tensas River in 1975.

2000 (right)

The images show a tremendous forest loss over the 28-year time period. Forests have been replaced by agricultural and urban land uses as can be seen by comparing the images to observe the forest loss over 20 years. The net forest loss for this period is 45,491 hectares, 12.3% of the land area. The river is more channelized and many of the oxbow lakes and their associated wetlands are reduced in size.





Vancouver and Seattle, Canada/US

Urban Growth In The Pacific Northwest

The Pacific Northwest's two major metropolitan areas, Seattle and Vancouver, each grew by about the same number of people in the 1990s, but satellite images reveal that more previously undeveloped land was paved over in greater Seattle than in Vancouver. On average, ten 4 ha. were developed per day in greater Seattle, but only 1.6 ha per day in greater Vancouver.

During the 1990s, the two main Pacific Northwest metro areas (Vancouver and Seattle) have experienced a very similar growth in population (approx 450,000 to 500,000 people). However, the patterns of growth are very different as can be seen in the satellite images.





Vancouver, 1976 (upper left)

The Vancouver, B.C., urban area grew denser since the 1980s. Compact, pedestrian-friendly neighborhoods contained 80 percent of the city's growth between 1986 and 1996. The Vancouver, B.C., metro area lost about 1.6 ha. a day for development.

Vancouver, 2000 (lower left)

The population is nearly 2 million in 2001 compared to 1.3 million in 1976. The 2000 satellite image shows the increased urban area in the Vancouver region.

Seattle, 1985 (upper right)

Seattle has sprawled since 1980's. Low-density residential areas made up three-fifths of the Seattle-Tacoma urban area's growth during the 1990s. During the decade, the Seattle-Tacoma metro area lost an average of 4 ha. of open space per day to suburban development, as measured by satellite imagery. There was an overall increase of 500,000 people from 1990-2000.

Seattle, 2000 (lower right)

The current population is 3.2 million and of that, 2.5 million were living in "car-dependent" low-density neighborhoods.

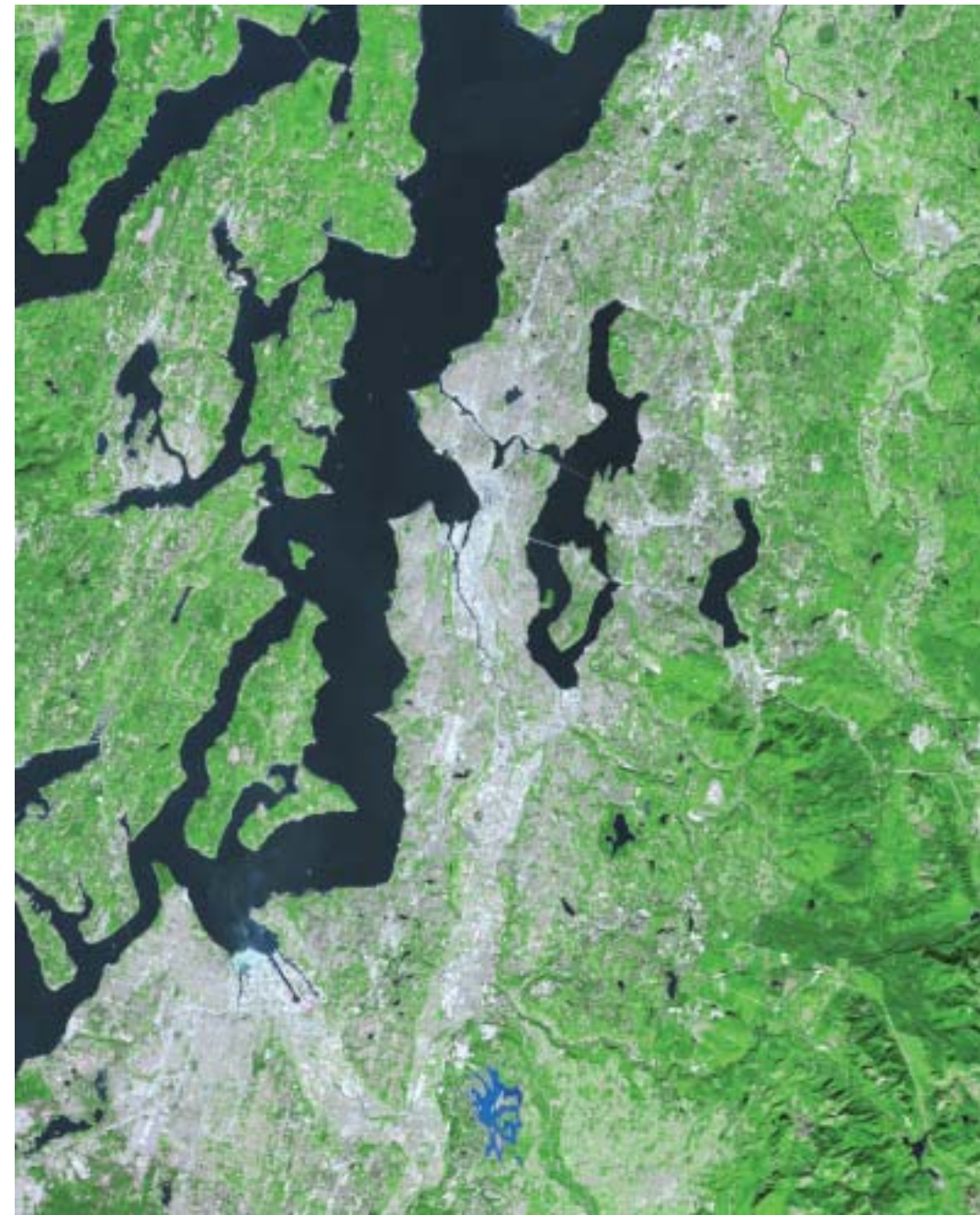


Photo Credits:
 USDA/NRCS—Gary Wilson
 Courtesy of Louise Krohn, www.krohn.org



South America

At A Glance

Population: 351 million

Percent of World's Population: 5.72%

Land area: 17,819,000 sq km

Percent of Earth's Land: 12%

Key Environmental Issues:

Land degradation

Deforestation

Forest degradation

Habitat conversion and destruction

Over-exploitation of resources and illegal trade

Decreasing water available per capita

Water quality

Degradation of coastal and marine areas

Sites for South America

Brasilia, Brazil

Gulf of Guayaquil, Ecuador

Iquazú National Park, Argentina

Manaus, Brazil

Rondônia, Brazil

Santa Cruz, Bolivia

Santiago, Chile

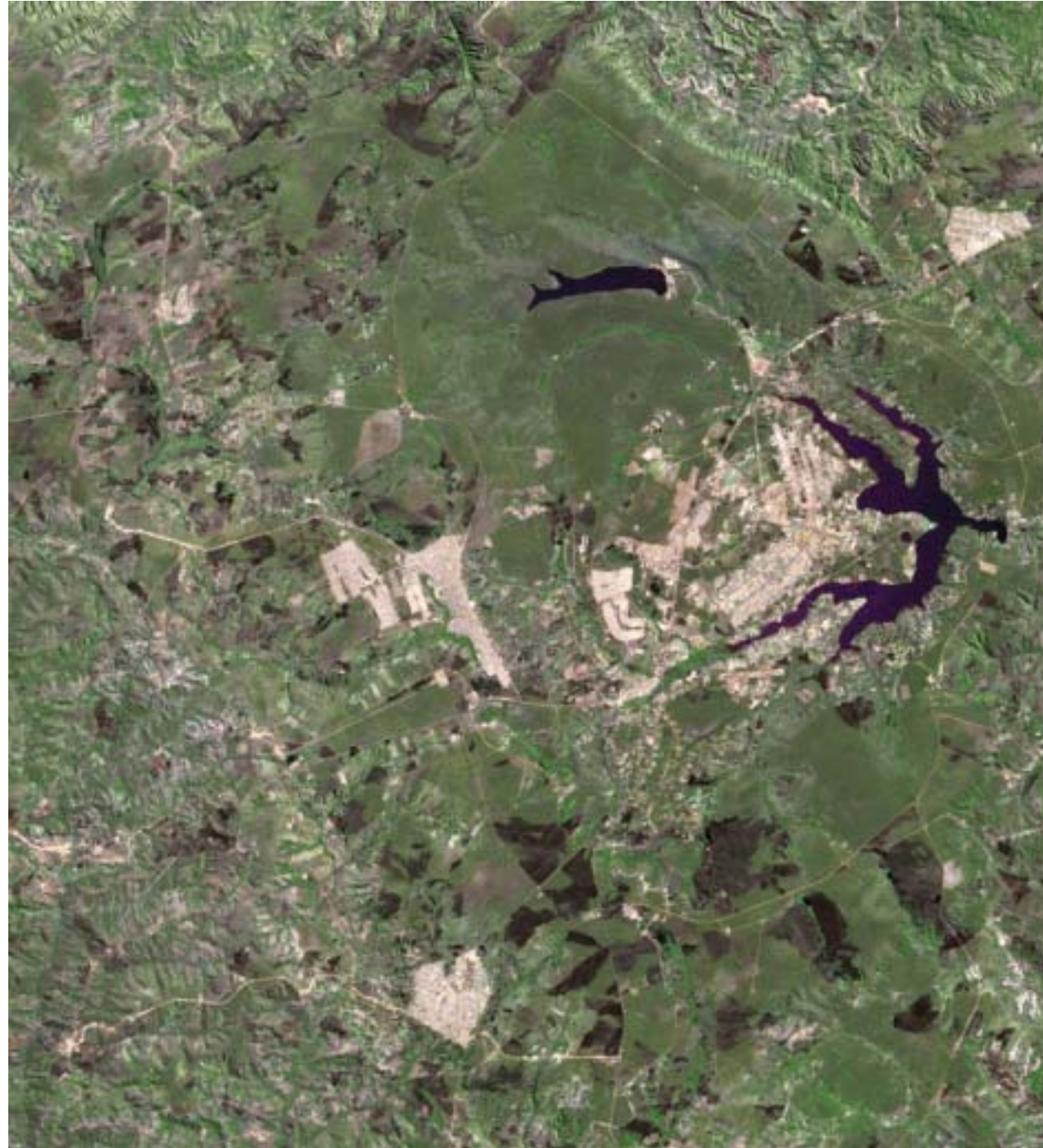


Brasilia, Brazil

Growth of a Capitol

Brasilia, Brazil's new capital, was inaugurated on April 21, 1960 with a population of 140,000 and a master plan for only 500,000 inhabitants. The city was a landmark in the history of town planning, and was recognised as a world heritage site in 1987. Urban planner Lucio Costa and architect Oscar Niemeyer intended that every element—from the layout of the residential and administrative districts to the symmetry of the buildings themselves—should be in harmony with the city's overall design. The official buildings, in particular, are innovative and imaginative. Plans were first proposed to move the capital of Brazil to the interior highlands in 1789. The new location promotes the development of the interior and unifies the country.

The satellite images show the dramatic growth and transformation of Brasilia. The dark green color in the images represents forest, agriculture appears light green, bright white spots represents planned areas for infrastructure and pink shows urban growth.





1973 (left)

The Pilot Plan of Brasilia consists solely of the bird shaped core area and residential areas between the arms of the Lake Paranoá. The urban developments away from the core are the initially unplanned satellite cities. The population of Brasilia and its satellite cities in 1970 was about 500,000.

2000 (right)

Due to population influx, currently more than 2,000,000 inhabitants now live in Brasilia and its satellite towns. The 2000 image shows fair amount of urban growth in planned areas and in the satellite cities. The National Park of Brasilia clearly stands out in 2000 as densely vegetated dark green. Several new reservoirs have also been constructed.





Gulf of Guayaquil, Ecuador

Expansion of Shrimp Culture

Guayaquil is Ecuador's main Pacific port located on the northern side of the Gulf of Guayaquil. The Gulf of Guayaquil is the largest estuarine ecosystem on the Pacific coast of South America. The low topography of the coastal region combined with high tides allows salt water to penetrate far inland, which helps to produce shrimp. Ecuador is the world's second largest producer of shrimp grown in captivity. Shrimp farming in Ecuador began in the Guayaquil region over thirty years ago. Many of the shrimp farms in this area have been abandoned with the shrimp farming activity moving to other stretches of the coast. Knowledge and awareness of the impact of shrimp farming on traditional agriculture, fisheries and wetlands is beginning to result in better regulation of shrimp farming in Ecuador. Many of the unregulated and often illegal shrimp farms were extremely destructive to the coastal ecosystem. Newer, ecologically sound shrimp farms are under development in 2000. Their design enables them to be less destructive and more sustainable. The tan color in the image shows shrimp-farming areas, where green represents natural vegetation and blue represents water.



1985 (left)

The satellite image of 1985 shows agricultural and mangrove areas in the Gulf of Guayaquil region. Farmers were converting to shrimp farming from agriculture at that time.

2000 (right)

The satellite image of 2000 shows the dramatic expansion of shrimp farms. Agricultural and mangrove areas have been converted to shrimp farms. It is estimated that in 1984 there were 893.68 sq. km. of shrimp ponds, while in 2000, with the expansion of shrimp breeding, the area increased to 1,176.31 sq. km.





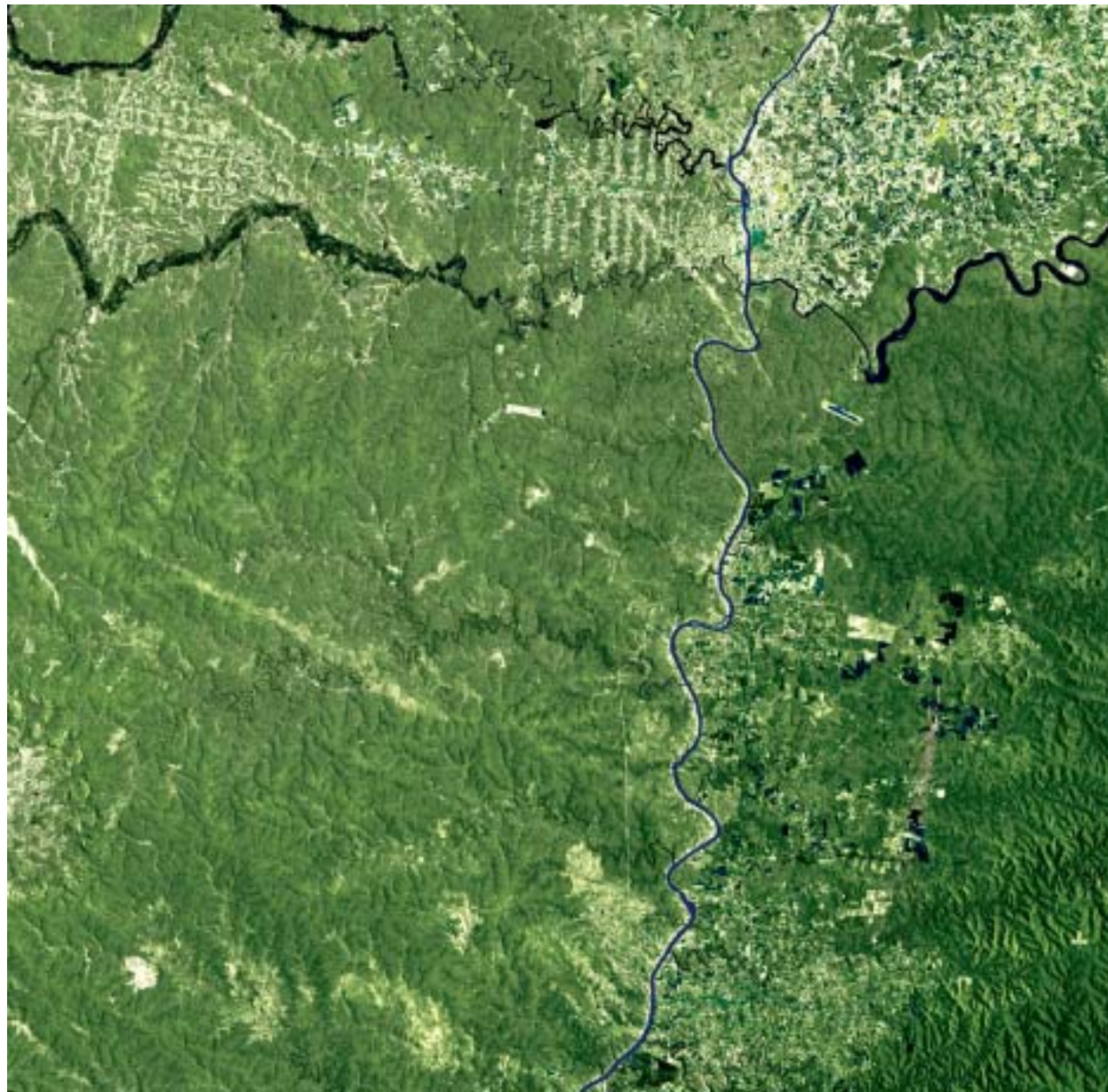
Iguazú National Park, Argentina

Vulnerable Paranaense Forest

Iguazú National Park is located in Argentina on the border with Brazil and Paraguay. This world heritage site covers a total area of 555 sq. km.: the National Park covers 492 sq. km. and the National Reserve covers 63 sq. km. Conservation of this park is critical because it harbours one of the most complete remnant patches of the highly endangered Paranaense forest. The park is rich in fauna and includes 68 species of mammals, 422 of birds, 38 of reptiles and 18 of amphibians, a large number of which are threatened or vulnerable.

The Iguazú Falls, among the most impressive in the world, are on the Iguazú River, which serves as the border between Brazil and Argentina. The Itaipu Dam is on the Paraná River north of its confluence with the Iguazú. This dam is presently the largest in the world, prior to the completion of the Three Gorges Dam. In 1995, it provided 25% and 78% of the energy supply to Brazil and Paraguay respectively.

The satellite images show how land clearing and logging have opened up a previously forested landscape.

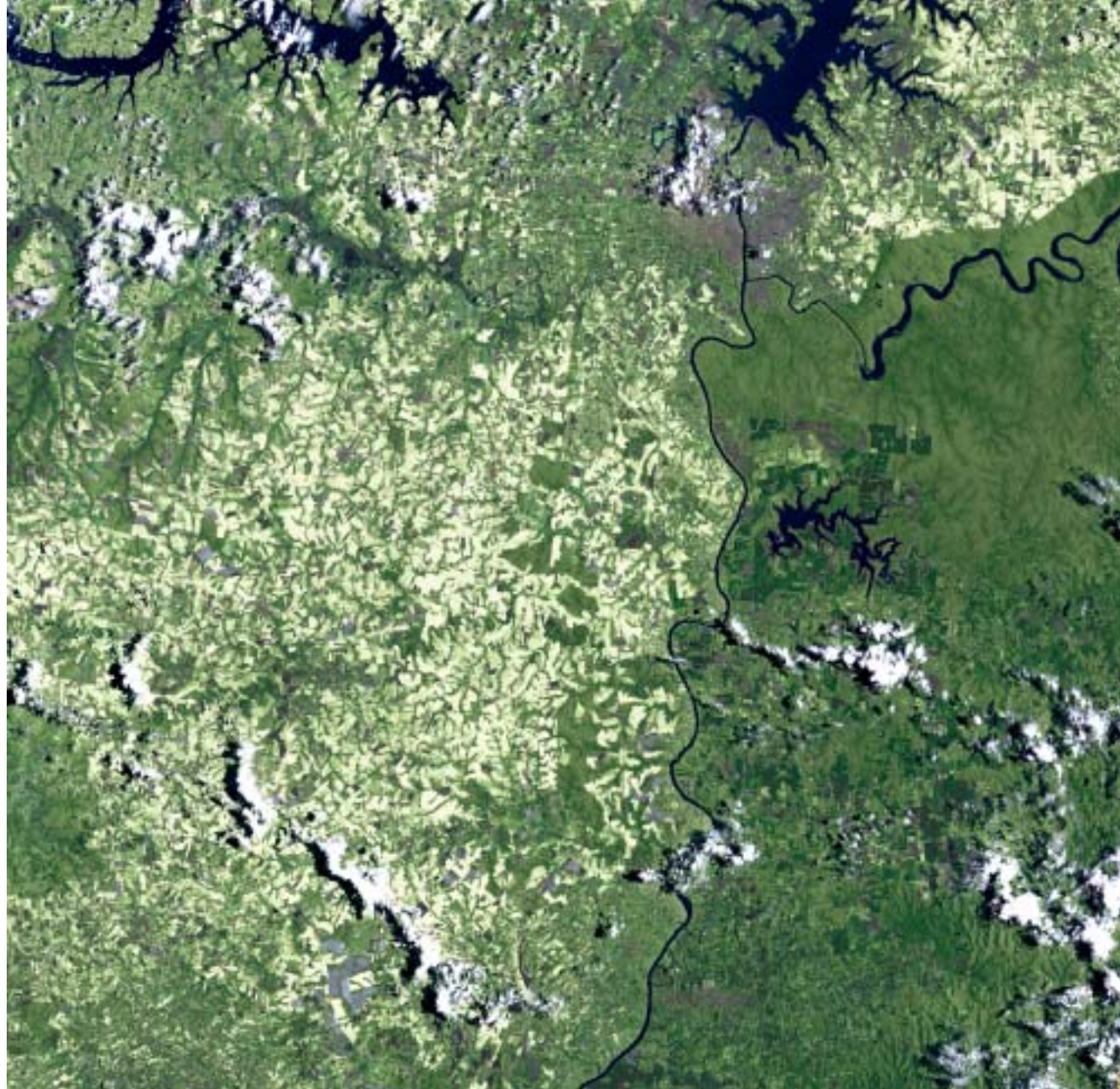


1973 (left)

The image shows extensive forest cover throughout the image.

2000 (right)

The protected area of Iguazú National Park, located in Argentina on the border with Brazil and Paraguay, is sharply defined as the dark green enclave on the right of the images and is the only remaining original forest in the region. A new reservoir is visible inside the Park. On the Brazilian side of the Iguazú River is the Iguazú National Park, which by 2000 has returned to a more vegetated condition. The Itaipu Reservoir is very visible in the top-center of the image. The three towns of Ciudad del Este in Paraguay, Foz do Iguaçu in Brazil and Puerto Iguazu in Argentina have grown substantially since the construction of the dam and presently are reliant on tourism.





Manaus, Brazil

Conversion of Brazilian Rainforest

Manaus, the capital of the state of Amazonia, is located on the north bank of the River Negro and its confluence with the Solimões River, which extends eastward as the Amazon River. Manaus was settled in 1669 and was a rubber boomtown between 1890 and 1920. Commercial activity in Manaus presently is largely in forest and petroleum products. The Pan American highway meets the river here and connects Manaus to Caracas. No paved roads connect Manaus to other cities. Oceangoing shippers have access to the port of Manaus. Air and river transportation connect Manaus to the outside. The city population grew by more than 65 per cent to 1.5 million in the past decade.

These two Landsat images document the conversion of forest areas due to logging and urbanization between 1987 and 1999.



1987 (left)

Manaus appears as tan/white color at the right corner of the image. About 15 kilometers from Manaus, Rio Negro (Black River) meets Rio Solimoes to create an amazing confluence of brownish white water from the Salaomes joining black water (caused by the very high acidity from tannin) from the Rio Negro. The Rio Negro flows 2,300 km from Colombia, and is the dark current forming the north side of the river. It gets its color from the high tannin content in the water. The Rio Solimoes appears blue in this image. The black waters of the Rio Negro are not completely absorbed until many miles after the confluence.

1999 (right)

The image shows the expansion of logging and road construction north of Manaus between 1987 and 1999. Manaus has grown to meet the border of the rectangular Adolpho Ducke Forest Reserve (100 sq. km.). Mature forest appears as green. The white/purple color shows converted urban areas.





Rondônia, Brazil

Deforestation for Agriculture

Brazil is the home of approximately 30% (3,562,800 sq. km.) of the world's tropical rainforests. The southern Amazon Basin in Brazil is one of the regions of the Amazon rainforest undergoing rapid change. In a continuing effort to decentralize the Brazilian population and populate undeveloped regions, the Brazilian government constructed the Cuiabá-Pôrto Velho highway through the province of Rondônia. Completed in 1960, the road served as the spine of access for infrastructure development into tropical rainforest ecosystems, previously occupied only by the indigenous people of the region. The highway connects the north and west parts of Brazil with the more urbanized areas of the south-central and coastal areas. In-migration increased substantially after infrastructure development. This series of satellite images shows land use change and deforestation in Rondônia. The deforested land and urban areas appear in gray white and healthy vegetation appears green.





1975 (left)

The image shows healthy natural vegetation, indicating minor human interference.

1986 (upper right)

The image exhibits substantial immigration to the area between 1975-1986. The predominant “Feathered” or “Fishbone” pattern on the landscape is the result of logging operations, providing mechanized access to land resources. Primary land uses are cattle ranching and annual crop farming. More sustainable perennial crops like coffee and cocoa occupy less than 10 percent of the agricultural land areas.

2000 (lower right)

The image shows the demand for agricultural land continues to threaten the Brazilian rainforest. In the central portion of the image, a distinctive net shaped pattern of clear-cut is evident.

Despite encroachment, programs are attempting to preserve the land with multi-use functions providing a wider array of income producing products to local farmers, which might mitigate adverse impact on the tropical rainforest.

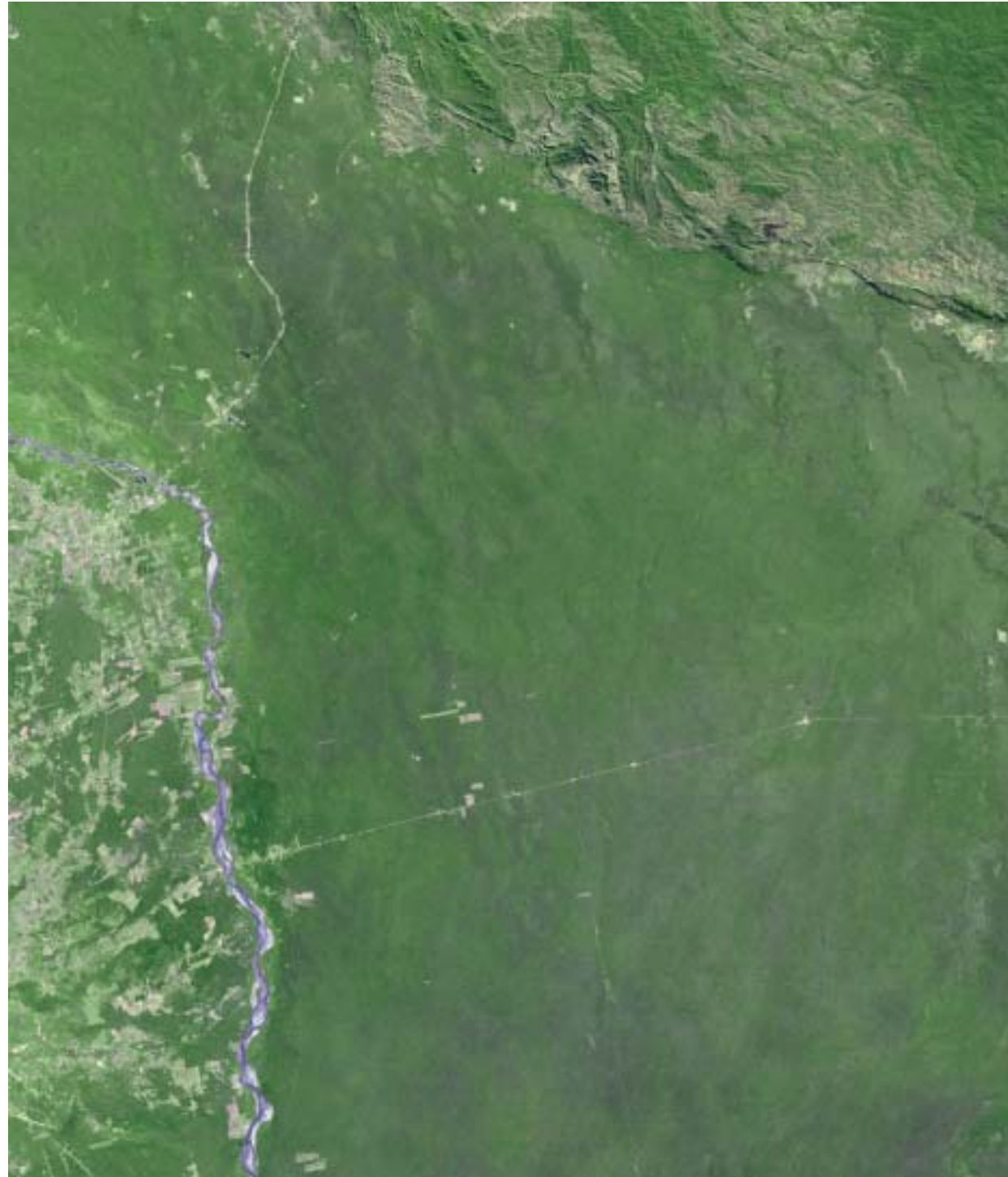




Santa Cruz, Bolivia

Land Use Change in Bolivia

Santa Cruz is situated in the rich, fertile Bolivian lowlands, highly suitable for agriculture. The area was formerly isolated due to natural forest, mountain, and river boundaries. But the isolation was overcome by the construction of highway and railway links in the mid 1950s. The population of Santa Cruz increased from 26,000 to 1.1 million in the last 35 years. Land reform, infrastructure improvements and colonization are the three main factors that influenced the influx into Santa Cruz in the 1950s. The new highway from Cochabamba to Santa Cruz and a railroad to Sao Paulo, Brazil allowed the transportation of goods and encourages commercial farming in this region. The government also facilitated new settlers coming into the region. The series of satellite images shows land use change due to human encroachment in forested areas surrounding Santa Cruz.





1975 (left)

The satellite image shows the status of Santa Cruz in 1975.

1992 (upper right)

Resettlement of the rural people from the Antiplano (the Andean high plains) is evident in the starburst patterns in the upper left. At the center of each is a small community including a church, bar/cafe, school, and a soccer field.

2000 (lower right)

The large corporate agricultural fields in the center of the imagery are producing soybeans for export. The dark green strips are windbreaks to prevent wind erosion of the very fine soils.



Photo Credits:
NASA—Compton Tucker





Santiago, Chile

Urban Growth in Chile

Santiago is the capital of Chile and has more than one third (35.2%) of the country's total population of 5 million. The exponential population growth of Santiago is part of a national trend but also results from the city's ability to attract immigrants. Santiago's population growth has led to the horizontal expansion of the city. Chilean urban scholars speak of this expansion as the "urban stain" which, through a process of sub-urbanization, continually exceeds and expands the limits of the Metropolitan Region of Santiago (MRS), incorporating previously rural areas into the MRS. The salient characteristics of this urban sprawl are haphazard growth, low density housing, excessive public costs, poor transportation and air pollution.

Between 1970 and 2000, Santiago's population increased from 2.7 million to over 5.1 million. In spite of a population that has nearly doubled, these satellite images show surprisingly little growth in geographic urban area. In the image, green shows natural vegetation and dark pink shows urban areas in the center.

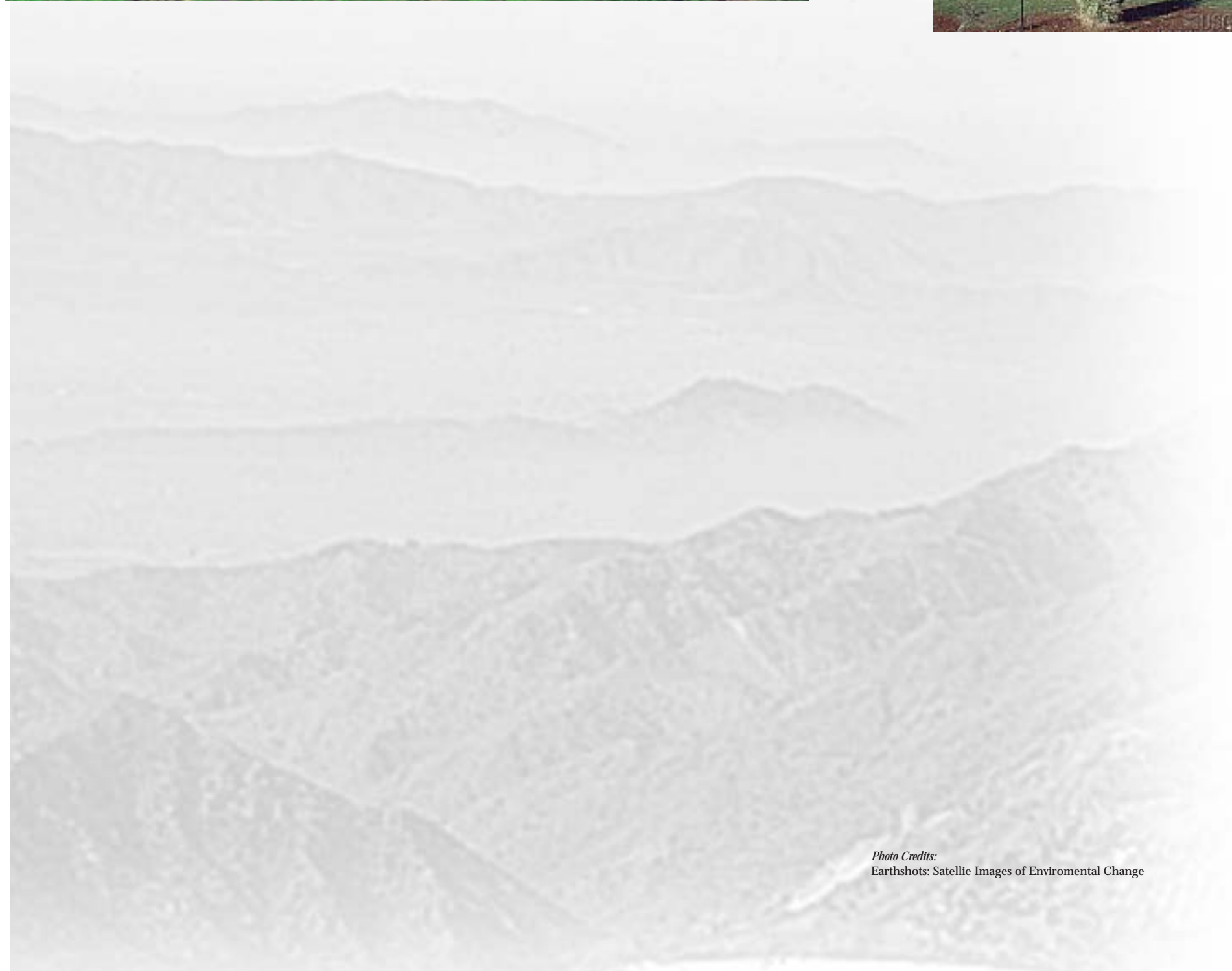


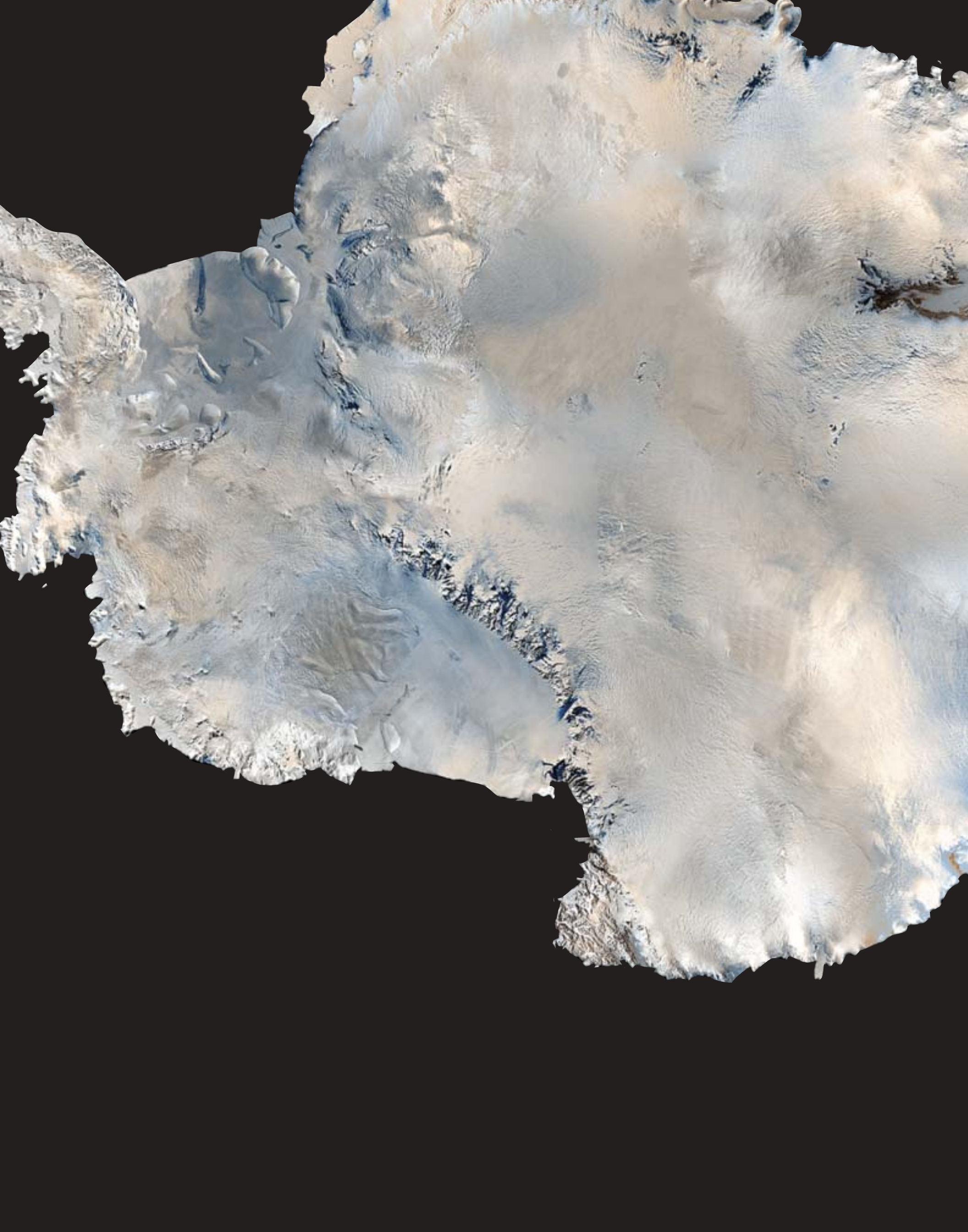
1975 (left)

The 1975 image shows the status of Santiago with a population of 2.9 million.

2000 (right)

The 2000 image shows expansion of urban areas in the city, now with a population of 5 million. This population growth has led to the horizontal expansion of the city principally towards the south and southeast.





Antarctica

At A Glance

Population: No permanent population

Percent of World's Population: 0%

Land Area: 13,209,000 sq km

Percent of Earth's Land: 8.9%

Key Environmental Issues:

Climate change impacts

Depletion of the ozone layer

Threats to biodiversity in the polar region

Sites for Antarctica

Larsen Ice Shelf, Antarctica

Filchner Ice Shelf, Antarctica

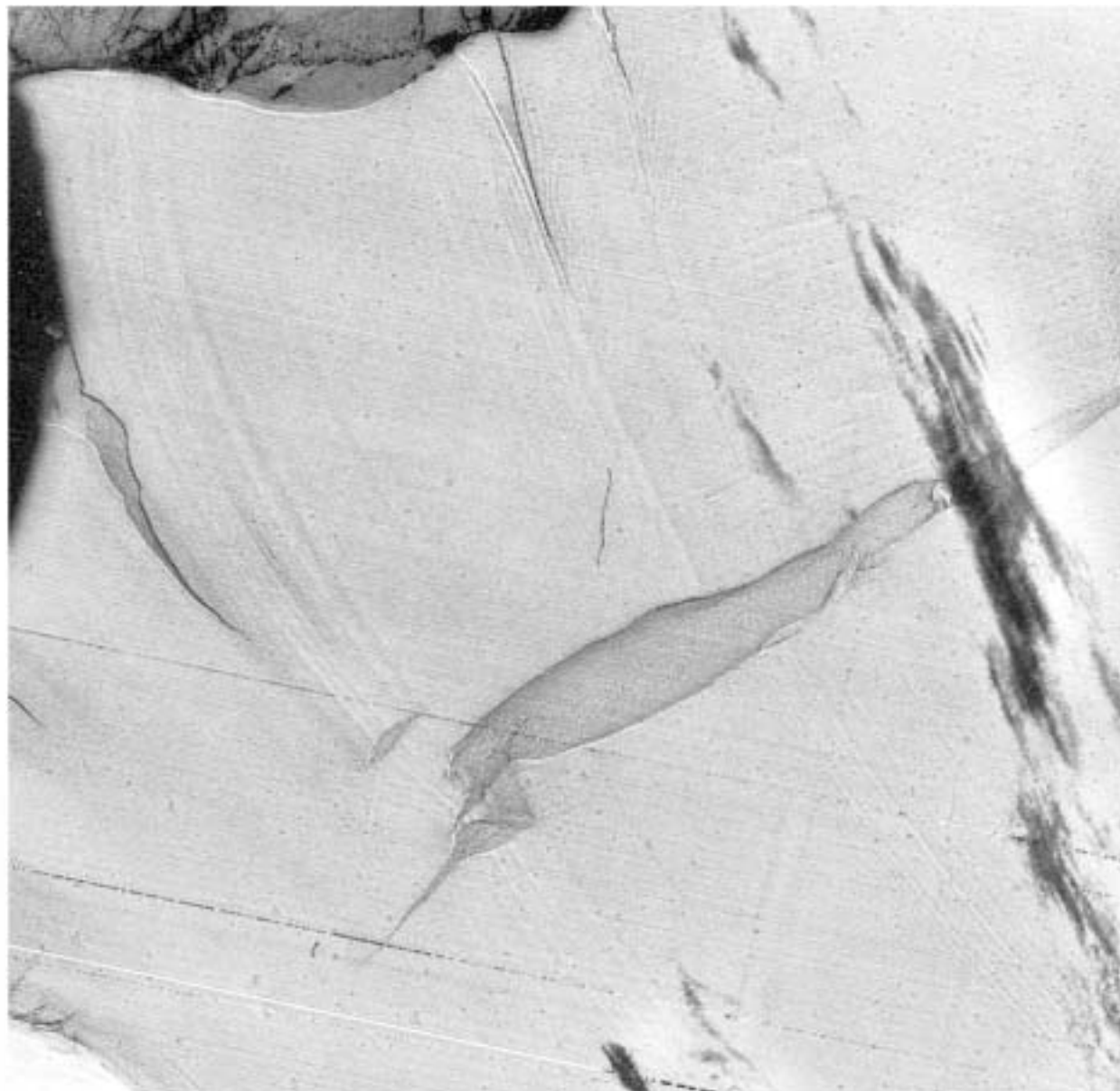


Filchner Ice Shelf, Antarctica

Melting Ice In Antarctica

The Filchner-Ronne Ice Shelf is one of many ice shelves that lie along the continental margin of Antarctica. The Filchner-Ronne faces South America, and it is by volume the largest ice shelf on Earth. Researchers are closely monitoring the Antarctic ice shelves, because they can provide an important indicator of the mass balance (net volumetric gain or loss) of the Antarctic ice sheet as a whole. They help us to determine whether it is growing or shrinking, and this has important implications for our understanding of global climate change.

These satellite images show the seaward edge of the Filchner Ice Shelf on the coast of Antarctica, facing the Atlantic.



1973 (left)

The 1973 image shows a portion, representing approximately 40 years of advancing ice, of the Filchner Ice Shelf prior to calving.

1986 (upper right)

The 1986 image shows the calving of the Filchner Ice Shelf. The calved ice broke into three large icebergs. As expected, the shelf finally broke along the Grand Chasms.





Larsen Ice Shelf, Antarctica

Ice Shelf Collapse

The northern section of the Larsen B ice shelf in Antarctica totally disintegrated in less than a month during 2002 in one of the warmest summers on record. This news grabbed the attention of the whole science community as well as newspapers.

Scientists at the U.S. National Snow and Ice Data Center reported that the 200 meter thick ice shelf shattered and separated from the continent, forming a plume of thousands of icebergs drifting through the Weddell Sea. In 1995 the Larsen A broke off during an extended summer melt. The Larsen Ice Shelf has now lost about 40 percent of its original stable mass. This collapse is the largest single event in a series of ice shelf retreats in the Antarctic Peninsula over the last 30 years. Geoscientists think the Larsen B shelf has likely existed since the last major glaciation 12,000 years ago. Larsen C will likely follow in the coming years if the warming trend continues. Other even larger ice shelves along the Antarctic are also under threat if average temperatures continue to rise. However the climate trend is not the same throughout Antarctica; in some regions, glaciers are in fact thickening.



January 31, 2002 (left)

Recent satellite imagery shows the northern section of the Larsen B ice shelf, a large floating ice mass on the eastern side of the Antarctic Peninsula.

March 7, 2002 (right)

Between Jan. 31 and March 7, the ice shelf lost about 500 billion tons of ice and 3,250 square km of area. The time series of images below documents the collapse of the ice shelf.

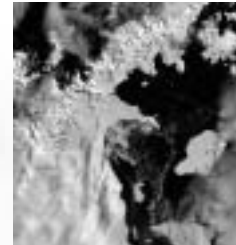
January 31



February 17



February 23



March 5



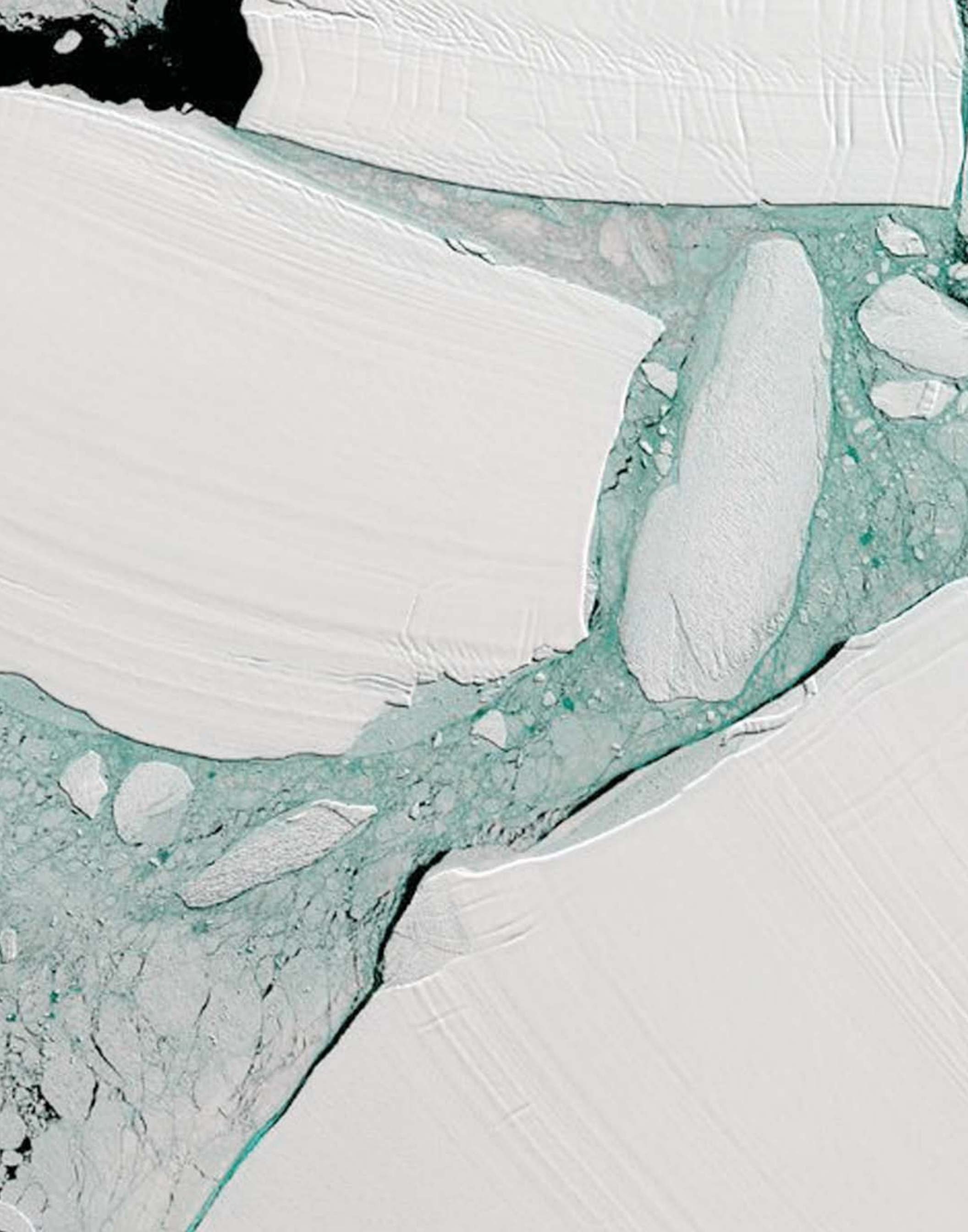
March 7



March 17



Photo Credits:
NOAA/NESDIS/ORR—Michael Van Woert



Credits

The Earth at Night, Where We Live (page *x* & *xv*) This image of Earth's city lights was created with data from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS). Originally designed to view clouds by moonlight, the OLS is also used to map the locations of permanent lights on the Earth's surface. Data courtesy Marc Imhoff of NASA GSFC and Christopher Elvidge of NOAA NGDC. Image by Craig Mayhew and Robert Simmon, NASA GSFC. <http://visibleearth.nasa.gov>

The Earth During the Day, the Environment We Live In (page *xii* & *xiii*): NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, and clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group; MODIS Science Data Support Team; MODIS Atmosphere Group; MODIS Ocean Group Additional data: USGS EROS Data Center (topography); USGS Terrestrial Remote Sensing Flagstaff Field Center (Antarctica). <http://visibleearth.nasa.gov>

Our Forests (page *xiv* & *xv*): Map produced for the United Nations Food and Agriculture Organization, Forest Resources Assessment 2000 Program, by the USGS EROS Data Center, lead scientist Zhiliang Zhu. Enhancements and cartography by John Hutchinson. Data and technical support: USGS Land Cover Characterization and Digital Data Production Teams. Additional data: USGS EROS Data Center (topography).

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GTOPO30
<http://edcdaac.usgs.gov/gtopo30/gtopo30.html>

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Al Isawiya	LE717203900006450	172	39	3/4/2000	Larsen Ice Shelf	MODIS			01/31/2002	
	LT4172039009105510	172	39	2/24/1991		MODIS			02/17/2002	
	LT5172039008603310	172	39	2/2/1986		MODIS			02/23/2002	
Aral Sea	LE7160028009921750	160	28	08/05/1999	Las Vegas	LE7039035000026850	39	35	09/24/2000	
	LE7160029009921750	160	29	08/05/1999		LM1042035007225790	42	35	09/13/1972	
	LE7160030009921750	160	30	08/05/1999	Lesotho Highlands Dam	LE7169080000128550	169	80	10/12/2001	
	LE7161028009932050	161	28	11/16/1999		LT5169080008614010	169	80	05/20/1986	
	LE7161029009922450	161	29	08/12/1999	Manaus	LE7231062009933050	231	62	11/26/1999	
	LE7161030009922450	161	30	08/12/1999		LT5231062008719310	231	62	7/12/1987	
	LE7162028009923151	162	28	08/19/1999		Mesopotamian Wetlands	LE7166038000008650	166	38	03/26/2000
	LE7162029009923151	162	29	08/19/1999			LE7166039000008650	166	39	03/26/2000
	LE7162030009923151	162	30	08/19/1999			Earth Satellite Corp.	178	38	09/07/1990
	LM2172028007711890	172	28	04/28/1977	Earth Satellite Corp.		178	39	09/07/1990	
	LM1172029007325690	172	29	09/13/1973	LM2178038007614890		178	38	05/27/1976	
	LM1172030007325690	172	30	09/13/1973	LM2178039007504590		178	39	02/14/1975	
	LM1173030007314990	173	30	05/29/1973	LM1179038007304790		179	38	02/16/1973	
	LM2174028007712090	174	28	04/30/1977	LM1179039007304790	179	39	02/16/1973		
	LM1174029007322290	174	29	08/10/1973	Mexico City	LE7027046000010450	27	46	04/13/2000	
LM1174030007322290	174	30	08/10/1973	LE7026046100008150		26	46	03/21/2000		
Aug-Sept 1987 TM mosaic MODIS			09/27/2002	LM1028047007311190		28	47	04/21/1973		
Atatürk Dam	LE7173034009924450	173	34	09/01/1999	LM1027047007311190	27	47	04/20/1973		
	LM2186034007517990	186	34	06/28/1975	Midrand	LE7170078000113250	170	78	05/12/2001	
Banjul Region	LE7205051000100950	205	51	01/09/2001		LT5170078008503210	170	78	02/1/1985	
	LM1220051007305290	220	51	02/21/1973	Mount Kilimanjaro	LE7168062000005250	168	62	02/21/2000	
Beijing	LE77123032000012150	123	32	04/30/2000		LM2180062007602490	180	62	01/24/1976	
	LM2132032007816390	132	32	06/12/1978	Mount St. Helens	LE7046028000026950	46	28	09/25/2000	
Brasilia	LE7221071000026350	221	71	09/19/2000		LM4046028008314290	46	28	05/22/1983	
	LM1237071007321390	237	71	08/01/1973		LM1049028007325890	49	28	09/15/1973	
Cape York Bauxite Mine	LE7099069000121150	99	69	07/30/2001	New Delhi	LE7146040009929550	146	40	10/22/1999	
	LM1105069007320790	105	69	07/26/1973		LM2157040007706790	157	40	03/08/1977	
Challawa Dam	LE7189052000024750	189	52	09/03/2000	New Valley Project	LE7176044000135050	176	44	12/16/2001	
	LT4189052009033110	189	52	11/27/1990		LE7176044009931350	176	44	11/9/1999	
Dhaka	LE7137044000005950	137	44	02/28/2000	Oil Well Fires	LT5165040009131810	165	40	11/14/1991	
	LM2147044007703990	147	44	02/28/1977		LT4165040009105410	165	40	02/23/1991	
Everglades	LE7015042000003650	15	42	02/05/2000		LT4165040009024310	165	40	08/31/1990	
	LM1016042007308190	16	42	03/22/1973	LE7165040000003150	165	40	01/31/2000		
Filchner Ice Shelf	LM5187116008631490	187	116	11/10/1986	Paektu San	LE7116031009918150	116	31	06/30/1999	
	LM1194117007331590	194	117	11/11/1973		LM3125031008019190	125	31	07/09/1980	
Gabcikovo	LE7189027000029552	189	27	10/21/2000	Phnom Penh	LE7126052000027050	126	52	09/15/2000	
	p189r27_4t920828	189	27	08/28/1992		LE7126052000035050	126	52	12/15/2000	
Gulf of Fonesca	LE7017051009931950	17	51	11/15/1999		LM1135052007300390	135	52	01/03/1973	
	LE7018051000036150	18	51	12/26/2000		LM5126052008534890	126	52	12/14/1985	
Gulf of Guayaquil	LE7011062000032850	11	62	11/23/2000	Rondonia	LE7232067000018050	232	67	06/28/2000	
	LT5011062008508610	11	62	03/27/1985		LM5232067008621390	232	67	08/01/1986	
Hayman Wildfires	LE7033033000218350	33	33	07/02/2002		LM2249067007517090	249	67	06/19/1975	
	LE7033033000113250	33	33	05/12/2001	Santa Cruz de la Sierra	LE7230072000021450	230	72	08/01/2000	
Huang River Delta	LE7121034000005950	121	34	02/28/2000		LM2247072007516890	247	72	06/17/1975	
	p130r34_3m790527	130	34	05/27/1979		LT4230072009219210	230	72	07/10/1992	
Iguazú National Park	LE7224078000002850	224	78	01/28/2000	Santiago	LE7233083000009150	233	83	03/31/2000	
	LM1240078007305490	240	78	02/23/1973		LM2250083007508190	225	83	03/22/1975	
IJsselmeer	LE7198023000013450	198	23	05/13/2000	Shenzhen	LE7122044000000250	122	44	01/2/2000	
	LM5198023008718690	198	23	07/05/1987			122	44	12/1986	
	LM1214023007308290	214	23	03/23/1973	Sundarbans	LE7137044000005950	137	44	02/28/2000	
	DS09066A011MC055			08/21/1964		LE7137045000005950	137	45	02/28/2000	
Irian Jaya	LE7100065000029650	100	65	10/22/2000		LE7138044009931950	138	44	11/15/1999	
	LE7100065000230150	100	65	10/28/2002	LE7138045009931950	138	45	11/15/1999		
	ETP10100R65-5t19901120	100	65	11/20/1990	LM2147044007703990	147	44	02/08/1977		
	Isahaya Bay Reclamation	Aster	113	37	04/08/2000	LM2147045007703990	147	45	02/08/1977	
P113R37_5T19930515		113	37	5/15/1993	LM2148044007704090	148	44	02/09/1977		
Itampolo	LM1171077007305790	171	77	2/26/1973	Taiga Forest	LE7175015000018150	175	15	06/29/2000	
	LE7160077000028450	160	77	10/13/2000		LM1188015007320090	188	15	07/19/1973	
Lake Chad	LE7184051009928950	184	51	10/16/1999	LT5175015008720110	175	15	07/20/1987		
	LE7185050000028350	185	50	10/9/2000	Tensas River Basin	LE7023038000030050	23	38	10/26/2000	
	LE7185051009929650	185	51	10/23/1999		LM2025038007227690	25	38	10/02/1975	
	LE7186050000029050	186	50	10/16/2000	Thailand Aquaculture	LE7129051109932050	129	51	01/08/2002	
	LE7186051000032250	186	51	11/17/2000		LM1138051007300690	138	51	01/06/1973	
	DS09059A073MC034			10/31/1963		LM1139051007300790	139	51	01/07/1973	
	LM1198051007236090	198	51	12/25/1972		LM1138051007300690	138	51	01/06/1973	
	LM1199050007303190	199	50	01/31/1973	Three Gorges Dam	p125r39_5t870417	125	39	04/07/1987	
LM1199051007303190	199	51	01/31/1973	Aster		125	39	07/20/2000		
Lake Hamoun	LE7157038000129750	157	38	10/24/2001	Vancouver and Seattle	LE7047026000018050	47	26	06/28/2000	
	LE7157039000129750	157	39	10/24/2001		LE7046027000026950	46	27	09/25/2000	
	LM2169038007631990	169	38	11/14/1976		LM1051026007620990	51	26	07/27/1976	
	LM2169039007631990	169	39	11/14/1976		LT5046027008523510	46	27	08/23/1985	
Lake Nakuru	LE716906000004352	169	60	02/12/2000	Wyperfeld National Park	LE7095085000016550	95	85	06/16/2000	
	LM118060007303190	181	60	01/31/1973		LM5095085008516290	95	85	06/11/1985	
Lake Victoria	LE7171060009935850	171	60	12/25/1999		p101r85_lm730703	101	86	07/03/1973	
	LT5171060009501910	171	60	01/19/1995						

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Acronyms and Abbreviations

ETM/LANDSAT	Enhanced Thematic Mapper (ETM+). Equipped with high resolution instruments, Landsat- 7 was successfully launched on April 15, 1999. This satellite carries the Enhanced Thermal Mapper Plus (ETM+), which is an eight-band, multispectral scanning radiometer. The ETM+ is capable of resolving distances of meters in the panchromatic band; 30 meters in the visible, near and short-wave infrared band; and 60 meters in the thermal infrared band.
LANDSAT	On July 23, 1972, NASA launched the first in a series of satellites designed to provide repetitive global coverage of the Earth's land masses. It was designated initially as the 'Earth Resources Technology Satellite-A'. The second in this series of Earth resources satellites (designated 'ERTS-B') was launched January 22, 1975. It was renamed 'Landsat 2' by NASA, which also renamed 'ERTS-1' as 'Landsat 1'. Four additional Landsats were launched in 1978, 1982, and 1999 (Landsat 3, 4, 5 and 7)
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
GRID	Global Resource Information Database
KM	Kilometer
MSS	Multispectral Scanner
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
TM	Thematic Mapper
UNEP	United Nations Environment Programme
USGS	United States Geological Survey