

accomplishes this, but at considerable dollar cost. Internal combustion engines can be designed to operate at lower temperatures to lower the emissions of nitrogen oxides, but they are less efficient when so run. In smelting operations the ores can be pre-concentrated so that a smaller amount of undesired minerals enters the smelter itself. For example, a mixed iron sulfide/nickel sulfide ore can be concentrated to minimize the iron sulfide content and take mainly the more desired nickel mineral to the smelter.

Once the oxides are formed, they can be removed from the exit gases or they can be subjected to further reaction to change them into compounds with less environmental impact. Sulfur dioxide from roasting can be trapped in the liquid form or can be converted to liquid sulfuric acid and, in each case, sold as a by-product. The sulfur dioxide in the exhaust from burning is not concentrated enough to be treated in this fashion, but it can be removed from the exhaust stream by absorbing it in a limestone slurry for later landfill disposal. The current answer for the nitrogen oxide emissions is treatment with a catalytic converter in the exhaust line of the engine. The catalyst converts the oxides back to elemental nitrogen and water at about 80 percent efficiency.

Kenneth H. Brown

FURTHER READING

- Bunce, Nigel J. "Acid Rain." In *Introduction to Environmental Chemistry*. 2d ed. Winnipeg, Man.: Wuerz, 1994.
- Howells, Gwyneth Parry. *Acid Rain and Acid Waters*. 2d ed. New York: E. Horwood, 1995.
- Johnson, Russell W., et al., eds. *The Chemistry of Acid Rain: Sources and Atmospheric Processes*. Washington, D.C.: American Chemical Society, 1987.
- Legge, Allan H., and Sagar V. Krupa, eds. *Air Pollutants and Their Effects on the Terrestrial Ecosystem*. New York: Wiley, 1986.
- McCormick, John. *Acid Earth: The Politics of Acid Pollution*. 3d ed. London: Earthscan, 1997.
- Manahan, Stanley E. *Environmental Chemistry*. 8th ed. Boca Raton, Fla.: CRC Press, 2005.
- Somerville, Richard C. J. "Air Pollution and Acid Rain." In *The Forgiving Air: Understanding Environmental Change*. 2d ed. Boston: American Meteorological Society, 2008.
- Visgilio, Gerald R., and Diana M. Whitelaw, eds. *Acid in the Environment: Lessons Learned and Future Prospects*. New York: Springer, 2007.

Whelpdale, D. M., and M. S. Kaiser, eds. *Global Acid Deposition Assessment*. Geneva, Switzerland: World Meteorological Organization, Global Atmosphere Watch, 1997.

WEB SITES

ENVIRONMENT CANADA

Acid Rain
<http://www.ec.gc.ca/acidrain>

U.S. ENVIRONMENTAL PROTECTION AGENCY

Acid Rain
<http://www.epa.gov/acidrain>

U.S. GEOLOGICAL SURVEY

Acid Rain, Atmospheric Deposition, and Precipitation Chemistry
http://bqs.usgs.gov/acidrain/new/frontpage_home.htm

SEE ALSO: Air pollution and air pollution control; Atmosphere; Coal gasification and liquefaction; Hydrology and the hydrologic cycle; Internal combustion engine; Metals and metallurgy; Nitrogen cycle; Sulfur cycle.

Aerial photography

CATEGORY: Obtaining and using resources

Aerial photography, which dates to the nineteenth century, has enabled scientists to quantify and predict changes in land use, soil erosion, agricultural development, water resources, habitat, vegetation distribution, animal and human populations, and ecosystems. Aerial photography also is used to construct thematic maps that show the distribution of a variety of global resources.

DEFINITION

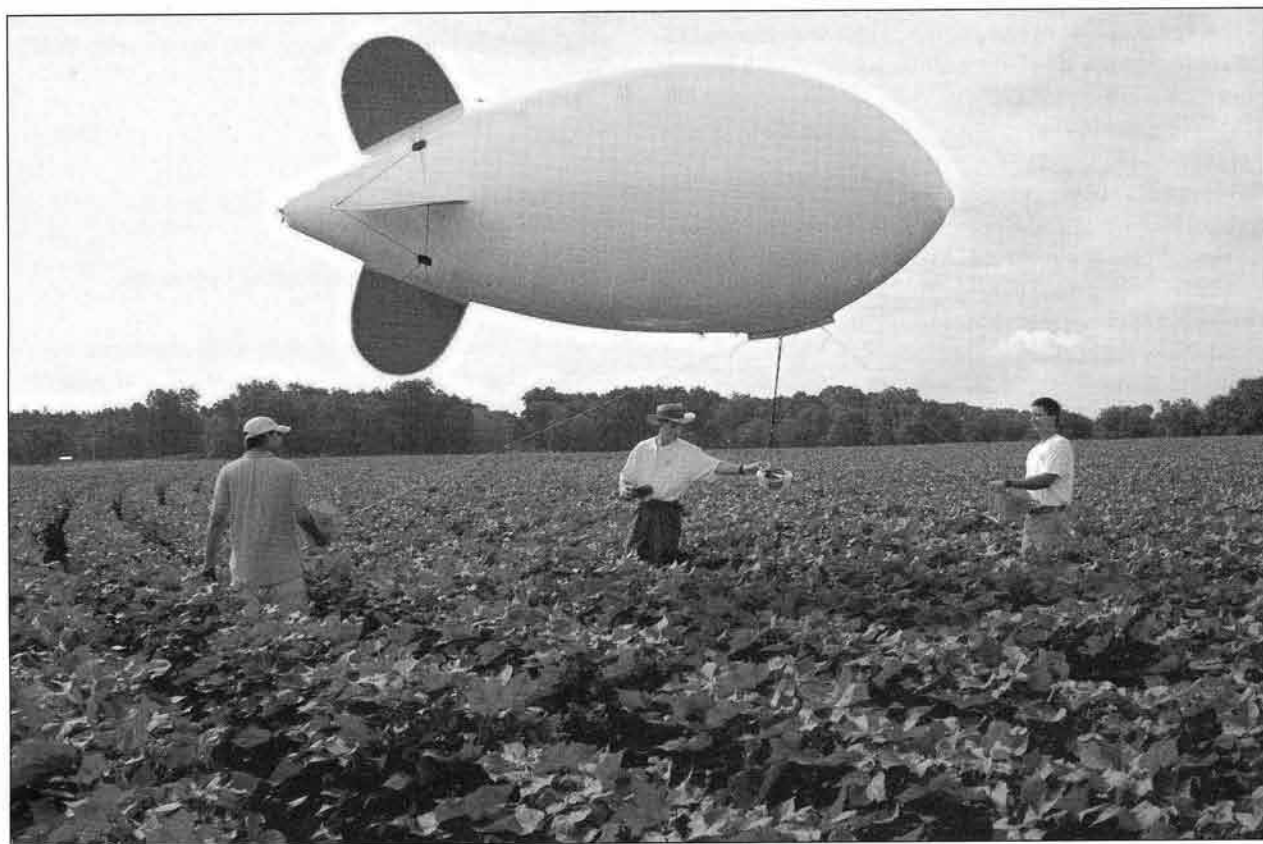
Aerial photography is a form of remote sensing that relies on film or digital capture to acquire information about Earth's surface from elevated platforms. These platforms include balloons, airplanes, and satellites. The primary advantage of aerial photography over ground-based observations is the elevated vantage point, which can provide images covering vast expanses of Earth's surface.

OVERVIEW

The invention of photography was announced in 1839 at the joint meeting of the Academies of Sciences and Fine Arts in Paris, France. Nineteen years later, in 1858, Gaspard-Nadar Félix Tournachon made the first aerial photograph from a tethered balloon over Val de Bièvre, France. The oldest extant aerial photograph dates to 1860, when James Wallace Black photographed Boston, Massachusetts, from a balloon tethered above Boston Common. The first aerial photograph made from an airplane was in 1908; the first aerial photograph made from a satellite was in 1959. In the twenty-first century, aerial photography is a vital tool for documenting and managing Earth's resources.

In order to obtain quantitative information about the Earth's resources from an aerial photograph, methods must be applied to the photograph that allow for reliable estimates of spatial relationships. Obtaining such relationships falls under the broad field of photogrammetry. By applying photogrammetric

methods, analysts can relate distances on the photograph to distances on the ground. Object heights and terrain elevations can be obtained by comparing photographs made from two different vantage points, each with a different line of sight. This method is based on the principle of parallax, wherein the apparent change in relative position of stationary objects is compared between the photographs. Additional information can be gleaned from aerial photographs by examining tonal changes and shadow distributions within the photograph. Tonal changes can provide information on texture, which can be used to distinguish between vegetation type, soil type, and other surface features. Because the shapes of shadows change with time of day and are unique to particular objects, such as bridges, trees, and buildings, the shadows can be used to aid in the identification of the objects. Because film can record wavelengths of radiation that are invisible to the eye, such as thermal infrared radiation, features such as plant canopy tempera-



University of Georgia researchers rely on a farm blimp to provide aerial images in their quest to detect drought stress in cotton fields. (AP/Wide World Photos)

ture can be measured and displayed on an aerial photograph.

Aerial photography has many applications, including geologic and soil mapping, agricultural crop management, forest monitoring and management, rangeland management, water pollution detection, water resource management, and urban and regional planning. In geologic mapping, for example, aerial photography can be used to identify faults and fractures in Earth's surface as well as rock and soil types. By comparing these features over time, scientists can make inferences about the forcing agents, such as wind and water, that have shaped the land. As world population grows and demand for global resources increases, aerial photography will continue to be an important tool for guiding global resource management.

Terrence R. Nathan

SEE ALSO: Conservation; Environmental engineering; Geology; Irrigation; Land management; Land-use planning; Rain forests; U.S. Geological Survey; Wind energy.

Agenda 21

CATEGORY: Laws and conventions

DATE: Adopted June, 1992

Agenda 21 is the action plan of the United Nations for the promotion of sustainable development in the twenty-first century.

BACKGROUND

Agenda 21 was approved in the United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, from June 3 to 14, 1992, when more than one hundred heads of state met in the first Earth Summit. Sustainable development means that which "meets the needs of the present, without compromising the capacity of future generations to meet their own needs." This concept was first mentioned in the 1980 report *World Conservation Strategy*, published by the International Union for Conservation of Nature (IUCN), and defined, in 1987, in the Brundtland Report (*Our Common Future*), prepared by the U.N. World Commission on Environment and Development, created in 1983 and chaired by Gro Harlem Brundtland.

PROVISIONS

The Earth Summit adopted key documents such as the Rio Declaration on Environment and Development, the Statement of Principles for the Sustainable Management of Forests, the Convention on Climate Change, the Convention on Biological Diversity, and Agenda 21—the global plan of action on sustainable development. The monitoring of these agreements is conducted by the U.N. Commission on Sustainable Development.

Agenda 21 is a global partnership promoted by the United Nations, based on the principle that it is necessary to meet equitably the needs of present and future generations and on the idea of the indivisibility of environmental protection and economic and social development. Agenda 21 calls for ensuring the sustainable development of the environment through social and economic programs, through protection and conservation of national resources, by enabling major government and civilian groups, and by embracing education, technology, and innovation.

After 1992, the United Nations reaffirmed on several occasions that Agenda 21 remained the main program of action for achieving sustainable development, and programs for the further implementation of Agenda 21 were also adopted. In 2002, the World Summit on Sustainable Development, held in Johannesburg, South Africa, through the Johannesburg Plan of Implementation, strongly reaffirmed the U.N. commitment to the Rio principles and to the full implementation of Agenda 21 and the development goals contained in the 2000 U.N. Millennium Declaration. In 2009, the financial crisis and the global economic recession coupled with the food, energy, and climate crisis made more explicit the need for global and local approaches to sustainable development.

Chapter 28 of Agenda 21 calls for local authorities to develop their own local version of the agenda. Local Agenda 21 includes the preparation and implementation of a long-term strategic action plan for sustainable development. It is a participative, multi-sector, and multistakeholder process and aims to fulfill locally the objectives of Agenda 21. It is a process in which local governments, citizens, professionals, entrepreneurs, and organizations from the civil society work together to define priorities for local sustainable development in environmental, social, and economic areas. Organizations and networks of local governments have been active in the implementation of Local Agenda 21 in all continents, with such groups as