The Water Forest of Mexico City

A Vital but Imperiled Urban Wilderness

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"Urban wilderness" is sometimes considered a misnomer by those who work solely with very remote wildland areas; however, it is an important and often neglected classification of wildlands that provide a range of critical and irreplaceable benefits to very large numbers of urban and near-urban residents. One of the world's most outstanding urban proximate wildernesses is the Water Forest on the southern outskirts of the rapidly expanding Mexico City, second largest city in the world. This forest is adjacent to several urban areas and is extensive in size, so that the ecological services it provides and the threats to its condition need to be considered from the perspective of several population centers.

Mexico is among the world's seven most biodiverse countries. Its Transverse Neovolcanic Axis is one of the country's two geomorphologic regions (along with the Sierras of Oaxaca) with the highest number of endemic species, including 50% of all mammalian species known to Mexico. As the transition zone of the American continent's two biogeographic regions, it harbors both Nearctic and Neotropical ecosystems and species (Velázquez and Romero 1999).

A Speck of Green in an Urban Landscape

The genus- and species-rich Water Forest lies on the central range of this Neovolcanic Axis, comprising approximately 147,000 hectares (363,245 acres) of natural area in the mountains that lie between three political entities: the Federal District (Mexico City), and the states of Mexico and Morelos.

An elevation variation of 1,800 to 3,930 meters (5,905 to 12,894 feet) above sea level creates a temperature gradient that allows for nine types of plant associations in the Water Forest, resulting in great biological diversity (Jaramillo and Aguilar 1998). The highlands are dominated by fir forests and mountain grasslands with half a dozen small lakes that used to sustain a well-represented lacustric vegetation. Pine and pine-oak forests cover the midlands along with meadow

vegetation mixed with agricultural fields. In the lowlands of the southern slopes, oak forests are intersected by volcanic shrubs that grow in the abundant basaltic litosols. Several streams provide for lotic and subhumid riparian vegetation. In spite of land-use pressures, a large area of mesophilous woods persists, officially recognized by Mexico's National Biodiversity Strategy as a threatened ecosystem and conservation priority.

Close to 2% of the world's flora and fauna biodiversity is found in the Water Forest (Velázquez 1993). Although it represents only 0.06% of the national territory, the Water Forest currently harbors an important proportion of Mexico's biodiversity: three of its six ecological zones, five of its nine types of ecosystems, 3% to 5% of its species of plants and fungii, 6% of its invertebrate species, and 7% of all vertebrate species known to Mexico (Velázquez and Romero 1999). Dozens of migratory bird species hibernate in the Water Forest. Of the region's biotic diversity, approximately 10% is endemic: a total of 325 species found nowhere else on Earth (CONABIO 1998). The area is indeed a critical, rich, and functioning biological corridor (CONABIO and UAEM 2006), even though it is now much diminished.

Ecological Services

The Water Forest provides a full range of ecosystem services to over 20 million people who live in the adjacent cities of Mexico D.F., Toluca, Cuernavaca, and other surrounding communities. The economic impact of the forest's potential reduced capacity to provide environmental services can be best understood through considering its water contributions. Although 75% of Mexico City's water is supplied from this forest, with minimal forest management costs, approximately US$120 million are spent annually to supply the other 25% of the water that Mexico City consumes. All of the water used in the city of Cuernavaca is supplied from the Water Forest. The Water Forest is on the highlands of Mexico's three most important watersheds (Mexico Valley, Balsas River, and Lerma River) and is considered as a Hydrological Priority Region and as a Conservation Priority Terrestrial Zone (CONABIO 2007).

Beyond rainwater catchment and replenishment of underground aquifers, millions of dollars more would have to be spent to restore the other environmental services provided by the Water Forest, such as erosion control, oxygen production, carbon sinks, biodiversity platforms, wildlife habitat, and air pollution buffers. On a global scale, the Water Forest is large enough to help mitigate some of the effects of climate change.

Conservation

Despite the strategic importance of this region, very few efforts have been made to conserve and manage its wildlands. Given this lack of interest in its protection, some conservationists see it as "the hole in the conservation doughnut."

Approximately 80% of the Water Forest is legally protected for conservation under various formats. However, incredibly, there is no program to monitor its natural resources, no conservation strategies and programs have been adequately implemented, and no international support for its conservation. Furthermore, areas of high biodiversity and some of its best-preserved woods are devoid of any legal protection.

Despite the tremendous human population pressures and the relative lack of conservation actions and programs, the Water Forest still harbors vigorous, healthy wild areas, haven to large mammalians such as white-tailed deer (*Odoicoleus virginianus*), coyote (*Canis latrans*), and five of the six wild felines found in Mexico: puma (*Puma concolor*), lynx (*Lynx rufus*), ocelot (*Felis pardalis*), tigrillo (*Felis weiddi*), and jaguarundi (*Felis yagouaroundi*). Although the puma was considered

The extraction of "zacatón" grass to manufacture brooms and brushes, among other products, causes irreversible damage on certain gramineous bunch grass species, causing habitat transformations that affect many other plant and animal species. Poor diversity of employment opportunities makes certain Water Forest inhabitants dependent on these resources. Photo by Alejandro Velázquez, in Velázquez, A., Romero, F. J. (1999)

Illegal hunting is widespread all over the region and preys on anything that moves or breathes. This image of a local hunter in the town of El Capulín, on the Water Forest heights, holds a Lynx recently captured for no specific reason (although they did afterwards eat it). Hunting is permanently forbidden in the Water Forest, but the lack of surveillance by the authorities only further encourages sport hunters from nearby urban centres. Photo by Jürgen Hoth, in Velázquez, A., Romero, F. J. (1999)

The endangered Furcraea bedinghausii (an agave) is endemic to the Neovolcanic Axis. Up to 8 m in height, it and is usually found in alpine grasslands of the volcanic slopes. By Jaime Rojo

extinct, there are recent anecdotal accounts of sightings by scientists working in the area, such as in 1997 by Francisco Romero who saw a juvenile puma fleeing from dogs and hunters, while doing field work in the highlands of the Water Forest (Velázquez and Romero 1999).

Threats

Human population growth has rapidly increased threats to and demands on this area's natural resources. From 1959 to 1999, Mexico City's population grew by 315% and today surpasses 20 million people (including urban sprawl into adjacent states), with an average density of 5,799 people per square kilometer (0.38 sq mi). The expansion of towns, advance of agricultural fields, deliberate and accidental forest fires, illegal logging, extraction of rocks and soil (with seeds), overgrazing, highway projects, real estate projects, and other human activities in the area are critically fragmenting, reducing, and changing the structure and composition of Water Forest ecosystems and their associated wildlife populations. From 1959 to 1999, the natural forest cover was reduced by 30%, and most surface water bodies dried up. Several animal and plant populations are restricted to relic areas of the original ecosystem. According to the Geography Institute of the National Autonomous University of Mexico, the Water Forest is disappearing at the rate of 2,400 hectares (5,928 acres) per year and could be entirely gone within 50 years.

Construction of two highways through the most natural areas of the Water Forest is scheduled to begin in 2008. On its southern slopes, the Libramiento Norponiente highway project would traverse the last woods of Cuernavaca, featuring important water springs and the best preserved forest in the state of Morelos, which includes mesophilous woods—Mexico's most threatened type of ecosystem. Most of these woods are jointly owned by *comuneros*, but companies interested in the construction of the highway and development of housing in the area have already bought much of their land. The Libramiento Norponiente highway project, as currently planned, would be very damaging to the environment. In the past three decades, 80% of forest cover in the state of Morelos was lost, and according to the Biodiversity Strategy for the state of Morelos, more than 3,000 hectares (7,410 acres) of forest are being lost every year (CONABIO and CEAMA 2003). Cuernavaca's northern forests represent nearly 90% of what forest cover is left in the state of Morelos.

On the highlands, the Lerma-Tres Marias highway would run a few meters away from the Chalchihuites central zone of the protected Ajusco-Chichinautzin Biological Corridor and through the protected Otomí-Mexica State Reserve, as well as through some very well-preserved and unprotected areas that adjoin the protected areas. The Lerma-Tres Marias highway would traverse the Water Forest's most important rain catching closed drainage basin. The highway project is motivated by commercial land developers. If this highway is built, urban sprawl would expand in this area of critical environmental importance to central Mexico.

A unique feature of the Water Forest is the Buenavista Glacis, a system of 260 ravines that originate at the Zempoala lagoons and extends south beyond the Water Forest boundaries. A glacis with these landscape characteristics is only elsewhere found in the Himalayas. A potentially serious and immediate threat is the project to build a landfill right atop the Buenavista Glacis. Given its high hydrological conductivity, fluids from the landfill would rapidly pollute the rivers of the region, damage their biodiversity, and, within two years, reach the city of Temixco's underground water reservoir, on which a human population exceeding 100,000 depends. Local communities, academics, and activists have pursued all legal avenues to dissuade Cuernavaca's authorities from placing the landfill in this area, but to no avail—even though opponents have proposed several other locations that do meet legally defined landfill requirements. The current waste-management crisis in the city is being used as an excuse to open roads into the glacis for urban development purposes.

Confronting the Threats

Although in the past four years local communities, environmentalists, and academic researchers have jointly managed to hinder the Lerma-Tres Marias and Libramiento Norponiente highway projects, governments are determined to start constructing both in 2008. Despite knowledge that these forests

are the water supply for millions of people, governments are still willing to sacrifice the Water Forest to economic development. On November 2007, opponents appealed to the International Court of Environmental Arbitration and Settlement denouncing the Lerma-Tres Marias highway project.

Scientists from several universities, supported by research information, have put forth proposals for potential corridors where vegetation cover, number of species, and importance for wildlife continuity and connectivity among wooded areas would be least affected and allow for creation of a protected area large enough for the adequate conservation of the Water Forest's wealth of species and natural resources. However, due to budgetary, bureaucratic, or political issues, the advice of academics has not been heeded nor supported and the forest continues to deteriorate.

Professor Francisco J. Romero and researchers from the Ecology and Wildlife Conservation Laboratory of the Metropolitan Autonomous University (UAMX), in collaboration with biologist Hector Magallón's Greenpeace Mexico Forest Campaign team, are developing an ecological zoning project to establish strategic guidelines for adequate Water Forest management and restoration. This research included:

- detailed geo-referenced Water Forest borders using geographical information systems and field data;
- classification and zoning of all the region's plant communities in relation to their topographical, geological, and geomorphological basis, plus geo-referenced registries of indicator flora and wildlife;
- definition under multiple criteria of where urban, agricultural, and wild areas converge;
- identification of rural populations and their areas of influence within the Water Forest;
- identification of limits officially agreed upon by the federal and local governments regarding areas with irregular human settlements;
- identification of areas that present high risks for human settlements;
- identification, with a view to restoration, of affected wildlands and abandoned agricultural fields; and
- revision and outline of areas with legal conservation status, such as: federal and local Protected Natural Areas, Ecological Conservation Soils, Forest Reserves, zones considered Historical Monuments, World Heritage areas, RAMSAR wetlands, and Farmers' Ecological Reserves.

The rainy season and high temperatures form a fine mist, providing a special mood to the water forest, and emphasizing its importance as a water catchment. By Jaime Rojo

Although this research project is due to be completed in 2008, preliminary results indicate that the total surface area of the Water Forest is more than 147,000 hectares (363,245 acres). The project's delimitation of the Water Forest only takes into account what is left of it, leaving out areas that have been claimed by urban sprawl or agriculture, yet including those that have been seriously affected, but are surrounded by wooded areas. Most (80–85%) of the Water Forest retains natural vegetation cover (e.g., forest stands, alpine and subalpine grasslands and shrublands). The rest is mostly composed of rural towns, agricultural fields, and the World Heritage site of Xochimilco. Preliminary results reveal that in the past five years, land use in the Water Forest has changed dramatically to the detriment of natural vegetation cover.

On the southern slopes, in the state of Morelos, a group of scientists from the Regional Centre of Multidisciplinary Research of the National Autonomous University of Mexico (CRIM–UNAM), has been working since 2000 to protect the Water Forest. The research team believes that the future protection of the Water Forest is best assured with good scientific information implemented through participatory processes with local residents. The team is led by Dr. Raúl García Barrios and operates in the framework of the Macro-Project for Ecosystem Management and Human Development created by several UNAM faculties and research institutes. This group has focused on promoting the following:

- creation and/or empowerment of grassroots institutions for conservation, restoration, and ecosystem damage-prevention;
- synergies among civilian groups, governments, and academic institutions;
- community-based land-use planning;
- lobbying for the environment, involving academic, legislative, political, and community stakeholders;

- training and support to local stakeholders to learn and implement new skills (e.g., use and reuse of water, adequate management of solid waste, Geographical Information Systems, how to tackle illegal logging);
- creation and management of protected areas and a wildlife corridor;
- environmental restoration of forests, soils, flora, and fauna;
- multidisciplinary research; and
- remediation of the Quila and Hueyapan lagoons.

Wilderness beyond the Biological

Ecosystem services are biological and include the increasingly important aspects of solitude, remoteness, and spiritual regeneration opportunities that are part of all wilderness areas around the world, regardless of their location. The urban wilderness of the Water Forest can provide this, but personal security is an issue, especially in the most accessible areas. Not everyone in this forest is there to experience its beauty and spiritual and recreational values. However, the forest still has virtually unvisited areas, remote ravines, and steep forested canyons that require two days or more travel by foot to access, where security and solitude are available. It is envisioned that, once the forest's potential to generate local incomes from ecotourism is tapped, and once effective conservation programs are implemented, personal safety in these beautiful woods might no longer be an issue.

Closing Remarks

More than 300 million people live at a distance of fewer than 10 kilometers (16 miles) away from protected wildlands in the world's endangered terrestrial ecoregions of highest biodiversity (Mittermeier et al. 2004). A considerable percentage of these people are the millions of neighbors who live closely adjacent to the Water Forest. The size and extent of the Water Forest provide for a varied and functioning ecosystem with ecological services that benefit several human communities, including one of the largest metropolitan areas in the world, and make it a singularly important example of urban wildlands.

Beyond ecological services rendered to humans, the wilderness value of the Water Forest is priceless. Bird populations are a clear example of the critical need to reduce the increasing threats. The relatively small surface area of this forest's mountains is haven to 211 bird species (Romero et al. 2006), 40% of which are migratory and arrive mostly from the United States and Canada. These bird species represent one-fifth of the avian species known to exist in Mexico (Velázquez and Romero 1999) and more than one-third of the bird species shared among the United States and Canada together (Romero et al. 2006). Their loss would affect Mexico's species wealth and potential, as well as impact those countries with whom we share the migratory species.

The final example is about wilderness and people. The Water Forest, being an urban wilderness, is a critical retreat area for city dwellers. A recent story is told of a jogger descending swiftly down a Water Forest ravine, at the bottom of which he leapt into the narrow creekbed, landing simultaneously with an ocelot. Stunned, both remained utterly still and, within a blink, the feline vanished. Lords of the wild such as this ocelot, although shy, secretive, and assailed by urban sprawl, are in the Water Forest. So are people. We need each other to survive our increasingly urbanized world. IJW

One of the world's most outstanding urban proximate wildernesses is the Water Forest on the southern outskirts of the rapidly expanding Mexico City.

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decline. ARMI scientists whose studies include significant backcountry work include Mike Adams (Forest and Rangelands Ecosystem Science Center, Corvallis, Oregon) Gary Fellers (Western Ecological Research Center, Point Reyes National Seashore, California), Erin Muths (Fort Collins Science Center, Colorado), and myself. Projects have included extensive monitoring of population status, attempted reintroduction of extirpated species, effects of potential stressors such as wildfire and ultraviolet radiation, and detection of pesticides in amphibian tissues in remote watersheds.

The areas of emphasis recommended by the FS panel review are not really discrete categories, and many studies will address more than one topic. The studies by the Colorado Water Science Center demonstrate this by monitoring wilderness condition (topic 1) and using wilderness as an unmanaged standard (topic 3), in addition to studying hydrology (topic 2). The Western Mountain Initiative (WMI) is a collection of independent research projects that also encompass more than one of the recommended research topics. The WMI addresses the role of climate change in mountain ecosystems in the western United States, with emphasis on disturbance (fire), vegetation, hydrology, and identifying sensitive resources and potential management responses. USGS scientists involved in the WMI include Craig Allen (Fort Collins Science Center, Bandelier National Monument, New Mexico), Jill Baron (Fort Collins Science Center, Natural Resource Ecology Laboratory, Colorado State University), Dan Fagre (Northern Rocky Mountain Science Center, Glacier National Park, Montana), and Nate Stephenson (Western Ecological Research Center, Sequoia-King's Canyon National Park, California).

The distinction between wilderness managed by the FS and by DOI agencies is also fuzzy. USGS scientists work in FS wilderness, much as FS scientists at ALWRI and elsewhere have projects that include DOI wilderness. Furthermore, research conducted in undeveloped areas of DOI protected areas is typically applicable to the management of lands designated as wilderness. The lack of clear distinctions in wilderness research indicates that the recommendations of the FS panel review are also applicable to the USGS. For example, the USGS is devoting increasing resources to global change research; therefore, the recommendation in the review to increase the integration between wilderness and global change research is especially important. This is the approach begun by the WMI and likely to be emulated by more projects as funding for global change studies increases.

A needed step is to conduct a complete review of the wilderness-related research currently being carried out by USGS.

The FS panel review dealt only with FS research and did not address USGS projects. However, a logical extension of the recommendations would be a better integration of all federal research relating to wilderness, and a needed step is to conduct a complete review of the wilderness-related research currently being carried out by the USGS. IJW

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