Are Wildland Watersheds Safest and Best?

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Abstract—The 2003 International Year of Freshwater highlighted the critical current and future scenario, on a global scale, of scarcity of adequate water—the essential need for all living things. About 40 percent of the world's population currently have moderate to high water stress, and it is estimated that by 2025 about two-thirds of the world will live in areas facing such water stress.

Within a given climate and physiographic situation, the human land use (or lack of it, as in wild lands) strongly influences the available quantity and quality of water. After briefly discussing the impacts of various land uses, it is concluded that wild land (or wilderness) is the hydrologically safest and best allocation of land. This is examined from the standpoints of wetlands, headwaters (including montane cloud forests) and the surface waters themselves. While sustainable use, and providing livelihoods to local people are desirable goals, there are just some situations where human use must surely give way or be strictly controlled, if water and its services are to play their full, critical role. Where highest quality and best regulated water is a necessity, wildlands or wilderness is the way to go. Examples of water resources protection giving opportunity for wilderness designation and protection are presented, for example, in New York State's Adirondack Forest Preserve.

Introduction

Freshwater is the most crucial of all resources for humans, and essential for all other creatures that live in terrestrial or freshwater aquatic environments. A serious crisis looms, or already exists, in much of the world with its increasing population and burgeoning demand. The 2003 International Year of Freshwater attempted to raise public awareness of the problems we face in securing adequate supplies of suitable quality water, in the right places at affordable cost, given that:

- About 40 percent of the world's population currently have moderate to high water stress.
- By 2005 it is estimated that about two-thirds of the world will live in areas facing such water stress.
- By the year 2025 it is predicted that water withdrawal will increase by 50 percent in developing countries and 18 percent in developed countries (United Nations 2003).

Land cover and land-use activities strongly affect the availability and quality of freshwater that comes to us via the hydrologic cycle. As competition increases for scarce water, societies will be increasingly searching for interventions in this cycle to capture more water (for example, through storages on watercourses, reducing evaporative losses from open water, pumping more groundwater and manipulating vegetative cover to reduce evapo-transpiration "losses"). None of this bodes well for wildlands, wild rivers and wild wetlands. But is this a necessary scenario?

Aside from all the compelling reasons for establishing and maintaining wildland protected areas having to do with biological diversity, cultural heritage, scenic amenity, healing value, limited recreational use, scientific benchmark and research area, the role of wilderness in watershed protection merits much more attention. The quest for adequate supplies of water of suitable quality will dominate much of the world's development agenda in this 21st Century and beyond. For potable water, industrial and irrigation supplies, hydroelectric use, navigation, recreation, and for all aquatic life, there are requirements for availability at the right place at the right time, and of the right quality (freedom from sediment or pollution). It is the thesis of this paper, that these requirements are best met from watersheds in some kind of protective status, but above all by wildland protected areas.

The Early Wilderness-Water Connections

One of the historically earliest concerns about water and what our assault on the forest wilderness had done to it was expressed by a fellow Vermonter, George Perkins Marsh, a much under appreciated chap. In his great work, "Man and Nature, or Physical Geography as Modified by Human Action," published in 1864, and in earlier lectures and writings from 1856 on, Marsh linked water problems being experienced in the USA to human activity in forest clearing and logging, and related this to what he had seen in his foreign diplomatic posts in Turkey, Greece and Italy and travels in Egypt and Arabia (Trombulak 2001). His thinking and writing were seized upon by Verplank Colvin, New York State surveyor in the Adirondacks, who pointed out that: the Adirondack Wilderness contains the springs that are the sources of principal rivers and the feeders of the canals. Each summer the water supply for these rivers and canals is lessened, and commerce has suffered (Terrie 1992).

This was in 1870, but it took 15 years for this concept to materialize into a 1885 law establishing the New York State Forest Preserve in the Adirondack Mountains and also in the Catskills. (The State-owned Preserve constituted roughly 551,093 acres [223,000 ha] in the Adirondacks.) On these State lands the forest was to be kept "forever wild" according to the State Constitution (1902), and the rationale was for watershed protection. Thus, the first officially designated area

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for water protection was this first wilderness. Yellowstone had been created as a National Park in 1875, but it was primarily for the scenic value and thermal phenomena, not wildness. In 1902, the large Adirondack Park, including both Forest Preserve lands and private lands was established. The Park today embraces 5.9 million acres (2.39 million ha), of which 2.7 million acres (1.09 million ha) are "forever wild" Forest Preserve (personal communication, David Winchell, N. Y. S. Dept. of Environmental Conservation 2005).

At the end of the 19th and beginning of the 20th Centuries there arose a powerful doctrine in the watershed arena—that forests were the key to abundant, well-regulated, high quality water. Lands in the Public Domain of the American West were reserved from entry and alienation as Forest Reserves (later called National Forests), partly as timber supply, but also for watershed protection (Hibbard 1965). Some of this would eventually become designated "wilderness." Moreover, we owe the existence of National Forests in the East to land acquisition authorized by the Weeks Act of 1911, "to protect the headwaters of navigable streams" (Dana 1956). In fact, it was only because of water's importance for interstate navigation that the Federal Government was permitted to purchase land within the States. The bulk of our wilderness and wildlands in the East, aside from New York and Maine, occur in these purchased National Forests.

Separating Myth From Reality

During these early years, respected professionals, politicians and even some scholars reinforced the popular conception that forests could prevent floods, ameliorate droughts, provide more low flow and that reforestation or afforestation would raise levels in wells, cause springs to flow again and reduce flooding in the lower basins. For instance, it has even fairly recently (1981) been claimed that logging and land clearing in the Nepal Himalayas has been responsible for devastating flooding in the lower Ganges basin in India, and that restoring forests can cause dry rivers to flow again, relieving drought (World Water 1981). Even my friend and respected, courageous campaigner for conservation, Dr. Norman Myers and others, as recently as 1983 were stating that tree roots soak up water in wet periods and release it slowly and evenly in the dry season to keep water supplies adequately restored (Myers 1983; Spears 1982). This is nonsense, for tree roots are more like pumps. It led to my writing of a landmark book of 1983 dealing with the 4 M's: myth, misunderstanding, misinterpretation and misinformation (Hamilton with King 1983).

The popular thinking just does not "square" with the following phenomena, of which I have personal knowledge and experience:

1. Following large-scale reforestation of abandoned farmland in central New York, 1920s-1940, fishermen found that summer streamflows were diminished and adversely affecting trout fishing. This lower flow phenomena was confirmed by a famous U.S. Geological Survey stream monitoring study. Irate fishermen were saying to professional foresters, "You lied to us."

2. Forest clearing in certain areas of Australia for pasture or crops resulted in salts being brought closer to the soil surface by rising water tables, rendering the soils saline and unfit for crops, in other words, rising, not falling, water tables following deforestation! And, the Chinese are planting trees in wet areas to draw down the water table.

3. Monsoon rains even on unlogged forests produced devastating floods in Malaysia.

4. Following large-scale forest blowdown in the 1938 New England hurricane, there were no disastrous floods the following two years. The same was true for the Big Blowdown in the Adirondacks in 1950.

5. Serious flooding occurred following the tail end of 1955 Hurricane Hugo in the Catskills, a largely forested area, which did not prevent flooding.

Scientific research in the watershed arena has given us a better understanding of the hydrologic role of forests, and forest alteration. Let me give you a few bits of this:

Tree roots are not a **sponge** as has been stated by some. They absorb water, but do not give it back to the soil. Trees transpire it, and they evaporate it, from foliage. In fact, they are more like a **pump**, taking from the soil more water than other vegetation because of deep roots, and evaporating more because of canopy roughness. Hence, when trees are cut down this heavy use is diminished. On deep soils, every experiment has shown an increase in water in the dry season, but also to a smaller extent in the wet season, when we do not want it in streams (Hamilton with King 1983). Nor does the tree canopy protect the soil from the kinetic impact of falling raindrops that causes splash erosion and dislodging of soil particles. Tree canopies are more like **umbrellas**, producing larger drop size, and once the surface is wetted, it all flows off or drips down. The larger drop size, and if the canopy is higher than 20 ft (6 m), means that terminal velocity is reached, and the energy of rain hitting the ground per unit area can be higher than in the open. It is the understory—short trees, shrubs, ground vegetation, litter, and forest-floor debris—that protect against raindrop impact and soil dislodging (Wiersum 1984). It is the soil with its organic matter that stores water, reducing overland flow, and that permits water to infiltrate and recharge ground water.

So, having "trashed" trees/forest, what can I, as a druid, say about them? First, they are **anchors**, with their root systems' shear strength providing a greater safety margin against shallow landslips when steep slopes become saturated (O'Loughin 1974). Moreover, they provide leaf litter and debris that reduces surface erosion. Forests also are usually not subject to frequent intensive human or animal uses that make land more susceptible to erosion. Less erosion means less sediment, which means higher water quality.

Second, through their use of soil water, they keep the soil in the best state of preparedness to receive additional water for storage instead of runoff. In deep soils, this function can reduce **local** flooding from small or short storms that occur with great frequency. However, for prolonged rains (monsoon type) or high-intensity rains, soil water storage capacity determines whether there will be floods or not. If 5 inches (127 mm) of rain in 12 hours falls on soils whose storage is only 3 inches (76 mm) (especially previously wetted), there will be flooding, even if covered with pristine forests, three deep. It is also necessary to realize that the farther one moves down a watershed, into large basins, the role of headwaters forests in reducing flooding becomes overwhelmed by other factors.

And what about water shortage in dry season? I recall in the dry years in the 1960s, when New York City was terribly short of water and there were "shaveless Wednesdays" being advocated as a water conservation measure. By then, also, research had appeared that pointed out that trees use water. I was asked by a New York newspaper reporter, "What about cutting the Catskill forest to increase water availability for the City's Catskill reservoirs?" I had to point out that the Catskill Park and Preserve perform many other ecosystem services than water, including erosion protection, wildlife habitat, wilderness experience, carbon sequestration, outdoor recreation (including a tourism industry), and fine scenery. Moreover, that there was a constitutional protection for forests in the Preserve. This illustrates the danger of small-box thinking in complex situations. This narrow thinking surfaces again from time to time as a proposal for U.S. National Forests in the Intermountain West, as a measure to provide more water.

There are also unusual types of forests in mountains that experience persistent or frequent cloud or fog, especially where wind-driven. These are the legendary cloud forests (also known as, elfin forests or mossy forests). Ladened with epiphytes on their branches and stems, these forest surfaces rake moisture from the fog, which drips or runs down to the ground and is added to the water budget (Bruijnzeel and Hamilton 2000). Due to high humidity and lower radiation, evaporation/transpiration is lower than normal forests, and this water **capture** from horizontal precipitation is extra—a bonus. In this case, removal of forest does result in less water available in streams, groundwater or springs. These sensitive ecosystems need total protection as wild lands everywhere they occur.

And now, having raised some questions about the role of forests and water, by dispelling some myths and misunderstanding, what can we say about wild lands as a producer of water?

Wilderness or Extraction/ Conversion?

Untrammeled (wild) forests are absolutely the **safest and best watershed cover** if we want the highest quality of water, in a **natural streamflow** pattern (quantity and timing), which has been long established so that streams, aquatic life, and people are adjusted to that pattern. Let us consider some alternative land uses.

- **Cutting some or all of the trees and extracting them**. While it will result in greater water yield, it does somewhat increase streamflows when you do not want it, during floods. This effect may be important close to the area logged, and in the more frequently occurring smaller storms (Hamilton with King 1983). In major storm events and in large basins, the effect is dwarfed by other factors. It would not be as harmful to water quality if the trees were airlifted out (or perhaps carried out by elephants); no roads, skid trails, or log landings. But logging **does** involve these ground-baring passageways, and moreover usually heavy equipment, which compacts soil, thus reducing infiltration. Both more rapid runoff and greater soil erosion are a consequence of getting wood out. Greater erosion means more sediment, which impairs water quality for human use and aquatic organisms. Moreover, the loss of root shear strength of the cut trees renders the area (if sloping) more susceptible to landslips (O'Loughlin 1974), until regeneration is well established.
- **Conversion to grassland**. Grasslands are excellent watershed cover and yield more water than the same area in a forest. But where there is grass, it is usually called "range" or "grazing land," and someone will be putting livestock on it. And, while lightly grazed grassland is hydrologically and erosionally satisfactory watershed land use, it is rare, and overgrazing usually prevails. Here then, soil compaction and accelerated erosion again come into play, especially along streambanks where stock go to drink water. Here too, animal manure may impair water quality. Fire is used in some regions to maintain grasslands, and this has its own baggage of reducing water quality and altering streamflow regimes. Grazing of grasslands does present problems. Alpine meadows or other wild grasslands are superb watershed land cover.
- **Conversion to crops**. Large areas of former wild land have been cleared for agricultural crops, and this process continues. While none can fault the "traditional," carefully constructed and maintained rice terraces from a hydrologic and soil conservation standpoint (and even aesthetic), these again are rare. Most sloping agricultural cropland is accompanied by bare soil at times (hence erosion), compaction, susceptibility to soil slips if on steep slopes, additions of fertilizers and often pesticides, all of which impair water quality and hasten run-off. Eutrophication of rivers and lakes from agricultural nitrogen and phosphorus runoff is a problem in many areas.
- **Human habitation and associated business** have the most adverse impacts. One scarcely needs to enumerate a list that includes non-absorbing surfaces, soil disturbance, human waste disposition to water or groundwater, or other wastes and chemicals from human occupation, transportation, and industry, pesticides and so forth.
- **Mining** has very serious impacts such as from road building, waste pile erosion and drainage, toxic mine drainage, work force wastes and the practice in some areas of mountain top removal and fill in valleys or depressions. Add in requirements for water diversion and use, which adds toxins and so forth. The quest for new sources of fossil fuels can severely, adversely impact both wilderness and water.
- **Roads** are a common element in all of these alternatives, and their construction and maintenance must be labeled as having some of the most seriously negative impacts on water quality, and to some extent quantity. Hence, roadless wilderness areas have much going for them as best water source areas.

In summary, wild lands, because they represent the least human disturbance and intensity of use, best maintain the quality of water for human use and all other living creatures. Wild lands as watersheds have produced over time a certain volume delivery and timing of water to which the stream, river pattern and landscape has adjusted. Changes from wild status change that pattern, usually to the detriment of the downstream environment. This is why there are so many instances of the setting aside of watershed conservation areas, as water reserves, national parks or other kinds of protected areas that reduce human impact. Thirty of the world's major cities, including Cape Town, Rio de Janeiro, Singapore, Caracas, Quito, Vienna, Tokyo and New York, obtain all or some of their water supplies from protected area watersheds (Dudley and Stolton 2003). Increasingly, we are witnessing payment transfers from water users to the protection of land at the source. The city of Quito puts a charge on each water bill that goes to a Condor BioReserve complex of National Parks and Ecological Reserves in the Andes—wild lands (Echavarría and Arroyo 2004). New York City gets its high quality water from the Catskill Forest Preserve and is spending large amounts of money to upgrade land use practices on adjacent private land and municipal settlements in the Catskill Park.

Wetlands as Wildlands

Wetlands are areas where water is the primary factor controlling environmental processes and the plant and animal life (Maltby 1986). Their role as natural water retention and storage sites hardly needs emphasis. Draining or draining and filling these wildland ecosystems speeds water into channels and hence aggravates downstream flooding. Moreover, without their slow release function, downstream water low flows are aggravated. Habitat for important wetland flora and fauna is eliminated along with the water filtration and groundwater recharge functions. Whether they are swamp forests, bogs, marshes, fens, vernal pools or given other names, they need protection. This may be either through wetland conservation legislation (for example, a permit for alteration is required) or designation as some kind of Protected Area such as Waterfowl Reserve, Wildlife Sanctuary, Wetland Park, or Wilderness (if large enough). The international protection that is afforded to globally important wetlands comes under the Ramsar Convention.

Wetlands worldwide have been unduly lost or degraded because society has not comprehended their valuable functions. They have been appropriately called "Wetland Wealth" (Maltby 1986). In a recent paper, I have designated them as "Red Flag" areas, which need to be carefully assessed and valued prior to clearing, draining or serious alteration (Hamilton 2004). While we talk much of mitigation and restoration, these are poor (though perhaps at times necessary) measures. We really need much more coverage of wetlands in our Protected Area Systems, and especially into categories or types that maintain them as natural, wildland ecosystems, of as large a size (including buffer zones) as possible. Then they perform best their critical watershed functions, as well as recreational use.

Montane Cloud Forests

Of particular relevance and concern are mountain forests in the tropics called "cloud forests." These vegetation types capture additional water above normal vertical rainfall from persistent clouds and horizontally wind-driven fog or cloud water. In continental situations, such as the Andes, they occur from 2,000 to 3,500 m (6,562 to 11,483 ft) in elevation, and are known there as *selva de neblina* or *bosque nuboso* (Hamilton and others 1995). On oceanic islands, they may occur as low as 300 m (984 ft), and may be known as mossy forests or elfin forests. The extra water captured by the leaves, twigs, branches and abundant epiphytes (mosses, bromeliads, ferns, liverworts, orchids and lichens) varies from 15 percent to 60 percent of regular rainfall, more in dry locations with fog. If these forests are cut and removed, this cloud water function is lost. Moreover, they are also treasure houses of unusual biodiversity, much of it endemic. Well- known and threatened species such as mountain tapirs, quetzals, Andean spectacled bear and mountain gorillas inhabit cloud forests. Their loss is basically irreversible and even modest utilization has not proven to be sustainable (Bruijnzeel and Hamilton 2000). With a maximum potential occurrence of only 2.5 percent of all tropical forests (Bubb and others 2004), and disappearing fast, these unusual water-producing ecosystems need protection rather than utilization. Having them in wildland status would be the best policy.

Wild Waterways

While this paper deals primarily with water and **wildlands**, it would be remiss not to briefly mention wild waterways. Our meeting host State of Alaska has many fine wilderness rivers, including significant portions of the Yukon River whose capacity is exceeded by only four other rivers, the Amazon, Mississippi, Missouri and St. Lawrence. One way to protect the wilderness character of a waterway is to include it in a formal protected area. For instance, a portion of the Yukon is conserved within the Yukon-Charley Rivers National Preserve (915,000 ha or 2.26 million acres). Not far away, in Alberta, the Ghost River has been designated as a Wilderness Area (15,317 ha or 41,500 acres). Meanwhile, a little farther away, in Siberia the 4,347 km (2,700 mile) long Lena River, Russia's most pristine river, the only major waterway free of dams, with water clean enough to drink, is facing new development threats without any formal protection (Tayler 2005).

Extremely effective in maintaining the natural character of some of the United States' waterways has been the Wild and Scenic Rivers System. Enacted in 1968, the Wild and Scenic Rivers Act provided that some of America's rivers were to be preserved in a free-flowing condition. "Wild" rivers were "those rivers or sections of rivers free from impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These present vestiges of primitive America." (Public Law 90-542).

There is now significant action and a growing movement for dam removal, to restore some of the free-flowing nature of rivers. There are an estimated 800,000 dams of all sizes blocking the free flow of the world's rivers (Postel and Richter 2003). But flow restoration efforts are underway on more than 230 rivers in at least 20 countries (Postel and Richter 2003). In my own State of Vermont, many of the small hydropower dams are currently coming up for licensing renewal review, and in many cases, we are saying no. A landmark case in Olympic National Park is the removal of the dams on the Elwha River, which is currently underway. There is even a movement to remove the dam flooding the Hetch Hetchy portion of Yosemite National Park, whose reservoir supplies drinking water and power to San Francisco. "Restore Hetch Hetchy" and the Sierra Club are two of the groups pushing for this. Governor Schwarzenegger has ordered a study review.

National Parks and Water

While National Parks worldwide are often far from being equivalent to wildlands, they are usually the next best thing, in that human uses are regulated in the interests of nature protection. Many watershed headwater areas have been formed into National Parks or equivalent reserves with a major objective of conserving water resources. In Malawi, for instance, a long narrow country consisting basically of three increasingly high plateaus separated by escarpment, large portions of the highest plateau have been designated as reserves of different kinds for watershed purposes. Here are located most of the Forest Reserves: Nyika National Park and its extensions, Nkhotakota Game Reserve and the extension to Lengwe National Park, and Majete and Mwabri Game Reserves (Kombe 1984). One of the best known examples of recognition of the key role protected areas can play in safeguarding water values is the case of Dumoga Bone National Park in Sulawesi, Indonesia. Here, The World Bank in funding the Dumoga Valley Irrigation Schemes, allocated funds to support the establishment and management of this park in the catchment headwaters (MacKinnon and others 1986).

José Rafael García, the former Director of National Parks in Venezuela, aptly pointed out that Canaima National Park, with savannahs, gallery forests, *tepuys*, rivers, and waterfalls (including Angel Falls), is a guardian of the hydroelectric production of 9 million kilowatts from the Caroní River (García 1984). The park was enlarged from its original 1 million ha (2.5 million acre) size of 1962 to 3 million ha (7.4 million acres) in 1975, so that it now covers one-third of the Caroní basin. The justification for the tripling in size was not scenery or endangered species, but to safeguard the huge investment in power development then, and in future expansion to 20 million kilowatts, by supplying high quality (low sediment) water. Likewise for Guatopo National Park which is headwaters for a major water supply area for Caracas. García stated, "the most important thing is that the water from this park is of very high quality, and for this reason, its treatment for human consumption is less expensive" (García 1984). Spectacular rainforest and high quality water source only two hours from Caracas!

Conclusions

It is fortunate that as wildlands and protected areas face increasing pressures for development in an increasingly populous world, that the critical task of securing adequate supplies of suitable quality water also increases, and this could mean more protection for wilderness watersheds. Water has been identified as a most pressing global problem as highlighted in the 2003 International Year of Freshwater. **Take-home message**: A watershed with the least human intervention produces the safest and best hydrologic situation. Sounds like wildlands to me.

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