

Overcoming myths about soil and water impacts of tropical forest land uses

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In many developing countries forest land use policies are predicated on the forest's assumed effects on certain watershed hydrologic characteristics and soil erosion control and sediment reduction benefits. In some cases there is scientific basis for these assumptions, but others are based on folklore, myth, or misinterpretation of research.

It seems desirable to shed some light on a few of the hydrologic and soil functions of forests in a watershed/land use context and to reveal at least some of the "four Ms"—myth, misinterpretation, misinformation, and misunderstanding—about the effects of using or converting tropical forest lands. For example, it has been suggested that cutting of rainforests will result in desertification. There is no evidence that rainfall will decline to the point where the area becomes arid. It also has been suggested that reforestation or afforestation of nonforested lands, including extensive grasslands, will cause higher well levels, renewed spring flows, and increased low flows in streams. All evidence from temperate zone research, however, indicates the reverse. Is this research inapplicable to the tropics, or are policymakers using the wrong arguments for the right reasons? Does it depend upon how badly the land was abused prior to planting? Floods in the lower stretches of major rivers, for example, the floods in Bangkok and New Delhi, are blamed on tree harvesting or shifting cultivators in the uplands far away. This relationship has never been proved. But could it still be correct and therefore a basis for land use policies? Yes, it could be. But it might partly be that urban people refuse to look at their own actions in floodplain occupancy, channel constriction and alteration,

and the effects of such important sediment producers as roads in the upper watershed.

I would like to discuss some policies that have been advocated based on supposedly sound soil or water conservation rationales, but which in fact have little, or worse, a countervailing, scientific basis. It is important to bear in mind, however, that lacking good information it is better to err on the conservative, conserving side.

Cutting reduces rainfall?

Many conservationists advocate that we save tropical forests, particularly tropical rainforests, because cutting them will convert the areas into deserts and create droughts. The World Wildlife Fund/International Union for the Conservation of Nature and Natural Resources (IUCN) Tropical Forests Campaign was initiated in October 1982 at Bali in Indonesia. It suggested that following logging the "land of green gold" is turned into "useless desert" and that "take away the trees and you get withering drought in the dry season" (33). Suggestive of the same thinking was the title of a fine and influential book, *Amazon Jungle: Green Hell to Red Desert?* (14). The leader of the Tree Hugging Movement (Chipko) in India has claimed that forest cutting results in drought (32). Sharp and Sharp (30) claimed that "deserts can develop with great speed even in the heart of a tropical jungle." In these cases there may be some slippery semantics in the words desert and drought, but a dictionary suggests that a desert is "arid land with insufficient precipitation to permit plant growth" and that a drought is "lack of precipitation or moisture." It is hard to see how a tropical moist forest area receiving upwards of 1,800 mm/yr of rain can be converted into a *desert* by logging. True, logging followed by fire and conversion to abusive agriculture or grazing can result in degraded *wasteland*, but deserts do not follow logging.

Pereira (24) synthesized research on forest influences showing little or no relationship between presence or absence of trees and the precipitation falling on that area. Yet the idea persists that cutting forests reduces local rainfall. I, indeed, have encountered folklore to this effect, particularly among banana growers in Central America and policymakers in South Asia. Some recent work in the Amazon basin, however, does indicate that, for this large area with its unique hydrometeorology, a forest does regenerate some of its own rain (28). Possibly, therefore, large-scale and permanent deforestation (not just logging) could reduce or alter rainfall in parts of the basin.¹ Salati's latter speculation has not yet received ring-

¹Salati, E. 1981. "Precipitation and Water Recycling in Tropical Rain Forests with Special Reference to the Amazon Basin." Unpublished paper, presented to workshop at Centro de Energia Nuclear na Agricultura, Piracicaba, Sao Paulo, Brazil. 12 pp.

ing scientific endorsement, but a prudent policy should definitely err on the conservative side until more is known.

Saving complex tropical lowland rainforests from the logger is indeed a worthy cause and I devote a substantial portion of my time to attempting this (15, 16). There are many compelling, scientifically sound, and philosophically rewarding reasons for preserving a large amount of our remaining primary tropical rainforest. But fear of reduced rainfall is not one of them.

There is one exception. In certain physiographic situations, for example, in coastal fog belts or at high elevations characterized by frequent or persistent clouds, forests can capture and condense atmospheric moisture. This so-called "occult" precipitation adds to the effective moisture received by the area, possibly representing a substantial percentage of total rainfall. For example, in Hawaii such precipitation represented an extra 760 mm above a nonforested 2,600 mm of rainfall (12). Cutting forests results in loss of this occult precipitation, although it is restored as the forest regrows. If the area is converted to another use, this moisture is removed from the water budget of the watershed, including water outflow from the immediate watershed (34). Saving the cloud forests and fog forests makes good hydrologic sense.

Cutting reduces water supplies?

There is a widespread belief that logging tropical forest watersheds has caused wells, springs, streams, and even major rivers to cease flowing, at least during the dry season (11, 30). Policies to set up protection forests that may not be cut are being advocated because of a supposed "sponge" effect, in which roots soak up water in the wet periods and release it slowly and evenly in the dry season.² It is difficult to reconcile such policies with small watershed cutting experiments that almost universally have found increased total water yields over the year, with the greatest proportional increases usually in the low flow months. Bosch and Hewlett (3) reviewed 94 controlled-catchment studies and reinforced this relationship. They also indicated some predictive quantification as to the amount of increase. Moreover, most cutting experiments have shown increases in groundwater levels (4).

Perhaps some of the dilemma arises because of semantics. The catchment experiments involved forest cutting and logging, not conversion of the land to another use, such as grazing or annual cropping. The real-life problem in the tropics is that forest cutting is often the precursor of land conversion. The term deforestation, which is often used, may refer to the

²Roots more appropriately may be labelled a "pump" rather than "sponge." They certainly do not release water in the dry season, but rather remove it from the soil.

sequence of logging, clearing, and then unsustainable agriculture or grazing without soil and water conservation. If compacted surfaces with intervening and frequent gullies are the end result—and one finds such landscapes all too commonly in the upland tropics—then lower water tables, less reliable springs and wells, and lower dry season flows in streams may result. There are, unfortunately, no large-scale, long-term experiments to support this intuition and professional judgment. Correlations between land area deforested over time and reduced streamflows are not cause and effect, although authors have claimed such a relationship using such statistics.

One problem is that most controlled watershed experiments are in the temperate zone. The few reliable tropical paired catchment experiments that do exist, however, do not indicate any different results.

There are valid reasons for establishing totally protected watershed forests with no forest harvesting permitted. But concerns that cutting alone results in dry wells and springs and ephemeral streams where perennial streams once prevailed does not have a scientific basis. Conversion and subsequent land degradation on a large scale is a different story.

Cutting causes floods?

There is indeed an intuitive feeling, based on some scientific evidence, that forest cover on a watershed does offer the best guarantee against local flash flooding. However, I become somewhat uneasy when I hear such statements as "forests guard against flooding" (13) because persons saying this are referring to major floods on large rivers. Beliefs in such statements about the hydrologic safety of forest cover are misinterpreted to mean that forests cutting causes major floods.

Thus, monsoon floods in the Ganges and the Indus, which have always occurred, have been attributed to upland tree cutting (32). Openshaw's statement that "the principal cause of the recent floods in the Indian subcontinent was the removal of tree cover in the catchment areas for fuelwood" (23) was repeated at the 1978 World Forestry Congress (1). In the Philippines, following the great Agusan flood of 1981, the state minister placed "30 percent of the blame on logging of headwater forests," even though "flooding is an annual event, and major floods are expected about every 20 years" (7). There followed in the same newspaper an interview with a top official in the Philippine Bureau of Forest Development on the subject of actions by that organization to control logging and encourage reforestation (7). Sharp and Sharp have suggested that "overlogging is now officially recognized as the cause of last July's severe flooding of the Yangtze" in China (30).

Are these concerns about forest cutting and floods valid, or are they misinterpretations of research findings? Are people looking for a scape-

goat because floods have always occurred, but damage has increased because of greater floodplain occupancy, greater channel constriction, alteration by human structures, and more roads and ditches that speed water on its way downhill?

Findings from paired catchment research in which one catchment has been logged usually, but not always, show greater stormflow volumes, higher peakflows, and earlier peaks in streams emanating from the logged area (9, 27). Flooding may increase close to the area cut. But as water moves down a major river basin, this effect is quickly reduced to insignificance amid other more important processes, such as the nature and intensity of the precipitation, the direction it moves across the basin, and the size and morphology of the basin.

Hewlett (18) examined the evidence worldwide from forest watershed research and reported that there was no cause-and-effect relationship between forest cutting in headwater areas and floods in the lower basin. Even if a whole basin were under a forest harvesting regime, normally it would not be logged off all in one year. Those portions that are logged quickly return to a prelogging hydrologic regime as the forest regenerates and full canopy is restored, even though it is young growth. Moreover, a substantial part of this stormflow and peakflow effect is due to poorly designed and located roads, skid trails, and log landings, all of which speed water off-site. Thus, proper conservation logging can reduce even small effects on upstream flooding. Major floods occur because too much precipitation falls at too great an intensity or over too long a time, beyond the capacity of the soil mantle to store it and the stream channel to handle it.

These arguments again refer to the impacts of forest harvesting on floods, not on the effects of forest harvesting followed by conversion to agriculture and grazing and subsequent land degradation. Such degraded areas, encompassing whole river basins, may indeed aggravate flooding and be one of the causes of serious flood damage. However, if converted to controlled grazing land or agriculture under a sound soil and water conservation regime, such land use in watersheds should no more cause floods than careful forest harvesting.

Shifting agriculture causes erosion and reservoir sedimentation?

The press, environmentalists, politicians, and even land use professionals have condemned shifting agriculture as the cause of most environmental problems in the tropics—except for those caused by foreign logging companies, America's insatiable appetite for McDonald's hamburgers, and illegal trade in endangered species (13).

Eliminating primary tropical forest is an inevitable consequence of shifting agriculture that does have serious policy implications. Aside from this, however, the ancient land use system most specifically has been tar-

geted as the cause of massive erosion in the uplands and accelerated reservoir sedimentation in the valleys, as reported for the Ambuklao Reservoir in the Philippines (5).

I believe misinformation, in pointing the finger of blame at shifting agricultures, such as swidden, kaingin, milpa, conuco, jhum, bush fallow, or slash-and-burn, is partly semantic. In its traditional form, shifting agriculture is applied to a system of forest cutting, cropping, and fallowing that was sustainable because the cultivator was a long-term resident in one place who rotated cropping in the surrounding areas. The fallow period was long enough in secondary forest to permit rebuilding of the nutrient budget on one site prior to its being cut, and usually burned, for the next cropping period.

With relatively low population densities, low technology, and a subsistence economy, these were stable systems—ecologically well adapted to the tropical environment. Even on fairly steep slopes, the small amount of soil disturbance that occurred during planting and cultivation accelerated erosion only slightly. The area cultivated at any one time, typically less than 3 percent of the total area, in relation to the mosaic fallow area also meant that any soil moving from the cultivated area usually was trapped by the fallow. Stream sediment levels did not increase necessarily in response to shifting agriculture (17). Many tribal peoples in the tropics still practice this stable system. But they represent a declining minority compared to a more recently developed unstable system that is also referred to as "shifting agriculture."

The new system is an outgrowth of increased population pressure, landlessness, increased technology, and a shift to cash cropping rather than subsistence. These new shifting agriculturists are indeed true shifters or migrants. The move into a new area, clear large blocks by slash-and-burn methods, cultivate the land until it is worn out, and then move on to a new area. The distinction between these systems has been clearly identified by Watters (31) and by Kundstadter, Chapman, and Sabhasri (20).

These shifting agriculturalists are, in essence, perennial new colonists, attacking the edge of the pristine forest and leaving behind degraded land that has suffered serious erosion because soil conservation methods are not part of the strategy of the landless and poor. Moreover, because there seldom is a mosaic of uncut forest and fallow patches of scrub, much of the eroded soil moves into stream channels as sediment and causes a host of adverse consequences. The legacy left behind is that of degraded lands that recover only slowly to grow species-impovertised forests and eroded material that has disrupted stream channels, aggravated flood problems, and reduced reservoir storage capacity.

It is inappropriate to group these two different systems under one blanket term and to attribute the well-documented environmental problems of one system to both. This has had disastrous consequences for tribal

peoples in many parts of the tropical world. They sometimes have been evicted from public domain lands in the name of preventing forest, soil, and water degradation. A more humane, thoughtful, and ecologically sound strategy would be to assist these tribes in improving agricultural practices, perhaps in an agroforestry context, with the introduction of new food tree crops. A recent program of forest occupancy management begun in the Philippines is an important step in this direction (10).

Scientists must be more precise in their language when discussing erosion and sedimentation from shifting agriculture. Even under the unstable form of shifting agriculture, erosion consequences may be somewhat overrated or at least may be dwarfed by erosion resulting from road construction, urban development, drainage outlets, and other civil engineering rather than agronomic activities (29).

Grassland is better than forest?

Forest watershed research has shown that conversion of forest to grassland as the dominant cover usually resulted in greater water yield (19, 25) and higher groundwater levels in deep soils (4, 21) with only small increases or no increases in stormflow volume, peakflows, or storm duration flow, depending upon grass density and productivity (19, 25).³ The grasslands were not grazed in this research because the experiments were designed to compare the hydrologic effects of the different vegetative covers. Once the grass was established, there were no differences in erosion rates or sediment production from the area (8).⁴

Some politicians, water development engineers, and planners have read or heard about these results and suggested that grass would be a better cover than trees on watersheds because increased water yields in streams and rivers are important in water projects for water supply, hydroelectric power, and irrigation. They have been told that deep-rooted forests are heavy water users. Now they suggest replacing trees with grasslands that use less water but still provide hydrologic safety.

Such a policy, if widely adopted, would be inappropriate for at least two important reasons. First, these experiments were conducted on moderate slopes not prone to mass wasting. The importance of tree root shear strength in maintaining slope stability on steep lands prone to landslide and slumping has been well documented (22). On such areas, forest cover gives the greatest protection against this most damaging form of erosion and its corresponding increase in sedimentation.

Second, the aforementioned experimental results were obtained on un-

grazed and unburned grasslands. In actual practice in the tropics, any grassland area likely will be grazed and usually overgrazed. Also, grasslands are burned to maintain the area in grass. Controlled grazing and prescribed burning at appropriate intervals need not seriously impact the hydrology and soils of a watershed. But such controls are practically impossible to achieve in most tropical countries where populations are increasing rapidly and food production needs are high. Overgrazing and indiscriminate burning, especially over long periods, result in adverse hydrologic and soil movement effects (6, 26). The extensive degraded grasslands in the tropics are unravelling testimony.

Forests, hydrologically and from the erosion control standpoint, provide more protection because they are less susceptible to intensive use so long as they are maintained as forest lands. Harvesting of minor forest products has little effect on watershed values (17). Commercial wood harvesting, even with clearcutting, is relatively infrequent compared to continuous grazing. And regrowth of vegetation quickly restores any hydrologic or erosion impacts to preharvest levels, at least in the more humid tropics. Of some concern to watershed relationships, however, is the increasing emphasis on rapidly growing tree plantations that are harvested totally, with large equipment and on very short rotations, for either wood pulp or bioenergy.

Reforestation or afforestation is a panacea for water problems?

Many people are advocating large-scale reforestation or afforestation programs on tropical watersheds. Such programs are being carried out to some extent. As a strategy to establish "wood factories" to meet fuel, timber, and wood product needs, this makes sense. Hopefully, it can relieve pressures on remaining areas of natural forest. Moreover, as a rehabilitation device, to make unproductive lands more productive, to minimize erosion, and to rebuild nutrient budgets, such efforts are well conceived. Problems occur, however, when the clarion call goes out that after planting trees rainfall will increase (droughts cease); springs, wells, and streams will flow once more; and floods will be prevented.

In most respects, putting trees back on open land, reforestation, or planting them on areas long without or never with forest, afforestation, produces the opposite effects of tree harvesting. I have discussed the effects of forest cutting, but will summarize those effects again in terms of their reverse effects.

There is no evidence that planting forests increases rainfall, except in those physiographic-special cases of fog or cloud capture of moisture. In those circumstances, forest establishment may result in additional effective precipitation, which under many geologic and soil situations will increase groundwater and baseflow. While this does not influence local or

³Helvey, J. D., and J. E. Douglass. 1971. "Effects of Some Forest Resource Management Alternatives on Storm Hydrograph Characteristics in the Southern Appalachians." Unpublished paper presented at IUFRO Congress, Gainesville, Fla.

⁴Ibid.

regional rainfall, it may improve well levels and springs and increase stream yields, including low-season flows.

In most experiments, however, reforestation of nonforested land has resulted in lower water tables, less reliable springs, and reduced streamflow, especially in the dry season (2, 17). An example of this policy dilemma recently occurred in Fiji. Contrary to conventional wisdom and expectations of a decade ago, the large reforestation program of the Fiji Pine Commission has resulted in reduced streamflows.⁵

While stormflows may be somewhat reduced, most experiments have shown rather small effects (18). It is doubtful whether even large-scale forest planting programs have much impact on flooding of lower reaches of rivers unless a major portion of the catchment is degraded, severely gullied, or the soil compacted, such that almost all precipitation is channeled quickly to streams and rivers and sediment from upland erosion is a major contributor to flooding. In such cases—and there are many landscapes in the hilly tropics that have been so abused—forest establishment might slow and reduce surface runoff to the point where flooding would be reduced, although not eliminated. Erosion rates and resulting sedimentation certainly would be reduced.

Conclusion

Problems in achieving sustainable development and conservation of soil and water resources in the tropics are legion enough without being plagued by myth, misunderstanding, misinformation, and misinterpretation. Semantic fuzziness adds to the scene. Words such as deforestation, shifting agriculture, marginal lands, and desertification usually need to be defined or avoided in favor of more precise words or phrases. The consequences may be seen in fruitless disagreement between interest groups, propaganda instead of education, bad policies based on shaky scientific base, or even good policies based on the wrong reasons and vulnerable to attack.

Perhaps foresters have been guilty of acquiescing by silence because the arguments or rhetoric were aimed at protecting forest resources or at establishing new forests—surely actions worthy of nations and statesmen. But if we close the watershed forests to human use and reservoirs still silt up, if we totally reclothe the basin in forest and still have floods, and if the streams still dry up or dry up even more, there may be a well-deserved backlash. The credibility of foresters and other watershed professionals may be called into serious question. There are many eminently sound reasons for forest conservation and reforestation in the tropical develop-

ing countries. We should not condone the use of unsupportable or questionable hydrologic and erosional relationships in this important policy scenario.

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⁵Personal communication from P. Drysdale, Manager, Forestry Division, Fiji Pine Commission, Lautoka, Fiji.

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