Will forestry follow agriculture toward unsustainable soil depletion?

by Peter Salonius[1]

ABSTRACT

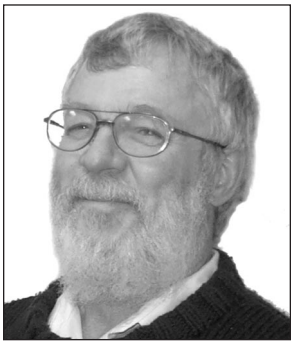
Human settlement has increased food production by progressively converting complex, self-managing natural ecosystems with tight nutrient cycles into simplified, intensively-managed agricultural ecosystems that are subject to nutrient leaching. Conventional stem wood forest harvesting is now poised to be replaced by intensive harvesting of biomass to substitute for increasingly scarce non renewable fossil fuels. Removal of nutrient-rich forest biomass (harvesting slash) can not be sustained in the long term.

Key words: soil nutrient depletion, biomass harvesting, site productivity

RÉSUMÉ

La colonisation humaine a accru la production alimentaire en convertissant progressivement des écosystèmes naturels auto-aménagés ayant des cycles stricts de production d'éléments nutritifs en des écosystèmes agricoles simplifiés sous aménagement intensif menacés par le lessivage des éléments nutritifs. La récolte conventionnelle de la matière ligneuse est sur le point d'être remplacée par la récolte intensive de la biomasse en substitution aux ressources en énergie fossile non-renouvelable de plus en plus rares. La récolte de la biomasse forestière riche en éléments nutritifs (récolte des débris ligneux) ne peut pas être durable à long terme.

Mots clés : perte des éléments nutritifs du sol, récolte de la biomasse, productivité de la station



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Introduction

A general discussion of the concept of sustainability was presented by Gatto (1995), who suggested that notions of sustainability "reflect different priorities and optimization criteria, which are notoriously subjective"; however, the goal of maintaining soil productive capacity is not a subjective notion. In this paper I will show that long-term sustainable terrestrial carrying capacity depends on the maintenance of self-managing, nutrient-conservative plant communities.

The dynamic cyclical stability of complex ecosystems has been shown, for most animal populations, to depend on the ability of predators to dampen overshoot and runaway consumption dynamics of prey species (Rooney *et al.* 2006). Predators, parasites and diseases deplete very high herbivore populations that have already encountered Malthusian constraints (Royama 1992), before they produce extreme devastation of the plant ecosystems upon which they depend. In the absence of top predators, very high animal populations can degrade the biological diversity, carrying capacity and biological productivity of their environments (Terborgh *et al.* 2001).

There have not been top predators able to keep humans from overshoot of carrying capacity. Before the advent of agriculture, human populations used culturally mediated behaviour like extended infant suckling, abortifactants and infanticide to limit their fertility, to keep their numbers far below carrying capacity, and to avoid Malthusian constraints like starvation (Read and LeBlanc 2003). Warfare between groups competing for the same resources, before the evolution of states, also appears to have been a significant constraint on the growth of human numbers (Keeley 1996). This conflict often produced very high group extinction rates (Read and Leblanc 2003). Mortality rates, caused by conflict, decreased somewhat as local raiding by chiefdoms evolved into long-distance territorial conquest by states that developed complex patterns of authority delegation (Spencer 2003). These cultural and conflict behaviours, that limited human population growth, served to maintain balance between humans and other species during most of the historical record. Read and Leblanc (2003) suggest that hunter-gatherers, in areas of low resource density, tend to maintain generally stable populations, while high resource density, such as that produced by agriculture, decreases the spacing of births more rapidly than the increase in resource density which results in repeating cycles of carrying-capacity overshoot and population collapse. While Boserup (2005) maintained that agricultural production was necessitated by the pressure of population increase, others suggest that the advent of agriculture allowed human carrying capacity to increase by increasing the access to and consistency of food supplies (Youngquist 1999, Hopfenberg and Pimentel 2001, Abernethy 2002). However, as most agriculture is a soil-nutrient-depleting practice, this carrying-capacity increase is unsustainable in the absence of exogenous nutrient supplies.

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Carrying capacity of terrestrial ecosystems is hinged, in the long term, on the supply of nutrients for plant growth. Only the hunter-gatherer culture appears to have been sustainable because human numbers were controlled by the productivity limits of self-managed, nutrient-conserving forest and grassland ecosystems (Manning 2004).

Intensive Forest Clearing Begins in Europe

Human numbers increased slowly until massive forest clearing and ploughing for agriculture, in Western Europe 1000 years ago, increased food production enough to fuel much more rapid population growth; this assault on forests spread as European empires colonized the rest of the globe (Williams 2006). The exponential increase of human numbers during the last millennium has been relentless, although the elimination of one third of the people between India and Iceland in the 1300s, as a result of Bubonic Plague, did produce a very small dip in the growth curve before its inexorable increase resumed within a century (Stanton 2003).

The scarcity of forest land for agricultural clearing and the nutrient depletion of farmed soils have produced brakes on local population growth at various times during the last 10 000 years. When soil productivity was seriously diminished by agriculture in a particular area and/or population numbers exceeded local carrying capacity, the propensity of humans to migrate came into play as new forest lands were cleared and cultivated (Manning 2004, Williams 2006). Agriculture has mined soil carbon and available soil nutrients to produce increasing amounts of foodstuffs and the growing number of people who depend on them.

Recent Population Growth

Just at the time that most of the earth had been submitted to human patch disturbance, forest depletion and the unsustainable practice of farming, finite fossil fuels allowed geological energy to replace wood fuel, draft animal power and to facilitate the mining, chemical synthesis and long-distance transport of fertilizer nutrients to replace those removed by soil depleting agriculture. Bartlett (1978) has said that "modern agriculture is the use of land to convert petroleum into food."

The ten-fold population growth, from 1750 to the present, was facilitated by augmenting limited solar energy with massive amounts of temporarily available, geologically stored, non-renewable fossil and nuclear fuels. As these fuel sources are exhausted in the future, we can anticipate the replacement of population growth with energy-depletion-orchestrated economic and population shrinkage (Campbell 2002, Salonius 2005). Humans have far outstripped any equilibrium levels as they have usurped the living space of almost all other species on earth, and completely eliminated many of them. Humans have degraded the productive capacity of most of the ecosystems on the planet and are now proceeding to make more alterations to the atmosphere than have been experienced naturally in the last 600 000 years (Brook 2005) by burning fossil fuels and clearing forests.

Unsustainable Exploitation

Among natural resource exploitative industries, forest harvesting and ocean fisheries offered the best possibility for long-term sustainability. Currently, as the marine food chain has been fished down and the ability of the oceans to absorb pollutants has been compromised, marine productivity of food that is useful to humans has been, at least temporarily, diminished.

There have been episodes of forest foliage and litter collection to augment depleted fertility levels on agricultural lands, in the period before non-renewable-energy-dependent mining, chemical synthesis and long-distance transport of fertilizers made such collections unnecessary. However, most forest harvesting, not associated with land clearing for agriculture, has been confined to the removal of tree stems. Nutrient-rich small branches and foliage were not removed from harvesting sites. This appears to have been sustainable, if harvest openings were sized to approximate natural disturbance dynamics, at least as concerns the maintenance of soil nutrients for plant growth, even though biodiversity and forest ecosystem stability appear to have been compromised in many cases by unnaturally large harvest openings (Perera *et al.* 2004, Salonius 2007).

Impending energy scarcity, exacerbated by continuing human population growth, is influencing the forest industry to consider high-nutrient slash (foliage, and fine branches with large bark / wood ratios) from forest harvesting operations as a source of biomass energy. Removal of this material will deplete the nutrient capital of forest soils and degrade their productive capacity (Sterba 1988, Rolff and Agren 1999, Dzwonko and Gawronski 2002, Jandl *et al.* 2002, Merganicova *et al.* 2005).

Policy Implications

Whole tree harvesting, with delimbing at roadside, has been found to lower harvesting costs in comparison to methods that remove only stem wood (Meek and Cormier 2004). Crown land managers, especially west of Quebec, have allowed this wasteful practice, which previously necessitated burning piled harvesting fines at roadside. The value of this waste material is increasing in concert with developing markets for biomass energy. A return to harvesting methods that remove only stem wood will not occur without regulations designed to conserve plant nutrients and maintain long-term site productivity.

Crown land managers in several Canadian provinces are presently attempting to assess the proportion of harvesting fines that can be safely removed according to the nutrient status of individual forest sites. As the pressure to make very large harvest openings and remove smaller tree parts (nutrient- rich branches and foliage) increases in response to the demand for forest biomass energy, even forest harvesting is becoming an unsustainable soil-nutrient-mining endeavour similar to agriculture because of the depletion of soil nutrients and the consequent erosion of long-term productivity.

Scarcity of conventional energy sources will develop during the next forest rotation (Salonius 2005), and pulp and paper production is shifting to countries with lower production costs. Decisions must be made as to what proportions of the stem wood harvest are to be used for pulp and paper, lumber or biomass energy and as a source of industrial chemicals. Wood is becoming the new petroleum. Wood can be a renewable resource if harvested responsibly; however, each unit of wood can only be used once. Decisions are required as to whether to produce wealth by the sale of forest products to

distant markets or whether some of the harvest, which historically has been directed to commodity markets, is to be used locally for the production of organic chemicals, liquid biofuels and cogeneration of heat and electricity.

Long-Term Constraints on Growth Are Necessary

Malthus predicted that agricultural production increases would not be able to meet the requirements of a steadily growing human population. However, he was not aware that the depletion of soils by the agriculture, that was feeding less than one billion humans in the 1700s, was already unsustainable in the long term. Malthus could not have conceived of the temporary increase of carrying capacity and food production that would be made possible by the use of non-renewable fossil and nuclear fuels during the period after his death. The abandonment of the effective controls on human birth rates exercised by pre-agricultural societies and the decrease in mortality by warfare that followed the evolution of states have allowed the exponential expansion of human numbers to be fuelled by increased availability of food. This expanded human population now sees forest biomass as a partial substitute for declining supplies of geologically stored fossil fuels. The long-term solution to the natural resource demand / supply mismatch requires a gradual, planned shrinkage of human numbers (Scientists for Population Reduction 2006) as opposed to continually attempting to meet the nutritional and energy needs of an expanding population.

Summary and Conclusions

Humanity must understand that, in the absence of effective natural or cultural controls on its numbers, population limits should be established by mutual social consent to avoid the overshoot of long-term carrying capacity. *Homo sapiens*, the species with the large brain and the capacity to foresee future consequences, has not collectively understood the need for the control of its fecundity.

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