

Review

Global Ecological Signpost, Local Reality: The Moraballi Creek Studies in Guyana and What Happened Afterwards

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Abstract: There is a common assumption that when sustainable forest management (SFM) is not practised the reasons are usually a lack of knowledge or lack of training in applying those techniques. We trace the intermittent development of techniques for SFM in the tropical rainforest of Guyana (South America), beginning with the classical observational ecology at Moraballi Creek in 1929. We reference the deliberate lack of application of SFM in spite of access to science-based information and repeated training. In this country, a precarious political democracy is destabilised by the gigantic profits from illegal logging and log trading which support corruption in the sector and generally across regulatory systems. The highest rate of graduate emigration in the world contributes to the difficulty of creating the core of moral leadership required to rise above the local tradition of under-the-table negotiation in place of the rule of law.

Keywords: Guyana; Moraballi; mono-dominance; selective logging; governance; species extinction

1. Introduction

Grulke et al. [1] collected data from 51 commercial enterprises logging in tropical or subtropical forests. All the enterprises had quality assurance certificates for their management operations issued under Forest Stewardship Council (FSC) or Programme for the Endorsement of Forest Certification (PEFC) standards. Seventy per cent of the companies worked in concessions issued by national or state governments; the other 30 per cent owned their forests. It is not clear from Grulke et al. [1] if the companies had only “controlled wood” certification—that is, only avoiding the worst practices—or if they were certified to forest management standards for good or best practice. Most conducted some kind of reduced-impact logging and 48 per cent conducted some post-logging silviculture, so these companies represent about the best forest management in commercial operations in developing countries. However, most enterprises were working in polyspecific forests yet continued to focus on extracting just the traditionally preferred timbers, and apparently made little effort to commercialise the many technically adequate but lesser-known timbers. Also, only 20 per cent of the companies focused post-logging silviculture on the potential crop trees for the next harvest and even fewer employed liberation thinning, in spite of the documented positive research results from such silviculture in enhanced growth and commercial yield [2]. For the companies logging in government concessions, the lack of tenure security was a deterrent; they had no assurance that their investment in silviculture would yield a reward as they might not hold the concession at the next scheduled harvest time.

In this paper, we trace briefly the history of planned accumulation of knowledge to aid tropical forest management and silviculture in Guyana, South America. With almost no competition from

demand for resource access for agriculture, and with some peculiar ecological advantages, Guyana ought to be a model country for managed tropical forests. The country had nearly achieved that status once, and has had the knowledge to do so twice more. In the 1930s, the publications on the 1929 observational research at Moraballi Creek, plus the Forest Department research on silviculture for various species but mainly greenheart (*Chlorocardium rodiei* (Schom.) Rohwer, Richter & van de Werff) gave a good basis for forest management planning at the concession level. This possibility was removed by the global economic recession during this decade, which caused less and less fieldwork as government staff were made redundant.

In the late 1960s/early 1970s a well-planned and well-executed UN Food and Agriculture Organization (FAO) development project provided wide ranging inventory data mostly for planning but also one which is usable at the concession level. The innovative inventories were complemented by planning and training for mechanized logging, and by studies on many aspects of timber utilization to overcome the preference for very few timbers. Uptake from this project was defeated by the Forest Department's lack of legal control over commercial loggers and by the emigration of trained staff, want of foreign currency and the onset of the siege economy. All sectors were affected, not only forestry.

Recovery of the national economy in the 1990s included foreign inputs into the forest sector. The University of Utrecht began ecological and silvicultural studies concentrated in the logging concessions of Demerara Timbers Limited from 1988, later expanded with Dutch bilateral aid through Stichting Tropenbos International for Dutch doctoral and masters student studies until 2002. The Malaysian transnational logger Samling, operating as Barama from 1991, engaged the Edinburgh Centre for Tropical Forestry to develop a mainly silvicultural research programme during 1993–2000. The UK Overseas Development Administration conducted an institutional strengthening and training project with the Guyana Forestry Commission (national forest service, transformed from the Forest Department in 1979) during 1995–2002.

In contrast to these two earlier situations, the current inattention to sustainable forest management (SFM) is entirely self-inflicted. What is striking in recent history is that the country has deliberately set aside the accumulated knowledge and has retreated into crude forest piracy, with full government collusion and entirely contrary to approved national policy. We attempt to explain why this retreat has occurred, being aware that the arguments are circumstantial rather than proven in court; the courts being corrupt and so not dealing with white collar or most environmental crimes.

The story shows that by itself the provision of technical knowledge and the training to make use of this knowledge to develop and operate sustainable forest management can be overpowered by forces sustained by the huge income from illegal logging and Customs fraud in export of unprocessed logs. Emigration of qualified staff, racial discrimination, corruption, poor political leadership, no tradition of timber marketing, a primitive banking system, and absence of parliamentary oversight are among the factors blocking good forestry [3]. This story has parallels in the illegalities associated with gold mining [4] and fisheries, also in Guyana. It is not particular to the forest sector.

2. Background to the Moraballi Creek Studies

With its small human population concentrated in the treeless coastland and its naturally infertile hinterland soils, Guyana has mostly retained its cover of natural tropical rainforest since European contact in the late 1500s. The hard, heavy and naturally durable timbers were appreciated by the European traders for marine construction work in Europe (dock piling, especially with the iconic and nearly endemic *Chlorocardium rodiei*). By 1815 the Indigenous Peoples, referred to as “Amerindians”, were making formal complaints about damage to their forest resources by licensed woodcutters [5]. McTurk et al. [6] noted the destruction caused by the woodcutters and the likelihood of exhaustion of the preferred timbers within human hauling distance of the waterways; the hinterland being almost completely roadless. Forest regulations in 1890 included minimum tree diameters for cutting, retention of trees of economic timbers spread through the forest, imposition of royalty taxes, requirements for timber removal permits and the boundary marking of working blocks within woodcutting leases [7].

A forestry branch was created in the Department of Lands and Mines in 1908, and formal strip transect surveys began in 1910, covering the forests accessible to woodcutters by 1916 [8]. The increased demand for the durable timbers for dock work in Europe during 1914–1918 and dissatisfaction with the lack of quality control of exported timbers led to the recruitment of professional staff from the Indian Forest Service and the establishment of a separate government Forest Department in 1925. The Conservator of Forests, B R Woods, noted that he felt like “a flea in a cathedral”, in the sense of the lack of data about the hinterland forests. Locally organized vegetation surveys and tree inventories continued over the next 25 years, allowing type descriptions to be fitted into the classification developed from observations across the Caribbean [9–12].

Moraballi Creek 1929

The gradual accumulation of knowledge about the forest was accelerated when Oxford University began its series of tropical expeditions for undergraduates. The forestry adviser in the British Colonial Office, Major Ralph Furse, suggested British Guiana as a destination and organized diplomatic cover. The British Museum and other museums largely funded the expedition in the hope of obtaining specimens for taxonomic systematics. T.A.W. Davis, deputy conservator of forests, was attached to the expedition for its whole duration and recruited the 12 Amerindians whose local knowledge was vital to the inexperienced undergraduates. Other government staff joined for shorter periods, so that up to 12 people were working on scientific studies at any one time. Davis selected the working site at Moraballi Creek, only an hour by boat from the town of Bartica and having the mixed forest types typical of the Bartica-Cuyuni triangle in Guyana; see Figure 1.

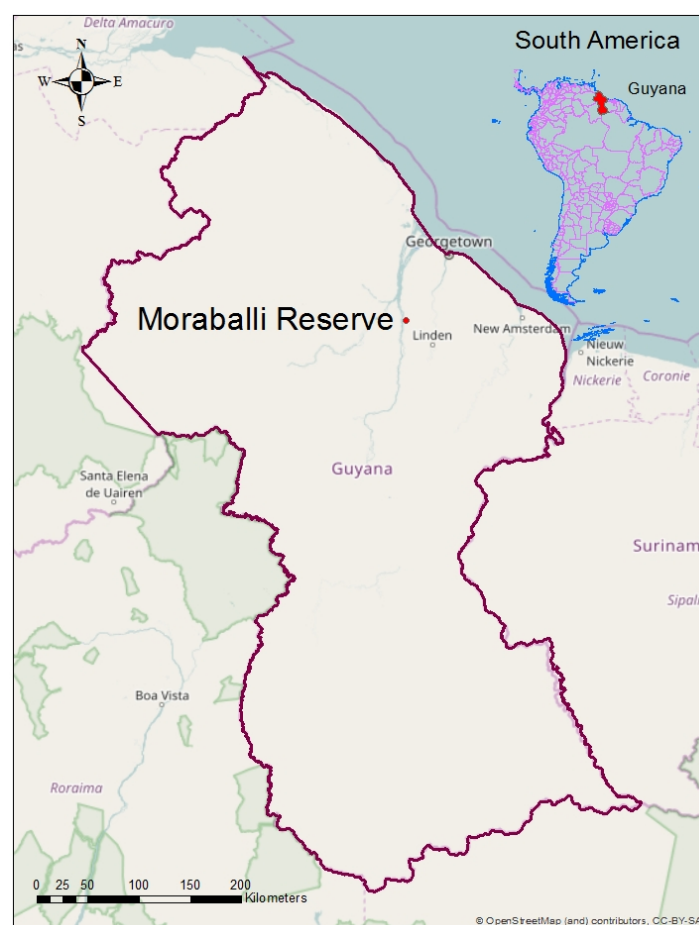


Figure 1. MAP of the Moraballi Reserve, Guyana [13].

This was not the first residential study of the ecology of the forest of Guyana. The New York Zoological Society had established a research station at Kartabo in 1919, concentrating on the fauna from the top of the forest canopy to below ground level in a defined square of 16 hectares (ha) [14–17]. This approach, of studying each vertical level of the forest and soil layer by layer, was also used by the Oxford students in addition to the more track-based collecting of flora and fauna [18].

The Moraballi Creek studies of 1929 continue to be cited in the global literature because of the pioneering observational ecology on spatial distributional patterns—horizontally and vertically—of trees in natural tropical rainforest and the associated speculation about causative eco-physiological processes. Studies of the standing forest were complemented by measurements of trees after some plots were clear-felled.

At least on these highly leached infertile soils, not rejuvenated by geological processes for millions of years, simple plot-based surveys could show distinct correlations between species composition and soil texture and drainage, while vertical structures (*synusiae*) appeared to be related to access to light. That is, it was possible to resolve and at least tentatively explain what at first was a confusing mass of apparently randomly positioned trees and species. Davis and Richards were careful to qualify the findings: “It is hardly necessary to point out that the deductions . . . are very tentative and are only put forward as working hypotheses for future research” [19] (p. 132). Richards went on to use similar techniques in the Oxford University expedition to the Tinjar River in Sarawak in 1932 [20], the results influencing his typologies in the first great synthesis of knowledge of the tropical rainforest globally [21]. Sixty years after the Moraballi Creek expedition, ter Steege summarized several studies which examined some of the Davis and Richards hypotheses [22]; see Section 8 below. The expedition also developed ingenious and pioneering ways of gaining access to lofty tree crowns, some of which were re-invented half a century later [23,24]. All the studies were written up and published, mostly in peer-reviewed journals, and then also collected into more than 30 chapters in the expedition’s formal book from Oxford University Press in 1938 [25]. The eco-botanical studies informed subsequent vegetation surveys by the Forest Department, and were used during the equally pioneering FAO forest inventories of the late 1960s.

The need for forestry statistics and surveys was laid out at the first Empire Forestry Conference held in 1920:

“In order to give a complete picture of the forest resources of the Empire and of the prospects of their maintenance and development, there will be required both information of a purely statistical nature which Governments should collect and publish at definite intervals, and surveys will largely depend upon the possibility of comparing the facts exhibited at different dates—annual, quinquennial or decennial—and upon having all the data prepared upon the same principles throughout the Empire. Methods must therefore be standardized” [26].

3. Observations on Pattern and Process

As a result of the relatively limited time period (the university summer vacation), the Davis and Richards papers [19,27] have more to say about pattern than process. Pattern is relatively static and can be observed through a snapshot survey like a university expedition, while process, if it is to be studied in a verifiable manner, requires close, long-term observation. It is sometimes difficult to separate what were verified observations from the interpretations of Davis and Richards. Davis had transferred from the Indian Forest Service to the British Guiana Forest Department in 1925 and thus had had four years of field experience before the 1929 expedition, and had been able to review the forest timber surveys which had been conducted by the Forestry Branch of the Department of Lands and Mines (DLM) apparently annually since 1908 [8,28]. Nevertheless, in their Introduction, the authors were careful to recognize that the work was site-specific. They supplemented the plot work with visits to other locales with different forest types which were on riverbanks and less than 40 km distant from the main camp [27] (pp. 350–352). Most of the interpretations about the process of rainforest dynamics were supported by circumstantial evidence and not through experimentation, as would be *de rigueur* today.

In the case of Guyana, for example, the studies published from the 1990s under the Tropenbos Guyana Programme generally resulted from at least a year's fieldwork study for a doctoral degree.

The second paper by Davis and Richards, published in 1934, summarises the descriptions of the five forest types which they distinguished by species composition, population structure (stem frequencies in diameter classes) and soil type [19]. The team recognized that the forest types of central Guyana were unusual: "While four of the forest types of our area are exceptional among tropical rain forest communities in having single dominant species there is one type which approaches the more normal condition of no single clear dominant. It is a curious fact that even here a small number of closely allied species of one family are together clearly dominant" ([27], p. 117).

The current view is that on more variable and younger soils, as in the Amazon basin, under a moderately stable climate (but still subject to ENSO-related droughts), there are perhaps 150 tree species which are found over large areas [29]. These widespread oligarchs may occur in greater or lesser numbers of trees and sizes, depending on soil fertility, and are mixed with many other species which have more restricted distributions. These modern findings accord with Davis and Richards, who noted that much the same species were found in all their five forest types but the proportions of the species, in numbers of stems per unit area and in size class distributions, differed greatly between forest types.

The Evidence for Forest Type—Soil Type Associations; The Special Situations of the Nutrient-Poor Sandy, Swampy and Rocky Soils of the Guiana Shield

Davis and Richards also noted the eco-dominance of particular species—greenheart (*Chlorocardium rodiei*) and wallaba (*Eperua* spp.) in specific soil types, dominance being defined then as more than 40 per cent of trees above 40 cm DBH [19] (p. 120). They recognized the pattern that these tree species were pre-adapted to these soils, or had co-evolved with soils. The gradual loss of soil fertility through leaching during aeons, without rejuvenation by tectonic processes or vulcanism, allowed (or forced) specialization to occur on the permeable sandy soils and the soils with limited plant-useful soil volume (such as rocky and swampy soils where morabukea (*Mora gonggrijpii* (Kleinhoontei) Sandw.) is the dominant tree); a pattern which probably happened only rarely elsewhere, because such immensely old and stable soils are rare. Compare, for example, the abeum or limbali (*Gilbertiodendron dewevorei* (De Wild.) J. Leonard) monodominant stands in the Ituri Forest of the Cuvette of the Congo Basin [30,31].

The forests on brown sands and more loamy soils were called "Mixed" (in species) and divided into consociations where it was perceived that particular tree species were more dominant than elsewhere. Moraballi Creek was a good place to study single-dominant forests. Greenheart (*Chlorocardium*) and wallaba (*Eperua*) dominance are now recognized as unusual for continental tropical moist forests. However, dominant and monodominant forests are known from all the major areas of tropical moist forest. They are found especially on shallow and nutrient-poor soils.

4. Process in Vegetation Ecology

4.1. Wind

Davis and Richards also observed that wind squalls led to single-tree falls which in turn led to small gaps and they heard of wind-flattened wallaba (*Eperua*) forest [27] (pp. 357–358). They speculated that the ensuing pulse of light favoured the greater height of single trees surrounding that small gap [27] (p. 370). Ecologists now would think in terms of patch dynamics [32] where inter-plant competition and micro-site variation (especially narrow spatial variation in soils) interact; patch dynamics itself being developed from Watt's 1947 paper [33]. Later, gap dynamics were used in the development of the silvicultural aspects of the CELOS system in Suriname [34,35].

4.2. Drought in Tropical Moist Forest

Davis and Richards were also right in positing the greater importance of seasonality of rain over equability of temperature in rainforest dynamics. They were not the first to observe this. Bates [36] and Wallace [37,38] before them had noted that rain seasonality affected leaf phenology, flowering and fruiting in the Amazon basin. This observation was confirmed by many and widespread observations and experimentation. Davis and Richards reported Amerindian claims of differential seedling survival in drought years [27] (p. 356). Amerindian observation that drought could lead to forest fires which could in turn affect forest dynamics would later be proven true. At the time of the Moraballi Creek expedition, memories were still strong of the extensive fires in the hinterland of Guyana from the 1925 drought [28,39]. From the middle 1960s, studies of running means of daily rainfall showed how drought for as little as 30 days could affect the growth of large forest trees [40,41]. Studies of ENSO-related droughts at Barro Colorado Island in Panama showed how forest growth and seeding floristic composition could be drastically affected, through effects on the pollinators and fruit/seed dispersers [42].

4.3. Canopy Studies

The Moraballi Creek expedition is widely credited for its pioneering efforts to study canopy biodiversity using ladders and pulley systems [18] (pp. 46–63), even though the limitations at that time meant that they could only write about canopy biodiversity in the most general terms. Specialist study had to await the development of insecticidal fogging systems and thermo-nebulisers that could bring down the entire arthropod population in a fogged area [43]. Entomologists have now established that there are vastly larger numbers of arthropod species, and absolute numbers of individuals, than had previously been imagined. However, their role is still not well understood. Canopy studies are now much more important, including towers, cranes, canopy walkways, balloons and rafts that may be suspended from a balloon [44]. The Iwokrama canopy walkway, south of Moraballi and erected in 2002 with Canadian CIDA funds, is used principally for eco-tourism. That may explain why the Iwokrama International Centre for Rainforest Conservation and Development is not an active member of the global canopy research network [24].

4.4. Assessment of Forest Productivity

Davis and Richards noted variations in leaf litter depth but had little information on soil fertility (as opposed to soil texture which was studied in one pit per plot and samples taken for laboratory analysis in Georgetown), or on turnover of litter or turnover of leaves on a living tree. Trophic studies, on the circulation of energy between group of organisms, were in their infancy in 1929 and not contemplated by Davis and Richards. However, on these very ancient and nutrient-poor soils, the Tropenbos programme (1988–2002) in particular has shown how tenaciously each trophic group captures and retains the sparse pool of nutrients for survival and growth, and how important are the interactions between herbivorous insects and long-lived trees, and between producer and decomposer organisms [45].

In 1929, it was not appreciated that productivity can be measured indirectly from the fine leaf litter as it falls off the trees. Nor was there any understanding of the roles of ectomycorrhiza and root mats in trapping nutrients in the decomposer cycles. We now know about the importance of tree root mats on white sands [46–48]. Leguminous trees show a wide variety of nutrient trapping mechanisms, which helps to explain their relative abundance on the nutrient-poor soils of the Guiana Shield and on other nutrient-poor tropical forest soils [49].

It is reasonable to suppose that on these very ancient soils the co-evolution of trees and pests has been intense [39]. Crude logging methods which do not safeguard the small nutrient pool should have no place.

4.5. Silviculture of Trees in Tropical Moist Forests, Need for Field Controls

The only physiological-silvicultural studies available at the time of the Moraballi fieldwork were for tropical plantation crops—cacao, cinchona, citrus, coffee, rubber—but almost nothing on trees. Shortly after his arrival in 1925, Conservator Wood and his team began seedling studies at their field station at Her Majesty's Prison Service (HMPS), Bartica. From its inception, the Forest Department (FD) was known for its cutting edge forest field research, but, anomalously, with no integral linkages to forestry activities in the field. Silvicultural studies were recorded from 1932 since Wood realized that selective logging was impoverishing the forest. Wood and his team, including Davis, focused on seedling growth and survival. Methods for successful greenheart regeneration were known by 1936. Plantation trials with local and exotic species were carried out from 1926 to 1936. Forest Improvement Operations (FIOs)—underbrushing—were carried out in greenheart areas from 1937, and heavier canopy opening briefly during 1943–1944 [8] (pp. 18–30). There were a few silvicultural trials in the 1950s [50]. However, because of lack of legal and field control over loggers, the FD in Guyana was unable to prescribe and enforce forest management techniques based on in-country research.

4.6. Stifling Effect of the Great Economic Depression

Staffing in all the British colonial forest departments was reduced severely during the global economic depression of the 1930s but in British Guiana empirical research on seedling regeneration of *C. rodiei*—by far the most important timber commercially and a dominant species in the Bartica-Cuyuni triangle where logging was concentrated—continued, together with silvicultural reductions in forest canopy density. The Forest Department concluded that rates of regeneration and growth were too slow to justify investment in post-harvest silviculture. Conservator Wood concluded in 1944 that routine silviculture was not worthwhile unless or until the FD could prevent repeated re-entry into forest areas already logged for smaller and smaller logs of this species. This control was not achieved on paper until passage of the *Forests Act* in 1953 under Conservator Gordon and in practice not until 1960; logging licences and administration remained in the hands of the Department of Lands and Mines until 1953. By 1960, interest had switched to industrial-scale logging and timber processing and the FD itself (and the successor Guyana Forestry Commission from 1979) has conducted no significant ecological work since the mid-1950s.

It is not clear why legal powers given by the *Forests Act* 1953 and associated Forest Regulations 1954 did not result in forest developments as proposed by Conservator Wood in 1926, although weak leadership following the departure of Conservator Gordon was probably one factor. Instead, the loggers continued to focus on the traditional prime commercial species with repeated entry into the more accessible forests and national production levels maintained by simply expanding the area logged each year [8].

5. The Second Major Advance—Forest Industries Development Survey

At last in the late 1960s and following Independence from colonial rule in 1966, the United Nations Special Fund (later, the United Nations Development Programme—UNDP) financed an international team organised by the FAO to carry out the Forest Industries Development Survey (FIDS). This was one of the first major attempts by FAO to modernise a national forest sector. Using good quality aerial photographs covering the whole country which had been flown by the Royal Air Force and Canadian companies in the 1950s and 1960s [51,52], reconnaissance level inventories sampled all the main forest areas using then innovative statistical sampling and computerised analysis of field data. Planning and stratification for the inventories drew on the previous 50 years of forest valuation and vegetation surveys by Forest Department, including the forest botanist's typology [53]. Innovations included the use of powered drills to sample inventoried trees, showing that the traditional designation of trees as solid or hollow by striking with a cutlass (machete) and listening to the sound of the reverberations was entirely unreliable [54].

The remote sensing, large-scale forest type mapping and static inventory data were intended to form a reliable basis for industrial-scale management planning [55–59]. Complementary studies including logging and forest management planning [60,61], forest economics [62], timber grading standards, timber preservation and seasoning trials [63], veneer and plywood evaluation [64], use of wood in housing [65], sawmill planning and sawdoctoring [66,67], timber marketing and export planning [68,69], creation of a central timber manufacturing plant to conduct research and give demonstrations and training [70,71]. This wealth of information and training placed Guyana at the cutting edge of tropical rainforest management and utilization.

6. Siege Economy

However, even before the FIDS project closed, national and international politics were causing emigration of government staff and a high proportion of the university-educated population, one of the effects of the Cuban missile crisis in 1962 [72]. British concern about a democratically elected but possibly communist-led government caused colonial interference by installing rule by the decree of the Governor in 1953. A short-lived period of working class unity across racial lines was followed by repeated inter-racial violence in the period up to Independence in 1966, initial support of the PNC (the African political Party) by the USA's CIA and the UK's MI5, rigged elections during 1968–1987, and a shift by the ruling PNC from opportunism in 1964 to socialism in 1970 [73]. International credit was refused repeatedly to a regime believed to be antagonistic to the Western Powers; a regime which had nationalised foreign-owned industries although with generous and promptly paid compensation. The regime turned inwards to self-sufficiency but was unable to counter the Guyanese propensity to import far more than it exported in spite of the near-absence of foreign currency. The economy collapsed from the mid-1970s to 1989. Government jobs in many cases depended on membership of the ruling political party. During this period, government interfered substantially in private sector business and corruption flourished at all levels as deals under-the-table became the norm, replacing the rule of law [72] (pp. 76–77). The earlier tradition of training and accrediting lawyers through university education in London became too expensive. A weakly accredited training at the University of the West Indies correlates with a Guyanese judiciary which shows little understanding of resource management and land title laws [74].

During the time of the siege economy, the Government attempted to reduce budgets. The three land administering departments, including the Forest Department, were converted into semi-autonomous agencies with some powers to raise and retain taxes. The Forest Department became the Guyana Forestry Commission (GFC) in 1979. However, all these agencies haemorrhaged educated and trained staff, leaving the forest open to private sector pillage [75]. Through US diplomatic pressure, the international finance institutions (IFI) including the World Bank and Inter-American Development Bank shut off lines of credit. Canada, a bilateral donor, provided lines of credit and loans to keep the forest sector alive by facilitating purchase of machinery and spare parts which were wearing out in the traditional absence of preventive maintenance. However, the enterprises in the forest sector which received this financial support used it almost exclusively to maintain the owner family lifestyles, did not import spare parts and did not repay loans.

Canada also facilitated a training visit to New Zealand for senior GFC staff. From this visit emerged a new class of logging concessions, large scale Timber Sales Agreement (TSA) (>20,000 ha) and long duration (15–25 years), codified briefly and simply in amended Forest Regulations 1982, and intended to provide a sound legal basis and tenurial security for active SFM. Instead of auctioning these concessions, the GFC awarded them by administrative fiat to the more influential of the traditional logging companies from 1985. The enterprises continued to harvest in the same manner as before, extracting only the logs for which there was a ready market and sawing crudely and inefficiently in inappropriate gangsaw mills with low rates of lumber recovery. There is no record of any attempt to make use of the information and advice acquired through FIDS in the late 1960s/early 1970s [76]. Again with patient Canadian support, Guyana was enrolled in the early phases of the UNDP/FAO

Tropical Forest Action Plan (TFAP) in the late 1980s [77]. With very few senior staff left in the GFC, Canadian technical cooperation concentrated on forest inventories to support planning for the new TSA concessions. No inventory reports from this period are now in the public domain in Guyana, nor any other TFAP document. Canadian CIDA also supported the development of the first edition of the National Forest Policy and National Forestry Action Plan in 1989 ([22], p. 9).

7. Transnational Loggers

Following the death of the authoritarian President Forbes Burnham in 1985, the Western powers recognised that the economy of Guyana was close to collapse, with huge unpayable government and commercial debts. Typical of the time, the International Monetary Fund (IMF) opened credit lines including foreign currency but imposed strict fiscal discipline through a structural adjustment programme. The SAP, known locally as the Economic Recovery Programme (ERP), began privatising the industries which had been nationalised in the 1970s. The ERP, which brought great hardship to the majority of Guyanese although not the elite, included IMF dissemination of information about investment opportunities in Guyana. In the forest sector, Asian-owned transnational loggers already operating concessions in neighbouring Suriname began to enquire about logging in Guyana. A Malaysian-Korean consortium acquired non-competitively 1.65 million hectares (Mha) of hitherto unlogged forest in the northwest of Guyana in 1991, writing its own foreign direct investment agreement which was, naturally, extremely favourable to the investor and notably demanding of tax and other concessions from the Government [78,79]. With no relevant skills in hinterland roadbuilding and no experience of operating a large-scale logging concession in spite of the knowledge on file from FIDS, Guyana allowed the Samling-Sunkyong consortium to bring in large numbers of experienced Indonesian and Malaysian field workers. The second-hand plywood mill imported to make use of the hitherto unused light- and medium-density timbers for utility grade plywood never achieved its rated 108,000 m³ installed capacity but the local subsidiary registered as Barama Company Limited learned quickly to extract maximum tax concessions, effectively covering all its local costs through such FDI benefits [80,81]. The perennially undercapitalised family-owned Guyanese logging companies have learned almost nothing from Barama in the last 25 years but some have been willing to rent illegally to Barama the access to their TSAs [82].

8. The Third Major Advance

Donor concern that the IMF's neoliberalism was stimulating a rush by disreputable transnational loggers through the open door of Guyana led to technical cooperation projects, initially providing a formal policy on logging concessions [83] and then an institutional strengthening project to inject some skills into the moribund GFC. A condition of donor support was a brief (3-year) moratorium on the issue of new TSAs, and the introduction of a no-logging 3-year exploratory phase (State Forest Exploratory Permits) to give time for the potential investors to carry out forest inventories and develop forest management and business plans as well as environmental and social impact assessments (ESIA), and to allow the GFC to conduct due diligence audits of the investors. The DFID-funded (UK-Aid) GFC Institutional Support project developed during 1995–2002 a series of standard operating procedures and associated manuals, including for forest management planning, pre-harvest forest inventory, annual operational plans, and post-harvest silvicultural assessment. Associated research developed and improved new legislation, species-specific growth and yield models, procedures for reduced-impact logging, timber use and marketing, as well as how to run the GFC as a quasi-government corporation. All developments included training of local staff. The GFC, however, paid only lip service to the procedures and continued the traditional uncompetitive administrative allocation of logging concessions with little or no due diligence audits of applicants [82].

8.1. Tropenbos Guyana Programme

The University of Utrecht began in 1988 a programme of field studies undertaken by Dutch PhD students in a 0.5 Mha concession privatised from government control to a British non-forestry entrepreneur in 1990 and quickly sold on to a Dutch consortium in 1991 and soon after that to the Prime Group in Singapore which includes Rimbunan Hijau [84]. The Utrecht research also led quickly into the long-term multi-university programme of Tropenbos Guyana, financed from Dutch education funds. The apparent security of the 50-year concession duration for the two adjacent Demerara Timbers Limited (DTL) concessions allowed long-term research planning. The DTL area is just south of the traditional centre of logging in Guyana in the Bartica-Cuyuni triangle, so the ecological and experimental silvicultural studies have immediate applicability [7]. Likewise, in the northwest, Barama contracted its silvicultural research to the Edinburgh Centre for Tropical Forestry (ECTF), also with a view to long-term research in its 25-year TSA renewable for a further 25 years from 2016 [85]. Barama/ECTF installed some 78 one-ha growth and yield plots, providing the data on growth and survival after logging. These data were used by other DFID-funded research projects and the DFID/GFC Institutional Support project to produce species-specific growth and yield functions for management planning and yield control through annual allowable cut allocations by 2002 [86–93]. Barama/ECTF also installed one formal experiment on four levels of logging intensity. The various observational and experimental research plots created and maintained by Dutch students produced other growth, yield and survival data particular to the Central Wet forest zone [94], summarised by ter Steege et al. [45,49] and leading to a generalised recommendation for a country-wide harvest limit of $20 \text{ m}^3/\text{ha}$ of commercial timbers (taken together) in one 60-year rotation. As all logging concessions had durations less than 60 years, the maximum allowable harvest was reduced by the crude proportion (duration of concession licence $\times 20/60$). Thus, concessions with a 25-year duration would have an all-timbers annual allowable cut of $25 \times 20/60 = 8.3 \text{ m}^3/\text{ha}$ (but without the conventional change in the minimum tree felling diameters). In addition, Tropenbos research recommended that there should be a minimum inter-stump distance of 10 m to help prevent the over-felling of the naturally occurring stands dominated by a single species (known locally as “reefs”).

8.2. Tropenbos Follow-up to Original Moraballi Studies

As noted above, the few weeks of the Oxford expedition to Moraballi in 1929 generated more questions than answers. The University of Utrecht research programme and the successor Tropenbos Guyana programme addressed some of the questions during 1988–2002. Hans ter Steege and colleagues focused initially on problems in managing *Chlorocardium* [22], with later theses looking at ecology, physiology, hydrology and biochemistry of the Central Wet forest more broadly. Tropenbos [95] noted that, while *Chlorocardium* comprised only 0.5–1.5 per cent of the standing timber, around 45 per cent of the timber harvest [22] (p. 9) and more than 70 per cent of exports were of this species; [96]. Ter Steege considered possible reasons for the conspicuous single-species dominance [22], (pp. 10–11) and noted that mast fruiting did not seem to occur [22] (p. 27). Not surprisingly, the studies in 1929 remarked on the greenheart reefs but later inventories showed that greenheart is also widespread as single trees of commercial size in mixed-species forest on brown sand soils in the Central Wet forest but is absent from some areas. While associations of species can be distinguished [53], the relationship between forest types and soil factors is not as clear as the Moraballi studies had suggested [22] (p. 47). However, within the mixed-species forest on brown sands, whether well or poorly drained, a rather constant mixture of non-dominant species is present [22] (pp. 56, 59–60). This same kind of relationship, a group of widespread but non-dominant species, now seems to be a common feature in the Brazilian Amazon basin [97].

Compared with the usual de Liocourt stem diameter distribution curve, *Chlorocardium* and *Mora gonggrijpii* show a deficiency of stems in the lower size classes, which may indicate irregular recruitment [22] (p. 61 and Figure 8 on p. 63). The Utrecht team therefore argued that studies should concentrate on seedlings and saplings because up to 80 per cent of mortality occurs in the year after

germination for *Chlorocardium* [22] (p. 14), with mortality thereafter being at a small steady rate across the higher size classes. Seeding from big old trees is regular but insect attack on the large heavy seeds is severe in spite of phytotoxins. Germination is best in shade and is much reduced in large canopy gaps. There is no germination in felled reefs where seeds are exposed to full sun. Seedlings and saplings are shade tolerant but respond well to new canopy gaps. By 1 year of age, seedlings in sun are larger, heavier, have more branches and leaves and leaf area but are not taller than 1-year seedlings in shade because the epicotyls are shorter. The combination of seedling shade tolerance but fast growth in small but rare canopy gaps may explain the size class distribution in natural forest as punctuated recruitment [22] (pp. 74–86). While the formation of reefs is explained partly by the heavy greenheart seed germinating mostly beneath the canopy of the mother tree, the wide distribution of greenheart trees across the brown sands of the Central Wet forest is not explained.

In addition to the ecological and silvicultural studies at Mabura Hill, Utrecht and Tropenbos made use of and extended the inventory work carried out by FIDS in the late 1960s. The combined data sets extended and synthesised knowledge of tree species distributions, and showed the interactions between regional-scale evolutionary processes and local-scale ecological processes. Maps from earlier geological and soil surveys showed the sometimes remarkably abrupt limits to tree species distributions at rivers separating geological formations [98–100]. These synthetic studies showed where protected areas such as national parks might be constituted in order to safeguard the most biodiversity in the smallest space.

Some 80 research publications were produced by the Tropenbos Guyana programme during 1989–2000 but doctoral theses continued to be published in The Netherlands until at least 2005. Tropenbos also produced the syntheses of the ECTF research in 2002, after a change of management philosophy by Barama terminated the research contract and abandoned the yield plots. Before the end of the GFC Institutional Support project, the DFID technical cooperation staff had produced the second edition of the Code of Practice for Timber Harvesting [101] which was based on the generic FAO Model Code of Forest Harvesting Practice (1996) [102], that in turn having been based largely on trials in mixed dipterocarp forest in Sarawak in the 1970s. In addition, the international auditor SGS had produced a workable proposal for a timber tracking system (1999) [103].

8.3. Achievements by End of Third Major Advance

By the end of 2002 when the DFID support for the GFC institutional reform concluded and the Tropenbos research programme also ended, Guyana was once again at or near the cutting edge of tropical forest management in terms of immediately applicable knowledge and trained staff. Major supporting documents were:

- policy on issue of logging concessions in three area size classes [83];
- diagnosis of timber processing sub-sector for Caribbean Development Bank [104];
- diagnosis of the forest sector in chapter 30 of the National Development Strategy (NDS) [105], endorsed by the National Assembly, and in chapter 14 of the shortened NDS [106];
- Interim revised forest law enacted by the National Assembly (cap. 67:01 Forests Act, 1997);
- provisional timber tracking system with bar-coded plastic tags [103];
- National Forest Plan (2001) based on the National Forest Policy 1997 [107,108];
- Guidelines for—forest management plans, pre-harvest forest inventory, annual operational plans, all in 1999;
- Post-harvest silvicultural survey: proposed approach (2000);
- National vegetation type map (ter Steege and GFC Forest Management Division 2001—no longer web-accessible 2016);
- Estimates of standing biomass and carbon content in forest type classes [109];
- Code of Practice for Timber Harvesting [101] (second edition, earlier editions 1994 and 1998).

9. Interplay of Human and Natural Disturbances on Pattern in Forest Ecosystems in Guyana

9.1. Deforestation for Farming

Because of the small and dispersed human populations in the forested hinterland of Guyana, the human influence through farming on forest patterns has been negligible. Indigenous villages are found almost exclusively at the interface of forest and savanna in the Rupununi region south of the 4th parallel of north latitude, while to the north the indigenous villages are enclaves in the otherwise continuous forest cover. Subsistence-level rotational cropping systems cut and burn small farms, less than one hectare per family per year. Farms are located near riverbanks, in “bush islands” in the savanna, and on the piedmont at the foot of hill ranges. Farms traditionally were farmed for 3–4 years then allowed to fallow for 12–20 years before being farmed again [110]. Farm fallows are tended for fruits and medicinal plants and house poles and posts; they are certainly not abandoned lands. Cropping cycles have shortened as villages have stabilized and enlarged because of the attractions of schools and health posts. When, as now, gold prices are relatively high, the menfolk will work most or all of the year in the hydraulically mined gold fields and farming will be neglected, with family food purchased from the goldfield earnings.

At least in southern Guyana, the ecologically sound practice of moving farmsteads and hamlets from time to time to allow farm fallows to recover soil fertility is now little practiced. The coastland-minded government agencies have difficulty in comprehending rotational agriculture and farm fallowing compared with sedentary fields of rice and sugar cane, so the land tenure regimes greatly favour stable sedentary villages over shifting villages. In spite of the rapidly growing indigenous population in the hinterland (over 3 per cent annually), there is no significant pressure to deforest large areas for farming, mainly because the soils are so notoriously infertile for agriculture. This makes Guyana significantly different from the Brazilian Amazon except for the adjacent state of Roraima.

9.2. Storm Damage

There is a single unconfirmed report of a Tunguska-like meteorite strike destroying a forest area estimated at 8 km × 16 km in 1935 [111].

9.3. Wildfire Damage

One benefit from the monitoring, reporting and verification (MRV) process funded by Norway's International Forest and Climate Initiative (NICFI) during 2009–2015 has been annual interpretation of repeated remotely sensed space imagery over the whole of Guyana. The German “RapidEye” imagery provides roughly 5 m resolution. Condensed images provided by Indufor Asia Pacific [112,113] show the locations of fires, clearly associated with Amerindian rotational agriculture in the south of Guyana and with logging and mining infrastructure in northern Guyana. Lightning strikes during the dry season in drought years associated with the ENSO cycle may burn areas usually unaffected by fires; for example, a large area of swamp in the Waini area, south of Shell Beach, was burned in 1998 [114]. Ecological effects of forest fires are described by Whitton [115] and Hammond and ter Steege [116,117].

Most recently, a fire in late 2012 in *Dimorphandra conjugata* (Dakama) forest on white sand soils in a Bai Shan Lin logging concession covered over 900 ha and should have been easily detected and reported through the MRV system. The law also requires holders of logging concessions to report fires (Forests Act 2009, Section 27 (2)) and aid their suppression (Section 28). However, no such area was reported in the national statistics for either 2012 or 2013, and the GFC has redacted the report by its own staff to reduce the size of the fire [118].

Such doctoring of records appears to be routine to conceal the illegal airstrips used for transshipment of cocaine. Some illegal airstrips are large, for example, 1100 m × 115 m (13 ha) close to the Corentyne river in 2007 [119]. None of these airstrips has been noted in the MRV reports issued since 2011.

In practice, the GFC has no real-time fire-detection or fire-fighting capability and does not train the holders of the logging concessions covering 6.9 Mha of forest [120] in fire prevention or suppression. Fire is also associated with mining areas, and likewise the Guyana Geology and Mines Commission has no capacity for prevention or suppression. The concentration of fires in the human-disturbed areas at the forest margins within the closed-canopy natural tropical rainforest is clear in the summary images published in the annual MRV reports since 2011 [112,113]. It is thus fortunate that the natural forest is generally sufficiently moist to snuff out the human-caused fires and that deep penetration into the standing forest is rare except in strong ENSO years [28].

9.4. Flood Damage

During particularly wet rainy seasons, the major rivers rise by several metres and flood riverside villages but the effects are temporary and houses on stilts are generally above the expected flood levels. Large areas of swamp forests occur along the middle reaches of the major rivers such as the Mazaruni and absorb most of the excess water, so that the lower reaches of the rivers maintain a fairly even height above chart datum.

The flood damage which does occur, such as at the beginning of 2005, is due to long-term poor management and limited maintenance of the coastland drainage and irrigation system, far from the forests.

9.5. Coastal Protection

Narrow belts of mangrove forest advance and retreat as the off-shore banks of mud discharged by the estuary of the Amazon River far to the east roll past to the north west [98,121]. Local anecdotes suggest a 20-year cycle of erosion and accretion [122]. As elsewhere in the tropics, mangrove forests in Guyana have been intensively harvested for construction poles and firewood. At least until the 2000s, mangrove trees near the mouth of the Waini River were felled and stripped of their bark for cutch for tanning cattle hides for leather.

There is a widespread belief that mangroves south of the artificial sea wall can be harvested and cleared for farms and housing. This is not legally correct and the Sea Defences Act (cap. 64:01 of 1883/1997) penalizes destruction of underwood, shrubs and trees. Amendment to the Forest Regulations in 2011 made the three main species of mangroves protected trees requiring explicit government permission for felling. Reports published in the independent Press show that selective felling and land clearing in mangroves continue, notwithstanding the legal protection and the large donor funding for maintenance and repair of the long-neglected sea defences. The European Union grant specifically for mangrove restoration and planting in 2010–2012 was not extended after an audit showed that less than half the target planting had been achieved. However, the multi-aspect grant had enabled progress with improving livelihoods in mangrove areas by providing training and stimulating eco-tourism, bee-keeping for honey-production, and candle-making from the beeswax [123].

Perhaps because of lack of clarity for which agency is responsible for mangrove administration, the 2010 national survey of forest/non-forest areas neglected mangroves entirely, although the proclamation of the Forests Act in 1953 included most of the mangroves in the northwest district within the State Forest area. The GFC provided an estimate of 91,000 ha of mangroves to FAO in 1990, refined by ter Steege to 80,432 ha in 2001 for the national vegetation map, but much reduced in a GFC mangrove inventory during 2004–2009 to only 22,632 ha [124]. This unexplained loss is by far the largest single change in forest ecosystem pattern in Guyana. There was heavy demand for local firewood and charcoal when imported fuel was very scarce and expensive during the siege economy of the 1970s/1980s but this does not explain the difference between the 2001 and 2009 estimates.

So far, with no notable trend which can be ascribed to climate change, the spatial pattern (of forest types) of the natural tropical forest of Guyana has been affected by human disturbance only in localised areas.

10. Interplay of Human and Natural Disturbances on Process in Forest Ecosystems

Forest degradation is a generic term covering negative effects on process in the forest. Here, we focus on the effects of long-term highly selective logging concentrated on just a few highly preferred commercial timbers.

10.1. Impact of Selective Logging on Populations of Preferred Timbers

By 1882, specific useful properties were known by experience with hand tools and simple saws for some 68 timber species [6]. By far the largest volume was being harvested and exported from *Chlorocardium rodiei* because of its durable heartwood and long straight lengths suitable for construction and marine piling. Even by this date, the more accessible riverside stands were being harvested for the third time and concern was expressed about “the growing scarcity of the timber” and declining quality [6] (p. 176). The woodcutters’ response was “it will last our time”. This is very much the same as beliefs expressed by members of the Forest Products Association, which represents the large forest concession holders, 130 years later when the area under harvest is very much larger and almost all extraction is by truck; the Creole expression is “Da wood cain’ done”: that is, the forest is inexhaustible. Impoverishment was at last being recognized by 1999 when Tropenbos compared summaries of forest inventories from 1924, 1964 and 1999 in the Bartica Triangle, the centre of occurrence of the near-endemic *Chlorocardium*: “several concessionaires claimed that it was no longer possible, in economic terms, to extract Greenheart from the area” [125] (p. 130).

Forest Department studies from 1925 to the 1970s concentrated on *Chlorocardium* ecology and silviculture. The extraordinarily high stocking of trees per hectare in some places but the infrequency of the seedling release in occasional small canopy gaps suggest a species with punctuated regeneration [22,122]. The heavy seed means only small dispersion beyond the radius of the tree crown, mainly by nocturnal rodents [126], and thus the sensitivity of the seedling population to damage when parent trees are felled. In order to reduce damage to regeneration by extraction tractors and to minimize the size of felling gaps, Tropenbos recommended reduced impact logging (RIL) techniques [45] (p. 73).

Training on the procedures for these activities was provided as part of the DFID Institutional Support project for the GFC during 1995–2002. Training for both GFC staff and field workers in logging concessions on reduced-impact logging was provided by Fundação Florestal Tropical (Brazil, training given by Johan Zweede) through the Forestry Training Centre Inc., a unit of the GFC initially funded by a project of the International Tropical Timber Organization (ITTO).

Although RIL has been in the GFC’s Code of Practice for Timber Harvesting since 1996 [101,127,128], the Code remains voluntary because the GFC has not activated the legal procedure to make its application obligatory. Consequently, except for the 180,000 ha of the sustainable management area of the Iwokrama International Centre for Rainforest Conservation and Development, harvesting techniques are unskilled and destructive. Even in *Chlorocardium* “reefs” which were being harvested for the valuable marine piles in a concession already holding a Rainforest Alliance Verification of Legal Origin (VLO) certificate, damage to branches of the next-crop trees was high (Variety Woods and Greenheart Limited concession in Berbice) [129]. This is particularly degrading because fungus causing pipe rot enters through broken branches of *Chlorocardium* [54].

The repeatedly logged stands thus tend to show huge hollow veteran trees, a few remaining but damaged next-crop trees, and damaged regeneration. The danger of arriving at this state had been foreseen years ago ([7], pp. 180–183,139). Yet, the GFC and timber trade rely on gross numbers of trees without regard to size class or pathological condition to suggest that these stands are in good condition and that logging is sustainable [130] (p. 20). The GFC and timber trade also fail to note that the annual harvest area has greatly increased since 2008, with the short-term (2-year) State Forest Permissions doubling to over 2 Mha while the harvest of *Chlorocardium* logs has increased by some 50 per cent (45,000 to 67,000 m³) in that time but well below the peak of 164,000 m³ in 2006 when the Barama Company Limited was expanding to support the Initial Public Offering of the parent company Samling Global Limited on the Hong Kong Stock Exchange in early 2007 [131,132]; see Figure 2.

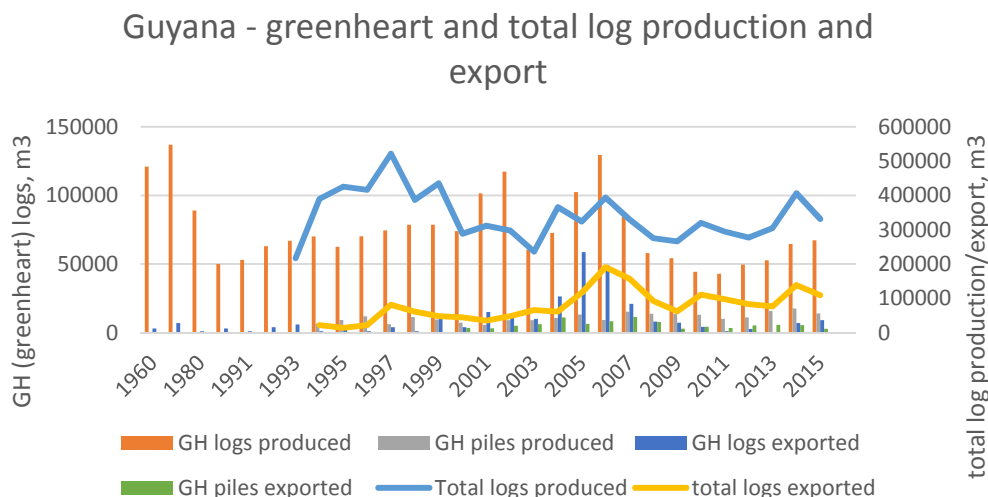


Figure 2. Guyana—greenheart and total log production and export.

From the extensive studies by Tropenbos on gap sizes, extraction tracks and felling damage, Neil Bird formulated the rule for a minimum inter-stump distance of 10 m (Section 5.1.3) [101] (p. 42). Showing notable disdain for the accumulated research, a Ministerial Order (policy directive) in July 2011 reduced the minimum inter-stump distance to 8 m, and this is further qualified by allowing an even lesser distance by written permission of the GFC Commissioner in the third edition of the Code of Practice (Section 4.4.2, p. 49) [128]. This reduction was sought by the Forest Products Association, apparently propelled by the Asian loggers and those supplying the North American market with marine piling. The reduction has no support in the research data on the Tropenbos Guyana programme.

10.2. Overharvesting

The 20 m³/ha harvest limit over a 60 year rotation, also derived from Tropenbos studies mostly at Mabura Hill and the ECTF growth and yield plots for Barama in the 1990s, was devised as an upper limit for all commercial species taken together; see above. That is, 40–50 timber species. Growth, yield and survival data were available for yield modelling of the popular species [86,133] so yield control by species was practicable. "... sustained yields can only be ensured if a minimum stocking is retained after logging for each individual desirable species. GFC developed growth and yield models during 1999–2002 that can assist in determining the number of trees that can be felled per ha as well as the minimum size (diameter) for each individual species" (Section 2.3, p. 8) [101]. The development of the growth and yield models for individual species allowed a re-think about the inappropriate single-rotation age of 60 years for all forests, inappropriate because of the very different growth rates of the trees of the component species. Neil Bird (2000) provided preliminary estimates for management rotations for groups of species [134]. Training was given to GFC staff during the development of the tree growth, yield and survival models.

The importance of single-species yield allocation was shown by the contemporaneous post-harvest silvicultural surveys of sample logging blocks. Although a draft field manual for reduced-impact logging had been developed by 1994, and a fuller first edition by 1998, its use was not obligatory. Post-logging silvicultural surveys were the norm in Sarawak (Malaysia) by the 1960s and showed the importance of field controls within forest types, not just at national scale. All the currently accessible five out of seven reports on silvicultural surveys in Guyana [135–139] show that the excessive felling of the preferred commercial species has made it impossible to secure similar production from a second felling at the end of the current felling cycles. That is, the conventional controls against over-harvesting should have been applied much earlier, when doubts about sustainability of greenheart harvests had been expressed since 1882 (see above) and certainly by the mid-1990s. In addition to reduced-impact logging, the main options are: lengthen the felling cycle to allow more time for next-crop trees to

mature; increase the minimum diameter for tree felling, to allow trees to grow larger and more trees to regenerate before a felling; control the number of trees per species per unit area which may be felled by increasing inter-stump distance—this is especially important for reef-forming species such as *Chlorocardium* and *Peltogyne*. Bird (2000, in Silvicultural survey number 1, felling block 2, Wappu compartment, DTL TSA 02/1991) [140] also stressed the importance of preventing re-entry felling before the scheduled felling cycle is completed, an important warning given the propensity of Malaysian loggers (such as DTL and Barama) to return for a destructive premature harvest when markets widen to accept more timber species. All five survey reports contain phrases similar to “Existing timber harvesting controls have been insufficient to safeguard the medium-term sustainability of the timber resource within this felling block. The company’s logging operations complied with existing regulations, yet these did not limit the yield to a level that can be sustained under the present forest management system” [136].

Bird’s 2000 paper on rotations [134], the two silvicultural survey reports 2000 and 2001 [136,140], Marshall and Bird’s 2002 summary paper [141] and the availability of computerised growth and yield species-specific models with trained staff gave every opportunity to the GFC to correct its forest harvest regime by 2002. Warnings continued through the last two available silvicultural survey reports in 2004.

In practice, the GFC has not applied these models and allows loggers to take as much volume as they want from as few species as they wish. This is exactly the situation against which the Conservator of Forests W A Gordon warned a half-century earlier [142] and which the GFC Code of Practice [101,128] should deter. Even the crude 20 m³/ha annual allowable cut (expressed as 2000 m³ per 100 ha square logging block regardless of the natural clumping of some commercial species) can be varied by negotiation with the GFC, according to the indicators evaluated by the Norway-paid auditors for a (highly selective) independent forest monitoring—undertaken by the GFA Consulting Group with reports in December 2011, October 2013 and July 2014 [143–145]. See also Section 2.4.3, item 9 in [128].

The over-selective and repeated harvesting which McTurk (1882) [6] noted and which has been the subject of repeated warnings since then has thus become more damaging. By June 2016, Assistant and Deputy Commissioners of the GFC were showing that *Chlorocardium* logs were only just above the minimum felling diameter limit. The appearance of sustained production has been possible only by doubling the annual area of harvest in short-term State Forest Permissions since 2008 to more than 2 Mha, as noted above. Given that intermediate sizes are sparse anyway for this species after repeated logging (and ter Steege arguing for punctuated regeneration) [146], that the intermediate sizes (tree diameters 30–55 cm) are preferred for marine piling, and that the ground skidding by tractor is destructive of the regeneration clustered under the tree canopy, this species is headed for commercial extinction (Figure 1).

Similar selective over-harvesting of preferred timber species for particular markets and end uses is shown in the accompanying graph for the flooring timber *Swartzia leiocalycina* Benth. Similar graphs can be shown for darina (*Hymenolobium flavum* Kleinh., flooring and furniture) and purpleheart (*Peltogyne venosa* (Valh) Benth., furniture, panelling and mill work). Post-logging block closing surveys should show the state of the residual forest in each logging block and the population structure for each species, but such surveys have not been routine since they were devised in 1999 [147], the last known reports being in 2004 [138,139].

The available growth data for all the species with hard heavy timber show that they are slow-growing and have rather short-range seed dispersal mechanisms (birds, bats, ground mammals or no-assist) [148]. In each case, the ratio of log production of species \times to total log production greatly exceeds the ratio of standing volume of species \times to total commercial standing volume (GFC data on standing volume) [149]. In the case of *Peltogyne venosa*, the difference is a factor of 30 [150].

10.3. Protection of Individual Species and Trees

The Forest Regulations 1954/1982, third schedule, lists 43 timber species or species groups which must be 34 cm or greater in diameter at breast height for felling. All other species of tree must be at least 19 cm in diameter. The GFC does include sample checks on tree stump diameters in logging areas [144,145]. Minimum felling diameters are conventionally related to age/size of abundant fertile fruiting and to the felling cycle. The intention behind the diameter limit is to prevent the felling of immature trees and thus safeguard fruiting and seeding and viable seedling growth to populate the natural regeneration. This safeguard is particularly important for the slow-growing tree species in Guyana's forests which do not produce crops of fertile seed until the crown has reached the forest canopy but which are commercially valuable in smaller sizes. Also, a felling cycle which is shorter than the tree rotation should be linked to proportionately greater minimum felling diameters because the recovery period between fellings is less [134]. The GFC ignores this important consideration for the logging concessions operating on felling cycles which are shorter than the nominal rotation age of 60 years.

The GFC gives permission for loggers to have extended access in time to individual logging blocks (roll-over, re-entry and in advance of the schedule, thus making a nonsense of rotational felling cycles and leading to destruction of advance regeneration) (Section 2.4.3, p. 27) [128]. In effect, the GFC is allowing loggers to take almost whatever species and sizes which they can market, and inevitably leading to rapid forest degradation. These destructive habits were not addressed in the third edition of the Code of Practice for Timber Harvesting [125] and appear to be a result of pressure from Malaysian and Chinese loggers to copy the disastrous logging which has devastated Sarawak and Papua New Guinea.

Legal protection for the balata tree, *Manilkara bidentata*, was important during the 1920s–1960s for the latex which is similar to *Hevea* rubber but more elastic, preferred for waterproofing submarine communications cables before the advent of synthetic polymers. The felling control on *Manilkara* in Forest Regulation 17 (1954) is now nominal, given the small market demand for balata latex, and the GFC freely allows felling and export. As noted above, three mangrove species became legally protected trees in 2011 by amendment of Forest Regulation 17.

The second edition of the Code of Practice included “Potential crop trees and trees belonging to protected species should be marked for retention and protection within a radius of 30 m around the tree to be felled” (Section 5.1.6) [101].

The third edition of the voluntary Code of Practice (Section 4.4.6) [128] provides more extensive protection which is here quoted *in extenso* -

“

4.4.6. Trees to Be Protected during Harvesting

A “keystone” or “cornerstone” species is a species that has a disproportionately large effect on its environment relative to its abundance. Such species play a critical role in maintaining the structure of an ecological community, affecting many other organisms in an ecosystem. Certain plant species are considered a keystone species because they are important to the animals in the forest; e.g., because the species bears fruit several times a year or during periods when few other species are fruiting. . . . The keystone species are those which indigenous Amerindians have identified as important food sources for hunted wildlife . . . The concessionaire shall not fell, injure, or kill any protected species without special permission. Trees that should be protected during harvesting belong to roughly five groups:

Trees belonging to keystone species. They should be marked with a “P”:

Hog Plum (*Spondias mombin*)

Ubudi (*Anacardium giganteum*)

Kokoritiballi (*Pouteria egregia*)

Duru (*Apeiba* spp.)
 Pasture tree (*Trymatococcus paraensis*)
 Sawari (Butternut) (*Caryocar nuciferum*)
 Akuyuru (*Astrocaryum aculeatum*)

Trees belonging to the following two species may be felled, but at least three trees of these species with a diameter at breast height greater than 40 cm shall remain in the block (100 ha) following logging:

Aromata (*Clathrotropis brachypetala*)
 Maho (*Sterculia pruriens* and *S. rugosa*)

Potential crop trees:

These trees will reconstitute the harvestable volume after one cutting cycle. They should be protected so that the harvested volume can be reconstituted and should be marked with a “Ø”

Heritage trees:

Social studies conducted during the development of the management plan will identify any heritage trees. These trees are of great social importance and should therefore be protected. They should be marked with a “P”.

Seed trees:

A certain proportion of the commercial trees that have been inventoried and numbered should serve as seed trees. They should be marked with a “P”. These trees should be selected according to the following criteria:

- * A minimum of 0.02 trees per hectare or 2 per 100 ha of each harvested species should be retained;
- * Trees should have a grade A or B (perfect or acceptable stem quality);
- * Preferably with a very large diameter (≥ 120 cm), or in diameter classes with the highest fructification rate according to phenological studies’.” Quotation ends here from [128] (pp. 50–52)

It is not possible to say if any of these precautions are actually implemented because the post-logging silvicultural surveys developed for the GFC [128,140] (p. 16) equivalent to closing reports for logging blocks in other countries, are not reported by the GFC. Stump inspections—to check on the accuracy of log tagging—are reported in some GFC annual reports during 2005–2015 but these inspections give no indication of the post-logging state of the forest.

10.4. Bushmeat Harvesting

Significant number of commercial species have seeds adapted for dispersal by birds, bats or ground mammals, especially rodents [148]. During the 1993–1999 studies by ECTF for the Barama logging company, anecdotal evidence was collected from loggers about effects on the species hunted for the wildlife trade and for family consumption. ECTF anticipated that there would be an “increase in wildlife trade, hunting pressure and illegal timber felling as a result of improved access”. ECTF concluded that “no evidence of an increase in wildlife trade has been identified. Possible reduction in trade with alternative sources of income now available. Additional hunting to supplement diet for increased population around Port Kaituma (then the Barama logistic base). Timber felling restricted to very limited local consumption” [151].

Similarly, Bicknell et al. (2015) concluded for the relatively isolated Iwokrama forest that reduced-impact logging has a relatively benign effect on birds, bats and large mammals, where

these pollinators and dispersers can move easily into neighbouring undisturbed forest and move back again after logging has been completed [152].

In contrast, many indigenous Amerindian communities close to logging areas which were interviewed in 2006 or 2007 protested strongly against under-fed loggers stealing their growing crops and hunting and eating indiscriminately any animal which could be found, including animals considered as taboo by the Amerindians (such as eels and snakes) [153].

The effectively uncontrolled logging thus affects animal pollinators and dispersers by removing their food source (in the selectively felled tree species, such as the bat-dispersed wamara, *Swartzia leiocalycina*) rather than the tree populations lacking their usual pollinators and dispersers rather than the tree populations lacking their usual pollinators and dispersers.

11. Verifying Sustainable Forest Management in Practice

Superficially, the GFC appeared to be well placed to administer SFM in the State Forests of Guyana and the holders of the logging concessions appeared to be well provided with guidelines and at least basic legislation. So, indeed, the GFC has repeatedly claimed in public, both in Guyana and at conferences abroad [154,155]. Verifying this claim is difficult. The GFC published production and trade statistics only intermittently during the 1990s and until 2005. Highly aggregated information has been published for half-yearly periods in GFC Forest Sector Information Reports since 2005, up to a year late.

The GFC's formal annual report should be laid in the National Assembly by the responsible Minister within eight months of the close of the financial year. In practice, the annual reports for 2005–2012 were provided alongside much delayed annual reports from several other government agencies at one time in November 2013 [156]. None of this batch of some 40+ annual reports has been subject to scrutiny by the responsible Natural Resources Sectoral Committee of the National Assembly, nor have the subsequently published and even more aggregated GFC annual reports for 2013 and 2014. The latest report, for 2015, is still in draft for the GFC Board of Directors and is further condensed. Only very limited and intermittent trend analysis is shown in these reports. It is impossible to know from these reports what is happening in any one concession or the conservation status or population health of any one timber species.

A memorandum of understanding (MoU) between Norway and Guyana was signed in November 2009 for the period 2010–2015. The MoU provides for generous financial aid from the international development aid budget of Norway if Guyana's deforestation and forest degradation rates were maintained at low levels. Guyana also committed to (a) keeping its total timber harvest to less than the average for the six years 2003–2008; (b) to enter into negotiations for a voluntary partnership agreement under the EU Forest Law Enforcement, Governance and Trade action plan (EU-FLEGT 2003); (c) to join the Extractive Industries Transparency Initiative (EITI); etc. The commitments were further detailed in a simultaneous Joint Concept Note which provided for a REDD+ Governance Development Plan, itself incorporating independent forest monitoring [157]. Alarm at the prospect of public scrutiny of the extractive industries—mining and logging—was reduced by statements by the then President Bharrat Jagdeo that it would be business-as-usual for the sectors unless external auditors insisted on the implementation of laws [158]. Norway helped by providing auditors of the “three wise monkeys” type—see no evil, hear no evil, speak no evil. The sole attempt at a professional audit, the second by Rainforest Alliance, and the consequent publication of even mildly critical comments resulted in Norway hiring a public relations firm in New York to undermine the report [159] and the non-renewal by Norway of the audit contract for Rainforest Alliance [160,161].

Analysis of letters and articles in the independent newspapers of Guyana in part fills the space normally occupied by academic studies on extractive sectors. The University of Guyana undertakes very little public research on forestry and plays no part in public discussions on the sector. Permits for research by foreigners are managed by the Environmental Protection Agency, under the Ministry of Natural Resources and the Environment during 2012–2015 but otherwise under the Office of the

President (1996–2012) or Ministry of the Presidency (2016). Criteria for issue of permits to foreigners are not clear [162] and the bureaucracy is opaque, uncertain and lengthy as well as expensive. Little external research is thus undertaken or published. Since 2005, civil society has analysed and published in the independent newspapers on the scanty data sometimes released incidentally by the GFC or made available through the trade bodies, Forest Products Association (FPA) and Guyana Manufacturing and Services Association (GMSA). Information may also be released internationally in association with IPOs on the Hong Kong stock exchange (loggers Ja Ling in 2006 and Barama in 2007) [131,132,163] or in public summaries of forest certification audits [164,165].

The data show unequivocally that the GFC has allowed harvesting without approved management plans or environmental management permits, and has allowed massive selective over-harvesting of slow-growing timbers preferred for luxury furniture and impact-resistant flooring, as well as under-valued export of unprocessed logs contrary to national forest policy and Customs law. Far more logging blocks are opened than are allowed by the calculated annual allowable cut and blocks are left open for more years for re-entry to harvest new timbers or smaller sizes as the market allows. The bar-coded timber tag system [103] is useless at preventing improper, out of place, and excessive cutting because the GFC issues far too many tags and they are used as a hinterland currency [166]. Moreover, the numbers of issued tags are related to a crude all-species annual allowable cut calculation by the GFC; see above. For a 60-year timber growing rotation and an upper harvest limit of 20 m³/ha during the 60 years, the weak GFC control allows a logger to focus the entire harvest on a single species, out of the 1000+ tree species in Guyana. This is entirely contrary to the policy on conservation and use of forest resources (III B 2 in the Forest Policy 1997 and 2011) [107,167] and Code of Practice on Timber Harvesting quoted above (Section 2.3, p. 8) [101].

However, this aspect of policy is ignored by the GFC and the legal process for making the Code of Practice obligatory has not been put into operation (Forests Act 2009, Section 35). The Code is thus voluntary and in practice it is observed only or mainly by the small-scale logging and in-forest milling at the Iwokrama International Centre for Rainforest Conservation and Development.

12. Explanations for Unsustainable Forest Management in Guyana

Few countries with commercially valuable tropical rainforest have been in the position of Guyana in 2002, when trained GFC staff had available up-to-date operational manuals of procedures for species-specific yield control of timber harvests, backed by 14 years of doctorate level ecological and silvicultural research, recently revised legislation and the second edition of a code of practice. Why did Guyana not move to the forefront of tropical SFM? Why instead has it regressed to a situation of uncontrolled overharvesting with almost no environmental controls, while logging companies are allowed to accumulate millions of dollars of debts to government while exporting under fraudulent papers hundreds of millions of dollars' worth of unprocessed timber logs, entirely contrary to national policy [168]?

However, the progress under the DFID/GFC Institutional Support project during 1995–2002 did not survive the closure of the project. The forest-experienced African Guyanese staff who manned the GFC in the mid-1990s did not have the paper qualifications to secure good positions in the evolving GFC, and were overtaken or replaced by town-bred East Indian Guyanese with schooling but no or limited field experience. In the politics of the time, the prospects for senior African Guyanese staff were poor and most (all but one) emigrated quickly to North America or the UK. Similarly, most of the GFC staff trained to use and develop the computerised growth and yield models left quickly for better-paid jobs abroad or in other sectors needing computer-literate staff.

So why did not the GFC train replacements? Confidential interviews with staff and former staff indicated that there was a growing trend to selective application of laws and procedures, that some logging companies were so politically protected that they were effectively immune from GFC requirements, and that attempts by trained staff to apply their training were shut down by higher authorities. Evidence for this state emerged during the independent audits of Barama for FSC

certification in 2006–2007, when Barama’s logging without an approved management and other illegalities were revealed [164], and token penalties of half a million US dollars were imposed by the GFC in 2007 [169]. In other words, the politicisation of the GFC prevented trained staff from applying their knowledge, and they left or were forced out (allegedly).

Meanwhile, the then ruling East Indian-dominated political party (Peoples Progressive Party/Civic, which gained power by election in 1992) realised that the GFC could be a cash cow for revenue which was not being deposited in the Ministry of Finance’s Consolidated Fund and which was not liable to detailed scrutiny by the annual checks of the Auditor-General. At least some of this revenue was raised from the fiscally ineffective export commission on unprocessed logs which, even after being raised from 2009, is still too low to deter export in spite of being levied on logs which were and are under-valued at Customs (FOB). Revenue was also raised from administratively estimated penalties applied outside the court system, an abuse of the “compounding procedure” designed only for minor one-off offences [170,171]. Millions of US dollars were transferred by illegal Ministerial order from the GFC to other entities favoured by the political party (National Industrial and Commercial Investments Ltd., Marriott Hotel, Iwokrama, and the Environment Protection Agency, among others [156,172,173], contrary to the legal mandate of the GFC Act 2007.

From 2007 onwards, the setting aside of the requirements of law and policy have become more prevalent. Private trading of logging concessions is contrary to law, unless approved in advance by the President (Forest Regulation 12 and Clause 13 in the TSA licence) but the GFC has allowed multiple transfers of ownership of the long-term large-scale logging concessions from Guyanese companies to the Chinese transnational logger Bai Shan Lin [174].

13. Current Situation 2016

With the relative wealth of forest data, a national policy and forest plan, field manuals and training, the GFC should have been in a good position to engage in countrywide SFM.

Asian markets, especially in China and India, had recovered from the late 1980s downturn and there was a rapidly growing demand for tropical timbers for luxury furniture and flooring. Logging companies and log traders in Guyana realized that the departure of Dutch and British foresters in 2002 left almost no one with field experience in the GFC. Paying bribes at various levels (“lunch money”) was cheaper than following the rules for SFM. With a dominant East Indian political party holding the Executive Presidency, protests about violations by GFC staff of the civil service Code of Conduct (schedule 2 in the Integrity Commission Act 1997) were unlikely to be heeded.

Instead of implementing its outline plans for value addition beyond utility-grade plywood, Malaysian-owned Barama imported managers experienced in Papua New Guinea with Rimbunan Hijau (pers. comm.). The declining production of plywood was counterbalanced by a great surge in export of unprocessed logs during 2005–2007 [81,175]. Barama continued to receive maximum tax incentives, ostensibly for its value-addition, while actually exporting unprocessed logs for value addition in Asia, especially China and India.

The super-profits obtained from transfer pricing [176] easily enabled bribes to be spread across all levels of government. Incoming Chinese loggers and log traders (Bai Shan Lin and Ja Ling) likewise promised tens and hundreds of millions of dollars for on-shore investment in wood processing, secured FDI tax concessions, and then exported only raw logs [177].

With payments totalling US\$ 3.25 million in 2010, the Indian high street coffee retailer Café Coffee Day secured 738,000 ha of forest in two concessions in spite of having no prior experience or qualifications for SFM [178,179]. Café Coffee Day’s local subsidiary Vaitarna Holding Private Inc. (VHPI) apparently satisfied the Guyana Revenue Authority’s call for the promised investment in wood processing by belatedly installing three small WoodMizer saws in 2014 as tokens for value addition, after obtaining tax concessions on US\$ 5.7 million of imports. VHPI probably exported to India at least 20,000 m³ of raw logs during the three years 2012–2014, with an FOB value of US\$ 6 million under its

own name, and possibly a further 70,000 m³ using false names of log sellers [180]. In contrast, VHPI sawed locally only 2500 m³ of logs during the period mid-2015 to mid-2016 (GFC data).

None of the US\$3 million initial payment by Café Coffee Day was applied to the forest sector. It was used by former President Bharrat Jagdeo to pay off some of the outstanding debts of the Guyana branch of the bankrupt insurance company CLICO to politically connected investors [179].

Scandals repeat across the forest sector. In spite of a commitment to improve forest governance (the Norway-Guyana REDD+ Forest Governance Development Plan of 2010), the only formal change in policy or practice has been a relaxation of the inter-stump minimum distance from 10 to 8 m, thus facilitating in 2011 the more intensive logging of the ecologically-sensitive slow-growing monodominant stands (“reefs”) of *Chlorocardium rodiei*. This change, entirely contrary to the guidance provided from research by Tropenbos [45,148], was based on no research but apparently in response to requests from Chinese loggers, and was approved in a Ministerial “policy directive” [143] for which there is no provision in forest law; see above.

How could this neglected state of public forest assets have arisen after the promise of 2002? The more politically-connected businesses in the forest sector were making vast profits from the booming log exports and from the rising demand for sawn lumber for the expansion of suburban residential estates on former government-owned sugar cane lands on the outskirts of the capital Georgetown. Paying bribes to politicians and to GFC staff was cheaper than complying with GFC forest management requirements and cheaper than paying outstanding forest taxation (area fees and timber royalties) and penalties levied for forest offences. The GFC has been and continues to be an enthusiastic practitioner of the Leninist “democratic centralist” approach to communications: the government authority controls information flows, decides what civil society needs to know, and actively suppresses civil society attempts to earn more about the condition of the State Forests [181].

The simple answer to the question at the head of the previous paragraph is that what happens in and to the State Forests is not of great concern to the coastland-focused 90 per cent of the population. For some two decades, the economy has been supported to a huge extent by facilitation of the smuggling of drugs (cocaine from South American producers) and of undeclared artisanal gold [4,182,183]. The weak and distorted performance of the forest sector is only a small part of the national economy. The part-time National Assembly works under a system by which the parliamentarians are appointed by the party leaders, not the geographic constituents. In effect, there are few parliamentary voices to represent the hinterland inhabitants. The Sectoral Committee on Natural Resources of the National Assembly should scrutinize the performance of the forest sector and implementation of policies, and especially the performance of the GFC but in practice this does not happen. Corrupt political ministers clearly have no interest in such parliamentary or other scrutiny, and the Board of Directors of the GFC is appointed by the Minister. Corrupt staff at the GFC are almost exempt from scrutiny, and have rejected or ignored even mild questioning of GFC actions or inactions for at least 14 years, since 2002 [143,184].

The long-term illegalities of the GFC and the failures to apply approved laws and policies have been overlooked or ignored by the GFC Boards appointed annually by the forestry minister, originally the President. Little attention has been given to the repeated appointment of members unqualified according to the criteria in the GFC Acts of 1979 and 2007. The deficiencies should have been detected when the annual reports of the GFC were submitted by the Minister to the National Assembly for scrutiny by the Natural Resources sector committee. However, under whichever political party has been in power, that committee has failed to notice the absence of such reports for 2005–2012 until those for the GFC were included in a single batch of 43 overdue reports from several government agencies in November 2013. None of these reports has been subject to review by the National Assembly, nor the subsequent 2013 and 2014 annual reports, in spite of detailed questions being posed by civil society in the independent press [156]. The GFC replied briefly and uninformatively after several months to the compilation republished by www.redd-monitor.org [185].

At the time of writing, November 2016, the Cabinet has yet to make decisions on the 30 forensic audits commissioned after the change of government in May 2015. All these audit reports indicate multiple illegalities in the government agencies and government-owned corporations. Legislation has been drafted to facilitate recovery of some of the illegal earnings or property acquired from the illegal earnings, but this legislation has not yet been presented for parliamentary debate. Some of the named actors in other agencies have fled the country but the GFC staff have remained in place with no Ministerial sanction. Under such circumstances, it is not surprising that sustainable forest management exists in Guyana only on paper, and for showing to consultants hired by some bilateral donor agencies. This story has parallels in the illegalities associated with gold mining [4] and fisheries also in Guyana. It is not peculiar to the forest sector.

Nevertheless, civil society pressure prevented the illegal extension of two 3-year State Forest Exploratory Permits held by Chinese transnational logger Bai Shan Lin. Some of the illegal transfers of TSAs were detected during the forensic audit by accountant Anand Goolsarran [172], others were admitted by the GFC Commissioner to the GFC Board of Directors, and stimulated their formal cancellation by the GFC in April 2016 [186]. Similar pressure also led to the rescission of five long-term Timber Sales Agreements (TSAs) illegally acquired by the same Chinese group, in September 2016. These actions and others in the last year have reduced the Chinese holding from some 1.5 Mha to perhaps 900,000 ha but operational control of some 700,000 ha is being disputed between private parties in court actions.

Likewise, 90 per cent of the Guyanese-held long-term TSA were shown to have been in long-term debt to the government for US\$ millions by June 2016, and to be making no effort to undertake SFM or cut more than a very few timber species [187]. The net effect is considerable forest degradation, with the populations of the preferred commercial timbers selectively harvested with no concern for the rest of the forest (as the Code of Practice for Timber Harvesting is voluntary and hence not used). In the case of *Peltogyne*, the proportion by volume of harvested logs of this timber to total harvest of all logs is some 30 times the proportion of the standing volume of this timber to total forest standing volume during the period 1996–2003 [150].

Of concern is not just the biological degradation of the forest but also the failure to capture tax revenue from the harvest of the State Forests because of the very low rates of taxes [188–191]. Under-declaration of volumes and FOB values of exported logs has also led to revenue capture failures over many years [192]. During April 2016, the GFC Commissioner admitted to the Board the long-time collusion in Customs fraud in endorsing false names and values on export forms, contrary to Customs law (sections 157 and 158). Around half of the illicit flows from Guyana (US \$1,464 million for 2003–2012) were attributed to export under-invoicing [182].

All these faults are directly attributable to failures in the GFC. There was considerable hope that a change in government through the May 2015 national elections would result in a lessening of corrupt practices in all sectors. A year later, this has not been achieved. The new administration has allowed the US Drug Enforcement Agency (DEA) to install an office in Guyana, after years of prevarication by the previous government. The DEA and local Customs and Narcotics Unit seem to have caused a rapid decline in the contribution of drug smuggling to the local economy, previously estimated at some 40–60 per cent [193]. Gold smuggling and Customs failures in timber export seem not to have declined, there being no corresponding external agency to set and enforce operational standards. But surely the millions of US dollars paid to Guyana for REDD+ preparation and institutional strengthening and training under the World Bank's Forest Carbon Partnership [194] and the REDD+ Governance Development Plan under the Norway-Guyana MoU of 2009 [195] have had measurable benefit? There are no reports of independent audits to check how those millions have been used, but there have been no improvements to either policy or practice in forest management since the advent of those funds in 2008–2009. Delays in delivery of FCPF funds are due partly to disagreements on safeguards with the Multiple Delivery Partner (the InterAmerican Development Bank acting in behalf of the World Bank at the insistence of former President Jagdeo). Delays in actions in Guyana may be due to the

loss of almost all trained staff through emigration, thus requiring external consultants to be hired to undertake even simple technical work. Also, all the external funds from those sources had been exhausted by August 2016, according to the GFC Commissioner's statement to the GFC Board.

There remains a single external source which has the potential to push Guyana to implement its claimed SFM. In 2012, as one of the commitments under the Norway-Guyana MoU, Guyana agreed in 2012 to enrol in the process to develop a voluntary partnership agreement (VPA) under the EU Forest Law Enforcement, Governance and Trade (FLEGT) action plan [196]. A key component of the VPA is the legality verification system (LVS), whose functioning would be checked by EU-appointed auditors. In the six VPAs concluded to date, and the nine countries in negotiation, the EU has been careful not to dictate the precise components of the LVS, as these should depend on the appropriate national laws, regulations and administrative procedures. At the same time, the EU technical staff have pointed out that the EU Parliament, which must approve VPAs, is keen to see evidence of strong commitments to good forest governance in the VPAs. This could be one effective channel for stimulating genuine improvements in the forest sector of Guyana.

Given the past decades of corrupt forest management and the allocation of almost all the easy-access natural tropical rainforest in the State Forests to piratical and careless loggers, is further effort worthwhile? There still remain some 5.7 Mha of State Forest not yet allocated to loggers. Most of this is in swamps or on steep terrain, effectively inaccessible to the crude logging machinery which has been used to date in Guyana, but could be harvested with more advanced machinery as used in Malaysian and Indonesian Borneo. This would not be possible for the family-owned logging enterprises in Guyana which lack capital and skills, but might be attractive to foreign companies. Such logging would call for a serious skilful enterprise and it is not clear that the Ministry of Business has the appropriate negotiating skills or knowledge of due diligence audits for a foreign direct investment agreement. Though, it is a possibility.

14. Conclusions

The Moraballi Creek studies of 1929 continue to be cited in the global literature because of the pioneering observational ecology on distributional patterns of trees in natural tropical rainforest and the associated speculation about causative eco-physiological processes. The eco-botanical studies of that first phase of tropical forest research informed subsequent vegetation surveys by the Forest Department, and were used during the second phase — the equally pioneering FAO FIDS forest inventories of the late 1960s. The Tropenbos programme of The Netherlands (1988–2002) carried out the third phase of forest research. Successive governments in post-independence Guyana have evinced interest neither in these studies more generally nor in Moraballi in particular, a globally famous location designated as a State Lands reserve but controlled by the GFC.

Throughout this almost century-long period (1929–2016), the State agencies that had and have administrative control over the State Forests have ignored the scientific findings, even when incorporated in their own Codes of Practice (CoP). Those CoPs remain voluntary so are almost entirely ignored by forest concession holders. Instead the single-minded concentration on logging a handful of dark, hard, heavy commercial timbers for export has resulted in localized commercial extinction and forest degradation. Many people have called attention to the dangers but both governments and the majority coastland-based population are indifferent to the fate of the forest. During the final editing of this paper in December 2016, the forestry Minister is proposing to re-allocate for export logging almost 3 million hectares of State Forest in an essentially arbitrary and politicized manner, with no apparent regard for indicative guidance from science-based knowledge or approved national policy [197]. It is hard to think of what might convince the State to exercise responsible leadership over these remaining tracts of fragile Guiana Shield forests, other than donor country pressure through the FLEGT VPA process and licensing.

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Appendix A

Botanical Authorities for the Latin binomials:

Hog Plum (*Spondias mombin* L.)

Ubudi (*Anacardium giganteum* W. Hanc. ex Engl.)

Kokoritiballi (*Pouteria egregia* Sandw.)

Duru (*Apeiba* spp.)

Pasture tree (*Trymatococcus paraensis* Ducke)

Sawari (Butternut) (*Caryocar nuciferum* L.)

Akuyuru (*Astrocaryum aculeatum* G. Meyer)

Aromata (*Clathrotropis brachypetala* (Tul.) Kleinhoonte)

Maho (*Sterculia pruriens* (Aublet) Schumann and *S. rugose* R. Br.)

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