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A Paradigm of Tropical Forest Management

Klaus G. Hering

Abstract: The regeneration of a pristine tropical forest continuously substitutes weak trees byvigorous individuals. Extracting the timber of those week trees does not endangersbiodiversity and the adaptive long run evolution of the biome. The carbon volume contained inthe extracted trunks is re-absorbed in the regeneration process. Anational Basic Rate of Forest Preservation together with a Basic Carbon Credit Value for tropical forests as an international policytool could contain greenhouse emissionsas afforded by cost requirements of CO_2 absorption and carbon sinks retention. An institution with a threefold governance (forest owners, public agents and NGOs) enforces required management norms and enables the conciliation of preservation and economic feasibility.

Keywords: Regeneration, carbon sequestration, economic feasibility, institutional framework.

Introduction

Notwithstanding the growing environmental consciousness of the aggressive human activity endangering renewable natural resources, it remains an unbridgeable gap between ecological ideology and economic reality. Both sides, ecology and economics, have their flaws which have to be focused in order to face the risks involved in the perspective of drastic climatic changes.

Materials and Methods

Envisaging a synergetic outcome for tropical forest management given two mostly conflicting perspectives, the ecological and the economic, an **ecounit** will be defined as a set of 620 trees on a tropical biome in an area of about 1 hectare as, for instance, on the slopes of the Atlantic Forest of South Brazil.This ecological unit; independent of the measurement of its underlying area; entails a twofold approach to a tropical arboreal stand, an analytical and a pragmatic. The analytical one is explicit in the Results of Hering[i]:

> "The structure of a forest' stand is described by a two-dimensional matrix of tree species and DBH-class intervals in logarithmic scale, whereby cohorts of populations with similar adaptation strategies are identified and survival coefficients are estimated from inventory data. Non-linear algorithms simulate future states for every stand of pristine and the managed forest, specifically its growth along a cutting cycle."

In the actual text a pragmatic approach as a system of abductive inferences[1]is presented. The arboreal structure of an ecounit is described by a matrix ***S***with 620 columns and a set ofrowswith variables as species name, the trunk's diameters at breast height (dbh ≥ 10 cm) , the usable trunk height, the utilization factor at saw mill and, finally, the estimated crownquality (dead, weak, normal, strong). This last <u>fuzzy variable</u> is essential to a tree preserving management in a dynamic perspective. Defining a premise as an empirically testable assumption, some general statements are required to clarify the meaning of this last variable. <u>Premise 1</u>: a pristine ecounit is the outcome of a biome's evolutionaryprocess to its physical environment since at least the last Ice Age. <u>Premise 2</u>: the arboreal pristine structure of an ecosystem is a mosaic of ecounits with distinct structures S_I, for instance, a set of tree species at one unit may be missing in a next one. <u>Premise 3</u>: the basal area$\lambda_0 = \sum(((\text{dbh}/2)^2).\pi)$of an ecounit is an estimate of the limiting density of a pristine stand S_0. <u>Premise 4</u>: once the dbh of every living tree continually grows, the competition leads gradually to the elimination of less vigorous trees. <u>Premise 5</u>: this natural selection is disclosed by a decay of crown volume, from strong to normal, from normal to weak and finally to dead, a sequence correlated to the reduction of average dbh rates of increase per species. <u>Premise 6</u>: trees with weak crownshave a low probability of pollen and seed production.<u>Premise7</u>: the intraspecies genetic diversity of an ecounit, in addition to the mutational process, is favored through its interaction with the surrounding ecosystem. <u>Premise 8</u>: most of the weak-crowned trees are fellable without damaging nearby individuals dbh ≥ 10 cm. <u>Premise 9</u>: to evaluate the quality of a crown requires a detailed knowledge of all tree species of the ecosystem, oncethe size of anormal crown of one species may be a weak or

[1]WIKIPEDIA: 'Abduction is a method for fruitful clarification of conceptions by equating the meaning of a conception with the conceivable practical implications of its object's conceived effects. Peirce held that that is precisely tailored to abduction's purpose in inquiry, the forming of an idea that could conceivably shape informed conduct.'

even a strong one of another species.Premise 10: after removing the weak-crowned trees, the new structure $\boldsymbol{S_1}$ will tend in about 23 years (as estimated for an Atlantic forestin Hering) to the pristine basal limit λ_0. Thedifference $\boldsymbol{S_{23}} \neq \boldsymbol{S_0}$is due tothe decline of some strongand normal- crowded trees and the emergence of young ones above the dbh limit of 10 cm and eventually with ingrowth of some new species of surrounding ecounits. Given these premises, felling only the weak-crowned trees ensuresthe regeneration of the stand and its evolutionary potential to challenge the expected climatic changes in the future.The remaining normal and strong crowned trees together with the newcomers will be striving up to the limiting basal areaλ_0. Preserving a strong or normal crowned tree is at least a precautionary measure to avoid the loss of a possibly precious adaptive property of the species and the biome as well as the ecosystem as a. whole. The forest system following these norms is denominated **natural management** in Hering[ii].

One ha of a soybean plantation in Brazil is valued around US$ 5,000. Assuming that 1 ecounit of a tropical forest has an area of 1 hectare then, in order to a private forest owner maintain the forest instead of opting for a soybean plantation, his investment requires an expected minimumrate of return to compete with its alternative. For natural management with a long time horizon a safe rate of return could be the basic interest rate of about 5% of the Brazilian Treasury bill. If implemented, would transform an endangered ecounit into a financial marketable asset of a modern economy. The afforded resources foreseen in the Union Guidance will have their origin in another economic activity, once the simple preservation of a pristine forest neither contributes to economic development nor absorbs greenhouse gasses. Keeping untouched the remains of the Amazon forest, for instance, most probably ensuring the hydric equilibrium of all of Brazil’s agriculture and electricity generation, as well as complying with the commitments to the Paris Agreement, are additionally relevantreasons to justify a Basic Rate of Forest Preservation as anenvironmental national subsidy.However, such a rate of return is only a necessary **first condition.** Anadditional **second condition** is the duty to inform, whatever the source of the required subsidized resources, about the effective preservation of every ecounit and the biome protected by its arboreal stand. Natural management fulfills this condition through the inventory of the two above matrices $\boldsymbol{S_0}$ and $\boldsymbol{S_1}$ accessible in a digital cloud in addition to all required intermediate structures up to $\boldsymbol{S_{23}}$ and farther. Thereby is automatically reported any abnormal intervention to all partners.These two conditions, however, are not yet sufficient.

In a market economy with mostly private ownership of capital goods, the outstanding proactive agent is the private entrepreneur. As a microeconomic decision-maker in producing, distributing, financing and whatever else, he is the main responsible forthe accomplishment ofeconomic growth. Unfortunately, the once assumed invisible hand, supposedly leading through market mechanism to a welfare state, is blind with regard to externalities, namely, to many not considered side effects of microeconomic decisions. For instance, the climatic impact in deforesting an ecounit to establish a soybean plantation is not a cost to the farmer and not foreseen in his taxation and therefore ignored in the product’s price.In order to achieve the conciliation of economic feasibility and ecologic preservation, the actual value of natural management cash flow of an ecounit has to be at least equal to the actual values of the cash flows in competing alternatives as cattle raising or soybean plantation on the same area. Once market forces alone do not endeavor the more selfish behavior of private economic agents to take in account negative externalities, a higher-level enforcement has to be called for. In the last century to overcome economic crisis the monetary authorities of developed nations established basic interest rates to control the overall economic activity. This interest rate is the outcome of a decision taken by members of a committee and is based on their expectations about its influence on the level of employment and growth of the nation, *inter allia*. A Basic Value of Carbon Credits may be an international policy tool for an additional control of greenhouse emissionsand enhancing investment in clean energy technologies.

Taking a pristine ecounit in the Atlantic forest as representative of a pristine tropical wood stand, Table 1 also transcribed from [iii]Hering, about 22% of the trees presented poor crowns available for felling. The structure $\boldsymbol{S}_0$ shrunk to $\boldsymbol{S}_1$. After 23 years, the limiting basal area rises again to $\lambda_0$and a new management cycle may start. The volume of all inventoried trunks in the ecounit amounted to 204 m^3 of green timber. It contained 49 tons of carbon (C) or 180 tons of carbon dioxide (CO_2), since for a tropical forest is computed an average of 0.24 tons ofcarbon per m^3 of green timber. Assuming that branches, leaves, roots and the soil covering dead biomass contain also 180 tons of CO_2 then the carbon sink of the ecounit comes up to 360 tons of CO_2.

Accurate measurements of the raising atmospheric temperature resulting from emission of $CO_2$and othergasses from fossil hydrocarbons and deforestation with already dangerous climatic consequences stimulated a carbon credits market to subsidize activities in their efforts to reduce gas emissions. Natural management offers the additional opportunity to absorb carbon dioxide in its activity. It absorbs in enduring lumber products 1.2 ton of greenhouse gases annually per ecounit along at least a management cycle of 23 years. The successful tropical entrepreneurs in soy and meat production would be tempted to preserve their forests if their management would offer a higher expected return as the alternative activities. This would bring the proactive entrepreneurship to focus its attention on the potentialities of a tropical forestwith its hundreds of wood species, honey, palm hearts, latex, nuts, fruits and medicinal herbs.

The cash flowsof Table II translated from [ii] Heringstart from an *ex post* cash flow of natural management in 1992, after years of research in preservationist management in the Atlantic Forest in an agreement with the national agency IBAMA and cooperation with two universities. The second and third *ex ante* cash flows of 2002 estimate the externality gap of a high-cost natural management as compared to a predatory use of the resource. At that time an additional cash-in of aboutUS$31.00 per m^3 of green timber to naturalmanagement (at an exchange rate of R$2.20/US$) would be required in order to make it competitive to the predatory activity. Just as a reference and as reported, currently the value of carbon credits varies from US$ 17.0o in California to US$ 31.00 in Europe, but still unavailable for tropical forests not fulfilling the above mentioned second condition.For any set of ecounits there is a value of carbon credits, added to the Basic Rate of Forest Preservation such that its *ex ante* cash flow turns it competitive to alternate activities. To start preservationist managements in the tropics a Basic Value of Carbon Creditsfixed at a United Nations agency wouldengender an international negotiation to ensure an environmental worldwide policy. To attain this goal, if this aim will really be attained, than accurate microeconomic cash flows will find out a minimum rate of carbon credits endeavoring the economic feasibility in managing some most promising ecosystems in a first step. Therefore, the availability of a high enough carbon credit is a **third condition** to implement a preservationist management in the tropics.

An institution is a social requirement to aggregate individuals to join efforts to accomplish one or more goals in benefit of all. Once established, it brings with it a coercive power on all the members of the social group to behave according to its established norms. The Brazilian legislation onconservation units offers the possibility of an Area of Environmental Protection (AEP) with the possibility of a threefold governanceof (1) private forest owners, (2) public environmental officers and (3) NGOs and universities,all with equal decision power.Acting separately, the selfishness of private entrepreneurs, thedemotivation of public officers, the vain NGO activism, led to the continuousdowngrading and devastation of the Brazilian tropical forests.A higher-level institution is required to conciliate the individual divergences around a center of socially established well-defined aims and enforcing their accomplishment. However, each one of the three actors has to keep its specific function. Therefore, the forest owner/entrepreneur as the proactive responsible for economic growthwill have to achieve the highest surplus in hiscash flow, where the fixed rate of interest and the value of the carbon credit are outstanding parameters. The public environmental officer, along his role in the governance board and checking the fulfilment of the established management norms, is an essential link of the microeconomic unit to a central national environmental agency, contributing to their mutual evolution with the detailed available information at ecounit and cash flow level. By their way, the national and foreign NGOs, together with their critical view on the environmental effectiveness of the preservation activity, will contribute to the worldwide awareness of the risk involved in the unconstrained economic activity and thereby a most important actor to establish an effective value of international carbon credits. Finally, remembering that the research agencies, mainly of universities, stimulated by the availability of detailed ecounit data, will contribute to the improvement of natural management norms.

In the Atlantic forest in south Brazil in 2003 were created successfully 9 of such AEP conservation units with hundreds of forest owners. They stopped the predatory cutting of the valuable palm hearts (*Euterpe edulis*) and the hunting of endangered species.These pioneering institutionsunfortunately went overshadowed by a National Park inefficient in its preservationist imaginary aim.

Results

Natural management, supported by two policy tools, the Basic Rate of Forest Preservation and the Basic Value of Carbon Credits, together with a suggested institutional framework, ensure the compatibility of both intents - to preserve tropical forests and its economic feasibility-enforcing a more factual and less imaginary perspective to the contribution of native biomes to overall human activity

Discussion

To put into practice natural management requires the initiative of forest owners to include their forests in a conservation unit and that presupposes the existence of a Basic Rate of Forest Preservation warranted by the Federal Government. Then the mayor and the city council may enact the conservation unit with its tripartite governance. The management may be carry out by an hired enterprise. The *exante* cash flow of the conservation unit, along the expected costs, has two outstanding components to consider\: the timber prices of the hundreds of tree species and the expected value of carbon credits. In South Brazil, at the beginning of prescriptionstowards tree cutting in the Atlantic forest in 1990, all kinds of timber had a commercial value. It will be a challenge to natural management to legalize and gradually find a market, for example, for the Amazonian timber diversity. Institutional research will have the role to adjust the actual inefficient and degrading legal norms to an effective and viable preservationist forest management. Given these assumptions, a favorable negotiation with developed and polluting countries is possible about a Basic Value of Carbon Credits and even about punctual adjustments above the minimum, as required for less favorable ecounits and ecosystems, forming a carbon price structure alike the diversity of market interest rates.

Final considerations

The symbiotic process of cooperation and competition from microorganisms to the summit of the food chain, including the *homo* presumably *sapiens*, led to all worldwide biomes and ecosystems, specifically the highly diversified tropical forests. This selective process leads to a better adaptation of the species to a changing physical environment and from the human perspective led to the consciousness of this unique mind in the universe.It is at least a precautionary reason to assure the tropical forest diversity to enable the evolutionary process of the human mind in a synergetic effortwith all existing living beings.Remembering the old wise Noah taking with himself and his family seeds and couples of all living beings in his spaceship, escaping the diluvian human excessiveness to restock an otherwise sterile world.

References

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[ii] HERING, K.G., 2002. *Formulação axiomática de uma política florestal: preservação das espécies arbóreas tropicais e desenvolvimento econômico* (Axiomatic formulation of a forest policy: preservation of tropical arboreal species and economic development. (2002). Doctorate dissertation in Production Engineering at Universidade Federal de Santa Catarina, accessible at
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Table I - Reproduction of Table 1 in [i]Hering

	DENSITIES								Bas. Area	Vol.
	DBH Classes (upper limit:)									
COHORT/Population of (#)	12.9	16.6	21.4	27.5	35.5	45.7	≥45.	Total	m^2	m^3
LONGI-DIAMETRIC (7 pop.)	27	25	30	30	25	32	30	199	18.6	70.8
Psidium sp	5	4	7	13	8	4	1	42		
Ocotea catharinensis	3	4	7	3	2	6	9	34		
Myrciaria obscura	9	8	7	4	2	2	1	33		
Alchornea sidifolia	5	4	2	2	5	6	6	30		
Araçá-ferro (Myrtaceae)	1	2	2	4	5	7	7	28		
Araçá-vermelho (Myrtaceae)	2	2	3	3	1	3	2	16		
Cedrela fissilis	2	1	2	1	2	4	4	16		
SENILE (9)	3	1	5	15	17	24	30	95	19.7	60.6
Sloanea sp					2	3	17	22		
Alchornea triplinervea			2		2	8	8	20		
Crysophyllum viride			1		4	7	3	15		
Pela-cavalo				5	1	1		7		
Matayba guianensis	2			2	2	1		7		
Ocotea kulmanii			1	3	3			7		
Phytolaca dioica			1	2		1	2	6		
Rapanea umbellata	1			1	1	3		6		
Ingabauva		1		2	2			5		
MESO-DIAMETRIC (19)	63	43	33	21	12	4	3	179	5.2	15.0
Casearia sp.	4	8	7	6	5	1		31		
Guamirim-folha-miuda	7	7	7	1		1		23		
Araçá-folha-miuda	5		2	1	2		1	11		
Inga sessilis	5	3		3				11		
Cabralea canjerana	1	1	5	1	2		1	11		
Other Meso-Diam. Pop. (14)	41	24	12	9	3	2	1	92		
CLONAL (9)	13	12	9	12	12	8	20	86	10.4	39.6
Cryptocaria sp	4	2	5	4	2	2	5	24		
Cinnamomum riedelianum	1	2				3	13	19		
Aparisthmium cordatum	4	4	2	5	1			16		
Ocotea sp	3	3	1	1	4			12		
Maria-faceira	1	1		1	2	1		6		
Ocotea porosa			1		1	1	1	4		
Ocotea odorifera				1		1	1	3		
Aniba fimula					1			1		
Pau-toucinho					1			,1		
SPARSE (17)	8	10	11	9	7	10	6	61	4.8	18.6
Sickingia sampaiana						2	1	3		
Seca-ligeiro			1		1			2		
Posoqueria latifolia				1		1		2		
Vitex megapotamica						1	1	2		
Arco-de-Serra		1			1			2		
Other Sparse Pop. (12)		1	4	3	2	1	2	13		12
Non-Identified trees	8	8	6	5	3	5	2	37		
TOTAL (61)	114	91	88	87	73	78	89	620	58.0	204
Poor-Crowned Trees(*)				5%	5%	5%	7%		22%	
Nornal-Crowned Trees(*)				13%	11%	11	11%		46%	
Strong-Crowned Trees(*)				9%	7%	7%	9%		32%	
Basal Area (m^2)	1.2	1.5	2.5	4.0	5.5	9.8	39.4	58.0		
Tree-Volume (m^3)(*)				13	22	40	114	189		

Table 1: Population and cohort density distributions on logarithmic DBH classes of the stand Imbuia, on the southern slopes of the Atlantic forest in Brazil, at 800 meters a.s.l., with basal area and timber volume at cohort level and class-percentages of trees classified according to their crown-quality; botanically not identified species are listed under popular names (Section 4.2.1).

(*) Considering only trees with (commercial) DBH ≥ 21.4

Table II – Translated from Tabela 1 in [II]Hering

Chart 1. Cash flows of natural management and of a technique inattentive to original diversity (IOD) of tree species in a pristine Atlantic forest in Santa Catarina (Brazil)

Specifications		.
Carbon /dry timber	Kg Carbon / Kg timber	48%
Water concentration	Kg water / Kg green timber	40%
Mass density at 0%	Mass/ Volume	0.82
Exchange rate	R$ / US$	2.30
Average price of green timber	R$ / m³	87.45
Over-price of certified green tmber		1.15
Ratio CO_2/C	44/12	3.67
Undegraded wood		67%
Sawmill breaks l		20%
C/m^3 of green timber0.24		
Carbon credits/m^{3}of green timber	31.00	
Minimum cost of the Carbon's Credit	US$/ Ton CO_2	29.00

Cash Flow	Natural Management 1992		Natural Management 2002		IODextreme 2002	
	Total cost US$	R$/ m^3	Total cost US$	R$/ m3	Total cost US$	R$/ m3
Cash in $	**227,009**	**109.64**	**208,218**	**131.56**	**181,060**	**87.45**
Wood Logs $	227,009	109.64	208,218	100.57	181,060	87,45
Carbon Credit $				31.00		
Green timber volume **M^3**	4,762		4,762		4,762	
Useful area **Ha**	1,860		1,860			
Cash out $	**132,607**	**64.05**	**132,607**	**27.85**	**93,809**	**19.70**
Administration (total) **$**	42,717	20.63	42,717	20.63	31,774	6.67
Manager **$**	11,346		11,346		11,364	
Forest worker **$**	4,255		4,255		4,255	
Forest engineer **$**	1,080		1,080			
Forest wardens**#**	2		2			
$** Food **$	798		798			
Housing and Transport **$**	1,192		1,192		715	
Accounting **$**	3,712		3,712		2,227	
Divers Materials**$**	2,165		2,165			
Rural Tax **$**	1,435		1,435		718	
Data processing **$**	1,754		1,754		1,754	
Telephone/ Fax**$**	402		402		402	
Vehicle **#**	1,913		1,913		1,913	
Fuels and lubrication**$**	3		3		2	
Keeping**$**	1,584		1,584		1,056	
Insurance and IPVA**$**	8,009		8,009		5,339	
	3,073		3,073		2,049	
Log extraction (total)**$**	89,890	43.42	89,890	43.42	62,034	13.03
Forest workers**$**	48,446	23.40	48,446		31,347	
#	17		17		11	
Food **$**	6,102	2.95	6,102		3,948	
Road construction **$**	9,866	4.77	9,866		3,946	
Km	5		5		2	
Winch tractors**$**	18,571	8.97	18,571		18,571	
#	3		3		3	
Chainsaw**$**	4,222	2.04	5		4,222	
#	5		2,683		5	
Tags**$**	2,683	1.30	58,181			
#	58,181					
Cash balance (Without Carbon Credit)	**94,402**	**R$ 46**	**75,611**	**R$ 37**	**87,251**	**R$ 68**
Cash balance(Including Carbon Credit)				**R$ 68**		**R$ 68**