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I have been asked to present my initial thoughts on the Carbon sequestration potential of a new forestry approach, the Generation Forest, as presented by Futuro Forestal S. A. The current research work and development of the Generation Forest model is supported by the Good Energies Foundation.

I have worked in the field of 'carbon forestry' for roughly 17 years. During that time, I have designed, developed, certified, validated, verified and registered forest carbon projects, as well as, brokered forest carbon credits from projects all over the world. I spent a number of years working on Afforestation/Reforestation (A/R) project activities – much like the early stages of the Generation Forest. More recently, I have focused more on Reduced Emissions from avoided Deforestation and Degradation (REDD) projects – much like the latter stages of the Generation Forest. While the Generation Forest concept represents the logical evolution of a number of active forest management activities, it is startling to realize that these concepts are not commonplace in the tropical forests of the world. Forestry professionals in temperate countries regularly engage in phased, multi-aged, multi-species silvicultural activities with a focus on long-term ecologic/economic sustainability with continuous harvest and the maintenance of constant forest cover. For a number of reasons, this has not often been the case in tropical forests.

For a number of years I have watched as Futuro Forestal developed an innovative forest management approach. Starting over 20 years ago, they were the first Central American forestry services company to establish native species plantations as part of a commercial reforestation activity. Their early work, including the first Forest Stewardship Council certified plantation in Panama, established them as a company that pushed boundaries and sought more out of tropical forestry activities. They were trying to develop and promote a more holistic vision about the future of tropical forestry, a vision that showed how native species and reforestation could help to heal the many wounds left behind from previous, more extractive forestry activities. This goal has led them to develop the Generation Forest concept. A vision of commercial forestry that embraces complexity, as does nature. Their vision has a multi-aged, multi-species, native species focus. Generation Forest rightly allows for local conditions to influence management decisions about; species assemblages, planting spacing, selection harvesting, shelterwood thinning, thinning intensity, monitoring frequency and the inclusion of economic, financial, political, institutional and technological conditions. The Generation Forest is designed to generate value, and revenue, at many steps along the way, and then continue to do so for the long haul.

The Carbon sequestration potential of the Generation Forest concept, in Panama, is encouraging. The Carbon baseline land use activity that I will compare Generation Forest

activities to, are highly degraded cattle pastures. This fits with the past experience of Futuro Forestal, and is representative of all of the lands that they currently operate, and that I have received monitoring data from. Lands put into Generation Forest have been deforested and grazed extensively for years, to the point where the soil conditions and nutrient quality is so low that they aren't even chosen to support monoculture forest plantations. Therefore, the baseline is very little aboveground biomass, mostly in grasses, very little belowground biomass and exceedingly low levels of soil carbon. This baseline land use, if left alone, has been shown to need decades to develop into a secondary forest (depending upon site conditions). From a macro-ecological and macro-economic perspective, Generation Forests could take the worst soils and get forest to grow on them and leave soils that are apt for agriculture to food production, instead of monoculture forest plantations. A societal and ecological win-win.

The sequestration scenario, for the Generation Forests, include the following Carbon sinks:

- Aboveground tree trunk biomass (directly measured & monitored);
- Aboveground biomass (use of IPCC expansion factors for limbs, branches & leaves);
- Belowground biomass (use of IPCC expansion factors for roots);
- Deadwood (can be directly measured or use of IPCC expansion factors);
- Leaf litter-soil organic mat (can be directly measured or use of IPCC expansion factors);
- Soil Carbon (can be directly measured or use of IPCC expansion factors);
- Durable forest products harvested from Generation Forests (thinning and selective harvest trees).

Futuro Forestal has established roughly 55 fixed, permanent plots as part of its Generation Forest monitoring program. The monitoring program measures indicators related to forest tree growth, floral & faunal biodiversity and socioeconomic impacts of their activities. The direct measurement of Carbon cycling, and the sinks above, is incomplete. They have measured only the first of the 7 Carbon pools that can influence the sequestration capacity of their work. Therefore, I need to speculate on most of the issues related to Carbon sequestration. Many questions remain: Formal measurement of actual baselines (including soil carbon content), how long-term carbon sinking occurs in highly degraded soils (ultisols, alfisols and oxisols) in Panama, what is the rate of sequestration in biomass over time (above and below ground & short term establishment vs. closed canopy growth), the role of harvested wood products in overall sequestration rates, the role of canopy gaps created by selective harvesting on overall closed-canopy forest growth rates, rates of leaf litter decay, rates of deadwood decomposition, questions about belowground biomass by forest type (likely using IPCC expansion factors), and a thorough analysis of leakage and direct emissions related to establishing and operating a Generation Forest in Panama.

Taking the available data, from a recent study done by University EARTH, that established and monitored 55 permanent monitoring plots across 9 different Futuro Forestal reforestation-plantation sites in Panama. The study looked at forest tree growth on reforestation sites from 1999-2013 with a variety of species, planting plans and differing levels of mixed species assemblages. I have simplified the data to provide a coarse estimate of the first phase of Generation Forest sequestration rates on a tCO2/ha/yr basis, which is a standard metric for forest carbon projects. Please note, the permanent plots were 1,000m^2, and I scaled them up to hectare size assuming homogenous growth across the site.

Reforestation site	Year of forest establishment	Average tCO2 (in above-ground biomass)	Average tCO2/ha (extapolated from plot scale, multiply by 10)	Average tCO2 on that finca (multiply average tCO2 by the área in hectares)	Average tCO2/ha/year sequestered after planting (data gathered in 2015)
Palmas Bellas, Darien	2008	17.99	179.9	179.9 * 200 = 35,980	179.9/7= 25.7
Kapok, Darien	2008	12.4	124	124 * 54 = 6,696	124/7=17.71
Santa Rita, Colon	2011 & 2014	Too small to measure		44 hectare farm	
Manuel Castillo, Veraguas	2013	Too small to measure		15 hectare farm	
La Torcaza, Veraguas	2012	Too small to measure		200 hectare farm	
Katival, Las Lajas	2011	Too small to measure		48 hectare farm	
Los Rios 2, Las Lajas	1999	31.28	312.8	312.8 * 5.8 = 1,814	312.8/16=19.55
Silimin, Las Lajas	2011	Too small to measure		10 hectare farm	
La Concordia, Las Lajas	2011	Too small to measure		8 hectare farm	

Data gathered from "Establecimiento y medición de Parcelas Permanentes do monitoreo (PPM), en fincas forestales de las regioned de Darien, Chiriqui, Colon y Veraguas. Futuro Forestal-Panama." Septiembre, 2015. Carlos Bojorquez, Abner Mendoza, Adrián Odio, Norman Reyes, Sergio Curruchiche y José Maldonado.

The variability in the monitoring data of various plantations, while they have the same monitoring protocols, is due to the forests having been established for different purposes and with different species, different initial soil qualities and many other variables which complicate the analysis and interpretation. That said, on the monitoring plots in the Darien and Las Lajas, where the trees were big enough to measure their bole-wood (tree stem or trunk), they indicate an annual stem-wood sequestration rate of between 17-25 tCO2/ha/yr, with a conservative average, across all reforestation plots, assumed to be in the 14-21 tCO2/ha/yr. This aboveground stem-wood growth rate is similar to many other A/R projects throughout Central America.

The aboveground growth rate noted previously is assumed to last for roughly 10-12 years. That is roughly the time it will take to reach canopy closure in the plantation. At that time, the Generation Forests, proposed to implement a first thinning and enrichment planting. The idea is to remove commercially viable, early successional species and establish later successional species (hardwoods) in the understory. Selective forest thinning continues until about year 30, after which the structure of the forest is managed through selective logging. Space is created in the canopy, or the understory, of the forest by removing specific individual trees and regeneration is either enriched with planting or the seed bank is assumed to have sufficient seeds to support forest renewal. After year 30, it is no longer a plantation, but a continuous cycle of forest management on a closed-canopy, established forest. Harvested wood products are likely to be high quality, fine tropical hardwoods - meaning the carbon stored in them will stay out of the atmosphere for an extended period of time. Additionally, after 30 years there will

be a thorough and thickening organic root mat on the soil surface. This root mat, dramatically increases on-site biomass accumulation, specifically noted as increased soil carbon.

I anticipate that a well-managed, closed canopy Generation Forest will continue to grow and sequester biomass. Even after a 2nd or 3rd cycle in the Generation Forest, I anticipate slightly lower carbon sequestration rates as compared with the early plantation establishment phase, but further research is needed in this area. The change of sequestration rate will be principally due to the forest successional transition from sun tolerant species to shade tolerant species, the dramatically increased number of stems per hectare in the more mature ecosystem, and it will also be due to the active management and creation of continuous gaps in the canopy that facilitate new growth throughout the structure of the forest. Canopy gaps are vital for the creation of a multi-age, multi-species forest. With canopy closure and a thick root mat, on-site soil carbon sequestration will take place more efficiently and could complete with biomass accumulation for the most important element of carbon sequestration on site.

There is a need for future research on the Generation Forest model. What are the carbon benefits on a long-term, actively managed forest that was established on highly degraded soils? How does it compare to extensive cattle ranching? Given that we have long histories of what abandoned cattle ranches do, it is timely to study what would happen to carbon pools under an established, diverse, native species forest. I predict that aboveground, bole-wood Carbon sequestration rates under the Generation Forest model will be maintained around 14-21 tCO2/ha/yr for the first growth phase and then taper off slightly during the second and third 30 year cycles. I anticipate the rate of sequestration of soil carbon to dramatically increase during the same time, but overall biomass growth could be similar throughout – depending upon the intensity of desired management activity and selective tree harvests.

I present my opinion above having physically been to many of Futuro Forestal's managed forests in Panama. I have seen the work and know some of the team, as well as having looked at the recent research done by: Universidad EARTH, ANCON (Rapid Evaluation of Forest Species' regeneration under plantation conditions), Guillermo Navarro's overview of Generational Forests as permanent forest production system.

Carbon credits will be able to play a role, as a revenue stream, in the financial flows for a project like the Generation Forest. It will not be a major financial contributor, but it will be able to easily generate something in the range of $40-$100/ha/yr[1]. That can be important in adjusting where profitability occurs. Alternatively, the certified carbon credits from Generation Forests can be used to directly offset the carbon footprints of the investors in the forest. A mixture of these approaches could also work, where investors get the credits they need/want and the remainder is sold on the market to enhance revenue streams.

If you have any further questions, please contact me directly.

Sincerely,
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[1] Depending on credit sales prices for ONLY aboveground Carbon credits, and the brokerage commission. I assumed a sales price of US$3/tCO2 & US$6/tCO2, with a commission of $1/credit.