Universität für Bodenkultur Wien
University of Natural Resources and Applied Life Sciences, Vienna

Department für Integrative Biologie
Institut für Botanik
Univ.Prof. Dr. Peter Hietz

Proposal for the BOKU Carbon Offsetting System

Reforestation in La Gamba/the Golfo Dulce region, Costa Rica

Background

La Gamba is a small village in the Golfo Dulce region of Costa Rica. The region was deforested and settled in the 1930s to establish banana plantations. When a disease became uncontrollable, plantations were abandoned and the land was handed over to the workers, who previously had little background in agriculture. Since that time, economic life has been dominated by small-scale agriculture. After the forest of the Corcovado peninsula, which had remained largely intact, had become a national park in 1991, the forest in the vicinity of La Gamba was also designed to become a national park (the Piedras Blancas NP) but large parts were privately owned. An Austrian initiative, which became the NGO "Regenwald der Österreicher" ("Rainforest of the Austrians"), played a substantial role in compensating landholders. (The name may be somewhat misleading because the rainforest does not belong to the Austrians but to Costa Rica, nevertheless it creates a helpful identification for the mainly Austrian supporters). An eco-lodge, established with help from Austrian development aid at the edge of the primary forest, is now one of the few local employer. A nearby research station (Tropenstation La Gamba, www.univie.ac.at/lagamba), established in 1994 has been the base of Austrian (and other) research in tropical biology and other sciences. It has a local staff of 15. A few people from the village found work in nearby towns or on palm oil plantations.

In 1996 a project of the Fundación Neotrópica was launched that promoted reforestation with useful tree species by farmers, which also resulted in several farmers establishing tree nurseries and a guide to propagating and planting trees (Barquero Palma et al. 2012). Other aspects of the project were organic farming, compost production and a co-operation of women producing handicrafts. Since 2006 the strategy has been to reforest plots outside the national park in order to create a biological corridor through the cultural landscape between the protected areas in the lowlands and lower montane forests (Weissenhofer et al. 2008). The project is coordinated by the Field Station, recently with scientific contributions from Peter Hietz. To date, some 45 ha have been reforested with more than 36 000 trees. The prime purpose of the reforestation being conservation, a substantial effort went into planting a high diversity of (over 100) local tree species, which are propagated in a local nursery and cared for during the first years after planting. The Finca Modelo, where the nursery is located, is also a showcase for small-scale agriculture and home-gardens to promote a diversity of crops to local farmers. The field station and the NGO have excellent relationships with the local community: a visit of local schoolchildren to the station, a football-match and a "day of the tree" where seedlings are given to farmers and generally the promotion of environmental awareness are regular activities. On the more practical side, apart from directly employing a few, they have been active in directly financing or helping to find funds for local community infrastructure and stipends for children to attend college. Foreign guests are also visiting and encouraged to support the village. Due to the establishment of the national park, law enforcement (the NGO also finances some forest guards) and environmental awareness campaigns, illegal logging and hunting, though still occurring, have been substantially reduced. The social and economic situation in the village and the effect of the national park have been analyzed in a student project[1]. While Costa Rica is not a Least Developed Country, the local community certainly is poor with few options for generating income and is thus eligible for a project under the BOKU Carbon Offset call.

More recently the planting took place on mostly marginal land purchased for reforestation. For various reasons the planting by the farmers on their own land did not really take off, even though the National Fund for Financing Forestry (FONAFIFO) provides additional payments for ecosystem services. One reason is that given their economic situation farmers seek more immediate returns, the other that under the strict Costa Rican forest protection laws, applying for a permit to cut trees planted on one's own land and also applying for FONAFIFO support appears onerous for smallholders. During the past years many farmers therefore switched from food crops and cattle to palm oil plantations. These promise good profits, but a large package of agrochemicals is usually applied. In general the biodiversity of oil palm plantations is very low.

Intervention logic

Tropical reforestation is among the most efficient ways to sequester CO2 from the atmosphere. Initial growth in tropical rainforests is very high. In addition, reforestation counteracts the very high net deforestation in tropical countries and contributes to the protection of local biodiversity, watersheds and soils. Under various CO2 compensation schemes, many projects have been initiated in developing countries whereby local communities obtain financial or other benefits from reforestation or forest protection. Costa Rica is among the few tropical countries that have made ambitious commitments for reducing CO2 emissions, with a strong emphasis also on reducing deforestation and active reforestation. This ensures a supportive policy framework important for the long-term success of such a project.

Substantial experience exists with local reforestation (obtaining seeds, providing and caring for trees, organizing local work etc.) where the focus has been biodiversity protection (see above). Because the project goal has been ambitious - planting some 100 different species in relatively dense rows and attempting to create a natural forest fast – it is also relatively costly. An initial estimate of costs arrived at c. 50 € per t CO2 (including a BOKU project overhead and monitoring; Stoderegger 2014). Alternatively, the land could be left fallow to permit natural succession, which would not incur additional costs, apart from monitoring. Natural succession will be slower than reforestation but can still be quite fast (see below). However, on many deforested areas aggressive introduced grasses or native ferns outcompete tree seedlings, arresting natural succession for many years so that simply waiting appears a poor strategy. It is therefore planned to

[1] Goff D., Kleinschmidt S., Ivaylova Petrova M., Söderlund S. 2014. Conservation areas in developing countries – poverty traps or treasures?

shift to a more cost-efficient intervention plan such as the framework species method (Lamb 2011) whereby the initial planting will be mainly with a lower number of fast-growing pioneer species, including nitrogen fixing *Inga*, which outgrow herbaceous vegetation within one year and soon provide sufficient shade to suppress grasses and permit the establishment of late successional trees. Since growth and survival of trees have been and will continue to be monitored for the past two reforestation projects, there is good information on the best species to use. Also a large trial in Panama provides useful experience (van Breugel et al. 2011a). Species to be planted include some fast-growing pioneers (*Ochroma, Schizolobium*), but also mature forest trees (*Ceiba, Terminalia Anacardium*) and legumes (*Inga, Platymiscium*). After the establishment of sufficient shade by fast-growing pioneer species, the succession will be monitored and important late successional species can be planted, if they do not establish themselves.

Initial planting of the 14.6 ha available immediately will take about two years (incl. replacing died trees and weeding for the first 2 years, "Project phase 1"). During this time, people from the local communities will be paid as workers, gaining experience in planting and caring for the trees. Some tasks are also outsourced to foster small business by purchasing e.g. compost and seedlings. Monitoring of the planted trees will continue for another 28 years ("Project phase 2"). To plant additional areas, we will encourage greater contribution and ownership of local stakeholders. During the first three years community meetings will be held, interested farmers will be able to compare the different approaches, learn techniques and discuss their priorities. Subsequently, one or all of three strategies can be followed. This and the monitoring and reporting of the planting on the first area will be the main tasks of the project employee at BOKU. One is planting trees on other land made available by "Regenwald der Österreicher" or other conservation groups with no interest in using the land. In this case the legal protection of the land is guaranteed and local stakeholders will be involved as workers or as suppliers and private entrepreneurs. A second is planting by landowners on their private land, in which case the landholders themselves will be paid and will be responsible for the reforestation. We will monitor progress and discuss strategies and prices individually. A landholder may decide between a biodiverse-rich forest, which requires more effort but will be valued higher, a plantation to sequester carbon, or an agroforestry system where trees or other products can be harvested but long-term carbon sequestration and hence the price paid will be lower. The landholders will in any case get technical support, but otherwise can decide if to do everything by themselves, employ labourers, purchase trees or compost from others or organize in co-operatives. A third strategy would be planting on public land that is not used but where spontaneous succession is impeded, for instance by dense competing vegetation. In this case the carbon credits are shared by those carrying out the reforestation. We will probably organize the first trails ourselves (a few trees have already been planted in cleared fern fields). If a successful strategy is seen, this should also be taken over by locals. In this case also persons without land tenure would benefit and be empowered. Planting on further areas will depend on continuous project support.

In contrast to many indigenous communities elsewhere, the Latino community in the area has no tradition of communal land management and we therefore do not intend to promote a co-op. If one is established, we will work with a co-op, but otherwise with individual stakeholders.

Silviculture in the area is uncommon, maybe because trees used to be taken from the nearby primary forest. Since the national park was installed in 1991, logging is forbidden and wood for fuel and construction is scarce. In addition to reforesting for conservation, the objective of the project is therefore to promote silviculture and agroforestry on farmers' land. The basis for this has been laid, but barriers for a more widespread use still need to be overcome.

Methodology

Currently, an area of 14.6 ha is available on Finca Alexis, land owned by the NGO in San Miguel for immediate planting. The total area of the farm is 76 ha, in addition to the pasture, some is covered by secondary vegetation of various age and 5 ha by a poorly-growing teak plantation. San Miguel is a small community located c 10 km from La Gamba on the foothills of the Fila Cal, where access is not easy and infrastructure is poor, so that people tend to move out and leave their fields fallow or sell their land. The Finca is accessible by road, crossing a ramshackle bridge, and holds a house, which lacks water supply and other basic infrastructure. We have agreed with the NGO that if the area is planted via the BOKU carbon offset project, they will provide the necessary basic repair of the road and the house, so that workers can stay overnight and access is guaranteed.

During the previous project several farmer, including one in San Miguel had established successful nurseries, another one is producing compost. To increase the number of local people involved, we will seek to purchase trees and compost locally, also because seedlings should be pre-grown in the local climate.

A main challenge of the project will be to promote planting on farmers' land. While the knowhow, infrastructure and community contact are all well-established, landholders are reluctant to invest resources and time for long-distant gains. Here, direct payments for CO2 sequestered, the amount of which will be monitored via the project, may provide a vital incentive. In addition, we will organize and help farmers in their dealings with Costa Rican authorities, which is necessary to obtain logging permits and can help to obtain additional funds via FONAFIFO.

While myriad informal contacts between the Research Station and locals exist, information on the community living around the project area is not systematized. Thus structured interviews to identify the priorities of the local community as well as "Social Impact Assessment" based on the guidelines of the manual for REDD+ Projects "Social and Biodiversity Impact Assessment (SBIA)" should be part of the project planning.

Financial accounting basically follows the previous BOKU CO2 project. None of these currently meet the highest standards of internationally recognized CO2 offset projects, but we agreed to follow the Gold Standard as far as feasible. We expect that within the next few years, as more projects are managed through BOKU, we will strive to develop common accounting protocols.

The carbon price of previous projects by "Regenwald der Österreicher" varied substantially, based on project costs (from land purchase to labour) and intervention strategies, from waiting for natural succession to planting 100+ tree species in a complex scientific design. This latter experiment unsurprisingly was particularly costly and resulted in a carbon price of c. 50€/ton. For the proposed CO2 compensation project where we use fewer and faster-growing species and the exact arrangement of species is not important, the cost for planting trees and the necessary care (additional planting, weeding) during the first years will be c. 31 € per ton. This includes monitoring over 30 years, a 10% for unexpected costs (eg exchange rate fluctuations) and the initiation of the next project phase (see Excel sheet for details).

Carbon budget

Carbon sequestration

The rate of a forest's growth and the maximum biomass achieved differs substantially between forests, depending mainly on climate, soil and tree species. Tropical wet forests and forest plantations, unless severely limited by nutrients, generally have high growth rates and a high biomass of the mature forest. Most carbon is stored in trees. Aboveground tree biomass is estimated by allometric models and root biomass by an estimator for the root/shoot ratio. Soil carbon is mostly ignored by similar reforestation projects because it can be more difficult to quantify, changes are slow and the long-term dynamics is difficult to predict. While forests continue to accrete biomass for much longer, we use the project horizon of 30 years. Although initial growth rates are likely higher in a planted forest and they should have reached a more mature state at age 30 than naturally regenerating forests, our estimate is conservatively based on biomass in naturally regeneration as no comparable data for planted forests are available.

The quantification of carbon sequestration is well established. Many old and secondary forests in Costa Rica have been studied before (eg., Chazdon 2014). Allometric models relate tree size (diameter and, if available, height) and wood density to biomass. We will use a published model for tropical wet forests (Chave et al. 2005), which is based on a collation of global data and is the most widely used model for tropical forests. Some local and species-specific models for small trees exist and may produce more precise biomass estimates for individual species (e.g.van Breugel et al. 2011b for 26 species from secondary forests in Panama). However, it is unlikely that equations for all our species and large trees sizes will become available and we prefer not to mix models or change them when trees get larger or new models become available. Several previous and ongoing studies around La Gamba have measured trees in old-growth and secondary forests as well as in reforestation plots. These measurements are taken by students for their theses, volunteers working at the field station, or also local staff at the field station.

Published values for aboveground biomass (AGB) of tropical rainforests in Central America range between 125 and 474 t / ha. The Biodiversity and Ecosystem Functions (BDEF) project of the University of Vienna measured twelve mature and four secondary forests in the Golfo Dulce region, where La Gamba is located. Mature forests have a mean AGB of 254.7 t/ha, secondary forests with an estimated age of 30 – 40 years 161.8 t/ha (Table 1).

Forest type:	Secondary		Primary	
Cluster	30 – 40 yrs	ridge	ravine	slope
La Gamba	151.5	246.5	158.5	208.1
Piro	184.8	223.3	275.2	224.4
Rincon	191.2	385.2	267.4	347.5
Riyito	119.8	250.9	251.7	217.1
	Secondary		Primary	
Mean (SD)	161.8 (33.0)		254.7 (61.1)	

Table 1. Aboveground biomass estimates for mature and secondary forests in the project region. Estimates are based on measurements of tree height, diameter at breast height (dbh) and wood specific gravity (WSG) of trees > 10 cm dbh within 1-ha plots using the allometric formula $0.0776*(WSG*dbh*height)^{0.94}$ (Chave et al. 2005).

Twelve secondary forest plots, c. 6 to 55 years old, which were sampled in the area around La Gamba in 2015, suggest a somewhat higher aboveground biomass at age 30 (Fig. 1 right). Overall, the values reported regionally are fairly typical for tropical re-growing forests that on average accumulate biomass at a rate of 6.2 t / ha / yr over the first 20 years (Silver et al. 2000). Initial growth of reforestation plots can be fast, but also depends on the species composition (Fig. 1 left). A planted forest will likely have faster initial growth and rainforests in the region continue to accumulate biomass for several more decades, but since the time frame of the project is 30 years we use 165 t / ha as the background estimate for biomass accumulation. Biomass accumulation and carbon sequestration will likely not be linear over the 30 years, but for simplicity and lacking more precise data we will use a linear projection of carbon sequestration. Trees on several reforestation plots have been measured soon after planting (Hördegen 2011, Kleinschmidt 2014, Schnetzer 2014) and are being re-measured in a current project in 2015 and 2016. Although it is too early to say if biomass accumulation on these plots is above or below our estimate, biomass will in any case be monitored and projections, if necessary, adjusted.

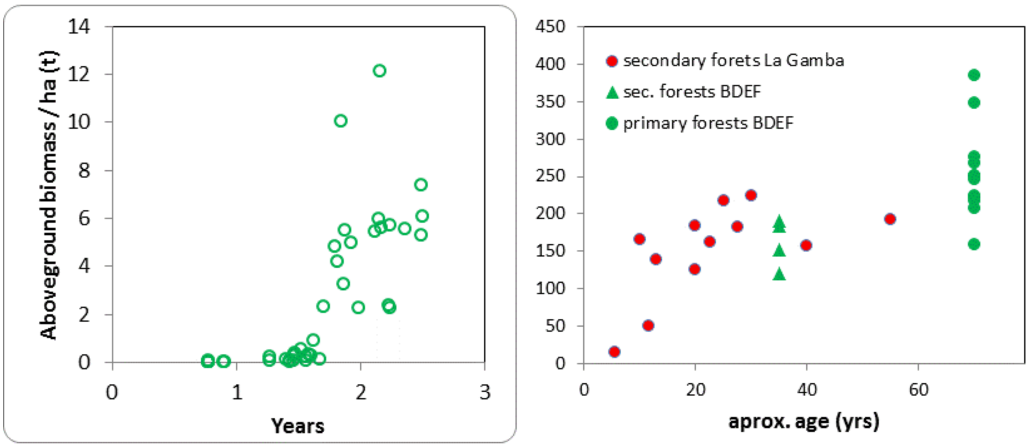

Fig. 1. Initial biomass accumulation in planted forests (left; individual points represent plots with different species combinations on Finca Amable, La Gamba) and naturally regenerating forests (right). Green symbols on the far right side represent old-growth forests.

Root biomass of forests is more difficult to quantify. A review of 39 studies from tropical forests found an average root:shoot ratio of 0.24 (Cairns et al. 1997). We use the formula to estimate belowground biomass by Pearson et al. (Pearson et al. 2005), which yields a conservative root:shoot ratio of 0.19.

Biomass carbon content is mainly the carbon content of wood, which is sometimes taken as 0.5, but more data for tropical trees suggest a value close to 0.48 (Martin and Thomas 2011). The carbon to CO2 conversion factor is 3.66.

Based on these calculations, we estimate a net carbon sequestration of 346 t over 30 years. If private land is included and landholders plan to harvest trees, we will define the amount to be harvested and discount this from carbon sequestration.

Baseline

For afforestation and reforestation projects for carbon sequestration the baseline needs to be defined, which is the carbon sequestration that would occur without intervention. On private land currently in use, we assume that the current use, generally pastures, would continue (i.e. the carbon sequestration is tree biomass accretion minus biomass in pastures) and use the reference value of 6.2 t biomass / ha (National default value; Reference: 07-01_2006 IPCC GfNGGI_Grassland, p. 27). If new land were purchased by the project, the baseline would also be carbon stored by the previous form of land use, but the price of land purchase would be included in the carbon price. On public land that is not in use and where natural succession could take place, the baseline is biomass accretion without intervention. To monitor this, we will leave unmanaged control plots (e.g. fern thickets) alongside reforestation plots. Some of the examined fern thickets around La Gamba are known to have persisted for decades without substantial forest re-growth, but we currently do not have the experience to predict how long this state continues. This is a risk, so carbon accretion minus the baseline and hence payments may be higher or lower.

Project-related emissions

Nitrogen fertilizer is energy-intensive to produce and results in N2O emissions, but the amount of fertilizer used is very small. Emissions due to transport and machinery are minor and do not have to be calculated because gasoline and diesel are not consumed heavily as part of project activities (Pearson et al. 2005). Transportation of the tree seedlings will be managed as environmental friendly as possible and will be done just once a week.

The estimation of leakage and risk is more difficult. Leakage is likely very low as farmers contributing to the project with their labour or farming area will be drawn in the activities of the project for income possibilities, mainly as an alternative to pastures. The chance of new areas being converted to pasture as a result are very low because land clearing is difficult get a permission for even of secondary forests on private land and forestry laws are being enforced. Some illegal logging is still taking place to extract wood, but here a forestry component of the project where individual timber trees can be harvested would be a disincentive to illegal logging. Also, if income shifts from cattle to trees, a reduction of the number of cows and their methane emissions is likely.

The risk is also considered low. The area is very humid and forests, even young ones in the dry season, do not burn. Trees can die from pests and abiotic stress, but this only affects individual trees and perhaps species and this mortality is included in the estimate of biomass accumulation. Costa Rica is a stable democracy with a long tradition of environmental. The country has made ambitious commitments to reduce carbon emissions, generating a general policy climate that is supportive of the project goals. Private property is respected and logging bans on public property are enforced.

We therefore add leakage and a risk to project-related emissions each with 5% of carbon sequestration.

Financial budget

See the detailed calculations in the Excel file “La Gamba Carbon and financial budget”.

Consideration of co-benefits

Apart from sequestering CO2, the co-benefits are manifold. The Golfo Dulce region is an area of high biodiversity and most of the native diversity lives in forests. The reforested areas, including those for silviculture, will provide stepping stones for the Biological Corridor between lowland and montane forests. Particularly in the montane forest area, tree cover provides important protection for water quality and soils. By involving the local community it can create a source of income via CO2 credits and on private land a potential important source of wood for a farming community. Environmental awareness will be promoted and people’s dealings with Costa Rican authorities will be supported.

The co-benefits will to some extent depend on the choices of the persons participating (e.g. production of timber and non-timber forest products or primarily financial rewards via carbon sequestration). So far, women have hardly been involved in reforestation, though in a similar project (http://www.bauminvest.de/) they comprise nearly half the workforce. A previous project in La Gamba encouraged the formation of an artisans’ cooperative producing handicrafts from local materials (the cooperative is no longer functional but several women are still involved in manufacturing). There should be no barrier for women to participate in the reforestation project and we will try to encourage this, but with insecure outcome.

Experience

Project leader Peter Hietz is professor at the Institute of Botany with a focus on tropical forest ecology, particularly in Central America. He is vice-head of the scientific committee for La Gamba and is involved in the scientific analysis and design of the reforestation project.

Project partner Anton Weissenhofer is co-director of the field station and the main person responsible for organizing the reforestation. During the past years, Daniel Jenkins, a Costa Rican forest engineer, has been supervising and monitoring planting and tree propagation on site. There are intensive and long-term research collaborations between the Field Station / University of Vienna, BOKU, the Universidad Nacional de Costa Rica and the Universidad de Costa Rica.

Previous theses on the reforestation project include land cover change (Höbinger 2010, Stender 2011), autecology and reforestation (Hördegen 2011, Hauer 2012, Kleinschmidt 2014, Schnetzer 2014), natural succession and their influence on biotic and abiotic factors (Horn 2012, Tichelmann 2012). Currently, three master theses on a reforestation plot (which includes a scientific planting design and also addresses questions of basic forest ecology) and three theses on secondary forests are carried out by students from BOKU, the University of Vienna and Belgium, co-supervised by Peter Hietz, Wolfgang Wanek and Anton Weissenhofer. A previous project in the region studied a teak plantation and involved several BOKU institutes.

The NGO “Regenwald der Österreicher” is providing land for reforestation, has been promoting reforestation and is supportive of research on their sites. It has provided additional resources for a complex planting scheme and is financing three of the master theses. We agreed that they would improve infrastructure at the Finca and do some road repairs in the case of a BOKU-led project on Finca Alexis. Other in kind contributions of project partners are the use of infrastructure (including the nursery at Finca Modelo), tools and the use of a pickup (for a moderate mileage fee) to transport seedlings. We did not quantify these contributions, but starting a similar project from scratch would incur substantial additional costs.

Integration into BOKU teaching and research

Research on the reforestation sites is an important focus of Peter Hietz at the Institute of Botany. Several other BOKU institutes have been and are actively involved in La Gamba. Institutes that would be encouraged to contribute are Forest Ecology, Silviculture, Agricultural and Forestry Economics and the Center for Global Change and Sustainability. Research questions for the proposed project could be the design and species selection for a framework species planting (previously trees were planted in a replicated design) and quantification of ecosystem services (including CO2 absorption and provision of wood).

The field station, and Costa Rica in general, are ideally suited for student excursions. A previous BOKU excursion was in 2012. In 2015 and 2016 excursions with mainly high-school students will take place in the frame of a current Sparkling Science project. A few years later, a BOKU excursion/field camp, during which re-measurements of planted trees could take place, should be organized. The topic would address primary and secondary forests, conservation and commercial plantations and, depending on the interest of students and researchers, might include tropical agriculture, tourism, landscape planning and other fields.

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