Ecological Restoration of a Cloud Forest in Costa Rica

by Stephan Lehmann

1. Problem description

After climate change has found strong acceptance in the public and media and politics – due to the enormous public pressure – are now starting to take counteractive measures, protection and restoration of the nature have become keywords used almost inflationary in any context. Special attention appertains here the protection of the forests worldwide and particularly the various forest types in the tropics which partly disappear by wood clearings even before they have been explored. One of this respective sensitive ecosystem is the cloud forest of Central America captivating by its unique diversity of species and the rarity of many biocoenosis. Component of this cloud forest area is the „Oak-Cloudforest“ (STADTMÜLLER, 1987) in the Talamanca mountain chain in Costa Rica/Panama for whose restoration my dissertation is to be realized.

According to the STATE OF THE WORLD'S FORESTS (FAO-WALDBERICHT) from 14.11.2005 wood clearance and steppization of the earth's surface still remains alarming. However, the rate of the worldwide wood decline receded. While the forest areas declined by 8,9 million ha/year between 1990 and 2000, this value decreased the following years until 2005 to 7,3 million hat (FAO-WALDBERICHT, 2005). The total decline of the forest results from the sum of the lost areas (i.e. by clearings) and the already restored forest areas. The damage caused by wood clearing is 13 million ha every year. By reforestation programs these losses are partly relieved so that there remains a decline of 7,3 million ha each year. Out of this the high global significance of reforestation programs become visible.

Although due to political, social, economic and ecological reasons Costa Rica is often called as a Hispanic model country, even there the forest decrease is extremely appalling. Costa Rica once was almost totally forested but because of innumerable clearings undertaken especially for grazing lands constituting now 46 % of the state's area (WRI, 1997), the percentage of the wooden areas in Costa Rica is about 28 % as per estimations of the FAO (FEDLMEIER, 1996).

2. Relevance and content

As the scientific area “Ecological Restoration” is still young and also the cognitions for the restoration of tropical cloud forests are only existent in a small scale, the relevance for the realization of the dissertation is very high. Therefore it is direfully necessary to develop strategies and achieve solutions for the reforestation of cloud forest areas.

Subjective of this dissertation is the testing of model projects for silvicultural procedures for the installation of reforestation areas in the cloud forest areas of the ‘Talamanca mountains. It has to be examined which structure of the area to be restorated assures the best way of reforestation. The temporal and spacious structure of the areas will be diversified, i.e. how does the the temporally shifted planting of different tree species effect for instance the growth and the vitality of the trees and in which way determines the choice of the tree species and the spacious location the appearance and the silvicultural parameter of the trees.

The dissertation consists of firstly the documentation of the practical installation of the sample area and secondly of the inquiry, estimation and comparison of data relating to the growth and the vitality of the planted trees as well as the biodiversity. In doing so, specific characteristics of the different models have to be developed and identified.

As a matter of course, maintenance and further monitoring of the sample area is aspired after finishing the dissertation. This could be ensured by the Cloudbridge Reserve. It is desirable to use and supervise the sample area prospectively as a permanent research object.

On the basis of the knowledge gained of the dissertation, an ecologically correct restoration of the cloud forest area surrounding the Cloudbridge Reserve should be assured. In the course of this project scientific funded regulations for the installation of restoration areas in the cloud forests of the Talamanca Mountains could be developed for the first time. The won experiences would equally constitute as a model for other cloud forest areas on earth (e.g. in South America or Central Africa.

3. Problems / Questions

a) Practical installation of an investigation area

- Is a special preparation of the area necessary?
- When should be planted (within the course of a year)?
- How should be planted (planting procedure)?
- Are fostering measures necessary? If yes, how should the fostering be executed (cycle, type/form of fostering)?
- Should other plants (especially bushes) be implicated for supporting the growth behavior of the trees in the first years of growing?

b) Inquiry and investigating of data

- How is the growth behavior and the development of the tree species of the different plots to be evaluated?
- Which factors take a constitutive impact on the growth and development of the examined tree species?
- How is the species composition of the sample areas varying due to the course of the inventory period?
- How is the biomass development of the several plots to be evaluated?
- Is there a coherence between biomass development and biodiversity?
- Which species composition of which plot is most similar to that of the primary forest?
- After 3 years supervision, is there already a tendency visible which plot is the most qualified for the restoration of the surrounding degraded areas?

4. Investigation area

The dissertation should be proceeded in the Cloudbridge Reserve in the southern Central Costa Rica in a secluded cloud forest area on the hillsides of the Cordillera-Talamanca-mountain chain. The reserve is a non-profit protection project for the reforestation of the cloud forest. The size of the reserve is about 174 hectares and the height circumference ranges from 1.565 m over sea level to 2.600 m over sea level. It is located directly to the Chirripo National Park (UNESCO world cultural heritage). It is part of the unique nature area cloud forest whose areas – as is known - are heavily declining worldwide. The cloud forest of Costa Rica is habitat for several endangered animal species, e.g. the Resplendent Quetzal or the tapir, and contains a plurality of organisms still to be identified.

5. Methods

5.1. Structure of the sample area

The investigation area should be composed of 4 model plots and one reference plot with 4 repetitions each which are allocated coincidently on the investigation area. The size of each single plot amounts to 400 m² (20 m x 20 m). The tree to tree distance is – according to recommendations of ROJAS (2001) – 3 m x 3 m. Resulting from that there is a number of 36 trees per plot. The total size of the investigation area is about 0,8 ha.

It follows a description of the separate models:

0 –Reference Area– no inserting of plants:

It is not intervened in this area and it will be left to its own resources. Naturally running succession allowed.

1 – Use of medium and fast growing tree species:

Trees representing subsequent succession stadiums are inserted. With that a canopy for other shade tolerant species should be created and a nearly ultimate species composition should be achieved.

2 – Use of fast growing, short-lived tree species:

Tree species representing early succession stadiums are inserted. With that a canopy for colonisation species from the near primary wood should be created.

3 – Concurrent use of fast, medium and slow growing tree species:

Tree species representing all succession stadiums are inserted simultaneously. With that a canopy of fast and medium growing tree species should be created for the shade tolerant slow growing species.

4 – Temporary shifted use of fast, medium and slow growing tree species:

Tree species representing early and medium succession stadiums are inserted. With that a canopy for the more shade tolerant, slow

growing tree species should be created which will be planted after successful canopy creation (ca. 4 years).

Basis for the selection of the tree species to be used are my diploma thesis "Untersuchung zur Eignung von Baumarten für die Anlage von Renaturierungsplantagen am Beispiel des ‚Cloudbridge'-Reservates in Costa Rica" (LEHMANN, 2006) and the currently processed project from Ivo Polach „Monitoring and Assessment of Biodiversity at the Cloudbridge Nature Reserve, Costa Rica" (see Chapter 5.1.3.). Furthermore, the classification in pioneer-, successor- und climax tree species is conducted due to aut-ecological factors, i.e. size and weight of the seed, due to preference of different insolation, due to leaf shape, size and consistency etc.

5.2. Special methodology

To 3. a): Practical installation of the investigation area

Before the practical installation of the investigation area the territory should be inspected with the Management and the staff. The following factors should be taken into consideration:

- Available resources (e.g. staff, financial resources)
- Guarantee of the realization of the later maintenance measures
- Compulsory outcomes and additional, desirable outcomes
- Initial condition of the restoration area (rate and homogeneity of the destruction in this area)

After the audit a final determination of the planting procedure and based on the existent initial condition of the area to be restorated as well as the available means a finalization for the planting procedure and the means of work and staff should be defined.

To 3. b): Inquiry and investigating of data

For the evaluation of the growth and the development of the trees, of the biomass development and for the determination of the amount of canopy it is essential to identify silvicultural basis data including the height of the trees, the diameter at breast height (BHD), the diameter at stem base (WHD) and the crown radius. For the evaluation of the biomass development all existing trees – not only the planted ones – have to be taken into

consideration. Additionally, the following data for a full estimation of the growth situation of the trees will be collected: slope angle, grade and type of theground cover, crown competition and vitality of the trees by means of reserve specific vitality codification (cp. LEHMANN, 2006). Furthermore, a damage analysis of the planted trees will be executed. The determination of the data needs to be done once a year.

Likewise each year per plot a estimation of the biodiversity according to the method of BRAUN/BLANQUET (1964) has to be realized.

The analysis of the data will be realized by standard methods of statistics, e.g. variance analysis, T-Test or regression analysis.

For the measurement and evaluation of the biodiversity the following publications inter alia will serve as a basis: ZERBE/KREYER (2006), MAYER (2006), SCHMIDT et al. (2006) and FEEST (2006).

6. Restoration Ecology – Status of the research

Already in 1987 BRADSHAW wrote that „a successful restoration of a destroyed ecosystem constitutes an evidence of our understanding for this ecosystem". Nothing has changed on that until today. The many failed forestation trials demonstrate this matter of fact.

The certainty of the manifold terminologicals which describe the return of the ecosystem into a primordial and which are partially used as a synonym for restoration, reveals the high need for research in that sector. In order to correctly characterize the used phrases like remediation or rehabilitation of ecosystems, the terminologicals mentioned in the context with "Ecological Restoration" are clarified in the following paragraph.

6.1. Ecological Restoration - Definitions

In the scientific field of "Ecological Restoration" there are basically four phrases in usage – „Restoration", „Rehabilitation", „Remediation" and „Reclamation" (BRADSHAW, 2002), however, there exist also other but less meaningful ones (BRADSHAW, 1997). In the following these phrases are directly defined from English as the german translations could be understood mistakably.

What does "Restoration" mean? The appropriate definition provides the OXFORD ENGLISH DICTIONARY (1971): „the act of restoring to a former state or position...or to an unimpaired

or perfect condition". To restore is: "to bring back to the original state...or to a healthy or vigorous state".

The different possibilities to ameliorate a demoted ecosystem can be characterized with two key features – structure and function (see BRADSHAW, 1987b). The NATIONAL RESEARCH COUNCIL (1992) mentions in its definition of „Restoration" these two main characteristics. Here „Restoration" is defined as an ecosystem returning to the condition very near to that before the demolition. In case of a „Restoration" the ecological detriment inflicted to the environment will be repaired. Both structure and function of an ecosystem will be reestablished.

Merely establishing the appearance or shape without the functions or function in a simulated configuration only showing an affinity to a natural resource, does not constitute "Restoration". The subjective is to create a natural, efficient, self-regulating system which is integrated in the ecological landscape in which it exists.

The two above-mentioned definitions implicate the return of the ecosystem to an origin, healthy or ideal condition. For the SOCIETY FOR ECOLOGICAL RESTORATION (1996) „Restoration" means the process of supporting recovery and generation of ecological diversity or completeness. Ecological diversity comprehends a certain scope of variability of biodiversity, ecological processes and structures, regional and historical interrelations and adhered cultural practices.

„Rehabilitation" is defined in the OXFORD ENGLISH DICTIONARY (1971) as " the action of restoring a thing to a previous condition or status". The condition of the ecosystem after "Rehabilitation" approximates to that before the destruction of the ecosystem but is usually shortly equivalent to it.

6.2. Restoration plantings

Restoration plantings are defined as agricultural ventures "with the subjective to try to reestablish the original silvicultural ecosystem" due to LAMB et al. (2005).

Two general approaches have been tested successfully under the following conditions:

- The usage of a small number of fast growing short-lived trees representing the early succession stadiums. With that a canopy stand will be created which ensures the

colonization of the area for a high number of tree species from the near intact forest (zoochor seed dispersal).

- The usage of a major number of medium and slow growing tree species representing the later succession stadiums. With that a Schirmbestand will be created for the planting or cropping of further shade tolerant species and a nearly definitive species composition of the forest (cp. POHRIS, 2006).

In this dissertation both approaches and mixed forms will find usage for the installation of the investigation area.

6.3. Significant publications for the realization of the dissertation

An essential preliminary work states my own thesis „Untersuchung zur Eignung von Baumarten für die Anlage von Renaturierungsplantagen am Beispiel des ‚Cloudbridge'-Reservates in Costa Rica" (LEHMANN, 2006). It investigates the elementary qualification of different tropical tree species for the restoration of the mentioned investigation area and the impact of environmental influences on the growth and the vitality of the tree species. An english summary of the results can be found in the internet under http://cloudbridge.org/forestry_economics.pdf.

Furthermore, a preparatory work with a high significance is ongoing in the „Cloudbridge Nature Reserve" at the moment. In 2006 and under the direction of Ivo Polach from the Smithsonian Institute (USA) a one hectare investigation and monitoring area was installed in a primary wood directly bordering the area to be restorated. Amongst others the intention of this project is to collect and describe the totality of the plant species in this investigation area. The knowledge of the plant and especially tree species of the primary wood is indispensable for a promissory pilot plant for the ecological restoration of this area. An „Interim Report (Status: January 2007)" of this activity is already on hand.

The article „Tropical Montane Forest Restoration in Costa Rica: Overcoming Barriers to Dispersal and Establishment" from HOLL et al. (2000) in the magazine *Restoration Ecology* Vol. 8 researches the natural dispersion of seed, the survival stategies and the growth of the seedlings, the planting of autochthonal tree seedlings and the drilling of bushes to find out which factors have an impact on a successful restoration and which restoration strategies could be used in the future.

A general disquisition on the restoration of tropical rain forests provides KAREN D. HOLL (2002). In her disquisition called „Tropical moist forest“ she describes the limiting factors opposed to a recovery of the ecosystem as well as important strategies to accelerate the recovery of the ecosystem rainforest.

How and under which aspects the development of the restoration is correctly supervised and monitored is also recorded by KAREN D. HOLL in cooperation withJOHN CAIRNS JR. (2002).

More publications used for the dissertation are: „Restoration Ecology in Europe“ (URBANSKA/GRODZINSKA, 1995), „The Tallgrass Restoration Handbook“ (PACKARD/MUTEL, 1997), „Repairing Damaged Wildlands“ (WHISENANT, 1999) and „Assembly Rules and Restoration Ecology (TEMPERTON et al., 2004).

Appendixes:

- Detailed time schedule
- Literature

Bibliography:

BRADSHAW, A. D. (2002): Introduction and Philosophy. Pages 3 – 9 in Handbook of Ecological Restauration – Volume 1 Principles of Restoration, eds. M. R. Perrow and A. J. Davy. Cambridge University Press

BRADSHAW, A. D. (1987): Restoration: an acid test for ecology. Pages 23 – 29 in W. R. Jordan, M. Gilpin, and J. D. Aber, editors. Restoration ecology. Cambridge University Press, Cambridge, England.

BRADSHAW, A. D. (1987b): The Reclamation of derelict land and the ecology of ecosystems. In Restoration Ecology, eds. W. R. Jordan, M. Gilpin, and J. D. Aber, Cambridge University Press

BRADSHAW, A. D. (1997): What do we mean by Restoration. In Restoration Ecology and Sustainable Developement, eds. K. M. Urbanska, N. R. Webb and P. J. Edwards. Pages 8 – 16. Cambridge University Press

BRAUN-BLANQUET, J. (1964): Pflanzensoziologie 3. Auflage. Wien

FAO - WALDBERICHT (2005): www.fao.org/forestry/fra2005. 20.11.2005

FEDLMEIER, C. (1996): Sekundärentwicklung auf aufgegebenen Weideflächen im Norden Costa Ricas - Dissertation. Göttinger Beiträge zur Land- und Forstwirtschaft in den Tropen und Subtropen - Heft 109. Institut für Waldbau Georg-August-Universität, Göttingen

FEEST, ALAN (2006): Establishing Baseline Indices fort he Quality of the Biodiversity of Restored Habitats Using a Standardized Sampling Process. Restoration Ecology 14, pp. 112 – 122

HOLL, KAREN D. (2002): Tropical moist forest. Handbook of Ecological Restoration Vol. 2 – Restoration in Practice, eds. M. Perrow and A.J. Davy. Pages 539 – 558. Cambridge University Press

HOLL, KAREN D.; CAIRNS, JOHN JR. (2002): Monitoring and Appraisal. Handbook of Ecological Restoration Vol. 2 – Principles of Restoration, eds. M. Perrow and A.J. Davy. Pages 411 – 432. Cambridge University Press

HOLL, KAREN D.; LOIK, MICHAEL E.; LIN, ELEANOR H.V.; SAMUELS, IVAN A. (2000): Tropical Montane Forest Restoration in Costa Rica: Overcoming Barriers to Dispersal and Establishment. Restoration Ecology 8, pp. 339 - 3349 Lamp, D.; Erskine, P.D.; Parrotta, J.A. (2005) Restoration of degraded tropical forest landscape. Science 310, 1628-1632

LEHMANN, STEPHAN (2006): Untersuchung zur Eignung von Baumarten für die Anlage

von Renaturierungsplantagen am Beispiel des ‚Cloudbridge'-Reservates in Costa Rica, Diplomarbeit. Institut für Waldwachstum und Holzmesskunde der Technischen Universität Dresden

MAYER, PHILIPP (2006): Biodiversity – The Appreciation of Different Thoght Styles and Values Helps to Clarify the Term. Restoration Ecology 14, pp. 105 - 111

NATIONAL RESEARCH COUNCIL (1992): Restoration of Aquatic Ecosystems: Science, Technology and Public Policy. National Acadamy Press, Washington, DC.

OXFORD ENGLISH DICTIONARY (1971): The Oxford English Dictionary. Oxford University Press

PACKARD, STEPHEN; MUTEL, CORNELIA F. (1997): The Tallgrass Restoration Handbook – For Prairies, Savannas, and Woodlands. Island Press, Society of Ecological Restoration

POHRIS, HUBERTUS (2006): Long-term Training Course "Managing Biodiversity" 2006/2007 (InWEnt – TU Dresden – Universität Göttingen) – Modul 10 – Biological diversity in forest plantations and its ptential contribution to their sustainability – Skript. Institut für Internationale Forst- und Holzwirtschaft. TU Dresden

ROJAS, F. (2001): Plantaciones Forestales. Euned

SCHMIDT, INGA; ZERBE, STEFAN; BETZIN, JÖRG; WECKESSER, MARTIN (2006): An Approach to the Identification of Indicators for Forest Biodiversity – The Solling Mountains (NW Germany) as an Example. Restoration Ecology 14, pp. 123 - 136

STADTMÜLLER, T. (1987): Cloud Forests in the Humid Tropics - A Bibliographic Review. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE). The United Nations University

TEMPERTON, VICKY M.; HOBBS, RICHARD J.; NUTTLE, TIM; HALLE, STEFAN (2004): Assembly Rules and Restoration Ecology – Bridging the Gap between Theory and Practice. Island Press, Society of Ecological Restoration

URBANSKA, K.M.; GRODZINSKA, K. (1995): Restoration Ecology in Europe. Geobotanical Institute SFIT Zürich

WHISENANT, STEVEN G. (1999): Repairing Damaged Wildlands. Cambridge University Press

WRI - WORLD RESOURCES INSTITUTE (1997):World Resources 1997-1998. Oxford University Press, Oxford

ZERBE, STEFAN; KREYER, DARIA (2006): Introduction to Special Section on "Ecosystem

Restoration and Biodiversity: How to Asses and Measure Biological Diversity?”. Restoration Ecology 14, pp. 103 - 104