Principles of

# successional agroforestry

Dynamic Agroforestry Systems

# DAFs

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ECOTOP



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ECOTOP archives

Field practice. Team work of interpretation of the successional model.


# FOREWORD

Dynamic agroforestry (DAF) originated in Brazil and was first introduced in Bolivia in 1995. Thanks to the good results, DAF gradually spread and young farmers began to convert their farms. ECOTOP Bolivia began to systematise these experiences and integrated DAF as an integral part of its extension work. In this way, ECOTOP has introduced DAF in Latin America, Africa and Asia over the last 20 years.

SANKOFA was the first project, which has promoted DAF in various areas in Ghana since 2016. A central role plays the Kuapa Kokoo Farmers Union (KKFU), which enabled their farmers to diversify their crops and incomes and to be more climate resilient. At the same time, the cooperative could differentiate itself from other cooperatives by integrating DAF as one of their main strategies. The founding partners of the SANKOFA project are KKFU, Fairtrade Africa, HALBA, Max Havelaar Switzerland and the International Trade Centre (ITC). Donors are HALBA, Coop Switzerland, the State Secretariat for Economic Affairs, the Danish International Development Agency and ITC.

This DAF manual summarises experiences from ECOTOP trainings over the last decades and DAF plot installations within the SANKOFA project. It is mainly addressed to the technical staff of KKFU who contribute to the innovation and continuity of DAF implementation.

MÓDULO 1

# The Principles of Nature . to create Fertile Landscapes

## The Successional Model

## Contents

# 1. Introduction

The following **training unit deals with the basic principles of life**. By means of examples, it is **made clear how landscapes gradually become more and more fertile** over very long periods of time. It is at these locations, the most fertile ones, **that human being has finally settled to cultivate the soil**.

**The main tool to be used** in order to visualize how landscapes are transformed due to natural processes on earth during very long periods of time **is the successional model**. We will know **how to set up and use this model** and ask the following questions:

What is the **condition of our soils today**?
**Could** the initial fertility of the soils **be recovered** and maintained?
If not, what happened?

**What will we learn by recognizing and understanding the successional model?**

**A** – The **consequences** regarding **deforestation** of landscapes and **erosion** of soil

**B** – **Alternative** forms of production that are **oriented** towards the **principles** of **life.**

**C** – **How** these **principles can be incorporated** into the practice of **agricultural production**



# 2. Summary

The model is used to explain and understand how life on Earth has evolved over very long periods of time.

In recent decades, **large tropical forest areas have been destroyed for agricultural productions or cattle raising**. Today, smallholders in these areas see a decrease in soil fertility and increase problems due to diseases and pests.

It describes the process of forest ecosystem degradation and **the consequences of not changing cultivation methods**, especially the use of fire in land preparation by cutting and burning the forest and tillage with machinery.

**Participants usually work on deforested and degraded plots** and, in the model, they occupy the space that symbolizes them (page 36). By analyzing and reflecting, t**hey will reach correct conclusions without the facilitator having to explain**.

The conclusion is that **we must move in life's direction, increasing fertility and abundance. Technical and practical training** to establish plots in dynamic agroforestry systems i**s one way to do this**.

## 3. Learning structure

| Topic | Content | Tools/method | To consider | Time |
|---|---|---|---|---|
| **How life evolves on earth** | Processes of evolution on landscape development | Successional model | | |
| **Construction of the successional model** | Preparation time for building the model. | Hoe, pruning shears, cutless. | Vegetative material as cut branches from shrubs and trees has to beincluded just before the presentation. The smoother the angle, the better. The bigger the model, the more impressive.. | 1,5 hr |
| **Interpretation of the model** | The model is interpreted in group work from the participants | observations and discussions in groups, exchange with other groups, conlusions. | Do not interrupt the interpretationprocess of the participants | 30 min. |
| **How landscapes are evolving towards more and more life and fertility** | The facilitator completes the conclusions of the group observations using the model, explaining the processes in nature with the different stages (colonizer, accumulation and primary). | | | 1 hr |
| **The effects of land use on soil fertility** | The effect of slash and burn in the long term. | The participants understand the consequences and impact of their own agricultural practices and the need for change towards DAF. | Use creativity to visualize agricultural practices. (slash and burning practice) | 1 hr |
| **Total time required** | | | **Preparation 1.5 h / Classes 2.5 h** | |



## 4. Learning target

**Participants understand the principles of how landscapes in nature** become more and more fertile and what happens when slash-and-burn farming is practiced over a longer period of time.

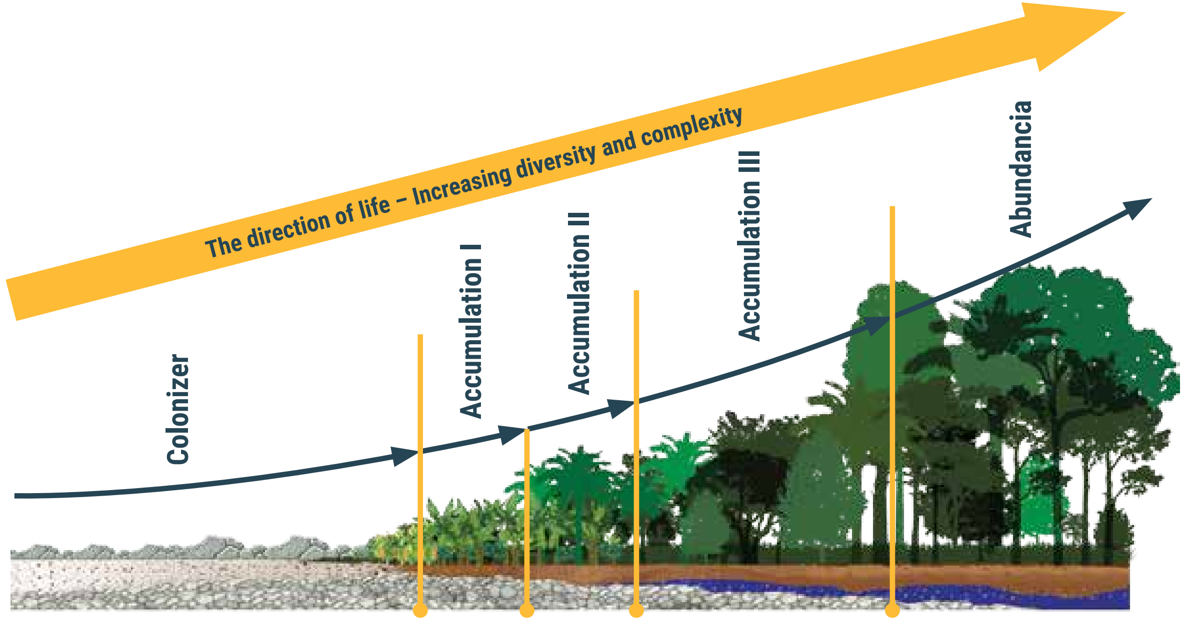
## 5. Workplace

**Outdoors preferable under the shade** where the whole group has enough space to observe the model **and to discuss in small groups.**

# 6. How life evolves on earth

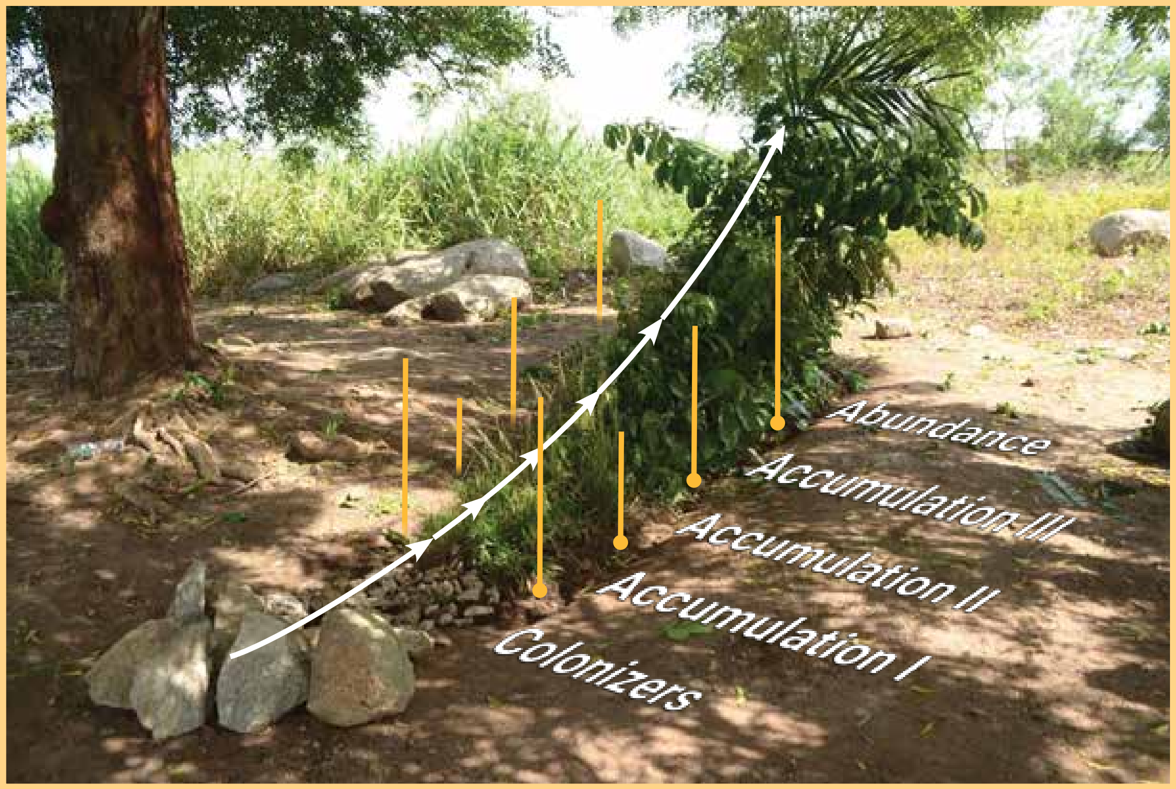
## The Successional Model

**Life on Earth developed during millions of years following principles that are described here in a simplified way.**




The entire process is visualized using the **"succession model", which simulates the different stages of development of landscapes on earth**. **People have always sought** places **where food could be collected** or **animals hunted**. **These places** have always been the most fertile and **belonged to the so-called Abundance Systems**, shown on the right side of the figure above.






**The succession model illustrates the path of life on earth, how fertile habitats with ever greater diversity and better living conditions for large animals and humans could develop over millions of years.**

## **The first step:** Colonizers

**In every place life is organized in systems.**

This means that **different organisms or species are collaborating each other** to improve the given conditions.

**The "colonisers"** who find themselves in completely destroyed lands, in ravines, gullies and overexploited places **take the first step**.

**In bare rocks, for example, the first to colonize may be different bacteria that create conditions for the development of some fungi, mosses and lichens.**


**Figure 1** Materials used for the colonizer phase of the sucessional model.



**Sequences of species arise that accumulate some organic matter and therefore improve the fertility of the site step by step, establishing the conditions for more demanding organizations.**

We often **see this phase on bare rocks**, in depressions where the accumulated moisture develops the first organisms.

**More demanding species evolve where some organic matter was accumulated.**

**Figure 2** The first Accumulation systems

## **Second step:** Accumulation systems

To allow the development of **more demanding species**, the **first organisms create** sufficient conditions (**nutrients** and **humidity**) on a specific plate,

Then, **pioneer plants appear**, somewhat more demanding species, which form the first **Accumulation Systems**: species with slowly decomposing **organic material** (leaves and woody parts) that produce more **accumulation of organic matter on the soil**.

**More nutrients and moisture improve the soil**. Even more demanding species proliferate that little by little mark the **next stage** of development (consortia with other groups of plants).


**Figure 3** Accumulation systems

**The first accumulation systems are characterized by rustic plant communities,** which have very hard branches and twigs and are therefore difficult to decompose.**Organic material** layer **gradually grows**, **accumulates** more **moisture** and, thanks to its slow decomposition, **accumulates a cushion of organic matter**.



**Trees which do not have edible fruit** for man or large animals appear in these systems. **It is the place of harmful insects** for us and small animals such as mice, poisonous snakes and small birds.

When **living conditions have improved** through the dynamics of life itself (successional processes), **other species begin to emerge** gradually that form the sequences of the next phase of Accumulation Systems with now even higher diversity and species more demanding in nutrients and humidity.

**Life more easily reaches the accumulation state in flat areas and soils formed by rocks rich in minerals** and there are **better conditions** for other species, **better fruits, seeds and food** for medium-sized animals. Life passes to **Systems of Abundance** more easily generally near rivers, in trenches and basins.


**Figure 4** Advanced accumulation system in Central America. These are places with fertile soils that are suitable for humans.

## **Third step:** Abundance systems

### Human being's place


**Figure 5** Abundance systems

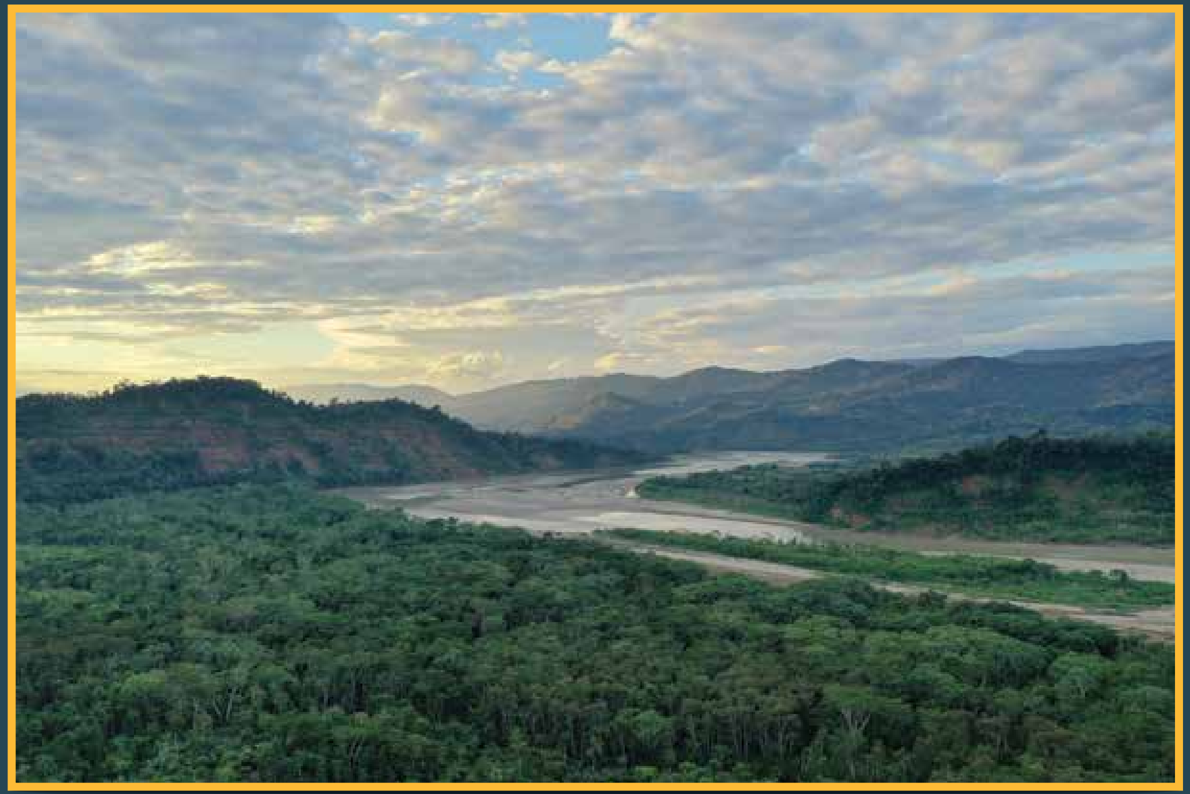
**Many tropical forests** mostly those near to big rivers are **characterised by fertile soils and belong therefore to the so called Abundance System.**

**In these systems, the fruits of plant species are high in nutrients, carbohydrates and proteins.**

**To exist, humans need the conditions of a System of Abundance, where they cultivate the land and hunt animals.**



**In these systems, the decomposition processes of organic matter are intensive** (due to the increased activity of microorganisms). At places of abundance **processes of development can last dozens thousands of years,** as long as the conditions are met.





## 7. Materials and tools

The instruments and materials to construct the stages (successional stages) of development represented in the mockup are:

Hoe

Soil

Vegetative material*

*Every phase requires a different vegetative material type that is specified in each case.

# 8. Successional model construction phases

## A Colonization

Collect rocks with moss and lichens, sand or gravel and place it at the beginning of the model.




## B Accumulation I

Add grasses, ferns

## C Accumulation II


Incorporate shrubs and bush, branches and twigs of different species, if available.



## D Accumulation III

Place bushes and trees of greater density, with branches and twigs of different species.

At this time the model should show a significant increase, with higher vegetation than in the previous phase and a little more organic matter on the surface.

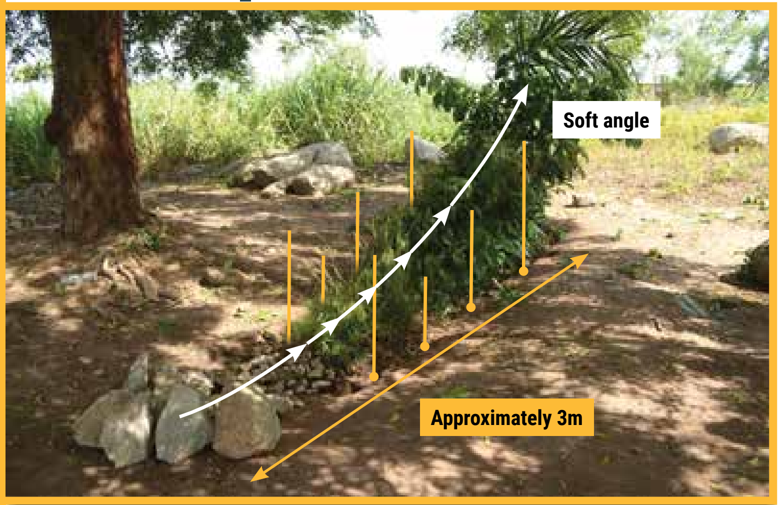
## E Abundance

Finally, trees of different sizes and with less density than before are added, represented by branches of different species present near

The model should increase significantly. Vegetation should be higher than in the previous phase and strata must be clearly identifiable.




## Important remarks:




The minimum length of the model is 3m. The larger and longer it is, and the greater the diversity of species used in the model, the more illustrative and the better the visual effect.

The colonization phase is 50cm long, the accumulation phase 1.5m. Together they take up most of the model. The abundance phase measures 1m.

Soil content increases from accumulation phase to the abundance phase.

It is important to see a significant layer of organic material and a more prominent layer of fertile soil, as the abundance phase approaches.

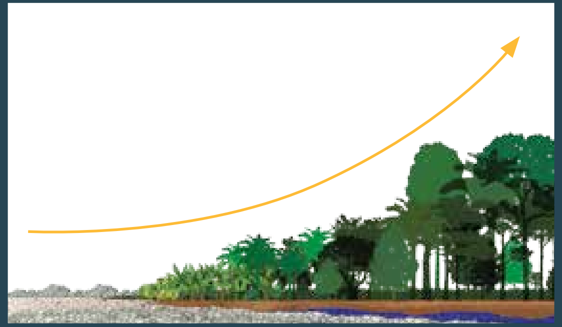
The angle from the first coloniser phase up to the end should be smoothly done. Do not build it with a sharp angle. The primary stage should visualise some stratification.

## 8.1 Installation steps

### A. The soil

The model has to show visible growth of soil in space and time

The soil content has to be built in an angle in order to see where less and more soil content is.



**At the end of the model, where there is more soil content, a significant thicker layer of organic matter has to cover the surface representing the organic matter of a forest.**



### B. The vegetation

The vegetation is built with grass and branches of tree, shrub and bush species growing around.

Both are previously cut off and stick into the surface of the soil.

**If possible different species should be used.**

**Figure 6** Building the accumulation stage of the first succession phase in the model.

**The model has to visualise the development of a different system towards an abundance forest system. Hence all successional stages have to be included.**

**Phase 1**

Colonizers represented by stones, gravel or whatever available at the site

**Phase 2**

Accumulation systems I to III = Increasing density, height and diversity

**Phase 3**

Abundance Systems = Primary, forest system with different layers

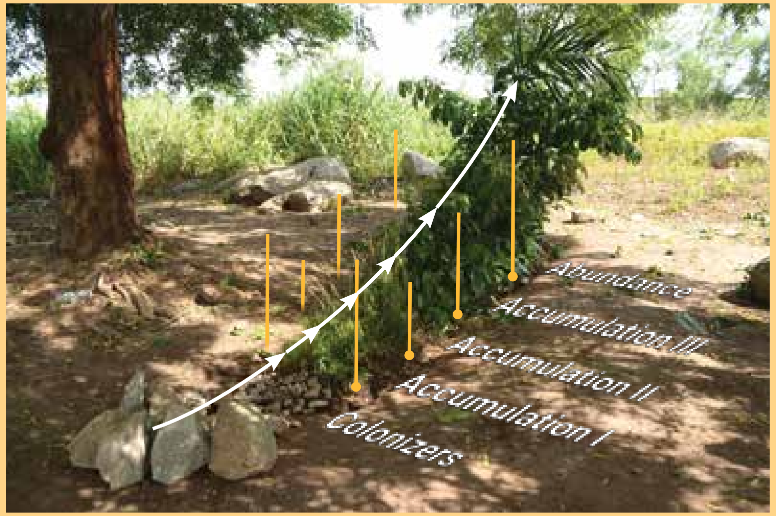



**Figure 7** Different phase of the model



# 9. Methodology

## Group work

Depending on the number of participants, the observation and interpretation of the model is done in groups of 5 to 7 persons.

Each group should first observe in detail the model and than exchange their observations and conclusions.

**The conclusions are than presented to the plenary.**

## 10. Interpretation

15 min

Describe all the details of the model and interpret the observations in each group."

What does the model represent? Each group presents its observations and interpretation

15 min

**Then a group synthesis is made where all conclusions are presented from each group.**

**Figure 8** Interpreting the model



Based on the contribution of the different groups, **the facilitator complements the meaning of the model emphasising on the successional processes** (phases: coloniser, accumulation primary) and the fundamental principles:

1. Accumulation of organic matter (layer of leaves and branches on the surface) and denser vegetation.
2. No monoculture, plant diversity in high density.
3. The direction towards "life", diversity and soil fertilty versus the direction of erosion, soil degredation and reduced diversity.


**Figure 9** Direction of nature

**The logic of nature always goes towards diversity and fertility but human behavior goes in the opposite direction, as shown here.**

Since 1960, many areas have been deforested for the production of food and cash crops. The common practice was slash and burn. The first years everything grew without problems and the yields were quite high, but little by little it was more difficult to maintain the level of productivity.

**Using the model, the current agricultural practices and the consequences in the long term are presented. The facilitator launches the question:**

1. ¿Where or in which phase of the successional model would you prefer to start with agriculture and why?
2. ¿Where or in which stage of the successional model they ancestors had practised agriculture?
3. If the ancestors (grandparents) started in abundance systems in which successional stage are your fields today"?

It is recommended to visualise the slash and burning practice on the same model by taking the vegetation down and removing it from the abundance area burning it symbolically.




**Figure 10** Slash and burn practice visualization

Which part of the model corresponds to your farm where you are currently farming?

**The participants are then asked to position themselves one after the other at the position of the model that corresponds to the situation of their field.**

**Figure 11** Participants lining up on the model. None of the participants has conditions of abundancy on their agricultural fields – see the yellow bars



**The positioning of the participants in the model according to the current situation of their fields has the purpose of visualising the extent to which the degradation process has already progressed for each individual. If their grandparents had started in abundance systems (cutting forest), why are their fields today in conditions of accumulation systems with steadily decreasing fertility?**

Are the yields today just as good as those of parents or grandparents?

If you compare them over time, you will probably find that current returns are very low.

Do you know how your grandparents started farming?"

A small piece of forest was cut down and burned for the production of food crops and cocoa.

What did the farmers do when a field no longer produced good harvests?

After a couple of years, the field was left fallow and a new area of forest was cleared and burned.

# 11. Final reflection

**A change of direction in our agricultural practices is necessary, towards fertility and abundance, since in the future more and more people will have to be fed. In ancient times, the grandparents had very good starting conditions, but the current situation is much more critical. Then you need to ask yourself the following questions before moving on to the next lesson.**

1. And what do you think will happen if we continue as we are now?
2. How will the future be of the next generation if nothing changes?
3. And what can we do to reverse the situation and improve fertility of our soil?



# 12. Conclusions and lessons learned

- The principle of nature always goes in the direction of abundance - fertility.
- Rich ecosistems are the prerequisite for human life.
- Current agricultural practices and regular burning of the fields are changing direction by transforming fertile soils and landscapes in degraded and poor areas.
- The challenge is how to change the current direction of degradation towards abundance and happiness.

MODULE 2

The Principles of

# species succession

in forestry systems and use in dynamic agroforestry systems (DAFs)

## Secondary succession


## Contents

# 1. Introduction

**A** In nature, **most species live together (in consortia) with other species and need appropriate support** for their optimal growth.

**B** Thus, **in dynamic agroforestry, species are planted that occupy different strata (height) and life cycle** together. In this way they complement and help each other in their development.

**C** Dynamic agroforestry only tries to **imitate processes that occur in nature** when a forest gap is restored.

**This lesson introduces the principles of processes of sequences of plant communities that occur in forest systems (succession processes in forest systems) when closing a gap in the forest and how they can be applied to our agroforestry practice.**



# 2. Summary

In the last lesson geological processes of landscape development were explained with the use of the succession model (sequence of plant communities).

**This lesson describes the principles and sequence of plant communities** that arise during regeneration of a naturally cleared or destroyed area (forest) and how these principles are applied in the design of our dynamic agroforestry system (DAFs)**.**

Most of our crops are very demanding in terms of soil fertility, they are belonging hence to abundance systems. **Many areas have already been impoverished and soil fertility diminished** (degraded to accumulation systems) **due to production methods such as slash-and-burn and monocultures**.

In these places, corn, beans or cocoa are still grown, although they no longer flourish. **The result is the increase in the incidence of diseases, pests and unwanted herbs (weeds) and the application of pesticides**, herbicides and other chemicals to control them.

Therefore, **the challenge is to produce profitable food and crops, while improving soil fertility and restoring impoverished soils and destroyed landscapes**. This can be accomplished by applying the SAF principles and techniques described in this lesson.

## 3. Learning structure

| Topic | Content | Learning target | To consider | Time |
|---|---|---|---|---|
| **The main characteristics of a forest ecosystem** | • Diversity<br>• Stratification<br>• Production of biomass<br>• Water balance | The participant understands the importance of trees for soil fertility | 90% of soils used for agricultural production developed under forest | 30 min |
| **The principles of sequence of species development called "succession" in forest ecosystems** | The development and successional processes in a forest ecosystem starting from a natural or men made clearing | Life cycle of different plant communities (consortiums) during the development of a new forest | Today it is no longer feasible and possible to regain the fertility of soils with prolonged periods of fallow. | 30 min |
| **How to apply these principles in DAFs** | Characterization of the main principles applied in DAFs | How to achieve successional processes with our crops in DAFs | Alternatives to stop soil degradation and restore depleted soils. | 1 Hr |
| | | | **Total time required** | **2 hours** |

**Phases of development of a forest ecosystem**




## 4. Learning target

The participants understand the principles of species succession in forest ecosystems and the application for the design of dynamic agroforestry systems.

## 5. Work space

Outdoors or indoors.

## 6. Materials and tools

The following tools and materials are required.

- Papel de rotafolio
- Flip chart paper
- Posters
- Tape

## 7. Methodology and content

Plenary sessions | Group sessions

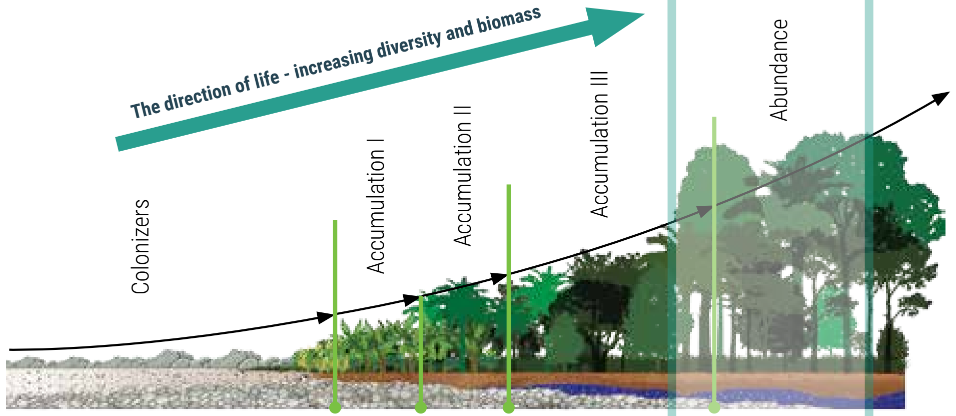
The session is started with the following question:

**To return to the successonal model: At what point in the succession model did your grandparents start to cultivate the land, and why there?**

**Answer:**

They began to clear a patch of forest with fertile soils, they started here (prominent strip) because they knew that the denser the vegetation, the greater the fertility of the soil.






**Everybody knows that usually the soil under a forest is fertile and after clearing it all that is cultivated there grows well. It is therefore the forest with its trees and vegetation that are responsible for maintaining soil fertility.**

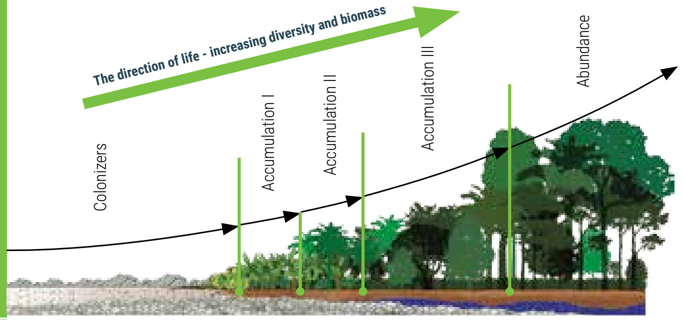
**Let's see what happens when a forest restores a clearing caused by the fall of an emerging tree, the tallest.**

**Figure 2** Restoration of a forest after a disturbance

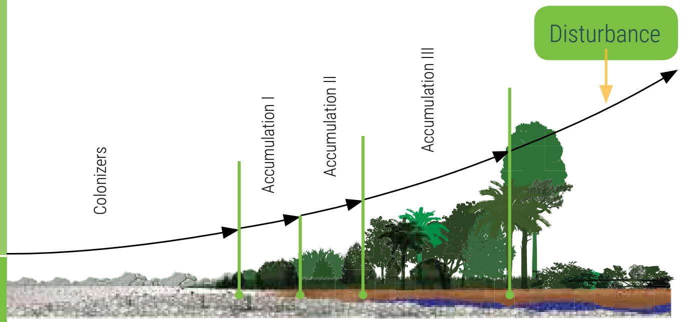
Image based on vector elements by brgfx / FREEPIK



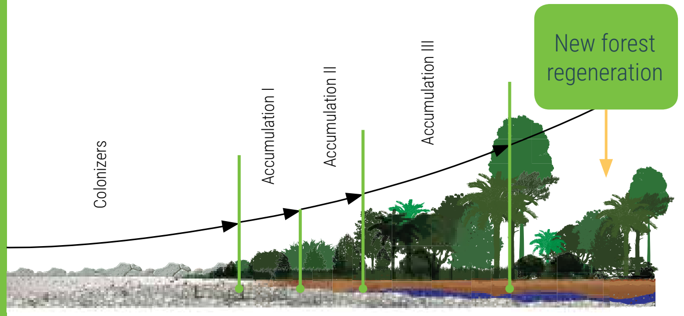
After disturbances in a forest – such as opening a clearing due to a lightning strike or a heavy storm - **the forest restores its functionality and fertility through sequences of plant communities called "successional processes"** driven by a vast number of species.




Most of them grow together up from the beginning. E**ach species of each plant community or consortium will fit in time and space throughout the time, in a steady increase of organic matter** above, on and under the ground.




Before long, the clearing closes in with fast-growing species such as grasses and shrubs, and **a new forest is rebuilt step by step**. Thus, each consortium creates the conditions for the next and enriches the site with its organic matter. The different species do not compete with each other but cooperate with each other.



# 8. Natural succession of species

A forest ecosystem can be considered as an organism or an individual completely interrelated with each of its elements, which in turn represent other subsystems.

**In a closed forest system, a clearing appears (by burning or by the fall of a tree) that will be closed with pioneer plants, such** as grass, grass and shrubs, which, in general, are species whose life cycle lasts a few months.

**Species of the secondary system with different life cycles also germinate, marking for a time the external appearance of the forest.** Short, medium and long cycle secondary forest formations are broadly distinguished.

**Along with the pioneers and secondary species, there are also typical primary forest species with a life cycle of more than one hundred years.** For example, mahogany, cocoa, coffee, coconut, jackfruit, rubber tree, Amazonian nut, etc.

**Just like the metamorphosis of a butterfly, in its evolution the forest ecosystem goes through different development stages,** modifying its species composition, as well as its external visible image, until finally, the adult individual comes to light, in our case, the primary forest.



## Comparison of the evolution of a forest ecosystem with the metamorphosis of a butterfly

All the system information is present in the egg.

**Egg**

The first larvae that will soon give rise to the next phase emerge.

Pupa: this phase, like the others, conditions the previous one and determines the one to come.

**Larva and pupa**

Finally the adult organism, butterfly, appears.

**Butterfly**

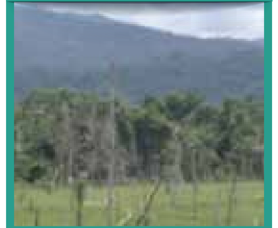
**Pioneers**

Naturally or by human action, a clearing appears.

**Secondary I, II, III**

In a short time it will be closed with pioneer plants (grasses, herbs and shrubs).

Later, different life cycle trees dominate the short-cycle species.



**Primary**

Primary system trees with a more than 100 years life cycle form the forest.

Species that occupy different floors make up the forest. For example: mahogany occupies the upper floor while cocoa occupies the lower floor.

# 9. Questions and answers*

**What to do when a field dedicated for years to annual crops no longer gives good yields?**

**Answer**: We give up the place and let the field lie fallow".

**After a period of fallow, does soil fertility increase or decrease?**

**Answer:** Soil becomes more fertile.

**What do we observe in the abandoned plot?**

**Answer:** New dense vegetation is normally observed covering the entire area. Organic matter accumulates on the soil surface.

**Leaving a plot uncultivated does it improve or worsens soil fertility?**

**Answer**: Improves soil fertility

**Why is the soil fertile and productive again?**

**Answer:** Due to the accumulation of organic matter and vegetation on the soil.

## Conclusion:

When we cultivate the soil as we used to do with burning and monocropping then the soil fertility decreases continuously. But if we do nothing anymore and leave the land to nature, soil fertility increases again.

*** Write down the answers on flip charts or draw them specifying the observations.**

**Why we cannot achieve the same result with our agricultural practices?**

Ask several participants

**How long do you grow the same piece of land? and what is observed in the crops?**

**Answer:** Generally, the land is used for growing annual crops, usually for one or two growing seasons. The plot is left fallow due to high pressure from weeds, increased diseases, pests and low crop yields. Or herbicides, pesticides and fertilizers are used that do not solve the problems but are crutches to temporarily maintain some level of performance.



**How long do you leave the land fallow, without cultivating it?**

Ask several participants

**Answer:** The answer depends on several factors: land ownership, soil fertility, farm history, farm size, etc.

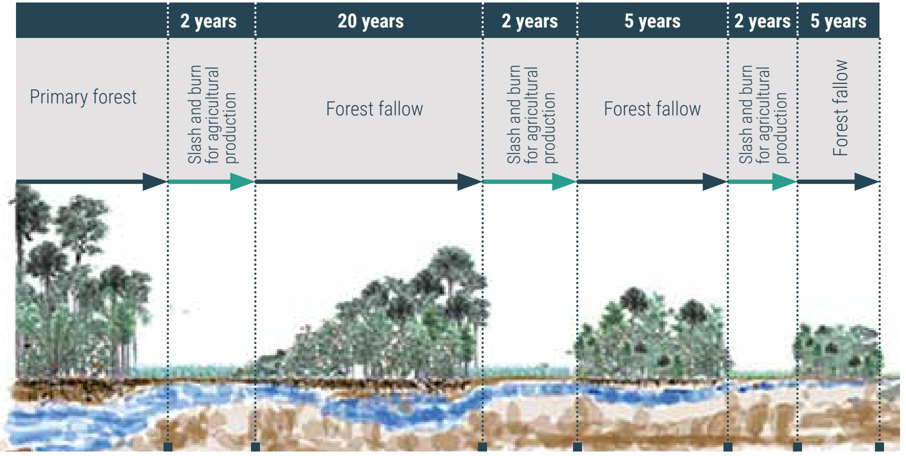
**Fallow periods for soil regeneration have been continuously shortened for generations. The shorter they are, the faster soil fertility and water availability decline. Likewise, the rains diminish. The consequences of this cannot be restored even with use of synthetic fertilizers.**

**The questions that arise are**

**How to keep the soil used for agricultural production fertile? and how to keep the land fertile in the long term?**



**The rice, as shown in the illustration, develops a little less each time between the shorter fallow periods and the yields decrease.**




As population increases the fallow periods are shortened and do not wait 50 years, as before, to regenerate the forest and clear it for another crop. Soil fertility and water reserves are not regenerated in a sustainable way. Dry seasons reduce performance further. Cut down and burned vegetation makes restoring original fertility more difficult and time-consuming. Yields decrease, weeds, pests, and diseases increase. The shorter the fallow period, the shorter and weaker the regeneration is, the less organic matter accumulates and the less the restoration of soil fertility

# 10. Workgroups

## Plenary Session

Think and discuss what can or should be done to prevent decreased soil fertility, losses due to diseases and pests in our crops and improve weed control.

- Collect the ideas and write each contribution on a flip chart card

**Conclusion:**

When a piece of land is left to itself, it is immediately occupied by a variety of species with different life cycles in high density. Little by little, different groups of trees will dominate and build up a new forest of different species composition.

The soil thereby become increasingly fertile. This technique of clearing a forest alternated with periods of forest fallow was traditionally practiced by small farmers worldwide.

Over a period of about 50 years, a field was left to nature in the form of fallow land before it was used for agriculture again. This is known as "shifting cultivation".



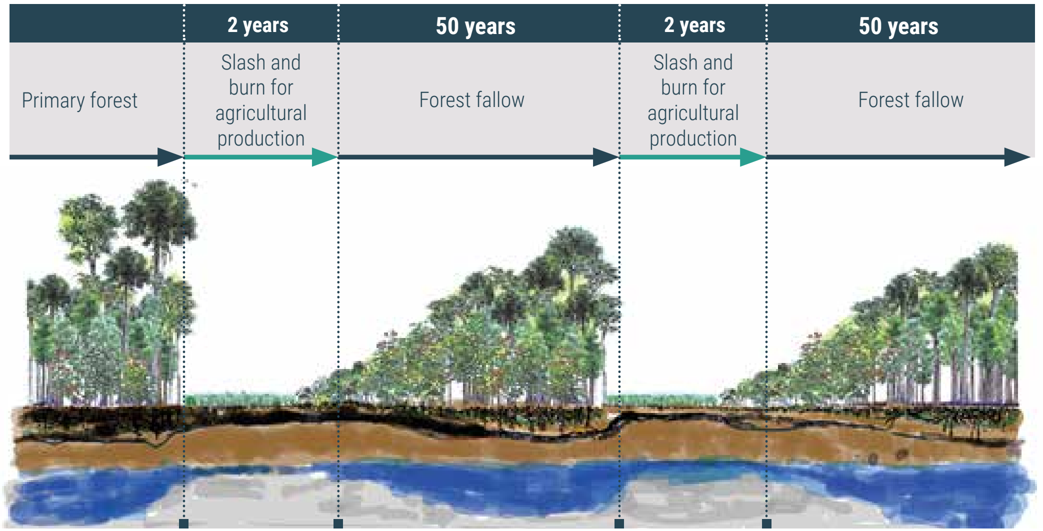



**Figure 4:** Traditional crop rotation form with long fallow periods.

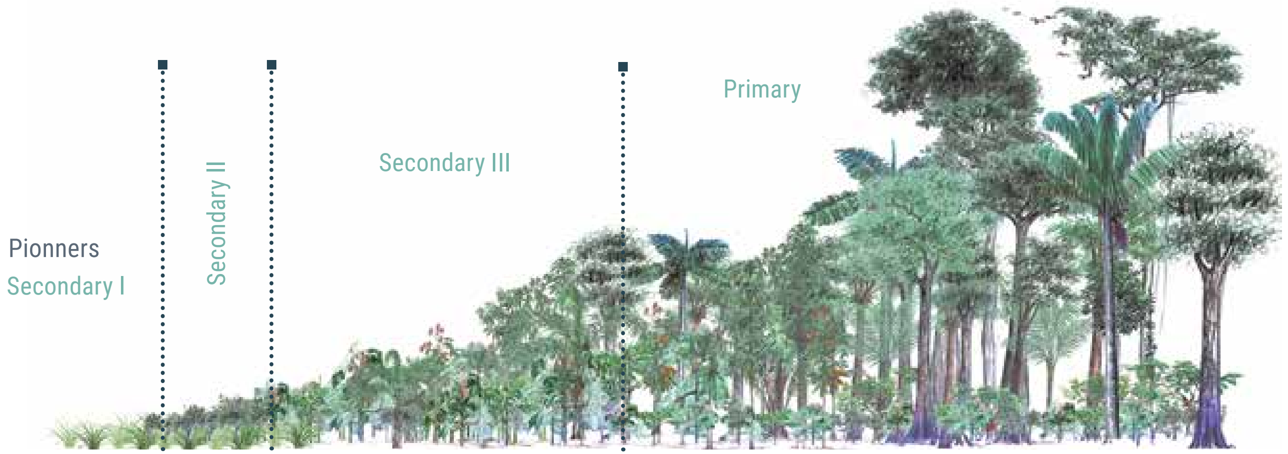
At first, people settled in forest areas cleared a piece of land, and cultivated it for about two years.

Afterward, people moved to clear another piece of forest. Only after about 50 years, they return to the same place.

Meanwhile, a new forest grows. Soil fertility and hydric (water) balance regenerate during fallow.

**The process illustrated here shows the regeneration of the forest after a period of rice cultivation and about 50 years fallow phase**

## 11. Sequences of species in successional processes






What we are now doing in dynamic agroforestry is ultimately only imitating this strategy of nature to restore or maintain soil fertility.

But we must know how to classify our crops according to their duration or life cycle and the needs of light, to grow them in agroforestry systems.

**We know that organic matter is crucial to keep soil fertility. That is why we need to combine the crop that interests us with species used only for the production of biomass, which enriches the soil through regular pruning. This will be explained in more depth in Module 3 on Management Practices.**

In dynamic agroforestry we classify crops into similar groups, according to their life span and the stratum or floor they occupy within their consortium to imitate the processes that occur in nature.

**After the clearing of a fallow we combine many different species with different lifecycles cultivating them together.**

In DAFs it is impossible to achieve the same density and diversity as in natural forests, but it is crucial to apply the same principles that govern in nature, follow successional processes and occupy different strata.

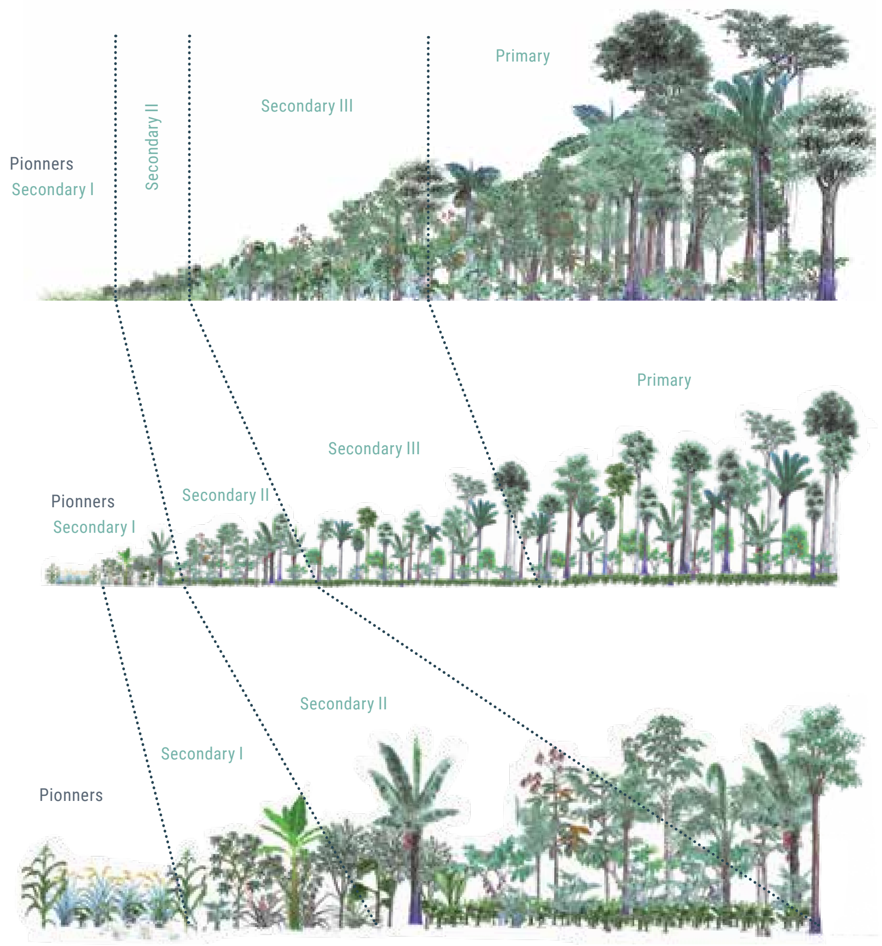
Furthermore, our DAFs is not designed for a productive phase of more than 50 years. When a productive cycle is finished, the timber can be harvested and a new cycle can be started with a very good soil fertility, provided the field is not burned down.

Starting with a new plantation we combine crops that produce after a couple of months (pioneers) like maize, beans, groundnut, sweet potato together with crops that last up to 2 years (cassava, pineapple, pigeon pea, chili, eggplant etc.). In addition to all these crops we will plant still banana and papaya, if available and if the conditions are given black pepper or other crops and all together will thrive until cocoa, fruit, palm and timber trees are dominating our field, converting it in a productive forest system.

This sequence of plant communities we call “species succession”.

**In the following lesson we will learn how to classify our crops and other native species as tools for designing a dynamic agroforestry field avoiding competition between them and improving soil fertility and plant health at the same time.**






**Pionners**

Species that live only a couple of months or up to a year like:

Maize Bean Rice

**Secondary I**

Crops up to two years old such as:

Yucca Tomato Chili Eggplant Pineapple Gandul

**Secondary II**

Crops up to fifteen years old such as:

Banana Annatto Pawpaw Passion fruit Pepper

# 11. Literature

**Lotufo y Trevelin (2019)**: Agroforestería en viñetas. Un breve manual práctico agroflorestaemquadrinhos.wordpress.com (12.10.2020)

**GÖTSCH, E. (1994)**: Break-through in agriculture. Rio de Janeiro, ASPTA, 19 S.

**MILZ, J. (1997)**: Guía para el establecimiento de sistemas agroforestales en Alto Beni, Yucumo y Rurrenabaque. La Paz – Bolivia, DED, 91 P.

**Milz, J. (2009)**: chapter 3.3.2. Examples from annual cropping systems in tropical zones and chapter 3.4.3 examples for perenial cropping systems in tropical zones en: IFOAM Guide to Biodiversity and Landscape Quality in Organic Agriculture (2009)

**Milz, J. (2010)**: Producción de naranja (Citrus sinensis) en sistemas agroforestales sucesionales en Alto Beni, Bolivia – estudio de caso. En: Stephan G.Beck et.al. (Editores). Biodiversidad y Ecología en Bolivia. Simposio XXX Aniversario Instituto de Ecología Universidad Mayor de San Andres. Instituto de Ecología. La Paz-Bolivia 2010 (p. 324 – 340).

**Milz, J. (2012) in**: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Forests and Climate Change Programme (FORCLIME). Successional Agroforestry Systems for Sustainable Cocoa Production within the Conservation Districts of Malinau and Kapuas Hulu. GTZ Manggala Wanabakti Building, Block VII, 6th Floor Jln. Jenderal Gatot Subroto, Jakarta 10270, Indonesia

**Milz, J. (2009)**: Case study of annual cropping systems in tropical zones employing natural processes in species succession. Poster presentation. 2nd World Congress of Agroforestry, Nairobi, Kenia. 23 to 28 August 2009

**Milz, J. (2009)**: Successional Agroforestry Systems: Principles, research and application by small farmers in the Alto Beni Region of Bolivia. Poster presentation. 2nd World Congress of Agroforestry, Nairobi, Kenia. 23 to 28 August 2009