Vol. 13(1), pp. 11-17, January-March 2021
DOI: 10.5897/JENE2020.0864
Article Number: 226C8C866191
ISSN 2006-9847

http://www.academicjournals.org/JENE

Journal of Ecology and The Natural Environment

*Full Length Research Paper*

# Regenerating plant species of a highly anthropised tropical forest in Côte d'Ivoire, West Africa

**Kouame Jean Marc KOUMAN[1*], Yao Sadaiou Sabas BARIMA[1] and Michel GODRON[2]**

[1]Jean Lorougnon Guédé University, UFR Environment, BP 150 Daloa, Côte d'Ivoire.
[2]The Graineterie, 18410 Brinon, France.

Received 5 November, 2020; Accepted 8 February, 2021

**Haut-Sassandra classified forest (FCHS) lost more than 70% of its forest cover between 2000 and 2011 due to armed conflict and cocoa cultivation. The government is concerned about the future of this forest and whether it can regenerate naturally. Observations likely to uncover plant species that are capable of regenerating the forest were collected through systematic sampling comprising 18 line transects each containing 20 segments. In each segment, it was noted, firstly, the species present and their height and, secondly, the forest cover and the artificial features that reflect human actions. Different observations recorded in the field were processed by frequency analysis in order to find the species able to regenerate easily for a best forest because they belong to a vegetation reconstitution. Principal results showed that the numerous coexistences, in the segments, of the fallow and forest characters in reconstitution mean that fallow land allows for the reconstitution of the forest, in a progressive vegetation sequence. Fifty-nine species appeared capable of naturally regenerating the classified FCHS. This result will help authorities and other deciders to adopt an adequate scenario for this forest management.**

**Key words:** Deforestation, abandoned cocoa farms, forest regeneration, agricultural activity, tropical forest.

## INTRODUCTION

Côte d'Ivoire's protected areas and classified forests were higly affected by the armed conflicts from 2002 to 2011 (Barima et al., 2016). During this period, absence of management authority and the paralysis of state institutions had trainee agricultural practices development in classified forest. One of the most typical examples is that of the Haut-Sassandra Classified Forest (FCHS) located in the Centre-West of Côte d'Ivoire. At the beginning of the 2000s, this forest was one of the most relic forests until clandestine farmer's invasion for cacaoculture causing a high perturbation of this ecosystem (Barima et al., 2016). This forest restoration became a major priority for the administrative and political authorities who engaged some actions for FCHS preservation through the remove of farmers illegaly settled in the forest. This brutal solution has been applied in other Africa's forests such as the Mont Peko National Park and has been ineffective (Ousmane et al., 2020). In

*Corresponding author. E-mail: somia2kjm@gmail.com. Tel: +225 0748080055.

order to reconstitute a forest on the FCHS territory, it would be possible to carry out monospecific artificial plantations, for example *Tectona grandis*, but this expensive solution would drastically reduce the diversity of forest species which is the natural ecological potential of this forest. Field observations (Assalé et al., 2016; Barima et al., 2016) suggest that gradual natural regeneration is possible from local forest species as long as they are still present. The question that then arises is: Which species present in the FCHS that can ensure sustainable forest regeneration? To find an answer, the most useful notion is the vegetation sequence which is the set of successive stages of vegetation evolution that can be deduced from observations made in the field (Godron, 2012) and which makes it possible to distinguish between progressive and regressive sequences.

Indeed, in the past, the classified forest was in a state of stabilised dynamic equilibrium where the physiognomy of the forest hardly changed over the years and oscillated around an average situation (Kouamé, 1998; Chatelain et al., 2004). Crop establishment is a regressive crisis so strong that it destroys the regulations that ensured the stability of the forest and replaces them with the regulations imposed each year by the farmers (Godron, 2012). New species then germinate; thanks to the light that reaches the soil. When the cacao farm is then abandoned, the series of successive stages of a 'progressive' vegetation sequence gradually takes place (Akodéwo et al., 2019).

According to previous studies on the establishment of crops in tropical forests (Kouassi et al., 2009; Assalé et al., 2016; Akodéwo et al., 2019), this operation is often described as 'degradation' as if human actions automatically led to a loss of quality compared to an ideal that would be the natural state of the vegetation before the arrival of humans (Arbelot, 1979). To avoid any ambiguity we consider the evolution of vegetation corresponding to forest clearance to be regressive and the sequence of forest regeneration to be progressive (Assalé et al., 2016). This study aims to identify the species capable of initiating the natural regeneration of FCHS. Specifically, it will be focused on (1) determining the features of artificialisation and (2) identifying progressive species by highlighting, by contrast, the "regressive" species established following deforestation.

## MATERIALS AND METHODS

### Study area

The study area is the Haut-Sassandra Classified Forest, located in the central-western part of Côte d'Ivoire between the departments of Vavoua and Daloa (Figure 1). It covers an area of 102,400 ha. This region is characterised by a humid tropical climate. The average annual rainfall is 688 mm with a minimum of 673 mm and a maximum of 1036 mm. The soils of the FCHS are ferralitic type (Kouamé, 1998). The vegetation of the FCHS belonged to the domain of semi-deciduous humid dense forests with *Celtis* species and *Triplochiton scleroxylon* (Kouamé, 1998).

### Data collection

Data collection was carried out in March 2018. For the sampling, 18 line transects were used evenly distributed around the FCHS (Godron, 2012). Each transect is 50 m long and 10 m wide; it is subdivided into 20 segments, 25 m long and 10 m wide, giving a surface area of 250 m² for each segment. Over 5 m on either side of the line marking each transect, the presence of plant species and their height with a dendrometer was noted. The Angiosperm Phylogeny Group III (APG III) has been adopted for the families of plant species.

### Human actions and artificial features

Artificialization features" (Godron et al., 1968; Papillon et al., 2008) which reflect human actions were observed in each segment of the transect. Artificial features similar to those proposed by Godron et al. (1968) and Papillon et al. (2008) were used.

In each transect, field observations were recorded in the form of a matrix where the presence of each feature is indicated by the number 1 and the absence by the number 0. Traces of clearing and various crops are clearly the most frequent artificial features; those of forests undergoing reconstitution are less frequent but their number is sufficient to make it reasonable to think that these places can be the basis for forest regeneration.

### Data analysis

To find relationships between vegetation and the characteristics of its environment, multivariate methods and in particular factorial correspondence analysis are very often used (Lebreton et al., 1988; Ahmed et al., 2015). These methods give an interesting picture of the statistical proximities between vegetation and its environment, but they do not include tests to calculate the degree of significance of these proximities (Dolédec et al., 1995; Xiaobing and van der Maarel, 1997).

In this case, it is particularly essential to implement precise direct probabilistic tests because the relationships between vegetation and artificial features are less direct than the causal relationships between vegetation and the physical or chemical characteristics of the environment. Moreover, the landscapes in the study area are highly heterogeneous at two scales (Forman and Godron, 1986; Papillon, 1997), and they cannot constitute the infinite universe from which representative samples can be drawn for the inferential estimates presented in the usual statistics manuals. Therefore, the probabilistic tests of frequency analysis (Godron, 2012) which suffer from no estimation bias and which are accurate in the sense of Fisher were used.

A combinatorial calculation makes it possible to directly calculate the probability of finding coexistences (P), without using the law of large numbers and without referring to an infinite and unknown universe, based on Brillouin's formula (1962):

$$Ib = \log_2 1/P$$

where Ib is the amount of information measured in binons and P is the probability of the observed event.

This information is marked with a + sign when the number of coexistences is very high; it is negative and marked with a - sign when there are few coexistences, and it constitutes the ecological profile of the species in relation to the artificial trait. These tests will also be used to find groups of artificialization traits.

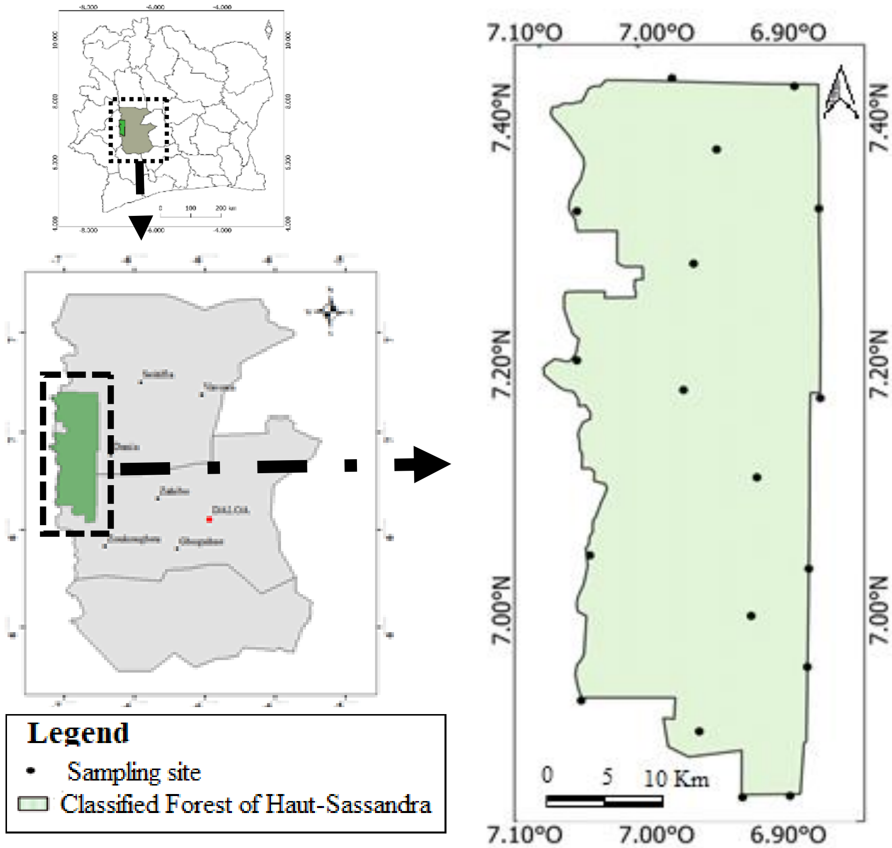


**Figure 1.** Location of the Haut-Sassandra classified forest in Côte d'Ivoire and sampling sites.

**Species and their place in vegetation sequences**

The link between the presence of a species and artificialization traits is complex, and it is necessary to see whether each species is predominantly present in segments where numerous traits indicate a regressive sequence or whether, on the contrary, it is present in segments where traces of the forest indicate a progressive sequence.

**Criteria for the classification of species**

The first species classification criterion (Tr-) is derived from the number of times a species was significantly found in a segment where a regressive human action trait was observed. The second criterion, the opposite of the first (Tr+), is deduced from the number of times a species was observed in a segment where a progressive human action trait such as Fairly conserved forest or forest in recovery was observed. The third criterion (Sc.) comes from the number of times the species has been found under one of the 5 cover classes between 0 and 100%; for this sciaphilia index (the opposite of heliophyte) the species can then be: 1 typical heliophyte, 2 heliophyte, 3 shade-tolerant, 4 shade-preferant, 5 sciaphyte. The fourth and fifth criteria are the mean of the logarithms of the heights (H) of the species and the corresponding variance (var). The synthesis of these criteria gives the regenerating index (I). For this index, the species can then be: 1 very regressive, 2 often regressive, 3 ubiquitous, 4 often regenerating, 5 very regenerating (Godron, 2012).

## RESULTS

### Artificialization features

A total of 41 artificial features were identified within the FCHS (Table 1). Falling dead trees, burning of tree trunks and crop associations are clearly the most frequently represented artificialization traits with absolute frequencies of 206, 189 and 149, respectively. However, reconstituted forests are less frequent (09), but their number is sufficient to suggest that they can be the basis for forest regeneration. Artificialization features are unevenly distributed in the FCHS and are not independent. Burning affected most of the segments, and resulted in the fall of dead trees on a large number of them. These plantations have been productive enough for a place of denting of the cabosses to be installed. It was noted that the presence of a track that crosses the second segment and the mosaic of crops is installed next to the track.

### Regeneration species

A total of 59 plant species belonging to 52 genera and 28

**Table 1.** Absolute frequency of strokes in Haut-Sassandra classified forest.

| Trait | Absolute frequency | Trait | Absolute frequency |
|---|---|---|---|
| Association of cultures | 149 | Fallow land | 43 |
| Burning of tree base | 189 | Crushing site | 5 |
| Camp | 3 | Little intact edge | 1 |
| Chablis | 39 | Track | 32 |
| Yam field | 2 | Cocoa farm of + 5 years | 10 |
| Cassava field | 8 | 1 year cocoa farm | 61 |
| Corn field | 10 | 2 years cocoa farm | 68 |
| Rice field | 6 | 3 years cocoa farm | 59 |
| Falling dead trees | 206 | 4 years cocoa farm | 15 |
| Clearing the undergrowth | 31 | 5 years cocoa farm | 3 |
| Extraction of firewood | 10 | Presence of large creepers | 1 |
| Forest in reconstitution | 9 | Well | 1 |
| Riparian Forest | 2 | Cocoa nursery | 1 |
| Fairly conserved riparian forest | 4 | Bare soil | 2 |
| Cleared riparian forest | 10 | Gramineae carpet | 2 |
| Intact riparian forest | 2 | Logging trace | 22 |
| Fairly conserved secondary forest | 32 | Trace of bush fire | 4 |
| Secondary forest cleared | 20 | Herbicide treatment | 1 |
| Secondary forest in reconstruction | 1 | Flooded area | 2 |
| Poorly conserved secondary forest | 1 | Relatively wet area | 2 |
| Lightly cleared secondary forest | 4 | | |

families were identified from the study area. The seven species-rich families contributed (Fabaceae, Sterculiaceae and Euphorbiaceae) 26% of the total plant species, and the remaining 25 families contributed 74% of the total plant species. These species are capable to regenerating the Haut-Sassandra Classified Forest (Table 2). All species have the number 5 in regenerating idex. They are said to be regenerating and are sufficiently numerous for forest management authorities to search for them in the field to find places where forest regeneration can develop.

## DISCUSSION

Artificialization features recorded in the database are not independent of each other and some of them are often found together. The corresponding contingency tables give the most positively related groups of traits. For example, burning the tree base, falling dead trees, 1, 2, 3, 4 and 5 year cocoa plantations, cassava, yam and rice plantations, grass patches and crop association are the most frequent traits and they very often coexist in more than 100 segments. For example, the burning of tree stands and falling dead trees are enough for farmers to establish 1, 2 or 3 year old combination crops and cocoa plantations in more than 50 segments.

The features little cleared secondary forest, trace of bush fire, fairly conserved secondary forest and little conserved secondary forest are often found together in the same segment. This observation confirms that fire is the primary tool for attacking the forest. The fallow and the reconstructed forest found together shows a possibility of reconstructing the forest after fallow. These features also show that fallow land allows a reconstitution of the forest in a progressive vegetation sequence. It is possible that farmers allow fallows to establish themselves because they realise that cultivation leads to a decrease in soil fertility (Kouassi et al., 2009). The classified forest was in a state of stabilised dynamic equilibrium where the physiognomy of the forest hardly changes over the years and hovered around an average situation (Godron, 2012). The installation of crops is such a strong crisis that it destroys the regulations that ensured the stability of the forest and replaces them with the regulations imposed each year by the farmers. New species germinate thanks to the light that arrives on the ground. When the plantation is then abandoned, the series of successive stages of a progressive vegetation sequence gradually takes place. The image that best captures this succession of stages is Figure 2, which shows the states of equilibrium of a log placed in a box with an undulating bottom and shaken by disturbances (Godron, 2012).

This model helps to understand the evolution of the vegetation of a forest after a violent cultivation crisis. The natural primary forests are in the very deep stability trough D, which is very deep, since these forests are

**Table 2.** List of regeneration species in the Haut-Sassandra classified forest.

| Plant species | Familie | Tb | I | Tr- | Tr+ | Sc | H | var. |
|---|---|---|---|---|---|---|---|---|
| *Adenia lobata* (Jacq.) Engl. | Passifloraceae | mp | 5 | -380 | 81 | 3 | 6 | 2.58 |
| *Aidia genipiflora* (DC.) Dandy | Rubiaceae | mp | 5 | -103 | 35 | 4 | 7 | 3.6 |
| *Alafia barteri* Oliv. | Apocynaceae | Mp | 5 | -76 | 30 | 4 | 6 | 2.14 |
| *Alchornea cordifolia* Müll.Arg. | Euphorbiaceae | mp | 5 | -131 | 28 | 3 | 6 | 2.06 |
| *Ancistrocladus abbreviatus* Airy Shaw | Ancistrocladaceae | Mp | 5 | -29 | 16 | 3 | 7 | 5.18 |
| *Baphia pubescens* Hook. f. | Fabaceae | mp | 5 | -842 | 138 | 2 | 6 | 3.11 |
| *Bussea occidentalis* Hutch. | Caesalpiniaceae | Mp | 5 | -147 | 27 | 3 | 8 | 6.5 |
| *Calycobolus heudelotii* Heine | Convolvulaceae | mP | 5 | -95 | 25 | 3 | 6 | 2.96 |
| *Ceiba pentandra* (L.) Gaertn. | Bombacaceae | MP | 5 | -445 | 56 | 3 | 8 | 11.39 |
| *Celtis adolfi-friderici* Engl. | Cannabaceae | MP | 5 | -303 | 45 | 3 | 8 | 8.08 |
| *Celtis mildbraedii* Engl. | Cannabaceae | mP | 5 | -757 | 89 | 3 | 7 | 5.92 |
| *Celtis zenkeri* Engl. | Cannabaceae | mP | 5 | -311 | 70 | 3 | 8 | 8.74 |
| *Centrosema pubescens* Benth. | Fabaceae | mp | 5 | -186 | 32 | 3 | 6 | 2.46 |
| *Christiana africana* DC. | Tiliaceae | mp | 5 | -197 | 66 | 3 | 7 | 4.47 |
| *Chrysophyllum giganteum* A. Chev. | Sapotaceae | MP | 5 | -137 | 32 | 3 | 7 | 5.96 |
| *Cnestis corniculata* Lam. | Connaraceae | mp | 5 | -83 | 14 | 3 | 4 | 0.6 |
| *Cissus producta* Afzel. | Vitaceae | mp | 5 | -80 | 12 | 3 | 6 | 1.62 |
| *Cnestis ferruginea* DC. | Connaraceae | mp | 5 | -144 | 26 | 3 | 4 | 0.57 |
| *Combretum racemosum* P. Beauv. | Combretaceae | mP | 5 | -238 | 47 | 3 | 5 | 2 |
| *Cynometra megalophylla* Harms. | Fabaceae | mP | 5 | -26 | 21 | 3 | 8 | 7.99 |
| *Dialium aubrevillei* Pellegr. | Caesalpiniaceae | mP | 5 | -46 | 14 | 3 | 6 | 6.31 |
| *Dioscorea minutiflora* Engl. | Dioscoreaceae | G | 5 | -311 | 53 | 3 | 5 | 1.24 |
| *Dioscorea odoratissima* Pax | Dioscoreaceae | G | 5 | -165 | 23 | 4 | 5 | 1.72 |
| *Dioscorea smilacifolia* De Wild. | Dioscoreaceae | G | 5 | -101 | 39 | 4 | 5 | 1.54 |
| *Diospyros soubreana* F. White | Ebenaceae | mp | 5 | -37 | 6 | 2 | 5 | 1.23 |
| *Drypetes gilgiana* Pax | Euphorbiaceae | mp | 5 | -233 | 54 | 4 | 5 | 1.21 |
| *Entandrophragma utile* Sprague | Meliaceae | MP | 5 | -55 | 20 | 3 | 8 | 11.68 |
| *Eribroma oblongum* (Mast.) | Sterculiaceae | MP | 5 | -120 | 22 | 4 | 7 | 7.3 |
| *Ficus asperifolia* Miq. | Moraceae | mp | 5 | -8 | 11 | 4 | 6 | 0.75 |
| *Funtumia africana* Stapf | Apocynaceae | mP | 5 | -347 | 52 | 3 | 7 | 4.33 |
| *Guibourtia ehie* (A. Chev.) | Caesalpiniaceae | MP | 5 | -416 | 82 | 3 | 7 | 9.22 |
| *Holoptelea grandis* (Hutch.) | Ulmaceae | MP | 5 | -58 | 28 | 4 | 8 | 12.28 |
| *Manniophyton fluvum* Müll. Arg. | Euphorbiaceae | mp | 5 | -59 | 23 | 3 | 6 | 6.3 |
| *Mansonia altissima* (A. Chev.) | Sterculiaceae | MP | 5 | -391 | 108 | 3 | 7 | 6.61 |
| *Mareya micrantha* (Benth.) | Euphorbiaceae | mp | 5 | -157 | 24 | 2 | 7 | 3.45 |
| *Monodora tenuifolia* Benth. | Annonaceae | mp | 5 | -223 | 41 | 3 | 5 | 1.35 |
| *Nesogordonia papaverifera* (A. Chev.) | Sterculiaceae | MP | 5 | -1000 | 156 | 3 | 7 | 8.59 |
| *Neuropeltis acuminata* (P. Beauv.) | Convolvulaceae | MP | 5 | -193 | 44 | 3 | 6 | 5.75 |
| *Paullinia pinnata* L. | Sapindaceae | mp | 5 | -83 | 44 | 3 | 6 | 2.68 |
| *Platysepalum hirsutum* Hepper | Fabaceae | mP | 5 | -124 | 46 | 4 | 7 | 9.29 |
| *Pouteria aningeri* (A. Chev.) | Sapotaceae | MP | 5 | -194 | 27 | 3 | 6 | 3.35 |
| *Pterocarpus santalinoides* DC. | Fabaceae | mp | 5 | -22 | 20 | 3 | 7 | 3.21 |
| *Pterygota macrocarpa* K. Schum. | Sterculiaceae | MP | 5 | -47 | 25 | 4 | 8 | 11.75 |
| *Rinorea longicuspis* Engl | Violaceae | mp | 5 | -44 | 21 | 3 | 7 | 2.67 |
| *Sterculia rhinopetala* K. Schum. | Sterculiaceae | MP | 5 | -298 | 48 | 3 | 8 | 10.36 |
| *Streblus usambarensis* (Engl.) | Moraceae | mp | 5 | -276 | 65 | 3 | 5 | 1.94 |
| *Streptogyna crinita* P. Beauv. | Poaceae | G | 5 | -253 | 61 | 3 | 4 | 0.49 |
| *Strombosia pustulata* Oliv. | Olacaceae | mp | 5 | -61 | 30 | 4 | 6 | 1.93 |
| *Strophanthus sarmentosus* DC. | Apocynaceae | mP | 5 | -59 | 24 | 3 | 6 | 3.45 |
| *Terminalia superba* Engl. & Diels | Combretaceae | MP | 5 | -182 | 25 | 3 | 8 | 9.38 |
| *Thaumatococcus daniellii* Benth. | Marantaceae | G | 5 | -114 | 28 | 3 | 5 | 0.79 |

**Table 2.** Contd.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Tiliacora dinklagei* Engl. | Mennispermaceae | MP | 5 | -273 | 89 | 3 | 5 | 2.95 |
| *Trachyphrynium braunianum* Baker | Marantaceae | mp | 5 | -62 | 46 | 3 | 6 | 1.02 |
| *Trema orientalis* (L.) Blume | Ulmaceae | mp | 5 | -307 | 53 | 3 | 6 | 2.42 |
| *Trichilia monadelpha* (Thonn.) | Meliaceae | mp | 5 | -90 | 26 | 3 | 6 | 2.67 |
| *Triplochiton scleroxylon* K. Schum. | Sterculiaceae | MP | 5 | -156 | 39 | 3 | 8 | 10.96 |
| *Xylia evansii* Hutch. | Mimosaceae | mP | 5 | -131 | 40 | 3 | 7 | 8.03 |

Tb = Biological type; Tr- = sum of links with regressive features considered negative; Tr+ = sum of links with progressive features considered positive; Sc. = average sciaphilia index; H = average height observed in the field; var. = variance of heights; I = index of the species in the regressive vegetation series (between 1 and 5); MP = megaphanerophyte; mP = mesophanerophyte; mp = microphanerophyte; G = geophyte.

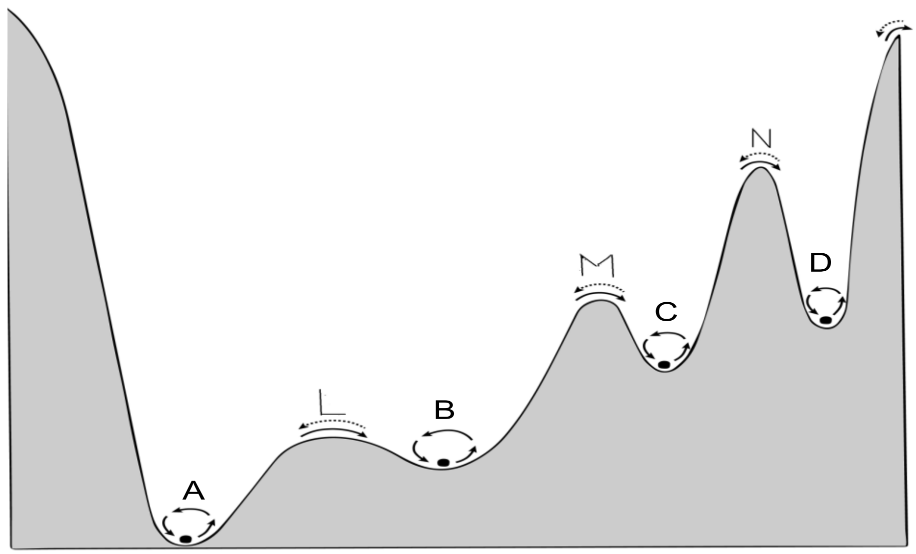


**Figure 2.** This rollercoaster-shaped model shows how biological systems remain in more or less stable states (A, B, C, D) separated by moments of crisis (L, M, N) for varying lengths of time.

almost unchanging for several centuries. Forests that have just been destroyed to establish food plants follow a regressive sequence that leads them into trough A where the new equilibrium controlled by the farmers is metastable because it can be broken if cultivation is abandoned (Akodéwou et al., 2019); fallow then settles and stabilises for a few years in trough B in a progressive sequence at first. The species in the fallow are not large and trees can gradually establish themselves by disturbing the functioning of the fallow, since their shade will kill species that need sunlight. Very slowly, the forest will resettle and arrive in the C-trough, often passing through some intermediate stages where some transitional species will be temporarily dominant. Hollow C is not identical to hollow D because the species typical of primary forests, called dryads, have disappeared. In studies on the establishment of crops in tropical forests (Assalé et al., 2016; Akodéwou et al., 2019), this operation is often described as 'degradation' as if human actions automatically led to a loss of quality compared to an ideal which would be the natural state of the vegetation before the arrival of humans (Arbelot, 1979). On the contrary, for an agronomist, agriculture is progress and not degradation. It is to avoid this ambiguity that we have said that the evolution of vegetation corresponding to forest clearing (from trough D to trough A) is regressive and that the sequence of forest regeneration is progressive. The problem of forest regeneration after the abandonment of food crops is therefore that of the transition from trough C to trough D. Progressive species capable of initiating natural regeneration of FCHS have been known to be evident. If the crop is abandoned, a sequence of progressive vegetation begins as a prelude to forest regeneration in places where forest species are present. Either because they have survived when the crop was planted, or because they have reestablished themselves through seed germination or the production of shoots, the most significant result of this work is that the progressive species are sufficiently numerous and frequent that the installation of crops in the FCHS has not yet crossed the threshold of irreversibility beyond which forest regeneration would be impossible.

## Conclusion

The problem to be solved was whether the FCHS, which lost more than 70% of its forest cover during the 10 years of conflict in Côte d'Ivoire, between 2002 and 2013, and to cocoa cultivation can be regenerated naturally from the species present on the ground. The results showed that the numerous coexistences of fallow land and regenerating forest mean that fallow land allows the forest to regenerate in a progressive sequence of vegetation. Farmers may allow fallows to establish themselves because they realise that cultivation leads to a decrease in sustainable soil fertility. A total of 59 regenerating species have been recorded in the classified forest of Upper Sassandra. They are numerous enough for the forest management authorities to search for them in the field to find places where forest regeneration can develop. The table summarising the relationship of species to the results of human actions shows that there are enough species capable of natural forest regeneration that foresters can find in the field for the forest to reestablish itself. This result is a first step towards ensuring that the authorities responsible for forest management are aware of the measures to be taken to regenerate the forest.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

### REFERENCES


Ahmed DA, Fawzy M, Saeed NM, Awad MA (2015). Effect of the recent land use on the plant diversity and community structure of Omayed Biosphere Reserve. Global Ecology and Conservation 4:26-37.

Akodéwou A, Oszwald J, Akpavi S, Gazull L, Akpagana K, Gond V (2019). Problématique des plantes envahissantes au sud du Togo (Afrique de l'Ouest): apport de l'analyse systémique paysagère et de la télédétection. Biotechnologie, Agronomie, Société et Environnement 23:88-103.

Arbelot V (1979). Essai de caractérisation des principaux stades de l'"évolution" de la végétation par la distribution verticale de la phytomasse dans la garrigue montpelliéraine. Approche de la notion de dégradation. Mémoire de diplôme d'études approfondies Université des Sciences et Techniques du Languedoc, Montpellier 33 p.

Assalé AAY, Barima YSS, Kouakou KA, Kouakou ATM, Bogaert J (2016). Agents de dégradation d'une aire protégée après une décennie de conflits en Côte d'Ivoire cas de la forêt classée du Haut-Sassandra. International Journal of Innovation Science and Research 2:123-133.

Barima YSS, Kouakou ATM, Bamba I, Sangne YC, Godron M, Andrieu J, Bogaert J (2016). Cocoa crops are destroying the forest reserves of the classified forest of Haut-Sassandra (Ivory Coast). Global Ecology and Conservation 8:85-98.

Brillouin L (1962). Science and Information Academic Press, 2nd ed., New-York.

Chatelain C, Dao QH, Gautier L, Spichiger RE (2004). Forest cover changes in Côte d'Ivoire and Upper Guinea. Biodiversity of West African forests: an ecological atlas of woody plant species pp. 45-82.

Dolédec S, Chessel D, Olivier JM (1995). L'analyse des correspondances décentrée: application aux peuplements ichtyologiques du Haut-Rhône Bulletin français de la pêche et de la pisciculture 336:29-40.

Forman R, Godron M (1986). Landscape ecology, Wiley, New-York 619 p.

Godron M (2012). Écologie et évolution du monde vivant, Ed. L'Harmattan, 8 chapitres connectés 1850 p.

Godron M, Daget Ph, Emberger L, Le Floc'h E, Long G, Poissonet J, Sauvage Ch, Wacquant J-P (1968). Code pour le relevé méthodique de la végétation et du milieu Éditions du Centre national de la recherche scientifique, Paris, 292p.

Kouamé NF (1998). Influence de l'exploitation forestière sur la végétation et la flore de la forêt classée du Haut-Sassandra (Centre-Ouest de la Côte d'Ivoire). Thèse Doctorat 3e Cycle, Université Cocody- Abidjan, 227p.

Kouassi KH, Koffi N, Modeste G, Konan K (2009). Flore post-culturale en zone de forêt dense semi décidue de côte d'Ivoire. International Journal of Applied Biosciences 19:1026-1040.

Lebreton DJ, Chessel D. Richarlot-Coulet M (1988). L'analyse des relations espèces-milieu par l'analyse canonique des correspondances. Acta Oecologica 9(2):137-151.

Ousmane S, N'da Dibi H, Kouassi KH, Kouassi KÉ, Ouattara K (2020). Crises politico-militaires et dynamique de la végétation du Parc national du Mont Péko en Côte d'Ivoire. Bois et Forets Des Tropiques 343:27-37.

Papillon Y, Godron M (1997). Distribution spatiale du Lapin de garenne (*Oryctolagus cuniculus*) dans le Puy-de-Dôme: l'apport des analyses de paysages. Gibier Faune sauvage 14:3.

Papillon Y, Godron M, Delattre P (2008). Ecological affinity changes in a sudano-sahelian Rodent community after slash-and-burn farming (Gonsé forest, Burkina-Faso) African Journal of Ecology 46:435-439.

Xiaobing D, van der Maarel E (1997). Transect-based patch size frequency analysis. Journal of Vegetation Science 8(6):865-872.