A Janus-faced biodiversity change and the partiality of ecological knowledge in a world biodiversity hotspot in Ghana: Implications for biodiversity rehabilitation

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Abstract

The Gyamfiase–Adenya–Obom cluster of villages in the forest-savanna region of Ghana is located within one of Conservation International’s 34 “World Biodiversity Hotspots” of the most biodiversity-threatened regions of the world. In collaboration with local farmers in this area since 1993, the People, Land Management and Ecological Change Project in Ghana (PLEC-Ghana) has been working on promoting biodiversity rehabilitation to address problems of biodiversity change. This goal is expected to be achieved through agrobiodiversity or biodiversity-friendly agricultural practices. However, farmers’ employment of these practices has been lackluster, even while they acknowledge biodiversity changes, dominated by Chromolaena odorata and other herbaceous species, that are driving the decline in forests and their biodiversity. In interpreting the difficulties of biodiversity rehabilitation in Gyamfiase–Adenya–Obom, this study outlines the diverging ecological knowledge of non-residents/outsiders and local farmers about biodiversity change, which it describes as Janus-like with two diverging faces. One face of biodiversity change shows the detrimental impacts on biodiversity and its observers—non-residents/outsiders—insist on biodiversity rehabilitation that nurtures forests, and the growth and domination of tree species. The other face of biodiversity change shows its agronomic advantages and its observers—the local farmers—are skeptical of current biodiversity rehabilitation practices. Farmers see agronomic benefits in biodiversity change, in particular the benefit of faster soil regeneration within the predominant bush fallow system of farming. And as a result of this observation, farmers continue with practices that sustain a decline in forests and biodiversity. Based on social and ecological research that explores three biodiversity-friendly practices promoted by PLEC-Ghana (fallow management, mulching, and intensive weeding to protect tree seedlings), this article discusses the partiality of ecological perspectives that emphasize either face of biodiversity change but not both, and the implications for biodiversity rehabilitation.

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1. Introduction

A third of the area of Ghana is located within one of Conservation International’s 34 “World Biodiversity Hotspots” of the most biodiversity-endangered and vulnerable regions of the world (Conservation International, 2005a). This most biodiversity-threatened area of Ghana is a subset of the larger Guinean Forest Region of West Africa (World Wildlife Fund, 2001; Conservation International, 2005a). The predominant view is that this region’s astounding biodiversity is being degraded by society. For instance, 85% of the original 620,314 km² of forest habitat has been cleared (Conservation International, 2005c) and what remains is “highly fragmented, largely due to human activities...primarily slash-and-burn agriculture” (World Wildlife Fund, 2001; Conservation International, 2005a). This same area is also one of the World Wildlife Fund’s “Global 200 Ecoregions” whose biodiversity is threatened (World Wildlife Fund, 2005).
Wildlife Fund, 2001). The loss of forest habitats is also extensive in Ghana’s biodiversity hotspot. Covering 8.2 million hectares (34% of Ghana’s total area) in the late 19th century, the Guinean canopy forest habitats of Ghana presently cover only 1.6 million hectares, or 7% of Ghana’s total area (The World Bank, 1998, p. 2; The Republic of Ghana, Ministry of Food and Agriculture, 1999, p. 1). It is threats to biodiversity, such as these, which led to the United Nations Convention on Biological Diversity (CBD) of June 1992. This global treaty calls for a global commitment to meeting the goal of “rehabilitating and restoring degraded ecosystems and promoting the recovery of threatened species in collaboration with local residents” (Secretariat of the Convention on Biological Diversity, 2000, p. 9).

In response to this call, the People, Land Management and Ecological Change Project in Ghana (PLEC-Ghana) is collaborating with local farmers to promote biodiversity rehabilitation through agrobiodiversity or biodiversity-friendly agricultural practices within Ghana. The Gyamfiase–Adenya–Obom cluster of villages in the forest-savanna ecological zone (a part of the Guinean Forest Region) in the Eastern Region of Ghana (Fig. 1) is one of PLEC-Ghana’s project sites and is this study’s research site. A primary focus of PLEC-Ghana in this area since 1993 is to collaborate with local farmers to revive the biodiversity-friendly traditional agroforestry practices that would rehabilitate the degraded forest ecosystem and conserve its natural life forms (Gyasi, 2002). In PLEC-Ghana’s view, biodiversity-unfriendly practices have “exerted a disturbing effect on the fragile forest ecosystem through the widespread removal of the ground storey of the natural forest, through the erosion of soils and the leaching of their nutrients and through the loss of natural plant and animal species” (Gyasi, 1997, p. 85). This perspective is described in this study as the endangerment discourse, and it suggests that these problems of endangerment can be addressed with biodiversity-friendly practices.

Local anecdotes indicated to this author that the general response of farmers to biodiversity rehabilitation has been lackluster. These local stories pointed to a continuing general decline in forests and their biodiversity. Given the unanimous view of widespread biodiversity decline in the study area, and given the endangerment discourse about the benefits of biodiversity rehabilitation, why are many farmers not employing the biodiversity rehabilitation practices being promoted, and are there benefits to biodiversity rehabilitation than are being realized by many farmers? This was the study’s research problem, and local anecdotes prior to the study provided an initial answer to this problem. These anecdotes presented a different viewpoint from those of outsiders about the benefits of biodiversity rehabilitation. Apparently, biodiversity change in the study area is Janus-faced, that is it has two diverging faces. One face of biodiversity change shows the detrimental impacts of such change. This face is emphasized by non-locals (more so than locals), and observers of this face—the outsiders—insist on biodiversity rehabilitation. The other face of biodiversity change shows the agronomic advantages of such change, and this perspective is emphasized by locals (more so than non-locals). Observers of this face—the local farmers—are skeptical of biodiversity rehabilitation, and as a result farmers continue with practices that sustain the decline in forests and biodiversity.

Within this context that suggests contradictory faces of biodiversity change, the answers to the following research questions were pursued in order to address the larger research problem:

1. What is farmers’ local ecological knowledge of biodiversity change and of the benefits of biodiversity rehabilitation, and how does this knowledge diverge from the endangerment discourse?
2. How does this knowledge support or undermine biodiversity rehabilitation?

3. Are there agronomic benefits to biodiversity rehabilitation practices that are not acknowledged by farmers' local knowledge and by the many farmers that local anecdotes suggest are not participating in biodiversity rehabilitation?

2. The partiality of environmental discourses

The apparently contradictory faces of biodiversity change and different perceptions about the need for biodiversity rehabilitation are important for comprehending the realization of biodiversity rehabilitation in the study area. These disjunctions between the emphases of the environmental discourses articulated by non-local actors and those of locals and their implications have been stressed by a large body of literature (Amanor, 1996; Fairhead and Leach, 1996a,b; Leach and Mearns, 1996; Bassett and Zueili, 2000; Robbins, 2001). Drawing significantly on the work of Foucault (1980), this literature has been especially critical of the partiality of the ecological knowledge of nonlocals about local environmental problems and solutions to them. These held views of non-locals about environmental problems and their solutions may be described as a discourse of environmental endangerment. Applied to the study area, this discourse (which employs the methods and models of environmental science) suggests the area was a “virtually uninhabited virgin high forest” prior to 1850. This forest was subsequently degraded primarily by agricultural activities, leading to contemporary conditions of “widespread deforestation, loss of natural biodiversity and soils deterioration” and the “endangerment of the productive or life-support capacity of the land” (Gyasi, 1997, p. 84). Biodiversity rehabilitation is proposed as an answer to these biodiversity change problems and the agronomic problems that follow such change. However, a critique of this discourse of endangerment insists that the local environmental knowledge of farmers which employs different ecological insights, concepts, and explanations, and which has “different root assumptions concerning the relationship between social and ecological processes” is often devalued, or simply not taken seriously enough (Fairhead and Leach, 1996a, p. 5). In the context of the forest-savanna “biodiversity hotspot” of West Africa, the question posed by some of this critical literature (Fairhead and Leach, 1996a,b; Leach and Mearns, 1996; Bassett and Zueili, 2000, 2003) about this powerful endangerment discourse on nature–society relations is: “What perspectives, issues, and questions get disguised, buried, or eliminated . . . in the production and circulation of these universal scientific tools and models . . .?” (Goldman and Schurman, 2000, p. 577). The caveat underscored by this literature is that environmental knowledge is partial.

Highlighting the partiality of environmental knowledge that does not give sufficient weight to local ecological knowledge of local residents has practical implications as it provides insights for comprehending under-achieving environmental policies and projects. As Amanor (2002, p. 126) observes:

The knowledge and perceptions that rural communities hold about the environment will determine their relationship to the environment, and their capacities and willingness to engage in activities that will ameliorate environmental degradation or enable them to adapt to changing conditions . . . [A] failure to understand popular [local] perceptions of the environment and experiences of degradation, may lead to the failure in the design of ‘green technologies’, [particularly] if these do not take local farming styles, and the objectives and strategies of farmers, into consideration.

Such critical insights are particularly applicable to the study area, because contrary to the discourse of endangerment, local anecdotes point to the agronomic benefits of biodiversity change. As a result, farmers are sustaining the status-quo, and are in particular skeptical about whether the agronomic benefits of biodiversity rehabilitation are significant.

This study thus proceeds, first, with a conviction that to begin to comprehend the extent of biodiversity rehabilitation practices, the accounts and knowledge of ecological and agricultural endangerment held by non-local actors about the study area must be juxtaposed with that of local farmers.5 However, if such an approach is to acquire insights into how the realization of biodiversity rehabilitation may be expanded in the study area, it must also be open to the partiality of the local ecological knowledge held by local farmers which leads them to be skeptical about the benefits of biodiversity rehabilitation.6

3. The study area and methodology

The Gyamfiase–Adenya–Obom cluster of villages, with a population of 445 in the Eastern Region of Ghana (The Republic of Ghana Statistical Service, 2004), was selected as a study site based on the researcher’s personal

5 This approach would, first, highlight the seemingly incongruent accounts which point to the Janus-faced character of biodiversity change in the study area. Second, it would also illuminate gaps in ecological knowledge and uncover the silences and partiality of biodiversity narratives that sustain divergent perceptions of biodiversity change. Third, it would help address the practical question, “how do specific ideas about nature and society limit and direct what is taken to be true and possible?” (Robbins, 2004, p. 66).

6 It is in acknowledgement of these knowledge lacunae that calls have been made for the need to “build bridges across the gulf” that separates local actors and non-local actors (Bebbington, 1996, p. 86). Building bridges could be achieved in a process of generating knowledge that involves “exploring what one [actor] knows, recognizing the limitations of this knowledge, reaching out to find out what others know [that] can complement and advance the limitations of one’s [the actor’s] own knowledge . . .” (Amanor, 1996, p. 16).
contacts and experiences in the area and on its status as a project site for biodiversity rehabilitation. With an annual rainfall of 1260 mm, a wide variety of crops are cultivated in this part of Ghana’s “food crop belt” (Dickson and Benn, 1977, pp. 154–158). Farmers currently primarily cultivate cassava (Manihot esculenta), maize (Zea mays), and vegetables, with plantain (Musaspp.), yam (Dioscorea spp.), and cocoyam (Colocasia esculenta) as secondary crops on mixed crop farms. Agriculture continues to be largely based on the bush fallow system and on labor-intensive management practices involving the use of cutlasses and hoes. However, the previously predominant biodiversity-friendly traditional agroforestry practices of bush fallow have declined dramatically since the early 19th century in the aftermath of oil palm (Elaeis guineensis) and cacao (Theobroma cacao) production during the colonial era and the widespread cultivation of maize (Z. mays) and cassava (M. esculenta) thereafter. The production of these crops involved massive clearance of the canopy forests and the obstruction of biodiversity regeneration. Rebuilding this biodiversity is a goal of the PLEC-Ghana project.

The extent to which farmers are employing the practices being advocated by PLEC-Ghana for rehabilitating and conserving forest biodiversity was assessed in an 80-farmer sample survey, which was based on the referral sampling method for selecting farmers of varied social characteristics (Sudman and Kalton, 1986; Sudman et al., 1988; Singleton and Straits, 1999, p. 162-3). The divergent perceptions of biodiversity change, and the partial nature and the limitations of the ecological knowledge of both local and non-local actors (about the need for and the benefits of biodiversity rehabilitation practices) are explored with secondary and primary ecological research data. First, the local knowledge of outsiders about the specific biodiversity changes in the study area as well as the agronomic impact of such changes in terms of their specific implications for soils are indicated with secondary ecological data obtained from environmental specialists literature. Second, this ecological knowledge of outsiders is assessed against that of the local people with regard to biodiversity changes and the agronomic impacts of such changes. This assessment was based on primary social research, which pursued insights about local perceptions and experiences of environmental change. These insights were obtained through structured and unstructured interviews in 80 households, interviews with 12 family elders and four focus group discussions from 2002 to 2004. Also, follow-up interviews with all respondents for clarifications on a variety of issues occurred in 2005 and 2006. Aspects of this local ecological knowledge are confirmed with secondary ecological data. Third, within the context of divergent ecological perspectives and a project that is promoting biodiversity rehabilitation practices, critical primary ecological data are employed to show the extent to which biodiversity rehabilitation is actually being realized on the ground. Such data came from two sources—an experimental design and farmer testimonies. Both sources interrogated the extent to which farmers were regenerating biodiversity on their fallow plots by investigating the biodiversity and floristic characteristics of these plots, which are a focus of biodiversity rehabilitation efforts.

Primary data about biodiversity and floristic characteristics of biodiversity were derived from an experimental design. Financial constraints limited the experimental design to 12 farms. The 12 experimental farms were two replicates from each of six 1-ha fields of six volunteer farmers. Each experimental farm was thus half a hectare. The fields reflect the prevailing variations in the pivotal bush-fallow practice of recycling land between cultivation and fallow for the regeneration of biodiversity and soils. Thus the primary treatment applied to the experimental fields was the average length of fallow for biodiversity rehabilitation (following the average 2 years of cultivation)—fields with a history of fallow of 4–5 years (3 fields) compared to those with a fallow of 2–3 years (3 fields). A rapid floristic inventory survey was undertaken on these fields (fallow ≤3 years and fallows >3 years) from February to July 2002 to identify species life form distribution and the frequencies of species life forms. The goal was to indicate, with evidence on the ground, the extent to which farmers were or were not rehabilitating biodiversity in their fallow fields. Frequencies were assessed by listing species as present or absent (in other words, the chances of finding them) in 25 random 1 m² quadrats on each field. Inventories of tree species were based on continuous recording within the whole 1 ha of each experimental field as trees require larger sampling quadrats. These data were complemented by extensive farmer testimonies of their observations about the life form characteristics on their fallow fields.

The fourth component of ecological research was informed by the subsequent analysis of the floristic data on fallow fields which confirmed the elusiveness of biodiversity rehabilitation, and by farmers’ statements, in testimony-based primary ecological research. The statements pointed to skepticism about the agronomic benefits of biodiversity rehabilitation as reason for their lackluster adoption of biodiversity-friendly practices. It was critical to assess, on the ground, farmers’ ecological knowledge against that of outsiders about the agronomic benefits of biodiversity rehabilitation. This assessment was based on primary ecological research data from the experimental fields. Three biodiversity-friendly practices—fallow improvement/management (Nye and Greenland, 1965;
Young, 1976, pp. 101–124; Brand and Pfund, 1998; Slaats et al., 1998), mulching (Young, 1976, pp. 117–118; Norgrove et al., 2000), and intensive weeding (Slaats et al., 1998; Honu and Dang, 2000; Norgrove et al., 2000)—associated with the three stages of fallow, land preparation, and cultivation in the bush fallow system, respectively, were compared to prevailing farmer practices to unveil their relative agronomic benefits.10

To compare the agronomic benefits of biodiversity-friendly practices to prevailing farmer practices, secondary treatments were applied to the experimental farms (half of which had fallows ≤3 years/less improved fallows and the other had fallows >3 years/more improved fallows).11 Each farm had a split-plot design to reflect the land preparation practice of either burning after slashing the vegetation with a cutlass or the biodiversity-friendly practice of leaving the slashed vegetation as mulch. Thus, half of each experimental farm was burnt in preparation for farming and the other half was mulched. Maize and cassava—the most common crops—were cultivated on each split-plot on the same day and with uniform spacing. To further capture the ecological characteristics of farms under varied management practices, an additional secondary treatment was applied. This treatment involved varying levels of the potential biodiversity-friendly practice of intensive weeding during cultivation, which shapes the competition presented by weeds to preferred species. Five equal subplots were demarcated within each split-plot and each randomly subjected to one of 5-weeding regimes: 0 (no) weeding, 1, 2, 3, and 4 weeding (see Fig. 2 example). Weeding was performed on the same day according to treatment. Slashed weeds were left as mulch on all weeded plots after weeding, in line with the normal practice of all farmers during crop cultivation.

Floristic data from the various treatments of the experimental farms provide insights into how various land management practices of farmers might simultaneously impact biodiversity and have lesser or greater agronomic benefits, particularly in relation to the primary concern of farmers about competition by weeds to crops. These data about the various treatments on the experimental plots that reflect the three biodiversity enhancing practices promoted by PLEC-Ghana, and their alternatives were measured at the end of the farming season and focused on weed densities of five random 1 m² quadrats of each treatment.

Data from the floristic analyses are presented in a series of bar graphs, with standard error bars indicated where appropriate.12 The differences between fallow treatments with regard to the distribution and the frequencies of species life forms on the fallow fields are statistically analyzed using one-way analyses of variance (ANOVA). Weed densities and their relationships with practices of fallow, mulching, and the intensity of weeding are analyzed using three-way ANOVA, with diagnostic one-way ANOVAs to determine the significance of differences when combinations of mulching/burning, weeding regime, and practices of fallow are held constant. Significance was tested at the 5% level of significance (p < .05).13

4. Biodiversity rehabilitation agricultural practices and a Janus-faced biodiversity change

PLEC-Ghana is most credited by farmers for disseminating knowledge and for promoting fallow management

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10 How these three practices could simultaneously assist farmers in biodiversity rehabilitation by nurturing the growth of trees, particularly in the successional vegetation of fallows, is also outlined from this research.

11 Fallows of more than 3 years are considered by 12 elderly informants (who are perceived as among the most experienced farmers) as providing more significant biodiversity and agronomic benefits than fallows of up to 3 years. Fallows >3 years are thus considered improved fallows and ≤3 years fallows as less improved or unimproved.

12 The graphs enable “order of magnitude” statements to be made about the data collected from multiple samples. Statistical analyses provide further elaboration about the differences in the varied samples.

13 Data for the significance tests were analyzed for homogeneity using Levene’s Test of Equality of Variances.
that improves fallows with trees, and mulching and selective weeding that protect tree seedlings. Yet these tree conservation practices that assist in biodiversity rehabilitation have low rates of employment at 14% of the total sample of farmers for fallow management, 5% for mulching, and 19% for selective weeding to protect tree seedlings. Leach and Mearns (1996, p. 22) suggest that there is the temptation to implicitly assume that the ‘target group’ is recalcitrant or ignorant rather than because the problem was misconceived in the first place” when proposed environmentally friendly practices to address environmental problems are not readily picked up by local farmers. As local anecdotes indicated prior to this study, a misconception of the problem of biodiversity change may be at the heart of the lackluster adoption of many agrobiodiversity practices in the study area, and it is to this perception that the article now turns.

Environmental science evidence supports the view of biodiversity change which suggests that the previously extensive original closed canopy forests in the study area have been severely degraded. Trees comprise about 90% of the species life forms in such original forests (Hopkins, 1965, pp. 22–28; Lawson, 1966, pp. 10–16). But, this pattern of tree dominance has dramatically changed. On the basis of a floristic inventory of six study sites in the southern forest-savanna region of Ghana, including the Gyamfiase–Adenya–Obom area, the PLEC-Ghana botanist, Enu-Kwesi (1997) made these observations. First, trees comprised only 45% of the enumerated life forms (48% in Gyamfiase–Adenya–Obom), while herbs and shrubs comprised the rest (52% in Gyamfiase–Adenya–Obom). Second, the “original Antiaris–Chlorophora association” of forest vegetation (described by Taylor, 1960) is absent in the Gyamfiase–Adenya–Obom area. Third, Enu-Kwesi (1997) describes the floristic changes in the study area as a movement from closed canopy forests to “predominantly” herbaceous species. Fourth, the single most predominant species in all the sites PLEC-Ghana studied in the region is the highly competitive herb/shrub C. odorata. Many would thus concur with Enu-Kwesi (1997, p. 75) that “the vegetation of the forest-savanna zone is undergoing degradation, including the loss of floristic diversity, which might be countered by encouraging longer fallows, preservation of hillsides and endangered natural habitats, and other anti-deforestation measures”.

Further environmental science evidence is provided by PLEC-Ghana soil scientist, Owusu-Bennoah (1997), who compares “virgin” forest soils to continually cultivated soils in fields that employ biodiversity-unfriendly practices in the same six forest-savanna sites studied by Enu-Kwesi (1997). He observes that “virgin” forest soils are generally less acidic, have greater organic carbon, total phosphorous, and cation exchange capacities, and contain greater amounts of nitrogen than those in the biodiversity-unfriendly fields. He concludes that the data show “the decline in soil pH and plant nutrients with continuous cultivation” and “confirm the view that changes have taken place in the soils of the southern forest-savanna transition zone” (Owusu-Bennoah, 1997, p. 62). It is such evidence of outsiders about vegetation and edaphic deterioration in the study area that suggests the necessity for adopting biodiversity rehabilitation practices in agriculture to rehabilitate forests.

The ecological testimonies of farmers also unanimously conceded that forests were more extensive when their parents and grandparents established their farms, and that fallows regenerated forests in the past. Ninety-four percent of farmers also suggested that tree biodiversity had significantly declined. There was also unanimity among all

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14 The example of mulching illustrates the potential of these practices in enhancing the biodiversity and density of trees. PLEC-Ghana advocates mulching (known locally as oproka or proka, literally “leaving to rot” or “rotting that touches [the soil]”) whereby the well-slabbed vegetation is left on the soils prior to planting crops instead of burning the cleared vegetation, which creates an unsupportive environment for tree biodiversity (Gyasi, 2002, p. 254–5; Gyasi et al., 2003, pp. 99–104). Mulching instead of burning is particularly critical for biodiversity rehabilitation. The use of fire for clearing vegetation in the bush fallow system/slash-and-burn agriculture has actually been denounced as the greatest threat to forest establishment and biodiversity (Conservation International, 2000; World Wildlife Fund, 2001). For instance, fires directly destroy tree seeds and seedlings, and saplings, and the bare soils created by fires permit airborne colonizing seeds of weeds to establish and further choke out trees. As well, fires exacerbate moisture loss in soils. Fires also have detrimental effects on soil fertility by releasing nitrogen and sulphur into the atmosphere as gases, by removing organic matter, which is the primary source of soil nutrients, and by opening the soil to erosion and leaching (Nye and Greenland, 1965, p. 67, 88; Brand and Pfund, 1998; Norgrove et al., 2000, p. 205).

15 It should also be noted that in addition to the initiation of the PLEC-Ghana project in the early 1990s, two other critical periods in the recent environmental history of the area would seem intuitively likely to motivate farmers to adopt conservation agricultural practices that would rehabilitate forests. These periods were the early 1970s when Chromolaena odorata and other herbaceous species showed dominance, and when the El Nino related drought and the subsequent extensive bushfires of 1983, fueled by the dense thickets of C. odorata, destroyed farms. Despite these three significant environmental events—stretching over 35 years—only 14% of farmers reported changes in their practices in order to specifically rehabilitate forests following any of these environmental episodes. Farmers have “stubbornly” stuck with their practices.

16 In the original forest, Antiaris toxicaria/africana and Chlorophoral Milicia excelsa are the two most characteristic trees, however, Enu-Kwesi (1997, pp. 68–69) observed the presence of this association of megaphanerophytes (tall trees reaching over 30 m) in only one out of the six study sites in the forest-savanna region. The canopy forest of the Gyamfiase sacred grove prior to 2003 was cited by one respondent as an approximation of the density of fallow forests in the study site, as he worked on his grandparents’ farms (Interview at Adenya with A.K., 15th June, 2002).

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18 These findings also support PLEC-Ghana’s survey in 2000, which indicated that over 40% of a sample of farmers in three sites in the forest-savanna region, including Gyamfiase–Adenya–Obom, perceived a threat to the diversity of trees. Widely mentioned declining tree species among the present study’s respondents are Alstonia boonei (Onyenedua), Cibea pentandra (onyin), Milicia excelsa (odum), Triplochiton scleroxylon (wawa), and Antiaris toxicaria/africana (ofo)—all of which are pioneer species, and light-demanding megaphanerophytes.
respondents that *C. odorata* (*Acheampong*) has become the single most dominant species. In sum, these local views confirm Enu-Kwesi (1997) findings, and it would seem then that the PLEC-Ghana account of biodiversity change in the study area—one involving a decline in forest cover, a decline in the biodiversity of trees, and the increasing dominance of herbs and shrubs—is hardly a misconception. Yet, as previously indicated, not many have adopted the practices advocated by PLEC-Ghana since 1993, and most farmers in the study area continue with their practices that have maintained biodiversity change.

Floristic evidence of the lack of biodiversity rehabilitation indicated earlier in local anecdotes can be demonstrated in two ways. First, farmers’ testimonies of the extensiveness of forests in the past and their unanimous view about the continuing decline of forests point to the state of biodiversity rehabilitation. Further reinforcing these insights are farmers’ observations of current successional fallow vegetation on their fields. Their consistent observation is that the typical vegetation at the end of fallows (just prior to cultivation) is secondary bush rather than the secondary forest dominated by trees, characteristic of the past. This secondary bush is aptly described in Nye and Greenland (1965, p. 17) as “a chaotic wilderness of trees, shrubs, herbs, and climbers”. Respondents in the study area point to the continuing increasing dominance of herbs and shrubs and provide detail about the specific species composition of fallows. Respondent G.A. provides one of the most detailed accounts of species and describes the typical successional fallow vegetation as follows:

“In the first year of fallow there are many plants. But there is a lot of *Acheampong* [*C. odorata*, herb/shrub]. As soon as you leave the land [to fallow] *Acheampong* takes over the land. If the land has been cultivated for too long then you see a lot of “Juice” [*Euphorbia heterophylla*, herb]. All the plants “fight”. After 3 years the “stronger” plants grow well and survive and there are many plants. When the land is ready again for farming there are many plants like *Acheampong* [*C. odorata* (herb/shrub)], *Onyame bewu na mewu* [*Commelina vogelii*, herb], *Odwen* [*Baphia nitidia*, shrub], *Akakapenpen* [*Rauwolfia vomitoria*, tree], *Setedua* [*Mallotus oppositifolius*, shrub], *Nyamedua* [*A. boonei*, tree], *Nyinya* [*Mormondica charantia*, herb], *Okuro* [*Albizia zygia*, tree], some sare (grass), and many plants. You find *Acheampong* everywhere. They are big and spread out all over the farm.”

A second source of floristic evidence about the lack of biodiversity rehabilitation, in spite of the clear conception of biodiversity decline, comes from the experimental field research data about the study area’s typical 2–5-year fallows. The fallow floristic data suggests (like Enu-Kwesi (1997) floristic analysis) that life form characteristics continue to be significantly different from those that characterize forests. While typical tree species diversity in original forests range from 60 to 155 different species per hectare (Hopkins, 1965, p. 37; Lawson, 1966, p. 17), data from this study’s experimental fields suggest that tree diversities range on average from only 12 to 15 species per hectare (Fig. 3). Furthermore, no significant differences were observed between the ≤3 years fallows and the >3 years fallows in terms of the diversities of species of each life form. Yet in terms of order of magnitude, longer fallows had a larger number of tree species than shorter fallows. Fig. 3 also underlines another aspect of biodiversity change in a study area that
used to have extensive forests: the number of species that are herbs and shrubs is comparable to the number of tree species. A measurement of the likelihood of finding particular life forms, shown in Fig. 4, indicate the ubiquity of herbs, and in particular the importance of \textit{C. odorata} (a herb) as one of the most frequently occurring species.\footnote{Fig. 4 also suggests that the length of fallow has a significant effect on the frequencies of grass species and \textit{C. odorata}. The agronomic implication of this observation is addressed subsequently.}

In sum, secondary and primary floristic evidence support the conception of biodiversity change by both residents and non-residents of Gyamfiase–Adenya–Obom. There is clearly a face of biodiversity change involving forest and tree biodiversity decline. But, then, farmers are not enthusiastically embracing biodiversity rehabilitation. An especially relevant reason for this seems to be that the link between biodiversity change, the ill-health of the environment, and detrimental agronomic effects expressed by non-residents is challenged by the insights of local farmers. Farmers point instead to the agronomic advantages brought on by biodiversity change.

In response to the question, “Do the decline in forest fallows and an increase in other vegetation (such as \textit{Acheampong}) during fallows threaten your farming activities today and in the future? Please explain your response”, 86\% of the sample of 80 farmers insisted that the decline in forest fallows does not threaten their agricultural livelihoods. The trends of their explanation point to how the dominant plant species, \textit{Acheampong} (\textit{C. odorata}) intermixed with other herbs, shrubs, and trees—that is the current fallow vegetation of secondary bush—promotes soil regeneration. It achieves soil regeneration as well as, or better than, the heavy cover of trees used to characterize the critical fallow phase of farming in the past. And this soil regeneration under secondary bush is achieved in a shorter period of fallow than forest fallows. For farmers, the study area is not suffering from environmental ill-health, their soils are not degrading, and their agricultural livelihoods are not being threatened because of the biodiversity change linked to declining forest cover and the proliferation of herbs and shrubs. Productive land on a timely basis for agricultural production is what these farmers associate with biodiversity change—not the land endangerment emphasized by PLEC-Ghana (Gyasi, 1997, p. 84).\footnote{This is certainly a reminder of Leach and Mearns (1996, p. 12) caveat that conversion of forests by farmers, viewed as degradation by non-residents, “may be viewed positively by local inhabitants, for whom the resulting bush fallow vegetation provides a greater range of gathered plant products and more productive agricultural land”.}

This is the other face of Janus which shows the partiality of environmental knowledge that describes the study area as part of a biodiversity hotspot, as one in which livelihoods are threatened, and as one requiring intervention to promote biodiversity-friendly agricultural practices.

There are compelling reasons why farmers associate an agronomic benefit to an ostensibly detrimental biodiversity change. At the center of biodiversity change is the dominance of \textit{C. odorata}. “\textit{Chromolaena odorata} was found everywhere (in the forest-savanna region including Gyamfiase–Adenya–Obom) and in thick impenetrable masses, particularly over farm lands that were in fallow”, recounts \textit{Enu-Kwesi} (1997, p. 72).\footnote{The history of the diffusion of this exotic herb (which develops into a shrub) species and its dominance in Ghana are described in Hall et al. (1972), Amanor (1994, p. 201), and Awanyo (2001) and will not be repeated in this article. This exotic species’ enormously competitive nature has made it a dominant plant species and continues to sustain its dominance, which is clearly occurring at the expense of tree species.} With the dry weight above-ground biomass of this dominant species reaching about 21 tons/ha in a 3-year fallow in a West African study (Slats et al., 1996, p. 183), its role in soil regeneration becomes evident. While the greater above-ground biomass of a forest fallow provides largely woody tissues, the herbs and shrubs of \textit{C. odorata} fallsows consist primarily of leaves and soft stem tissue with higher nutrient concentrations, and provide these nutrients to soils within a much shorter time than forest fallsows (Nye and Greenland, 1965, 746).
undisturbed thus appears to be a major challenge. Hopkins (1965, p. 40) states: Biodiversity rehabilitation in the study area for forest fallows. Additional crop production of forest fallows are needed to provide ideal soils properties and amounts of forest fallows required to establish and provide soil regeneration, a farming system based on forest fallow would require a much longer period to establish. Oti (1965, p. 40) notes: at least 2 years to establish and provide soil regeneration, a farming system based on forest fallow would require a much longer period to establish. Approximately half of Ghana, is the problem of weeds, primarily C. odorata, slash, and not only to the soil during land preparation. The main difference between the two treatments is the vegetation—typically of 2–5 years—is a mix of trees, shrubs, herbs, and weeds. The evidence thus suggests that while a bush fallow farming system involving a C. odorata fallow would require a minimum of only 2–3 years to establish and provide soil regeneration, a farming system based on forest fallow would require a much longer period to establish. Estimates about the appropriate length of forest fallows vary depending upon ecological objectives. Nye and Greenland (1965, pp. 127–129) indicate that a minimum of more than 6 years is needed for a forest to establish in fallows. Dickson and Benneh (1977, p. 81) suggest 25–30 years of forest fallows are needed to provide ideal soils properties and amounts of soil nutrients. Seventy-five to 100 years of fallow are necessary to develop a mature secondary forest (Hopkins, 1965, p. 40), “which may have only 20 or 30 species of trees where there may originally have been several hundred” (Lawson, 1966, p. 27). If the ecological goal of fallows is to achieve conditions that closely approximate the original forest then fallow vegetation should in “certainly not less than 250 years . . . if still undisturbed . . . be almost indistinguishable from the original primary forest” (Hopkins, 1965, p. 40). Biodiversity rehabilitation in the study area thus appears to be a major challenge. As earlier indicated, these three biodiversity-enhancing practices with the lowest rates of adoption are the practices for which PLEC-Ghana is most credited with diffusing knowledge.

62 Thirty-one percent of all farmers maintained their practice of 2–3-year fallow/less improved fallows.

Data from Owusu-Bennoah (1997) indicate that soils under 2–3 year fallows dominated by thick masses of C. odorata in G Yamfia–Adenya had more favourable chemical and nutrient properties than the untouched “virgin” forest soils in nine out of a total of 10 measured properties, and were tied with forest soils in terms of sodium availability. The 10 measured properties were soil pH, organic carbon, total nitrogen, carbon: nitrogen ratio, calcium, magnesium, potassium, sodium, cation exchange capacity, and total phosphorous. The evidence thus suggests that while a bush fallow farming system involving a C. odorata fallow would require a minimum of only 2–3 years to establish and provide soil regeneration, a farming system based on forest fallow would require a much longer period to establish. Estimates about the appropriate length of forest fallows vary depending upon ecological objectives. Nye and Greenland (1965, pp. 127–129) indicate that a minimum of more than 6 years is needed for a forest to establish in fallows. Dickson and Benneh (1977, p. 81) suggest 25–30 years of forest fallows are needed to provide ideal soils properties and amounts of soil nutrients. Seventy-five to 100 years of fallow are necessary to develop a mature secondary forest (Hopkins, 1965, p. 40), “which may have only 20 or 30 species of trees where there may originally have been several hundred” (Lawson, 1966, p. 27). If the ecological goal of fallows is to achieve conditions that closely approximate the original forest then fallow vegetation should in “certainly not less than 250 years . . . if still undisturbed . . . be almost indistinguishable from the original primary forest” (Hopkins, 1965, p. 40). Biodiversity rehabilitation in the study area thus appears to be a major challenge. As earlier indicated, these three biodiversity-enhancing practices with the lowest rates of adoption are the practices for which PLEC-Ghana is most credited with diffusing knowledge.

62 Sixty-one percent of all farmers maintained their practice of 2–3-year fallow/less improved fallows.

Local ecological knowledge confirms these findings, and farmers choose, at the minimum, 2–3-year fallows dominated by C. odorata instead of secondary forest fallows.

Maintaining the environmental status-quo in spite of biodiversity change and biodiversity rehabilitation efforts, it would seem, is because farmers are not yet convinced about the agronomic benefits of agrobiodiversity practices. Farmers’ responses with regard to the agronomic advantages of the practices of fallow improvement, mulching, and intensive weeding to protect tree seedlings were as follows:

1. Eighty-six percent of farmers indicated no greater agricultural benefit of fallow improvement that lead to forest fallows, compared to their current practice of unassisted secondary bush fallows.

2. Eighty-three percent of farmers saw no greater agricultural benefit of mulching, compared to their current practice of burning during land preparation.

3. Eighty-one percent of farmers suggested no greater agricultural benefit of consistent and intensive selective weeding to assist in the growth of trees, compared to their current practice of not deliberately assisting in the growth of trees.

Does this raison d’être for the lackluster employment of biodiversity-friendly agricultural practices underscore the partiality of farmers’ local ecological knowledge and are there significant agronomic benefits to biodiversity-enhancing practices in this world biodiversity hotspot that are not indicated in farmers’ knowledge? Insights into these questions are provided by data from the experimental farms.

5. The agronomic and biodiversity benefits of fallow management

Fallow management that improves fallows with trees is generally rejected by farmers in favor of natural unmanaged fallows of 2–5 years, as the former is not perceived as carrying significant agronomic advantages over the latter. Thus, few farmers manage their fallows, and as a result this study was unable to obtain volunteers with managed fallow fields to compare to unmanaged fallows. However, among the typical fallow fields of 2–5 years obtained for the experimental farms (≤3 years fallow and the >3 years fallow), 12 elderly farmers, regarded as the most experienced, indicated that >3 years fallows represent improved fallows/better agronomic conditions than ≤3 years fallows. The ≤3 years fallows and >3 years fallow could in effect be viewed as useful proxies for unimproved/unmanaged fallows and improved/managed fallows, respectively. Thus, hereafter, ≤3 years fallows and >3 years fallows primary treatments of the experimental fields will also be referred to as unimproved fallows and improved fallows, respectively. Significant differences between the two treatments would suggest, at the very least, that management practices that improved ≤3 years fallows—a practice of 61% of the sample of farmers—to acquire the characteristics of >3 years fallows are advantageous for agriculture.

The major advantage of improving fallows is that it assists in resolving a major paradox faced by farmers as a result of biodiversity change. A constant complaint of farmers in the study area, as well as in the whole southern half of Ghana, is the problem of weeds, primarily the problem of C. odorata (Awanyo, 2001; Honu and Dang, 2000; Amanor, 1994, p. 201; Amanor, 1996, pp. 57–60; Hall et al., 1972). On the one hand, as previously noted, C. odorata’s prolific growth provides a major source of organic matter and soil nutrients during fallows and when this species is slashed and added to the soil during land preparation. On the other hand, farmers complain that this prolific growth during the cultivation stage of farming makes it a nutrient sink and an aggressive competitor to crops. At the end of the 16 weeks cultivation period, the
densities of weeds on each treatment of the experimental plots provided insight into the problem of weed competition.

Weed densities point to very vigorous weed growth right from the end of the cultivation period and continuing throughout the fallow period. The outcome is the “impenetrable” vegetation community observed in the fallow vegetation (Enu-Kwesi, 1997, p. 72). Fig. 5 shows for instance that on the control plots—0 weeding regime—there are massive weed infestations with densities from a low of 81 weeds per m² (810,000 weeds per hectare) to a high of 196 weeds per m² (1,960,000 weeds per hectare). On all the treatments, *C. odorata* was clearly the most dominant species, accounting for between 51% and 71% of the total number of weeds. Controlling this prolific weed growth during cultivation is a primary agronomic concern of farmers.

Fig. 5 shows that fallow improvement, which increases the density and variety of trees within the secondary bush fallow environment (see Figs. 3 and 4), reduces weed infestation—significantly. One-way (diagnostic) ANOVA shows the significant effect of improved fallows on weed densities (with the exception of the slash-and-burn, two weedings, \( p = .087 \)). Several studies support this finding and describe how the improved fallow conditions associated with reduced densities of the *C. odorata* weed. First, the massive seed production of this species declines under this improved condition, and second, seed mortality increases sharply with the rising density of trees (Roder et al., 1995, p. 88; Slaats et al., 1996, p. 188; Honu and Dang, 2000, p. 80). There is thus an agronomic benefit when fallows are improved to increase the density and diversity of trees, contrary to the majority view of farmers. Norgrove et al. (2000) show that forest fallows with high densities of trees lead to more rapid nutrient release and the higher risk of such nutrients being lost from the top soil compared to fallows with lower densities of trees. Soil nutrient loss in high tree density fallows might thus undermine the benefits of a reduced weed density. In sum, the agronomic benefits of improved fallows may best be realized under the secondary bush fallow conditions (with lower tree stand densities and dominated by *C. odorata*) that prevail in the study area (and whose agronomic advantages are touted by farmers) than under the high tree stand densities in forest fallow conditions, which seems to be the focus of outsiders concerned with biodiversity rehabilitation.

### 6. The agronomic and biodiversity benefits of mulching

Like fallow improvements, the experimental design showed that the practice of mulching during land preparation has both agronomic and biodiversity benefits, contrary to farmers’ partial knowledge that the practice carries no greater benefit than the predominant practice of slash-and-burn. These benefits of mulching arise because of its potential for reducing weed densities and the competition from the prolific *C. odorata*-led weed growth during cultivation.

Fig. 6 shows that the mulch treatments consistently had lower weed densities than the burn treatments in each fal-
low condition. This situation occurs as the use of fire leaves the soils bare, which permits the airborne colonizing seeds of *C. odorata* weeds in particular to establish and become more competitive. Beyond this agronomic challenge of competitive weeds, fire also produces a biodiversity challenge as it directly destroys tree seeds and seedlings, and saplings. Furthermore, the rapid *C. odorata* weed growth associated with fire impedes the growth of trees (Honu and Dang, 2000; Norgrove et al., 2000, p. 205). This impediment of tree growth continues into the fallow period as *C. odorata* seed production is profound and could be as much as 0.5 million seeds per square meter during the first 2 years of fallow (Roder et al., 1995, p. 88). Diagnostic one-way ANOVA however indicates that while there is a significant relationship between mulching and weed density, the significance occurs only on the one weeding regime treatment. The effect of weeding is explored next.

7. The agronomic and biodiversity benefits of careful/intensive weeding

Farmers are unanimous in their assertion that the *C. odorata*-led biodiversity change in Gyamfiase–Adenya–Obom has led to more intensive weeding during cultivation.28 The agronomic advantage of intensive weeding to reduce the competition presented by weeds to crops is self-evident to farmers. A reduced weed density also carries potentially important biodiversity benefits. PLEC-Ghana’s advocacy of intensive selective weeding that simultaneously reduces weed density and nurtures the growth of tree seedlings may give trees a better competitive start in fallows and thereby increase the density and biodiversity of trees and improve fallows.29 Farmers’ intensive weeding practice is however non-selective and all plants other than crops are cleared. Still, this non-discriminatory practice, simulated on the experimental farms, provides insight into the kind of weeding regime that reduces weed competition for the plants that are being nurtured—albeit crops and/or trees.

Data from the experimental plots suggest that intensity of weeding to control the competition from weeds is not synonymous with the number of times the plot is weeded but rather with how carefully the weeding is done. A three-way ANOVA suggested that fallow improvement, mode of land preparation (burning/mulching), and weeding regime significantly conditioned weed density. Diagnostic one-way ANOVA previously showed that generally fallow improvement significantly affected weed density (Fig. 5). Another diagnostic one-way ANOVA surprisingly established that while the tree biodiversity-friendly practice of mulching (Fig. 6) also significantly reduced weed density (compared to burning), the competition from weeds was only significantly reduced at the one-weeding regime.

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28 Similar observations about the intensive weeding required by farmers in controlling *C. odorata*, in particular, in other parts of Ghana are indicated in Awanyo (2001), and Amanor (1994, 1996).

29 As indicated above, slight fallow improvements provide further agronomic advantages during cultivation in the form of significantly reduced weed competition, which is presently not evident to many farmers.
Certainly, longer term studies are needed to further document how mulching combined with weeding regime affect weed densities. However, conversations with farmers who managed the experimental plots and farmers in the study sample provide immediate insights. The unanimous assertion was that the first weeding is the most carefully executed weeding regime, while the rest are less carefully done. The rationale was straightforward: germinating crops need the most protection from the more competitive weeds if these crops are to have acceptable yields. Latter weeding is less important, and this rationale is translated into their practices. In effect, Fig. 6 should be read as follows: careful/intensive weeding, combined with mulching, has a significant effect on the problem of weed densities. While farmers’ partial knowledge acknowledges that intensive weeding of farms to manage the weed problem produces agronomic benefits, it misses the significant advantages of mulching combined with intensive weeding, particularly intensive selective weeding that protects tree seedlings to improve fallows, which in turn reduces weed competition for crops. Mulching reduces weed competition and supports the growth of trees and crops more so than burning (Norgrove et al., 2000). And as Honu and Dang (2000) have shown, weeding that specifically removes C. odorata and protects tree seedlings is critical to rehabilitating tree species, which improves fallows.

8. Conclusion

The decline in forests and their biodiversity in Gyamfiase–Adenya–Obom lead to the identification of this area as part of the world’s biodiversity hotspots and as a good target for biodiversity rehabilitation. However, PLEC–Ghana led biodiversity rehabilitation efforts since 1993 have not reversed processes of biodiversity change, because of farmers’ lackluster adoption of forest biodiversity-friendly practices. In interpreting the difficulties of biodiversity rehabilitation, this study outlined the diverging ecological knowledge of outsiders and local farmers about biodiversity change, which it described as Janus-like with two diverging faces. One face shows detrimental impacts of biodiversity change. This is emphasized by non-locals (but less so by locals) and this perspective insists on biodiversity rehabilitation that nurtures the growth of tree species through all stages of the bush-fallow farming system. The other face shows agronomic advantages of biodiversity change. This is emphasized by locals (but less so by non-locals) and this perspective is skeptical of current biodiversity rehabilitation practices. Farmers see in biodiversity change the agronomic benefits of faster soil regeneration—brought on by the dominant C. odorata-led herbaecous species—in secondary bush fallows. This perception helps in comprehending farmers’ lackluster adoption of practices such as fallow management, mulching, and intensive weeding that nurture the growth and development of trees, in spite of the unanimous view of a continuing decline in forests and their biodiversity. This study suggests that ecological perspectives that emphasize either face of biodiversity change but not both are equally partial. The experimental design showed that contrary to farmers’ knowledge, the benefits of the biodiversity rehabilitation practices of fallow improvement, mulching, and intensive weeding to protect tree seedlings are also agronomic, and these practices carry significant agronomic advantages over current practices. These insights have implications for efforts at human-assisted biodiversity rehabilitation. Rather than dramatically different practices (which farmers might be reluctant or be unable to employ), the findings show the incremental benefits of practices that are set within the context of farmers’ knowledge that value current biodiversity conditions.

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