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Ranching, Logging, and the Transformation of an Amazonian Landscape

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INTRODUCTION

Human activity is rapidly changing the structural and functional characteristics of Amazonian ecosystems, altering regional hydrology, elevating concentrations of CO₂ in the atmosphere, and reducing species diversity. Strategies to conserve the regulatory functions performed by Amazon forests, and the numerous species of which they are composed, must look beyond the preservation of pristine forest reserves and consider the potential for forest recovery in the wake of the deforestation process. While forest regrowth is relatively rapid following such forms of deforestation as slash and burn agriculture, forest recovery on abandoned, grass-dominated pastures with histories of heavy use can be extremely slow (Uhl et al., 1988).

The significance of semi-permanent, abandoned pastures in eastern Amazonia goes beyond the forests that they displace, for these highly flammable ecosystems increase the likelihood that fire will be a component of this landscape for decades to come. In the Paragominas region of northeastern Pará (Figure 1), ranching and logging activities threaten to reduce the landscape to a frequently burned mosaic of abandoned, grass-dominated pastures and regrowth forests. In this article, I discuss the human activities and ecological processes that underly the transformation of the Paragominas landscape and briefly outline a strategy by which regional forest degradation might be averted.

RANCHING AND LOGGING IN THE PARAGOMINAS LANDSCAPE

Prompted by reports of vigorous grass production following forest conversion to pasture, Brazilian policymakers chose in the early 1960s to subsidize cattle production in Amazonia through low interest loans and other financial incentives (Hecht 1982). Paragominas arose as one of several centers of the burgeoning Amazonian cattle industry that resulted from these incentives. Reputedly fertile soils and the proximity of the Belém-Brasília highway, paved in 1969, lured thousands of settlers to the area. By 1985, 23% of the Municipality of Paragominas, a total of over 6,200 km², had been cleared and planted in pasture (Brazil, Superintendência de Desenvolvimento da Amazonia, unpublished data).

Grass production rates in pastures of the Paragominas region were often high during the first two to three years after formation, perhaps because of the pulse of phosphorus (P) and other nutrients released into the soil through burning of the forest biomass. The availability of soil P declined rapidly, however, falling to levels of the mature forest within 10 years of formation. As P availability dropped, the nutrient-demanding forage grasses, such as Panicum maximum, were gradually outcompeted by opportunistic shrubs (e.g. Stachytarpheta cayennensis) and herbs (e.g. Paspalum spp.). High stocking densities (>1 animal/ha) accelerated the replacement of forage grasses by weedy shrubs and herbs. By 1988, roughly half of the estimated 10 million hectares (ha) of Amazonian pastures formed on previously-forested land was in an advanced stage of degradation (Serrão and Toledo, in press) and much of this degraded pastureland was abandoned.

Figure 1. The Paragominas Region. Studies referred to in the text were conducted at Fazenda Vitoria ("Victory Ranch") indicated by the short arrow.
Forest recovery following pasture abandonment in the Paragominas region depends on the history of site utilization (Uhl et al., 1988). Biomass accumulation is rapid where pastures are abandoned within one year of formation because of poor grass establishment. In the absence of fire, regrowth secondary forests on abandoned pastures with histories of light use may regain most of the biomass of mature forests in less than a century. However, only a small proportion of the original flora and fauna may be represented in these regrowth forests.

The potential for forest regrowth can be greatly reduced when pastures are reformed through bulldozing or are used intensively, through a combination of high grazing density (>1 animal/hectare for a period of eight years), repeated burning and weeding, and herbicide application. Ranchers bulldoze degraded pastures to clear away logs, stumps and woody debris and to remove the root systems of weedy grasses, shrubs and woody sprouts in preparation for planting. In this process some topsoil is scraped away and relic tree root systems are destroyed. The soil is then disked, fertilized, and planted with the commercial forage grasses Brachiaria humidicola or B. brixantha. Eight years after abandonment, one pasture near Paragominas that had been reformed through bulldozing, fertilization, and replanting was dominated by weedy grasses and shrubs, contained only 5 Mg/ha of living, aboveground biomass and supported no trees species that were native to the original forest (Uhl et al., 1988).

Since there are numerous impediments to tree establishment from seed in abandoned pastures (Nepstad, 1989), management practices that kill or remove vegetative sources of new tree shoots favor the formation of semi-permanent, abandoned pastures. Although these semi-permanent, abandoned pastures are rare in the Paragominas region, they demonstrate the potential for pasture management practices to yield non-forest ecosystems that may persist long after pasture abandonment. The current trend among ranchers in eastern Amazonia is moving away from light pasture use and abandonment and toward heavy pasture management (Serrão and Toledo, in press). A hidden cost of pasture reformation for sustained cattle production is the risk that, should these systems fail, a highly flammable ecosystem will be produced, one that may fuel regional forest degradation.

While many ranches have failed in the Paragominas region, the lumber industry has expanded. Logging companies gain access to most of the region’s forests by extending the infrastructure of dirt roads associated with ranches. In 1986, there were more than 300 registered sawmills in the Municipality of Paragominas which were sawing lumber extracted from mature forests at the rate of ca. 20 m³/ha. On one logged site, 46% of the adult trees were knocked down or topped in order to harvest 3.4% of the trees.

Ranching and logging practices are transforming the Paragominas landscape into a mosaic of active pastures, regrowth forests on abandoned pastures, semi-permanent abandoned pastures, and logged forests (Figure 2). In contrast with the native forests of the region, which may never be ignitable under the current climatic regime, the altered ecosystems are highly flammable. They have an abundance of relatively dry organic matter fuel close to the ground due to a reduced canopy density and increased incident solar radiation. Pasturelands (active and abandoned) are the most flammable ecosystems in the Paragominas region. They can be ignited within one day of a rain event during the dry season. Regrowth forests and logged forests can catch fire within ten days of rain. Since there are annual droughts of at least 30 consecutive days in Paragominas, and numerous droughts of shorter duration (Nepstad, 1989), all of the anthropogenic ecosystems are vulnerable to fire during several weeks each year. During the severe dry season of 1987, roughly half of the secondary growth forest in the Paragominas region burned, mostly by accident, as fires initiated in pastures expanded into adjacent forests (personal observation).

Burns kill tree seedlings and saplings, and favor plant species that sprout following fire. Lianas often proliferate in frequently burned forest because of their exceptional capacity to sprout following stem damage and their rapid elongation under high light conditions. Fires initiated in pasturelands of the Paragominas region therefore set back forest recovery processes and drive the replacement of mature, species rich forest with forests of smaller stature, dominated by sprouting trees and lianas (Figure 2).

**ALTERNATIVES TO REGIONAL FOREST DEGRADATION**

In the likely event that semi-permanent, abandoned pastures expand in eastern Amazonia, it will become necessary for humans to facilitate forest regrowth in these highly flammable ecosystems if we hope to reduce the incidence of fire and the resulting degradation of the region’s forests. However, forest regrowth is limited by numerous obstacles to tree seedling establishment (Nepstad, 1989). Tree invasion of abandoned pastures is largely restricted to species that: (a) are disseminated into these ecosystems from nearby forests; (b) have seeds that can escape predation by the abandoned pasture animal community; (c) have seedlings that are unattractive to abandoned pasture herbivores, or can sprout following shoot removal; (d) are tolerant of drought; (e) root deeply soon after germination; and (f) are resistant to fire
damage. All of these characteristics can be found within the tree flora of the Paragominas region, but few species possess all of these traits. Several tree species of regrowth forest and treefall gaps are disseminated into abandoned pastures by bats and birds, but many of their small seeds and seedlings fall prey to abandoned pasture animals. The large seeds of some mature forest tree species escape seed predators, and their robust seedlings survive herbivory, tolerate drought, root deeply and sprout following fire. These species, however, are not disseminated into the abandoned pastures. Apparently the only tree species that can produce new shoots in grass/shrub vegetation are those that were present prior to pasture abandonment and expand clonally through root sprouting. These include *Solanum crinitum*, *Stryphnodendron pulcherrimum*, and *Vismia guianensis*, or the small-seeded trees species that are disseminated into the abandoned pasture in sufficiently large numbers to occasionally escape the numerous post-dispersal barriers to establishment (e.g. *Zanthoxylum rhoifolia*).

The establishment of a treelet or a mature tree in the abandoned pasture can improve the probability that other trees will also invade. Initially, the mature tree can facilitate additional invasion by providing perches and food (if it is fruiting) for frugivorous, seed-carrying bats and birds, thereby increasing the diversity and number of tree seeds that are deposited beneath its crown. As the mature tree expands through crown growth or root sprouting, grasses are shaded out and tree invasion is further enhanced. This occurs because dry season soil moisture deficits are less severe and root competition/interference encountered by new seedlings may decline. With the reduction of these limitations to dissemination, seedling survival and seedling growth, tree invasion beneath the mature tree increases, and a new “island” of trees begins to form. As tree islands expand and coalesce, more seed carriers will move between nearby forests and the abandoned pasture, fuel production (by grasses) will decline, and the ecosystem will become less flammable.

Strategies for reforesting semi-permanent, abandoned pastures should be designed to minimize the required inputs of capital and maximize the contribution of ecological processes. Abandoned pastures may be reforested cheaply if techniques for catalyzing tree island formation can be developed. The initial goal of reforestation strategies should therefore be the establishment of trees that attract a wide variety of seed-carrying animals. Several fruit trees native to eastern Amazonia may be good candidates for planting in abandoned pastures. For example, *Platonia esculenta* ("bacuri") is a large-seeded, deep-rooting forest tree that sprouts vigorously from its roots and produces a high quality fruit that is easily marketed in Belém. *Radhkoferella macrocarpa* ("guajará preto") exhibited 100% survival in grass/shrub vegetation at Fazenda Vitoria. It produces an edible fruit, and is common in mature forests of the Paragominas region. *Spondias mombin* ("taperebá") is a vigorous sprouter, produces a large-seeded, marketable fruit, and can be propagated from stem cuttings.

The viability of a reforestation strategy for semi-permanent, abandoned pastures in eastern Amazonia depends on the economic decision-making of the region’s land owners. The ranchers who now control this land spend money to eliminate trees from pastures, and they have little economic incentive to finance tree-planting projects. Ranchers have two specific reasons for not wanting to reforest grass-dominated, “abandoned” pastures. These pastures provide a source of emergency forage during the dry season when high-quality forage supplies are depleted (Serrão and Toledo, in press), and unforested lands are easier to hold against expropriation than forested lands (Hecht et al., 1988).

The most appropriate audience for strategies to reforest abandoned pastures is the future generation of land holders. As lumber supplies are depleted in the Paragominas region, ranchers will lose the revenue needed to finance pasture reformation and land may become available for other uses. Several land-uses may replace ranching and logging, such as charcoal production from residual wood in logged forests, or shifting cultivation. Both of

![Suggested pathways of ecosystem transformations in the Paragominas landscape.](image-url)
these practices would intensify the process of forest degradation in the Paragominas landscape (Figure 2).

A third land-use scenario includes the establishment of tree cover on abandoned pastures in the Paragominas region while providing a livelihood for many more people than are currently supported within this area. In this scenario, innovative farmers establish agricultural systems on abandoned pastures to produce a variety of tree crops, such as fruits and latex. The development of tree-based agriculture in the Paragominas region would reduce the flammability of the landscape by establishing tree cover on abandoned pasture, the most flammable ecosystem of the region. Tree-based agricultural systems would also reestablish mechanisms of forest regrowth in abandoned pastures, so that if these systems are eventually abandoned, forest recovery would proceed rapidly. The tree-based agricultural systems of Japanese immigrants in Amazonia may provide a model for the agricultural development of semi-permanent, abandoned pastures.

CONCLUSION

Highly flammable, semi-permanent abandoned pastures are fueling the degradation of the Paragominas landscape. Knowledge of the barriers to forest regrowth can serve as a basis for developing strategies to reforest these ecosystems. Reforestation techniques should be designed to overcome barriers to tree seedling establishment and to catalyze natural forest regrowth processes. There is little incentive for ranchers to reforest abandoned pastures. Reestablishment of tree cover on abandoned pasturelands may depend on the installation of tree-based agricultural systems by a future generation of enlightened land holders.

SELECTED BIBLIOGRAPHY


