ECOLOGICAL ASPECTS OF BAMBOO-DOMINATED FOREST IN SOUTHWESTERN AMAZONIA: AN ETHNOSCIENCE PERSPECTIVE

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INTRODUCTION

A large part of southwestern Amazonia is characterized by forests dominated by spiny arborescent bamboos (*Guadua* spp., Poaceae, Bambusoideae). These plants are known locally as *taboca*, and the bamboo-dominated stands *tabocal*. This ecosystem covers approximately 180,000 km² of the southwestern Brazilian Amazon and contiguous Peru (Nelson *et al.* 1997). About half the total area is in Brazil, in the States of Acre and southwestern Amazonas (Nelson 1994).

Preliminary surveys have shown that tree species richness is as high within bamboo patches as it is outside them, despite the dominance by a single species. Furthermore, recent discoveries of bird, amphibian, and insect species unique to Amazonian bamboo thickets (Conover 1994) suggest mutual specializations involving birds in particular (Kratter 1997), indicating that the habitat has a high conservation priority.

Ethnobiology, ethnoecology, and local knowledge all play a greater role today in research methodologies (Posey 1985). Ethnoknowledge is particularly appropriate in the study of the long life-cycles of these arborescent bamboos since it allows the researcher to draw on the experience of rubber tappers and indigenous peoples who have lived in the forest for generations, and who are aware of the pluriannual phenological phases of bamboo.

In this paper I present a conceptual ecological model of bamboo forest dynamics based on field observations, interviews and satellite image analyses. This is a pioneer effort to produce ecological informations about this little known Amazonian ecosystem.

MATERIAL AND METHODS

This paper is based on brief conversations and interviews supplemented by field observations, data from the scarce literature on this type of vegetation, and satellite image time series analysis.

I discussed bamboo forest ecology with more than 40 people and interviewed 21 rubber tappers, three Kaxinawá indians and one boatman, all of whom live or lived in areas of bamboo-dominated forest in seven municipalities in Acre state (Rio Branco, Sena Madureira, Brasiléia, Tarauacá, Cruzeiro do Sul, Mâncio Lima and Manoel Urbano).

From April 1995 to December 1996 I made field observations in Porto Acre (Humaitá Forestry Reserve), Sena Madureira, Cruzeiro do Sul region, and surveyed culms in permanent plots (0.3 ha) in Catuaba Experimental Farm, 30 km from Rio Branco.

The Landsat Thematic Mappers time series used (3, 4, and 5 bands) covers the period 1985–1995 and included most of Acre state and its border with Ama-

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zonas. I analyzed 35 mm color slides copied from National Institute of Spatial Research (INPE) images to check all interviews and field information.

Data from interviews, field observations and literature, coupled with satellite image analysis, are organized into a preliminary conceptual ecological model for bamboo-dominated forest. This model also considers some key aspects of the life-cycle of *Guadua weberbaueri* Pilger and *G. sarcocarpa* Londoño & Peterson, widespread bamboo species in Acre state.

RESULTS AND DISCUSSION

Using the TM sensor of the Landsat satellite, bamboo and non-bamboo forests are spectrally distinct. The first shows distinctive features made visible by their high infrared reflectance. Large patches with synchronized changes in color patterns are related to changes in leaf cover, senescence and the collapse of dead woody culms into the shade of surrounding trees. Prance (1989) compared bamboo forest with liana forest, which is also intermingled with dense forest.

Time series showed that phenological synchrony between bamboo patches is in some cases spectrally distinct and locally synchronized, but not in others. Based on two interviews with rubber tappers, dates of fertile bamboo collections, descriptions of naturalists, and analysis of Landsat images, Nelson (1994) suggested intervals of 26–29 years between successive mortality events in east-central Acre. In this study no person interviewed had observed more than one die-back event, but stories from their parents led the sources to speculate that cycles are 27–32 years for *G. weberbaueri* and 10–12 years for *G. sarcocarpa.*

The conceptual ecological model (Fig. 1) shows several features of bamboo forest ecology as well as some aspects of *Guadua weberbaueri* and *G. sarcocarpa* life cycles.

At maturity (stage 1), before mass flowering, bamboo forest displays a unique physiognomy; it fills large gaps between large scattered trees and dominates the understory, reaching the canopy at 35 m. In permanent plots, culms represent about 40% of the total number of stems of 2,5 cm or more diameter at breast height (DBH). The number of trees of 10 cm or more DBH, in contrast to dense forest, is 50% less. Torezan & Silveira (1996) estimated that the contribution of bamboo to the aboveground biomass of physiognomic units of bamboo forests is 13 T ha^{-1}. This value is less than 10% of the total above-

ground dry weight biomass of an average dense Amazonian forest (Brown *et al.* 1995). This value changes with forest ecological succession.

After mass flowering (stage 2), total or partial bamboo mortality occurs (stages 3 and 4), dramatically changing the forest physiognomy (stage 5). With total culm mortality, subcanopy density decreased significantly and light intensity and temperature at the understory and soil level increased. In general these changes characterize an open forest without bamboo (stage 6) and favor the establishment and growth of early successional species (stage 7).

A few months after flowering, seed production and predation are intense (stages 2 and 8). According to all informants, the seeds constitute a rich source of carbohydrates for many animal species, including *Mazama americana* (Red Brocket Deer), *M. gouazoubira* (Gray or Brown Brocket Deer), *Tayassu tajacu* (Collared Peccary), *Agouti paca* (Paca), *Dasyprocta* spp. (Agouti), *Dasypus novemcinctus* (Nine-banded Long-nosed Armadillo), *Sciurus* spp. (squirrels), and birds like Psittacidae (parrots and macaws), *Crax* spp. (currasows), *Penelope* spp. (guans), *Tinamus* spp. and *Cryptirellus* spp. (tinamous).

Although predation is intense, a great quantity of seeds survive (stage 9), possibly due to predator saturation (Janzen 1976). A visible seedling bank is formed on the forest floor (stage 10), comparable to a light green leafy carpet or a young rice field. *G. weberbaueri* seedlings suffer high mortality in the first years after germination (stage 11), and remain at low density for at least eight years after the senescence event. In 1995, I observed 50-cm-tall established and sprouted seedlings (stage 12), in Humaitá reserve and at Catuaba farm, where the tabocal died in 1992 and in 1984/85 respectively.

Complete decomposition of leaves, culms, and secondary branches takes 2–4 years, according to all those who commented on the process.

When the mortality is partial (stage 4) an open forest with small patches of surviving clumps results; these clumps provide a nucleus for vigorous shoot production, expansion and colonization (stage 13) to adjacent areas. Culms originating from surviving rhizomes have a larger diameter (average 4 cm) than culms originating from seeds (1–2 cm) and exhibit fast vertical shoot growth in the initial stages of culm development. As observed at Catuaba farm (unpublished data), they grew at remarkable rates of 10–15 cm day^{-1} in the rainy season, reaching the canopy at 15–20 meters just 3–4 months after sprouting. New
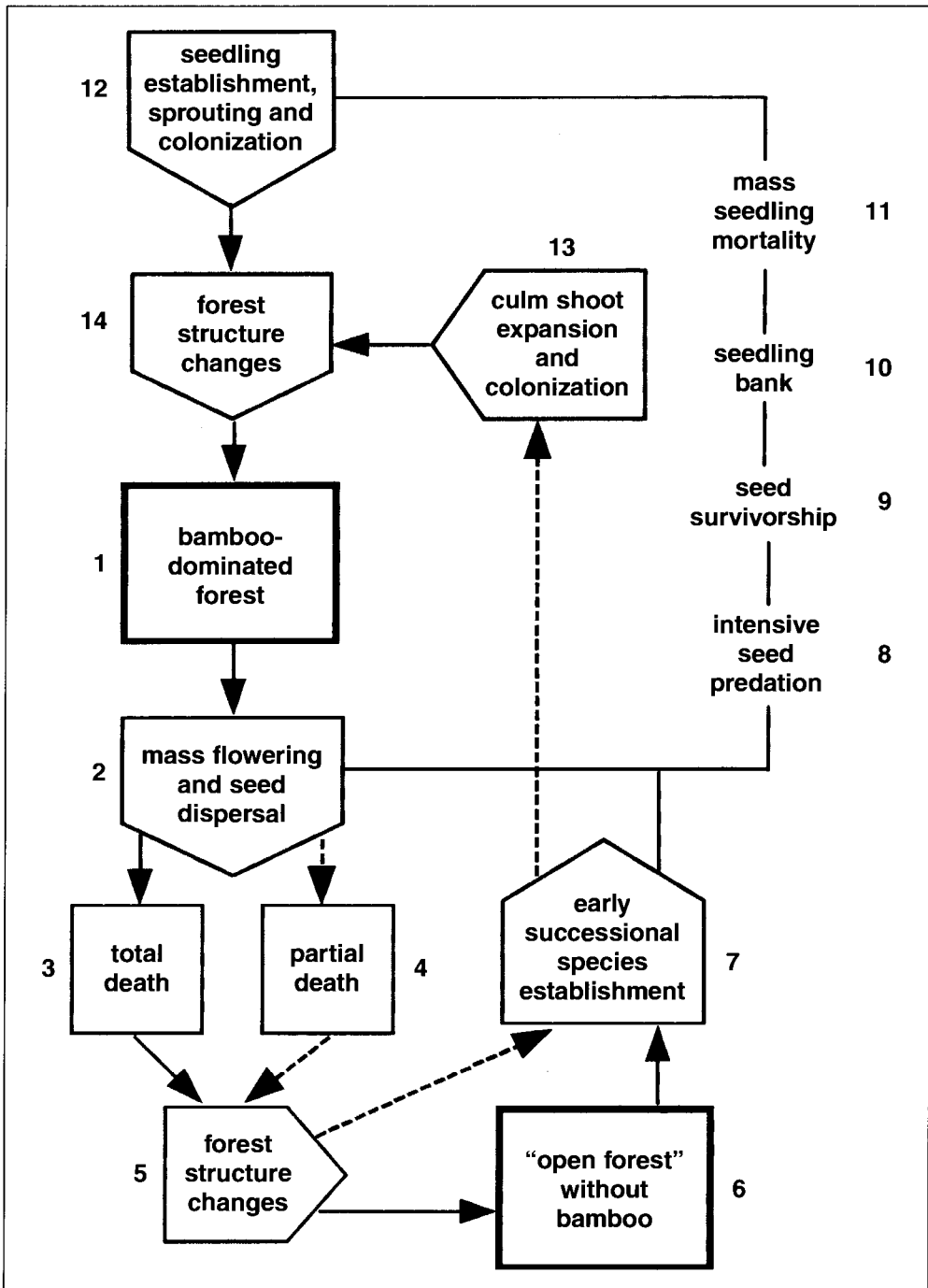
FIG 1. Conceptual ecological model of bamboo forest dynamics in southwestern Amazonia. The numbers indicate the stages of forest dynamics and bamboo life-cycle phases.

shoot production, growth and development is slow in plants originating from seeds.

At the end of vertical growth the stem arches over, ladder-like lateral branches appears and the sturdy reflexed spines on the culm and branches allow the development of a scandent climber habit. As in liana forests, taboca can cover small trees, crushing them under multiple layers of culms, branches and leaves, and changing the forest structure (stage 14).

During growth, the climbing bamboo may create the double burden of increased weight and greater susceptibility to wind stress for host trees. Wet culms, branches and leaves increase the weight even more, and this occurring together with the strong convective gusts of wind associated with tropical rains can result in a high number of treefall gaps. When this happens the trees have several culms attached to them, so the situation is similar to the self-favoring feedback mechanism of gap-creation by heavy lianas (Brokaw 1985, Lawton & Putz 1988).

At the Catuaba farm, treefall gaps favor bamboo expansion in the contact zone between bamboo forest and dense forest. It is possible that fire also supports bamboo expansion. Two informants said that bamboo is an excellent combustible material.

Permanent inventory plots are presently installed at Catuaba farm at the border between bamboo forest and dense forest without bamboo to document natural bamboo forest expansion and its influence on the structure and dynamics of regional ecosystems. In Serra do Divisor National Park, permanent plots assess the richness and diversity of trees. In the Rio Branco region, field experiments are testing the forest flammability, and research is under way to examine the demographic patterns, vegetative expansion and periodicity of synchronized mortality, all of which require long periods of field observation and a long time series of satellite imagery.

When considering bamboo forest size, changes in land uses, and the particularities (mortality and expansion) of this forest type in southwestern Amazonia, field data coupled with satellite imagery and local interviews are relevant tools in developing predictive models for the maintenance of bamboo forest in the region.

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