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# Tree species identification on large-scale aerial photographs in a tropical rain forest, French Guiana—application for management and conservation

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**Abstract**

Management and conservation planning of any ecosystem requires knowledge of species composition. This is a real challenge in tropical rain forests that are characterised by very high species richness and canopy access limitations. The possibility of approaching trees from remote sensing on large-scale aerial photographs, takes on its full significance in this context. Results of tree species identification by photo-interpretation in a French Guianan forest canopy are discussed, as well as an overview of the part of the forest accessible from the photographs. Two sets of aerial photographs were used. One set (1:3700 colour slides) covers 15 ha of primary forest, divided into a training set (TS, 5 ha) and a validation set (VS 1: 10 ha). Another validation set, taken in different conditions of acquisition, scale and season, is available for an adjacent area (VS 2: 6.5 ha). Aerial photographs captured a quarter of the tree community (dbh $\geq$ 10 cm) on average, and about 45% of the SGS (Species or Group of Species) on the training set. The crown appearance of 12 major canopy SGS, including commercial species and species of ecological interest, had been described in a previous work on the same training set. Following these descriptions, two photo-interpreters separately identified 309 tree crowns overall on VS 1, with a good agreement in their respective judgements. After their interpretations were checked in the field, the overall average identification success was high (87%) but the results varied according to the SGS. The results on VS 2 showed that some species displayed major seasonal and scale variations and were hardly recognized, whereas some others could be identified without modifying the learning process. The results are encouraging and this work will be extended as the identification of tropical rain forest trees from remote sensing has many applications, ranging from fundamental ecological knowledge of canopy species to the management and conservation of such highly diverse and hardly inventoried ecosystems.


*Keywords:* Tree species identification; Tropical rain forest; Aerial photographs; Forest canopy; Photo-interpretation; French Guiana

## 1. Introduction

As tropical rain forests disappear at alarming rates, we need to develop novel techniques to ensure the ongoing conservation of this ecosystem (Mittermeier et al., 1998; Hill, 2003). Management or conservation decisions for tropical rainforests, as in any natural ecosystem, often result from a multitude of biological criteria (Margules, 2000). Many of them are related to the assessment of biodiversity and imply the knowledge of species composition since some species may have a particular importance (Gentry, 1992; Myers et al., 2000; Hobhom, 2003). This is a major problem in tropical rain forests, which are characterised by their high density and their high species richness. The great trees in particular, which form the skeletal structure of these forests, develop their crowns several dozen metres high, out of sight from the ground, hidden by intermediate tree foliage.

The possibility of approaching trees from remote sensing platforms, rather than from ground-level takes on its full significance in this context, and various tools come into their own in an attempt to meet this need (see Sutton, 2001, for a review of canopy access techniques). New very high resolution remote sensing data (pixel size around 1 m) allow one to locate crowns in the rain forest canopy (Read et al., 2003; Clark et al., 2004) but are still not sensitive enough for

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species identification. Likewise, a method of identification of canopy trees through large-scale aerial photographs, without having the ambition to replace sample collection, would enable foresters, botanists and ecologists to survey larger surface areas than permitted by analysis from the ground. This approach may also allow areas to which access is otherwise particularly difficult to be surveyed. Such a method could be devoted to the identification of particular species of interest in a conservation or management framework: endemic species, commercially valuable species, patrimonial species, indicators of soil conditions, of disturbance level, of dynamic status.

Studies regarding the feasibility of tropical forest species identification by aerial viewing have mainly been carried out for the identification of one or two given species (Nyyssönen, 1962 for a review; Clément and Guellec, 1974; Vooren and Offermans, 1985; Herwitz et al., 1998). Published results dealing with the identification of a range of tropical forest species in natural stands are rare: Sayn-Wittgenstein et al. (1978) in Surinam, Myers and Benson (1981) in Australia. The results obtained by Sayn-Wittgenstein et al. (1978) are encouraging but they conclude that their identification criteria require further work. In comparison, the approach of Myers and Benson (1981) works. It therefore seemed of interest for us to attempt a similar study on a forest in French Guiana, where a great scientific effort is developed in forest studies, including methodology for the assessment of forest characteristics.

In a previous publication, Trichon (2001) drew up a list of 12 Guianese forest trees likely to be identifiable by aerial viewing. Each species (or group of species) was described according to criteria redefined based on the earlier works on the subject (Sayn-Wittgenstein et al., 1978; Myers, 1982). Here, we present results of the identification success of these species by photo-interpretation, in various conditions of photograph acquisition, scale or season. Since forest canopy is the only emergent portion of the whole forest, we first give an overview of the part of the forest accessible through large-scale aerial photographs.

## 2. Materials and methods

### 2.1. Study area

The study was undertaken in French Guiana, on the Paracou Experimental Station (5°15′N; 52°56W) operated by the CIRAD-forêt[1] since 1984 (Gourlet-Fleury et al., 2004). Paracou is located 15 km from the Atlantic coast, 50 km North-West of Kourou (Fig. 1). The climate is equatorial with a mean annual temperature of 26 °C and a mean annual rainfall of around 3000 mm. Rainfall is bimodal with peaks during the long wet season from April to July and the short rainy season in December–January, separated by a long dry season from August to November and a short dry season in February–March. Most of Paracou Experimental Station occurs on a


Fig. 1. Location of Paracou experimental site, French Guiana.

globally homogeneous formation characterised by schists and sandstones, locally crossed by veins of pegmatite, aplite and quartz. The relief consists of small hills (5–45 m above sea level) separated by narrow sandy waterbeds. Paracou, like most of French Guiana, is covered by lowland ''terra firme'' rain forest with a tree species richness above 140 trees/ha for trees having a diameter at breast height (dbh) above 10 cm (Sabatier and Prévost, 1990). Over 119 ha (16 plots), trees above 10 cm dbh are labelled, inventoried and monitored. Their location, diameter and botanical identification are recorded in a database (Cirad-Forêt database of Paracou). Botanical identifications are limited to 200 SGS (Species or Group of Species), some of them corresponding to one single species, some other to two or more species. Our work was conducted in two plots of undisturbed rain forest among the 16 plots that are monitored at Paracou: Plot P16 (25 ha) and plot P11 (6.25 ha).

### 2.2. Aerial photographs

Photographs were taken along parallel transects, enabling stereoscopic views between photo-pairs. We surveyed the P16 plot in October 1996 from a hot-air airship during the ''Opération Guyane 96'' scientific mission (Trichon et al., 1998). Flights were done on 3 successive days between 6.30 and 7.30 am. We used a FM2 Nikon® camera with a 35 mm lens loaded with colour slides (Fuji® Sensia, 400 ASA). The average scale of the slides is 1:3700.

Photographs over the P11 plot were taken in July 1997 from a helicopter, at three altitudes (Chareyre, 1998). The scales of the slides were approximately 1:1500, 1:3000 and 1:8000, respectively. The camera was loaded with 100 ASA colour slides (Fuji® Sensia) due to the greatest luminosity during the flights (middle and late morning). Photo 1 displays a view of the forest canopy at each scale.

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