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FROM SINGLE SPECIES TO MULTIETHNIC ETHNOBOTANICAL DATABASES TO UNDERSTAND PAST LAND USE

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Vegetation interpretation is among the most tangible tools for assessing past human presence in a landscape. Nevertheless, in the neotropics, due to the diversity and lability of human practices and to the different consequences they may have on forest regeneration, a probabilistic approach, supported by the compilation of hundreds of uses of hundreds of species, is needed. In this chapter, we will address how to build an efficient database and how to use it to answer historical-ecological questions in tropical areas instead of desperately searching for a single plant marker.

Why ethnobotany matters

From temperate ecosystems, such as the Mediterranean domain (Blondel 2006), to Amazonian lowlands (Balée 1994), it is widely assumed that interactions between humanity and biodiversity led to what Balée calls 'cultural forests' (Balée 2013), i.e. ecosystems in which the distribution and proportion of species are directly or indirectly influenced by past human activities. Such interactions are often inconspicuous, resulting in small changes accumulated over long periods, and it is probably why they are often invisible to non-experts. The mechanisms underlying this dynamic are complex due to long-term interactions between human activities and ecological factors such as seed dispersal by animals and climate. Recently, Levis *et al.* (2018) proposed a synthesis of the mechanisms underlying these long-term influences. They listed all types of potential human impacts, from the removal of non-useful plants to the planting of useful ones, to the attraction of non-human animal dispersers or very indirect influences such as soil improvement. Moreover, mechanisms of plant domestication in Amazonia are complex, and several steps can be observed. Clement (1999) proposes that wild, incidentally co-evolved, incipiently domesticated, semi-domesticated or domesticated plant populations can be found, representing a wide range of interactions between humans and their environment.

What do we have to look for?

The most obvious way to detect such interactions is to focus on single species, and several are particularly interesting clues in this case. A recent example from Australia shows how *Castanospermum australe* A.Cunn. & C.Fraser (Leguminosae), a 45-m undomesticated tree with very toxic but rich seeds edible after transformation, was spread by humans during the 2000 years before European arrival on the continent (Rossetto *et al.* 2017). In South America, the case of *Araucaria angustifolia* (Bertol.) Kuntze (Araucariaceae) is also well documented, and Brazilian pine forests are in all likelihood well related to ancient human occupations (Lauterjung *et al.* 2018). In Amazonia, *Bertholletia excelsa* Bonpl. (Lecythidaceae) is probably the best known of them (Shepard and Ramirez 2011), probably originating from the foothills of the Bolivian Andes and spread during the Holocene by Amazonian inhabitants (Clement *et al.* 2015). Nowadays, it is common throughout the Amazonian lowlands to find patches of *B. excelsa* in mature forests. Other massive trees are also known to be witnesses of past human presence, such as *Caryocar villosum* (Aubl.) Pers. (Caryocaraceae), a tree whose fruits are widely sought after for their fat-rich endosperm and exocarp (Alves *et al.* 2016). Its Wayãpi name, *peke'a* (common to most of Tupí-Guaraní languages), interestingly means 'the fruit of the ancient pathways'.

Among the most frequent sources of edible fruits in Amazonian forests are the Arecaceae. Balée (1994) already highlighted for the Ka'apor the cultural salience of the many palms species in their surroundings, as well as their key status in understanding the history of anthropised landscapes. Several works have confirmed this statement in the following years, and many genera are known throughout the area to be emblematic resources, leading some groups to identify with them, such as the A'shuar of eastern Ecuador, related to the *aguaje* (*Mauritia flexuosa* L.f.). *Attalea*, *Euterpe*, *Astrocaryum*, *Oenocarpus* or *Bactris* are among the most sought-after genera. Interestingly, palms are found in all Amazonian ecosystems, and several species are also among the most frequent taxa encountered in the region's forest biomes (ter Steege *et al.* 2013).

Nevertheless, variations in regional floras make it difficult to compare data on a large scale for reasons linked to discrepancies between phytogeographical patterns, endemicity of a resource in a restricted area, discontinuous distributions throughout the area or cultural specificities that do not allow the spread of given species by humans. Beyond the large-scale demonstration that much of the Amazonian forests have been influenced by human practices, it seems likely that other methods, more focused on geographically restricted resources, or taking into account a whole bunch of species instead of a few taxa, might help to highlight local practices and understand cultural variations.

Single species for rapid assessment

All of these methodologies are nevertheless complementary for a detailed understanding of past land uses. The presence of patches of some tall edible fruit trees, such as *B. excelsa*, *Caryocar* spp., *Spondias mombin* L., *Hymenaea courbaril* L., *Platonia insignis* Mart. or *Oenocarpus* spp. is potentially an excellent indicator of the existence of ancient villages, but it is generally insufficient because these patches are not common in the Amazon basin and these species are often difficult to detect, despite their size. Moreover, such plaques are sometimes only detectable by one or a few dominant trees. These isolated individuals will also escape quantitative approaches such as tree inventories on plots (see Chapter 11). However, in some preliminary surveys or rapid assessment protocols, they are indeed important qualitative markers of past anthropisation, often associated with other clues, such as charcoals and potsherds (see Chapters 7 and 10), and these taxa should therefore be considered indicator species. Most of those frequently observed in Amazonia are listed in Clement (1999). However, what may be an indicator species in one region may not be in another because of biogeographical factors related or not to past human presence.

Large databases for basin-wide studies

On the other hand, the pan-Amazonian database established by Levis *et al.* has proved to be very useful for detecting global trends through the analysis of the large Amazon Tree Diversity Network's data set (Levis *et al.* 2017). As species are unevenly distributed throughout Amazonia, with some being hyperdominant and others rare (ter Steege *et al.* 2013), these large-scale studies are of the highest interest for the most common species.

This approach is also well suited for the most common uses of plants, i.e. nutritional uses. Large edible fruit trees, as well as hyperdominant palms or most of the incipiently domesticated trees, are commonly used in large geographical areas.

The importance of local databases

Between these two alternatives, the intermediate step is to try to collect as much information as possible for a given area. Rather than a unique and homogeneous tropical rainforest, Amazonia is a mosaic of ecosystems consisting of montane forests, alluvial forests, várzea, savannahs, etc., on very distinct geological substrates, from the Andes in the west to the Guiana Shield in the east (Goulding *et al.* 2003). The use of biodiversity, and not only for food plants, is different from one place to another and from one culture to another. As each culture has particular relationships with its environment, it is through its knowledge that we must apprehend and list the resources it draws from its own milieu.

We have demonstrated for inner French Guiana that both food and construction past uses have influenced forest regeneration after abandonment of pre-Columbian sites (Odonne *et al.* 2019), the former by increasing the number of individuals and the latter by decreasing it. Meanwhile, the use of certain genera of Lecythidaceae, Annonaceae and Sapotaceae for construction purposes is a common feature of most present-day Amazonian societies (Ogeron *et al.* 2018). As a matter of fact, the genus is often the relevant taxonomic level for basin-wide comparisons, as species used in one place may not necessarily be found in another. A group of species of the same genus may sometimes be more relevant than a single species or the genus as a whole, which may complicate the task of ethnobotanists. In our opinion, the advantage of a local database is that all the species concerned will be considered through a better knowledge of local realities.

How to build a consistent regional database

The nature of the data collected in the database is of the utmost importance and depends on the research question. When it comes to human impact on biodiversity, it does not seem necessary to over-detail the identified uses. It might be sufficient to classify uses according to their impact on the resource i.e. distinguish between beneficial ones (concentration of seeds, conservation or planting of individuals) and harmful ones (debarking, tree felling), even if this does not correspond to any previous ethnobotanical classification. A rather well-accepted system includes 'construction', 'firewood', 'human food', 'medicine and magic' and 'arts and crafts' (inspired by Prance *et al.* 1987), although some categories such as 'firewood' are not as relevant because Amazonian peoples use already dry firewood, which has a low impact on the resource.

One of the main challenges is to deal with multiple uses of a given species, with potential opposite effects. Considering, for example, *Euterpe precatoria* Mart., a single-stemmed palm tree, the harvest of its heart (a highly appreciated food) will kill the individual, whereas collecting its seeds will help its dissemination. And the same question arises about the ambiguous effects of traditional uses: debarking a tree for craft purposes might have a negative effect on its survival, but on the opposite, could enhance its defence strategies, leading to an increase in resistance. Such trade-offs are obviously difficult to address.

An alternative to a simple species-centred classification of local uses is to consider the parts of the plant used. For instance, regardless of the end use, fruit harvesting usually contributes to the spread of the species. In Odonne *et al.* (2019), we applied this method to a data set of 13 plots, including more than 450 species and about 8000 individuals. Edible species, including fruit trees, appeared to be associated with archaeological plots, but while timber species were negatively associated with these plots, species whose wood has other uses were not, as these uses involve small pieces of wood, with minor impact on regeneration. Conversely, species with useful bark were negatively associated with archaeological plots, largely because timber species are precisely those that are easy to debark, and their bark is used to make ropes, straps or binding.

Broadly speaking, there is no perfect way to correlate ethnobotanical uses and influence on the resource, but it seems that for food and construction uses, the results are consistent.

How to correlate past to present uses

Among the numerous issues, consistency between past and current uses is still questionable. Even if most archaeological records highlight very common edible species, allowing us to date the use of these species back to the first occupation of Amazonia, most edible species are never found in archaeological sites, not because they have not been eaten, but because of the fragility of their remains. To approximate these past uses, the only data available are modern ethnobotanical uses. To overcome cultural differences, we compiled data from five cultural groups belonging to three linguistic families (Arawak, Tupí-Guaraní and Karib). The rationale for this process is that people from groups belonging to different linguistic families have probably more different practices than closer groups, which allows for a wider spectrum of ethnobotanical uses to be integrated.

The need to quantify these uses was also discussed, for example, by quoting the number of groups that use a given species for a given use or by weighting them according to their popularity among cultural groups. However, it appeared that such quantification was not necessary to exploit the database about potential ancient uses.

Conclusion

Such databases are greatly needed to interpret past human presence and activities but are still lacking in most areas of Amazonia. Interpretations can be drawn from generalist bases, allowing large-scale surveys, although these sometimes lack subtlety. Regional databases are certainly welcome, but due to the efforts required to structure them, they are very few to date and poorly accessible. Let us hope that one day ethnobotanists will have compiled such detailed regional data and merged all these local databases to have a global view of Amazonian ethnobotany. Such work, undertaken in close collaboration with local knowledge holders, will both help the preservation of their heritage and improve the understanding of long-term interactions between humans and landscapes.

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