

ARTICLE

Evidence for Landscape Transformation of Ridgetop Forests in Amazonian Ecuador

William Balée¹, Tod Swanson², María Gabriela Zurita-Benavides³, and Juan C. Ruiz Macedo⁴

¹Department of Anthropology, Tulane University, New Orleans, LA, USA, ²School of Historical, Philosophical, and Religious Studies, Arizona State University, Tempe, AZ, USA, ³Universidad Regional Amazónica Ikiam, Parroquia Muyuna, Ecuador, and ⁴Herbarium Amazonense, Universidad Nacional de la Amazonia Peruana, Iquitos, Loreto, Peru

Corresponding author: William Balée, email: wbalee@tulane.edu

(Received 25 February 2022; revised 18 April 2022; accepted 13 November 2022)

Abstract

The Napo River basin, which is situated within the Upper Amazon archaeological region, is one of the most speciose forests in Greater Amazonia. Standard thinking in scholarship and science holds that these forests are essentially pristine because any Indigenous impacts in the past would have been minimal, seedbanks would have been nearby, and natural forests would have reappeared after the humans left, died out, or dispersed. Inventory research in 2019 on three ridgetop forests in Waorani territory inside the Curaray basin (which drains to the right margin of the Napo River) and a comparable inventory on one control site forest along the Nushiño River (also in the Curaray basin) show human impacts from about the late nineteenth century to about 1960; they occurred during the period of wartime among Waorani themselves and between Wao people and outsiders. The human impacts resulted in the high basal-area presence of two long-lived species with important Waorani cultural uses: cacao (*Theobroma cacao* L.) and ungurahua palm (*Oenocarpus bataua* Mart.). These species have high frequency and dominance values and do not occur in the control site, which is comparable in terms of elevation above the flood zone of the rivers in the sample. These findings mean that alpha diversity in the right margin sector (or south) of the Napo River basin cannot a priori be explained by reference to traditionally, biologically accepted patterns of ecological succession but may require knowledge of historical patterns of Indigenous land use and secondary landscape transformation over time due to human (specifically Waorani) impacts of the past.

Resumen

La cuenca del Napo, donde se encuentra la región arqueológica del Alto Amazonas, es uno de los bosques con mayor diversidad de especies en la Gran Amazonía. El pensamiento académico y científico común sostiene que estos bosques son esencialmente prístinos, al asumir que el impacto indígena en el pasado habría sido mínimo, que la composición se explicaría por la disponibilidad de bancos de semillas contiguos y que los bosques naturales habrían reaparecido una vez que los humanos abandonaron, desaparecieron o se extinguieron. En 2019, se realizó un inventario florístico de tres bosques de tierra firme (o en la cima de las colinas) en el territorio Waorani en el río Curaray (que drena en el margen derecho del río Napo), que se comparó con una parcela control en el río Nushiño (también en la cuenca del Curaray). Demostramos que existen impactos humanos desde finales del siglo XIX hasta alrededor de 1960, período de guerra interna de los Waorani, y entre los Wao y los extranjeros. Los impactos antropogénicos dieron lugar a la presencia de un área basal elevada de dos especies longevas con importantes usos culturales para los Waorani: cacao (*Theobroma cacao* L.) y la palma de ungurahua (español) o petome (*Oenocarpus bataua* Mart.). La frecuencia y la dominancia de estas especies es característica de los bosques de tierra firme (o cimas de colinas) y, al contrario, no ocurren en la parcela control, comparable en términos de altura a las llanuras inundadas. Estos hallazgos significan que la diversidad alfa en el sector de la margen derecha de la cuenca del Napo no puede explicarse a priori por los patrones de sucesión ecológica tradicionalmente aceptados, sino que en muchos casos puede requerir primero el conocimiento de los patrones históricos de los pueblos

indígenas, el uso de la tierra y la transformación secundaria del paisaje, ya que la particularidad de estos se debe al impacto humano (específicamente Waorani) en el pasado.

Keywords: Waorani (people); historical ecology; ridgetop forests; Upper Amazon; Napo River basin

Palabras clave: Waorani (el pueblo); ecología histórica; bosques de tierra firme; Alto Amazonas; cuenca del Napo

We examine the impact that a small and isolated society had on ridgetop forest environments far from easy access to potable water in recent historical-archaeological times. Before contact in 1956, the Waorani, who at that time probably numbered no more than 500, lived in small family groups on interfluvial ridgetops far from water. This study is based on a systematic examination of these ridgetops and on interviews with older Waorani who were born before contact in the late 1950s.

Landscapes of the Upper Amazon, including the research area—the interfluvial region between the Napo and Pastaza Rivers of Ecuador—have long been seen by outsiders as pristine. The small-scale societies such as the Waorani who live there were dismissed as minor hunter-gatherers who had no long-term impact on their environment (e.g., Blomberg 1957; cf. Up de Graff 1921). At the same time, much evidence suggests that people lived in this region for thousands of years. Did they really have no historical impact? The historian Miguel Cabodevilla (1994:13) asked, “Do the Waorani have prehistory, or are they prehistory themselves?” We propose that the Waorani did have a history, one written in the altered composition of the ridgetop forests where they lived during wartime.

The Napo River basin lies within the loosely defined archaeological area known as the Upper Amazon, the watershed of which extends from the easternmost slopes of the Andes—below the tree line—to the mouth of the Madeira River (Clasby and Nesbitt 2021; Lathrap 1970); hence, it covers many distinct landforms with dissimilar elevations, plant physiognomies and species, fauna, rainfall amounts, seasonality, soil conditions, and the like. For the most part, the Napo River basin is heavily covered by mature rainforest, where there are no towns, small farms, or oil extraction roads. These forests are the most biologically diverse of any region in the Upper Amazon, and indeed the Amazon Basin: almost every other individual tree on a typical forest plot is a different or new species (Dangles et al. 2009; Gentry 1988). As we argue here, some of the mature forest sometimes shows effects of Indigenous management or disturbance in the past, even if that past coincides with conventionally defined historical time periods (cf. McMichael et al. 2012; Piperno et al. 2015).

No archaeological investigations have been carried out at the study sites reported here (Zurita-Benavides 2014:29). The only such investigations in Waorani Territory thus far are in its northern part (Netherly 1997), the area south of the Napo River and north of the Nushiño and Curaray River basins. For the most part, the archaeological periodification proposed by Evans and Meggers (1968) is little changed (Arroyo-Kalin and Rivas Panduro 2019), and few ¹⁴C dates for the region are published (Rostain and Saulieu 2013). No archaeological excavations have been conducted inside the Yasuni National Park. Much of the recent archaeological work has been in contract archaeology and remains in reports or is unpublished (Arroyo-Kalin and Rivas Panduro 2019). Agriculture is nevertheless ancient in the region because maize is known from 6,000 years ago (Bush et al. 1989) to the west, therefore implying the presence of archaeological sites in the area.

Our focus is on ridgetop forests whose history and origin have yet to be studied at all. As to the archaeological sequence in Waorani Territory, three phases associated with distinctive pottery types are usually recognized: the Yasuni Phase from around 50 BC–AD 500, which is considered part of the Formative period; the Tivacuno Phase from about AD 500–700; and the Napo Phase from about AD 1000–1500. Because no ceramics used in the processing of bitter manioc have been found, some researchers speculate that the Yasuni and Tivacuno Phases were associated with trekking people or incipient horticulturalists cultivating only sweet manioc, sweet potatoes, and perhaps other crops that do not require detoxification technology (Evans and Meggers 1968:18, 33; Porras 1987:245; Rostain and Saulieu 2013:116). The Napo Phase consists of sophisticated anthropomorphic pottery, including elaborate funerary urns (Arroyo-Kalin and Rivas Panduro 2019:344); it is associated with the grander Amazon Polychrome Tradition (Arroyo-Kalin and Rivas Panduro 2019; Rostain and Saulieu 2013) and perhaps with the cultivation of bitter manioc, based on material culture (Porras

1987:264). The Napo Phase of the Amazon Polychrome Tradition seems to have been replaced by or mixed with Omagua pottery seen initially by Orellana in his descent of the Napo and ultimately the Amazon River itself in AD 1541–1542 (Rostain and Salieu 2013). After the European conquest, Omagua people—already intrusive Tupí-Guaranian-speaking people originating from the east—ascended the Tiputini River, among other rivulets close to the Napo itself, and may have driven other groups out of the area (Cabodevilla 2013). In the region of study, the Waorani were evidently preceded by Zaparoan groups who by the early twentieth century were almost completely gone (Cipolletti 2002).

As mentioned, agriculture is ancient, because maize is known from a lakebed just to the north of Waorani Territory to have been cultivated 6,000 years ago (Bush et al. 1989). It is likely that domesticated crops native to the Amazon including tree crops—especially the edible variety of the peach palm *Bactris gasipaes* Mart.—precede that time period by several thousand years and were spread all over the area, as they are today (Clement et al. 2010; Levis et al. 2018). Arguably, people have altered lowland forests in the region since the Holocene (McMichael and Bush 2019), perhaps permanently.

Research since initial peaceful contact shows the existence of several atomistic sociopolitical subgroups or clusters of the Waorani (e.g., Cipolletti 2002; Zurita-Benavides 2014). The research reported here focuses only on those groups in the Curaray River basins and its affluent, the Nushiño River basin. We present evidence for human forest management on the interfluvial ridgetops in the southern part of Waorani Territory, all of which is south of the Napo River itself. Although there is no Amazon Dark Earth or major earthworks, in contrast to the Lower and Central Amazon (McMichael and Bush 2019), we argue, using original data, that the tree composition on these ridgetops has been altered by human—specifically Waorani—interaction with their forest dwelling sites: the ridgetop forests are anthropogenic and differ from undisturbed or minimally disturbed forests in the same region.

Cultural Forests

The idea that humans have contributed to the makeup of Amazonian forests seems obvious, especially when considering alpha diversity: species counts that are systematically measured in localized, controlled settings (see Levis et al. 2018). Arguably the collapse of any large primate population, such as woolly monkeys or howler monkeys, will alter seed distribution and hence the makeup of the forest (e.g., Redford 1992). If this is the case with woolly monkeys, human beings could have had a similar effect on the dispersal of seeds that, in some cases, become viable and mature into trees. In the Lower Amazon, nondomesticated cacao (*Theobroma speciosum* Mart.), for example, is dispersed both by Indigenous humans (e.g., the Ka'apor people) and capuchin monkeys (Balée 1994:149).

The Indigenous Kichwa-speaking peoples of Zaparoan descent who live between the Napo and the Pastaza Rivers take it for granted that their forests were the gardens of the Tayag, their name for the original inhabitants of the area. These inhabitants, not unlike the Dreaming Beings of Aboriginal Australia, were anthropomorphized to be sure, but were likely to have been *Homo sapiens* capable of art, ceramics, architecture, and—most important for our purpose here—landscape modification (Balée 2018; Crumley et al. 2018). Romantic Western ideas of virgin forest, untouched by the human hand or, as Thoreau put it in 1854 (2004), “never profaned by any human neighborhood,” have been difficult to shake even into the twenty-first century—especially for speciose landscapes like those of Amazonia. Regardless of romanticism, a widespread myth of untouched, pristine, virgin forest has been rejected by research demonstrating how the Indigenous populations of North America (Cronon 1983; Pyne 1982) or even the Lower Amazon contributed to the makeup of ancient forests (e.g., Balée 1989; Denevan 1992; Heckenberger et al. 2008; Levis et al. 2017, 2018; Rostain 2021; Winklerprins and Levis 2021).

Until now, however, the Upper Amazon has tended to be seen as not having intense human modifications: this view was supported by research into the floodplain forests. Based on a study of two lake districts in Amazonian Peru and Ecuador, paleoecologist Mark Bush and colleagues (2007:216) concluded, “Modern biodiversity and forest composition are not a product of land management, but have persisted despite it” (also see McMichael et al. 2012; Piperno et al. 2015). The hypothesis was that Indigenous impacts in prehistory were negligible over the long term and could not be used to explain current patterns of diversity in Amazonia, though that hypothesis has become more nuanced recently. McMichael and Bush (2019) note that much of the western Amazon biological diversity was influenced

by human activity in the Holocene. Our argument is that alpha (highly local) diversity in Upper Amazonian forests has at times been affected by anthropogenic means, which can be shown by combining Indigenous knowledge with forest inventories on ridgetops.

Historical-ecological arguments in support of long-term human impacts on Indigenous forests have recently been proposed (e.g., Levis et al. 2017, 2018; Stahl 2015). In Amazonia, it is conceivable that the temporary manioc gardens made by bands of hunter-gatherers along the floodplains of fast-flowing rivers like the Napo and its Upper Amazonian tributaries were simply washed away along with the volcanic silt these streams carry down from the Andes—just as the lack of Amazon Dark Earth and of evidence of large settlements in the vicinity of the monumental geoglyphs of Acre, Brazil, could be the result of meandering river flooding by the Purus River and its tributaries (Schaan 2011). Because these rivers change course rapidly, any effect of manioc gardening might have been covered with more volcanic silt. Such a scenario, however, is not the case with the ridgetop forests in the Nushíño and Curaray basins because they never flood, given their elevation above river floodplains.

An Isolated Language and Society

All Waorani speak a complex, difficult-to-analyze language isolate (Aikhenvald 2012:52, Map 1.7B; Peeke 1973): Wao Tededo. It has no living sister languages and pertains to no known family of languages (Wasserstrom 2016; Figure 1). Culturally and historically, little is known of the Waorani before the great Amazonian rubber boom, but it is clear that, at least from the late nineteenth century through the mid-1960s, they sought to avoid contact with the outside world. One Ecuadorian official wrote in 1887 that there were more than 500 *caucheros* (caucho: *Castilla ulei*; rubber gatherers) in the Napo River basin alone who had “committed many abuses against Indians” (Stanfield 1998:58). What contact the Waorani had during and after the rubber boom, with few exceptions, was hostile: they conducted raids on *caucheros* and other interlopers in their lands to obtain steel tools (Wasserstrom 2016), and tiny Waorani groups raided other such groups (Long 2019; Robarchek and Robarchek 1998). Peaceful contact with some subgroups dates from 1958, after six Wao men speared to death

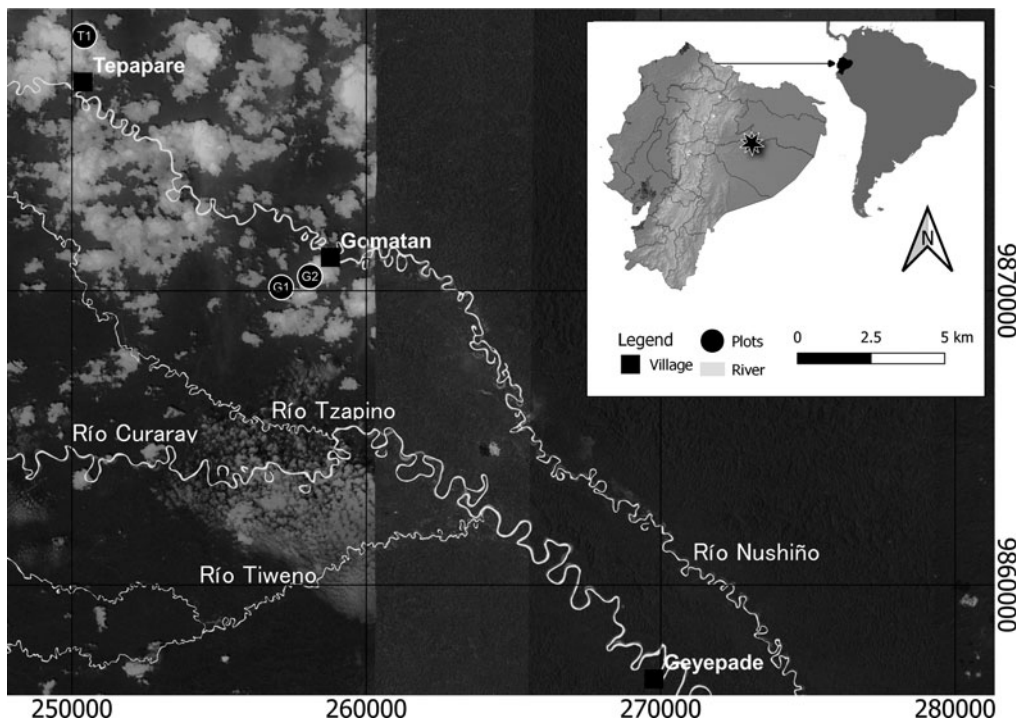


Figure 1. Area of research and inventory sites.

five evangelical Christian missionaries who had landed a small plane on a beach in the Curaray River (Long 2019:14–21). By 1975, most of the Waorani had been resettled to the Summer Institute of Linguistics mission station at Tewæno. After that time hostilities largely ceased. The Waorani families gradually moved from the mission to settle along the rivers where they now live, hunting, fishing, and farming sweet manioc mainly (Long 2019). At least two small groups of Waorani-language speakers referred to as the Tagædi (“Tagæ’s bunch”) and Taadomenani (the “lowlanders or meandering ones”; Long 2019:342) continue to live in “voluntary isolation” in the area called the *zona intangible* (intangible zone) inside Ecuador’s Yasuni National Park (Cabodevilla 2010; Finer 2009; Long 2019:182, 342).

During periods of conflict before contact with missionaries in the late 1950s and 1960s, our Wao collaborators tell us that Waorani ancestors preferred to live secluded on interfluvial ridgetops far from water, where they could avoid detection and from where they could more easily defend their homes. One kin-based political subgroup was called the “Ridge People” (Weipedi; Long 2019:162, 198), even though all the Waorani were living on ridgetops before contact. The Weipedi seemed invisible to the outside world—including to other Indigenous peoples in the environs—except when they conducted raids on settlements. They were living in a situation like that of a few Brazilian Indigenous groups today in the southwest Amazon (e.g., Moriconi and Londoño 2020), who could also be linguistic and cultural relatives of groups that have a long history of continuous contact with national societies. In the 1940s when the Swedish explorer Rolf Blomberg (1957) carried out a canoe expedition down the Río Nushiño through the territory of the Guiquitaidi—“Guiquita’s bunch” or cluster, a small kin-based, political subgroup of the Waorani, who accounted for about 10% of the entire Waorani population (Long 2019:15)—he was unable to locate any people. In fact, they were there but were safely hidden in dwellings on ridgetops, including ridgetops where the research sites reported here were situated. The isolated relatives of today—the Tagædi and Taadomenani—have an archetypal ancestral way of life. They are nearly naked trekkers—the men wear only a hip-cord known as a *come*—who establish small swiddens of manioc and plantain using stone axes and continue to reside on hidden ridgetops: in a real sense, they are still living in wartime mode (Long 2019:192).

Little is known about Waorani history in the colonial period. The names of most rivers between the Colombian border and the Río Pastaza and in a band running from the Andean foothills to the Peruvian border end in *-no/ro*, which are allophones for the same suffix used to designate rivers. Wao Tededo—the Waorani language—is the only language known to have this suffix for “river.”¹ Although the morphologically stand-alone terms for river are “*epene*” and “*ononga*,” when a given river is named, it is postposed to the name with the suffix *-no/ro*. Contemporary Waorani do not recognize the meaning of the first part of river names in the larger area surrounding their territory, such as *Araj-uno*, *Cuyab-eno*, *Payam-ino*, and *Vill-ano*.

One of the most important species that enabled the Waorani to flourish far from rivers on the ridgetops in times of war was the massive, solitary, slow-growing *Oenocarpus bataua* Mart. palm (Rival 2016:52). Regardless of Waorani prehistory and possible sedentism in this region, one may speculate that, on ridgetops high above the southern tributary waters of the Napo, the Waorani people—in the years before permanent contact by 1960—may have consumed greater quantities of *O. bataua* mesocarps and discarded the seeds around their homes; this then led to the altering of forest composition. We propose here that the particular way in which this wartime food was prepared, consumed, and discarded on the ridgetops led to a higher density of this palm species, thereby permanently changing the makeup of these ridgetop forests. It seems that in ridgetop forest occupation sites, to make *tepe* (a drink made from boiled manioc), *O. bataua* fruits were used in place of peach palm (*Bactris gasipaes* Mart.) fruits—a domesticated palm (Clement et al. 2017) only found in orchards nearest the riverbanks (Cerón and Montalvo Ayala 1998:180). This explains the abundant presence of the *O. bataua* palm on the forested ridgetops and its economic importance for those who live near there.

As substantiated in the later discussion, Waorani ancestors’ dispersal of the seeds and protection of seedlings of this economically important palm partly explain why it exhibits dominance among orthogonal plants in the size category of greater than 10 cm in diameter at breast height (1.3 m from the ground) in ridgetop forests. Indigenous groups in the Upper Amazon also consume proteinaceous palm grubs from fallen trees and may also take the heart of palm from juvenile specimens (Balick 1986). Laura Rival (2016:52) noted,

The unguhua [*petome* or *O. bataua*] palm provides rich food, building materials, and raw materials for the making of a wide range of artifacts and remedies. Besides being an extremely useful plant resource, the unguhua palm offers protection. . . . Those who flee from wars and spearing raids would not survive without the unguhua fruit. It is rich in fats and proteins and ripens throughout the year.

Ethnobotanists who studied a Wao site on the Shiripuno River also observed that *O. bataua* occurs on *bosque de colinas* (ridgetop forests) and *bosque aluvial* (floodplain forests), but not in between floodplains and ridgetops, the zone of the control site we examined (Ceron and Montalvo Ayala 1998:183).

Historical Background

The interfluvial ridgetops seem to be untouched by human influence because they are the most remote and inaccessible areas of the region. Our hypothesis is that it is just this quality of remoteness from the accessible riverbank fields, which are usually associated with human habitation, that accounts for how and why the ridgetop forests were shaped by people. Before 1956, Waorani tended to avoid contact with both Indigenous and non-Indigenous outsiders because they considered them to be extremely dangerous: they habitually refer to all outsiders as *cowode* (“barely human cannibals”; Long 2019:127). Ridgetops would have been strategic locations from which to watch over their territory, identify the presence of any intruders, and determine the ideal time to cross rivers and plant high-energy crops, such as manioc and plantains, in peacetime (Rival 2002; Robarchek and Robarchek 1998:77–78; Wierucka 2015; Zurita-Benavides et al. 2016). Ridgetops just large enough to support a longhouse containing an uxorilocally extended family (*nanicabo*) were the preferred domestic space. They also provided refuge for Waorani families in times of war (Wierucka 2015:71–72).

Elders who were young at the time of first contact describe an interfluvial lifestyle in which small family groups avoided the major rivers except for certain seasons each year. Away from the rivers, they lived on monkeys and birds killed with blowguns, as well as white-lipped peccary and fish from small inland streams. During peaceful times this diet was supplemented with starch from cultigen staples such as plantains, sweet manioc, and peach palms. The latter two plants were often consumed in the liquid form of *tepe*.

Rival (2002, 2016) describes a pattern of circular migration in which small Waorani bands would trek between inland peach palm groves to manage sites where trees had been planted in past generations. During times of war, which occurred frequently between 1910 and 1950, these agricultural foods became less accessible. Even inland peach palm groves were too dangerous to access because often the enemies from whom they hid were other Waorani who would have known the location of the groves. In these times, they substituted the fruits of *Oenocarpus bataua* for cultivated manioc or peach palm as a source of *tepe* to supplement the meat diet. In addition, the people enjoyed cacao fruit, and although several species of wild cacao *Theobroma* spp. occur in the region, the true domesticate, *T. cacao*, seems only to be found at previously inhabited sites such as these ridgetops.

To understand the highly secretive lifestyle that led to the substitution of nondomesticated fruits for agricultural food, one must appreciate the high levels of internecine violence among Waorani during times of war (e.g., Long 2019:114–116). Wasserstrom (2016) correctly rejects the evolutionary-biological explanation given by Beckerman and Yost (2007) for Waorani warfare, because it is unlikely that revenge and blood-feuding could have been adaptive without some form of occasional mediation, exogamy, and exchange of people, materials, goods, and ideas. It is also unlikely that being in geographic proximity to the Inca Empire, an area with a long history of endemic conflict, could have influenced Wao patterns of warfare, assuming the Waorani were recent intruders or arrivals in the area (Robarchek and Robarchek 1998:140–141). Instead, Wao internecine violence (between extended families living on ridgetops) and raids on non-Wao *cowode*) originated in a more recent period (Cipolletti 2002; Long 2019).

The Waorani as a modern ethnographically identifiable society emerge out of the watershed contact period of the rubber boom. During this period, raids for slaves to work with or for *caucheros* and the

incursions into their lands by Indigenous and non-Indigenous *caucheros* looking for latex led both to the growing isolation of each small Wao cluster and an increase in the number of daughter groups that were soon seen as strangers by the original group (e.g., Wasserstrom 2016). They may also have led to an increase in deaths from introduced disease to which minimally contacted Indigenous people had little or no herd immunity. Such disease-caused deaths could have exacerbated intragroup killings. Because the Waorani believe all deaths are caused by human agency, spearing those believed to be responsible for those deaths—even if these agents were perceived to be other Waorani—would have been seen as justified; these killings are termed “revenge spearings” (Long 2019:165). Interpreting these historical factors through Waorani cultural beliefs about grieving and the duty to express it by wreaking violence or revenge, as well as cultural beliefs that the historically contingent increase of sickness and death could be caused spiritually by enemies, resulted in a spiraling increase of internecine violence.

In the three settlements where we worked, every elder had experienced this local violence within his own recent family history. Our older collaborators portray the decades before contact as a period of heightened violence in which groups led by famous warriors such as Guiquita, Moipa, Iteka, and Nihua hid out on ridgetops, from which they could both attack and hide from each other and from interlopers in their habitat. During this period, before fusion and fission became common (Rival 2002), one way of gaining wives was for a warrior to kill the father or husband of the woman who would be taken for a wife. Marriage requests were also made during festivities, which were sometimes ended by violence.

To keep their location secret, the Waorani families of this time used fire only during the daytime and avoided going to small streams for water. Instead, they created drinking holes at tiny springs on the sides of the ridges, where trickles of water emerged from the holes of land crabs. According to Nemonte, daughter of the warrior Nihua,

The old people didn't drink the water that runs down the canyons. Now we drink water from the river. . . . But in the old days our grandmothers, our grandfathers drank the water that came out of the holes that the land crabs made. . . . That is why they didn't have stomachaches. They lived well drinking that water. . . . When they saw that water trickled out of a crab hole, they hollowed out the earth so that the water could fill in. And later they scooped up the water with a leaf (cup) and poured it into a large clay pot. . . . They filled (their pots) with those and drank water to live. . . . That's why the grandfathers searched for where the water came out and dug pits there. They bathed with that water. The grandmothers also took water from there to bathe.

This water was then carried back to the ridgetop camps where it was mixed with *petome* (*O. bataua* mesocarp) to drink as *tepe*.

To understand the prevalence of *O. bataua* on ridgetops occupied by Waorani in the past, it is also necessary to know something about how it was prepared and consumed, as well as its reproductive biology. *Petome* (the Waorani term for fruits of *O. bataua*) fruits are small, perhaps twice the size of a large olive, and grow in clusters. Beneath their hard black shell is a thin, edible mesocarp that covers a pit, which is the seed. Because the hard shell of the exocarp must be soaked in warm water before it can be removed, *petome* fruits were not eaten on the spot. Instead, large numbers of the fruits were gathered in nearby forests, carried back to the camp, and soaked in heated water. Because the water is only slightly heated but not boiled, the seeds of *petome* fruits tended to remain fertile. After being soaked in the warm water, the hard shells were removed and the mesocarp kneaded into *tepe*. Children also ate a few of the water-softened fruits as they walked around the camp. They then threw the pits a few yards from their houses, where they sprouted quickly.

This sprouting process creates a significantly different constellation of trees from what happens when *petowe* (*O. bataua*) palms bear fruit away from human habitation at lower elevations. In those cases, many of the fruits are swallowed whole by toucans that then fly away; in the absence of humans, toucans and related species (Ramphastidae) are by far the principal dispersal agents of this species (e.g., Lamperty et al. 2021). After the fruit is semi-digested, toucans and aracaris regurgitate the pits at a considerable distance from the mother tree, where they may sprout and grow to maturity; this process exemplifies destination-based dispersal (Karubian et al. 2010). Other fruits fall by gravity

and are dispersed at the base of the mother tree. Although many cotyledons sprout quickly there, the root chemistry of the mother tree eventually kills off the seedlings and prevents them from maturing. In the absence of human habitation, therefore, the mature trees tend to grow much farther apart than what we found on the ridgetop sites. Wao men only cut down these palms (with stone axes) that they planned to use in house construction; when their objective was to gather the fruits, they climbed the trees instead of felling them. Waorani today transplant seedlings away from the mother palm to encourage their growth.

The ridgetops themselves are isolating landscapes. Although they were evidently inhabited for long periods of time, they did not constitute villages per se. In terms of size, they were more like camps of simple foragers; the settlement group could be considered a semi-sedentary camp. The Waorani were not simple hunter-gatherers, however, given their domesticates, including cacao (*T. cacao*) and some minor horticulture (Rival 2002, 2015; Up de Graff, 1921; Zurita-Benavides 2017). It is in such landscapes—ridgetop forests that were settled by Waorani within the last 125 years or so but have not been occupied since about 1960—that we carried out three of the four forest inventories reported here (Supplemental Appendices 1–4).

Methodology

The objective of the investigation was to determine the extent to which, if any, the human occupants in the current era affected the distribution of tropical rainforest species, mostly on the alpha (or local) level of species diversity (e.g., Balée 2013). We used a new approach to studying the impact of recently contacted or still isolated groups in the Upper Amazonian forests. The evidence thus far suggests Indigenous utilization of the tropical forest over a relatively brief historical time of 100–125 years. Peaceful contact only occurred after the 1950s. Today, some Waorani remain out of contact with the members of the nation-state in which they live and are not even in contact with Indigenous persons who speak their own language or dialect.

Because of the features of Upper Amazonian geography and culture, we were not able to use some of the methods used to distinguish anthropogenic forests in the Central or Lower Amazon. In Central and Eastern Amazonia, for example, the presence of *terra preta*, an Amazon Dark Earth (ADE) containing phosphate and other human-indicator compounds, is a fertile vestige that indicates conscious human management of the soil (e.g., Heckenberger et al. 2008; Woods and McCann 1999). In the case of the Nushiño and the Napo generally, one does not encounter ADE because farming people lived on islands that were already made extremely fertile by the volcanism of the nearby Andes—and the Napo and its tributaries are, in fact, whitewater rivers that drain volcanic sediment directly from the Andes. ADE becomes more important the more downriver on the Amazon one descends (Woods and Denevan 2009).

In the absence of *terra preta*, our method for selecting where to find and study the precontact human impact began with living Wao people who could tell us about the recent past (i.e., considering 50–60 years to be “recent”) and how their immediate predecessors lived in and used the landscape available to them. Although this research could not have been completed with those Wao Tededo speakers who refuse interaction with external society or its agents (including scientists and researchers, such as us), we were able to interview people who lived before contact and who clearly remember life on the ridgetops. It is important to know this oral history from the Waorani point of view, so that we could combine it with the written history we do have access to, starting with the rubber cycle of the late nineteenth century. The business of rubber extraction was unable to penetrate the Waorani domain south of the Napo (we saw untapped rubber trees² as proof in the Curaray/Nushiño River valleys; Figure 1) because of the violence that would ensue: the Wao speared any intruders into their riverine domain. It was not only the threat of being speared in the open, however, that discouraged rubber tappers and would-be slavers: the Waorani were hidden away from the riverbanks of these small rivers.

The Waorani people who were alive before contact took us to these ridgetops where their grandparents or ancestors had lived. We observed and studied four of these ridgetops that together are roughly one-quarter of a hectare in size. These ridgetops were difficult to access, requiring nearly 50-degree angle climbs over a trail of about 1 km up to relatively small, flat occupation spaces that each were only about 2,500 m².



Figure 2. Potsherds found on the surface near the edge of the control site. Photo by William Balée. (Color online)

A forest inventory can reveal the anthropogenic influences on a landscape. In the Amazonian context, a forest inventory involves collecting all species greater than or equal to 10 cm in diameter at 1.3 m up from the ground level (called DBH) and then determining the frequency, density, and dominance of known disturbance indicators (e.g., Anderson and Posey 1989; Balée and Campbell 1990; Peters et al. 1989). The usual size of the forest inventory in Amazonia is 1 ha (ter Steege et al. 2013), although up to 3 ha were sometimes inventoried in the past to show asymptotic species/area curves: the amount of area needed in an alpha-type zone to accommodate the maximum or near-maximum number of species. It has also been suggested that most diversity can be sampled with highly linear inventories, such as $10 \times 1,000$ m or $10 \times 3,000$ m (e.g., Campbell et al. 1986).

Because of the small size of the ridgetops—the small mesas or tablelands that coalign with river shapes—and their location between rivers that come close to converging, as do the Curaray and the Nushiño at one point, we could not carry out 1 ha inventories, which as noted earlier are more or less the standard in Amazon forest inventories (e.g., ter Steege et al. 2013). Instead, taking the ridgetop to be a forest of its own kind and always limited in extent, we took three inventories of 0.20 ha each, or 2,000 m², at each site. We compared the findings from each of these inventories to a control site, on which the elders told us that the Waorani would not have had villages or any kind of small-scale settlement. The ground of the control site is still well drained, even though it is on a slope between the river and the ridgetop. We divided it into 20 subplots of 10×10 m. The four inventories were carried out in the environs of three small Wao settlements—Tepapare, Geyepade, and Gomatan; at the last site one ridgetop and the control site inventories were conducted (Figure 1; Supplemental Appendices 1–4). Voucher specimens are deposited at the Amazonian herbarium of Ecuador (ECUAMZ).

Although we did not make test pits or do other kinds of excavations on any ridgetop, we did find potsherds at two of them. Remarkably, potsherds were also found on the edge of the control site, near a drop-off to a tiny tributary of the Nushiño (Figure 2), even though our Wao collaborators told us that no one had ever lived there. The broken ceramics were evidence of where women in the past, having carried on their shoulders heavy water-filled urns from the tiny tributary far below to the top of the ravine (next to the control site), accidentally dropped and broke them. That is *prima facie* evidence that these ridgetops were occupied for defensive reasons, for why else would people live where potable water was so difficult to access?

Results

Table 1 shows the 20 most-dominant species from each of the four study sites. It is noteworthy that, on the three ridgetops, cacao and *O. bataua* occur among these dominants, but these two species were not found at the control site. These two species also account for between 14% and 24% of the entire basal area of the four sites and between 20% and 30% of the entire basal area of the 20 most-dominant species (Table 2).

The basal areas are large and as expected for high rainforests of the Upper Amazon (e.g., Pires and Prance 1985), as is the very high species diversity per unit area: almost every other tree is a different species (Gentry 1988). This is the most speciose region of the Amazon Basin because of its environmental gradients, including rainfall, latitude, solar radiation, and probably (young) geological age

Table 1. Twenty Most-Dominant Species in Rank Order of Basal Area (Dominance) from each of the Four Study Sites.

Ridgetop Inventory no. 1	Ridgetop Inventory no. 2	Ridgetop Inventory no. 3	Well-Drained Forest below Ridgetop Near Gomatan: Control Inventory
Gomatan 01 (G1) (ridgetop)	Tepapare (T1)	Geyepade (Ge1)	Gomatan 02 (control site) (G2)
<i>Ceiba insignis</i> (Kunth) P.E. Gibbs & Semir	<i>Theobroma cacao</i> L.	<i>Theobroma cacao</i> L.	<i>Otoba parvifolia</i> (Markgr.) A.H. Gentry
<i>Theobroma cacao</i> L.	<i>Matayba inelegans</i> Radlk.	<i>Oenocarpus bataua</i> Mart.	<i>Ficus americana</i> Aubl.
<i>Brosimum utile</i> (Kunth) Oken	<i>Pourouma cecropiifolia</i> Mart.	<i>Guarea guidonia</i> (L.) Sleumer	<i>Clarisia racemosa</i> Ruiz & Pav.
<i>Otoba parvifolia</i> (Markgr.) A. H. Gentry	<i>Ceiba samauma</i> (Mart.) K.Schum.	<i>Aspidosperma rigidum</i> Rusby	<i>Pourouma tomentosa</i> Miq.
<i>Aspidosperma rigidum</i> Rusby	<i>Otoba parvifolia</i> (Markgr.) A. H.Gentry	<i>Guarea trunciflora</i> C.D.C.	<i>Perebea guianensis</i> Aubl.
<i>Oenocarpus bataua</i> Mart.	<i>Brosimum utile</i> (Kunth) Oken	<i>Pourouma guianensis</i> Aubl.	<i>Licania apetala</i> Fritsch
<i>Guarea</i> sp. 8	<i>Apeiba membranacea</i> Spruce ex Benth.	<i>Trichilia cipo</i> C.DC.	<i>Pourouma guianensis</i> Aubl.
<i>Osteophloeum platyspermum</i> Warb.	<i>Browneopsis ucayalina</i> Huber	<i>Sapium laurifolium</i> (A.Rich.) Griseb.	<i>Nectandra</i> sp. 1
<i>Gutteria</i> sp. 2	<i>Ficus</i> sp. Indet.	<i>Sarcomphalus cinnamomum</i> (Triana & Planch.) Hauenschild	<i>Iriartea deltoidea</i> Ruiz & Pav.
<i>Tapirira guianensis</i> Aubl.	<i>Sterculia tessmannii</i> Mildbr.	<i>Sagotia racemosa</i> Baill.	<i>Neosprucea montana</i> Cuatrec.
<i>Jacaratia digitata</i> Solms	<i>Catheda acuminata</i> Miers	<i>Theobroma subincana</i> Mart.	<i>Sterculia tessmannii</i> Mildbr.
<i>Mollia gracilis</i> Spruce ex Benth.	<i>Clarisia biflora</i> Ruiz & Pav.	<i>Nealchornea yapurensis</i> Huber	<i>Pourouma cecropiifolia</i> Mart.
<i>Caryocar harlingii</i> Prance & Encarn.	<i>Oenocarpus bataua</i> Mart.	<i>Coccoloba</i> sp. 1	<i>Browneopsis ucayalina</i> Huber
<i>Newtonia</i> sp. 1	<i>Cecropia sciadophylla</i> Mart.	<i>Vismia sprucei</i> Sprague	<i>Sapium marmieri</i> Huber
<i>Simira cordifolia</i> (Hook. f.) Steyererm.	<i>Leonia crassa</i> L.B. Sm. & A. Ferna	<i>Licania brittoniana</i> Fritsch	<i>Pseudolmedia laevigata</i> Trécul
<i>Gutteria ramiflora</i> (D.R.Simpson) Erkens & Maas	<i>Neosprucea montana</i> Cuatrec.	<i>Pouteria lucuma</i> (Ruiz & Pav.) Kuntze	<i>Pouteria cladantha</i> Sandwith
<i>Protium picramnioides</i> Byng & Christenh.	<i>Pourouma tomentosa</i> Mart. ex Miq.	<i>Sloanea latifolia</i> K. Schum.	<i>Virola multinervia</i> Ducke
<i>Virola elongata</i> Warb.	<i>Nectandra acuminata</i> (Nees and C. Mart.) J. F. Macbr.	<i>Calyptanthes</i> sp. 1	<i>Virola elongata</i> Warb.
<i>Pterocarpus</i> sp. 1	<i>Gutteria megalophylla</i> Diels	<i>Virola albidiflora</i> Ducke	<i>Dialium guianense</i> (Aubl.) Sandwith
<i>Guarea pterorhachis</i> Harms	<i>Pseudolmedia laevigata</i> Trécul	<i>Browneopsis ucayalina</i> Huber	<i>Ocotea aciphylla</i> (Nees & Mart.) Mez

Table 2. Dominance Values of *Theobroma cacao* and *Oenocarpus bataua* at the Four Sites.

Species	Gomatan 01	Tepapare	Geyapade	Gomatan 02 (control site)
<i>Theobroma cacao</i> L.	1.3372 m ²	2.2048 m ²	0.890400 m ²	0
<i>Oenocarpus bataua</i> Mart.	0.2858 m ²	0.1973 m ²	0.711646 m ²	0
Subtotal	1.6230 m ²	2.4021 m ²	1.602000 m ²	0
Percent of total basal area at each study site	1.623 m ² / 11.2924 m ² = 0.1437 (× 100) = 14.37%	2.4021 m ² / 10.803 m ² = 0.2223 (× 100) = 22.23%	1.602 m ² / 9.5135 m ² = 0.1683 (× 100) = 16.83%	N/A
Percent of total of 20 most-dominant species	1.623 m ² / 8.0265 m ² = 0.2022 (× 100) = 20.22%	2.4021 m ² / 7.893 m ² = 0.3043 (× 100) = 30.43%	1.6020 m ² / 5.5417 m ² = 0.2829 (× 100) = 28.90%	N/A

Table 3. Species among the 20 Most-Dominant Species that Occur in Two or More Anthropogenic Forests but Not the Control Site (Gomatan 02).

Taxon	Sites Where the Taxon Is among the 20 Most- Dominant Species
<i>Aspidospermum rigidum</i> Rusby	Gomatan 01 and Geyapade
<i>Brosimum utile</i> (Kunth) Oken	Gomatan 01 and Tepapare
<i>Oenocarpus bataua</i> Mart.	Gomatan 01, Tepapare, and Geyapade
<i>Theobroma cacao</i> L.	Gomatan 01, Tepapare, Geyapade

(all species are ranked by dominance by each inventory in the Supplemental Material). Only two species other than *T. cacao* and *O. bataua* are found on two or more of the ridgetop forests (but not the control site; Table 3). In fact, it is the presence of these two extremely important economic species, *T. cacao* and *O. bataua*, that demonstrates human impact on the alpha diversity on what is supposedly the most pristine forest of Amazonia.

These results also show that the species that are found both on the control site (Gomatan 02) and the other three sites are not significantly economic or culturally important (Supplemental Table 1), with the exception of *Pourouma cecropiifolia* Mart., which has an edible grape-like fruit and has been considered a domesticate (Pedrosa et al. 2018). Its presence at Gomatan 02 (control site) may be the result of a dispersal or may reflect the original distribution of the species (cf. Clement et al. 2010; Pedrosa et al. 2018). These forests are otherwise all very different from each other (Supplemental Table 2), sharing low proportions of common species. What this means is that ridgetop forests have been manipulated by the Waorani over at least the last 125 years and that these forests—widely and historically considered to be among the most untouched Amazonian rainforests known—are in fact anthropogenic or cultural forests.

Discussion

The ironic question by Cabodevilla (1994:13), if unanswerable as originally posed, asks whether the Waorani exhibit a period in antiquity, or instead, do they—the Wao people—represent such a time period itself. Cabodevilla's question implicitly addresses the dividing line between antiquity and modernity or between archaeology and ethnography. What this article suggests is that the Waorani do have a history—one embedded in landscapes; namely, ridgetop forests that are not pristine. These landscapes represent vegetation cover managed by the Waorani and their ancestors themselves over about the last 125 years.

What is clear from our inventory fieldwork is that the Waorani occupied and managed ridgetop forests in the central Ecuadorian Amazon between the Napo and the Pastaza at least since the end of the nineteenth century, when they are first mentioned—by their correct ethnonym or not—in the literature (High 2015; Rival 2002, 2016; Wasserstrom 2016; Zurita-Benavides 2014). The question

then becomes whether history, in the broadest sense of the term as used in historical ecology (e.g., Crumley et al. 2018), can include a hypothetical time before documentation (as in historiographically defined history and ethnohistory), or vice versa, because the logic of the answer does not depend on the subject and predicate order of relations. Another way of asking the question is whether antiquity can be dated to the cultural origins of a place-making people, even if those origins seem recent. We believe that the landscape is key to the answer. One can adduce, as we have here, the historical time period with bookended watershed events from which the Waorani are definitively first known as a distinctive society with a known territory; that is, much of the forested region south of the Napo River. The first period begins with the terminal rubber cycle from about 1885 to 1890 and ends around 1914–1920. For those Waorani who entered into more or less peaceful permanent contact and their descendants, the second period would be from about 1920 to 1960. The bookend for the last period is not yet in place, because of those Tagædi and Taadomenani Wao subgroups who inferentially refuse to comply with or surrender to civilization.

Although we did not create any test pits on the sites, we did find a surface stone ax-head at the ridgetop near the village of Gomatan (Figure 3). Wao people claim to find these in riverbeds and then use them to clear gardens but not to have manufactured them (Cabodevilla 1994:13; Robarchek and Robarchek 1998:77; Yost 1981:98). The context of the stone ax-head we found is indicative nevertheless of land management by the Indigenous people in the last 100 or so years. Thus, exactly where human influence is thought to have been negligible on the alpha (and beta) distribution of species—the Upper Amazon, including the Napo and its ridgetop forests—we found artifactual evidence to the contrary.

Therefore, the original Waorani, as known to the documentary record, can be understood in terms of their interaction with and management of the landscape. The human management signatures that we registered on the ridgetop forest composition correspond to the Amazonian rubber cycle or boom in the period from 1850 to 1914—essentially the time frame in which the Wao first become known as a people who violently rejected any contact with outsiders. To clear gardens, they used stone tools made in the ancient past, perhaps thousands of years ago, whenever they did not have raided steel tools on hand (Wasserstrom 2016). They favored tree crops like *Oenocarpus bataua* and *Theobroma cacao* on ridgetops. These domesticates and other crops are native to the region and have ancestries predating contact by thousands of years.



Figure 3. Wao female elder, Omanca Enqueri, holds the stone ax-head found on the surface at the Gomatan ridgetop, where the photo was taken; she sits at the base of a cacao tree (*Theobroma cacao* L.). Note the numerous stems, a characteristic of this species. The profusion of stems maximizes the number of cauliflorous fruits that can ripen on a single organism, a feature not seen in other *Theobroma* species and hence suggestive of deep-time domestication. Photo by Tod Swanson. (Color online)

The Waorani ancestors also made use of natural resources by relocating them from the forests below the ridgetops to the ridgetops themselves, where they matured into adult *ungurahua* (*petowe*) palms and cacao trees (*boginka*). The distribution (density) and frequency patterns of *O. bataua* and *T. cacao* on the ridgetops are most economically explained by previous human habitation. These two species were dominant on all three ridgetop forests studied while not appearing once on the control site. The presence of these species is, in conclusion, a persuasive if unexpected signature of past Waorani management of tablelands high above fast-flowing tributaries south of the Napo River. Therefore, the ridgetop forests cannot a priori be considered to be pristine, just as the Waorani themselves are not savages “Aucas” and indeed never were. They are instead landscape managers—of ridgetop forests.

Acknowledgments. We appreciate the three anonymous peer reviewers for their constructive comments on how to improve this article. In the field, thanks are due to students of IKIAM who helped with measuring trees and laying out transects in three field sites: Angel Crespo, Cielo Montenegro, and Mathew Tello. We also acknowledge Elizabeth Swanson Andi for field assistance and these Indigenous collaborators and their families in the three settlements near where forest inventories were carried out: Cabé Ima, Patricia Irumenga, Wampi Mayancha, Andrés Chimbo, Tanya Mayancha, Omanca Enqueri, Ore Nenquimo, Guiqui Boyotaim, and Betty (Ahuani) Nihua. Diana Chavez Vargas helped with logistics and accounting through the Fundación Cotococha.

Funding Statement. We are grateful to the National Geographic Society for its financial support of project NGS-58639C-19.

Data Availability Statement. The plant specimens collected for the identifications listed in the text, tables, and Supplemental Material are housed in the herbarium city of Puyo, Ecuador: Herbario Amazónico del Ecuador ECUAMZ. These may be found in association with the collectors’ names and inventory numbers of individual trees and lianas on the four forest plots in the study.

Competing Interests. The authors declare none.

Supplemental Material. For supplemental material accompanying this article, visit <https://doi.org/10.1017/laq.2022.94>.

Supplemental Appendix 1. Ridgetop forest inventory near Gomatan village, ranked in order of dominance (basal area).

Supplemental Appendix 2. Control site forest inventory near Gomatan village, ranked in order of dominance (basal area).

Supplemental Appendix 3. Ridgetop forest inventory near Tepapare village, ranked in order of dominance (basal area).

Supplemental Appendix 4. Ridgetop forest inventory near Geyapare village, ranked in order of dominance (basal area).

Supplemental Table 1. Species shared between the control site (Gomatan 02) and any of the other study sites from among the 20 most-dominant species.

Supplemental Table 2. Jaccard coefficients of similarity between the six pairs of study sites.

Notes

1. The Kichwa and Spanish words for rivers, “yacu” and “río,” appear only on maps made after the mid-nineteenth century.
2. Interestingly, although we have seen (unscored) *Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg., which in the first rubber cycle of 1880–1914 commanded the highest prices on the world market and required special tapping methods, that species appears not to have been exploited in this region in favor of *Castilla ulei* Warb. (Wasserstrom 2016); rather than being scored or “tapped,” that latter species was merely cut down with an ax, and the copious white latex from the chopping site then was drained into a trough and prepared for export downriver. *Castilla ulei* occurs in the region of study, but it was not present on any inventory site; in this regard, it is useful to remember the extremely speciose nature of Napo River rainforests. Brazil and Bolivia fought a war (1899–1903) in the region where both rubber species occur together in abundance; whereas the Bolivian side mostly sought *Castilla ulei*, the Brazilian side procured *Hevea brasiliensis* (Hecht 2013). Brazilians won and then incorporated a large part of Bolivian territory into what is now the state of Acre. *Caucheros* from Peru also were affected by Brazilian expansionism in the early twentieth century: motivated largely by the location of rubber trees, many went upriver on the Napo and penetrated the region where the Wao people live today.

References Cited

- Aikhenvald, Alexandra Y. 2012. *The Languages of the Amazon*. Oxford University Press, New York.
- Anderson, Anthony B., and Darrell A. Posey. 1989. Management of a Tropical Scrub Savanna by the Gorotire Kayapó of Brazil. *Advances in Economic Botany* 7:159–173.
- Arroyo-Kalin, Manuel, and Santiago Rivas Panduro. 2019. La arqueología del río Napo: Noticias recientes y desafíos futuros. *Revista del Museo de La Plata* 4:331–352.
- Balée, William. 1989. The Culture of Amazonian Forests. *Advances in Economic Botany* 7:1–21.
- Balée, William. 1994. *Footprints of the Forest: Ka’apor Ethnobotany: The Historical Ecology of Plant Utilization by an Amazonian People*. Columbia University Press, New York.
- Balée, William. 2013. *Cultural Forests of the Amazon: A Historical Ecology of People and their Landscapes*. University of Alabama Press, Tuscaloosa.
- Balée, William. 2018. Brief Review of Historical Ecology. *Les Nouvelles de l’Archéologie* 152:7–10.
- Balée, William and David G. Campbell. 1990. Evidence for the Successional Status of Liana Forest (Xingu River Basin, Amazonian Brazil). *Biotropica* 22:36–47.

- Balick, Michael J. 1986. *Systematics and Economic Botany of the Oenocarpus-Jessenia (Palmae) Complex*. Advances in Economic Botany Vol. 3. New York Botanical Garden, Bronx, New York.
- Beckerman, Stephen, and James Yost. 2007. Upper Amazonian Warfare. In *Latin American Indigenous Warfare and Ritual Violence*, edited by Richard J. Chacon and Rubén G. Mendoza, pp. 142–179. University of Arizona Press, Tucson.
- Blomberg, Rolf. 1957. *The Naked Aucas: An Account of the Indians of Ecuador*. Translated by F. H. Lyon. Essential Books, Fair Lawn, New Jersey.
- Bush, Mark B., Dolores R. Piperno, and Paul A. 1989. A 6,000 Year History of Amazonian Maize Cultivation. *Nature* 340:303–305.
- Bush, Mark B., Miles R. Silman, Mauro B. de Toledo, Claudia Listopad, William D. Gosling, Christopher Williams, Paulo E. de Oliveira, and Carolyn Krisel. 2007. Holocene Fire and Occupation in Amazonia: Records from Two Lake Districts. *Philosophical Transactions of the Royal Society B* 362:209–218.
- Cabodevilla, Miguel Ángel. 1994. *Los huaorani en la historia de los pueblos del oriente*. Cicame, Coca, Ecuador.
- Cabodevilla, Miguel Ángel. 2010. *La Nación Waorani: Noticias históricas y territorio*. Vicariato Apostólica de Aguarico, Orellana, Ecuador.
- Cabodevilla, Miguel Ángel. 2013. Tiputini, el río de los piratas. *Ecuador: Tierra Incognita* 85:24–39.
- Campbell, David, Douglas C. Daly, Ghilleen T. Prance, and Ubirajara N. Maciel. 1986. Quantitative Ecological Inventory of Terra Firme and Várzea Tropical Forest on the Rio Xingu, Brazilian Amazon. *Brittonia* 38:369–341.
- Ceron, Carlos E. M., and Consuelo G. Montalvo Ayala. 1998. *Etnobotánica de los Huaorani de Quehueiri-ono Napo-Ecuador*. Abya-Yala, Quito.
- Cipolletti, María Susana. 2002. El testimonio de Joaquina Grefa, una cautiva quichua entre los Huaorani (Ecuador, 1945). *Journal de la Société des Americanistes* 88:111–135.
- Clasby, Ryan, and Jason Nesbitt (editors). 2021. *The Archaeology of the Upper Amazon: Complexity and Interaction in the Andean Tropical Forest*. University Press of Florida, Gainesville.
- Clement, Charles R., Michelly de Cristo-Araujo, Geo Coppens d'Eeckenbrugge, Vanessa Maciel dos Reis, Romain Lehnebach, and Doriane Picanço-Rodrigues. 2017. Origins and Dispersal of Domesticated Peach Palm. *Frontiers in Ecology and Evolution* 5:1–9.
- Clement, Charles R., Michelly de Cristo-Araújo, Geo Coppens D'Eeckenbrugge, Alessandro Alves Pereira, and Doriane Picanço-Rodrigues. 2010. Origin and Domestication of Native Amazonian Crops. *Diversity* 2(1):72–106. <https://doi.org/10.3390/d2010072>.
- Cronon, William. 1983. *Changes in the Land: Indians, Colonists, and the Ecology of New England*. Hill and Wang, New York.
- Crumley, Carole L., Tommy Lennartsson, and Anna Westin (editors). 2018. *Issues and Concepts in Historical Ecology: The Past and Future of Landscapes and Regions*. Cambridge University Press, Cambridge.
- Dangles, Olivier, Fernanda Nowicki, and Valencia Renato. 2009. *Biota máxima: Ecuador biodiverso*. IRD, PUCE, Quito.
- Denevan, William M. 1992. The Pristine Myth: The Landscape of the Americas in 1492. *Annals of the Association of American Geographers* 82:369–385.
- Evans, Clifford, and Betty J. Meggers. 1968. *Archeological Investigations on the Rio Napo, Eastern Ecuador*. Smithsonian Contributions to Anthropology Vol. 6. Smithsonian Institution, Washington, DC.
- Finer, Matt, Varsha Vijay, Fernando Ponce, Clinton N. Jenkins, and Ted R. Kahn. 2009. Ecuador's Yasuni Biosphere Reserve: A Brief Modern History and Conservation Challenges. *Environmental Research Letters* 4:1–15.
- Gentry, Alwyn H. 1988. Tree Species Richness of Upper Amazonian Forests. *PNAS* 85:156–159.
- Hecht, Susanna B. 2013. *The Scramble for the Amazon and the "Lost Paradise" of Euclides da Cunha*. University of Chicago Press, Chicago.
- Heckenberger, Michael J., J. Christian Russell, Carlos Fausto, Joshua R. Toney, Morgan J. Schmidt, Edithe Pereira, Bruna Franchetto, and Afukaka Kuikuro. 2008. A Pre-Columbian Urbanism, Anthropogenic Landscapes and the Future of the Amazon. *Science* 321:1214–1217.
- High, Casey. 2015. *Victims and Warriors: Violence, History, and Memory in Amazonia*. University of Illinois Press, Urbana.
- Karubian, Jordan, Victoria L. Sork, Tessa Roorda, Renata Durães, and Thomas B. Smith. 2010. Destination-Based Seed Dispersal Homogenizes Genetic Structure of a Tropical Palm. *Molecular Ecology* 19:1745–1753.
- Lamperty, Therese, Jordan Karubian, and Amy E. Dunham. 2021. Ecological Drivers of Intraspecific Variation in Seed Dispersal Services of a Common Neotropical Palm. *Biotropica* 53:1226–1237.
- Lathrap, Donald W. 1970. *The Upper Amazon*. Praeger, New York.
- Levis, Carolina, Flavia R. C. Costa, Frans Bongers, Marielos Peña-Claros, Charles R. Clement, André B. Junqueira, Eduardo G. Neves, et al. 2017. Persistent Effects of Pre-Columbian Plant Domestication on Amazonian Forest Composition. *Science* 355:925–931.
- Levis, Carolina, Bernardo M. Flores, Priscila A. Moreira, Bruno G. Luize, Rubana P. Alves, Juliano Franco-Moraes, Juliana Lins, et al. 2018. How People Domesticated Amazonian forests. *Frontiers in Ecology and Evolution* 5:171. <https://doi.org/10.3389/fevo.2017.00171>.
- Long, Kathryn T. 2019. *God in the Rainforest: A Tale of Martyrdom and Redemption in Amazonian Ecuador*. Oxford University Press, New York.
- McMichael, Crystal H., and Mark B. Bush. 2019. Spatiotemporal Patterns of Pre-Columbian People in Amazonia. *Quaternary Research* 92:53–69.
- McMichael, Crystal H., Dolores R. Piperno, Mark B. Bush, Miles R. Silman, Andrew R. Zimmerman, Marco F. Raczka, and Luiz C. Lobato. 2012. Sparse Pre-Columbian Human Habitation in Western Amazonia. *Science* 336:1429–1431.

- Moriconi, Liz, and Ernesto Londoño. 2020. Protecting Brazil's Uncontacted Tribes for 30 Years, then Killed by an Arrow. *New York Times*, September 11. <https://www.nytimes.com/2020/09/11/world/americas/brazil-uncontacted-tribes.html>, accessed November 9, 2022
- Netherly, Patricia J. 1997. Loma y ribera: patrones de asentamiento prehistóricos en la Amazonía equatoriana. *Fronteras de Investigación* 1(1):33–54.
- Pedrosa, Hermisia, Charles R. Clement, and Juliana Schiett. 2018. The Domestication of the Amazon Tree Grape (*Pourouma cecropiifolia*) under an Ecological Lens. *Frontiers in Plant Science* 9:203. <https://doi.org/10.3389/fpls.2018.00203>.
- Peeke, Catherine. 1973. *Preliminary Grammar of Auca*. Summer Institute of Linguistics, Norman, Oklahoma.
- Peters, Charles M., Michael J. Balick, Francis Kahn, and Anthony B. Anderson. 1989. Oligarchic Forests of Economic Plants in Amazonia: Utilization and Conservation of an Important Tropical Resource. *Conservation Biology* 3:341–349.
- Piperno, Dolores, Crystal McMichael, and Mark B. Bush. 2015. Amazonia and the Anthropocene: What Was the Spatial Extent and Intensity of Human Landscape Modification in the Amazon Basin at the End of Prehistory? *Holocene* 25:1588–1597.
- Pires, João Murça, and Ghilleant T. Prance. 1985. The Vegetation Types of the Brazilian Amazon. In *Key Environments: Amazonia*, edited by Ghilleant T. Prance and Thomas Lovejoy, pp. 109–145. Pergamon Press, New York.
- Porras, Pedro I. 1987. *Manual de arqueología ecuatoriana*. Centro de Investigaciones Arqueológicas, Quito.
- Pyne, Stephen J. 1982. *Fire in America: A Cultural History of Wildland and Rural Fire*. Princeton University Press, Princeton, New Jersey.
- Redford, Kent H. 1992. The Empty Forest. *BioScience* 42:412–422.
- Rival, Laura. 2002. *Trekking through History: The Huarani of Amazonian Ecuador*. Columbia University Press, New York.
- Rival, Laura. 2016. *Huaorani Transformations in Twenty-First Century Ecuador: Treks into the Future of Time*. University of Arizona Press, Tucson.
- Robarchek, Clayton, and Carole Robarchek. 1998. *Waarani: The Contexts of Violence and War*. Harcourt Brace College, Fort Worth, Texas
- Rostain, Stéphen. 2021. *La forêt vierge d'Amazonie n'existe pas*. Editions Le Pommier/Humensis, Paris.
- Rostain, Stéphen, and Geoffroy de Saulieu. 2013. *Antes: Arqueología de la Amazonía ecuatoriana*. Translated by Belém Muriel. UMIFRE Vol. 17. Instituto Francés de Estudios Andinos, CNRS-MAE, Lima.
- Schaan, Denise. 2011. *Sacred Geographies of Ancient Amazonia: Historical Ecology of Social Complexity*. Routledge, New York.
- Stahl, Peter. 2015. Interpreting Interfluvial Landscape Transformations in the Pre-Columbian Amazon. *Holocene* 25:1598–1603.
- Stanfield, Michael Edward. 1998. *Red Rubber, Bleeding Trees: Violence, Slavery, and Empire in Northwest Amazonia, 1850–1933*. University of New Mexico Press, Albuquerque.
- Ter Steege, Hans, Nigel C. A. Pitman, Daniel Sabatier, Christopher Barato, Rafael P. Salomão, Juan Ernesto Guevara, Oliver L. Phillips, et al. 2013. Hyperdominance in the Amazonian Tree Flora. *Science* 342:1243092.
- Thoreau, David H. 2004 [1854]. *Walden; or, Life in the Woods*. Edited by Jeffrey Cramer. Yale University Press, New Haven, Connecticut.
- Up de Graff, Fritz W. 1921. *Headhunters of the Amazon*. Herbert Jenkins, London.
- Wasserstrom, Robert. 2016. Waarani Warfare on the Ecuadorian Frontier, 1885–2013. *Journal of Latin American and Caribbean Anthropology* 21:497–516.
- Wierucka, Aleksandra. 2015. *Huaorani of the Western Snippet*. Palgrave MacMillan, New York.
- WinklerPrins, Antoinette M.G.A., and Carolina Levis. 2021. Reframing Pre-European Amazonia through an Anthropocene Lens. *Annals of the American Association of Geographers* 111:858–868.
- Woods, William I., and William M. Denevan. 2009. Amazonian Dark Earths: The First Century of Reports. In *Amazonian Dark Earths: Wim Sombroek's Vision*, edited by William I. Woods, Wenceslau G. Teixeira, Johannes Lehmann, Christoph Steiner, Antoinette M.G.A. WinklerPrins, and Lilian Rebellato, pp. 1–14. Springer, Dordrecht, Netherlands.
- Woods, William I., and Joseph M. McCann. 1999. The Anthropogenic Origin and Persistence of Amazonian Dark Earths. *Yearbook of the Conference of Latin Americanist Geographers* 25:7–14.
- Yost, James. 1981. Twenty Years of Contact: The Mechanisms of Change in Wao (“Auca”) Culture. In *Cultural Transformations and Ethnicity in Modern Ecuador*, edited by Norman E. Whitten Jr., pp. 677–704. University of Illinois Press, Urbana.
- Zurita-Benavides, María Gabriela. 2014. Du “temps du tapir” à nos jours: Les marques du temps dans le paysage. Perspectives de deux villages waarani sur les relations entre les espaces forestiers et le temps en Amazonie équatorienne. PhD dissertation, Ecole Doctorale Sciences de la Nature et de l'Homme, Museum National d'Histoire Naturelle, Paris.
- Zurita-Benavides, María Gabriela. 2017. Cultivando las plantas y la sociedad waarani. *Boletim do Museu Paraense Emílio Goeldi, Ciências Humanas* 12:495–516.
- Zurita-Benavides, María Gabriela, Pablo Jarrín, and Montserrat Rios. 2016. Oral History Reveals Landscape Ecology in Ecuadorian Amazonia: Time Categories and Ethnobotany among Waarani People. *Economic Botany* 70:1–14.