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How pristine are tropical forests? An ecological perspective on the pre-Columbian human footprint in Amazonia and implications for contemporary conservation

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ABSTRACT

Archeologists, paleoecologists and anthropologists argue that ecologists need to give greater consideration to the pre-historical influence of humans in shaping the current structure and composition of tropical forests. We examine these arguments within the context of Amazonia, and assess the extent to which (i) the concepts of "pristine forests" and "cultural parklands" are mutually exclusive, (ii) the aggregated distribution of some plants necessarily indicates enrichment planting, (iii) pre-Columbian human disturbance has increased forest biodiversity, (iv) pre-Columbian indigenous practices were always sustainable, and (v) if indeed, the ecological impacts of pre-Columbian peoples are relevant for modern biodiversity conservation. Overall, we reject the notion that "the pristine myth has been thoroughly debunked" by archeological evidence, and suggest that the environmental impacts of historical peoples occurred along gradients, with high-impacts in settlements and patches of Amazonian Dark Earth (ADE), lesser impacts where occasional enrichment planting took place in forests surrounding agricultural plots, and a very low influence (in terms of light hunting pressure and other types of resource extraction) across vast areas of Amazonia that may always have been far from permanent settlements and navigable rivers. We suggest that the spatial distribution of pre-Columbian finds is given more attention, and urge caution before case studies are extrapolated to the entire Basin. Above all, we feel that debates over "naturalness" and environmental impacts of pre-Columbian humans are of limited relevance to present and future biodiversity conservation, and can detract from the major challenges facing Amazonia and other tropical forest regions today.

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1. Introduction

Archeologists, paleoecologists and anthropologists have long suggested that ecologists should give greater consideration to the effects of pre-historical and modern human disturbance on the

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contemporary ecology of Amazonian forests (Denevan, 1992; Heckenberger et al., 2007; Willis et al., 2004). Clement and Junqueira (2010) suggest that although "the pristine myth has been thoroughly debunked, too many biodiversity researchers fail to incorporate historical ecology into their analyses", and similarly Heckenberger et al. (2007) argues that "The majority opinion still holds that natural forces and processes, little impacted by human actions until recently, are responsible for the current composition of the region".

These arguments could be important, as the disturbance history of tropical forests has repercussions for our understanding of contemporary global environmental change. For example, observed increases in aboveground biomass and turnover in Amazonian and African forests (Lewis et al., 2009; Phillips et al., 2008) could be explained by two alternative hypotheses: either global environmental change such as CO_2 fertilization or nutrient deposition may be accelerating the rate at which tropical trees are growing (Phillips et al., 2008), or tropical forests may simply be recovering from past (but unknown) disturbance events (Chave et al., 2008; Muller-Landau, 2009). Archeological evidence confirming widespread human disturbance would lend significant weight to the latter argument.

We take this opportunity, in memory of our colleague Navjot Sodhi, to discuss these arguments in more detail and provide an ecological perspective to the debate. We examine five arguments or claims that have been made about the influence and spatial distribution of pre-historical human disturbance in tropical forests, and show how greater scrutiny of biological detail and spatial scale could improve our understanding of the relative importance of such disturbances.

2. Are "Pristine Forests" and "Cultural Parklands" mutually exclusive?

Academic debates, especially those that span different disciplines, are readily polarized and often employ straw-men arguments to help establish particular positions. This problem can be exacerbated by high-impact publications that illicit a dose of controversy in their titles in order to attract the reader's attention. For example, Heckenberger et al. (2003) suggest two competing hypotheses about the make-up of Amazonia in 1492, suggesting it existed either as a "pristine forest" or a "cultural parkland", reinforcing the idea that the two concepts are mutually exclusive.

In fact, Heckenberger et al. (2003) reaches a far more nuanced and reasonable conclusion that points towards the "complex interplay of ecological, historical, and political conditions in Amazonia", which is supported by calls for a "middle path" that accepts that both extremes existed (Bush and Silman, 2007). However, some authors continue to deny the possibility that modern day tropical forests persist as mosaics, where the legacy of past human impacts is strongly evident in some places but virtually absent in others. For example, Clement and Junqueira (2010) argue that pre-Columbian peoples led to a "domestication of landscapes in Amazonia" and leave no space for the 'pristine' or 'primary' forests that ecologists refer to when representing the most natural conditions available.

We support calls to adopt a more considered assessment of the likely spatial distribution of the ecological impact of pre-Columbian peoples (Bush and Silman, 2007). Human decisions about where to settle, grow crops or hunt are far from random, and it is very unlikely that human impacts were dispersed homogenously across the basin. For example, much of the archeological evidence that has been used to promote so-called "cultural parklands" indicates that indigenous peoples focussed their settlements and agricultural activities in relatively confined areas. We examine the implication of this on two different spatial scales.

At a macro-scale, these include wetland regions such as the highly productive seasonally flooded savannas in French Guiana (McKey et al., 2010) and Marajó Island (Meggers, 2003), and the settlements and managed lands along the upper Xingú (Heckenberger et al., 2007) and parts of western Amazonia (Mann, 2008). At present there is insufficient evidence to know whether we can extrapolate evidence from these finds to other regions (Meggers, 2003), especially as the distribution of archeological sampling effort itself is not random, with archeologists tending to work in regions where they are most likely to find evidence of human settlements.

The focussed spatial distribution of pre-Columbian activities can also be observed at smaller scales, including their propensity to settle and intensively farm zones around riverine bluffs (Denevan, 1996). In particular, the extent of pre-Columbian agricultural activities has been largely informed by research on Amazonian Dark Earths (ADEs) (known as *terra preta* or *terra mulata*; Woods and McCann, 1999), which have been used as evidence for the widespread influence of pre-Columbian peoples on Amazonian forests (Willis et al., 2004). However, the majority of patches of ADE have been described along rivers and are either absent or undetected in much of Amazonia (see maps in (Fraser et al., 2011; Glaser, 2007)) and account for a very small proportion of total land cover in regions where they are present. For example, Woods and McCann (1999) studied 12 black earth locations ranging from 0.5 to 120 ha in the Santarém-Arapiuns region that hosted one of the most prominent pre-Columbian cultures, and estimated that "hundreds exist" across a study area that encompasses more than a million hectares of forest. However, a generous estimate of 1000 patches with an average size of 10 ha would still indicate that non-*terra preta* soils cover make up more than 99.9% of the land. Similar estimates could be made by extrapolating numbers from the middle Madeira, where 350 ha of ADEs have been found along 150 km stretch of river (Fraser et al., 2011). Our own observations (from a collective experience that includes over 60 years of work across the Amazon, including many regions notorious for their dark soils) suggest that while it is not uncommon to find evidence of ADE in the vicinity of riverine communities, these are invariably very localized and limited in extent, and ADEs are rarely encountered far from rivers. While any large-scale extrapolation from spatially focussed samples is likely to be highly inaccurate (c.f. Henige, 1998), the overall point remains: ADEs only account for a tiny fraction of Amazonia's total area.

The pre-Columbian land-use zones described by Heckenberger et al. (2007) could provide a useful framework for understanding impacts, as they include "areas of continual management", "areas of active but occasional management", and "areas that are utilized [for occasional hunting and NTFP extraction] but not actively managed". When ecologists use the notion of relatively undisturbed primary forests to represent reference conditions for assessing modern-day human impacts, they are normally referring to the latter category. Where our views diverge from Heckenberger's and others is in the likely spatial extent of the different activities: crude estimates and our own personal experiences suggest that unmanaged forests covered many orders of magnitude more land than managed forests (c.f. Bush and Silman, 2007).

3. Does the aggregated distribution of some plants always indicate enrichment planting?

Enrichment planting of economically important species to create 'forest gardens' is a central tenet of the cultural parkland theory (Balee, 1989), and archeologists often base their arguments on the local monodominance of certain economically important plants such as Brazil nut trees (*Bertholletia excelsa*) or Mauritia palms (*Mauritia flexuosa*). While indigenous peoples undoubtedly planted