The Gran Chaco harbors high biodiversity, including many endemic species (3, 6, 7). This region is also a global deforestation hotspot (8) due to the recently accelerated expansion of cattle ranching and soybean cultivation there (9, 10). Given the agricultural potential of the region and the growing global demands for agricultural products, the pressure to convert additional natural ecosystems into agricultural land remains very high. Yet, only 9% of the Gran Chaco is currently protected (6). For these reasons, the Gran Chaco is one of the most threatened ecoregions worldwide. Various definitions of dry forests exist, but the Gran Chaco should not be neglected when raising awareness to the urgent conservation needs in the often forgotten neotropical dry forests.

Tropical and subtropical dry forests around the globe are experiencing rapid clearing and concomitant biodiversity loss (1). In their Research Article “Plant diversity patterns in neotropical dry forests and their conservation implications” (23 September 2016, p. 1383), DRYFLOR et al. highlight the often underappreciated, yet exceptional floristic richness and uniqueness of these forests, and they provide compelling arguments for ramping up efforts to protect them.

We applaud the DRYFLOR team for their seminal work, but we are also concerned about the exclusion of the Gran Chaco, frequently considered the world’s largest continuous tropical dry forest region (2–4). The Gran Chaco covers more than 1,100,000 km² in Northern Argentina, Bolivia, Brazil, and Paraguay. The DRYFLOR team used a restrictive definition of dry forest that excludes the Gran Chaco because of some temperate elements in the Chaco’s flora and occasional freezing temperatures there. However, that applies only to parts of the Gran Chaco, and other neotropical dry forests that were included in the analysis also experience such temperatures (5).

**REFERENCES**

11. 10.1126/science.aal3020

**Response**

We AGREE WITH Kuehmerle et al. that the forests in the Gran Chaco region are under massive threat, underprotected, and deserving of greater attention from scientists and conservationists. We could have included the Chaco woodlands in our analyses, and their distinctive flora would have reinforced our conclusions of high floristic turnover among neotropical dry forests. However, level of threat and the label of “dry forest,” a term that has been notoriously loosely used across the neotropics (7–9), were not the criteria used in selecting sites for our study. Rather,
we focused on sites in the neotropical dry forest biome as defined based on climatic, soil, hydrologic, physiognomic, and floristic characteristics (4, 5). Based on these criteria, it is more biologically meaningful and relevant for conservation purposes to consider the Chaco woodlands as a distinct biome (6, 7)—essentially a separate evolutionary metacommunity (4, 5, 8).

We did include sites from within the Gran Chaco region in our analyses, such as the Cerro León in Paraguay, because these are floristically and ecologically dry forests. However, we did not include sites from the Chaco woodlands (6, 7) because these are dominated by a different, temperate-adapted flora. The Chaco woodlands receive regular and severe frost and also suffer the highest summer temperatures recorded in South America (9). We suggest that these extreme climatic conditions, added to saline soils and seasonal flooding in many areas (6), which contrast with the well-drained, fertile soils of tropical dry forests, have led to the distinctive evolutionary assembly of the temperate-adapted flora of the Chaco woodlands.

We agree with others (5) that there is a need to arrive at better, universally agreed-upon definitions of neotropical biomes, especially in seasonally dry areas and including the Gran Chaco region. For this reason, there are 50 inventories of Chaco woodland in the openly available DRYFLOR database (10). Exploring biome definitions at this continental scale will require quantitative analysis of how floristic composition and ecosystem function is influenced by environmental conditions and geographic distance across all major neotropical biomes, including rain forests, dry forests, and savannas. We predict that if the Chaco woodlands are included in such a broad-scale analysis, their highly distinctive flora would separate them as a biome at a continental scale, underlining the importance of conserving their unique plant diversity.

**References**

10. DRYFLOR: Latin American Seasonally Dry Tropical Forest Floristic Network (www.dryflor.info/).

10.1126/science.aal5010

**Forest conservation: Humans’ handprints**

NEOTROPICAL FORESTS HAVE been home to humans since the end of the Pleistocene and, pre-Columbian societies emerged in tropical dry forests in Central and South America and in wetter forests of the Amazon basin during the past several millennia. The role of humans in shaping species distributions, however, tends to be overlooked in ecological studies. For example, in their Research Article analyzing the largest data set of floristic inventories in neotropical dry forests (“Plant diversity patterns in neotropical dry forests and their conservation implications,” 23 September 2016, p. 1383), DRYFLOR et al. mentioned humans occasionally, but not as a potential driver of the patterns observed.

Although DRYFLOR et al. showed neotropical dry forests to be dominated by woody plant species with geographically restricted distributions, 17 of the 4660 species recorded were widespread across dry forests, occurring in at least 9 of 12 floristic groups. Interestingly, 8 of these 17 widespread species are known to be cultivated today (1), and two of those have populations that were cultivated and probably domesticated by pre-Columbian societies (Sapindus saponaria and Trema micrantha) (1). Surprisingly, all eight widespread species of the dry biome that were cultivated by past or modern Amerindians also occur in Amazonian forests (2). Amazonian forests are partly dominated by useful species, a pattern that might result from past management activities (2). The widespread distribution of cultivated and/or domesticated species across wet and dry biomes suggests that human-plant interactions transcend ecological boundaries and supports the hypothesis of a substantial effect of past human societies in shaping plant distributions across the neotropics. Accordingly, it is important that ecological studies take into account the potential role of prehisorical and historical human dispersal as a driver of plant distributions within and among neotropical biomes.

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**References**

10. DRYFLOR: Latin American Seasonally Dry Tropical Forest Floristic Network (www.dryflor.info/).

10.1126/science.aal5010
REFERENCES

1. The Mansfeld’s World Database of Agriculture and Horticultural Crops (http://mansfeld.ipk-gatersleben.de/).

Response

WE AGREE WITH Levis et al. that humans have influenced dry forests since their first arrival in the neotropics. This long interaction has had major effects, not least in leading to widespread destruction of this now highly threatened vegetation (1). It is also possible, as pointed out by Levis et al., that humans modified the distributions of useful woody plant species in dry forests and that this human influence could be partly responsible for their wide geographic distribution. However, the number of such species that are or were cultivated as a proportion of the overall flora of neotropical dry forests is small (8 out of the 4660 species in our data set, according to Levis et al.). We found high floristic turnover among major geographic areas of dry forest. This pattern is driven by the large numbers of range-restricted species in our data set: 3115 species are restricted to only one of the 12 regional floristic groups we identified. Therefore, the effect of geographically widespread species on our conclusions is negligible, whatever the reasons underlying their broad ranges.

Levis et al. suggest that the presence in the Amazonian rain forest biome of the same widespread, ecologically generalist, human-cultivated species found in the dry biome is surprising and may indicate that human-plant interactions transcend ecological boundaries. We find it more likely that the preferences of these species for disturbed areas underlie their wide distribution, given the high level of degradation of many dry forest sites. This would ultimately be a human effect, but one operating indirectly through the pioneer nature and wide ecological tolerances intrinsic to these species.

We agree that ecological studies should take into account the potential role of human dispersal as a driver of plant distributions in the neotropics (2), but we do not believe that the pattern of high floristic turnover that we described for dry forests, and its clear implication that many more protected areas are urgently required, is affected by previous human influence on the species’ ranges.

STOP DELETION


REFERENCES


10.1126/science.aal2175

Response

WE AGREE WITH Levis et al. that humans have influenced dry forests since their first arrival in the neotropics. This long interaction has had major effects, not least in leading to widespread destruction of this now highly threatened vegetation (1). It is also possible, as pointed out by Levis et al., that humans modified the distributions of useful woody plant species in dry forests and that this human influence could be partly responsible for their wide geographic distribution. However, the number of such species that are or were cultivated as a proportion of the overall flora of neotropical dry forests is small (8 out of the 4660 species in our data set, according to Levis et al.). We found high floristic turnover among major geographic areas of dry forest. This pattern is driven by the large numbers of range-restricted species in our data set: 3115 species are restricted to only one of the 12 regional floristic groups we identified. Therefore, the effect of geographically widespread species on our conclusions is negligible, whatever the reasons underlying their broad ranges.

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REFERENCES

Forest conservation: Remember Gran Chaco—Response


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