Caribbean Dry Forest Networking: An Opportunity for Conservation

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Abstract - Seasonally dry tropical forest is the most threatened tropical forest in the world. Though its overall plant species diversity is lower than in neighboring biomes such as rain forest, species endemism can be high, and its conservation has often been neglected. Caribbean dry forests face diverse threats including tourism, agriculture, and climate change. The Latin American Dry Tropical Forest Floristic Network (DRYFLOR) is a research network that seeks to understand the flora of dry forests at a broad scale across the Neotropics in order to promote their conservation. DRYFLOR is developing a continental-scale floristic dataset that can be used to contextualize regional and local dry forests with the aim of providing local communities, non-governmental organizations, and regional authorities with information that can help to underpin conservation decisions.

Introduction

The Caribbean Islands are a biodiversity hotspot (IUCN 2012, Myers et al. 2000) with \sim 10,500 native species of seed plants (Acevedo and Strong 2012). The interaction of geography and climate has shaped a diversity of habitats and ecosystems in the Caribbean, including seasonally dry tropical forest (SDTF), which is the focus of this paper.

There are many definitions for Neotropical SDTF (Janzen 1988, Miles et al. 2006, Mooney et al. 1995, Murphy and Lugo 1986, Olson et al. 2001, Pennington et al. 2006, Sánchez-Azofeifa et al. 2005). In a broad sense, SDTF is a formation dominated by trees, usually with a closed canopy; it occurs on fertile soils in frost-free regions where the rainfall is less than ~1800 mm per year, with a period of at least 5–6 months when precipitation is <100 mm per month (Gentry 1995, Murphy and Lugo 1986).

In the Caribbean, SDTF occurs in the lowlands of the Greater and Lesser Antilles (Fig. 1) on the lee side of mountainous islands or on coastal areas of low relief. Caribbean SDTFs show great variation in structure and composition due to differences in edaphic and climatic factors, biogeographic history, and disturbance history (Murphy and Lugo 1995). SDTF varies from open scrublands to closed-canopy forest (Pennington 2009), and enormous differences in the abiotic conditions at the sites where it occurs—a broad range of climatic conditions, altitude, and disturbance regimes (Murphy and Lugo 1995)—have made the definition of the limits of the biome problematic. Some digital biome maps are available (Eva et al. 2004, Miles et al. 2006, Olson et al. 2001); however, all of them have some

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limitations, e.g., poor spatial definition or lack of consideration of floristic information (Särkinen et al. 2011). Due to their small size, Caribbean islands are often under-represented or excluded from these maps (Weigelt et al. 2013).

In the Caribbean region, a considerable number of terms have been used to name SDTFs (Murphy and Lugo 1995, Pennington et al. 2006). For example, SDTF is called subtropical dry forest in the Dominican Republic (Fig. 2A), Puerto Rico, and US Virgin Islands (Daley 2010, Ramjohn et al. 2012); bosque semideciduo in Cuba (Fig. 2B) (Delgado 2012, Reyes and Cantillo 2011); and tropical dry forest in Jamaica (McLaren et al. 2005). Following Beard's (1944, 1955) vegetation classification, the name deciduous seasonal forest is commonly used in St. Lucia (Graveson 2009), whereas the terms blackland and whiteland coppice are utilized in the Bahamas (BNT 2008). This wide range of terms for related vegetation formations complicates communication among researchers and policy makers.

SDTF is considered perhaps the most threatened tropical forest in the world (Janzen 1988, Miles et al. 2006). Human impact has caused massive ecosystem transformation, and SDTF conservation has often been neglected. Areas that support SDTFs tend to have drier climates and relatively productive soils, two attributes that have hastened the degradation of these sites. Because they are favored for human habitation, few Caribbean dry forests remain undisturbed (CEPF 2010). The main causes of habitat alteration are agriculture, which since colonial times



Figure 1. Distribution of SDTF in the Caribbean based on terrestrial ecoregions of the world (Olson et al. 2001).

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has caused the loss of several habitats in Caribbean lowlands (Maunder et al. 2008), and tourism, which is the most important current economic activity in the region (Thacker et al. 2012) and a source of increasing stress to fragile ecosystems (SCBD 2004). In addition, there are other threats, such as extraction of fuel wood, charcoal burning, and alien species, which play an important role in the transformation of SDTF in some areas of the Caribbean. Although hurricanes, wild fires, drought, landslides, and volcanic eruptions are non-anthropogenic disturbances that affect the Caribbean region, climate change may enhance the frequency and severity of some them, with detrimental effects on vegetation. In particular, tropical storms and hurricanes may become more intense and frequent, and sea levels may rise (Trenberth 2005).

Islands are highly vulnerable to impacts of climate change on water supplies, agricultural productivity, coastal ecosystems, and tourism (Mirza 2003). Consequently, in the Caribbean, SDTF is in a critical state and requires urgent and concrete actions to preserve its biodiversity and the goods and services that it provides.

Improving communication between researchers and managers of threatened habitats such as SDTF can improve the effectiveness of conservation actions. Using scientific knowledge in conservation planning has been identified as a priority for the Caribbean region (Maunder et al. 2008), and networking among researchers and conservation managers is one route to achieve this. The 16th Caribbean Foresters Meeting on Forest Management, Climate Change, and Biodiversity held in the Dominican Republic in August 2013 sought to encourage the development of long-term regional networks, and highlighted the importance of collaborative work to improve the understanding and knowledge of the Caribbean Forest to support decision-making.

Efforts to create large biodiversity datasets have been made in the last decade. Encyclopedia of Life (http://eol.org), Global Biodiversity Facility (http://www.



Figure 2. (A) Subtropical dry forest in Punta Cana, Dominican Republic; (B) Bosque semideciduo in Trinidad, Cuba.

gbif.org), Salvias (http://www.salvias.net/pages/index.html), and RAINFOR: Amazon Forest Inventory Network (http://www.rainfor.org) are some initiatives of this type that gather data from museum specimens and forest-inventory plots. There are 183 databases worldwide specifically for vegetation data (Dengler et al. 2012). This synthesis of dispersed biodiversity information has much to offer for conservation, e.g., in identifying centers of species diversity and endemism.

DRYFLOR

The Latin American Dry Tropical Forest Floristic Network (DRYFLOR) aims to understand the flora of dry forests at a broad scale in the Neotropics in order to promote their conservation. The project is a partnership involving numerous workers across Latin America and the Caribbean. It is based at the Royal Botanic Garden Edinburgh (RBGE) and seeks to develop the first comprehensive dataset of the flora of Neotropical SDTF across this system's full range of distribution.

RBGE has a 50-year history of working in seasonally dry ecosystems in Latin America and has contributed considerably to their scientific understanding and conservation. Led by Dr. Jim Ratter, this work originally focused on tropical savannas, but in the last two decades more attention has been given to dry forest. The DRYFLOR project grew out of this recent research, the goal of which has been to understand the floristic composition and historical biogeography of dry forests based on extensive fieldwork in Latin America. This field experience has reinforced awareness of the terrible plight of SDTF and the poorly known nature of the flora of many areas. The network partners are 8 Neotropical dry forest experts working in regions that support significant areas of this vegetation: Brazil, Argentina, Peru, Ecuador, Colombia, Mexico, Venezuela, and the Caribbean. Each is well-connected to floristic research in SDTF in their geographic areas of expertise.

DRYFLOR data are focused on woody plants able to grow 3 m or more tall without climbing or leaning against other plants. An area for a floristic inventory is defined in the DRYFLOR database following the TreeAtlan database—which is a major contributor to DRYFLOR—as a 10-km-diameter circle of a specific vegetation type, for which the coordinates of the center point are recorded (Oliveira-Filho 2010). We use a broad definition of dry forest, following the concept of Beard (1955) for seasonal formations in tropical America, which includes tall evergreen forests on moister sites to thorn woodland and cactus scrub on the driest sites. Using such a wide definition is deliberate because it will allow investigation of the relations among different dry forest formations across their full continental range. This approach will enable us to determine how dry forest areas across the Neotropics relate to each other. For example, at the Caribbean scale, we can investigate how the "black coppice" of the Bahamas relates to the "bosque semideciduo" of Cuba.

Dr. Martin Pullan, from the biodiversity informatics lab at RBGE, has developed a central database, hosted at RBGE, into which all DRYFLOR partners across the Neotropics can enter data directly (M. Pullan, RBGE, UK, unpubl. data). Use of a single relational database offers the project enormous advantages, especially in terms of ensuring consistency of data entry by different users. For example, researchers choose species names from a list to eliminate the possibility of entering different synonyms for the same species.

The DRYFLOR database allows web-based entry and editing of plant-occurrence records. Each occurrence record documents the taxon present and the location of the occurrence. Voucher information in the form of references, images, and/or herbarium-specimen information are saved with each occurrence record (Pullan and Weintritt 2012). To capture regional SDTF information, floristic-data compilation begins with a review of available data (scientific papers, books, technical reports, theses, and grey literature) related to floristic studies of SDTF, followed by contacts with local researchers who are willing to provide unpublished floristic lists or quantitative ecological inventories. In some cases, as a final step, inventory and floristic data can be supplemented by herbarium-specimen data; rarely are such data used alone to build floristic lists of geographically limited areas. Judgment of the quality of the species identifications in a survey is essential, as is the determination and management of taxonomic synonymy. Nomenclature is checked with the current taxonomic resources (Acevedo and Strong 2013, IPJBRJ 2013) and whenever there is a conflict, specialists in the field are contacted.

A goal of the DRYFLOR network is open data-sharing, and ideally, all data will be publicly available at the end of the project. However, DRYFLOR will respect the personal choice of the data providers if they do not wish to make their data openly available and only wish it to be used in publications in which they are co-authors or contributors.

So far, the DRYFLOR database contains 152,979 species-occurrence records (as of 30 November 2014) from at least 1500 sites, mostly in Brazil and Andean countries. In addition, it contains 14,059 accepted scientific species names that are linked to 11,766 synonyms.

During the first meeting of the DRYFLOR network in June 2012 in Colombia, the necessity to improve the dataset for the Caribbean dry forests was evident. Since then, the network started to extend successfully to the Caribbean Region, and attendance at the 16th Caribbean Forester's Meeting in the Dominican Republic (August 2013) was an important part of this process. Fourteen researchers and institutions have now contributed data from several studies, covering at least 210 sites on 17 islands, including sites in most of the Greater Antilles Islands, but with fewer data from the Lesser Antilles (St. Lucia, Trinidad and Tobago, as of 30 November 2014). The help of regional experts is vital to improve our dataset and to fulfill the ultimate aim of the network: to improve communication and collaboration between research organizations studying dry forests and those responsible for the protection and management of endangered dry forests.

Caribbean Endemism and Conservation

Plant diversity is remarkable in the insular Caribbean, and the region is considered a distinctive phytogeographic unit within the Neotropics (Gentry 1982). Given the relatively small size of the Caribbean land-mass and the highly fragmented nature of habitats, the region's endemism is notable (Maunder et al. 2008). From

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a conservation perspective, endemism may be more important than overall diversity Gentry (1995). With 23.5 endemic species per 100 km² of land, the Caribbean Islands were listed among the top four of IUCN's 34 "Biodiversity Hot Spots" (IUCN 2012). Plant species endemism in the islands reaches around 71%, with an estimated 7446 species unique to the Caribbean (Acevedo and Strong 2012). Cuba, the largest Caribbean island, accounts for almost one quarter of the region's vascular flora, and 2980 species (51.3%) of its vascular plants are endemic, making it a top conservation priority for the region. The island with second highest endemism is Hispaniola, with 1881 endemic plant species (41.9% of its flora); followed by Jamaica (32.4%, 805 species), Puerto Rico (13.6%) , and Bahamas (9.4%) (Acevedo and Strong 2012).

For the Caribbean SDTF, Linares-Palomino et al.'s (2011) preliminary study reported an approximate rate of 77.5% endemism in woody species. The Cuban SDTF, in particular, shows high levels of local endemism (Borhidi 1993), with a remarkable importance for legumes (Leguminosae or Fabaceae), which is the dominant family in many Neotropical dry forests (Lavin and Matos 2008). Although such high numbers of endemic species might be produced by recent, rapid evolution, it seems more likely that in many dry forest regions, including Cuba, endemics represent the result of the considerable age of the biome, prolonged isolation, and limited arrival of immigrant lineages by dispersal (Pennington et al. 2009).

Some studies have inferred a close floristic relationship among the SDTF of the Caribbean, Mesoamerica, and northern South America (Linares-Palomino et al. 2011). However, these analyses must be considered preliminary because they were carried out with few floristic lists from the Greater Antilles. For this reason, more complete floristic information is needed from the Caribbean Region in order to understand relationships at a continental scale.

Investigations of the floristic relationships within SDTF in the Caribbean may lead to better-informed conservation decisions. Forests are the backbone of the dryland ecosystems that make up 44% of all cultivated land and support half of global livestock (UN 2013). Dry forests bring several goods and services to the Caribbean community. They are a source of fuel, wood for construction, food, and medicine; offer educational, recreational, and spiritual qualities; and regulate ecosystems by providing vital soil, water and climate management. Therefore, dry forests are critically important in the Caribbean region (CEPF 2010).

The loss of dry forest ecosystem services is intimately related to poverty due to the rapid soil degradation after deforestation (MEA 2005, Newton 2008). Forest canopies and the deep roots of trees maintain soil structure and serve as natural buffers against erosion, decreasing the high risk of slope failure and landslides that are common in the Caribbean Islands. Caribbean civil society, decision makers, and economic markets underestimate the value of ecosystem services, and Caribbean forests are under significant pressure in the name of economic development (CEPF 2010). However, it has recently been shown that enhanced forest-based economics—through eco-tourism as a growing economic alternative to the traditional tourism industry—may produce social and environmental benefits, including improving the livelihoods of forest-dependent people (Headley 2016).

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Twenty-five years after Janzen's (1988) alarming article about the state of dry forest, it is crucial that scientists, natural-resource managers, and society join their efforts in order to protect these valuable forests. It is possible that major progress can now be made in Caribbean dry forest conservation with the help of networking and initiatives such as Global Environmental Facility projects, the Critical Ecosystem Partnership Fund's 5-year investment in Caribbean, the Darwin Initiative's "Building Civil Society Capacity for Conservation in the Caribbean UK Overseas Territories", and the MacArthur Foundation's "Going from Strength to Strength: Building Capacity for Equitable, Effective, and Sustained Participation in Biodiversity Conservation in Caribbean Islands".

The DRYFLOR networking initiative sets out to improve our understanding of the floristic composition of dry forests at a broad geographic scale, and aims to deliver this information in ways relevant to the development of accurate conservation planning at regional and local scales. Based on a multilevel approach that includes floristic diversity and uniqueness, coupled to ecological and social dimensions, the conservation planning process may be able to establish effective protected areas that are supported and partly funded by ecotourism. Such protected areas, combined with restoration programs, can contribute to sustainable use and management of the Caribbean dry forest.

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