Part 1

The Forests and Their Trees

What is a Forest Tree?

With rare exceptions, a tree is considered here to be a perennial, self-supporting woody plant, typically with a single main stem or trunk, a distinct crown and capable of growing to a height of at least five metres. Trees grade physiognomically into large shrubs. A few species on the borderline between trees and shrubs have been included in this field guide, providing useful information for readers trying to distinguish them from those similar-looking plants that are clearly small trees.

The term 'forest', as used here, refers to a type of vegetation that typically has a continuous stand of trees, a tall canopy (10 to 50 m or more) and usually several layers of trees with crowns interdigitating with one another or overlapping (Fig. 1.1) (McElhinny *et al*. 2005; Obua *et al*. 2010; Côte *et al*. 2018; FAO 2018a, 2018d). It is a type of vegetation that regenerates naturally to maintain a complex structure (Kalema and Kasenene 2007; FAO 2018a, 2018d). Also known as tropical rainforest or, in Uganda, as Tropical High Forest, forest contrasts with certain other types of vegetation that are similarly dominated by trees and that are normally known by scientists concerned specifically with Ugandan vegetation as woodland (Langdale-Brown *et al*. 1964; White 1983). Woodland can usually be distinguished from forest in having only a single tree layer, an abundance of narrow-leaved grasses in the herbaceous layer (not the broad-leaved grasses common in some forests) and in being subject (and adapted) to burning. Also excluded are those other types of vegetation found in Uganda dominated by woody plants known scientifically as thicket and evergreen scrub. Forest becomes reduced in stature at high altitudes, with fewer tree layers, and, above the limit of broad-leaved trees, can grade into vegetation dominated by microphyllous trees (typical of the Ericaceous Belt) and giant groundsels (typical of the Afroalpine Belt). We have included trees found in these two vegetation belts here.

Confusingly, the term 'forest' is sometimes applied to other types of Ugandan vegetation apart from forest as we understand it. This means that reports on the state of Ugandan forests need to be read cautiously. The definition of forest, as used by the Secretariat of the Convention on Biological Diversity (2001) defines forest as including types of 'ecosystems in which trees are the predominant life forms', which is a very broad definition meant to cover global variations.

Vegetation on the boundary between forest and other forms of vegetation is in an intermediate situation and its flora can be distinctive (Fig. 1.2) (Marfo *et al*. 2019). This zone with its abrupt to gradual change in species composition is associated with changes in other aspects of the environment, such as climate, soils and human use of natural resources (Liautaud *et al*. 2019), but the extent to which the position of the boundary is a consequence of these other factors or these other factors are responsible for the position of the forest can be difficult to judge (Brownstein *et al*. 2015). The type of ecosystem found on one side of the boundary can have profound influence on that on the other and the boundary itself (an ecozone) can be

more biologically diverse in terms of numbers of species than the areas on either side (Hufkens *et al.* 2009; Marfo *et al.* 2018). We include here the commoner species of trees found in boundary zones and on forest edges, but omit those seen less frequently.

Fig. 1.1. Forest structure of Mpanga Central Forest Reserve, a lowland semi-deciduous forest of the Lake Victoria forest belt. Photo: Alan Hamilton (2019).

In an earlier field guide to Ugandan forest trees (Hamilton 1981), which was based on reports and observations made prior to 1972, it was stated that 'there is rarely any difficulty in determining whether or not a certain type of vegetation is forest, since marginal types of vegetation have been almost completely eliminated by burning, grazing and agriculture over a long period of time. Indeed, the boundaries of the great majority of forests are artificial and, in many cases *follow Forest Department demarcation lines* [our emphasis]'. This is no longer so true.

Many forests have been and continue to be degraded through human activities (Kalema *et al.* 2010), even in protected areas (Sassen and Sheil 2013). There has been widespread land use and land cover change (Kalema and Bukenya-Ziraba 2005; Kyarikunda *et al.* 2017). Extensive areas of ground now contain a mixture of forest and non-forest species. Sometimes, the clearance of forest to plant crops results in the leaving behind of impoverished ecosystems with only a few scattered tall trees (Fig. 1.3). It can be predicated that many of these trees, now

abandoned to the elements, will soon die. This degradation and loss continue despite enactment of a National Forestry and Tree Planting Act (Government of Uganda 2003) and new institutional arrangements. The latter include establishment of a Forest Sector Support Department, the National Forestry Authority (NFA) and District Forestry Services (Tumushabe and Mugyenyi 2017; Josephat 2018).

Fig. 1.2. Boundary of Mpanga Central Forest Reserve. Photo: John Kalule (2019).

Forest Distribution and Types in Uganda

Figure 1.4 shows the distribution of larger areas of forest in the 1950s, based on a map in Government of Uganda (1967). Also shown are those parts of Uganda that would naturally have carried forest before its clearance by people (estimated from a combination of climatic parameters and the presence of forest remnants). It can be seen that many of the forests lie in two regions, both of which are characterized by relatively high and well distributed rainfall. One is to the north of Lake Victoria (the lake belt) and the other, lying on or close to the border with D.R. Congo, is associated with the Albertine Rift. The forests shown in north-eastern Uganda (Kadam, Timu, etc.) are on mountains. Groundwater sometimes sustains forest in climatically dry areas, as along river banks (riverine forest).

The floristic composition of the forests, which in turn contributes to their structure, is greatly influenced by temperature, which reduces with altitude (FAO 2017; Mau *et al*. 2018; Mujawamariya *et al*. 2018; Cabrera *et al*. 2019), as well as climatic moistness and environmental history (Hamilton 1989; Tang 2019). A standard system of classification used for forests in Uganda recognizes two principal altitudinal types, High Altitude (or montane) Forest above 5000 ft (1525 m) and Mid Altitude Moist Forest below (Langdale-Brown *et al*. 1964). Mid Altitude Moist Forest, especially that below 1400 m, is floristically akin to forests at much lower altitudes (towards sea level) elsewhere in tropical Africa (Hamilton 1989; White 1983) and can be alternatively referred to as lowland. All the lake-belt forests are lowland, while both lowland and montane forests can be found along the Albertine Rift. Lowland forest varies in species complement and physiognomy between wetter and drier areas, an increased proportion of deciduous trees being found in the latter *(semi-deciduous forest).

Fig. 1.3. Matiri Central Forest Reserve, severely damaged by encroachment for agriculture and felling trees for charcoal. Photo: James Kalema (2009).

If the total altitudinal ranges of tree species in the country as a whole are considered, then lowland and montane forests grade gradually into one another without an abrupt transition (Hamilton 1989). However, there are some species that can assume great abundance over particular altitudinal ranges, providing handy ways to classify the forests further. Mountain bamboo (*Sinarundinaria alpina*) tends to form extensive stands in climatically wetter areas at high elevation (normally 2450-3050 m), thereby enabling recognition of a moist lower altitude montane forest zone below (1500-2450 m) (also known as *Pygeum* [= *Prunus*] Moist Montane Forest) and an upper montane forest zone above (3050-3300 m) (also known as *Hagenia-Rapanea* Moist Montane Forest) (Langdale-Brown *et al*. 1964). *Cynometra alexandri* and *Parinari excelsa* can be locally abundant in some of the Albertine Rift forests at altitudes of 700-1200 m and 1400-1500 m respectively.

Forest was restricted in distribution during the last global ice age, which was marked by a dry climate across much of tropical Africa (Hamilton *et al*. 2016). The climate became wetter 12,000 years ago, allowing many forest species to expand their ranges away from dry period forest refugia, including one in Kivu Province (eastern D.R. Congo). Species had different abilities to spread, the net result being for Uganda the creation of gradients of decreasing numbers of forest species away from the border with D.R. Congo, especially away from the south-west. This pattern is superimposed on other patterns considered to be caused by modern environmental factors, such as temperature and rainfall (Hamilton 1989; Howard 1991; Brack 2019; Tang 2019). It is predicted that modern anthropogenic climate change will further affect the forests (Lewis 2006). There are indications that tropical trees may be more vulnerable to continued warming than temperate species, as tropical trees have shown greater declines in growth and photosynthesis at elevated temperatures (Mau *et al*. 2018).

The richest forests in Uganda in terms of biodiversity, as measured by species scores for four taxonomic groups (one being forest trees), are Bwindi (Fig. 1.7) and Semliki (Howard 1991). Ishasha Gorge in Kayonza Forest (northern part of Bwindi) has a particularly diverse and unusual flora and could possibly have been the site of a minor forest refugium during the time of ice age aridity.

Some idea of the botanical diversity of the forests may be gauged from the numbers of tree and shrub species encountered in transect surveys through five of Uganda's forests carried out

for comparative biodiversity purposes (Howard 1991). The first number for each forest in the following list is the number of tree and shrub species classified as 'belonging to the forest interior' and the second for a wider ecological group of tree and shrub species 'deemed to be forest dependent': Budongo 123/233, Bwindi 106/188; Kalinzu 121/236; Kasyoha-Kitomi 120/226; Kibale 110/204; Semliki 108/199 (Davenport and Howard 1996; Davenport *et al.* 1996; Howard *et al.* 1996a-d).

Fig. 1.4. Distribution of forest in Uganda during the 1950s (Atlas of Uganda 1967).

There is much variation in the floristic composition of forest at the local level. Forests lying close to Lake Victoria within the lake belt (often developed on sandy soils) tend to have a distinctive tree flora, for example with an abundance of the large tree *Piptadeniastrum africanum*. They are known as lake-shore forests. Forests inland from Sango Bay (on the edge of Lake Victoria), some standing on swampy ground, are particularly unusual floristically, containing a number of typically montane trees, such as *Afrocarpus dawei* and *Podocarpus latifolius*. This may be the site of a minor forest refugium during the last ice age, a time when temperatures as well as rainfall were depressed. Possibly the forest was sustained by high levels of groundwater fed by a still active River Kagera.

More generally, forest composition varies everywhere according to position on slope, responding to catenary variations in soils and other environmental variables along gradients extending from hilltops to valley bottoms. Swampy ground has its particular trees. Both human activities and natural processes influence forest composition at the very local level. Forests are dynamic living systems, individual trees passing along pathways of establishment, growth, maturity and death. The falls of large trees create gaps in the forest canopy, triggering phases of new tree establishment and spurts of rapid growth on the part of trees already present. The dynamics of forest systems, such as this, have intimate influences on the exact positioning of individual trees on the ground.

Fig. 1.5. Making charcoal from indigenous forest trees in Mabira Central Forest Reserve. Photo: William Olupot (2018).

History of Human Influence on the Forests

Small-scale shifting agriculture within a forested environment started to have a significant influence on the local floristic composition of Ituri Forest (D.R. Congo) from the beginning of the first millennium CE (Hart *et al*. 1996) and the same is likely to have been the case in nearby Uganda. Shifting cultivation changes primary forest to secondary forest (Spracklen *et al*. 2018), which tends to be less diverse and structurally less complex. Probably all forests in Uganda have been influenced to at least some extent by the human hand, especially through previous clearance for agriculture (Hamilton *et al*. 2016). A widespread phase of forest reduction in Uganda at c. 1000 CE may have been associated with some major socio-economic developments, notably the establishment of more hierarchical societies (such as the

interlacustrine kingdoms), the onset of large-scale cattle-herding and the adoption of a perennially productive type of garden centred on the banana (known as *lusuku* in Luganda). Little is known about forest management practices before the first written records were made, which was during the second half of the 19th century.

Fig. 1.6. Illegal felling of *Funtumia* for drum-making, Mpanga Central Forest Reserve. Certain types of trees are favoured for this use. Photo: Alan Hamilton (2016).

The colonial era (1894-1962) saw the introduction of new concepts of land ownership and management. Many larger forests became Central Forest Reserves (CFRs) under the administration of a Forest Department (part of central government), while many smaller areas of indigenous forest, as well as the numerous small plantations of conifers and eucalyptus that became established, fell under the local governments as Local Forest Reserves (LFRs).

Forest (Tropical High Forest) covered about 4% of the land area of Uganda in the 1950s (Langdale-Brown *et al*. 1964), since when its extent has become seriously reduced. Details about how some of the individual forests have become lost or degraded are given in Hamilton *et al*. (2016) and, for the period up to 1982, in Hamilton (1984). The rate of deforestation during recent years (2.72% per annum) has become one of the highest in the world (FAO 2010a, 2010b). It has been concluded from a study of NFA records that the total forest area of Uganda ('forest' being taken to include other woody types of vegetation, not just 'forest' as understood in the present field guide) decreased from 4.9 million to less than 2.0 million ha between 1990 and 2015, a reduction of about 60% (IUCN 2018). Over the same period the cover of 'Natural Tropical High Forest' (equivalent to forest as used here) decreased from 850,693 to 567,168 ha, a reduction of about 33.3% (Ministry of Water and Environment 2016).

The key drivers of forest loss and degradation in Uganda are reported to be expansion of agriculture (subsistence and commercial), the unsustainable harvesting of tree products, mainly charcoal (Fig. 1.5), firewood and timber, expansion of human settlement (including to house a growing numbers of refugees), livestock grazing, wild fires and artisanal mining operations (Ministry of Water and Environment 2017). Various factors have been mentioned as underlying some of these immediate influences. The rate of growth of the population is one of the highest in the world (3.4% per annum between 1991 and 2002), there are inappropriate systems of land tenure, there is a high rate of economic dependency on subsistence agriculture (which covers a larger total area than commercial agriculture), there are weaknesses in governance (including in the implementation of forestry extension services) and climate change is having adverse effects (Banana *et al.* 2007; FAO 2017; Ministry of Water and Environment 2011, 2017).

The governance structure of forestry was changed in 2003, when the Forest Department was closed and replaced by a new National Forestry Authority (NFA), taking over responsibility for the CFRs. Six of the larger forests, Bwindi (Fig. 1.7), Elgon, Kibale, Mgahinga, Rwenzori and Semliki, were transferred from the Forest Department to Uganda National Parks (now Uganda Wildlife Authority) during the 1990s, resulting in an increased rigour in law enforcement according to anecdotal evidence.

Fig. 1.7. Sharp boundary between forest in Bwindi-Impenetrable National Park and surrounding farmland, south-west Uganda. Photo: James Kalema (2010).

Fig. 1.8. Pine seedlings being raised by the National Forestry Authority in their nursery at Banda. Photo: Alan Hamilton (2019).

A high priority in government forestry over recent decades has been the establishment of plantations of the exotic trees eucalyptus and pines, both of which can be fast-growing on suitable sites (Fig. 1.8) (Tumushabe and Mugyenyi 2017). The immediate aim has been to produce high volumes of general grade wood for use in construction or as wood fuel (firewood and charcoal) (Kaboggoza 2011). A subsidiary intention has been to reduce pressure on indigenous trees and natural forests by providing alternatives as sources of these products. In practice, this policy has led to relatively few resources being devoted to the management of natural forest and the planting of indigenous trees. Moreover, there are products, such as drums and medicines, that require the use of specific indigenous trees, so eucalyptus and pines cannot serve as alternative sources of supply in these cases (Fig. 1.6).

Carbon credit schemes, usually linked in Uganda to the planting of eucalyptus and pines (rather than indigenous species), have been introduced to incentivize tree planting to sequester carbon, hence contributing to combating global climate change. The theory is that planting trees in Africa will compensate for the use of fossil fuels in richer countries (especially European ones in Uganda's case) (Nabunya 2017; de Oliveira *et al*. 2018; Mujawamariya *et al*. 2018; Brack 2019; FAO 2018c; Lee *et al*. 2019; van Goor and Snoep 2019).

A change in government policy in 2001 emphasized a greater role for the private sector in forestry operations. NFA, which became responsible for CFRs in 2003 (when it took over this responsibility from the old Forest Department), started to issue permits to private operators for the development and utilization of particular forests (Tumushabe and Mugyenyi 2017). At the same time, the number of government forestry staff was reduced. The implementation of these new management arrangements has proved extremely poor, attributed to a combination of lack

of adequate capacity at NFA (including inadequate management systems), poor cross-sectoral coordination and weak forest laws (which, in practice, have been unevenly enforced) (Ministry of Water and Environment 2017).

There is general recognition globally that more attention should be devoted to the care and expansion of forests, as stated in Goal 1 of the UN's Strategic Plan for Forests 2017–2030 (Ellison 2018; Nakamura 2019): 'To reverse the loss of forest cover through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation and contribute to the global effort of addressing climate change'. If achieved, this will assist in meeting the Millennium Development Goals (Garrity 2004). Uganda itself declared a commitment to restore 2.5 million hectares of degraded forest by 2020 under the Bonn Challenge process (IUCN 2018). Inadequate funding of the forestry sector is a major issue (Tumushabe and Mugyenyi 2017). It has been recommended that a commitment to tree planting should be mainstreamed into development plans, including support for agroforestry through credit schemes and expansion of forestry extension services (NatureUganda 2011; Basamba *et al*. 2016; FAO 2017; Hillbrand *et al*. 2017; Kyarikunda *et al*. 2017; Nabunya 2017; de Oliveira *et al*. 2018). Tree planting at household level should be promoted (Kabiru *et al*. 2018). Traditional conservation practices should be encouraged (Fig. 1.9).

Fig. 1.9. Sacred forest near Mpigi, 40 km west of Kampala. The large tree is *Antiaris toxicaria*. This is an example of a traditional conservation practice.
Photo: Alan Hamilton (2019).

The Values of Indigenous Forest Trees and Natural Forests

The diverse forest tree flora of Uganda has many known uses (Egeru *et al*. 2015; Mulugo *et al*. 2019) and doubtless others await discovery. They yield many types of timber and other construction materials, cloth, fibres, latex, resins, fuels, fruits, edible greens, medicines and more (Akwatulira *et al.* 2011; Ojelel *et al.* 2019; Tugume *et al.* 2016). Forestry in Uganda currently places a strong emphasis on planting the exotic trees eucalyptus and pines (Kaboggoza 2011; Ministry of Water and Environment 2016), mainly with the aim of producing large quantities of a few types of product, notably medium-grade wood, poles and

wood fuel (FAO 2018b). It has been recommended that more emphasis be given to protection and restoration of natural forest across the landscape (Kazoora 2001; FAO 2017; Hillbrand *et al.* 2017; Lee *et al.* 2019; Schulte *et al.* 2019) and this has been accepted according to commitments made in the National Development Plan of Uganda and the National Forest Plan 2011/12 - 2021/22 (Ministry of Water and Environment 2013). If achieved, this will enable more people to enjoy local access to many types of forest produce. It will also better ensure future livelihood security (Egeru *et al*. 2015; HLPE 2017). Monocultures of plants, as increasingly represented by plantations of eucalyptus and pines, can be susceptible to attack by newly introduced or evolved pests and diseases (Nyeko and Nakabonge 2008; Liu *et al.* 2018).

To illustrate one of the diverse benefits that indigenous trees and associated knowledge can bring, there are many types of plants (some forest trees) that are used to this day in Uganda as anti-malarials (Adia *et al.* 2014; Anywar *et al.* 2016; Ssegawa and Kasenene 2007a, 2007b). The context is a high degree of reliance on local herbal medicine on the part of many people and the tendency of the available pharmaceutical drugs to lose effectiveness over time. Use of herbal medicine and indigenous knowledge in malaria treatment is not new. Many of the existing anti-malarial drugs owe their origin to research on ethnobotanical knowledge associated with the quinine tree (*Cinchona*) of South America and the Chinese annual mugwort (*Artemisia annua*). It is predictable that Uganda will benefit greatly if it manages to retain, in combination, its traditional healthcare knowledge and indigenous flora.

Additional to the particular benefits brought by each individual type of tree, natural forest collectively (as a form of vegetation) delivers a range of environmental services (Hillbrand *et al*. 2017), often with greater effectiveness than do plantations of eucalyptus and pines (Liu *et al.* 2018). Among them are:

- Carbon storage (Gallery 2014), thus contributing to reducing the amount of the greenhouse gas carbon dioxide in the atmosphere and so helping to combat global climate change (FAO 2017; Josephat 2018; Mujawamariya *et al.* 2018; Brack 2019; van Goor and Snoep 2019).
- Moderation of the local climate, making it more favourable for agriculture (Nabunya 2017; Spracklen *et al.* 2018; Brack 2019; Lee *et al.* 2019). This is related to the ways that natural forest influences the local environmental energy budget and how water circulates between air, soils and plants.
- Maintenance of perennial flows of water in streams and springs and into wells. The majority of households in Uganda, even those in Kampala, rely on natural sources of water, lacking the financial ability to pay for piped supplies.
- Reduction in soil erosion and risk of landslides. The dense canopy of natural forest reduces the erosive risk associated with the exposure of bare soil to heavy rain. The binding power of its tangle of roots resists loss of soil through surface wash and gully formation.
- Increasing the efficacy and maintenance of pollination systems that benefit agricultural crops (Nabunya 2017; van Goor and Snoep 2019). Forest plants provide additional sources of nectar and pollen that contribute to these systems. The forests provide places for the some of the pollinators to breed and to live during the earlier parts of their lives.
- Conservation of biodiversity. Trees and other forest plants capture solar radiation and make its energy available for the use of other organisms. The diverse forest flora supports a diverse forest fauna and the complex forest structure provides a wide range of physical habitats. Natural forest is the most biologically diverse type of ecosystem in Uganda.

The passing on to future generations of a world as diverse in natural wealth as the one that we ourselves have inherited will require widespread support across society. This responsibility is already recognized by many faiths, including the principal religions found in Uganda. Some political leaders in Uganda urge the planting of trees (we urge specific mention of indigenous species). However, there are others who continue to propose the replacement of substantial areas of indigenous forest with sugarcane, oil palm and other cash crops. Announcement of such schemes has sometimes resulted in public protest and expressions of concern by conservation groups (Birdlife International 2008; Nakkazi 2011; Tenywa 2005, 2013; van Schaik and Tickell 2015; Veit 2010).

Conservation Status of the Species

Three evaluations are available showing the conservation status of tree species indigenous to Uganda's forests. All refer to the same categories of threat (Table 4.2) and use the same criteria for assigning species to them (IUCN 2012, 2019). Two are for global conservation status (not necessarily the same as national conservation status for species that occur in other countries), one of them covering all 452 forest species known to occur in the forests at the time (Kalema and Beentje 2012) and the other, based on an on-going process, has so far covered 172 (IUCN 2019). The third evaluation referred to Uganda only, considered in geographical isolation (WCS 2016). WCS evaluated 42 species of forest trees, apparently pre-selected for consideration by an assembled group of experts. This evaluation made use of only three assessment categories (Vulnerable, Endangered, Critically Endangered), but helpfully provided the principal types of threat facing many of the species. The three sources are referred to below as TOU (Kalema and Beentje 2012), IUCN and WCS.

The total size of the indigenous forest tree flora of Uganda is 451 species by our own count. The slight difference with TOU is mainly due to a difference in assignment to life form of species close to the tree/shrub borderline. A total of 54 species of forest trees were identified as threatened taking all three evaluations together, but only three of these were common to all three lists, namely *Diospyros katendei*, *Encephalartos whitelockii* and *Uvariodendron magnificum*. The seven other species that were evaluated as globally threatened by TOU were *Cnestis mildbraedii*, *Desplatsia mildbraedii*, *Dicranolepis incisa*, *Ficus katendei*, *Idertia mildbraedii*, *Pandanus chiliocarpus* and *Vepris eggelingii*. All these are species with small total range or population sizes, and with their entire global distributions confined, or almost confined, to Uganda. Many of the species on the IUCN and WCS lists, but not on that of TOU, are species in high commercial demand for timber or harvested for medicinal properties (Galabuzi *et al.* 2015).

Regardless of what is happening globally, there is no doubt that many species of forest tree are in grave danger of extinction at Ugandan national level (Darbyshire *et al.* 2017; Deb *et al.* 2018; Kalema 2006; Kalema *et al.* 2010; Tumushabe and Mugyenyi 2017). TOU and WCS provide the following summary statements, clearly signalling great concern:

"... many species [of trees] are under threat in Uganda through habitat loss or habitat erosion, over-harvesting, and through other reasons." (TOU, page 4);

"Very few of the plant species considered could be given a near threatened or least concern status. Forest or woodland clearance, degradation and grazing combined with the rate of extraction for many of the plant species, particularly those harvested for timber, medicinal use, building or other materials and as a source for fuel, means that many of the species are under threat. With the longevity of tree species, this puts the rate of loss over 3 generations of almost all species at 30% which might otherwise be considered widespread." (WCS, page 62).