Chapter 8
Landscape Changes in Angola

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Abstract Landscape changes in Angola are dominated by woodland and forest losses due to clearing for crops, bush fires (which convert woodland into shrubland) and the harvesting of fuel (as wood and charcoal) and timber. Rates of clearing for small-scale dryland crops are high over much of Angola as a result of poor soil fertility. Erosion is also a severe problem, which has caused widespread losses of topsoil, soils nutrients and ground water. Rates of erosion are greatest in areas with steep slopes, sparse plant cover and high numbers of people, as well as around diamond mines in Lunda-Norte. Patterns of river flow and water quality have been changed, largely as a result of soil erosion and plant cover loss, as well as large irrigation schemes and dams. High rates of urban growth and the production of untreated urban waste have led to large concentrations of contamination around towns. Further research is needed, for example to assess the environmental impacts of the fishing and petroleum industries offshore, the effects of large volumes of urban waste being washed into and down major rivers to the sea, and landscape changes in an around areas of highland forests and grasslands that support populations of rare and endemic species.

Keywords Bushmeat · Charcoal · Deforestation · Fire · Land transformation · Mining impacts · River flows · Shifting cultivation · Soil erosion · Urbanisation

Introduction

Angola is a developing country, its development occurring in multiple ways in different areas of the country and affecting a variety of natural resources. Some changes and developments are likely to accelerate as the country seeks to diversify its economy and reduce dependence on revenues from oil and diamonds. It is also likely that the changes will contribute to such global trends as loss of biodiversity and land degradation.

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This brief review provides perspectives and information on changes to Angola's terrestrial landscapes, particularly in the southern half of the country. There are three sections to the chapter, the first of which describes the major kinds of landscape change. The second is an account of conditions that drive changes, both ultimately and proximately. Finally, areas most affected by major changes are identified in the third part of the paper.

Major Changes

Woodland and Forest Loss

Losses of woodland are by far the most obvious and conspicuous of changes in Angola. Much of this has been due to clearing for small-scale crop farming, particularly of dry-land crops, and large-scale commercial agriculture (including relatively small areas of exotic tree plantations). Other losses have come from the harvesting of charcoal, wood fuel, timber production (both for commercial and domestic uses), and runaway bush fires. On a smaller scale, swathes of riverine forest have been removed to give miners access to alluvial diamonds in rivers in Lunda-Norte.

As a result of all these losses, large areas of forest and savanna are now grasslands or shrublands. For example, the greater part of Huambo and Angola's central *planalto* was originally wooded, and 78.4% of the province of Huambo was covered in miombo woodland in 2002. In 13 years that figure had dropped in 2015 to 48.3%, amounting to the loss of some 1.265 million ha, 63.2% of which was converted from forest to crop land (Palacios et al. 2015). Similar losses in western Cuando Cubango, eastern Huíla and eastern Huambo have been documented by Schneibel et al. (2013), and elsewhere in Huíla and the Cuvelai drainage in Cunene (Mendelsohn and Mendelsohn 2018).

A countrywide perspective on the loss of forest or tree canopy cover is presented in Fig. 8.1. Several relevant features are visible in this image. First is the open, deforested expanse stretching southwest to northeast across western Huíla, southwestern Huambo and western Bié. Much of this area of highlands was cleared for crops between the 1950s and 1970s, although grasslands (*anharas do alto*) probably always dominated high altitude areas of the central *planalto* above about 1900 m above sea level. Substantial areas were cleared at the same time in parts of Cuanza-Norte, Cuanza-Sul and Malange, but their boundaries are not easily defined.

Second is the clearing of woodlands around urban areas. Many had already been cleared of tree cover by 2000, after which clearings expanded as trees were removed progressively further from the town centres, a trend illustrated by Schneibel et al. (2018). Examples of recent clearings between 2000 and 2015 are conspicuous as 'red bands' around Dundo, Menongue, Luena, Malange, Cafunfo, Cubal and Caimbambo in Fig. 8.1. Much of the deforestation is clear-felling for dryland fields by residents, while other trees are removed for charcoal production, wood fuel and timber.

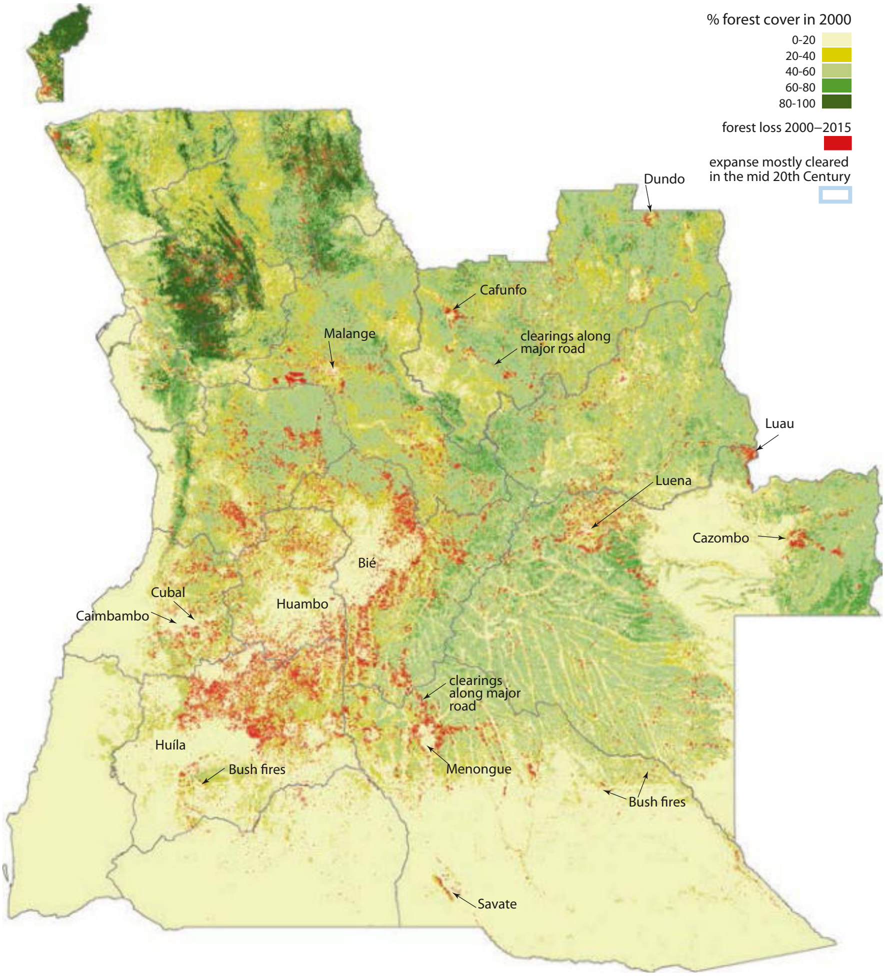

Fig. 8.1 Forest or tree canopy loss between 2000 and 2015 derived from data described by Hansen et al. (2013), updated and available from http://earthenginepartners.appspot.com/science-2013-global-forest. Percentage forest cover in the year 2000 is shown in shades of green. Red areas are those which, by 2015, had lost all the forest or canopy cover that still remained in 2000. (Source: Hansen/UMD/Google/NASA)

Third, the concentration of clearings along major roads where many rural families choose to settle is visible, but requires closer inspection of Fig. 8.1. Most losses of tree cover here are also due to clear-felling for dryland crops. Local residents also produce charcoal on a large scale, particularly along roads frequently travelled by trucks that can transport large volumes of charcoal to urban markets. However, the effects of charcoal – and timber – harvesting are seldom visible in satellite images of tree or canopy cover because harvesters typically remove only larger, taller trees, leaving smaller trees and shrubs which present a seemingly intact canopy of woodland when viewed from high above. After some years of regrowth, harvesters return to fell those bigger individual trees that produce good charcoal.

Timber has been harvested on a substantial scale for many years. Most of it has been used for the construction of domestic homes, palisades and fences, or sold as exported hardwood. The harvesting of selected species and large individual trees has evidently increased substantially in recent years, and further increases are to be expected (ANGOP 2017). Conversely, the use of poles for houses, palisades and fences may be declining, at least in certain areas where people increasingly build with home-made or bought bricks, and fence with wire (Calunga et al. 2015).

Trees were evidently harvested in large numbers to fuel railway engines running between Benguela and Huambo, and perhaps elsewhere, in the early twentieth century (Silva 2008). There are also reports of Zambezi teak *Baikiaea plurijuga* and *Marquesia macroura* timber being used for sleepers on the *Caminho do Ferro Moçâmedes* (CFM) and *Caminho de Ferro Benguela* (CFB) lines, respectively, while indigenous woodlands were cleared to make way for the many eucalyptus plantations established along the CFB line.

Bush fires have major effects on woodlands, particularly in limiting the growth of trees and shrubs in savannas. Indeed, fires maintain the 'balance' between grass and trees that characterise savannas. However, hot, intense runaway fires set by people are seemingly more frequent than before. The fiercest of fires kill all plants, old sizeable trees being burnt and scarred year after year until they eventually die. Large areas have thus been converted from woodland and forest into shrubland, particularly in southern Angola (Fig. 8.2). Much of Cuando Cubango and parts of Moxico are mosaics of open woodland separated along sharp margins from dense woodland and forest. As a probable result of fire, the edges of the dense cover are smoothed and often rounded, in some cases creating circular patches of forest (Fig. 8.3).

Soil Loss (Bulk and Nutrients)

At least three areas appear to have lost large volumes of soil and soil nutrients. The first is the central *planalto* and surrounding higher areas of ferralsol soils. In the catchment of the Cunene River, erosion has been greatest in areas that are densely populated, extensively cultivated with dryland crops, largely cleared of plant cover and that have at least moderate slopes (Fig. 8.4). The catchments of other major rivers (Cuando, Queve, Quicombo, Catumbela, Guvrire and Coporolo, for example) that drain the central catchment are likewise eroded, particularly where slopes are steep and plant cover is sparse. Similar, more concentrated effects are seen in cities where inadequate management of storm water has led to the formation of erosion gullies, many of them damaging urban roads, houses and other infrastructure.

Second is in Lunda-Norte where open-cast mining leads to considerable volumes of soil (probably also ferralsols) being washed into rivers that flow north into the Congo Basin (Fig. 8.5; see Ferreira-Baptista et al. 2018).

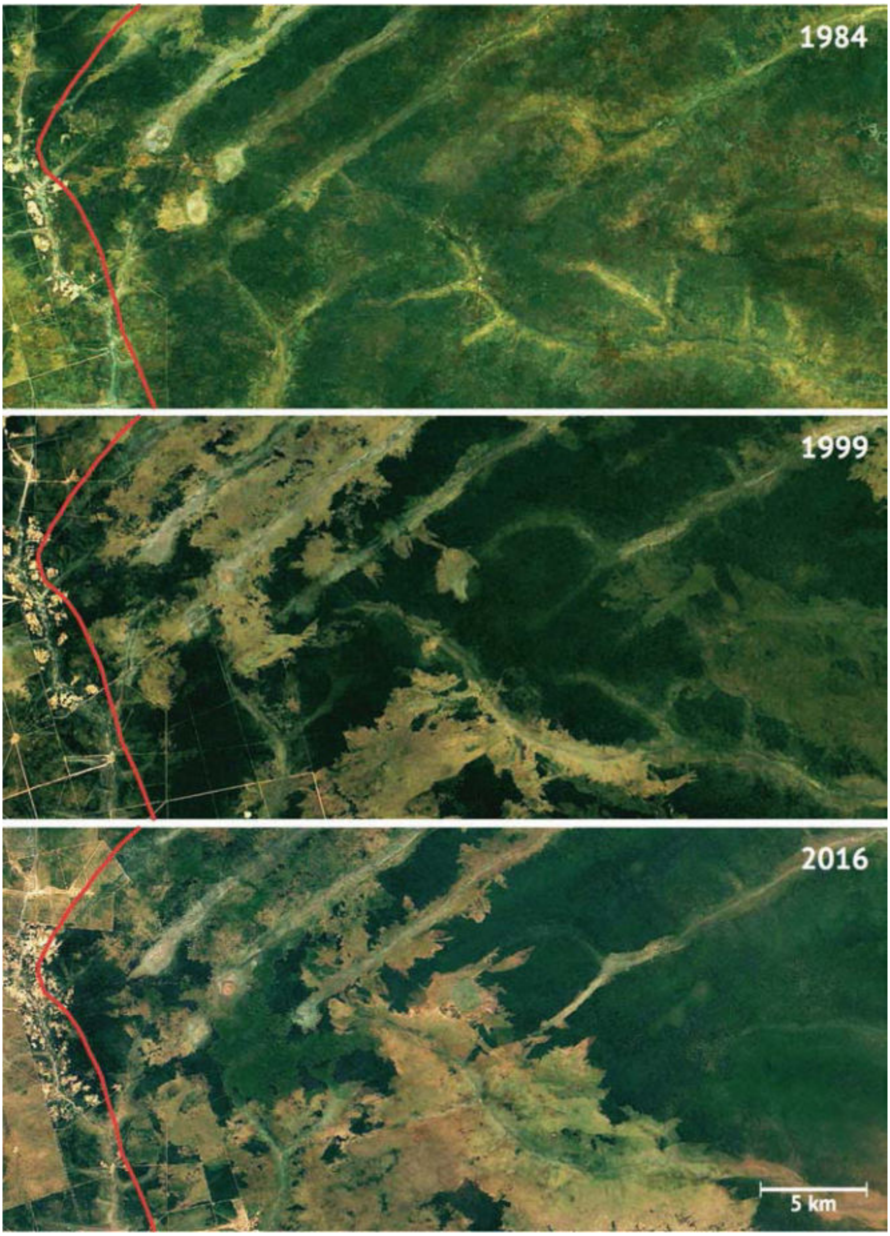

Fig. 8.2 An example of woodlands converted by repeated hot fires into shrublands in Bicuar National Park. The fires normally start in the grassy drainage lines (*mulolas*) from where they spread into the surrounding woodlands. With the same areas being burnt by fierce fires every few years, large areas of woodland (dark greenish zones) have progressively been turned into shrublands (pale areas). These satellite images from Google Earth (LandSat/Copernicus) were taken between 1984 and 2016, and viewed from about 15.3 South, 14.4 East. The red line marks the western border of Bicuar National Park. (From Mendelsohn and Mendelsohn 2018)

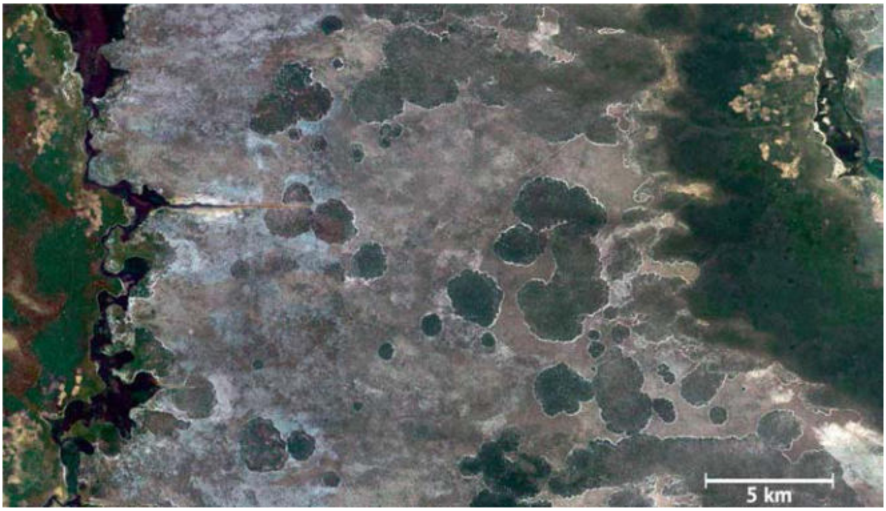

Fig. 8.3 Patches of open woodland (pale grey areas) and dense miombo forest (dark green) between the Longa and Sovi rivers in Cuando Cubango. The forest margins have probably been sharpened and smoothed by bush fires. Isolated blocks are so rounded and reminiscent of the Namib Desert's fairy circles that they may be called 'fairy forests'. (The image was taken from Google Earth (LandSat/Copernicus) as viewed from about 15.4 South, 18.9 East)

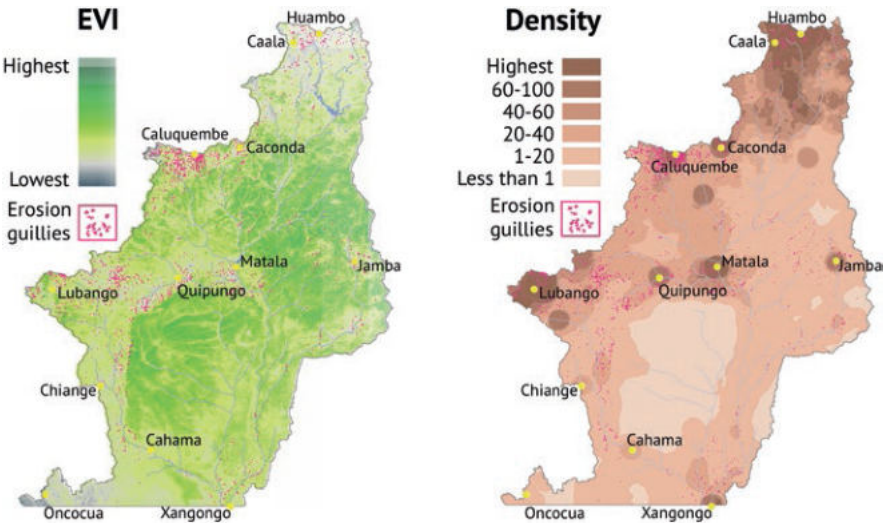

Fig. 8.4 The distribution of erosion gullies in relation to vegetation cover (Enhanced Vegetation Index – EVI) and population density in the catchment of the Cunene River between Huambo in the north and Xangongo in the south. (Adapted from Mendelsohn and Mendelsohn 2018)

Fig. 8.5 Mining impacts on Angolan rivers. Top left and right: The confluence of the clear Cassai River and the turbid Lubembe River carrying suspended sediments from open-cast diamond mining in Lunda-Norte. The confluence is in the DRC about 80 km north of Angola's border. The left photograph was taken on 30 May 2007, while the right image from Google Earth was taken 10 years later on 21 May 2017, viewed from 6.62 South, 21.07 East. Bottom left: The confluence of the Calonga and Cunene rivers at Quiteve (16.02 South, 15.20 East), showing the volumes of eroded sediments from upstream in the Cunene catchment. By contrast, the clear waters of the Calonga mainly come from areas where arenosols predominate, where few people live and where large areas of woodland have not been cleared for dryland agriculture. Bottom right: Erosion from open-cast mining along the Luachimo River 22 km north of Lucapa. (The image from Google Earth was taken in May 2017 as viewed from 8.23 South, 20.77 East)

There is a likely net loss of certain soil nutrients in the third area, which is where bush fires are frequent and/or intense, predominantly so in Cuando Cubango, Moxico and the Lunda provinces (Figs. 8.6 and 8.7). Fires often result in the loss of nitrogen, phosphorus and organic carbon, although cooler fires also facilitate the release of nutrients from plant matter into the soil (Jain et al. 2008). A study comparing open and dense woodland near Savate (see Fig. 8.1), found much lower nutrient levels in open than dense woodland soils (Wallenfang et al. 2015). This stark difference was probably a consequence of the open areas being burnt often and intensely, while the dense woodlands were seldom burnt (Stellmes et al. 2013).

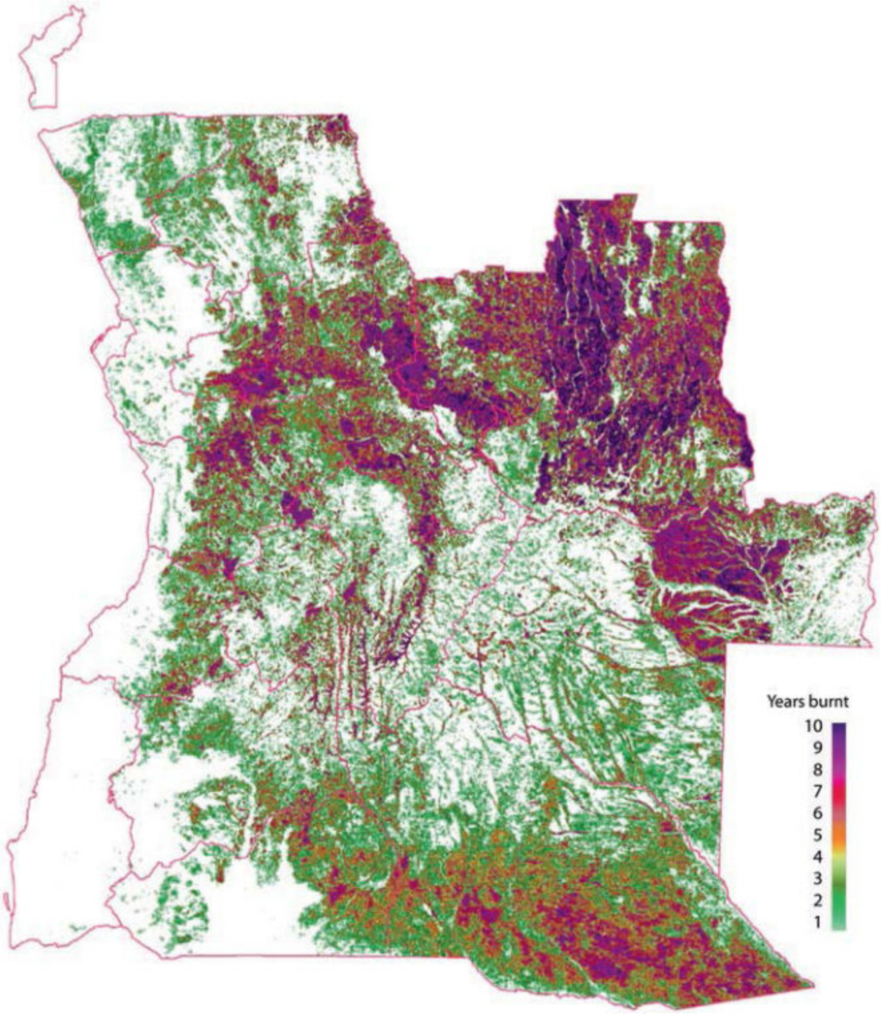

Fig. 8.6 The frequency of fires expressed as the number of years each area of 500 by 500 m burnt between 2000 and 2010. (From Archibald et al. (2010) and data available at http://wamis.meraka.org.za/products/firefrequency-map)

Water Flows and Quality

Discharges and the quality of water have changed significantly in certain rivers, and in a number of ways. The most obvious changes are in the heavy sediment loads which impair the functioning of aquatic animals and plants that require well-lit waters, and reduce the capacity of dams. For example, eroded sediments washed down the Cunene River have evidently accumulated in Gove and Matala dams to such an extent that their production of hydro-electricity has declined (António 2017).

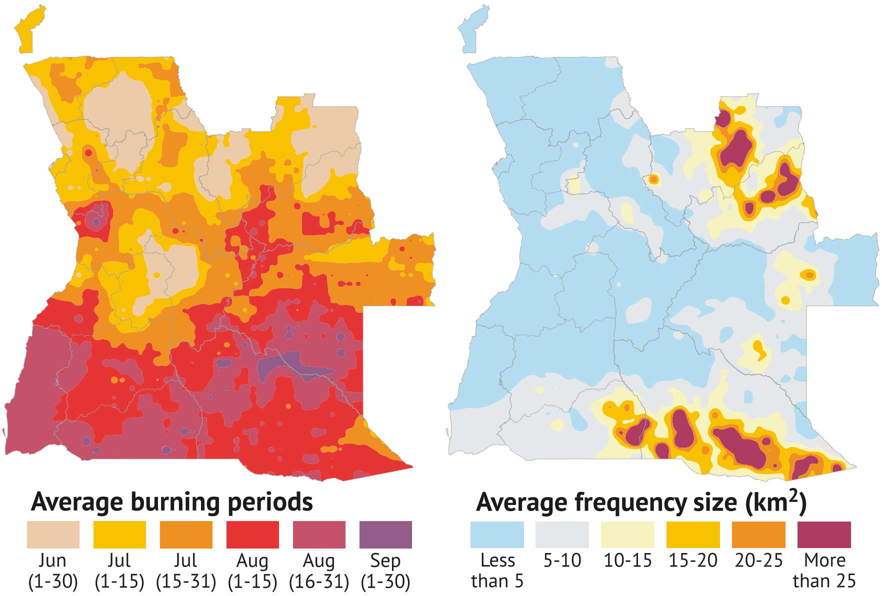

Fig. 8.7 Left: the seasonality of fires, reflected by the average period of the year when fires were recorded. Right: the average size of fires. (From Archibald et al. (2010) and data available at http://wamis.meraka.org.za/products/firefrequency-map)

River flows, soil moisture levels and groundwater recharge have been affected by losses of plant cover. Sheets of surface flows after heavy rain have increased in bare areas, causing higher river flows and probabilities of flooding, especially in seasons with above average rainfall. For example, the clearing of plant cover in the catchment of the Guvrire River around Caimbambo and Cubal (Fig. 8.1) is considered to have increased the risk and frequency of flooding at the river mouth in the city of Benguela (Development Workshop 2016).

A different impact of plant cover loss and erosion may affect the Cuvelai. Many residents there believe that surface flows down the floodplains (*chanas*) are now slower and wider than before because eroded sediments deposited in the shallow channels have further reduced their depths and slopes (Calunga et al. 2015).

Reductions in plant cover result in lower volumes of rain water being trapped or impeded, thus reducing seepage into the top soil to replenish soil moisture and recharge local aquifers. With lower soil moisture, seepage to sustain river flows during the dry season also declines. This is a likely – and at least partial – explanation for flows of the Cunene River at Ruacana dropping to less than 10 cubic metres/second in September 2017. Such low levels were only recorded previously during extreme drought years in 1993–1994 and 1994–1995 (Mendelsohn and Mendelsohn 2018).

Contamination

Quantitative assessments of the magnitude of environmental contamination from urban waste are apparently not available for Angola. However, substantial volumes of waste are generated, particularly in Luanda (now with more than seven million residents) and other major cities with populations approaching a million or more people, such as Cabinda, Lubango, Lobito, Huambo and Benguela. Solid waste is not collected in many middle to low-income *bairros*, which also lack sewage systems. The resulting volumes and concentrations of untreated waste from these large cities have significant impacts on human and environmental health (Development Workshop 2016).

Drivers of Landscape Change

Population Growth and Natural Resource Exploitation

As elsewhere in the world, but particularly in developing countries, most changes have been driven by rising demands for natural resources to meet the needs of Angola's growing population and increasing consumption per capita. The country's population rose from about 6 million people in 1970 to almost 26 million in 2014, which amounts to an annual growth rate of 3.4%. Over the same period a high proportion of the population shifted from rural to urban areas and their accompanying economies. Most urban residents live in low income areas where they generally lack piped water supplies, electricity, secure tenure, sewage systems and solid waste collection services. For example, 85% of Luanda residents live in such areas, with similar percentages in Lobito (90%), Cabinda (86%) and Benguela (92%) (Development Workshop 2016). Similar conditions and proportions hold in Huambo, Malange, Cuito and Ndalatando.

Urban consumption patterns differ from those in rural areas, but one difference of particular interest concerns the use of fuels for cooking. Rural homes generally use wood collected from around their homes, whereas the majority of urban people use purchased charcoal because alternative fuels are more expensive or not available in towns. Their supplies of charcoal all come from rural areas, in particular from poor families that harvest and then sell bags of charcoal along roads leading to major urban areas. The supply of charcoal is therefore an informal one that generates incomes for many rural homes. For both consumers and suppliers this seems to be an ideal market, providing affordable fuel for urban consumers and incomes for rural families, that often being their only monetary income. Similar market arrangements hold for supplies of bush meat from rural suppliers to urban consumers.

Another new, sometimes surprising economic link between urban and rural areas involves investments in cattle by wealthier town folk. Their cattle (and sometimes goats and sheep) are placed in rural areas where they are normally tended by relatives and held as savings or capital, with the best returns coming from large stock numbers (Gomes 2012). Owners are thus encouraged to have as many animals as possible, which places added pressures on forage, water and the limited resources available to poor rural residents (who seldom have other incomes).

Food Production

An abundance of wealth, much of it derived from the boom in oil revenues, has provided resources to develop large-scale agricultural projects, often with limited or no environmental impact assessments. For example, several new irrigation schemes have been developed along the Cunene River. If and when the farms are fully developed, downstream stretches of the Cunene could be dry for much of the year. Elsewhere, tens of thousands of hectares of woodland and forest have been cleared in recent years, one example being the Angola Biocom project which has 70,106 ha allocated to produce sugar, ethanol fuel and electricity south of Malange (Angola Biocom 2017).

Clearing for small-scale dryland crop production has caused much of the loss of woodland and forest in Angola. The *rate* at which trees are cleared is however driven by four related, but arguably separate factors. First is the need to feed a growing number of rural residents. Second is the need for farmers to abandon their fields after several years of use and to clear new fields (which will produce better yields than those that have had their supplies of nutrients exhausted). Third is the general low-input/low-output crop production strategy adopted and adapted for dryland agriculture, which means that fertilisers are seldom used to replenish soil nutrients. Fourth is the poor quality of soils available for dryland farming (Ucuassapi and Dias 2006; Asanzi et al. 2006; Wallenfang et al. 2015). Indeed, the relative lack of nutrients and moisture in soils is arguably the most important factor driving the rapid rate at which Angolan woodlands and forests are cleared, as well as the very slow rate of recovery.

Grassland and Woodland Fires

Much of Angola's vegetation has been moulded by frequent fire. This is particularly true for savanna woodlands, the grasslands of the *anharas de ongote* in the central highlands and grassy *chanas da borrachas* in the Lunda provinces. Most woody plants in the latter habitats and many in open woodlands are geoxylic suffrutices, their growth forms adapted to survive frequent hot fires (see Zigelski et al. 2019).

Fire therefore has major impacts on Angola's vegetation, and any changes in fire regimes are likely to result in landscape changes. Against that background, and the widely held assumption that burning has increased in frequency, the following information is provided on fires in Angola.

Fires are recorded most frequently in grasslands of the Lunda provinces, Malange, and the Bulozi Floodplains in Moxico, and in open, savanna woodlands in Cuando Cubango (Fig. 8.6). Additionally, fires are frequent in highland grasslands (*anharas do alto*) distributed between Serra da Chela (near Lubango) in the south, the Benguela, Huambo and Huíla highlands and higher elevations in northern Cuanza-Sul and southwestern Malange.

Almost all fires are in the dry season between late April and early November. However, those in northern Angola and the central highlands burn considerably earlier than in the south (Fig. 8.7). Grass fuel is likely to contain more moisture in June than later in August, with the likely result that the earlier fires are cooler, less intense and probably less damaging to vegetation than later, hotter burns in southern Angola. That seems true for the large fires in the tall grasses that comprise the widespread *chanas da borrachas* in the Lunda provinces (Huntley 2017). Similar trends were found by Stellmes et al. (2013) within the river basins of the Cubango and Cuito Rivers where fires in the northern catchment areas were both earlier and less intense than those in the south. That trend also roughly corresponded to land cover, with dense miombo woodland in the northern areas and open savanna woodland, often called *Baikiaea-Burkea* woodland in the southern zones.

Areas of Major and Widespread Landscape Change

Figure 8.8 provides perspectives on the distribution of the major landscape changes described in this chapter. The majority of changes are in and around the central plateau (*planalto*) and to the north in parts of Cuanza-Norte, Bengo and Uíge. The effects of fire are probably most severe in Cuando Cubango, although the large (but probably cooler) fires that are so frequent in Lunda provinces may too have major effects on those extensive grasslands.

The landscape changes around towns are limited to the 18 provincial capitals shown as dark red circles in Fig. 8.8. But landscape changes around many other large towns need to be recorded.

Future Needs for Research and Documentation

Large volumes of waste are washed into the Atlantic, both close to major coastal cities – such as Luanda, Benguela and Cabinda – and down large rivers that drain large areas of the country, such as the Cunene, Cuanza and Queve Rivers. As far as is known, the volumes, nature and impacts of the waste have not been assessed. The same is true for impacts on populations of fish and other marine animals which are harvested from Angolan and foreign vessels that operate offshore, where their activities and impacts are not monitored.

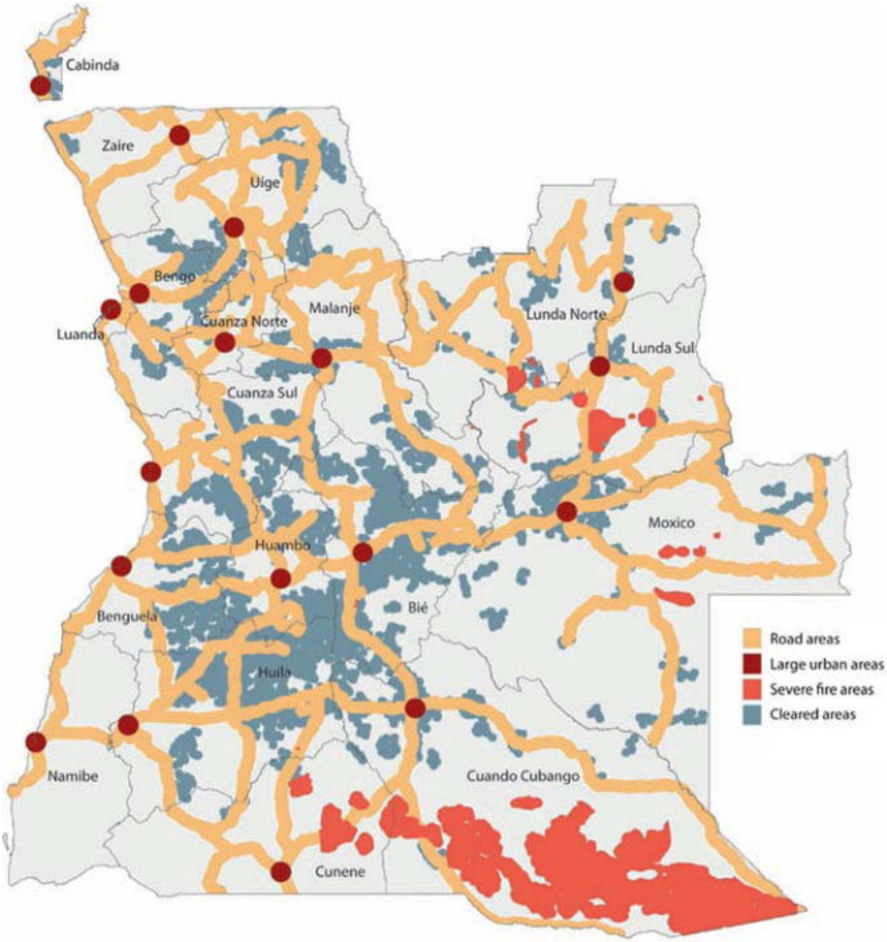

Fig. 8.8 Areas in Angola where substantial landscape changes have occurred in recent years as a result of woodland and forest clearing, and of bush fires, and in areas around main roads and towns where major changes have occurred, or are likely to occur. Woodland and forest clearings are large contiguous areas shown in Fig. 8.1. Severe fire areas are those where fires burnt in five or more years between 2000 and 2010, where fires normally burn in August and September when grass is driest and where fires are normally large (> 20 km^2), as derived from data shown in Figs. 8.6 and 8.7. Zones where people settle, farm and harvest wood are usually within 10 km either side of roads or within 15 km of major towns

The construction of very large dams on the Cuanza River is likely to have affected the functioning of that river. However, I am not aware of assessments of those effects, either by individual dams or the cumulative impounding of large volumes of water.

There are other activities and areas of concern, for example the offshore impacts of exploration and exploitation by the petroleum industry; large-scale logging in Cabinda and more recently Moxico and Cuando Cubango; pollution of river water used for washing and other domestic uses, especially where rivers flow through large towns; and pesticide contamination from crop farming, particularly from big commercial farms where large volumes of agricultural poisons are applied.

Finally, the fragmentary patchwork of mini-landscapes that support many species and which deserve special conservation measures, requires more study and documentation. These include the forests of the Escarpment Zone *(Faixa subplanaltica)* and Marginal Mountain Chain (*Cadeia Marginal de Montanhas*). Considerable numbers of rare and endemic plants and animal species are concentrated in these highland forests, many of which are small, covering no more than a few hundred hectares (Huntley and Matos 1994; Cáceres et al. 2014). The forests have shrunk, and continue to do so as a result of clearing for crops, harvesting of timber and charcoal, and grassland fires that kill trees on the forest edges. None of the forests are legally protected, and all are surrounded by substantial numbers of rural residents. Some forests are privately owned and their owners should be encouraged to manage them for conservation. Likewise, private ownership and management could be encouraged for the protection of other forests and areas of special value.

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