Food and Agriculture Organization of the United Nations

Trees, forests and land use in drylands: the first global assessment

Full report

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Cover photo: *Boswellia elongata*, Socotra Island, Yemen

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Foreword

Covering about 41 percent of the Earth's land surface – more than 6 billion hectares, distributed among all continents – drylands are home to an estimated 2 billion people, about 90 percent of them in developing countries. These ecosystems are vulnerable to water shortage, drought, desertification, land-use change and degradation and climate change impacts, with dangerous ramifications for the food security, livelihood and well-being of their populations. Trees and forests in these lands help mitigate the challenges through provision of economic products and vital environmental services such as habitat for biodiversity, prevention of erosion and desertification, and regulation of water, microclimate and soil fertility.

Urgent action is needed to improve the management and restoration of drylands. To this end, a comprehensive understanding of the global and regional threats to drylands and their populations is required, to pinpoint what interventions are needed and where. Unfortunately, however, the monitoring of dryland ecosystems has not attracted as much attention as that of other ecosystems such as humid tropical forests.

Seeking to catalyse a focus on drylands, the FAO Committee on Forestry (COFO), at its twenty-second session in 2014, called for action and investment in dryland assessment, monitoring, sustainable management and restoration. It requested that FAO undertake a global assessment of the extent and status of dryland forests, rangelands and agrosilvopastoral systems, with a view to better prioritizing and targeting the investments needed for dryland restoration and management. This report – the first global assessment of trees, forests and land use in drylands – has been produced in response to that request.

The assessment breaks new methodological ground. It was carried out through visual interpretation of freely available satellite images by more than 200 experts with knowledge of the land and land uses in their dryland regions. The analysis was conducted in a series of regional workshops organized in collaboration with partner universities, research institutes, governments and non-governmental organizations worldwide. The data were analysed using Collect Earth, a tool in the Open Foris suite of free, open-source software tools developed by FAO, in collaboration with Google, to facilitate flexible and efficient data collection, analysis and reporting.

Regular monitoring of changes in dryland forests, tree cover and land use is vital to evaluate the impact of climate change and human activities, the results of adaptation and mitigation measures and progress towards meeting regional targets for land degradation neutrality. This assessment provides the baseline for future monitoring, and will support countries in their efforts to develop strategies and identify appropriate investments for the sustainable management of drylands.

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FAO Forestry Department

Acronyms

AI	aridity index
COFO	FAO Committee on Forestry
FRA	Global Forest Resources Assessment
GDP	gross domestic product
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
MA	Millennium Ecosystem Assessment
MODIS	Moderate Resolution Imaging Spectroradiometer
NGO	non-governmental organization
NWFP	non-wood forest product
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
WRI	World Resources Institute

Acknowledgements

The first Global Drylands Assessment has been possible thanks to the contributions of many experts on drylands, assessment and monitoring. Special thanks for the financial support provided by the European Union in the framework of Action Against Desertification, and by Germany's Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety in the framework of the Global Forest Survey project implemented by FAO in collaboration with Google. Many thanks are given to the partner organizations that participated directly in the assessment and analysis, listed in Annex 2. Special thanks are due to Nora Berrahmouni, who supervised the design of the assessment. A special thanks also to the 2019 COFO Working Group on Drylands, which endorsed the results.

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Nora Berrahmouni and Danilo Mollicone coordinated the data collection. Jean-Francois Bastin, Adia Bey, Monica Garzuglia, Danae Maniatis, Giulio Marchi, Chiara Patriarca, Marcelo Rezende, Stefano Ricci and Alfonso Sanchez-Paus Diaz provided training on the use of Open Foris Collect Earth for participants involved in data analysis. Antonio Martucci developed the maps.

Internal reviewers of the report include Anssi Pekkarinen, Moctar Sacande, Tiina Vahanen, Mette Wilkie and Daowei Zhang.

Andrea Perlis edited the report and Kate Ferrucci designed the layout.

Executive summary

The first Global Drylands Assessment is a thematic study complementing FAO's Global Forest Resources Assessment (FRA) but differing from it in method and scope. Unlike FRA, which relies on official national statistics, the Global Drylands Assessment was prepared by a consortium of partner institutions and was carried out through visual interpretation of satellite images. The results are reported at the global and regional levels, not the country level.

The geographic scope of the assessment is based on the dryland definition and map of global drylands produced by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC). Drylands are defined as lands where the ratio of annual precipitation and mean annual potential evapotranspiration, also known as the aridity index (AI), is no more than 0.65. The UNEP-WCMC map divides these lands into four aridity zones:

- hyperarid: AI less than 0.05;
- arid: AI greater than 0.05 but less than 0.2;
- semi-arid: AI greater than 0.2 but less than 0.5;
- dry subhumid: AI greater than 0.5 but less than 0.65.

As defined by UNEP-WCMC, drylands cover 41 percent of the Earth's land surface, or about 6.1 billion hectares.

The assessment used publicly available satellite images from digital repositories (including but not limited to Google Maps and Bing Maps). More than 200 experts with knowledge of the land and land uses in specific dryland regions participated in the interpretation of the images using a software tool called Collect Earth, which is part of the Open Foris tool set developed by FAO and partners. The interpretation was carried out in the second half of 2015 in a series of regional workshops.

The assessment draws on information from 213 782 sample plots located across the world's drylands. Each plot measured 70 × 70 m (approximately 0.5 hectares), a size corresponding to the smallest patch that qualifies as forest according to the definition used in the assessment, which was that of FRA 2015: "Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*" (not including predominantly agricultural or urban land).

For each sample plot, data on 77 variables describing the sample site were collected through the visual interpretation of available satellite images. The characteristics were selected to describe land cover, land use, land-use change and other significant land dynamics (such as desertification and greening) over the reference period 2000–2015. The starting year, 2000, was selected because it is the first year for which consistent global coverage of satellite data is available.

For each region, the report provides background information on the climate, importance of forest and trees for biodiversity and livelihood, and trends and challenges in the drylands. It then provides the results of the data analysis, reporting on the distribution of forests, other wooded land and other land uses (such as grasslands, croplands, marshlands and wetlands, barren land, settlements and built-up areas), overall and by aridity zone.

MAIN FINDINGS

The results indicate that the world's drylands contain 1.1 billion hectares of forest, corresponding to 27 percent of the world's forest area.

Forest accounts for 18 percent of the dryland and other wooded land 10 percent, while barren land accounts for 28 percent, grassland 25 percent and cropland 14 percent. The

remaining 5 percent comprises water bodies, built-up areas and other unidentified land. Almost 99 percent of the hyperarid zone is classified as other land, because most of it is desert, characterized by sandy and rocky landscapes. In general, the proportion of other land decreases with decreasing aridity.

The least arid areas have the most forest. Forests account for 43 percent of land in the dry subhumid zone and 20 percent in the semi-arid zone, but occur rarely in the arid and hyperarid zones. More than half of the world's dryland forest (52 percent) is in the dry subhumid zone, mostly in the northeast of Southern Africa and western (pre-Andean) inland South America; 41 percent is in the semi-arid zone, compared with only 7 percent in the arid zone and less than 1 percent in the hyperarid zone.

The assessment shows that 51 percent of dryland forest has a dense canopy cover of 70 to 100 percent, while two-thirds has a closed tree canopy, with cover of more than 40 percent. The average tree canopy cover in the dry subhumid zone is ten times greater than that in the hyperarid zone. Of all the regions, average canopy cover is highest in South America.

Dryland forests are predominantly (about 66 percent) natural broadleaved forest, while about 15 and 10 percent are natural coniferous and mixed broadleaved and coniferous, respectively. Broadleaved forests are most dominant in South America (95 percent), Oceania (89 percent) and Eastern Africa (82 percent). At the global level, only about 2 percent of dryland forest was identified as planted forest. The assessment did not identify the vegetation cover for 7 percent of total forest.

Other wooded land covers less area than forest, 583 million hectares. More than half of it (55 percent, 317 million hectares) is in the semi-arid zone, mostly in Oceania, North and Central America and the Caribbean, the southwest of South America and Southern Africa.

The vegetation cover in other wooded land is mainly dominated by grassland with shrubs (54 percent of the total), with little variation among aridity zones. The percentage of grassland with shrubs is highest in South America (77 percent) and North and Central America and the Caribbean (71 percent), but less than 40 percent in Western and Central Africa and Northern Africa. More than half of other wooded land (56 percent, 328 million hectares) has no tree cover, thus consisting solely of bushes and shrubs, while 35 percent of other wooded land has a tree canopy cover of 1 to 9 percent.

Globally, the average shrub cover in other wooded land is 37 percent. Shrub cover in forest was estimated to be 9 percent. However, shrubs in forest are not always easy to detect, particularly where the canopy is dense.

Many trees in the drylands grow outside the forest. Almost 30 percent of cropland and 60 percent of built-up land have at least some tree cover. Asia and Europe have a much greater proportion of their trees outside forest (defined as the tree cover on other land) in cropland than other regions. Grassland has the greatest presence of trees outside forest in all aridity zones, but particularly in the arid and semi-arid zones. The vast majority of other land with trees – 95 percent – has tree canopy cover of less than 10 percent.

When forest, other wooded land and trees outside forest are all taken into account, trees are present on 2 billion hectares of drylands (32 percent of the total dryland area).

IMPORTANCE OF THE ASSESSMENT

The assessment results demonstrate that drylands are not wastelands, but productive landscapes with considerable economic potential and environmental value. They highlight the importance of investing in forest and woodland resources in drylands, including trees outside forest. The findings can be used as a baseline to highlight key emerging threats to drylands and their populations at the global and regional levels, including climate change, biodiversity and food security challenges. They can thus assist in prioritizing and targeting the investments needed for dryland restoration.

The assessment should be a step towards regular monitoring of changes in dry landscapes, which is vital to evaluate the impact of climate change and human activities, the results of adaptation and mitigation measures and progress towards meeting regional targets for land degradation neutrality. Regular monitoring can further support assessment of the impact of different governance frameworks, policies and legislation related to land use, for more effective improvement of the livelihoods and climate change resilience of dryland populations.

Extraction of valuable gum arabic from acacia, Senegal

1. Introduction

WHY ASSESS TREES, FORESTS AND LAND USE IN DRYLANDS?

Drylands, as defined in Box 1, cover about 41 percent of the Earth's land surface, or about 6.1 billion hectares – an area nearly four times the size of the Russian Federation. They are distributed among all continents at tropical and temperate latitudes. Africa has the largest area of drylands (with 32 percent of the world's total), followed by Asia, North America, Oceania, South America and Europe (Figure 1, Table 1).

An estimated 2 billion people live in drylands, about 90 percent of them in developing countries (Safriel *et al*., 2005). The majority of these people depend on forests and other wooded lands, grasslands and trees on farms for their livelihoods and to meet basic needs for food, medicines, wood energy and non-wood forest products (NWFPs) such as gums and resins and fodder for livestock. Trees tend to be integral parts of traditional food systems in drylands, because crops and livestock thrive in their presence. Their leaves and fruits are sources of food for people and fodder for animals.

BOX 1

What are drylands?

The United Nations (UNEP, 1992; EMG, 2011) defines drylands as lands where the ratio of annual precipitation and mean annual potential evapotranspiration, also known as the aridity index (AI), is no more than 0.65.

Based on this definition, the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC, 2007) has mapped the world's drylands, dividing them into four zones (Figure 1) based on their AI:

- hyperarid: AI less than 0.05;
- arid: AI greater than 0.05 but less than 0.2;
- semi-arid: AI greater than 0.2 but less than 0.5;
- dry subhumid: AI greater than 0.5 but less than 0.65.

The dry subhumid zone – the least dry of the four zones – accounts for 22 percent of the total dryland area. Major components of this zone are the Sudanian savannah, forests and grasslands in South America, the tree steppes of eastern Europe and southern Siberia, and the Canadian prairie. Most dryland forests occur in this zone, as do some large, irrigated, intensively farmed areas along perennial rivers.

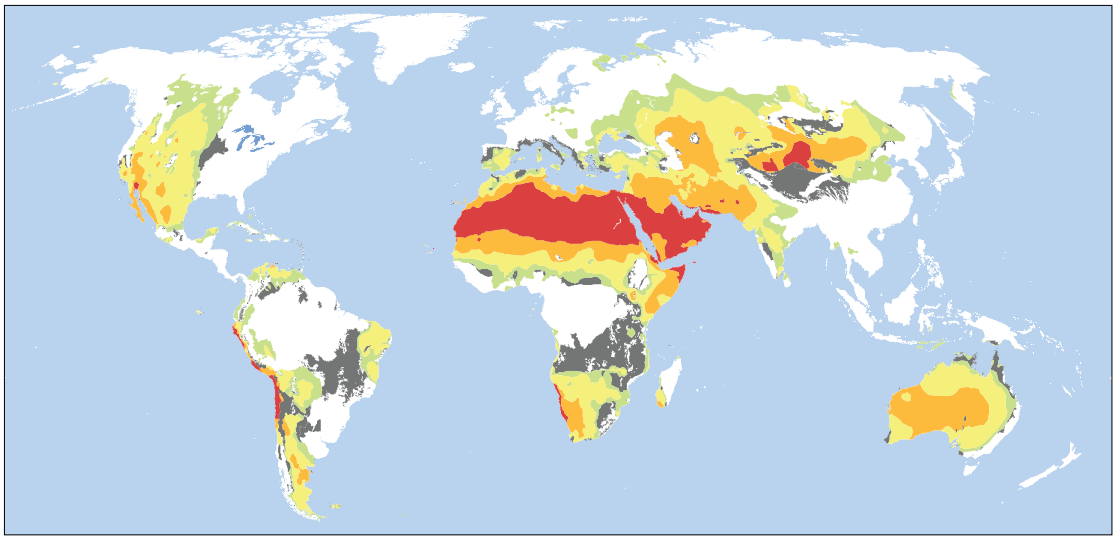
At the other extreme, the hyperarid zone is the driest zone; it constitutes 16 percent of the total dryland area. This zone is dominated by deserts; the Sahara alone accounts for 45 percent of the hyperarid zone, and the Arabian Desert constitutes another large component.

The semi-arid and arid zones comprise 37 and 25 percent, respectively, of the total dryland area.

Areas identified as "presumed drylands", having dryland features but an aridity index greater than or equal to 0.65 (UNEP-WCMC, 2007), are also presented in Figure 1 but were not included in the present assessment. FAO intends to publish an assessment of these presumed drylands, which cover 1 075 million hectares, in a future report.

Together with land-use categories (see "Data collection and analysis", p. 5), aridity zones were used in the assessment to help characterize the complexity and variability of the large area of land classified as drylands.

FIGURE 1
The world's drylands



Source: UNEP-WCMC, 2007

Trees and forests in drylands generate a wealth of environmental services; for example, they provide habitats for biodiversity, protect against water and wind erosion and desertification, provide shade for crops, animals and people, help water infiltrate soils and contribute to soil fertility. They also help increase the resilience of landscapes and communities in the face of global change (FAO, 2015a). Drylands are home to 35 percent of global biodiversity hotspot areas as well as one-third of all Endemic Bird Areas and Important Bird Areas (BirdLife International and Conservation International, 2010). Drylands also support half of the world's livestock (Allen-Diaz *et al.*, 1996), which is a source of food security for the 90 percent of the dryland population living in developing countries.

TABLE 1
Distribution of drylands among aridity zones, by region

Regional grouping	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	*%*	*'000 ha*	*%*	*'000 ha*	*%*	*'000 ha*	*%*	*'000 ha*	*%*
Northern Africa	463 948	47	153 647	10	88 943	4	18 724	1	725 263	12
Western and Central Africa	186 815	19	205 385	13	165 675	7	125 225	10	683 100	11
Eastern Africa	14 224	1	86 216	6	119 519	5	107 886	8	327 845	5
Southern Africa	8 183	1	53 653	3	134 873	6	27 045	2	223 753	4
Western Asia	215 535	22	112 719	7	62 959	3	35 698	3	426 911	7
Central and Eastern Asia	50 464	5	327 551	21	346 257	15	114 998	9	839 270	14
Southern Asia	11 175	1	192 781	12	190 636	8	84 642	6	479 234	8
Oceania	0	0	301 509	19	309 145	14	66 601	5	677 256	11
South America	25 142	3	43 651	3	253 192	11	223 702	17	545 688	9
North and Central America and the Caribbean	2 666	0	84 649	5	391 782	17	214 866	16	693 963	11
Europe	0	0	3 825	0	200 328	9	292 803	22	496 956	8
Total	**978 151**	**100**	**1 565 587**	**100**	**2 263 310**	**100**	**1 312 191**	**100**	**6 119 239**	**100**

Drylands are vulnerable to climate change, which will affect their ecosystem services and increase land degradation. According to the *World Atlas of Desertification* (Cherlet *et al.*, 2018), drylands have expanded significantly over the past 60 years and continue to do so, owing to changes in aridity index; they are expected to expand by 10 to 23 percent by the end of the twenty-first century. Arid regions are expected to expand in southwestern North America, the northern fringe of Africa, Southern Africa and Australia, while the semi-arid regions are expected to expand in the northern Mediterranean, Southern Africa and North and South America (Feng and Fu, 2013).

Life in drylands is precarious, and the socio-economic status of people in drylands is significantly lower than that of people in many other areas. Water availability in drylands, already (on average) one-third below the threshold for minimum human well-being and sustainable development, is expected to decline further owing to changes in climate and land use (Safriel *et al.*, 2005). Poor people living in areas remote from public services and markets and dependent on marginal natural resource bases will be most vulnerable to food shortages (WFP and ODI, 2015). Challenges such as land degradation and desertification, combined with drought, hunger and violence, are already leading to forced migration in dryland regions in Africa and western Asia.

Climate change, unsustainable land use and management and inefficient water use are the main causes of dryland degradation. Alarmingly, dryland degradation in developing countries is estimated to cost 4 to 8 percent of their gross domestic product (GDP) (EMG, 2011).

Urgent action is needed, therefore, to improve the management and restoration of drylands. Such action requires a comprehensive understanding of the complexity, status and roles of drylands, as well as context-specific approaches tailored to the unique conditions of drylands. But dryland forests and other ecosystems have not attracted the same level of interest and investment as other ecosystems, such as humid tropical forests. Thus, little has been known about tree cover and land use in drylands, even though recent studies have indicated the need to restore drylands to cope with the effects of drought, desertification, land degradation and climate change.

At its twenty-second session in 2014, the FAO Committee on Forestry (COFO) called for greater action and investment in the assessment, monitoring, sustainable management and restoration of drylands. It requested that FAO undertake a global assessment of the extent and status of dryland forests, rangelands and agrosilvopastoral systems, with a view to better prioritizing and targeting the investments needed for dryland restoration and management.

As part of its response to this request, FAO organized the first Drylands Monitoring Week in January 2015, which developed a set of recommendations (the "Rome Promise") and a road map outlining the next steps for advancing the assessment and monitoring of drylands on a global scale (Box 2).

The assessment reported in this document is a response by FAO and partners to COFO's request for a dryland assessment. While it builds on earlier work (e.g. Miles *et al.*, 2006; UNEP-WCMC, 2007), it is the first global assessment of trees, forests and land use in drylands.

METHODOLOGY

The Global Drylands Assessment is a thematic study complementing FAO's Global Forest Resources Assessment (FRA) but differing from it in both scope and method. FRA builds on a global network of officially nominated national correspondents and on the official statistics they report to the process. The Global Drylands Assessment, in contrast, was prepared by a consortium of partner institutions representing governments, academia, non-governmental organizations (NGOs) and other entities. The Global Drylands Assessment focuses on specific geographic areas and was carried out through visual interpretation of satellite images. No individual country reported data to the

BOX 2
Drylands Monitoring Week 2015

The first Drylands Monitoring Week, held in January 2015, gathered more than 60 experts to discuss the current state of dryland monitoring and to consider opportunities and tools for filling existing gaps. It was organized by FAO in collaboration with the World Resources Institute (WRI), the International Union for Conservation of Nature (IUCN) and the Global Environment Facility (GEF). Financial support was provided by the European Union within the framework of the African, Caribbean and Pacific Group of States (ACP) "Action Against Desertification" initiative (FAO, 2019) in support of the Great Green Wall and South–South cooperation in ACP countries. The theme of the week was "Monitoring and assessment of drylands: forests, rangelands, trees and agrosilvopastoral systems".

The participants endorsed the Rome Promise on Monitoring and Assessment of Drylands for Sustainable Management and Restoration (FAO, 2016), making a commitment to form a network or community of practice to advance monitoring and assessment of drylands; to communicate the value and importance of monitoring to relevant stakeholders; and to develop a dynamic road map for collaborative action. One of the main actions defined for the road map was to undertake the first global drylands assessment using the Collect Earth tool (see Methodology and Box 3), which was presented during the week.

assessment, and no official country information has been used. The results, therefore, are reported at the global and regional levels, not the country level.

The dryland definition and map of global drylands provided by UNEP-WCMC (2007) were adopted to define the geographic scope of the assessment. The satellite images used in the assessment are publicly available from digital repositories (including but not limited to Google Maps and Bing Maps). More than 200 experts with knowledge of the land and land uses in specific dryland regions participated in the interpretation of the images using a software tool called Collect Earth, which is part of the Open Foris tool set (Box 3). The interpretation was carried out in the second half of 2015 in regional workshops convened by FAO in collaboration with partner organizations.

BOX 3
Open Foris tools used in the assessment: Collect and Collect Earth

Open Foris is a suite of free, open-source software tools developed by the FAO Forestry Department to facilitate flexible and efficient data collection, analysis and reporting. Two of these tools were used in the drylands assessment: Collect and Collect Earth.

Collect is the main entry point for data collected in field-based inventories. It provides a fast, easy, flexible way to set up a survey with a user-friendly interface.

Collect Earth was developed in cooperation with Google Earth Outreach. It communicates with Google Earth to facilitate access to and analysis of freely available satellite images from sources such as Google Earth and Bing Maps. Through submission of pre-programmed scripts to Google Earth Engine Code Editor, the software can visualize time series of user-defined indices such as the Normalized Difference Vegetation Index, the Normalized Difference Water Index and the Enhanced Vegetation Index, using Landsat and MODIS (Moderate Resolution Imaging Spectroradiometer) satellite images. Collect Earth enables visual assessment of a grid of sample plots, and users can store the results directly in a database by completing an onscreen data-collection form. Stored data can be retrieved and analysed using Saiku Analytics, a free open-source software for business intelligence analysis, which has been integrated into Collect Earth.

Data collection and analysis

The design of the Global Drylands Assessment benefited from consultation with drylands experts engaged in the Action Against Desertification initiative and the Rome Promise Collaborative Network. The survey was set up using Open Foris Collect software and then embedded in Open Foris Collect Earth. For each sample plot, data on 77 variables describing the sample site were collected through the visual interpretation of available satellite images. The characteristics were selected to describe land cover, land use, land-use change and other significant land dynamics (such as desertification and greening), along with biophysical indicators (Box 4) over the reference period (2000–2015). The starting year, 2000, was selected because it is the first year for which consistent global coverage of satellite data (Landsat 7) is available.

Different classification schemes were used, depending on the variable. For example, land use was classified based on both the four categories of the Global Forest Resources Assessment 2015 (forest, other wooded land, other land, inland water bodies) (FAO, 2015b) and the six land-use categories of the Intergovernmental Panel on Climate Change (IPCC) (forest, cropland, grassland, wetlands, settlements, other land) (IPCC, 2006) (see Annex 1).

The assessment adopted the definition of forest used in FRA 2015: "Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use" (FAO, 2012a).

Other wooded land is "land not defined as 'forest', spanning more than 0.5 hectares, with trees higher than 5 metres and a canopy cover of 5–10 percent, or trees able to reach these thresholds; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use" (FAO, 2012a).

The data-collection form in Collect Earth was structured to guide operators in the survey process, starting with the identification and quantification of simple land elements (e.g. trees and shrubs) and the identification of the main land-use category. The approach enabled operators to report on impacts and disturbances over the reference period whenever

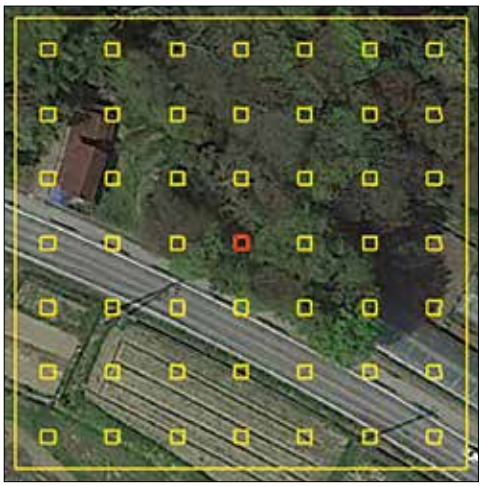
BOX 4

Some variables for which data were collected

- Plot identification: number, location, operator, time when saved
- Land use: FRA and IPCC category and accuracy, subcategory and accuracy, initial land use and year of change
- Remote-sensing data source: satellite, date
- Site characteristics: dryland region, dryland category, FAO ecozone, biome, ecoregion, country, climate zone farming method, soil type, elevation, slope, aspect, calculated elevation range, calculated aspect, calculated slope
- Type and cover of:
  - vegetation elements: trees, shrubs, palms, bamboo, crops
  - infrastructure elements: houses, other buildings, paved roads, unpaved roads
  - water bodies: lakes, rivers
  - other elements: rock, bare soil, other
- Desertification trend
- Disturbances: impact type and grade; continual or year; accuracy
- Trees and shrubs: many or count
- Length of linear features: vegetation, paved roads, unpaved roads, paths

these could be detected within plots. Collect Earth projected each sample plot as a rectangle containing a grid of 49 control points (Figure 2), enabling users to assess the proportion of plots taken up by trees, shrubs and other land elements.

FIGURE 2
Example of a sample plot



Only one land use could be assigned per sample plot. In the case of FRA categories, the assigned land use was that which covered the greatest area. For example, a sample plot with more than 10 percent tree cover was not classified as forest unless forest was the prevailing land use within the area of the whole plot. Lands with trees not constituting forest include settlements and croplands (e.g. the land use might be agroforestry). In the case of IPCC categories, a hierarchical rule was applied to define the main land use, as explained in Martínez and Mollicone (2012).

Subtypes of vegetation were also identified as subclasses of IPCC categories (see Annex 1). However, only the higher-level classifications are presented in this report, as the interpretation of subtypes can be less reliable.

In the visual interpretation, experts used their knowledge of the landscape characteristics of the sampling location as well as information provided by remote-sensing data to support the assessment. For example, crops were classified as irrigated based on the visible presence of pivots, pipes, water tanks or nearby rivers, or as perennial crops based on the visibility of crops such as bananas or coconuts in the very-high-resolution imagery.

The simultaneous use of low-resolution and very-high-resolution satellite imagery facilitated the assessment of land use and detection of land-use change. For assessment of some land elements (e.g. distinguishing between trees and shrubs), satellite data and local knowledge were sometimes insufficient, however, and a decision rule based on the crown diameter of trees and shrubs was therefore adopted. Elements with a crown diameter larger than 3 m were considered trees; elements with smaller diameters were considered shrubs. The Collect Earth tool does not allow tree height to be assessed; shadows were used in addition to the crown-diameter threshold to determine whether elements were sufficiently tall (i.e. 5 m or taller, consistent with the definition of forest used in the assessment) to be considered trees.

The FRA definition of forest includes areas with young trees that have not yet reached but are expected to reach a canopy cover of at least 10 percent and tree height of 5 m or more. It also includes areas that are temporarily unstocked as a result of clear-cutting as part of forest management practice or natural disasters, and that are expected to be regenerated within five years. Consequently, some areas classified as forest in the assessment may be identified as having zero canopy cover.

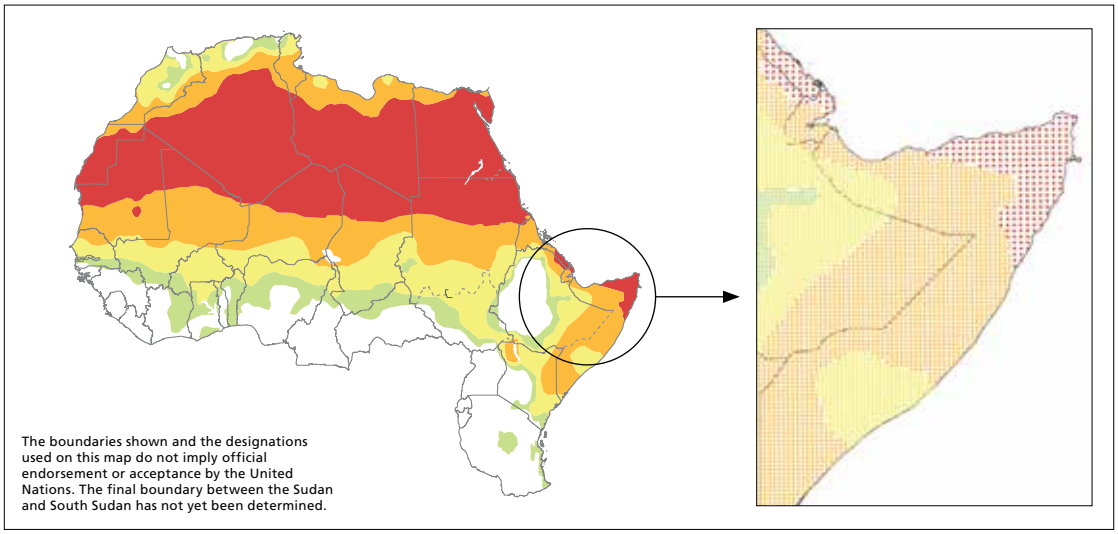
Sampling design

The assessment draws on information from 213 782 sample plots located across the world's drylands. Each plot measured 70 × 70 m (approximately 0.5 hectares), a size corresponding to the smallest patch that qualifies as forest according to the forest definition used in the assessment.

A stratified systematic grid of sample plots across the drylands was applied. Each aridity zone was treated as an independent stratum. The dry subhumid zone was sampled

FIGURE 3

Illustration of sampling intensity, by aridity zone



Source: UNEP-WCMC, 2007

at a higher intensity than the hyperarid zone because the probability of finding trees is lower in areas with higher aridity. The relative sampling intensity assigned to each aridity zone was as follows: hyperarid = 0.5; arid = 1; semi-arid and dry subhumid = 1.5 (Figure 3).

The error in the estimation of forest area has two main sources: sampling error and measurement error. The sampling error for the estimate of forest land at the global level is about ±1 percent. The measurement error, calculated by comparing the remote-sensing data from Collect Earth with field data for a subsample of 441 plots, was estimated to be about ±8.3 percent (Bastin *et al.*, 2017).

Data sources

Sample-plot data were collected from online digital repositories of satellite images using Collect Earth. Typically, each plot was shown in several images representing different points in time in the period 2000–2015, although the same points in time were not available for all plots. All plots were covered by Landsat imagery (30 m resolution), and 89 percent of plots were also described in higher-resolution images. More than half were described in images from DigitalGlobe with a resolution finer than 1 m (Figure 4). The proportion of satellite image types was similar for all land-use types. The temporal profiles of intra- and interannual vegetation indices were derived from low-resolution satellite data (with ground resolution of 30 to 250 m).

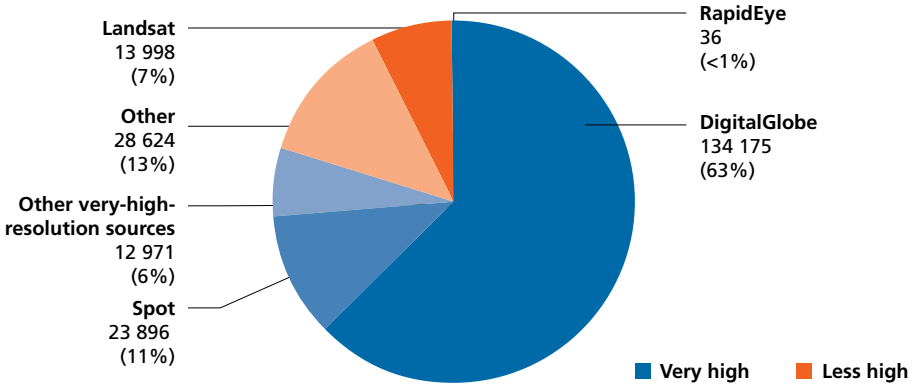
Implementation approach

The assessment was conducted through a series of regionally focused training and data-collection workshops, organized in collaboration with participants from universities, research institutes, governments and NGOs worldwide, most of them local experts (see Annex 2).

In the first week of each workshop, participants were instructed and trained by FAO staff. In the second week, participants collected data by assessing sample plots using Collect Earth. The purpose of this approach was to ensure that the interpretation

FIGURE 4

Distribution of sample plots, by highest-resolution source of data (number of plots)

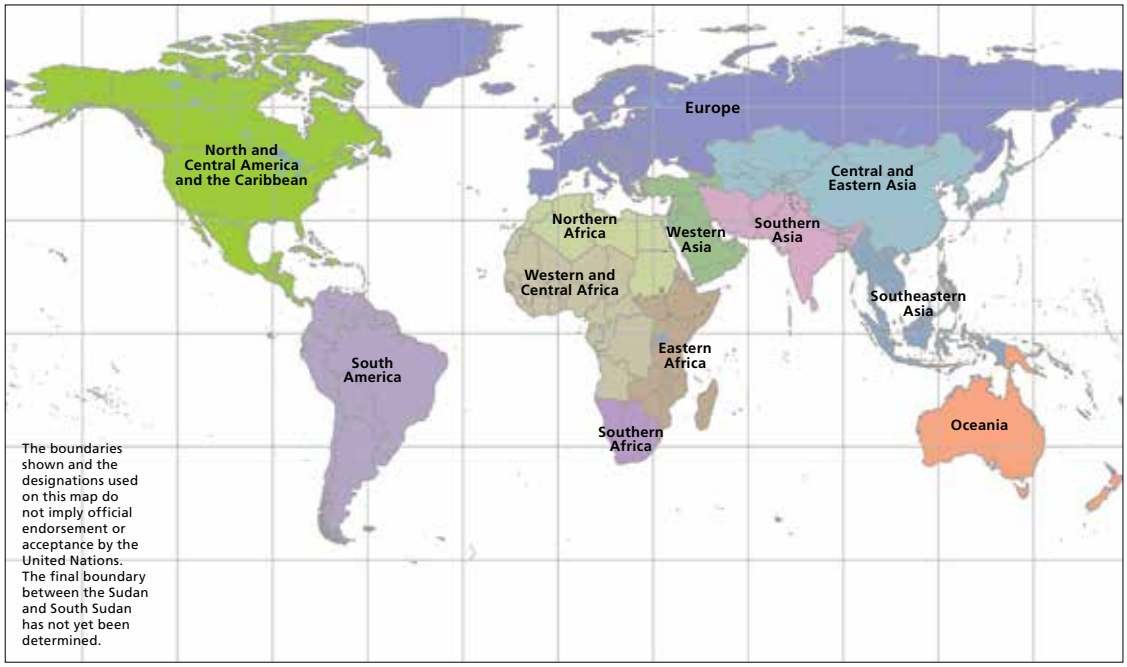


was performed consistently in all regions and benefited from the regional and local knowledge of participants.

The regional groupings used to structure the analysis and to present the results are based on the geoscheme of the United Nations Statistics Division (UN, 2019) (Figure 5). Of these regions, the only one for which the report does not include a chapter is Southeastern Asia, owing to the very few plots classified as drylands in this region (377 plots or 13 million hectares). Southeastern Asia falls entirely within the tropical and subtropical climatic zones and for the most part receives considerable annual precipitation. Indeed, the 377 plots assessed as drylands were all classified in the least-arid zone, the dry subhumid zone.

FIGURE 5

The regions used in the analysis



Source: UN Maps, 2019

Data processing

The sample plots were divided into geographically defined subsets, one for each regional training and data-collection workshop. Assessment data for each sample plot interpreted by an expert were saved directly into a database. FAO collated all the databases into a single database and cleansed the data using automatic and visual checks. The results were generated with Saiku Analytics, a free open-source software that enables users to visualize and aggregate data through a simple drag-and-drop interface. Uncertainly analysis was performed in Microsoft Excel.

Note that throughout this report, percentages may not add up to 100 percent because of rounding.

2. Global results

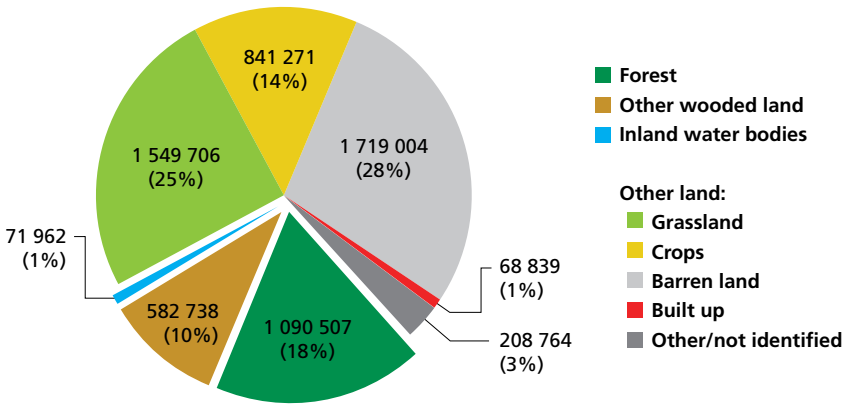
KEY FINDINGS

- The drylands contain 1.1 billion hectares of forest, corresponding to 27 percent of the world's forest area. Two-thirds of dryland forest area has a closed tree canopy, with cover of more than 40 percent.
- Forest accounts for 18 percent of dryland area, while barren land accounts for 28 percent, grassland 25 percent and cropland 14 percent.
- The least arid areas have the most forest; 52 percent of dryland forest is in the dry subhumid zone and 41 percent in the semi-arid zone, compared with only 7 percent in the arid zone and less than 1 percent in the hyperarid zone. The average tree canopy cover in the dry subhumid zone is ten times greater than that in the hyperarid zone.
- Many trees in the drylands grow outside the forest. Almost 30 percent of cropland and 60 percent of built-up land has at least some tree cover.
- When forest, other wooded land and trees outside forest are all taken into account, trees are present on 2 billion hectares of drylands (32 percent of the total dryland area).
- The findings can be used as a baseline to highlight key emerging threats to drylands and their populations at the global and regional levels, including climate change and food security challenges, and to pinpoint areas for restoration.

Green valley in the drylands of India

FIGURE 6

Distribution of land uses in drylands ('000 ha)



DISTRIBUTION OF FORESTS AND OTHER LAND USES

Of the world's 6.1 billion hectares of drylands, the assessment classifies 18 percent as forest and 10 percent as other wooded land. The remaining 71 percent are classified as other land, comprising predominantly barren land, such as bare soil and rock (28 percent of total dryland area), grasslands (25 percent) and croplands (14 percent) (Figure 6).

The distribution of land uses is highly dependent on aridity. Almost 99 percent of the hyperarid zone is classified as other land, because most of it is desert, characterized by sandy and rocky landscapes. In general, the proportion of other land decreases with decreasing aridity: It is 83 percent in the arid zone, 65 percent in the semi-arid zone and 49 percent in the dry subhumid zone (Figure 7). Forests exhibit the opposite distribution pattern, accounting for 43 percent of land in the dry subhumid zone and 20 percent in the semi-arid zone, with rare occurrence in the arid and hyperarid zones. Other wooded land makes up 6 percent of the dry subhumid zone but only 1 percent of the hyperarid zone.

FIGURE 7

Distribution of land uses by aridity zone

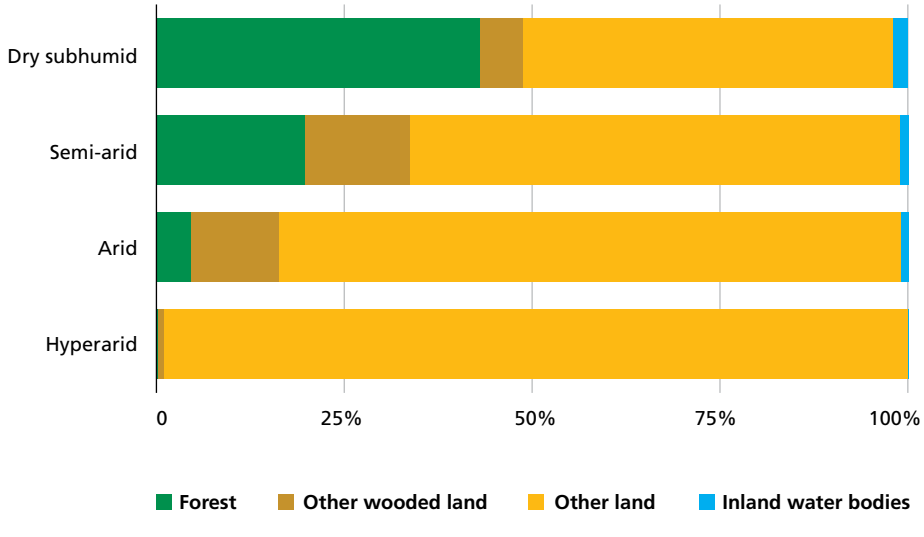
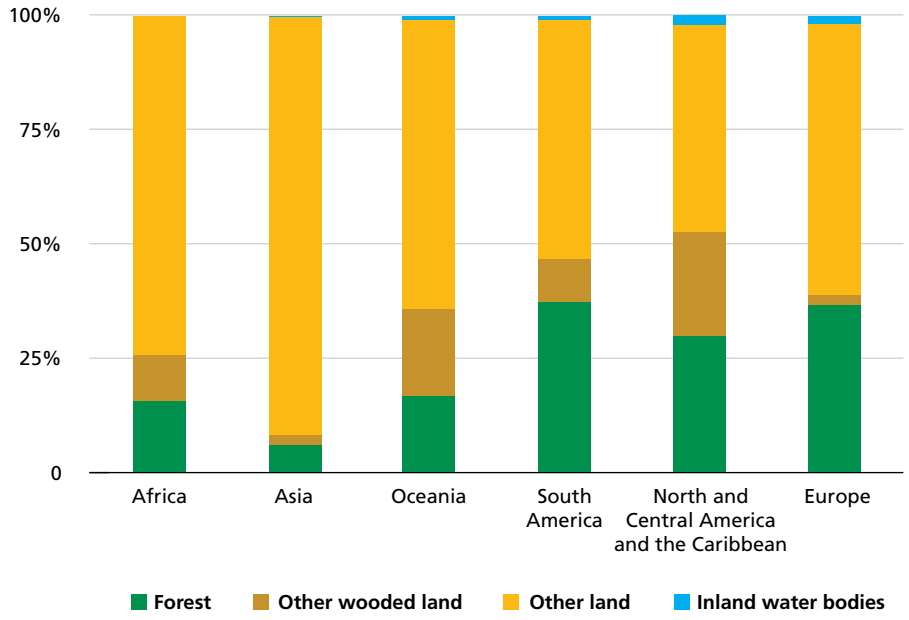


FIGURE 8

Distribution of land uses in drylands by continent

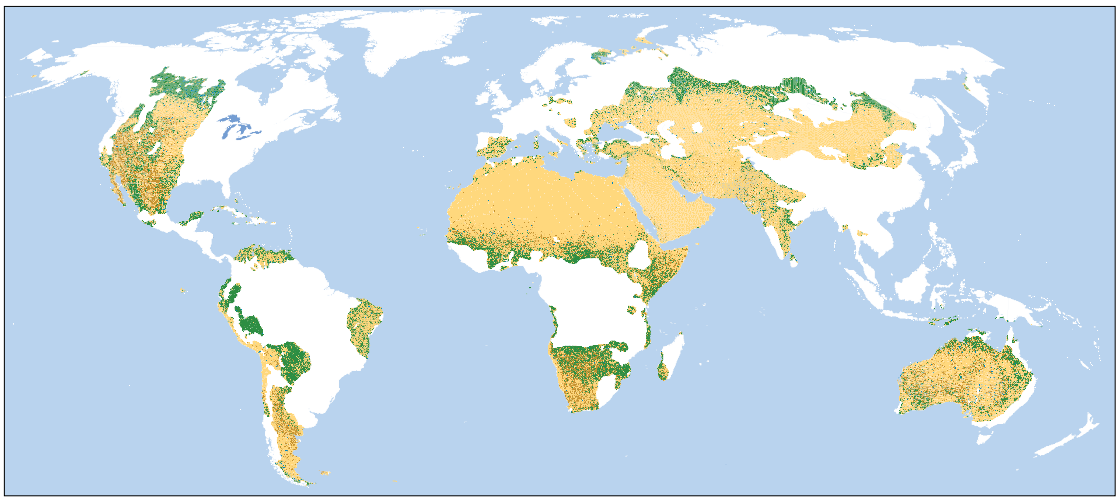


By continent, other land accounts for 85 percent of drylands in Asia, 68 percent in Africa, 62 percent in Oceania, 55 percent in Europe, 50 percent in South America and 42 percent in North and Central America and the Caribbean (Figures 8 and 9). Other wooded land is mostly found in North and Central America and the Caribbean and in Oceania. Drylands in South America and Europe have the highest distribution of forest (37 and 36 percent, respectively), while Asian drylands have the lowest (6 percent).

The world's drylands contain 1.1 billion hectares of forest. More than half (52 percent, 570 million hectares) is in the dry subhumid zone (Figure 10), mostly in the northeast

FIGURE 9

Global map of drylands by continent, showing the different land uses



Source: UN Maps, 2019

FIGURE 10
Distribution of dryland forest by aridity zone ('000 ha)

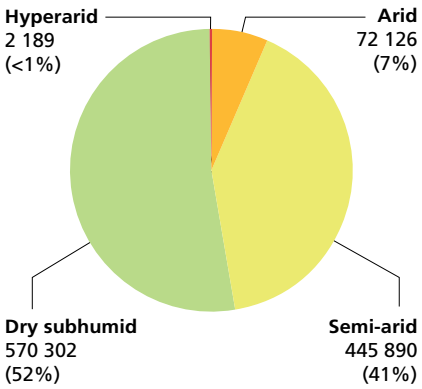
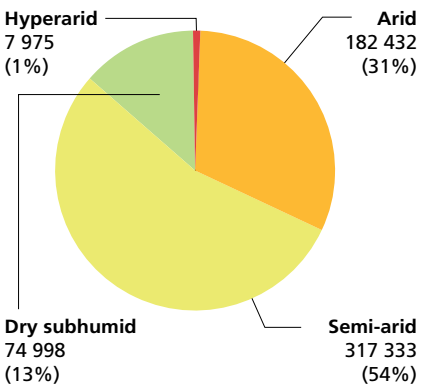


FIGURE 11
Distribution of other wooded land by aridity zone ('000 ha)



of Southern Africa and western (pre-Andean) inland South America (Figure 9). At the other extreme, the hyperarid zone contains less than 1 percent of the total forest area in drylands, mostly in the northwest of South America and the Horn of Africa.

Other wooded land covers less area than forest, 583 million hectares. More than half of it (55 percent, 317 million hectares) is in the semi-arid zone (Figure 11), mostly in Oceania, North and Central America and the Caribbean, the southwest of South America and Southern Africa (Figure 9).

When trees outside forest are also taken into account, trees are present in almost one-third of the world's drylands (2 billion hectares).

VEGETATION IN FORESTS AND OTHER WOODED LAND

Dryland forests are predominantly (about 66 percent) natural broadleaved forest, while about 15 and 10 percent are natural coniferous and mixed broadleaved and coniferous, respectively (Table 2). Broadleaved forests are most dominant in South America (95 percent), Oceania (89 percent) and Eastern Africa (82 percent) (Table 3, Figure 12). The assessment did not identify the vegetation cover for 7 percent of total forest.

The vegetation cover in other wooded land is mainly dominated by grassland with shrubs (54 percent of the total), with little variation among aridity zones (Table 4). The percentage of grassland with shrubs is highest in South America (77 percent) and North and Central America and the Caribbean (71 percent), but less than 40 percent in Western and Central Africa and Northern Africa (Table 5).

TABLE 2
Type of forest vegetation by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest										
Broadleaved	1 174	54	49 220	68	300 795	67	371 120	65	722 309	66
of which riparian	188	9	2 742	4	12 009	3	12 154	2	27 093	0
Coniferous	93	4	3 274	5	58 505	13	102 227	18	164 098	15
Mixed broadleaved and coniferous	102	5	2 153	3	36 676	8	68 073	12	107 004	10
Other/not identified	621	28	15 529	22	36 508	8	21 786	4	74 444	7
Planted forest	200	9	1 951	3	13 405	3	7 096	1	22 652	2
Total	**2 189**	**100**	**72 126**	**100**	**445 890**	**100**	**570 302**	**100**	**1 090 507**	**100**

TABLE 3
Type of forest vegetation by region: area and proportion of the region's total forest vegetation

Regional grouping	Natural forest									Planted forest	
	Broadleaved			Coniferous		Mixed coniferous and broadleaved		Other/not identified			
	'000 ha	*of which riparian*	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Northern Africa	10 465	449	66	3 628	23	321	2	846	5	567	4
Western and Central Africa	80 603	4 566	78	806	1	1 125	1	10 393	10	10 054	10
Eastern Africa	95 338	2 642	82	755	1	3 134	3	16 119	14	370	0
Southern Africa	45 063	1 381	76	109	0	1 872	3	12 249	21	86	0
Western Asia	6 407	132	36	7 262	41	2 489	14	403	2	1 023	6
Central and Eastern Asia	17 925	645	56	8 752	27	3 278	10	1 290	4	924	3
Southern Asia	27 936	933	60	3 058	7	3 172	7	11 876	25	565	1
Oceania	97 203	3 512	89	38	0	673	1	11 175	10	527	0
South America	189 829	4 468	95	328	0	1 575	1	5 632	3	2 065	1
North and Central America and the Caribbean	78 517	5 809	38	81 692	40	42 999	21	1 312	1	1 261	1
Europe	67 718	2 387	38	57 671	32	46 240	26	2 552	1	5 005	3

TABLE 4
Main vegetation types in other wooded land by aridity zone

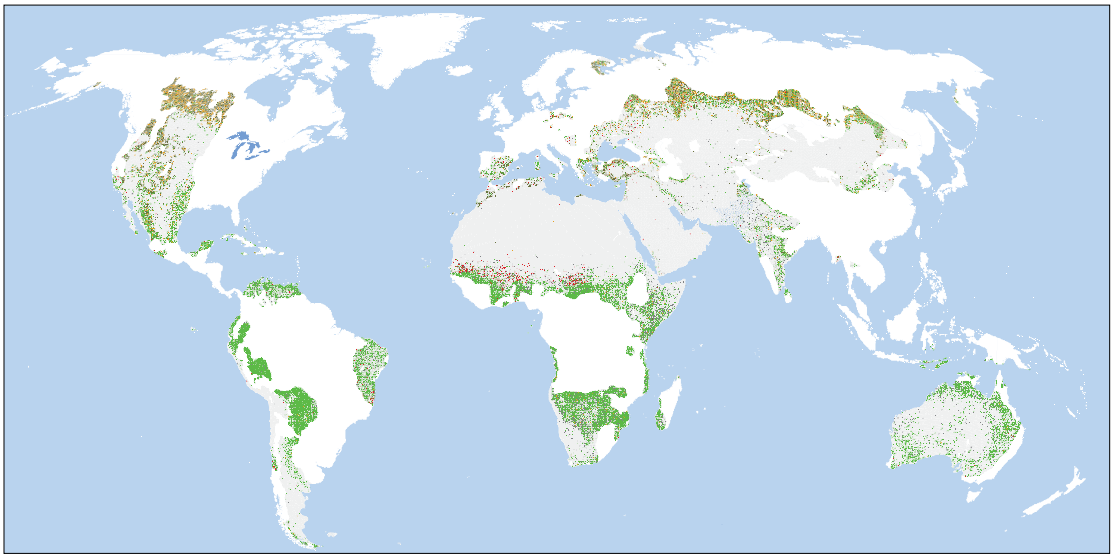
Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	4 082	51	109 442	60	169 876	54	31 354	42	314 754	54
Grassland with trees and shrubs	2 365	30	65 907	36	125 295	39	36 143	48	229 711	39
Shrubland	144	2	1 318	1	3 832	1	1 249	2	6 542	1
Other/not identified	1 385	17	5 765	3	18 331	6	6 251	8	31 732	5
Total	**7 976**	**100**	**182 432**	**100**	**317 333**	**100**	**74 998**	**100**	**582 739**	**100**

TABLE 5
Main vegetation types in other wooded land by region: area and proportion of the region's total vegetation in other wooded land

Regional grouping	Grassland with shrubs		Grassland with trees and shrubs		Shrubland		Other/ not identified	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Europe	4 202	40	4 688	44	0	0	1 705	16
Northern Africa	3 896	38	5 451	53	59	1	899	9
Western and Central Africa	19 911	33	26 746	44	3 509	6	10 776	18
Eastern Africa	23 905	44	27 233	50	569	1	2 616	5
Southern Africa	37 282	50	34 310	46	132	0	2 763	4
North and Central America and the Caribbean	110 295	71	43 105	28	266	0	2 632	2
South America	40 177	77	10 513	20	547	1	1 164	2
Central and Eastern Asia	732	44	471	28	174	10	296	18
Western Asia	3 171	50	1 833	29	116	2	1 162	18
Southern Asia	6 604	28	11 035	46	665	3	5 650	24
Oceania	64 432	49	64 031	49	562	0	1 246	1

FIGURE 12

Global distribution of dryland forest by subtypes



Source: UN Maps, 2019

TREE CANOPY COVER

The density of tree cover differs by region as well as by aridity zone. On average, canopy cover is ten times higher in the dry subhumid zone than in the hyperarid zone. Of all the regions, canopy cover on average is highest in South America, but in the arid and hyperarid zones it is highest in North and Central America and the Caribbean, where the canopy cover varies much less between the arid and semi-arid zones than in other regions (Figure 13). This result suggests the possibility that canopy cover in the arid zones of other regions could be increased substantially, at least to the level of North and Central America and the Caribbean, provided other ecological factors (such as soil properties) are favourable.

The assessment shows that 51 percent of dryland forest has a dense canopy cover of 70 to 100 percent, and less than 1 percent of the forest has canopy cover in the lowest range of 1 to 9 percent (Figure 14). Other wooded land exhibits the opposite pattern: more than half (56 percent, 328 million hectares) has no tree cover (thus consisting solely of bushes and shrubs), while 35 percent of other wooded land has canopy cover of 1 to 9 percent.

SHRUB COVER

Globally, the average shrub cover in other wooded land is 37 percent, while that in forest is 9 percent (Table 6). However, in forest, where shrubs represent a vegetation sublayer, they are not always easy to detect, particularly where the canopy is dense.

Almost half of other wooded land is sparsely covered with shrubs, having shrub cover ranging from 10 to 39 percent (Figure 15). About 18 percent of other wooded land has dense and continuous shrub cover (ranging from 70 to 100 percent). The semi-arid and dry subhumid zones have the highest shrub cover in other wooded land (40 and 38 percent respectively), while the hyperarid zone has the least.

Only 19 percent of forest has shrub cover between 10 and 39 percent, and only 6 percent has shrub cover of more than 40 percent. Shrub cover in forest varies little among aridity zones.

FIGURE 13

Average canopy cover by continent and aridity zone (%)

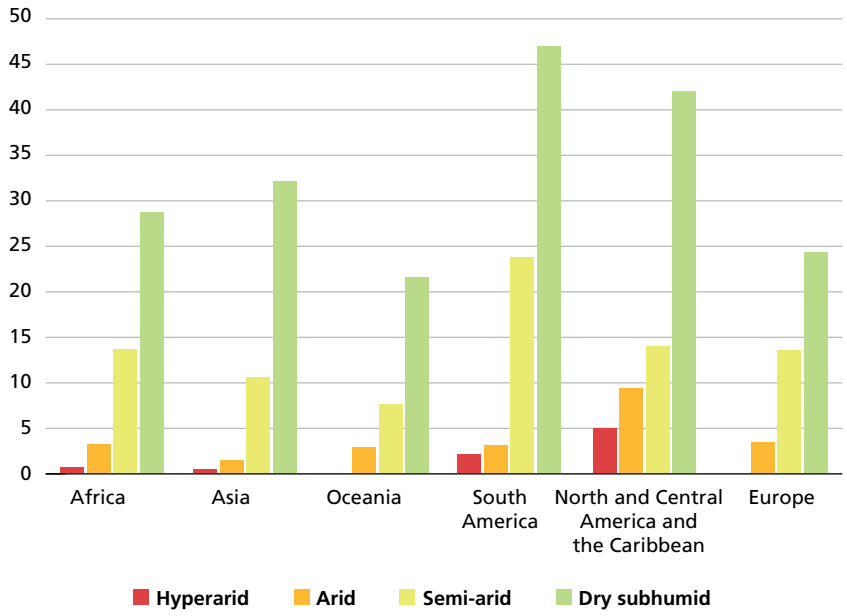


FIGURE 14

Tree canopy cover in forest and other wooded land

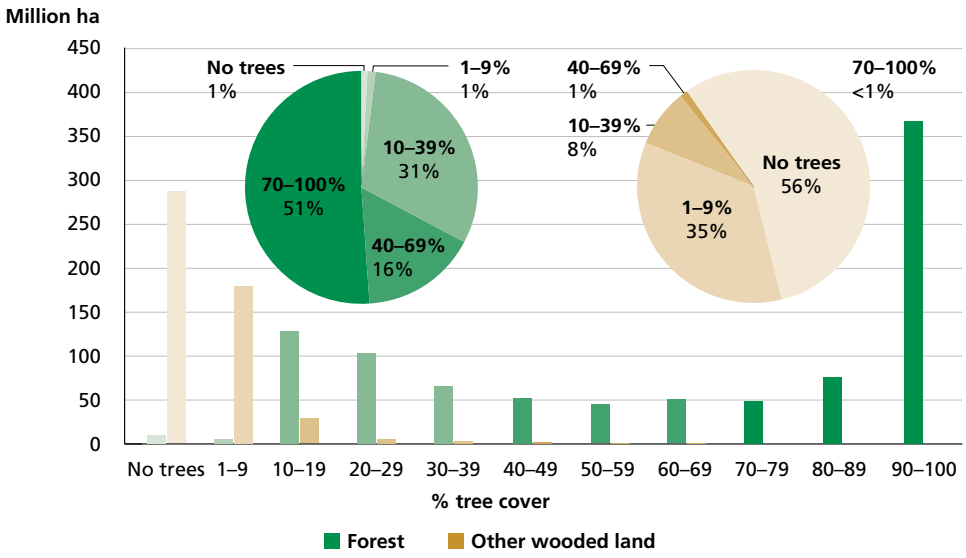


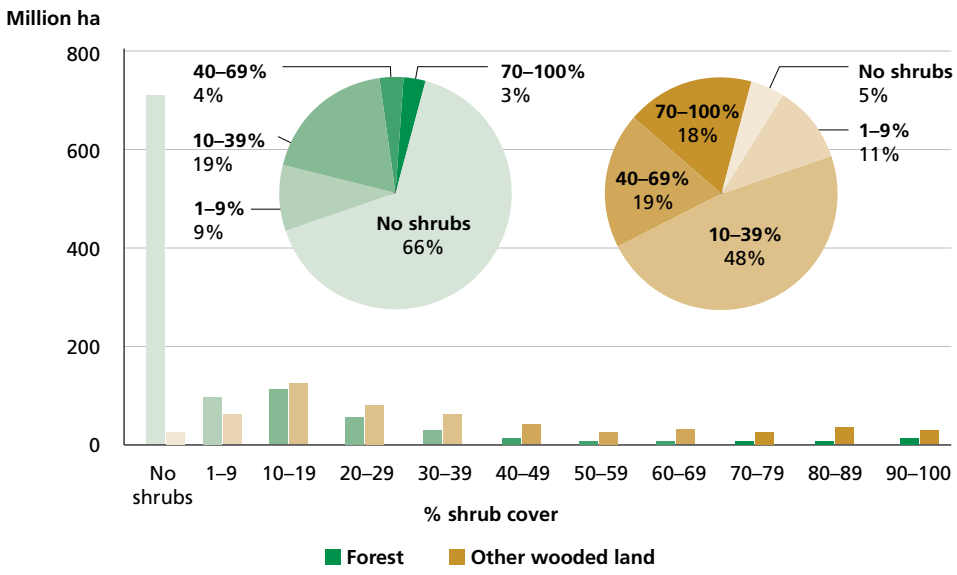
TABLE 6

Average shrub cover by aridity zone and land use (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	8	12	11	7	**9**
Other wooded land	28	31	40	38	**37**
Other land	1	4	6	5	**4**
Inland water bodies	1	3	2	1	**2**
All lands	**1**	**7**	**12**	**8**	**8**

FIGURE 15

Shrub cover in forest and other wooded land

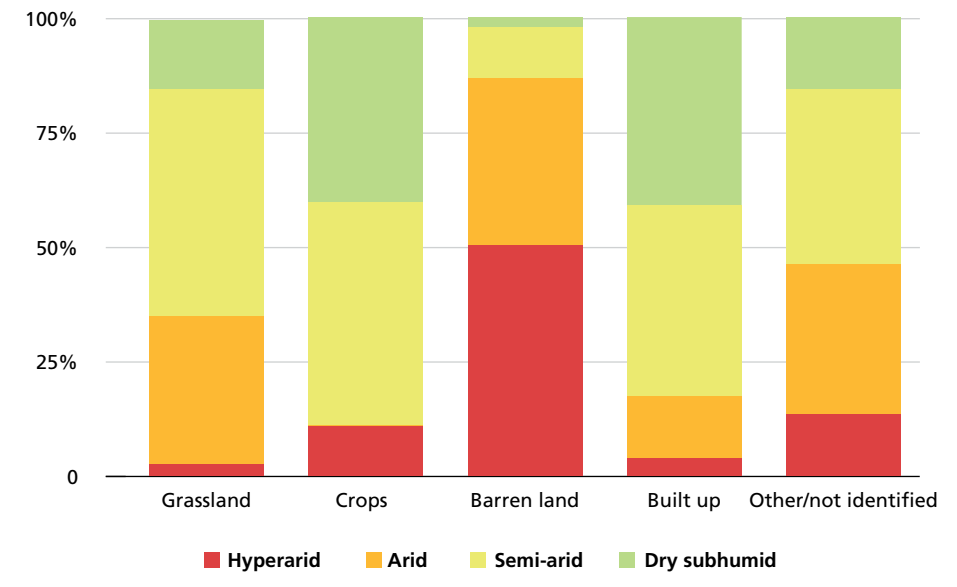


OTHER LAND

Other land comprises 39 percent barren land (1.7 billion hectares), 35 percent grassland (almost 1.6 billion hectares), 19 percent cropland (841 million hectares), 2 percent built-up land and 5 percent other or not identified. Crops have a crucial role in food security for people living in drylands; cropland makes up 49 percent of other land in the semi-arid zone and 40 percent in the dry subhumid zone (Figure 16). However, it represents only 1 percent of other land in the hyperarid zone, where it is almost exclusively near rivers – such as the Nile in Egypt – and other water bodies. Other land in Africa's drylands is

FIGURE 16

Land use in other land by aridity zone



mostly barren land (66 percent), while 87 percent of other land in Oceania is grassland, and cropland covers 57 percent of other land in Europe.

Non-irrigated cropland (of which 33.8 percent is in Europe) represents 48 percent of total cropland, while most of the remainder is distributed equally between irrigated crops and perennial crops (Table 7). Only 5 percent of cropland is fallow, found in Asia.

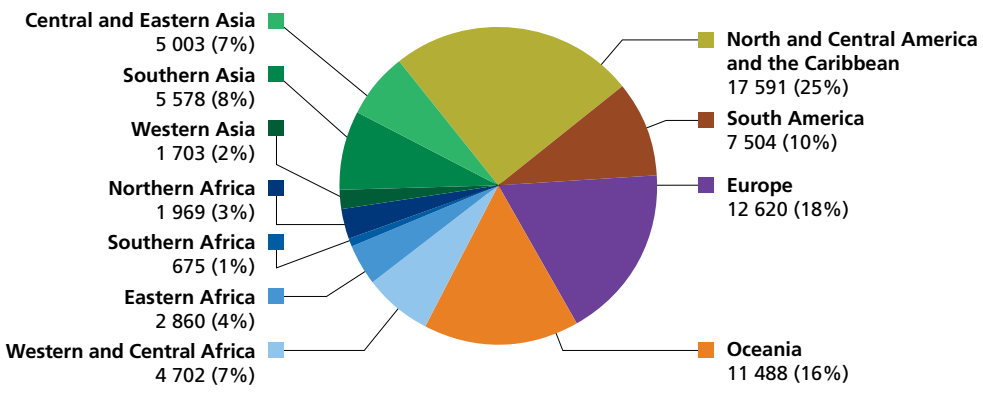
Of the barren land, 82 percent is covered by sand and dunes. Built-up land comprises 71 percent villages and urban settlements, highly distributed in Asia; 27 percent infrastructure, mostly in Africa; and 2 percent mining activity, mostly in Asia, followed by Oceania.

Although inland water bodies represent only about 1 percent of dryland area, they have an important role for migratory birds as well as for production of crops such as grapes and dates. The regions with the greatest area of inland water bodies in drylands are North and Central America and the Caribbean and Europe (Figure 17). The distribution of inland water bodies is highly dependent on aridity; they account for only 0.1 percent of the hyperarid zone, 1 percent of the semi-arid zone, 1 percent of the arid zone and 2 percent of the dry subhumid zone.

TABLE 7
Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	10 394	85 900	411 240	333 736	841 271	100
Irrigated crops	5 952	28 751	83 797	70 803	189 303	23
Non-irrigated cropland	3 024	28 484	200 033	174 720	406 261	48
Perennial crops (palms, orchards, others)	1 418	23 693	101 649	72 843	199 604	24
Cropland fallow	0	4 973	25 762	15 369	46 103	5
Grass	44 357	503 778	764 584	236 987	1 549 706	100
Barren land	880 209	627 268	189 958	21 569	1 719 004	100
Rock or stone	131 918	97 967	55 900	10 104	295 889	17
Sand and dunes	747 823	527 744	132 127	9 468	1 417 163	82
Snow and glaciers	468	1 557	1 930	1 997	5 952	0
Built up	3 067	9 416	28 520	27 837	68 839	100
Villages and urban settlements	1 717	5 968	20 248	21 129	49 062	71
Infrastructure	1 242	3 220	7 618	6 422	18 502	27
Mining	107	228	654	286	1 275	2

FIGURE 17
Distribution of inland water bodies among continents ('000 ha)



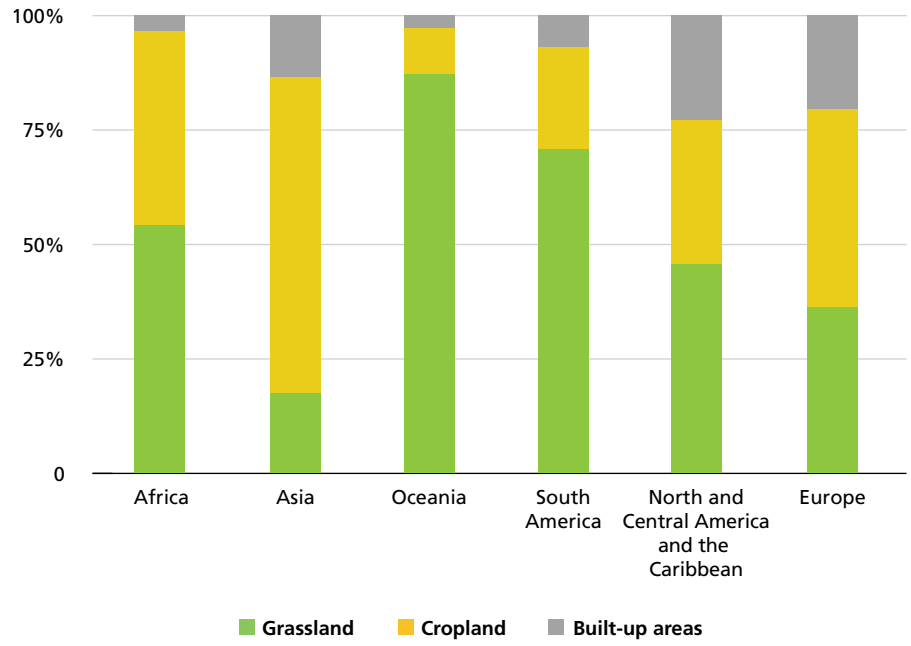
TREES OUTSIDE FOREST

Trees outside forest – defined as trees in other land – are found on 60 percent of the built-up area (41 million hectares) and 27 percent of cropland (228 million hectares). Asia and Europe have a much greater proportion of their trees outside forest in cropland than other regions (Figure 18).

Trees are present on other land across many land-use categories, with different categories dominant depending on the aridity zone. Grassland has the greatest presence of trees in all aridity zones, but particularly in the arid and semi-arid zones. The vast majority of other land with trees – 95 percent – has canopy cover of less than 10 percent.

FIGURE 18

Distribution of trees outside forest by land-use category



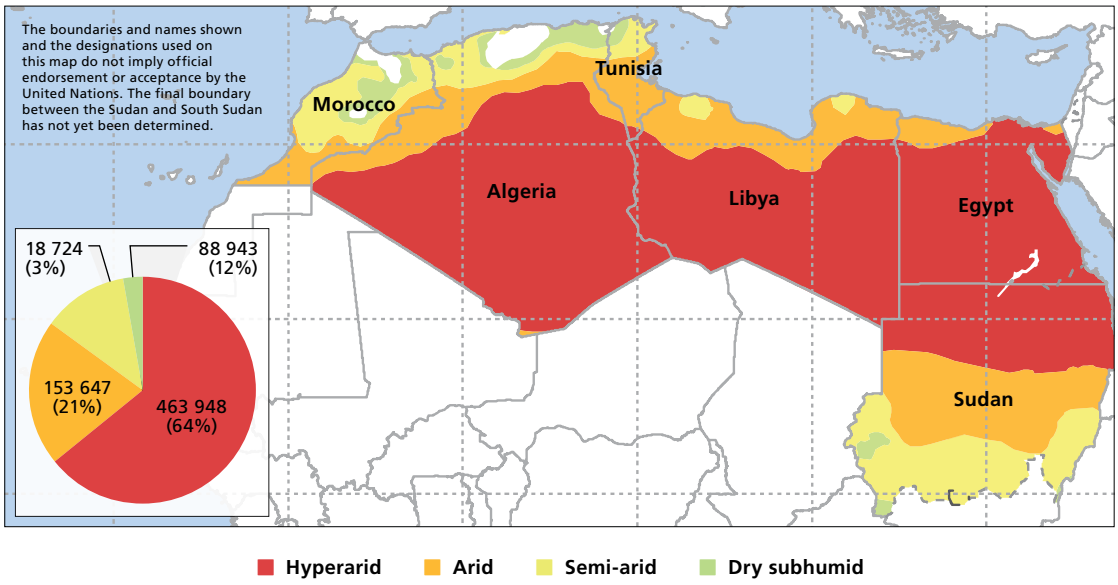
Northern Africa

KEY FINDINGS

- The drylands of Northern Africa cover almost 725 million hectares, representing 99 percent of the region's total land area and 12 percent of the global drylands.
- Most of the drylands – 64 percent – are in the hyperarid zone, where the Sahara dominates.
- Forest represents 2 percent of the drylands, while 96 percent of the drylands are classified as other land.
- Almost 69 percent of the forest and 67 percent of the other wooded land are located in the semi-arid zone of the Atlas Mountains.
- The main forest type is broadleaved, accounting for 66 percent of dryland forest, while 23 percent of forest is coniferous.
- In other wooded land, grassland with trees and shrubs is the most dominant vegetation type (53 percent of total vegetation), followed by grassland with shrubs (38 percent).
- About 93 percent of Northern Africa's drylands have no trees.
- Average tree canopy cover in forest is 34 percent. Only 11 percent of the forest has tree canopy cover of more than 70 percent.
- Canopy cover decreases with increasing aridity, being highest in the dry subhumid zone and lowest in the hyperarid zone.
- Barren land represents 80 percent of other land, with its greatest distribution in the hyperarid zone.
- Non-irrigated cropland accounts for 55 percent of all cropland; the largest amount is in the semi-arid zone, followed by the arid zone.

FIGURE 19

Distribution of drylands in Northern Africa by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

Northern Africa is well known for its Sahara Desert, the world's largest desert. Almost 99 percent of the region's land, 725 million hectares, is considered dryland. Northern Africa is highly arid: 64 percent of the dryland area (464 million hectares) is considered hyperarid, 21 percent (154 million hectares) arid, 12 percent (89 million hectares) semi-arid and 3 percent (19 million hectares) dry subhumid (Figure 19).

The results in this chapter are based on a survey of 21 527 plots. The analysis was completed by a team of 20 data interpreters coordinated by the General Directorate of Forestry, Tunisia, from 25 May to 6 June 2015.

BACKGROUND

Climate

Northern Africa has three climatic zones: Mediterranean (mainly along the coast and in the most southern part of the Sudan), steppe (in the mountains) and desert. July and August are the hottest months, with average temperatures of about 26 °C in summer and 10 to 13 °C in winter. The Sudan is the hottest country in the region, with average temperatures of 35 to 37 °C in summer and 10 to 13 °C in winter.

Importance of dryland forests, trees and biodiversity

The region is home to almost 240 million people, with 1.8 percent annual population growth. Rural communities in particular rely on natural resources for their livelihood activities – primarily raising sheep and goats – and to meet basic needs such as food, medicine, fuel and shelter. The region's nomadic people have traditionally conserved natural resources through customary land governance systems called *hima* in Egypt, Libya and the Sudan and *agdal* in the Maghreb countries, by which they set aside areas of land, typically pasture and forest, to protect them (see Box 8 on p. 83).

Owing to its location at the crossroads of the Atlas Mountains, the Nile River and the desert, the region has rich biodiversity, with many endemic species adapted to the dryland ecology. Forests, located primarily in areas with a Mediterranean climate, provide livelihoods for the population and contribute to GDP; they provide local communities

and pastoralists with important goods such as fuelwood, fodder and emergency food, while also producing valuable commodities such as gum arabic.

Trends and challenges

Land degradation and deforestation are among the main threats facing Northern Africa. As in other regions, the general drivers of degradation include urbanization, demographic changes, commerce and agricultural expansion. Changes in the nomadic lifestyle have led to extensive settlement in the mountain grasslands of the Maghreb, increasing overgrazing and illegal cutting of fuelwood and introducing agricultural activities. The Sudan has hosted more than 4 million refugees in the fragile arid zone, with significant environmental and social impacts. The growing demand on freshwater has increased the pressure on the region's ecosystems, especially the wetland resources. As a result of dam construction and water abstraction activities, 28.2 percent of the region's 877 freshwater species are considered threatened. Endangered endemic animal species in Northern Africa include Cuvier's gazelle, which has limited distribution in Morocco, Algeria and Tunisia, and the Barbary macaque in the Rif and Atlas Mountains of Morocco and Algeria (IUCN, 2019). Critically, the IPCC Fifth Assessment Report highlighted that part of Northern Africa will be vulnerable to an increase in drought and flood frequency, which will affect the region's socio-economic development, particularly for those populations that rely on environmental resources (ODI and CDKN, 2014).

DISTRIBUTION OF FORESTS AND OTHER LAND USES

The Sahara covers 80 percent of Northern Africa; accordingly, forest accounts for only 2 percent (15 million hectares) of the region's drylands, while other wooded land accounts for only 1 percent (10 million hectares) (Figure 20). The "other land" category accounts for 96 percent of the dryland area (697 million hectares) and is dominated by barren land, which accounts for 77 percent of the total dryland area, with a total area of 555 million hectares.

Most of the forest is distributed in the Atlas Mountains, the coastal plains of Morocco, Algeria and Tunisia, and the southern part of the Sudan (Figure 21). More than two-thirds of the forest is in semi-arid land, followed by almost one-quarter in the dry subhumid zone. Less than 10 percent is in the arid zone, and 1 percent in hyperarid land (Figures 22 and 23).

The semi-arid zone also accounts for more than two-thirds of other wooded land, with the next largest amount in the arid zone (Figure 24).

FIGURE 20

Distribution of land uses in Northern Africa's drylands ('000 ha)

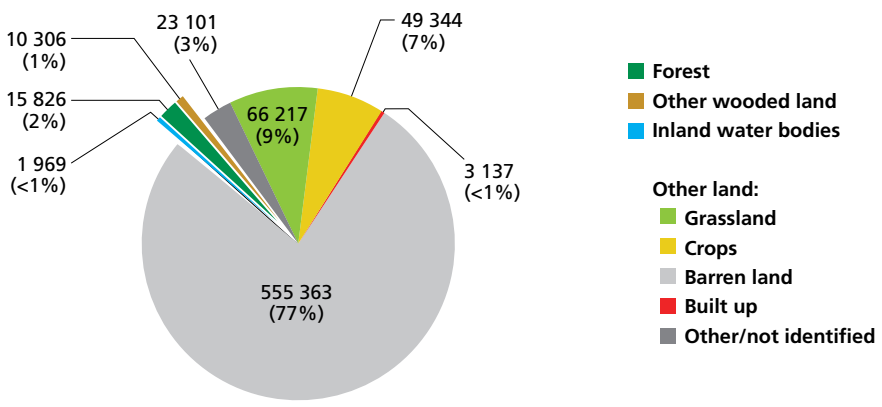
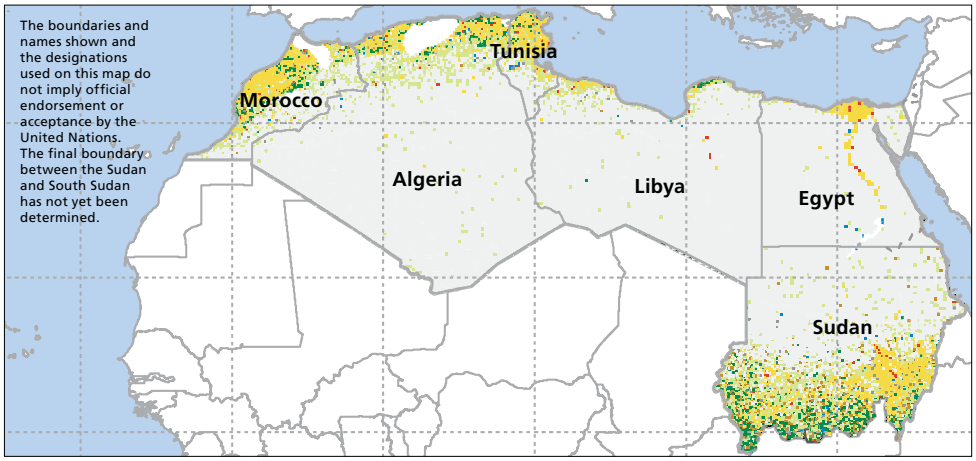


FIGURE 21

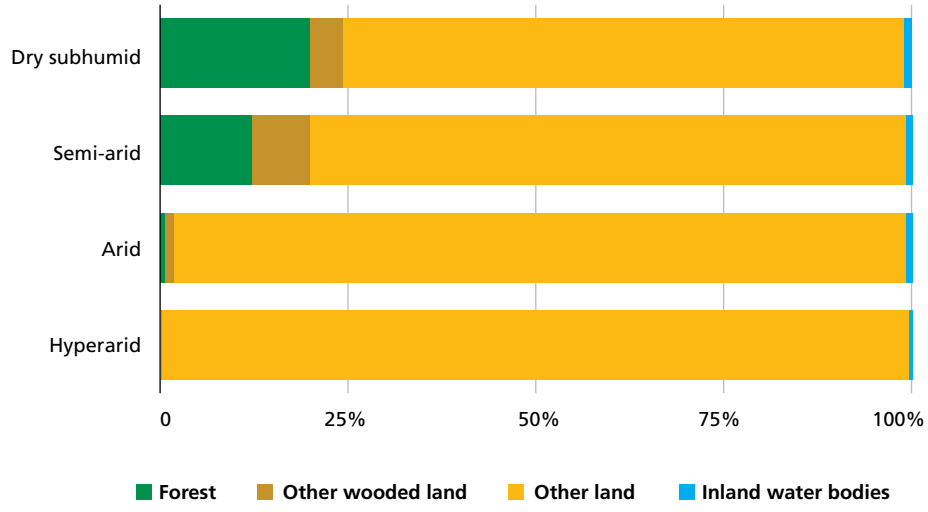
Main land uses in Northern Africa's drylands



Source: UN Maps, 2019

FIGURE 22

Distribution of land uses by aridity zone



VEGETATION IN FORESTS AND OTHER WOODED LAND

The forests in Northern Africa's drylands are about two-thirds broadleaved and almost one-quarter coniferous (Table 8, Figure 25; see also Box 5). Broadleaves account for 73 percent of the forest in the semi-arid zone and about 50 percent in each of the other zones. Coniferous forest represents 40 percent of the forest in the dry subhumid zone, 34 percent in the arid zone and 16 percent in the semi-arid zone. Mixed broadleaved and coniferous forest represents 2 percent of the total, while planted forest represents 4 percent, with about 5 percent unidentified by the assessment.

Other wooded land consists mostly of grassland with trees and shrubs (53 percent) and grassland with shrubs (38 percent) (Table 9). Grassland with trees and shrubs is

FIGURE 23
Distribution of dryland forest by aridity zone ('000 ha)

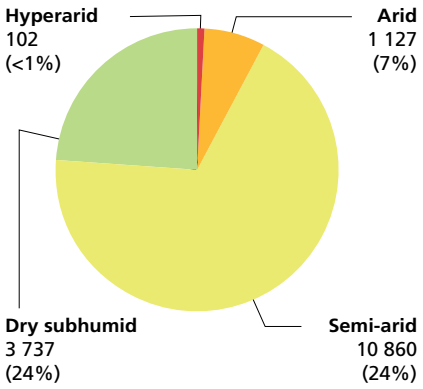
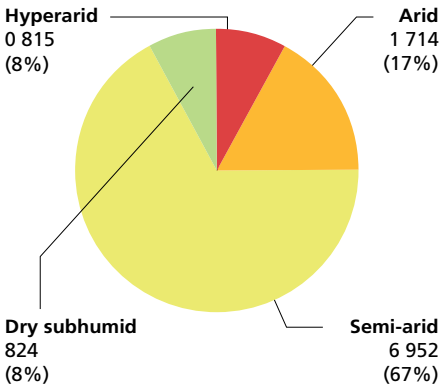


FIGURE 24
Distribution of other wooded land by aridity zone ('000 ha)



found in all aridity zones; it is the dominant vegetation type in the woodlands of the dry subhumid zone (accounting for 67 percent of other wooded land) and semi-arid zone (56 percent). The hyperarid and semi-arid zones have roughly equal distribution of grassland with shrubs and grassland with trees and shrubs. Grassland with shrubs is least prominent in the dry subhumid zone, where it accounts for 29 percent of other wooded land. Only 1 percent of other wooded land was identified as shrubland, mainly found in the arid zone. The vegetation type was not identified for about 9 percent of other wooded lands.

TABLE 8
Type of forest vegetation by aridity zone

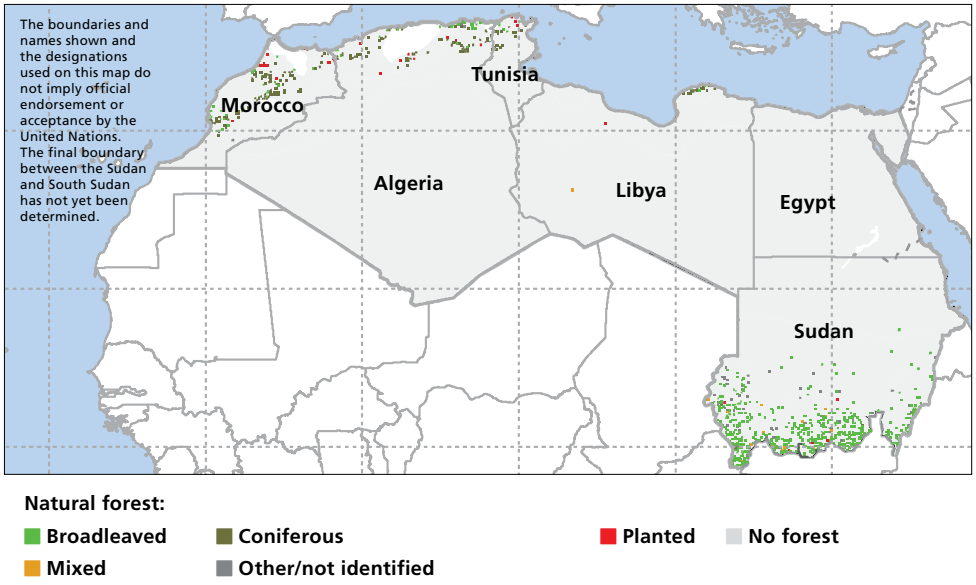
Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest										
Broadleaved	51	50	563	50	7 950	73	1 901	51	10 465	66
of which riparian	0	0	128	11	254	2	67	2	449	3
Coniferous	0	0	385	34	1 760	16	1 482	40	3 628	23
Mixed broadleaved and coniferous	51	50	0	0	220	2	50	1	321	2
Other/not identified	0	0	154	14	541	5	151	4	846	5
Planted forest	0	0	26	2	389	4	152	4	567	4
Total	**102**	**100**	**1 127**	**100**	**10 860**	**100**	**3 737**	**100**	**15 826**	**100**

TABLE 9
Main vegetation types in other wooded land by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	306	38	767	45	2 588	37	235	29	3 896	38
Grassland with trees and shrubs	306	38	717	42	3 873	56	555	67	5 451	53
Shrubland	0	0	26	1	34	0	0	0	59	1
Other/not identified	204	25	205	12	457	7	34	4	899	9
Total	**816**	**100**	**1 714**	**100**	**6 952**	**100**	**824**	**100**	**10 306**	**100**

FIGURE 25

Distribution of dryland forest by subtypes



Source: UN Maps, 2019

BOX 5

Forest and woodland vegetation types in the drylands of Northern Africa

Northern Africa, with its diverse geographic landscapes, has five main forest types: xeric pine forest (of which 85 percent is in Algeria); cork oak (*Quercus suber*) forest (again, with 85 percent in Algeria); holm oak (*Quercus ilex*) and holly oak (*Quercus coccifera*), which are the most abundant tree species in the Mediterranean areas (72 percent in Morocco and 34 percent in Algeria); and Berber thuya (*Tetraclinis articulata*), a very old conifer species endemic to Northern Africa, which can occur in coppice woodlands and extends over 70 percent of Morocco.

Another important endemic tree is the argan tree (*Argania spinosa*), found in southwestern Morocco and southwestern Algeria, which produces a highly valuable and expensive oil marketed for use in cosmetics, providing an economic activity for communities and investors.

Wild olive (*Olea europaea* and *Olea maroccana*) and carob (*Ceratonia siliqua*) were once widespread, but have now been widely domesticated (for production of olive oil and fodder, respectively), and only a few small stands maintain the natural structure of this forest type. Human impacts – mainly grazing, fire and fuelwood collection – have transformed most of the remaining communities into secondary dense shrubs and agroforestry landscapes.

Source: WWF, undated.

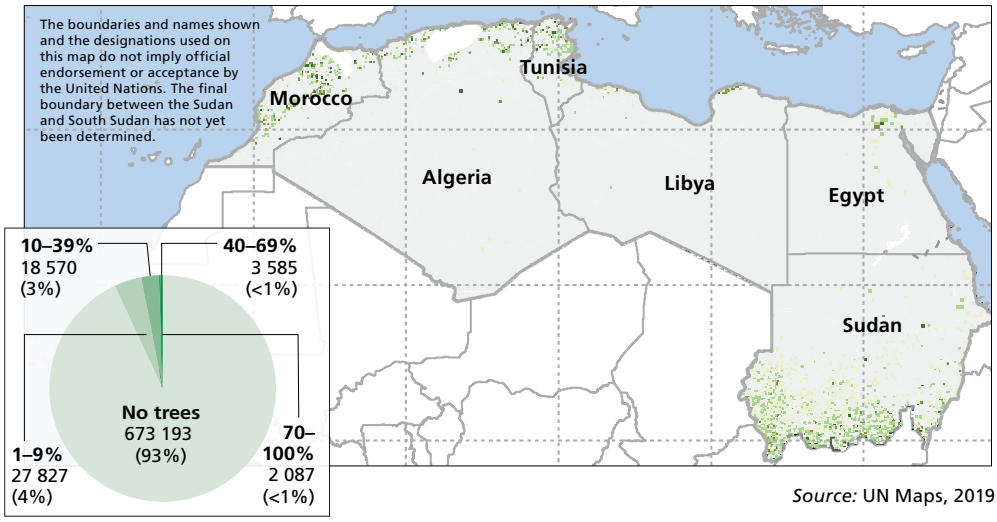
TREE CANOPY COVER

In general, 93 percent of Northern Africa's drylands have no trees. However, 3 percent of the dryland area has tree canopy cover of 10 to 39 percent. The remaining 4 percent has canopy cover in the range of 1 to 9 percent (Figure 26). In general, the tree cover decreases with increasing aridity, being highest in the dry subhumid zone and lowest in the hyperarid zone (Table 10).

TABLE 10
Average tree canopy cover in Northern African drylands by land use and aridity zone (%)

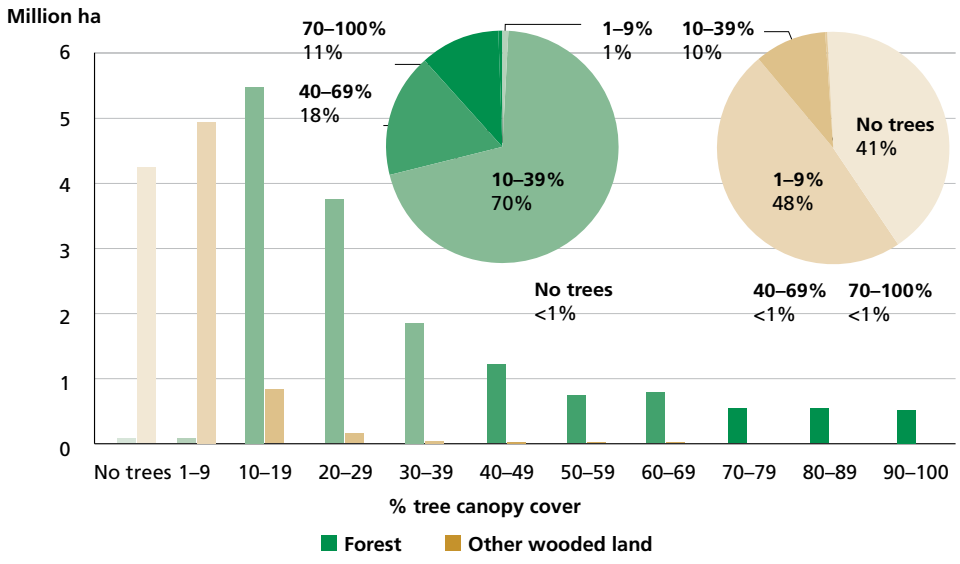
Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	15	34	31	42	**34**
Other wooded land	4	4	5	6	**5**
Other land	0	0	2	2	**0**
Inland water bodies	0	1	2	4	**1**
All lands	**0**	**1**	**6**	**11**	**1**

FIGURE 26
Distribution of tree canopy cover in Northern Africa's drylands by tree cover range ('000 ha)



Source: UN Maps, 2019

FIGURE 27
Tree canopy cover in forest and other wooded land



On average, tree canopy cover in forest is 34 percent. Only 11 percent of the forest in Northern Africa has tree canopy cover of more than 70 percent, while 29 percent has a closed canopy cover of over 40 percent (Figure 27). An estimated 70 percent of

the forest has canopy cover ranging from 10 to 39 percent. By aridity zone, the canopy cover in forest ranges from 41 percent in the dry subhumid zone to 15 percent in the hyperarid zone (Table 10).

Tree canopy cover in other wooded land is almost all below 40 percent; it is in the range of 1 to 9 percent on 48 percent of other wooded land, and in the range of 10 to 39 percent on 10 percent of other wooded land. In the region, 42 percent of other wooded land has no tree cover.

SHRUB COVER

The majority (91 percent) of Northern Africa's drylands is without shrub cover (Figure 28). Only 3 percent of the dryland area has shrub cover between 10 and 39 percent. In 5 percent of the area the coverage ranges from 1 to 9 percent.

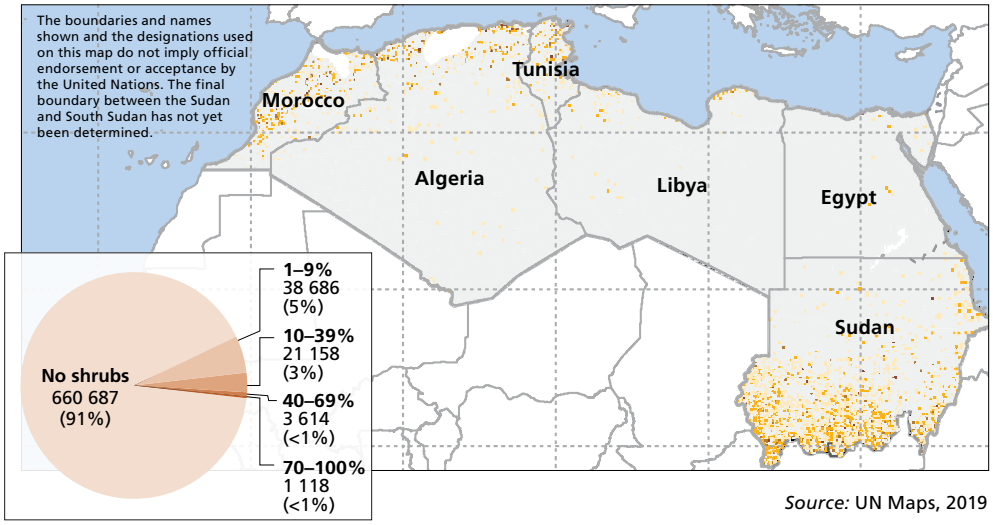
Average shrub cover in other wooded land is twice the average of shrub cover in forest (22 and 11 percent, respectively) (Table 11). Shrub cover is very low in other land. Shrub coverage shows little variation among aridity zones, especially in forest and other wooded land.

Almost 42 percent of forest has no shrub cover, compared with 10 percent of other wooded land (Figure 29). The next highest area, 36 percent of forest, has shrub cover between 10 to 39 percent. Only 1 percent of forest has shrub cover between 70 and 100 percent.

A slightly larger amount of other wooded land, 5 percent, has shrub cover between 70 and 100 percent. Shrub cover ranges from 10 to 39 percent on 48 percent of other wooded land and 37 percent of the other wooded land has less than 9 percent of shrub cover.

FIGURE 28

Shrub cover in Northern Africa's drylands ('000 ha)



Source: UN Maps, 2019

TABLE 11

Average shrub cover by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	9	10	11	14	**11**
Other wooded land	21	22	22	22	**22**
Other land	0	1	4	4	**1**
Inland water bodies	0	2	4	4	**2**
All lands	**0**	**1**	**6**	**7**	**1**

FIGURE 29

Shrub cover in forest and other wooded land

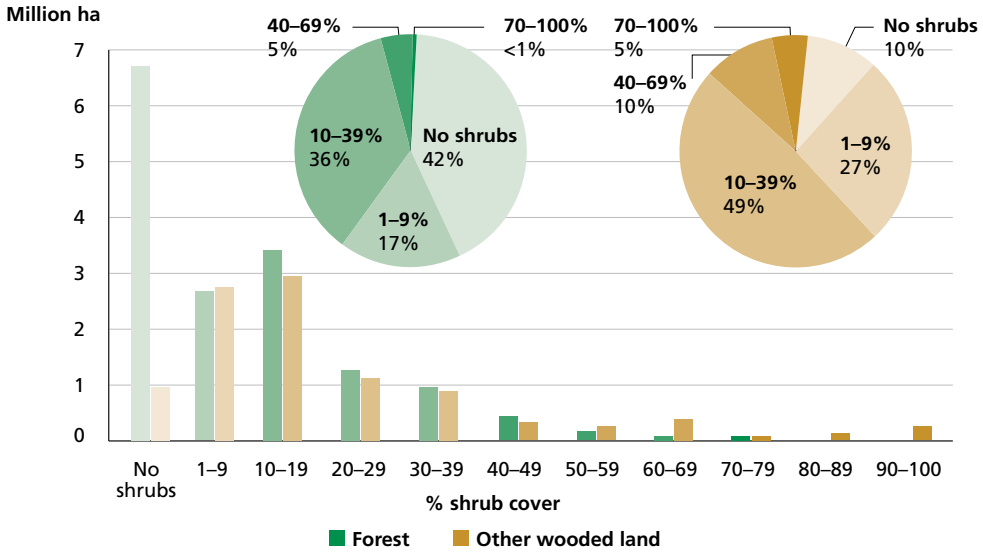
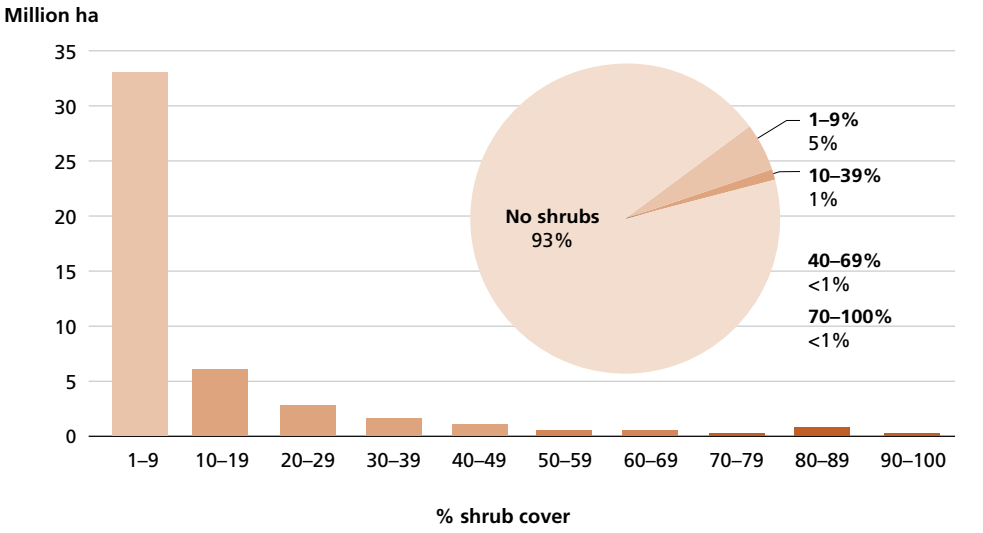


FIGURE 30

Shrub cover in other land



Almost 93 percent of other land has no shrub cover, while 5 percent (33 million hectares) has shrub cover ranging from 1 to 9 percent (Figure 30).

OTHER LAND

Two-thirds of other land is in the hyperarid zone, while 22 percent is in arid land, 10 percent in semi-arid land and only 2 percent in the dry subhumid zone (Figure 31).

Other land comprises 80 percent barren land (555 million hectares), 9 percent grassland (66 million hectares) and 7 percent cropland (49 million hectares) (Figure 32).

The barren lands are mainly (78 percent) in the hyperarid zone, where they cover 434 million hectares, and decrease with decreasing aridity; only 2 million hectares

FIGURE 31

Distribution of other land by aridity zone ('000 ha)

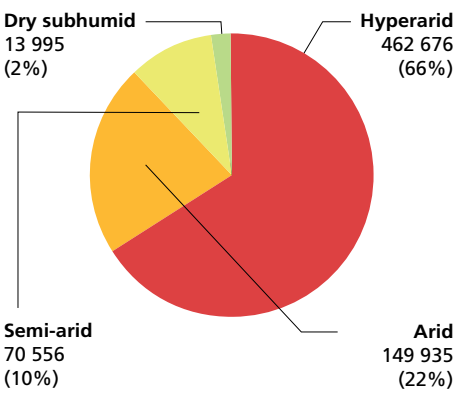


FIGURE 32

Distribution of other land by land use ('000 ha)

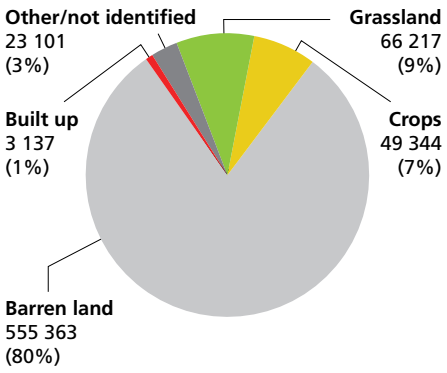
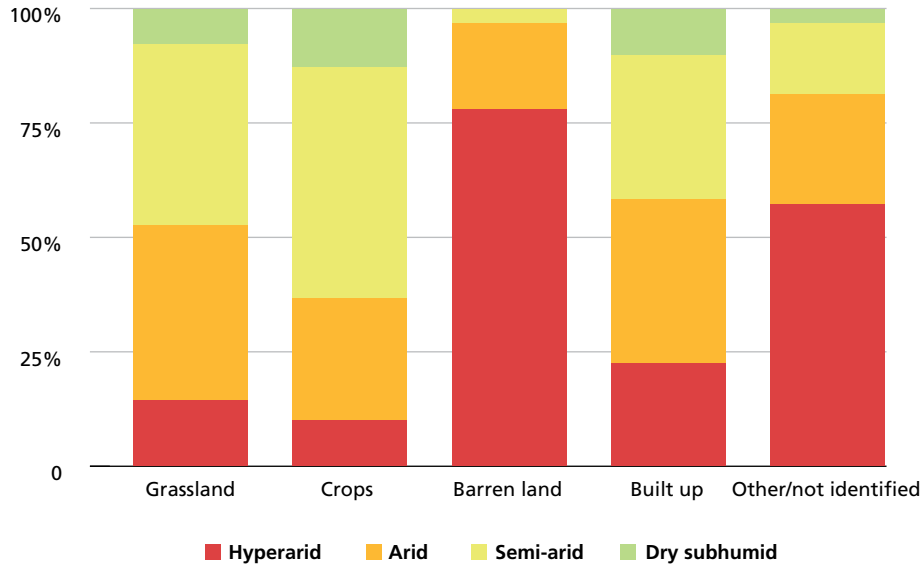


FIGURE 33

Land use in other land by aridity zone



are found in the dry subhumid zone (Figure 33, Table 12). Barren land comprises predominantly (87 percent) sand and dunes, and 13 percent rock or stone.

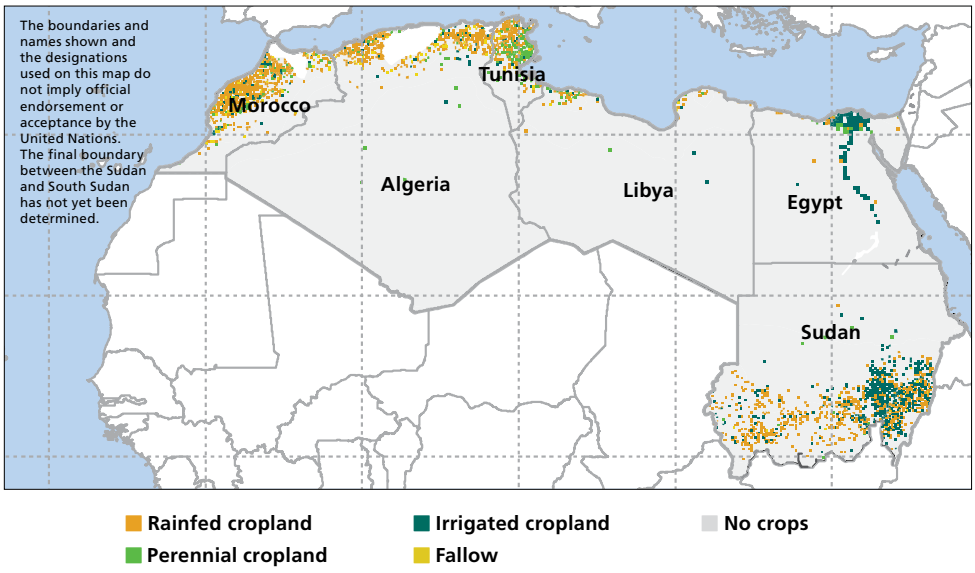
The grasslands are distributed evenly among the arid and semi-arid zones, which have 40 and 39 percent of the total, respectively, while the hyperarid and dry subhumid zones have 15 and 7 percent of total grasslands, respectively. The semi-arid and arid zones have the most grasslands, with about 26 million hectares each, compared with about 10 million hectares in hyperarid land and about 5 million hectares in the drysubhumid zone.

Cropland is distributed mainly in the semi-arid and arid zones near the Nile River and the Atlas Mountains. About 55 percent (27 million hectares) is categorized as non-irrigated cropland, found in the semi-arid (17 million hectares), arid (5 million hectares) and dry subhumid (4 million hectares) zones. Irrigated and perennial crops are found mostly in the semi-arid and arid zones, having the lowest distribution in the dry subhumid zone (Figure 34).

TABLE 12
Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	4 960	13 159	25 127	6 097	49 344	100
Irrigated crops	3 643	5 782	5 024	674	15 122	31
Non-irrigated cropland	405	5 325	16 735	4 430	26 895	55
Perennial crops (palms, orchards, others)	912	1 539	2 200	421	5 073	10
Cropland fallow	0	513	1 168	573	2 254	5
Grass	9 643	25 703	26 207	4 664	66 217	100
Barren land	434 051	104 435	14 569	2 307	555 363	100
Rock or stone	58 649	9 460	4 722	1 347	74 178	13
Sand and dunes	375 402	94 976	9 814	960	481 151	87
Snow and glaciers	0	0	34	0	34	0
Built up	709	1 127	998	303	3 137	100
Villages and urban settlements	456	897	795	286	2 434	78
Infrastructure	253	231	186	17	687	22
Mining	0	0	17	0	17	1

FIGURE 34
Distribution of crop types



Source: UN Maps, 2019

Built-up areas account for only 3 million hectares of Northern Africa's drylands. They are divided among urban and rural settlements (78 percent), infrastructure (22 percent) and mining (1 percent). Villages and urban areas are more predominant in the arid and semi-arid zones, where they account for 0.8 and 0.9 million hectares, respectively.

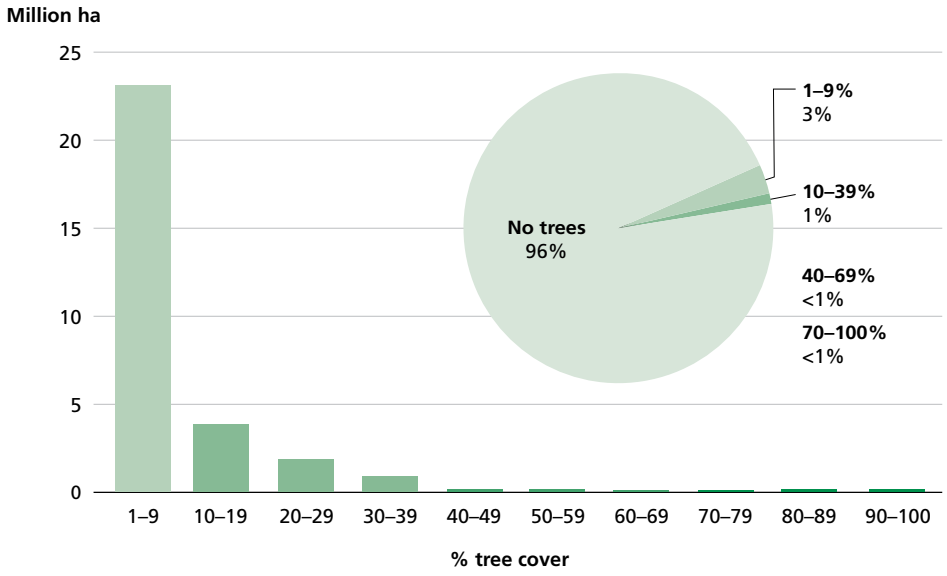
As Northern Africa is predominantly in the hyperarid zone, natural inland water bodies occupy less than 1 percent of the dryland area, covering around 2 million hectares. Most of the region's water bodies are saline waters (24 percent of inland water) and artificial lakes or reservoirs created through dam construction (23 percent). Permanent rivers and inland deltas, seasonal rivers and seasonal lakes account for 12 to 13 percent each.

TREES OUTSIDE FOREST

In the drylands of Northern Africa, 99 percent of other land has less than 10 percent tree canopy cover. The remaining 1 percent has tree cover below 40 percent (Figure 35).

FIGURE 35

Tree canopy cover in other land



Western and Central Africa

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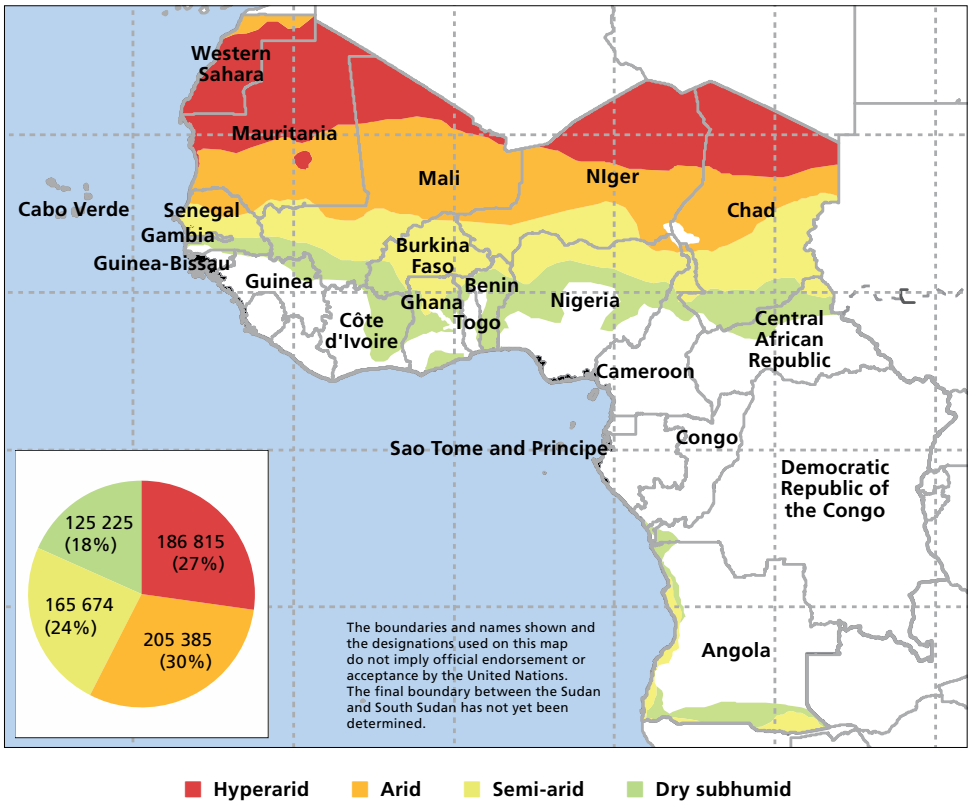
Trees in agricultural land, Burkina Faso

KEY FINDINGS

- The drylands of Western and Central Africa cover almost 683 million hectares, representing 53 percent of the region's total land area and 11 percent of the global drylands.
- The drylands of Western and Central Africa are predominantly (75 percent, or 514 million hectares) classified as other land.
- Forests cover 103 million hectares (15 percent of the drylands), mostly concentrated in the dry subhumid zone (66 percent) and the semi-arid zone (30 percent).
- Other wooded land covers 61 million hectares. More than half of it is in the semi-arid zone, with the rest divided almost evenly between the arid and dry subhumid zones.
- More than two-thirds of other land is categorized as barren land, comprising mostly sand and dunes.
- Grassland or herbaceous savannah makes up 16 percent of other lands (84 million hectares), distributed primarily in the semi-arid and arid zones.
- Crops, mostly rainfed, cover 11 percent of other land (56 million hectares) and are mainly in the semi-arid zone.
- Trees outside forest are present on 97 million hectares, or 19 percent of other land.

FIGURE 36

Distribution of drylands in Western and Central Africa by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

The drylands of Western and Central Africa cover a total area of 683 million hectares, representing 11 percent of the world's drylands. Most of these drylands occur in the West African Sahel – an expanse of grassland, shrubs and small, thorny trees lying just south of the Sahara – while only a minor part (4 percent or 25 million hectares of the total drylands) is located in Central Africa (Angola, the Congo, the Democratic Republic of the Congo) (Figure 36).

The drylands are distributed relatively evenly in the four aridity zones, with slightly more in the arid (30 percent) and hyperarid (28 percent) zones, which are located in the Saharan and sub-Saharan areas. The semi-arid and dry subhumid zones are closer to tropical Central Africa.

The regional assessment presented in this report is based on a survey of 29 187 plots. The data collection and the analyses were completed by a regional team including representatives of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS) and the Regional Training Centre for Agrometeorology and Operational Hydrology and their Applications (AGRHYMET) in Niamey, the Niger in 2015.

The data reported here were used to estimate the restoration needs for the core area of Africa's Great Green Wall (Berrahmouni *et al.*, 2016).

BACKGROUND

Climate

Western Africa's climate – resulting from the interaction of hot, dry continental air masses originating above the Sahara with moist equatorial air masses originating over the Atlantic Ocean – is characterized by dusty winds from November to February

and annual monsoon rains from May to September (USGS EROS, 2016). Temperatures over West Africa have increased over the past 50 years, in line with an increase in global temperatures (Niang *et al.*, 2014). In the Sahel, maximum temperatures can reach above 40 °C.

In the semi-arid zone, where average rainfall is skewed to dryness (i.e. a few heavy-rainfall years are balanced out by more years of below-average rainfall), drought is a recurring phenomenon. From the late 1960s through the 1980s, the Sahel zone experienced droughts of unprecedented spatial extent and duration (Hulme, 2001). These droughts followed a period of more favourable rainfall in the 1950s and early 1960s, which had encouraged government planners and farmers to expand agriculture northwards (Glantz, 1994).

Precipitation – by far the most significant climatic element – is characterized by latitudinal belts, with rainfall and wet-season duration decreasing with higher latitude. Ouagadougou, Burkina Faso (latitude 12° north) records a mean annual rainfall of 700 mm within a 5-month rainy season, while Agadez, the Niger (18° north) records 165 mm in a short 2.5-month rainy season. The variability and unpredictability of rainfall are as significant as its scarcity: Year-to-year variability reaches over 40 percent in the northern Sahel (Nicholson, 2013), and the semi-arid zone has witnessed shifts in rainfall from 50 mm per year in a rainy season of 1 to 2 months, to around 1 000 mm per year in a rainy season of 3 to 5 months.

Central Africa is bordered to the north and south by subtropical dry areas. The contrast in air temperature and pressure encourages the formation of strong winds (around 5 km) over northern and southern Central Africa from September to November, bringing heavy rains. The longer rainy season, during which rains are not as heavy, is from March to May (Future Climate for Africa, 2016).

Importance of forest and trees for biodiversity and livelihood

As rainfall increases progressively southward, the Sahel vegetation undergoes a gradual transition from semi-desert grassland to savannah grassland with low trees, shrubs and savannah woodlands. Along this gradient, the vegetation becomes increasingly taller and the proportion of woody species and the amount of ground cover increases.

Trees are often integral parts of traditional food systems in Western Africa. Agroforestry is a widespread practice. Mixed agroforestry regimes promote yields and resilience, contributing to improvement in income, diets and rural business development. Agroforestry also helps to protect and conserve land; to control soil erosion, salinity and water tables; and to improve timber quality control. A denser tree cover provides shelter to livestock during the warmer months, allowing the animals to conserve energy, and helps to block wind and boost water retention, which can help produce a more robust crop yield. *Faidherbia albida* is a valuable tree in agroforestry systems because it improves soil fertility and its pods are an important animal feedstock. Another important species is *Andansonia digitata* (baobab tree), which produces food for humans and is a significant source of vitamins and nutrients (Sacande, Sanou and Beentje, 2012; Sacande, Sanogo and Beentje, 2016).

Although the extent of mangroves is too small for them to have been mapped at the scale of this assessment, they fulfil important functions for the livelihoods of coastal populations throughout the Sahel and West Africa. They conserve valuable biodiversity and provide wood and non-wood forest products, habitat, coastal protection and spawning grounds and nutrients for a variety of fish and shellfish (Corcoran, Ravilious and Skuja, 2007). However, mangroves are a heavily threatened ecosystem throughout the region.

The farmlands, grasslands and woodlands of the Sahel are important wintering and staging areas for a wide variety of birds migrating from Europe. Many species undertake this migration, including waterfowl, waders, birds of prey and songbirds: over 2 billion songbirds migrate from Europe to sub-Saharan Africa each year. Birds that winter in

the Sahel use landscapes intensively managed by farmers and livestock keepers (Sanou and Oueda, 2009).

Trends and challenges

Climate variability and changes are having an impact on land cover in Western and Central Africa by changing the amount and timing of water availability to vegetation cover. Heavy and concentrated rainstorms, for example, damage crops and alter pasture composition unfavourably, while also causing severe soil erosion, particularly on cleared cultivated land. Land cover is also being modified or transformed through land-use decisions in response to the changes and variability of the climate.

The great Sahelian droughts forced the abandonment of agriculture at the arid margin. Vegetated and bare soils exhibit differences in temperature and humidity, particularly at a local scale (Reij, Tappan and Smale, 2009). Bare soils are vulnerable to wind and water erosion and hence to land degradation. Soil erosion in turn affects water regimes and freshwater ecosystems.

Direct human pressures, linked mainly to population growth, the need for more land to satisfy the demand for food and biomass energy, poverty, and cultivation and livestock methods, are also leading to changes in vegetation cover, loss of interspecies and genetic diversity, and decreased integrity of the wildlife habitat. Intensive grazing has led to degradation of natural pasture land. In Burkina Faso, for example, increases in livestock production, obtained through overgrazing and overstocking, have resulted in steady declines in pasture productivity and soil fertility (Government of Burkina Faso Ministry of Agriculture, Water and Fisheries & IFAD, 2007).

Woodlands provide shelter for a pastoralist family, the Niger

Encouraging recent research suggests that forests in protected areas or protected by conservation schemes are likely to survive the impacts of human development (Chazdon *et al.*, 2016; Lund, 2000; Romijn *et al.*, 2015). During the past half-century, many afforestation and reforestation efforts and initiatives in the region have aimed to reduce the further disappearance of species, not only in degraded and fragile ecosystems but also in those experiencing ongoing degradation (Ganaba, 2011). These include regreening efforts aimed at restoring the spatial patterns and original landscapes of the Sahel forest fragments through sowing of diversified endemic and naturalized trees and grasses. Such efforts are sustained through the ambitious Africa's Great Green Wall initiative, begun by the African Union in 2007, and also more recently by the African Forest Landscape Initiative (AFR100), launched at the 2015 United Nations Climate Change Conference in Paris, which has pledged to restore 100 million hectares of degraded and deforested land in Africa by 2030. FAO's Action Against Desertification in support of the Great Green Wall is paving the way for a large-scale restoration approach that benefits small-scale farming (FAO, 2019). The Sahel drylands have huge potential for restoration. A wealth of suitable intervention models could be scaled up and could bring rural development opportunities to the region's agrosilvopastoral systems (Sacande and Berrahmouni, 2016).

The proclamation of the UN Decade of Ecosystem Restoration 2021–2030 is expected to assist the recovery of degraded, damaged and destroyed ecosystems in the Sahel. Ecosystem restoration through a landscape approach will enhance conservation, recovery and sustainable land and forest management, to help the region's drylands regain ecological functionality and provide goods and services.

DISTRIBUTION OF FORESTS AND OTHER LAND USES

The region's drylands are predominantly (75 percent, or 514 million hectares) classified as other land (Figures 37 and 38). While forest covers the majority of land in the dry subhumid zone, other wooded land dominates the semi-arid zone (Figure 39). The arid zone, which is the largest zone in the region, is more than 90 percent other land.

Forests cover 103 million hectares (15 percent of the drylands), mostly concentrated in the dry subhumid zone (66 percent) and the semi-arid zone (30 percent) (Figure 40).

Other wooded land covers 61 million hectares, concentrated mainly in the semi-arid zone (52 percent), with the remaining area divided almost evenly between the arid and dry subhumid zones (22 and 24 percent, respectively) zones (Figure 41). Only 2 percent of other wooded land is in the hyperarid zone.

FIGURE 37

Distribution of land uses in the drylands of Western and Central Africa ('000 ha)

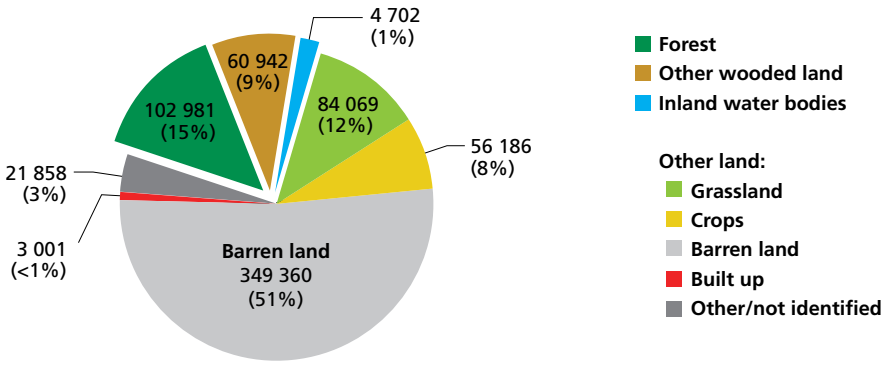
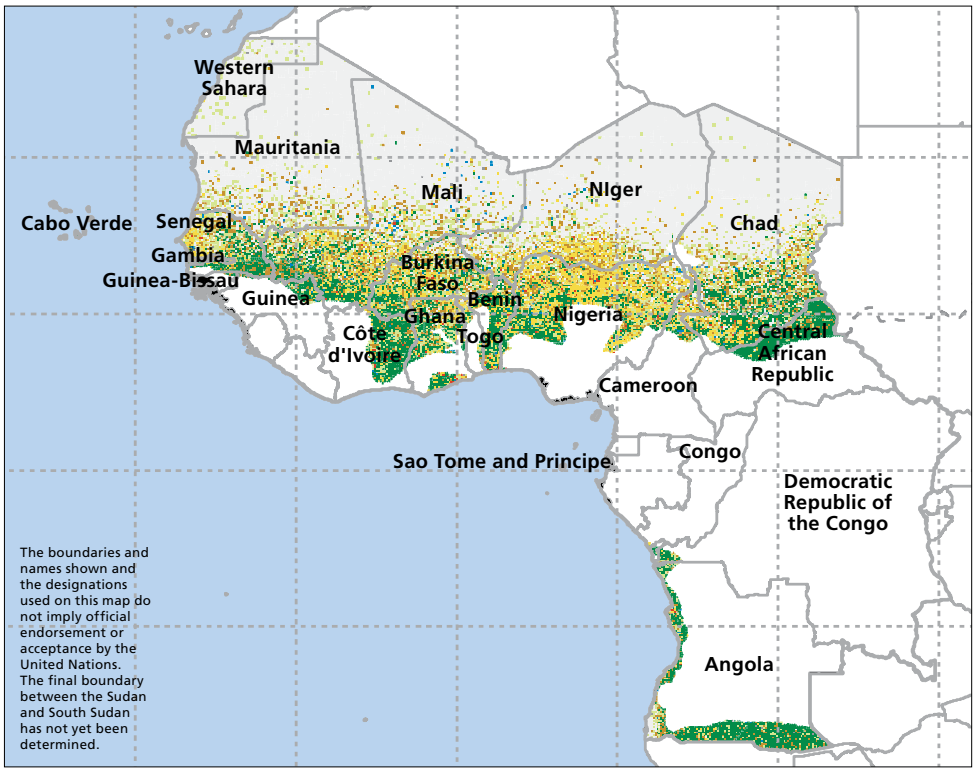


FIGURE 38

Main land uses in the drylands of Western and Central Africa



Source: UN Maps, 2019

FIGURE 39

Distribution of land uses by aridity zone

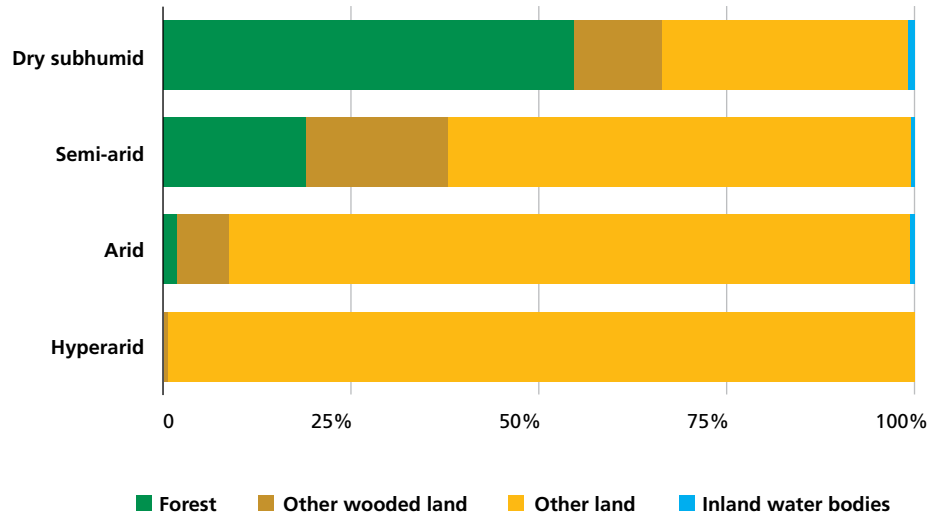


FIGURE 40

Distribution of dryland forest by aridity zone ('000 ha)

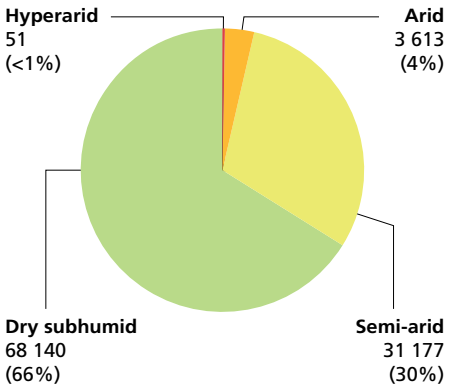
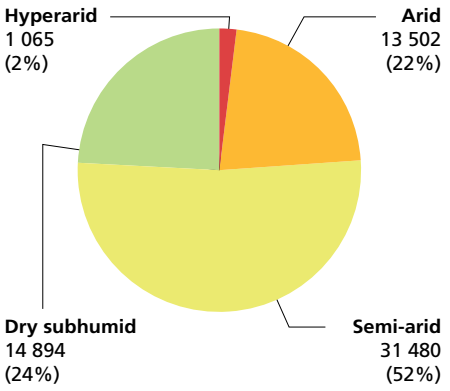


FIGURE 41

Distribution of other wooded land by aridity zone ('000 ha)

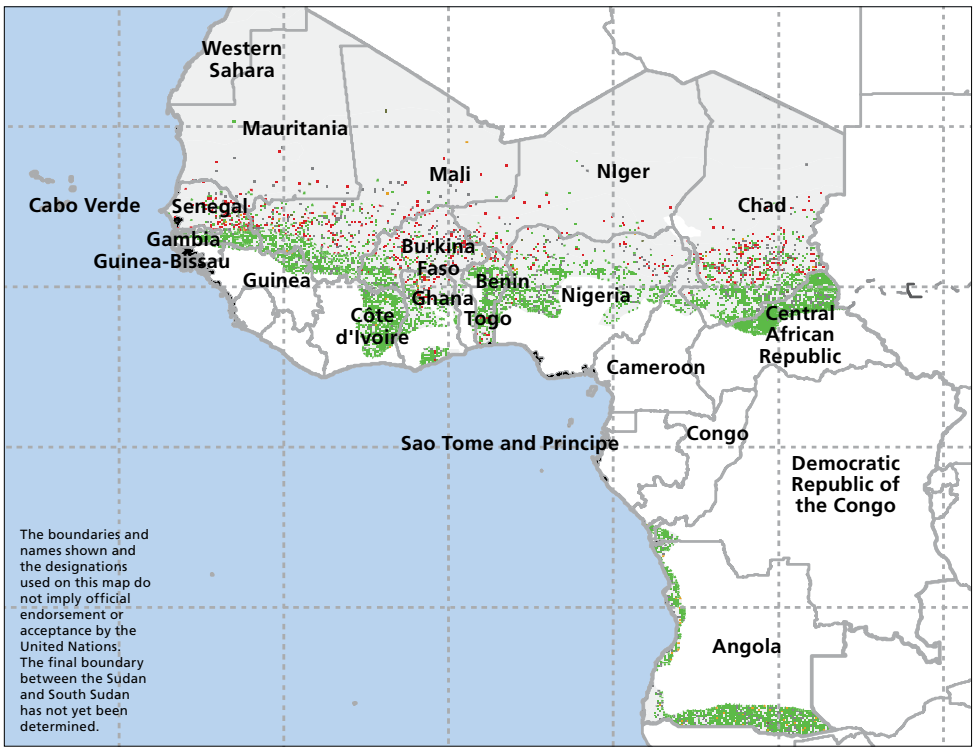


VEGETATION IN FORESTS AND OTHER WOODED LAND

Forests having a majority of broadleaved species represent more than three-quarters of all forests in the region's drylands (Figure 42, Table 13). An estimated 4 percent of broadleaved forest is riparian. Approximately 10 percent of the forest area is planted forest.

FIGURE 42

Distribution of dryland forest by subtypes



Source: UN Maps, 2019

TABLE 13
Type of forest vegetation by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest										
Broadleaved	51	100	1 332	37	17 382	56	61 838	91	80 603	78
of which riparian	0	0	487	13	2 925	9	1 154	2	4 566	4
Coniferous	0	0	51	1	639	2	116	0	806	1
Mixed broadleaved and coniferous	0	0	51	1	665	2	409	1	1 125	1
Other/not identified	0	0	871	24	4 065	13	5 457	8	10 393	10
Planted forest	0	0	1 307	36	8 426	27	321	0	10 054	10
Total	**51**	**100**	**3 613**	**100**	**31 177**	**100**	**68 140**	**100**	**102 981**	**100**

TABLE 14
Main vegetation types in other wooded land by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	761	71	5 739	43	8 367	27	5 044	34	19 911	33
Grassland with trees and shrubs	203	19	5 637	42	12 968	41	7 938	53	26 746	44
Shrubland	51	5	615	5	2 024	6	820	6	3 509	6
Other/not identified	51	5	1 512	11	8 122	26	1 092	7	10 776	18
Total	**1 065**	**100**	**13 502**	**100**	**31 481**	**100**	**14 894**	**100**	**60 942**	**100**

Other wooded land is dominated by grassland with shrubs (44 percent of the total) and grassland with small trees and shrubs (33 percent), such as tiger bush with acacia stands (Table 14). Grasses include both perennial species, generally not taller than 80 cm, and annual species. The surface is to a large extent bare soil, and the vegetation tends to form a mosaic pattern, clustered in regions of favourable soil or run-off.

TREE CANOPY COVER

In general, 65 percent or 446 million hectares of the drylands of Western and Central Africa have no trees. On average, tree canopy cover in the region's dryland forest is 54 percent (Figure 43). The density of tree canopy cover exhibits a clear gradient according to the degree of aridity, with denser forests in the dry subhumid zone (where tree canopy cover averages 60 percent) and sparse forests in the hyperarid zone (with an average canopy cover of 25 percent) (Table 15, Figure 44).

As shown in Figure 44, 40 percent of the forest in the region's drylands is open, with canopy cover below 40 percent; 21 percent has canopy cover ranging from 40 to 69 percent, and 37 percent has a dense canopy, with cover of 70 percent or above.

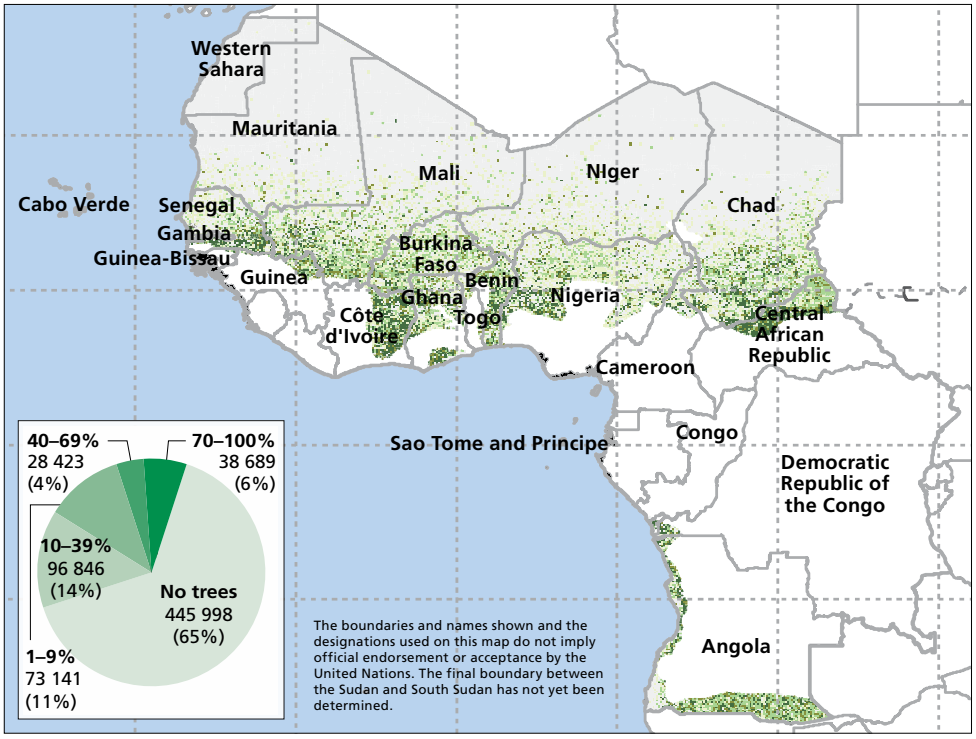
Average tree canopy cover in other wooded land is 7 percent (Table 15), while 40 percent of other wooded land has no trees.

TABLE 15
Average tree canopy cover in Western Africa's drylands by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	25	36	45	60	**54**
Other wooded land	1	5	8	5	**7**
Other land	0	1	6	6	**2**
Inland water bodies	0	0	0	0	**0**
All lands	**0**	**2**	**14**	**35**	**10**

FIGURE 43

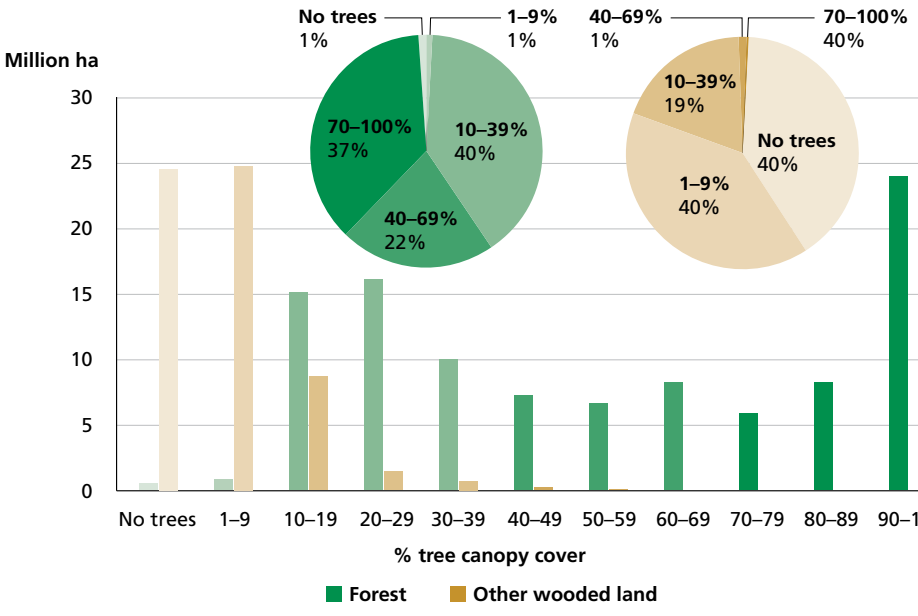
Distribution of tree canopy cover in the drylands of Western and Central Africa by tree cover range ('000 ha)



Source: UN Maps, 2019

FIGURE 44

Tree canopy cover in forest and other wooded land



SHRUB COVER

In general, 68 percent of the region's dryland has no shrubs (Figure 45).

Most other wooded land is sparsely covered with shrubs, with an average shrub cover of 26 percent. Shrubs in other wooded land are densest in the dry subhumid zone (42 percent) and most sparse in the arid zone (16 percent) (Table 16).

Shrub cover is in the range of 10 to 39 percent on more than one-third of other wooded land (37 percent), and in the range of 1 to 9 percent on about one-quarter (27 percent). Shrub cover is dense and continuous (ranging from 70 to 100 percent) on only 12 percent of other wooded land (Figure 46).

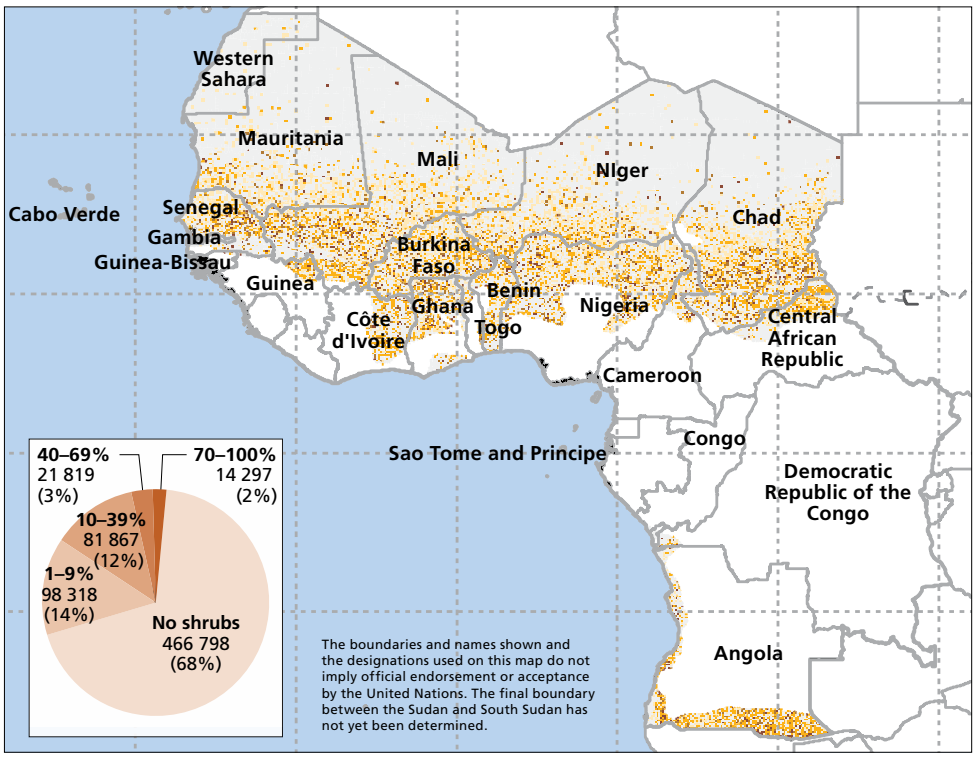
Most forest has little or no shrub cover (or shrubs could not be detected because of dense tree canopy cover). The average shrub cover is estimated to be 13 percent in the region's dryland forest. It is highest in forest located in the semi-arid and arid zones (18 and 17 percent, respectively) (Figure 46).

Most of the other land has little or no shrub cover: 79 percent has no shrubs, and 13 percent has very sparse shrub cover ranging from 1 to 9 percent (Figure 47).

TABLE 16
Average shrub cover by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	3	17	18	11	**13**
Other wooded land	34	16	23	42	**26**
Other land	0	3	9	6	**3**
Inland water bodies	0	3	8	1	**4**
All lands	**1**	**4**	**13**	**13**	**7**

FIGURE 45
Shrub cover in the drylands of Western and Central Africa ('000 ha)



Source: UN Maps, 2019

FIGURE 46

Shrub cover in forest and other wooded land

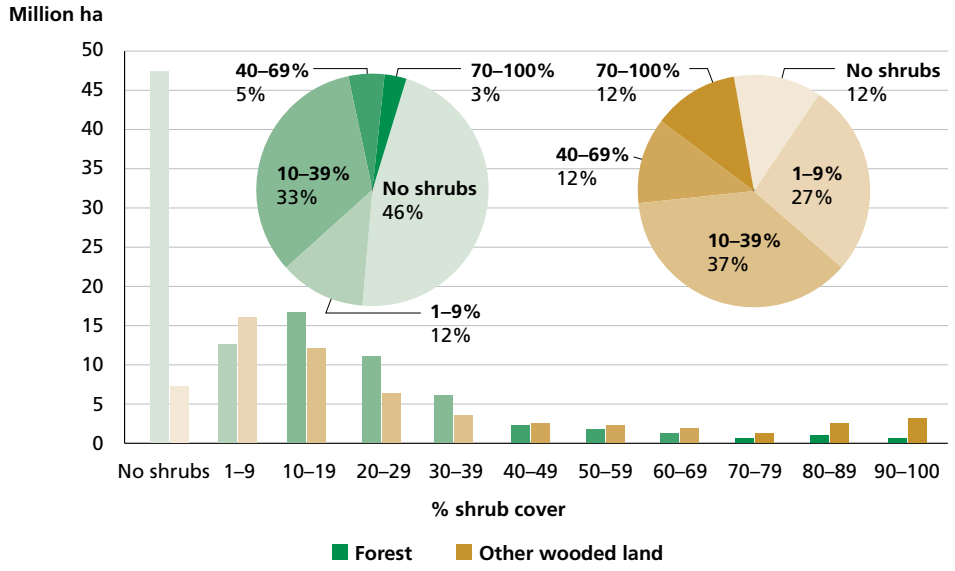
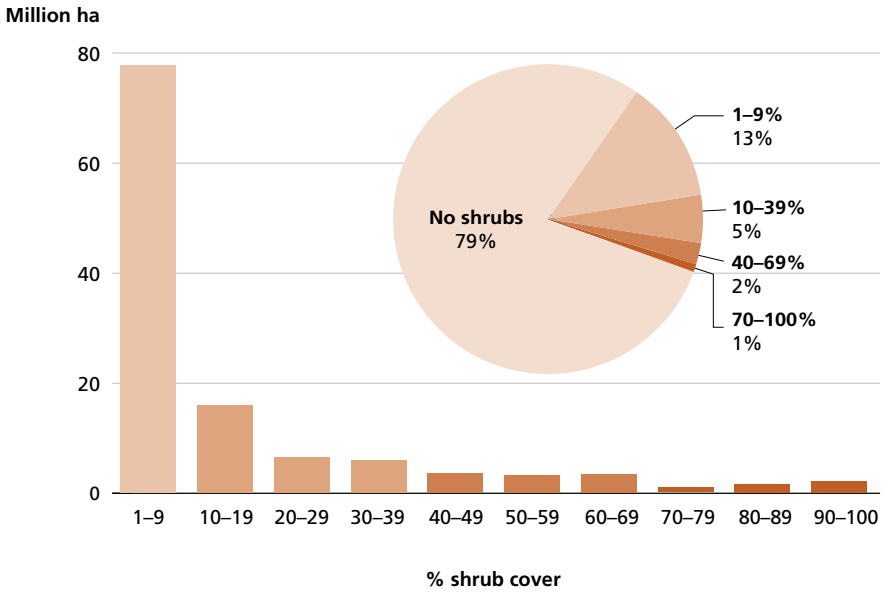


FIGURE 47

Shrub cover in other land



OTHER LAND

Most of the 514 million hectares of other land in the region's drylands is located in the hyperarid and arid zones, which account for 36 percent each (Figure 48). Only 8 percent of other land is in the dry subhumid zone.

Barren land, mostly sand and dunes, dominates the other land, accounting for 68 percent of it (Figure 49). Barren land is mainly located in the hyperarid and arid zones (Figure 50, Table 17).

FIGURE 48

Distribution of other land by aridity zone ('000 ha)

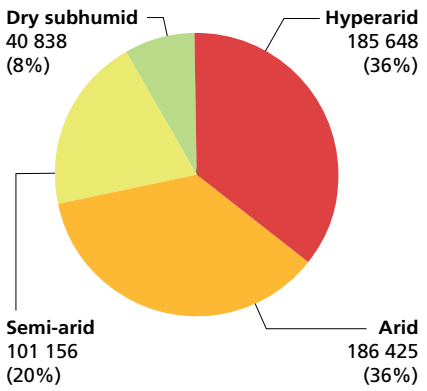


FIGURE 49

Distribution of other land by land use ('000 ha)

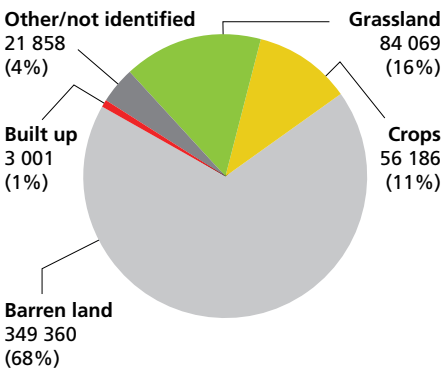
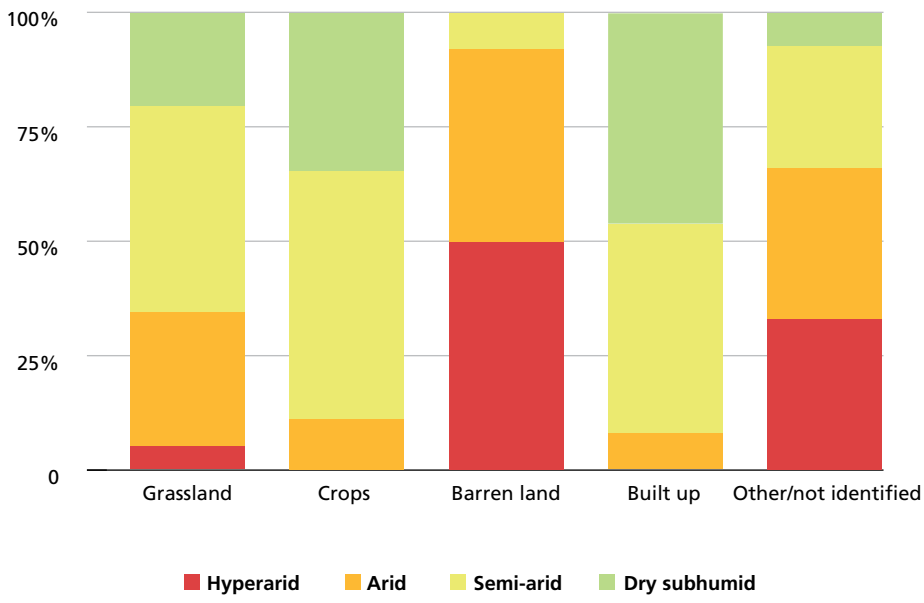


FIGURE 50

Land use in other land by aridity zone



Grassland or herbaceous savannah is the next largest category (16 percent of other land, or 84 million hectares), distributed primarily in the semi-arid and arid zones.

Crops cover 11 percent of other land, or 56 million hectares. Crops, mostly rainfed, are found mainly in the semi-arid zone (Figure 51).

Settlements and built-up areas, including urban and rural settlements, infrastructure and mines, occupy 1 percent (3 million hectares) of other lands and are predominantly found in the semi-arid and dry subhumid zones.

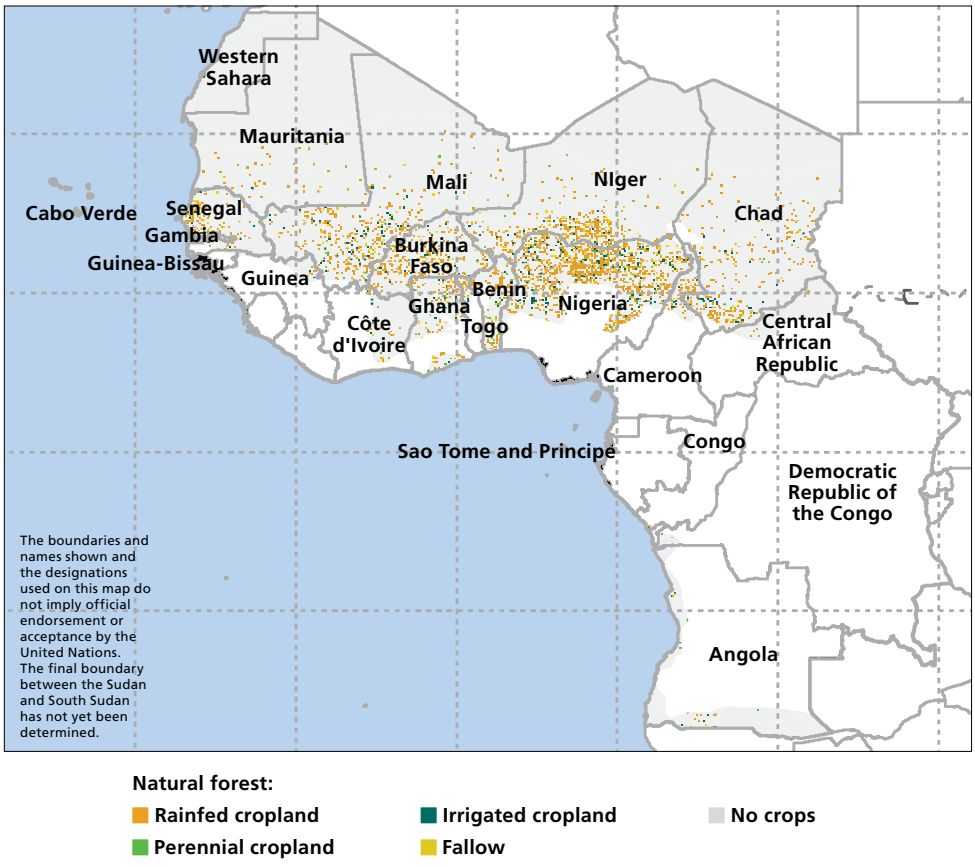
Inland water is mainly in the arid and semi-arid zones, with 39 and 31 percent respectively (around 1.8 and 1.5 million hectares), while 29 percent is in the dry subhumid zone. Only 1 percent of inland water is in the hyperarid zone.

TABLE 17
Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	51	5 867	30 952	19 316	56 186	100
Irrigated crops	51	333	4 127	2 322	6 833	12
Non-irrigated cropland	n.d.	4 740	23 131	15 184	43 055	77
Perennial crops (palms, orchards, others)	n.d.	51	502	919	1 471	3
Cropland fallow	n.d.	743	3 191	892	4 827	9
Grass	4 204	24 777	37 967	17 121	84 069	100
Barren land	174 144	148 351	25 473	1 393	349 360	100
Rock or stone	27 381	16 936	7 854	282	52 453	15
Sand and dunes	146 610	131 235	17 586	1 111	296 542	85
Snow and glaciers	152	179	34	–	365	0
Built up	–	231	1 389	1 382	3 001	100

n.d. = no data

FIGURE 51
Distribution of crop types



Source: UN Maps, 2019

TREES OUTSIDE FOREST

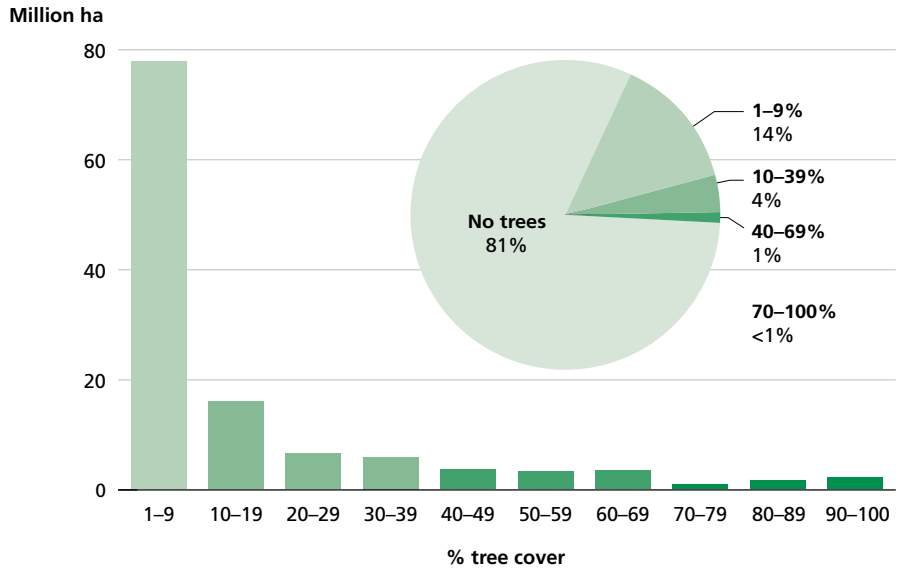
Trees are present in 19 percent of other land (97 million hectares). Tree canopy cover is below 10 percent in 488 million hectares of other land (95 percent). Only 5 percent of other land (26 million hectares) has tree cover above 10 percent (Figure 52).

Other land has 2 percent tree canopy cover on average (see Table 15), with a clear increasing gradient with decreasing aridity (from 0.1 percent in the hyperarid zone to 6 percent in the subhumid zone).

In total, considering all land uses, there are no trees on 65 percent of the region's dryland (445 million hectares).

FIGURE 52

Tree canopy cover in other land



Eastern Africa

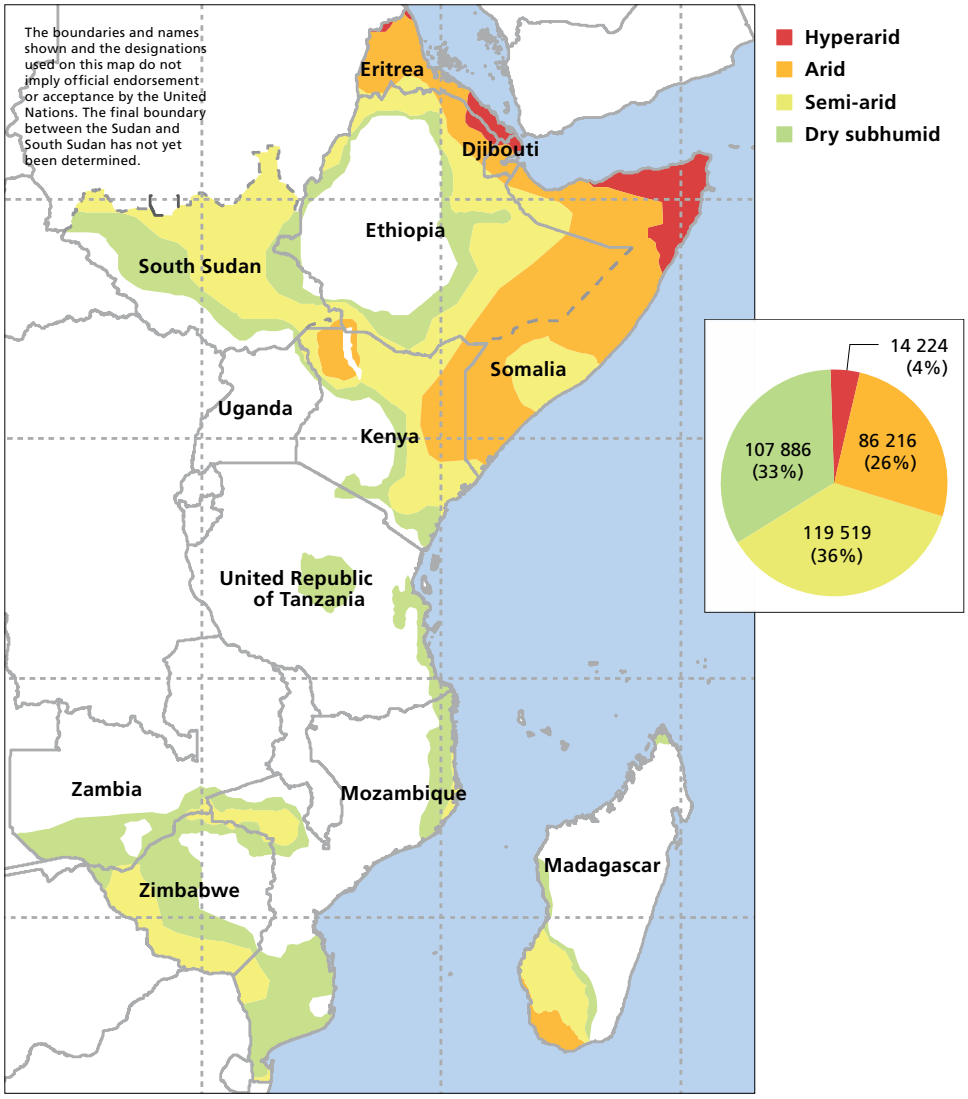
Ethiopia

KEY FINDINGS

- Drylands cover 47 percent of the land in Eastern Africa, or 328 million hectares, representing 5 percent of the global drylands.
- Most of the drylands are semi-arid (37 percent or 120 million hectares) and dry subhumid (33 percent or 108 million hectares).
- Forests span 35 percent of the drylands (116 million hectares). While 52 percent of dry subhumid areas are covered with forest, the rest of the drylands are dominated by other types of land cover, including crops and non-woody vegetation.
- Forests are mainly broadleaved. Riparian forests represent 2 percent of forest and cover less than 3 million hectares, but are important for pastoralism and grazing, especially during the dry season. The forest has a predominantly open tree canopy, with more than half having tree cover ranging from 10 to 40 percent.
- There are no trees on 40 percent (131 million hectares) of the drylands in Eastern Africa. The average tree canopy is 18 percent; it is denser in the southern part of the region and sparser in the northern part.
- About 45 percent of other wooded land, or 24 million hectares, is grassland or shrubland without trees.
- Shrubs are present in 60 percent of the drylands but are mainly sparse, with cover density ranging from 1 to 40 percent. Dense shrubs are only found in 3 percent of the total dryland area.
- Grassland covers 25 percent (82 million hectares) of Eastern Africa's drylands, while crops cover 6 percent (almost 20 million hectares). Most of the crops are rainfed; only 23 percent of cropland, 5 million hectares, is irrigated. Barren land, mostly rock, stone or sand, represents a substantial proportion of drylands (12 percent or 40 million hectares).
- Trees outside forest are found on 33 percent of other land (52 million hectares). Tree canopy cover is below 10 percent on 143 million hectares of other land (92 percent).

FIGURE 53

Distribution of drylands in Eastern Africa by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

Drylands cover 47 percent of the land in Eastern Africa, with a total area of 328 million hectares. They represent 5.3 percent of the world's drylands. These drylands are distributed mostly among the semi-arid (37 percent of dryland area), dry subhumid (33 percent) and arid (26 percent) zones (Figure 53). Only a small fraction of drylands is hyperarid (4 percent).

The regional assessment presented in this report is based on visual interpretation of 17 954 plots. The analysis was completed by a team of 20 data interpreters from the World Resources Institute (WRI) in July 2015.

BACKGROUND

Climate

Significant topographic variation, with elevation ranging from sea level to 2 500 m, results in significant climatic variation in Eastern Africa, creating conditions for a wide range of vegetation types, landscapes, biodiversity and human occupations (Njenga

et al., 2014). Rainfall patterns can be very different: The equatorial drylands of Eastern Africa have a bimodal rainfall regime, with long rains from March to May and short rains from October to December, while other areas have a unimodal rainfall pattern. Temperatures are generally moderate, except in the hot and generally humid coastal belt. At an altitude of 1 500 m, maxima are around 25 °C and minima 15 °C. At altitudes above 2 500 m, frosts are common during the dry season, and maxima are typically about 21 °C or less. Eastern Africa also includes one of the hottest known places on Earth, at the Dallol area in the Afar depression in Ethiopia (130 m below sea level), with an annual mean temperature of 35 °C.

In semi-arid and dry subhumid lands, mean annual precipitation ranges from 500 to 750 mm per year. On the coast of Somalia, many years can go by without any rain whatsoever. The annual rainfall generally increases towards the south and with altitude, reaching over 1 100 mm near Kilimanjaro. El Niño events have an influence in Eastern Africa, tending to increase rainfall.

Although drylands obviously have limited rainfall, the low water availability in Eastern Africa's drylands is a function of rainfall and temperature, with high temperatures ensuring evapotranspiration of most of the water.

Importance of dryland forests, trees and biodiversity

Dryland biodiversity, including the diversity of vegetation types, is of critical ecological, economic and social value to all countries in the region. The woodlands of the region are home to a rich diversity of indigenous plants and animals. Eastern Africa's dryland vegetation ranges from woodlands, where trees can reach up to 15 m in height and sometimes to 20 m in riparian ecosystems, to hyperarid landscapes with few shrubs and more dense shrubs occurring only along seasonal riverbeds and gulleys (Kojwang, undated). The woody vegetation depends not only on the physical conditions of soil nutrients, soil moisture and elevation, but also on grazing intensity and fire regimes.

Dryland vegetation provides goods and services essential to the livelihoods of rural and urban people in the region. Many households rely on woodland resources. Biomass from woodlands is used substantially for energy production in rural and urban areas; indeed the primary use of wood in Eastern Africa is for fuel. Most of the fuelwood and charcoal in the region comes from arid and semi-arid lands. Woodland species also provide wood and non-wood products such as fruits, honey and other foods, fibre, fodder for livestock, fertilizer, medicine and building material (timber and poles).

Drylands serve as natural rangelands for large livestock populations. Rearing livestock is the main agricultural activity in Eastern Africa's drylands. The drylands also host big populations of large herbivorous and carnivorous mammals, particularly in protected areas and ranches, attracting significant tourism for recreation and wildlife viewing.

Dryland vegetation also has a significant role in crop production: Some trees, such as acacias, increase soil fertility by fixing atmospheric nitrogen. They hence contribute to stabilizing yields and are used for desertification control.

A few woodland species have significant commercial value on the international market and provide employment and cash income to producing households and individuals. Gums, in particular, are traded worldwide. Gum arabic, a resin used in the food, pharmaceutical and textile industries, is produced in many countries in the region; the gum, produced from trees or shrubs of *Acacia senegal* and *Acacia seyal*, is gathered by pastoralists in the wild or traditionally cultivated in gum gardens, particularly in South Sudan, Eritrea, Somalia and northern Kenya. Other important gums include frankincense and myrrh, obtained in the dry savannahs of Ethiopia, Eritrea, Dijbouti and Somalia from various species of the genera *Boswellia* and *Commiphora*. Beekeeping is a major activity in the region; Ethiopia, Kenya, Malawi, the United Republic of Tanzania, Zambia and Zimbabwe are major producers and exporters of honey and beeswax.

Commercial timber harvesting in natural forests is limited by the generally low stocking levels of commercial timber species, the slow increment of wood biomass and the scattered distribution of timber resources, which hinders access. The most in demand commercial timber species present in the region's drylands include *Pterocarpus angolensis* (African teak), *Khaya anthotheca* and *Afzelia quanzensis*, which dominate domestic markets. Mopane (*Colophospermum mopane*), a hard, durable and termite-resistant wood, is gaining popularity outside Africa for flooring, musical instruments, sculptures and exterior construction. However, the amount of timber exported to regional or global markets is only about one-tenth that of domestic consumption. Timber plantations in the drylands of Eastern Africa are limited.

Trends and challenges

In the past few decades dryland forest and woodlands have been severely degraded, with high losses of biological diversity. A number of countries in the region have a very high rate of deforestation, which can be attributed to a variety of human activities and natural phenomena, including conversion of forest to cropland as a result of population growth and structural adjustment policies, urbanization, overgrazing, overdependence on wood-based energy, unsustainable harvesting of wood products, fire, climate change and variability, and policies that fail to address these issues (Chidumayo, 2011).

Increased intensity of livestock grazing is widely regarded as a major cause of degradation and desertification, particularly around watering points and in valleys. In recent years, traditional land-use patterns have been changing, including a shift in pastoralism from traditional to commercial economic activity. In certain areas with potential for rainfed cropping, new permanent to semi-permanent farming settlements are replacing nomadic systems of extensive pastoralism. Clearance for subsistence agriculture is one of the main drivers of deforestation, causing loss of forests, woodlands and shrublands in drylands. Agriculture is spreading from relatively fertile and high-rainfall areas to more marginal lands. To respond to the generally low nutrient status of the mesic woodlands, farmers traditionally practised shifting cultivation, but in many areas this is no longer feasible. Another recent driver of deforestation has been the expansion of smallholder tobacco production in the region.

Woodlands are under increasing human population pressure, and fire is used to remove the woody vegetation. In Mozambique, for instance, 40 percent of the land is burned every year, and more than 80 percent of the area affected is forested (Saket, 1999). Fire, used as a tool for land preparation for cultivation in savannah woodlands, predisposes trees to stress and secondary attack by pests and pathogens. Miombo woodlands are particularly prone to fires.

Most dryland forests and woodlands in the region consist of slow-growing species, with annual increments of about 1 to 2 m^3 per hectare. In most countries they are subjected to selective cutting based on a system of licences and concessions. A few valuable species are exploited beyond the sustainable yield, as seen in the periodic lowering of the exploitable diameter – for example, from 40 to 35 and then to 25 cm in Zimbabwe. Pressure on the few commercial species is increasing. Harvesting in most cases is on the increase.

Over the last century there have been significant efforts to plant trees, initially for food crops and ornamental purposes, and subsequently also to provide fuelwood and timber supplies for the mining and construction sectors. These activities have resulted in extensive single-species plantations of exotic timber species such as pine, gum, wattle, eucalyptus and teak, particularly in the higher rainfall areas. The establishment of numerous alien invasive plant species, such as *Lantana camara*, *Prosopis* spp., *Maesopsis* spp. and *Opuntia* spp., has had a detrimental impact on natural systems in some places (Obiri, 2011).

Ecotourism generates income for dryland populations, but it also often leads to habitat degradation. Large herbivores, particularly elephants, also cause damage to woody

vegetation in protected areas, even causing conversion of well-developed woodland to bushland or grassland. On the other hand, despite the efforts to protect the wildlife through a network of protected areas, increasing land-use conflicts and poaching are having significant negative effects on the wildlife.

As in other parts of the world, Eastern African drylands are experiencing disconcerting climatic changes. Increasing frequency, extent and intensity of drought is a major challenge. The mean temperature in the region as a whole increased by 0.7 to 1 °C from 1973 to 2013, depending on the season. Moderate decreases in annual rainfall and increases in interannual rainfall variability, extreme rainfall events and floods have been observed over parts of Eastern Africa. Over the next 50 years the semi-arid areas of the region are expected to become hotter, with more wet extremes. These anomalies can contribute to increased risk of desertification in such an ecologically fragile region. Climatic changes are expected to have a negative impact on food security, economic growth, infrastructure, human health, wildlife and ecosystems and to accentuate the vulnerability of the poor (Camberlin, 2018).

Trees and forests have an important role in arresting land degradation and desertification, as demonstrated by local community initiatives to raise windbreaks and shelterbelts to prevent the movement of sand dunes and to reduce the impact of desiccating winds on agricultural crops. However, investments in these efforts have been inadequate to address the problems effectively. In the face of continuing rapid growth of human populations and increased demand for water, food and energy, it seems inevitable that pressures on dryland forests and associated resources will continue to escalate, putting the livelihoods and food security of millions of rural dwellers at risk. Although demographic impacts may be partly offset by a parallel trend towards increasing urbanization, land degradation and desertification are likely to persist and worsen without appropriate investment in soil and water management.

DISTRIBUTION OF FORESTS AND OTHER LAND USES

Forests cover 116 million hectares, more than one-third of the drylands (Figure 54), and are mainly found in the southern part of the region (Figure 55). Other wooded land spans 54 million hectares, or 17 percent of the dryland area. The drylands in Eastern Africa are mainly (47 percent) classified as "other land". In the drylands in the northern part of the region, which are drier, other land and other wooded land dominate, with scattered forest patches.

FIGURE 54

Distribution of land uses in Eastern Africa's drylands ('000 ha)

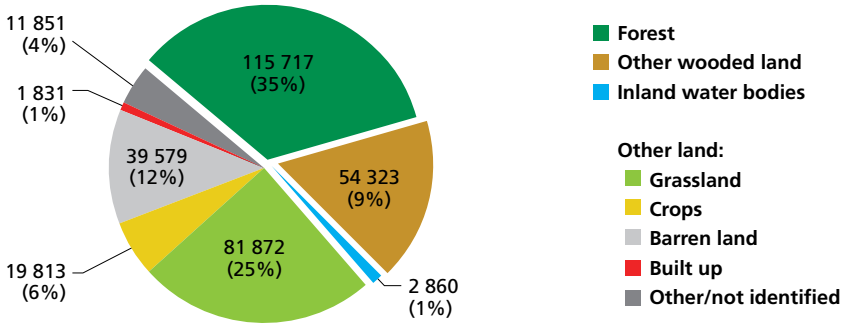
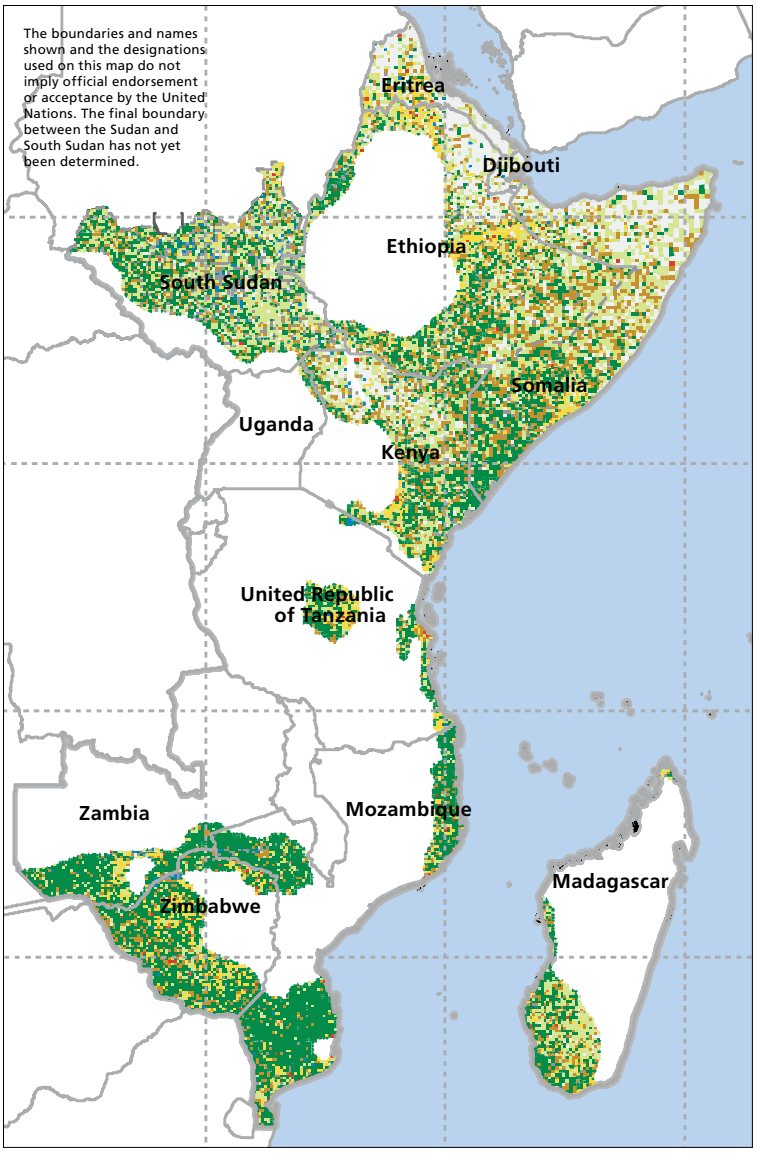


FIGURE 55

Main land uses in Eastern Africa's drylands



Source: UN Maps, 2019

Forests cover more than half of the dry subhumid areas (Figure 56). Their presence decreases with the level of aridity; they are rare and scattered in the arid zone. The hyperarid, arid and semi-arid zones are mainly covered with other land, with sparse vegetation. Other wooded land covers 22 percent in the arid zone, and from 10 to 17 percent in the other dryland zones.

Almost half of the forest occurs in the dry subhumid zone, while 36 percent is in the semi-arid zone (Figure 57). Other wooded land is mainly distributed in the semi-arid and arid zones (37 and 35 percent, respectively), while only 3 percent of it is in the hyperarid zone (Figure 58).

FIGURE 56

Distribution of land uses by aridity zone

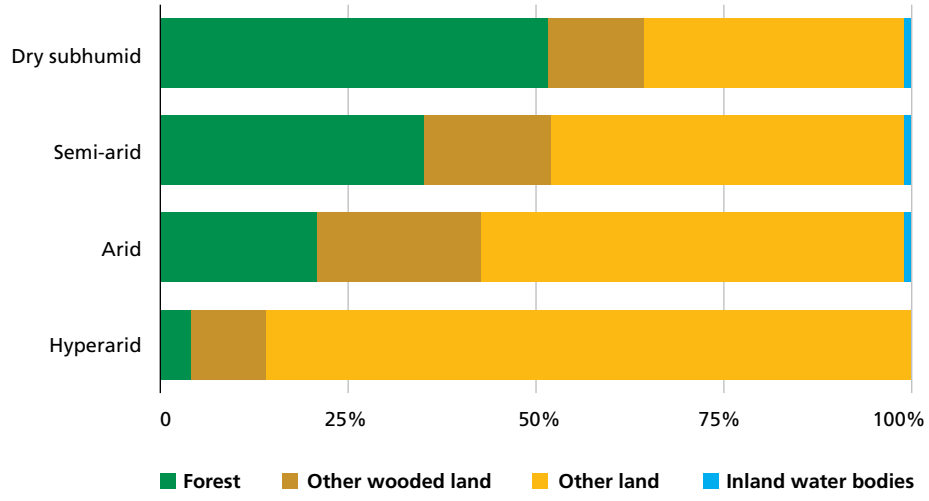


FIGURE 57

Distribution of dryland forest by aridity zone ('000 ha)

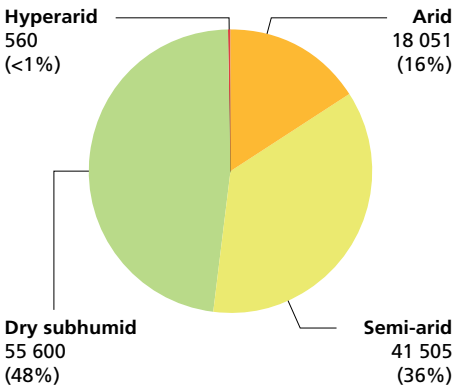
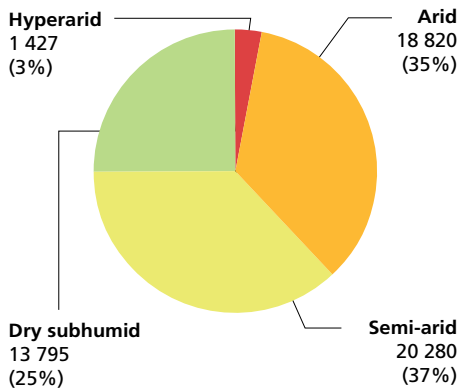


FIGURE 58

Distribution of other wooded land by aridity zone ('000 ha)



VEGETATION IN FORESTS AND OTHER WOODED LAND

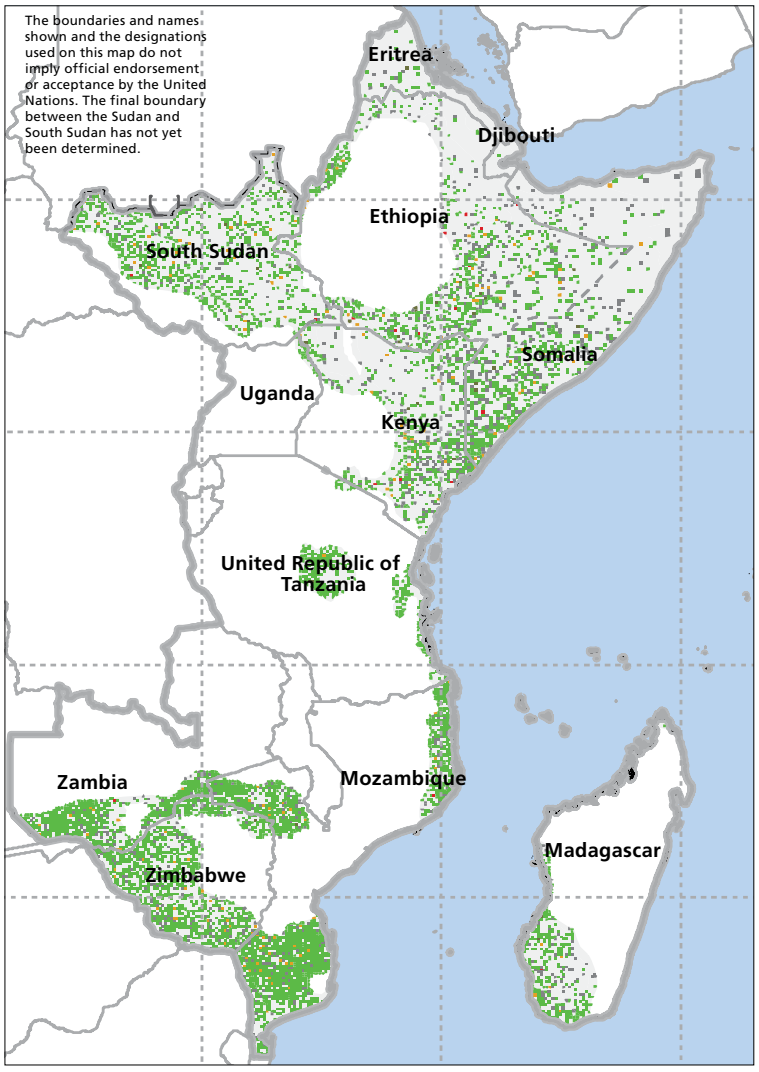
Over 80 percent of the forest in Eastern Africa's drylands is predominantly broadleaved (Table 18, Figure 59). This number might be higher, as the forest type was not specified for 14 percent of the forest, and 3 percent was classified as mixed. Riparian forests account for 2 percent of the forest (almost 3 million hectares). In Eastern Africa, riparian forests are particularly important for pastoralism and grazing, in particular during the dry season, as well as for ecosystem conservation and ecotourism (see also Box 6). Only a few planted forests and mangroves were identified. However, as they are scattered, the estimates derived from sampling are low in accuracy.

Most of the other wooded land (94 percent) is dominated by grassland with trees and shrubs or with shrubs alone (Table 19). This major type of vegetation is known locally as bushland and thicket.

TABLE 18
Type of forest vegetation by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest										
Broadleaved	153	27	12 308	69	34 828	82	50 692	90	95 338	83
of which riparian	0	0	150	1	1 243	3	1 249	2	2 642	2
Coniferous	0	0	227	1	299	1	228	0	755	1
Mixed broadleaved and coniferous	51	9	505	3	1 377	3	1 201	2	3 134	3
Other/not identified	357	64	5 084	28	6 110	15	4 568	8	16 119	14
Planted forest	0	0	77	0	133	0	161	0	370	0
Total	**561**	**100**	**18 202**	**100**	**42 748**	**100**	**56 849**	**100**	**115 717**	**100**

FIGURE 59
Distribution of dryland forest by subtypes



Source: UN Maps, 2019

BOX 6

Forest and woodland vegetation types in the drylands of Eastern Africa

Evergreen to semi-evergreen montane forests occur in upland pockets, in particular on mountaintops with high rainfall. Elsewhere, the vegetation varies from dry woodland to semi-desert shrubland, deciduous bushland and grassland, which is predominant in the region, especially in areas of higher aridity.

In the northern part of the region, deciduous bushland and thickets of various species of *Acacia* and *Commiphora* dominate.

In the south, miombo woodlands are the most extensive vegetation type. Canopy height is less than 15 m, and the vegetation comprises predominantly trees belonging to the family Caesalpiniaceae, such as species of *Brachystegia*, *Julbernardia* and *Isoberlinia*. Miombo woodlands can change in tree density and vary from woodland savannahs to savannah woodlands depending on land drainage. Miombo woodlands are characterized by *Brachystegia*, *Julbernadia* and *Isoberlinia* species.

African teak forests and woodlands grow in the Kalahari Sands region of the western parts of Zimbabwe and Zambia. The two main commercially important tree species are *Baikiaea plurijuga* (Zambezi teak) and *Pterocarpus angolensis*. Other tree species include *Burkea africana*, *Ricinodendron rautanenii*, *Terminalia sericeae* and *Lonchocarpus nelsii*. This forest type is sometimes also called "Kalahari forest".

The drier lowlands of the Zambezi River host mopane woodlands, associated with alkaline, shallow and poorly drained soils. The main species is *Colophospermum mopane*. The trees tend to vary between 4 and 18 m but can sporadically be taller than that. Mopane woodlands are often associated with other major vegetation types, such as miombo woodlands.

Riparian forests form a narrow belt along rivers such as the Tana and Zambezi. They contain mainly evergreen species. They are crucial for dry-season grazing.

A few mangrove areas are found along the coastline in Mozambique, Kenya and the United Republic of Tanzania. Although small in area, these forests are important because of their protective role along coastlines and their high species diversity.

Source: Kindt *et al.*, 2011

TABLE 19

Main vegetation types in other wooded land by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	765	54	9 483	50	8 986	44	4 671	34	23 905	44
Grassland with trees and shrubs	561	39	8 468	45	9 979	49	8 225	60	27 233	50
Shrubland	0	0	128	1	316	2	125	1	569	1
Other/not identified	102	7	742	4	999	5	773	6	2 616	5
Total	**1 428**	**100**	**18 820**	**100**	**20 281**	**100**	**13 795**	**100**	**54 323**	**100**

TREE CANOPY COVER

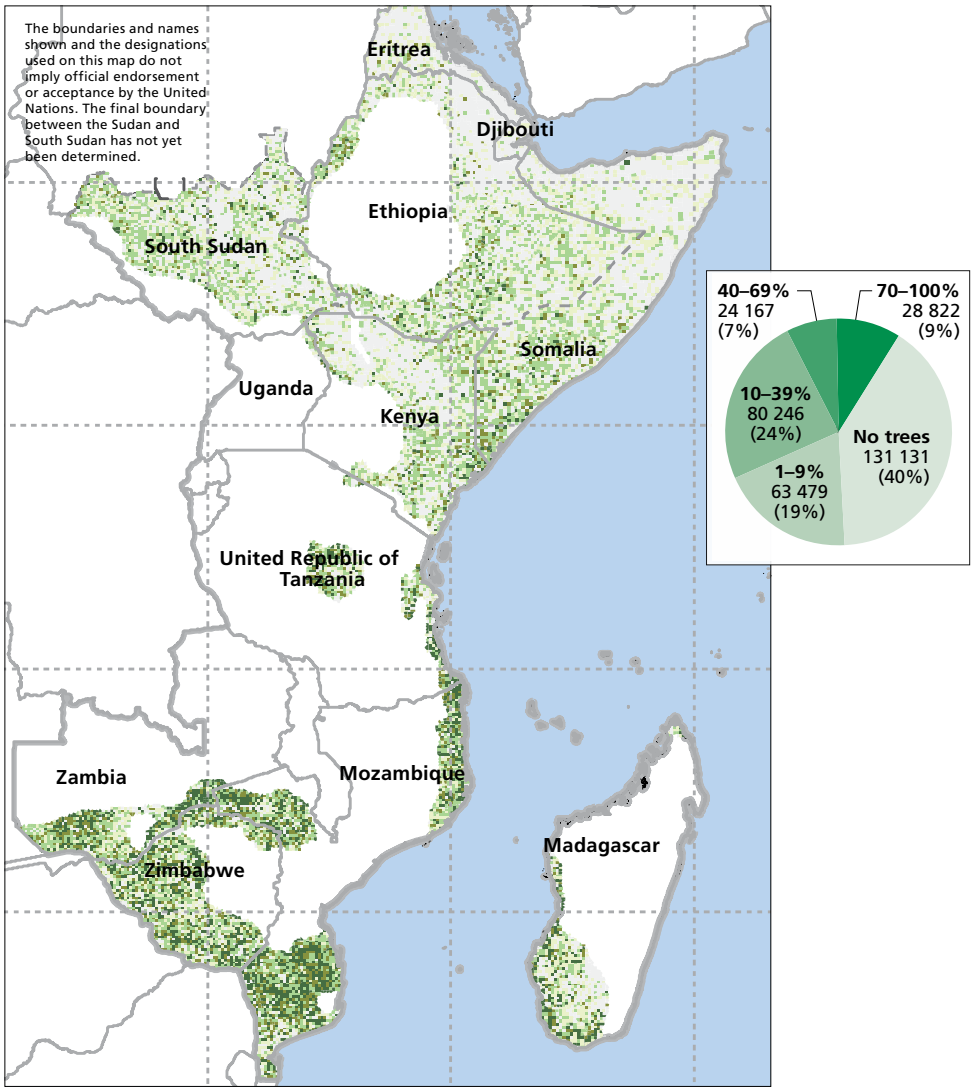
The average tree canopy cover in all of Eastern Africa's drylands is 18 percent. Roughly 131 million hectares or 40 percent of the drylands in the region have no trees (Figure 60). Tree canopy cover is denser in the southern part of the region.

Tree canopy cover in forest averages 45 percent, with a clear gradient according to the degree of aridity (Table 20). Forests are densest in the dry subhumid zone (with an average of 50 percent tree canopy cover) and sparsest in the hyperarid zone (with an average of 21 percent tree canopy cover).

TABLE 20
Average tree canopy cover in Eastern Africa's drylands by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	21	33	43	50	**45**
Other wooded land	3	5	5	6	**5**
Other land	1	2	3	5	**3**
Inland water bodies		0	0	0	**1**
All lands	**2**	**9**	**17**	**29**	**18**

FIGURE 60
Distribution of tree canopy cover in Eastern Africa's drylands by tree cover range ('000 ha)



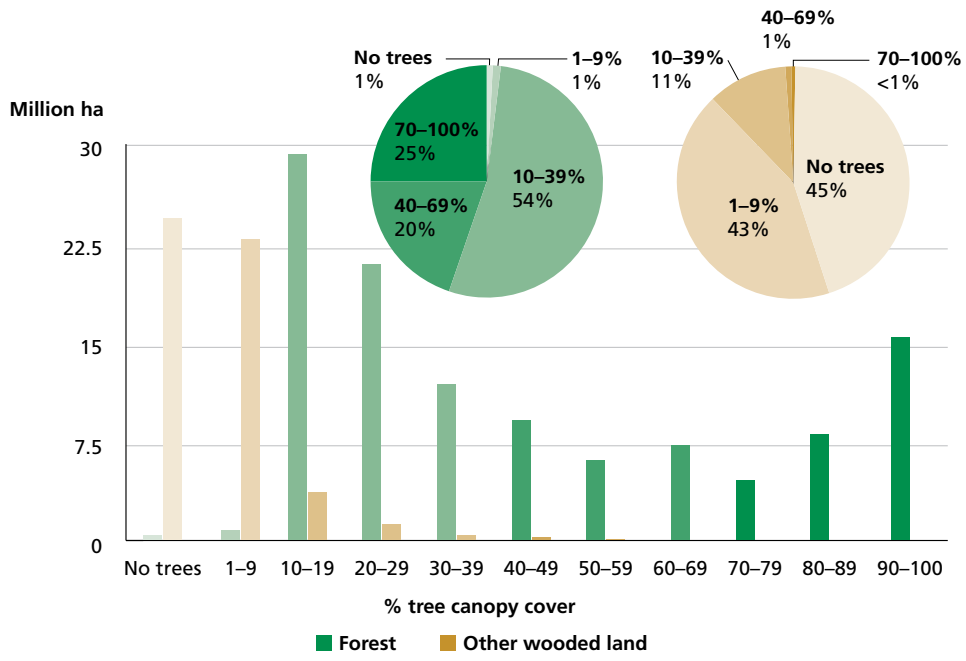
Source: UN Maps, 2019

In terms of the range of tree cover, 54 percent of the forest is open, with tree canopy cover below 40 percent; 20 percent has tree cover ranging from 40 to 70 percent; and 25 percent has a dense canopy, with tree cover greater than 70 percent (Figure 61).

Almost half (45 percent) of other wooded land has no tree cover and is predominantly covered with shrubs, while most of the rest (43 percent) has tree cover below 10 percent (Figure 61).

FIGURE 61

Tree canopy cover in forest and other wooded land



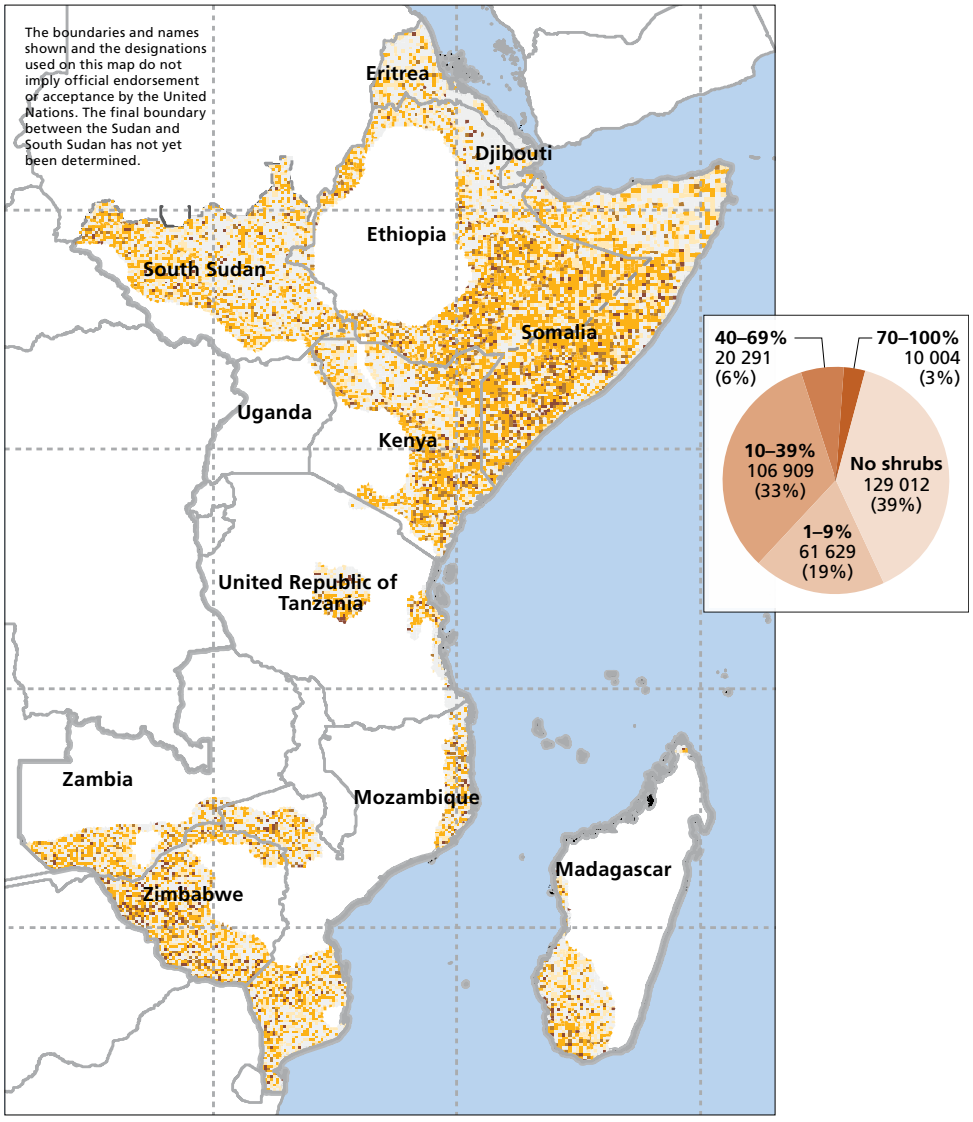
SHRUB COVER

Shrubs are present in 60 percent of Eastern Africa's drylands, but they are mainly sparse, with cover density ranging from 1 to 40 percent. Almost 20 percent of the dryland has shrub cover of less than 10 percent (Figure 62). Dense shrubs are only found in 3 percent of the total dryland area.

Grazing lands, Somalia

FIGURE 62

Shrub cover in Eastern Africa's drylands ('000 ha)



Source: UN Maps, 2019

Most other wooded land is shrubby: 83 percent has shrub cover of more than 10 percent. Most of those lands are sparsely covered with shrubs (Figure 63), with shrub cover ranging from 10 to 40 percent. Average shrub cover in other wooded land is 32 percent (Table 21). Shrub cover is dense or very dense (ranging from 70 to 100 percent) on 12 percent of other wooded land. Average shrub cover in other wooded land is densest in the semi-arid zone (35 percent) and lowest in hyperarid lands (20 percent).

Most dryland forest has little or no shrub cover (or shrubs could not be detected because of dense tree canopy cover). The average shrub cover in forest is estimated to be 13 percent. This percentage slightly increases with aridity (to 16 percent in hyperarid forests) (Table 21).

About 76 percent of the dryland classified as other land (118 million hectares) has little or no shrub cover (Figure 64). Less than 2 percent of other land (around 2 million hectares) has shrub cover above 70 percent.

FIGURE 63

Shrub cover in forest and other wooded land

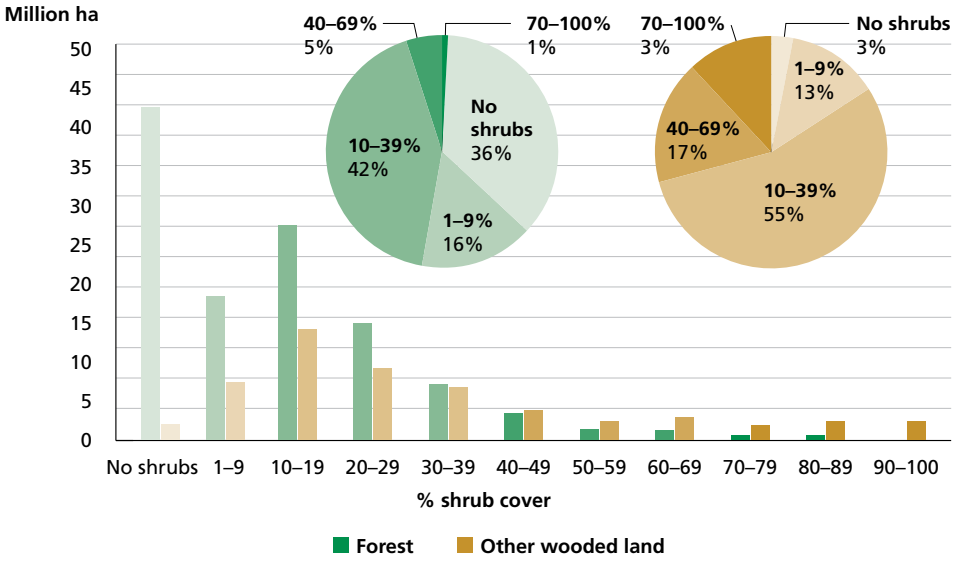


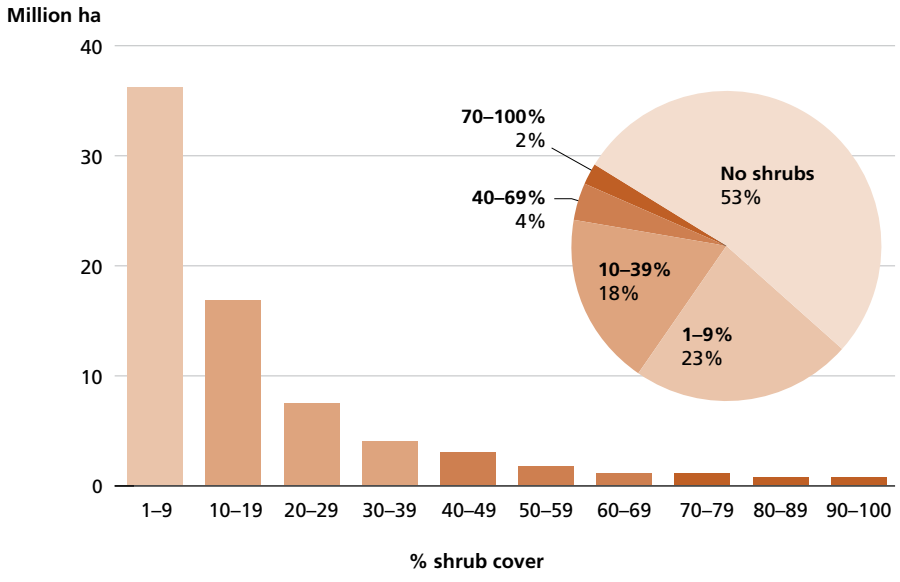
TABLE 21

Average shrub cover by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	16	15	14	12	**13**
Other wooded land	20	30	35	33	**32**
Other land	5	9	8	9	**8**
Inland water bodies		1	1	4	**2**
All lands	**7**	**7**	**15**	**13**	**7**

FIGURE 64

Shrub cover in other land



OTHER LAND

Of the 155 million hectares of other land in Eastern Africa's drylands, 36 percent is found in the semi-arid zone, 32 percent in the arid zone and 24 percent in the dry subhumid zone. Only 8 percent is in the hyperarid zone (Figure 65).

Other land is dominated by grassland or herbaceous savannah (53 percent of the total other land area, or 82 million hectares) (Figure 66, Table 22). This sparse vegetation is used almost exclusively for pastoral grazing (Njenga *et al.*, 2014). Grasslands are distributed primarily in the semi-arid zone (32 million hectares), followed by the arid zone (25 million hectares) (Figure 67).

FIGURE 65

Distribution of other land by aridity zone ('000 ha)

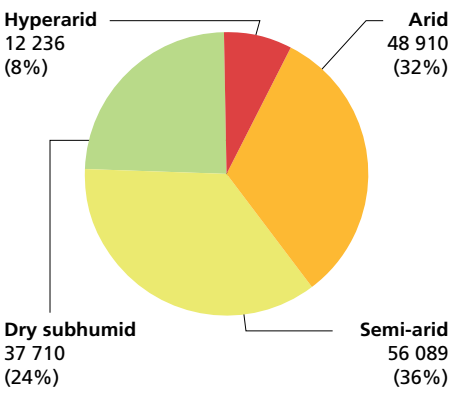


FIGURE 66

Distribution of other land by land use ('000 ha)

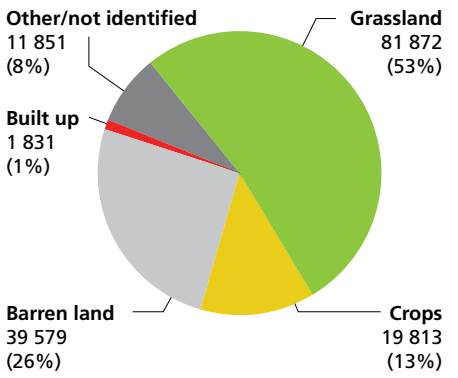
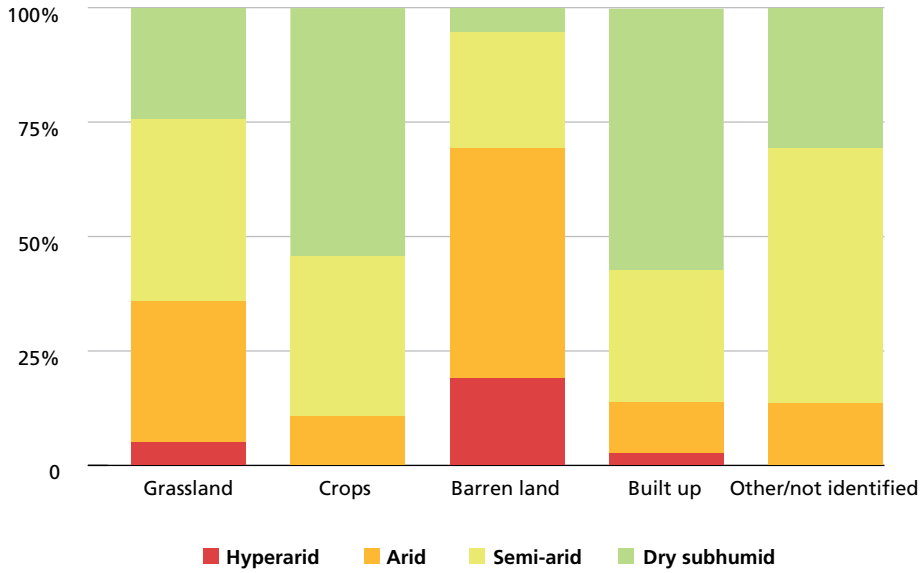


TABLE 22

Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	0	2 150	7 005	10 658	19 813	100
Irrigated crops	0	585	1 815	2 241	4 641	23
Non-irrigated cropland	0	1 417	4 876	7 522	13 815	70
Perennial crops (palms, orchards, others)	0	122	188	430	740	4
Cropland fallow	0	0	26	125	151	1
Grass	4 588	25 141	32 074	20 068	81 872	100
Barren land	7 546	19 813	9 949	2 272	39 579	100
Rock or stone	2 804	6 416	3 563	1 006	13 789	35
Sand and dunes	4 436	11 837	4 813	648	21 734	55
Snow and glaciers	306	1 560	1 573	617	4 056	10
Built up	51	205	526	1 049	1 831	100
Villages and urban settlements	0	153	477	934	1 565	85
Infrastructure	51	51	48	115	266	15

FIGURE 67
Land use in other land by aridity zone



Barren land represents 25 percent of the other land category in drylands (40 million hectares). The largest part of barren land is located in the arid zone (19 million hectares). Bare soil, rock or sandy areas dominate the shores of the Red Sea and Gulf of Aden, the Afar depression, parts of northern Somalia and the Turkana gap.

Crops are marginal in Eastern Africa's drylands; they cover 13 percent of the other land or 6 percent of the drylands. Crops are mainly found in the dry subhumid zone (11 million hectares) and in the semi-arid zone (7 million hectares). Most of them are non-irrigated annual or mixed crops (14 million hectares) (Figure 68). Irrigated crops are estimated to cover 5 million hectares or 23 percent of cropland, while fallow and perennial crops such as oil-palm and orchards are estimated to cover less than 1 million hectares each.

Marshland and other wetlands cover 4 percent of other land (almost 7 million hectares); they occur predominantly in the semi-arid zone (4 million hectares), particularly along the White Nile in South Sudan.

Settlements and built-up areas, including urban and rural settlements as well as infrastructure such as roads, occupy 1 percent of other land (almost 2 million hectares). These areas are predominantly found in the dry subhumid zone (1 million hectares) and in the semi-arid zone (0.5 million hectares).

Inland water occupies 2.8 million hectares or 1 percent of Eastern Africa's dryland area. It is found mainly in the semi-arid zone (58 percent, less than 2 million hectares), followed by the dry subhumid zone (27 percent of inland water or 0.8 million hectares). There is no inland water in the hyperarid zone.

FIGURE 68

Distribution of crop types

Source: UN Maps, 2019

TREES OUTSIDE FOREST

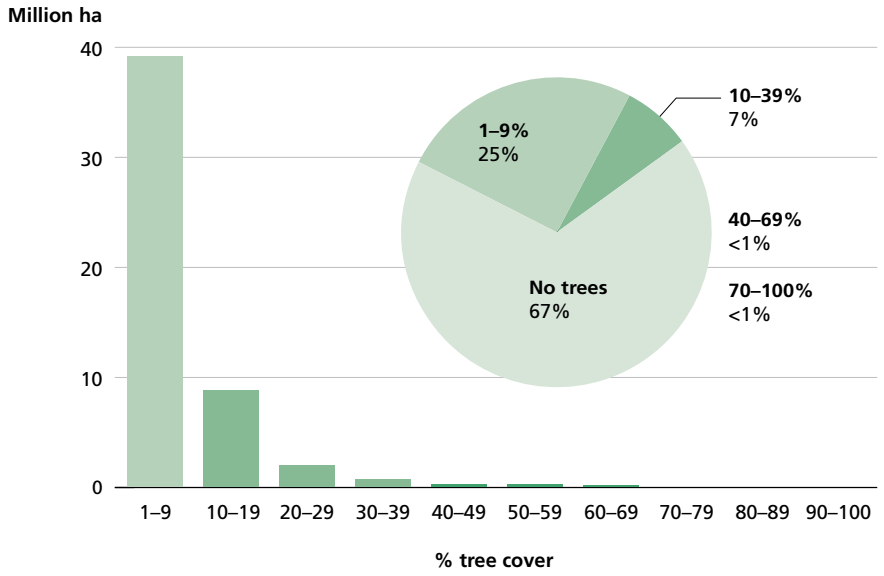
Trees outside forest are present on 52 million hectares (33 percent of the other land) (Figure 69).

As shown in Table 20, tree canopy cover on other land is 3 percent on average. It is below 10 percent on 143 million hectares of other land (92 percent), while the area of other land with tree cover above 10 percent is 12 million hectares (8 percent of other land).

Tree cover on other land increases with decreasing aridity (from 1 percent in the hyperarid zone to 5 percent in the dry subhumid zone).

FIGURE 69

Tree canopy cover in other land



Southern Africa

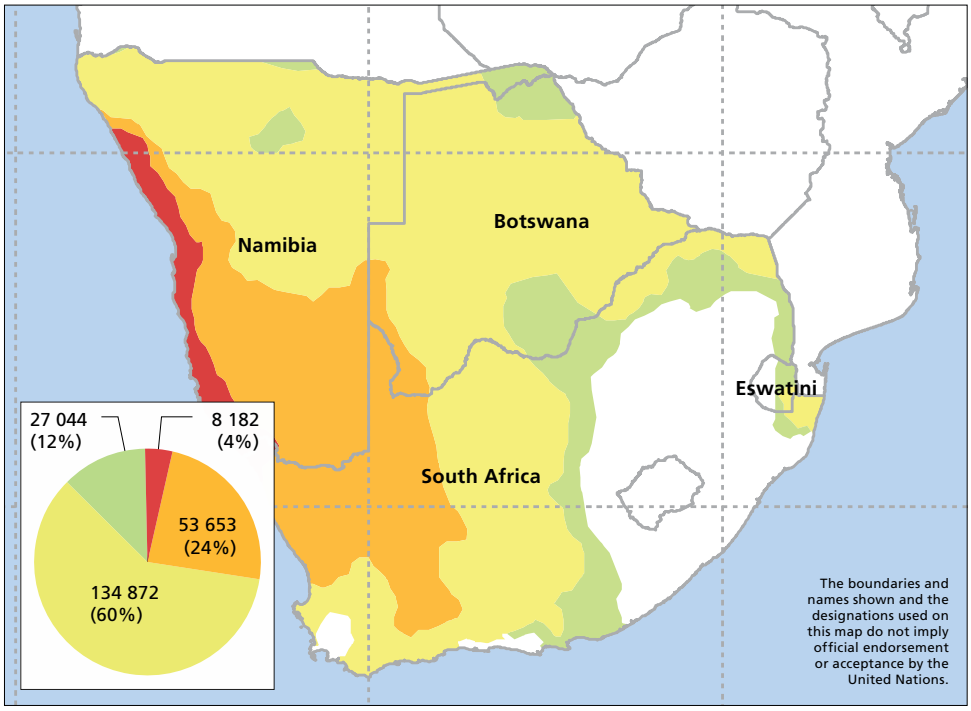
Quiver tree forest (Aloe dichotoma), *Namibia*

KEY FINDINGS

- The drylands of Southern Africa cover a total area of 224 million hectares, representing 84 percent of the region's land area and 4 percent of the global drylands.
- Most of this land – 60 percent – is semi-arid.
- Forests cover 27 percent of the drylands in the region and other wooded land 33 percent, yet 47 percent of the dryland area has no tree cover.
- The dry subhumid and semi-arid zones are the most forested, with 37 and 35 percent forest cover, respectively. About 78 percent of Southern Africa's forest is found in the semi-arid zone.
- Forests are mainly broadleaved. Riparian forests are estimated to make up 2 percent of the total forest area.
- The tree canopy in the region's dryland forests is predominantly open: More than 60 percent of the area has tree canopy cover below 40 percent. Only 20 percent of the forest has a dense canopy (with cover above 70 percent). The average tree cover in Southern Africa's drylands is 13 percent.
- Tree canopy cover decreases with the level of aridity.
- Shrubs are distributed throughout Southern Africa's drylands; they were observed on 73 percent of the dryland area, with the highest densities in the north-central part of the region. The average shrub cover in drylands is 24 percent.
- Grasslands or herbaceous savannah cover 28 percent of drylands, while crops are estimated to cover 9 million hectares or 4 percent of the dryland area. Barren land occupies 7 percent of the drylands. Almost 40 percent of the crops are irrigated, mainly in South Africa.
- Trees outside forest are present on 28 percent of the area not covered with forest and woodlands.

FIGURE 70

Distribution of drylands in Southern Africa by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

The drylands of Southern Africa cover a total area of 224 million hectares, 84 percent of the region (Figure 70), and represent 3.6 percent of the world's drylands.

The majority (60 percent) of the region's drylands, corresponding to the central plateau of Botswana, northern Namibia and South Africa, is semi-arid. About one-quarter of the drylands (24 percent) is arid, and 12 percent of the drylands are in the dry subhumid zone. A small portion (4 percent), corresponding to the coastal desert of Namibia, is hyperarid.

Some 2.9 million hectares in the region, mostly distributed in South Africa and Lesotho, are "presumed drylands", having dryland features but an aridity index greater than or equal to 0.65 (see Box 1, p. 1). The presumed drylands have been assessed but are not included in this report.

The regional assessment presented in this report is based on a survey of 13 794 plots. The analysis was completed by a team of 20 students from Sapienza University, Rome, in April and August 2015.

BACKGROUND

Climate

The climate in Southern Africa is influenced by the major circulation patterns of the southern hemisphere and the surrounding oceans, as well as the complex regional topography, which ranges from sea level to the central plateau at about 1 250 m and further to mountains higher than 3 000 m. As a result of these factors, the climate types vary from coastal desert in Namibia to a temperate climate over the central plateau, a subtropical climate over the coastal areas of the southeast and a Mediterranean climate in the southern part of South Africa.

The semi-arid central plateau has 430 mm mean annual rainfall and average annual temperature around 20 °C. The arid drylands have average rainfall of 190 mm per year and mean annual temperature of 19 °C. In the dry subhumid zone, average rainfall is around 700 mm per year and the temperatures are the warmest in the region, averaging 22 °C. The coastal desert has mean annual rainfall of 43 mm and the lowest average temperature, around 17°C, influenced by the cold Benguela Current, which flows northwards from Antarctica. In summer, the temperatures are highest over the desert regions of Namibia and Botswana and exceed 27 °C. Interannual rainfall variability in the region is high, linked to the El Niño-Southern Oscillation (ENSO) phenomenon. During warm ENSO events, dry conditions occur, especially in the southeastern part of the region.

Importance of dryland forests, trees and biodiversity

Forests and woodlands in the drylands in Southern Africa are an important economic resource on which a large number of people depend for their basic needs. They play an important part in soil and water conservation and support a large amount of livestock and game, which are crucial to food security and the valuable tourism industry.

The majority of people in Southern Africa live in areas dominated by dryland forests and many households, both rural and urban, remain strongly reliant on woodland resources. Dryland forests provide a wide range of wood and non-wood forest products that support rural and urban livelihoods, from foods (e.g. mushrooms, fruits, honey, insects and wildlife) and medicines to fuel and building materials (e.g. poles, grass and fibre). Woodfuel (mainly fuelwood in rural areas and charcoal in urban areas) remains a key source of energy across the region. The potential for the industrial development of timber and NWFPs such as ornaments, gums, resins and valuable fruits and medicines is still largely untapped.

Natural tree vegetation supports a relatively local timber industry. Wood is used for joinery, carving and traditional implements. Sawn timber is sold locally or exported in the region. The principal tree species used for timber include *Pterocarpus angolensis* (kiaat), *Baikiaea plurijuga* (Zambezi teak), *Colophospermum mopane* (mopane) and *Guibourtia coleosperma* (false mopane). Mopane is one of Southern Africa's heaviest woods and is termite resistant. For this reason, it has long been used for housing and fence construction, railway sleepers and pit props. It is also increasingly used in the construction of musical instruments.

The forest plantation sector in Southern Africa, especially in South Africa, Eswatini and Zimbabwe, is well developed, largely because it is well integrated with the processing sector and because most of the plantations are in the private sector where management objectives are clearly defined. South Africa's planted forest is among the most extensive in Africa, consisting of fast-growing exotic species such as *Pinus* spp., *Eucalyptus* spp. and *Acacia mearnsii*, established for production of industrial roundwood and in some cases for woodfuel (ADB, EC and FAO, 2003).

Forest and other woody vegetation is crucial for livestock production. Pastoralism or cattle ranching occupies a large portion of Southern Africa's drylands, including the southern part of Namibia.

Southern Africa's dryland biodiversity is also a major draw for ecosystem conservation and ecotourism. Wildlife, including high concentrations of large mammals, is one of the unique assets of Southern Africa and is an important element in the growing tourism industry, particularly in protected areas, ranches and private game farms. Some dryland areas are regions of unique endemism, such as the Waterberg Plateau in the central part of Namibia and the northern and central Namib Desert along the coast. Biodiversity hotspots in the region's drylands include the Succulent Karoo, along the coastal strip of southwestern Namibia and northwestern South Africa, notable for the world's richest flora of succulent plants; it harbours about one-third of the world's approximately 10 000 succulent species, including many endemic species.

Riparian forests are important ecosystems in the region, particularly for livestock and wildlife. In addition, a few mangrove forests are found in the mouths of rivers on the Indian Ocean coast of South Africa. Although small in area, these forests are important for their protective role along coastlines and their valuable habitat function, deriving from their high species diversity.

Trends and challenges

Overall, the area of forest and woodland has been declining in the past decade, with some variability by country. Because of the low population density the conversion rate is lower than in other parts of the world with similar vegetation. However, challenges related to desertification and land degradation, soil erosion, water scarcity, inefficiency of reforestation activities and the breakdown of traditional systems of conserving natural resources are expected to continue to provoke biodiversity loss and a decline in the overall value of forests.

The main causes of woodland degradation are unsustainable wood harvesting for timber and woodfuel and the lack of sustainable forest and woodland management. Others include encroachment, shifting cultivation, overgrazing, illegal activities and corruption. Population growth, poverty, energy demand and to some degree urbanization are widely recognized as underlying factors affecting the state of forests in the region's drylands. While some countries have a well-developed wood industry based on high-quality plantations, others have poorly developed forest industries and exploit the natural forests. Forests and woodlands designated as national parks and game reserves have some protection, but most woodlands outside protected areas are exploited unsustainably.

Most of the arid drylands are used as rangeland. Traditional systems of extensive pastoralism practised in sparsely populated areas can be considered ecologically sound, but during the second half of the nineteenth century large-scale commercial stockbreeding spread over the semi-arid drylands of South Africa, causing major land degradation (Safriel *et al*., 2005).

Severe human-induced soil degradation is also reported in the region's drylands. Desertification is particularly important in Botswana and Namibia.

Uncontrolled forest fire damage is also a key driver of degradation. The climatic conditions, frequent droughts and accumulation of dry leaf litter, grass and fallen dead branches create optimal conditions for intensive fires each year from May to October.

In semi-arid areas, high rainfall variability, frequent droughts, low soil moisture and extreme events such as flash floods are sources of vulnerability for communities dependent on primary production, natural resources and rainfed agriculture, which are sensitive to local climate.

DISTRIBUTION OF FORESTS AND OTHER LAND USES

Together, forests and other wooded land account for 60 percent of Southern Africa's drylands (Figures 71 and 72). Forest covers 26 percent of the dryland area (59 million hectares). Other wooded land covers one-third of total dryland area (74 million hectares), scattered throughout the drylands. The remaining 40 percent of the region's drylands (89 million hectares) is classified as other land. It is mainly located in the southern half of the region.

Forest is mainly found in the central plateau, in the northern part of the region. In the semi-arid zone, which is the main aridity zone in the region's drylands, as well as in the dry subhumid zone, forests cover more than one-third of the area (Figure 73). Hyperarid and arid lands are predominantly classified as other land (88 and 57 percent, respectively). The hyperarid zone has no forest, while the arid zone has very little (5 percent of dryland area). The highest percentage of other wooded land is found in the arid zone, where it represents 38 percent of the area. More than one-third of the semi-arid zone and 24 percent of the dry subhumid zone are other wooded land. Inland water

FIGURE 71

Distribution of land uses in Southern Africa's drylands ('000 ha)

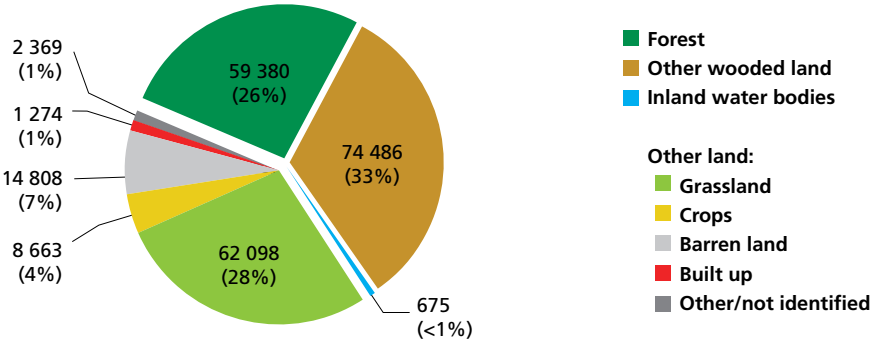
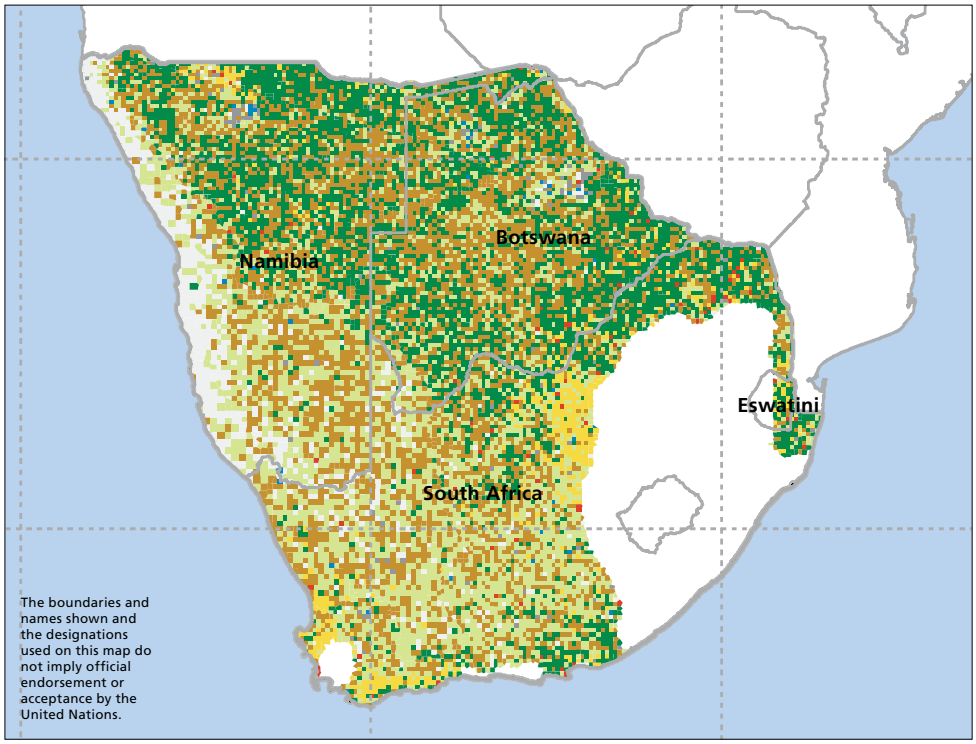


FIGURE 72

Main land uses in Southern Africa's drylands



Source: UN Maps, 2019

bodies account for a very small portion of all aridity zones, with the most (0.5 percent of dryland area) in the dry subhumid zone.

Of the 59 million hectares of dryland forest in Southern Africa, 78 percent is found in the semi-arid zone, 17 percent in the dry subhumid zone and a small portion (5 percent) in the arid zone, while the hyperarid zone has almost no forests (Figure 74).

FIGURE 73

Distribution of land uses by aridity zone

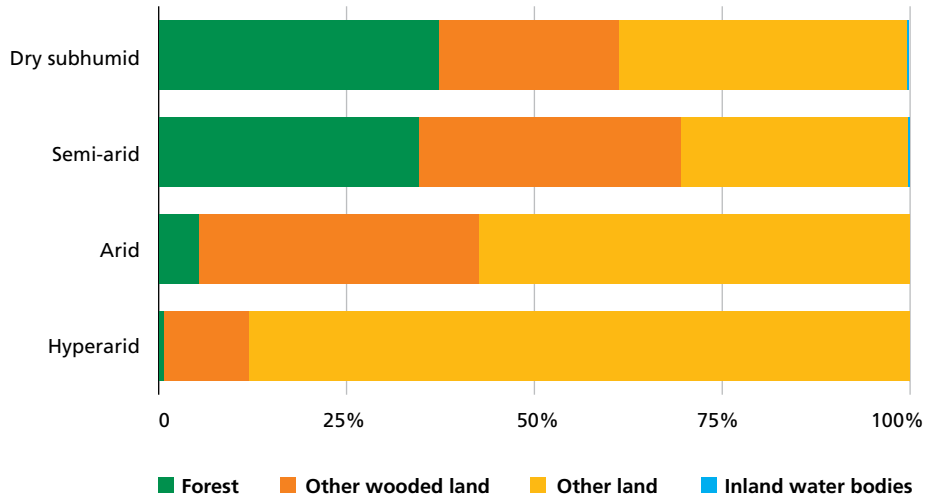


FIGURE 74

Distribution of dryland forest by aridity zone ('000 ha)

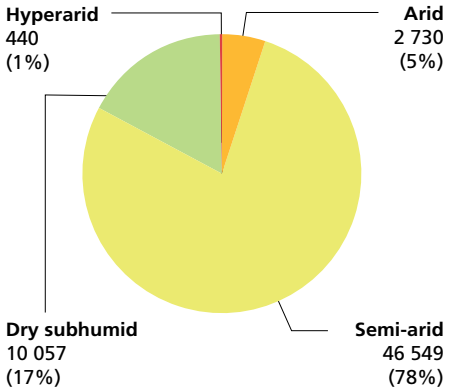
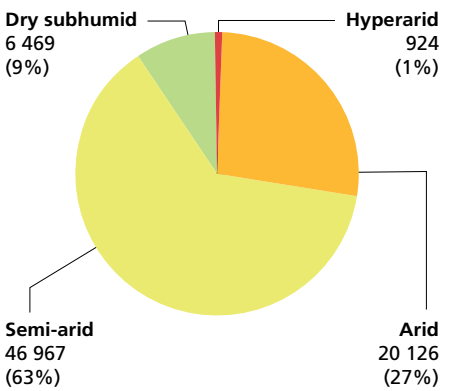


FIGURE 75

Distribution of other wooded land by aridity zone ('000 ha)



Other wooded land area is also largely concentrated in the semi-arid zone (63 percent); the remaining area is located mainly in the arid (27 percent) and dry subhumid (9 percent) zones, with only 1 percent in the hyperarid zone (Figure 75).

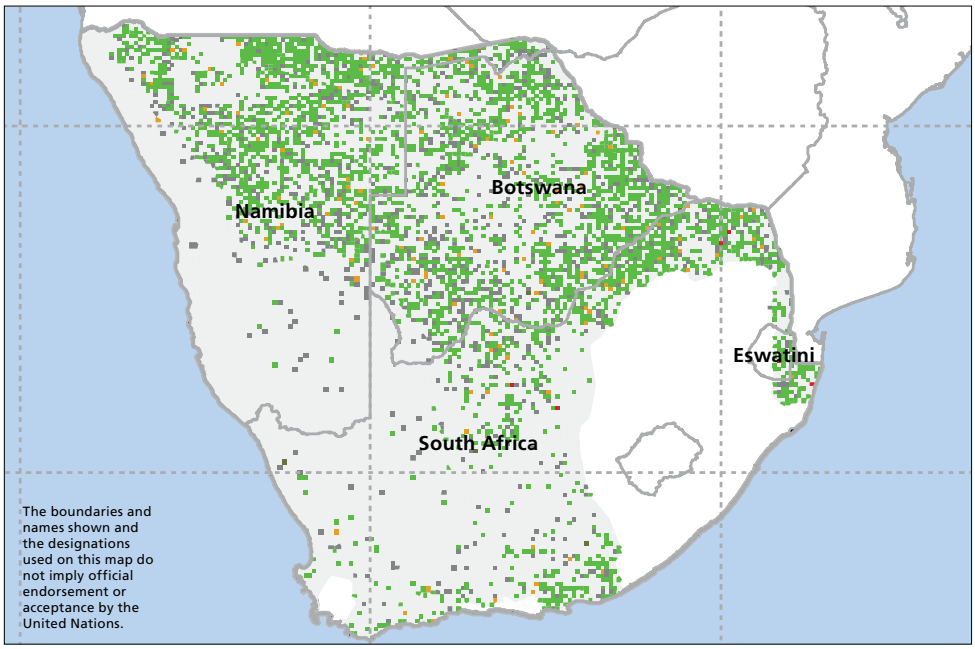
VEGETATION IN FORESTS AND OTHER WOODED LAND

More than three-quarters of Southern Africa's dryland forest is broadleaved (Figure 76, Table 23, Box 7). This number might be higher, as for 21 percent of forest, the forest type was not specified. Riparian forests (including riparian and gallery forests) are estimated to make up 2 percent of the forest (more than 1 million hectares). Only a few plantations could be identified, in particular in South Africa and Eswatini; however, as the sampling was not consistently high enough to verify the presence of plantations, the estimates are not precise.

Other wooded land is dominated by grassland: 50 percent grassland with shrubs and 46 percent grassland with trees and shrubs (Table 24).

FIGURE 76

Distribution of dryland forest by subtypes



Source: UN Maps, 2019

TABLE 23

Type of forest vegetation by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest										
Broadleaved	0	0	1 376	50	35 647	77	8 040	80	45 063	76
of which riparian	0	0	271	10	908	2	202	2	1 381	2
Coniferous	0	0	23	1	58	0	29	0	109	0
Mixed broadleaved and coniferous	0	0	113	4	1 500	3	259	3	1 872	3
Other/not identified	44	100	1 218	45	9 287	20	1 700	17	12 249	21
Planted forest	0	0	0	0	58	0	29	0	86	0
Total	**44**	**100**	**2 730**	**100**	**46 549**	**100**	**10 057**	**100**	**59 380**	**100**

TABLE 24

Main vegetation types in other wooded land by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	704	76	12 815	64	20 996	45	2 766	43	37 282	50
Grassland with trees and shrubs	88	10	6 408	32	24 615	52	3 199	49	34 310	46
Shrubland	0	0	45	0	87	0	0	0	132	0
Other/not identified	132	14	857	4	1 269	3	504	8	2 763	4
Total	**924**	**100**	**20 126**	**100**	**46 967**	**100**	**6 469**	**100**	**74 486**	**100**

BOX 7

Forest and woodland vegetation in the drylands of Southern Africa

The vegetation in the region's dryland forests and woodlands is highly variable but is characterized by a grassy ground layer together with a distinct upper layer of woody plants. Dominant trees in mature stands range in height from below 10 m to about 30 m, depending on rainfall. Where the woody layer is shorter, the vegetation is described as shrubland or bushland, although the canopy varies from open to closed. Key determinants of woodland composition and structure include soil moisture and soil nutrient status coupled with herbivory and fire regimes. Rainfall seasonality prevents the upper tree layer from dominating, while fires and grazing keep the grass layer dominant. Summer rainfall is essential for dominance of C_4-type grasses, which are favoured where the growing season is hot. The occurrence of a dry season, coupled with the presence of fine grassy material, results in regular fires, such that nearly all the species in both grass and tree layers are adapted to survive fires. Shrubs increase and grasses decrease with increasing aridity (Palmer and Hoffman, 1997).

In the Kalahari Sands region of Botswana and northeastern Namibia, Zambezi teak forests and woodlands (sometimes called "Kalahari forest") occur, made up of two main tree species with significant commercial value, *Baikiaea plurijuga* (Zambezi teak) and *Pterocarpus angolensis*, as well as other tree species such as *Burkea africana*, *Ricinodendron rautanenii*, *Terminalia sericeae* and *Lonchocarpus nelsii*. Mopane woodlands, where the dominant woody species is *Colophospermum mopane*, grow in lower areas, over the lowlands of the Zambezi River, in Botswana and South Africa as well as in northern Namibia, associated with alkaline, shallow and poorly drained soils. The trees tend to vary between 4 and 18 m but are sometimes taller where rainfall is higher. Mopane woodlands are often mixed with other major vegetation types such as acacia woodlands (dominated by the Acacia species *A. nigrescens*, *A. albida* and *A. tortilis* and by *Combretum imberbe*) and semi-arid shrublands. Typical shrub species include *Dichrostachys cinerea* and *Rhus lancea*. Acacia woodlands occur in pockets throughout the drier southeastern parts of the subcontinent. Shrublands dominate the more arid western areas, in particular the southern part of Namibia.

TREE CANOPY COVER

Tree canopy cover is denser in the northern parts of the region, while 47 percent of the drylands (105 million hectares) have no trees (Figure 77).

Most of the dryland forest in Southern Africa – 61 percent – has an open tree canopy cover (below 40 percent), while 19 percent has canopy cover ranging from 40 to 69 percent, and 20 percent has a dense canopy, with tree cover above 70 percent (Figure 78).

On average, tree canopy cover in dryland forest is 41 percent (Table 25), with a clear gradient according to the degree of aridity. Forests are densest in the dry subhumid zone (48 percent average tree canopy cover) and sparsest in the hyperarid zone (15 percent average canopy cover).

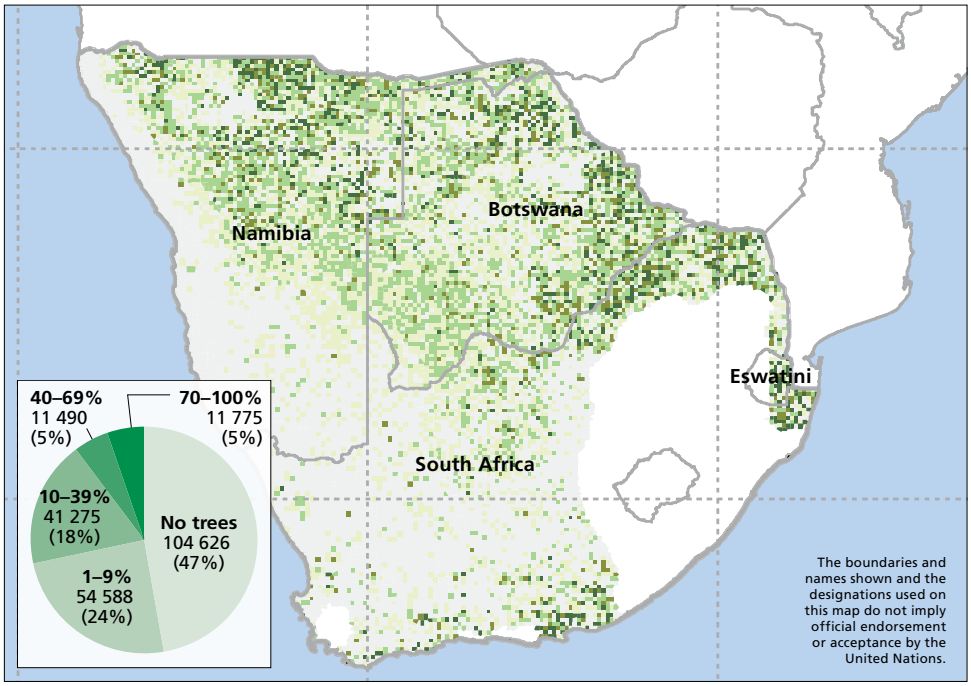
TABLE 25

Average tree canopy cover in Southern Africa's drylands by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	15	25	40	48	**41**
Other wooded land	<1	2	4	4	**3**
Other land	<1	1	3	3	**2**
Inland water bodies	0	<1	0	0	**0**
All lands	**2**	**9**	**17**	**29**	**18**

FIGURE 77

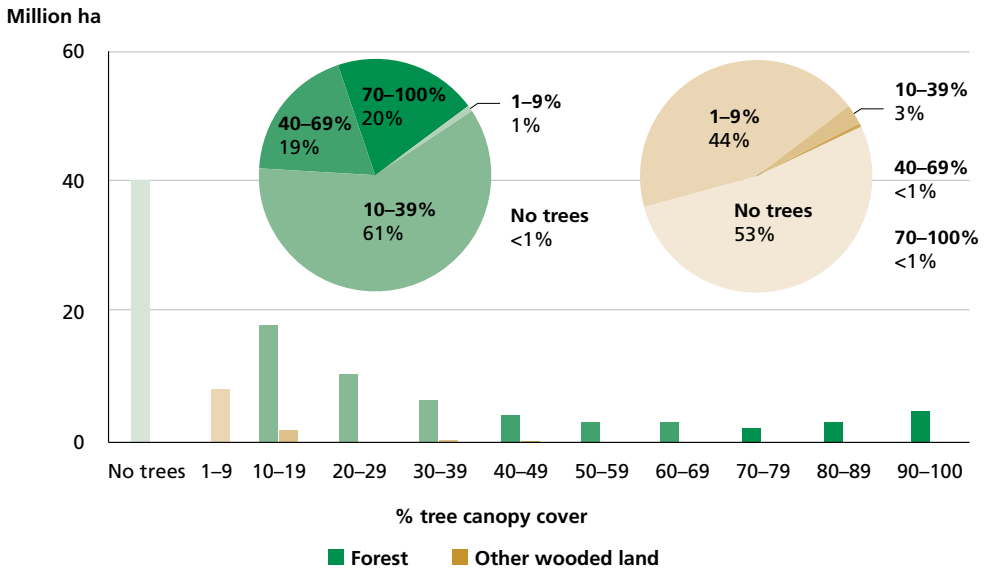
Distribution of tree canopy cover in Southern Africa's drylands by tree cover range ('000 ha)



Source: UN Maps, 2019

FIGURE 78

Tree canopy cover in forest and other wooded land



More than half of other wooded land (53 percent) has no tree cover and is therefore considered shrubland (Figure 78). The remainder, which corresponds to savannah, has tree cover below 10 percent.

SHRUB COVER

Shrubs cover 73 percent of Southern Africa's drylands, or 163 million hectares (Figure 79). Shrub coverage is densest in the north-central part of the region.

Shrub cover in other wooded land is sparse for the most part (Figure 80), ranging from 10 to 39 percent on about 43 percent of those lands, while 7 percent of other wooded land has shrub cover ranging from 1 to 9 percent. Shrub cover is dense and continuous (ranging from 70 to 100 percent) on 27 percent of other wooded land.

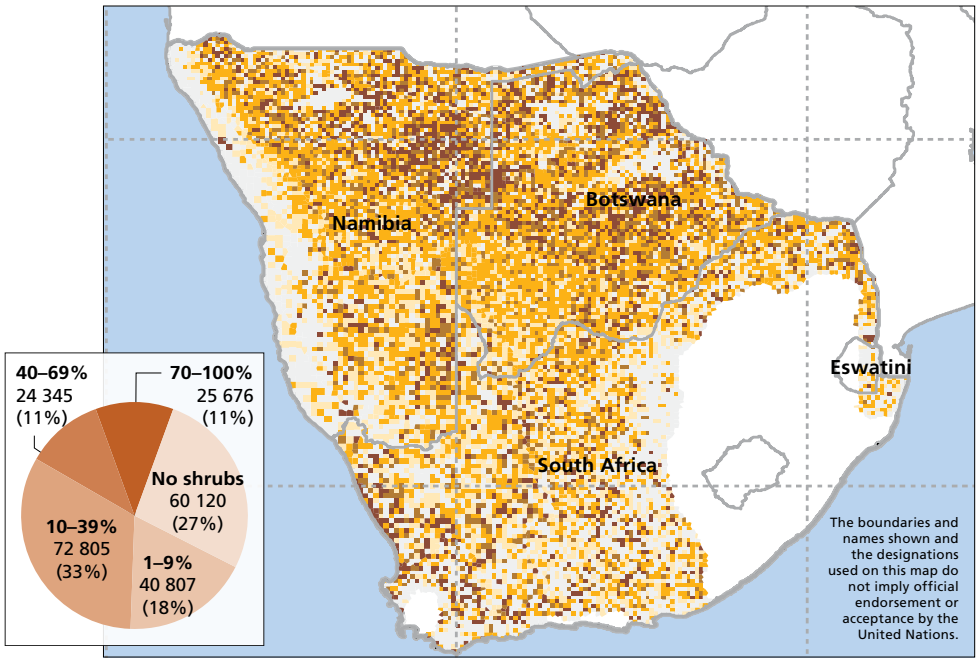
Average shrub coverage is 45 percent in other wooded land, with denser cover in the semi-arid and dry subhumid zones (48 and 46 percent, respectively) (Table 26).

Most forest has little or no shrub cover (or shrubs could not be detected because of tree canopy cover). The average shrub cover is estimated to be 19 percent in Southern Africa's dryland forests. The average cover is highest in forests located in the hyperarid zone (35 percent).

Most of the other land in the region's drylands has no shrubs (42 million hectares, or 47 percent) or very sparse shrub cover ranging from 1 to 9 percent (28 million hectares, or 31 percent) (Figure 81).

FIGURE 79

Shrub cover in Southern Africa's drylands ('000 ha)



Source: UN Maps, 2019

TABLE 26

Average shrub cover by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	35	21	20	16	**19**
Other wooded land	34	37	48	46	**45**
Other land	2	9	14	8	**11**
Inland water bodies		12	2	3	**4**
All lands	**6**	**20**	**28**	**20**	**24**

FIGURE 80

Shrub cover in forest and other wooded land

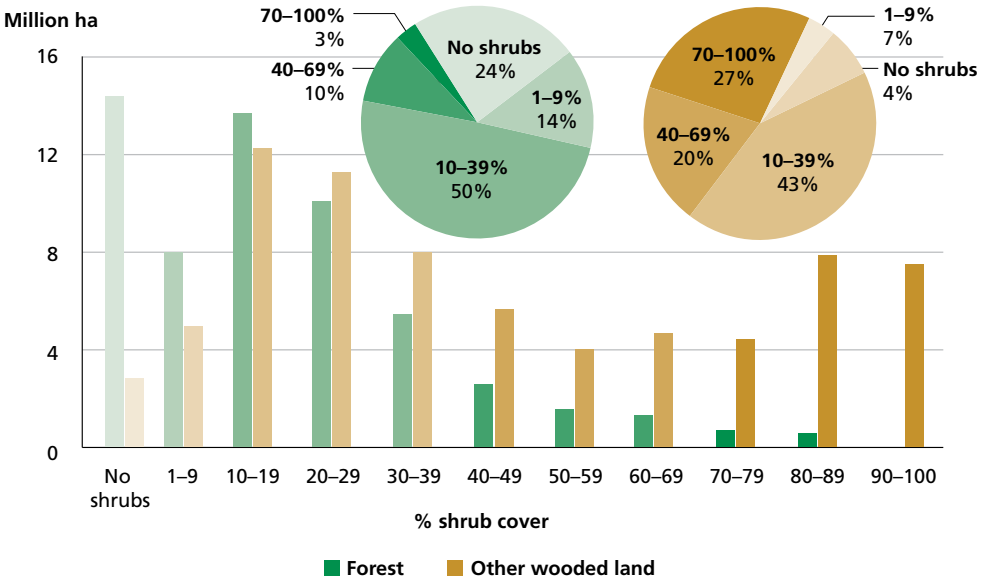
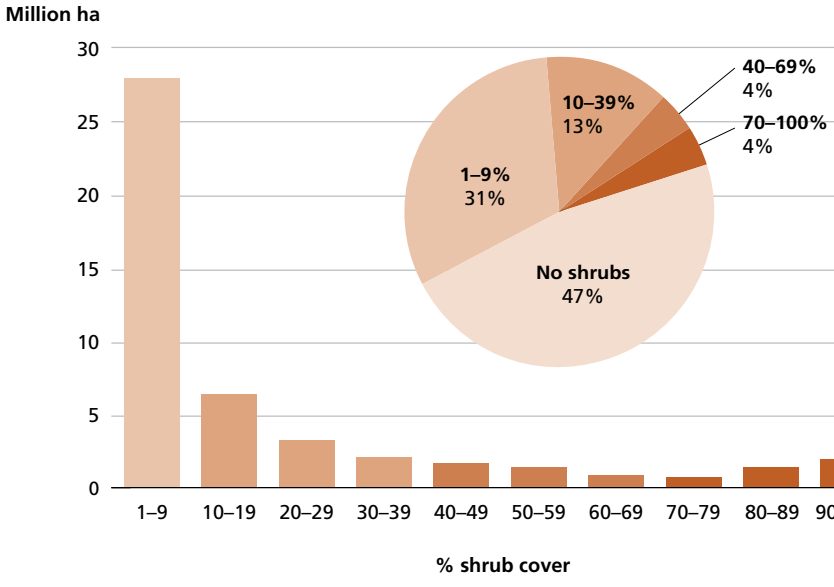


FIGURE 81

Shrub cover in other land



OTHER LAND

More than 89 million hectares of Southern Africa's drylands are classified as other land. About 46 percent of other land is in the semi-arid zone and 34 percent in the arid zone, while only 12 and 8 percent are in the dry subhumid and hyperarid zones, respectively (Figure 82).

The other lands are mainly composed of grassland or herbaceous savannah (70 percent of other land area, or 62 million hectares, equivalent to 28 percent of total drylands)

FIGURE 82

Distribution of other land by aridity zone ('000 ha)

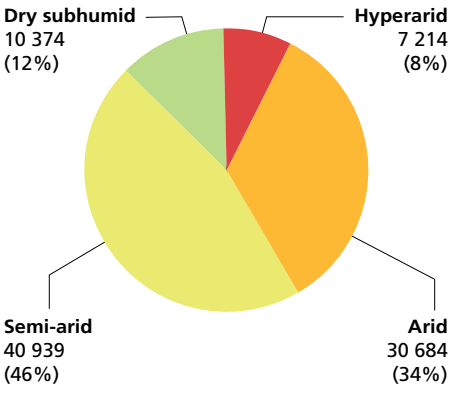
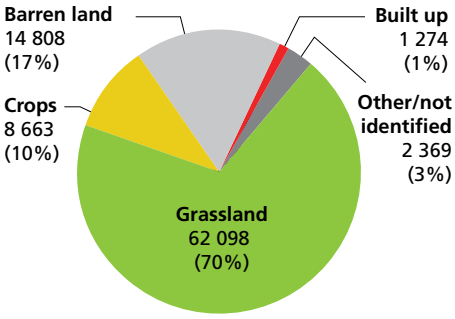


FIGURE 83

Distribution of other land by land use ('000 ha)



(Figure 83, Table 27). Barren land represents 17 percent (15 million hectares) of the other land category, while crops cover about 10 percent of other land (9 million hectares, or 4 percent of total drylands). Grassland is distributed primarily in the semi-arid zone (32 million hectares), followed by the arid zone (23 million hectares) (Table 27, Figure 84). They are found mainly in South Africa and in Namibia's arid zone.

Crops are mainly found in the semi-arid zone (5 million hectares) and in the dry subhumid zone (4 million hectares). Half of them are non-irrigated annual crops (4 million hectares). Irrigated crops are estimated to cover 3 million hectares (almost 40 percent of the cropland), mainly in South Africa (Figure 85).

Barren lands are situated primarily in the arid (7 million hectares) and hyperarid (5 million hectares) zones, corresponding in particular to the coastal desert in Namibia.

Marshlands, which include flooded and saline areas and other wetlands, are mainly found in the semi-arid zone.

TABLE 27

Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	0	519	4 542	3 602	8 663	100
Irrigated crops	0	158	1 687	1 542	3 387	39
Non-irrigated cropland	0	248	2 437	1 643	4 328	50
Perennial crops (palms, orchards, others)	0	68	130	158	356	4
Cropland fallow	0	45	288	259	593	7
Grass	2 244	22 540	31 595	5 720	62 098	100
Barren land	4 971	7 039	2 596	202	14 808	100
Rock or stone	1 452	2 166	1 009	101	4 728	32
Sand and dunes	3 519	4 851	1 572	101	10 043	68
Snow and glaciers	0	23	14	0	37	0
Built up	0	135	606	533	1 274	100
Villages and urban settlements	0	23	389	331	743	58
Infrastructure	0	113	173	202	488	38
Mining	0	0	43	0	43	3

FIGURE 84

Land use in other land by aridity zone

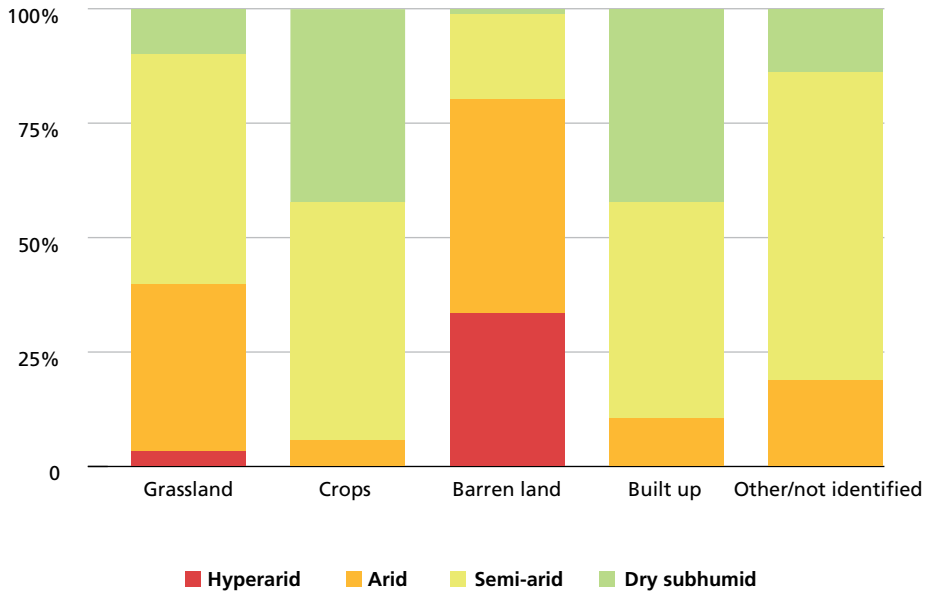
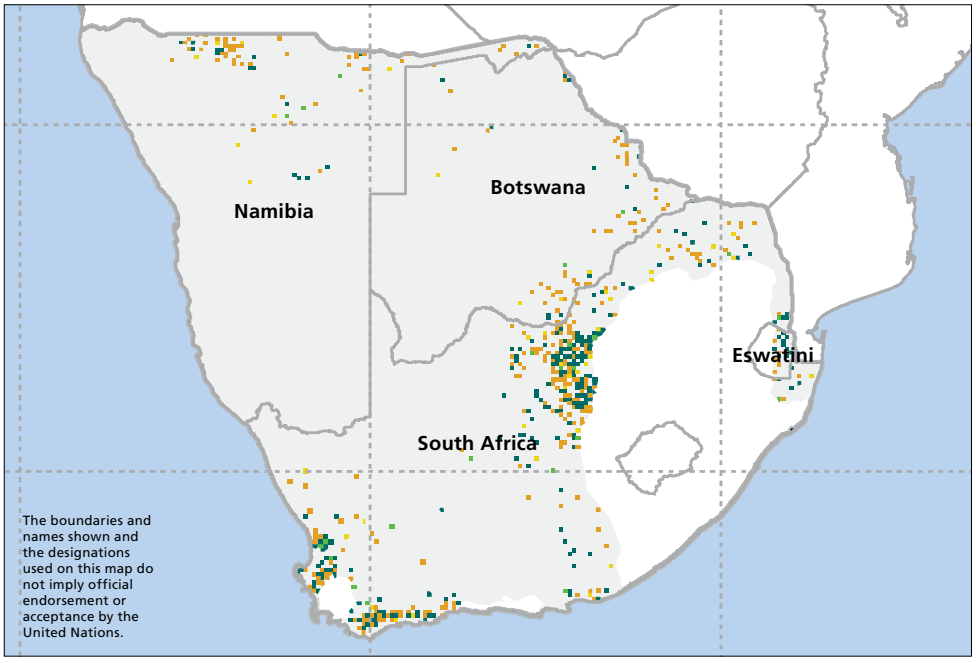


FIGURE 85

Distribution of crop types



Source: UN Maps, 2019

Built-up areas, which include urban and rural settlements, infrastructure and mines, are predominantly found in the semi-arid and dry subhumid zones.

Most of the inland water (62 percent) is in the semi-arid zone, while none was identified in the hyperarid zone.

TREES OUTSIDE FOREST

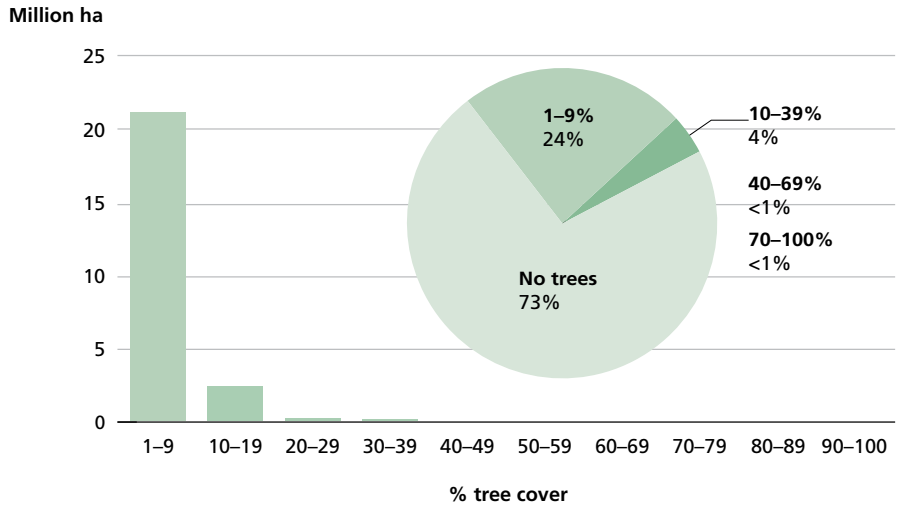
Trees outside forest are present on 25 million hectares (28 percent of other land). Thus most of the other land in the drylands (65 million hectares) has no trees.

Tree canopy cover is between 1 and 9 percent on 21 million hectares (24 percent of other land), while the area of other land with tree cover above 10 percent is 3.4 million hectares (4 percent of other land) (Figure 86).

Other land has 2 percent tree canopy cover on average, as indicated in Table 25. Here also, average canopy cover is observed to increase with decreasing aridity (from less than 1 percent in the hyperarid zone to 3 percent in the dry subhumid zone).

FIGURE 86

Tree canopy cover in other land



Western Asia

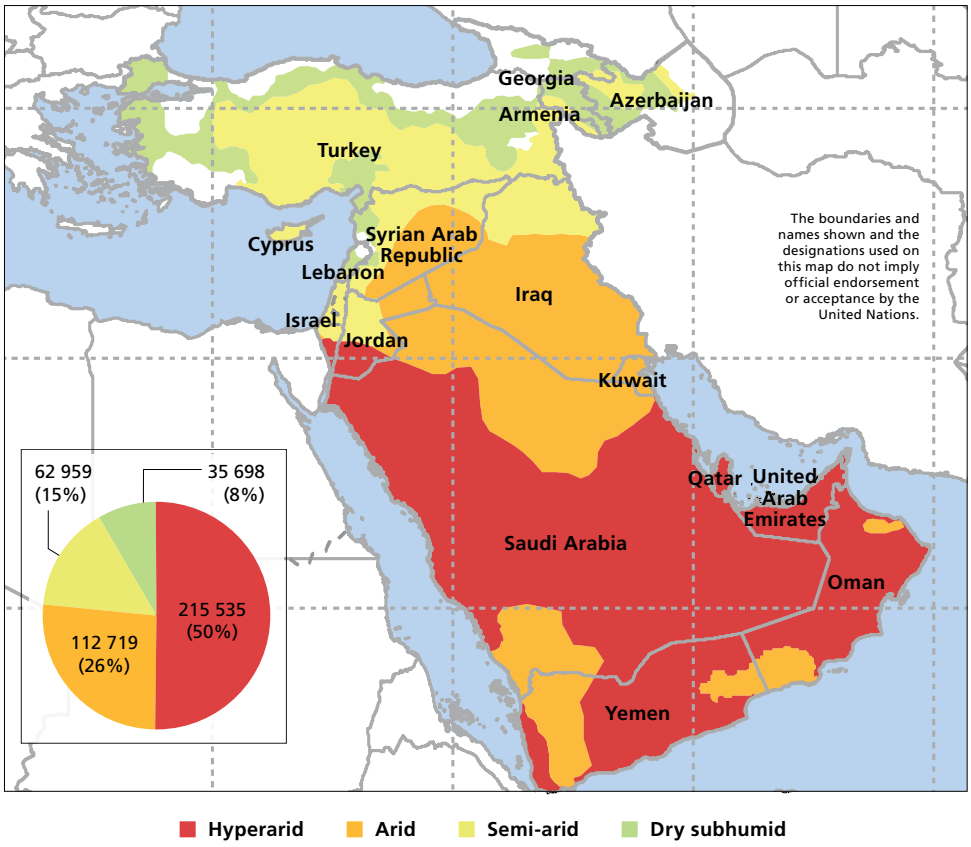
Sabha Reserve, Jordan

KEY FINDINGS

- Drylands cover 94 percent of the land area in Western Asia, or 427 million hectares, representing 7 percent of the global drylands.
- Most of these lands are hyperarid (51 percent) and arid (26 percent). Semi-arid and dry subhumid lands are concentrated in the northernmost part of the region and along the Mediterranean coast.
- Forests span only 4 percent of the drylands. The proportion of forest in land use rises to 30 percent in the dry subhumid zone, which covers 8 percent of the drylands.
- Other wooded land represents 2 percent of the drylands. The average canopy cover in other wooded land is 4 percent, while 52 percent of other wooded land, or 3 million hectares, is grassland or shrubland without trees.
- Forests are almost equally broadleaved and coniferous.
- Half of the forests have dense tree canopy cover, above 70 percent. The tree canopy cover in forests is 65 percent on average; it is denser in the northern part of the region and sparser in the southern part.
- There are no trees on 88 percent or 376 million hectares of drylands in Western Asia.
- Shrubs are present on 14 percent of the drylands and are mainly sparse (with cover density below 40 percent). Dense shrubs are only found in 1 percent of the drylands.
- The drylands are overwhelmingly (94 percent) classified as other land, of which three-quarters (299 million hectares) is barren land (rock, stone or sand). Other land also includes 41 million hectares of grasslands (10 percent of other land) and 50 million hectares of crops (13 percent of other land). Most of the crops (60 percent) are rainfed, but 33 percent (an estimated 17 million hectares) are irrigated.
- Trees outside forest are found on 8 percent of other land (31 million hectares). Tree canopy cover is below 10 percent on 390 million hectares of other land (97 percent).

FIGURE 87

Distribution of drylands in Western Asia by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

Drylands cover 94 percent of the land in Western Asia, with a total area of 427 million hectares. They represent 7 percent of the world's drylands. These drylands are predominantly hyperarid (51 percent) and arid (26 percent). The drylands of the Arabian Peninsula are mainly classified as hyperarid, whereas the drylands of the northern part of the region are for the most part semi-arid or dry subhumid (Figure 87).

The regional assessment presented in this report is based on a survey of 15 401 plots. The analysis was mostly completed by a team of 20 from the General Directorate of Forestry of the Ministry of Agriculture and Forestry of Turkey (covering Turkey, the Near East and the Arabian Peninsula). The Department of Forest and Hunting Inventory of Kyrgyzstan prepared the analysis for Armenia, Azerbaijan and Georgia.

BACKGROUND

Climate

The bioclimatic characteristics of Western Asia are, to a large extent, dictated by the regional atmospheric circulation pattern over Eurasia. The climate of this area is controlled by a complex interplay between the North Atlantic Oscillation, subtropical anticyclone, Indian monsoon and Siberian anticyclone. Several large water bodies (Black Sea, Persian Gulf and Caspian Sea) have a local impact on the general circulation pattern, modifying temperature and precipitation regimes. Most precipitation in the Near East falls during the winter months and is brought by westerly disturbances.

Western Asia shows a gradient of aridity from north to south (Figure 87). The climate is mostly Saharo-Sindian (the climate of the Arabian Peninsula), but the westernmost parts of the region have a Mediterranean climate and the northern parts an Irano-Turanian climate (Djamali *et al*., 2012).

The Mediterranean climate is strongly biseasonal, with most precipitation concentrated in winter and a pronounced dry season of about four months in summer. The amount of winter precipitation varies considerably, both spatially and interannually. Minimum temperatures in the coldest month are high.

The Saharo-Sindian climate is characterized by low annual rainfall and high winter minimum temperatures, with high spatial variation in precipitation, particularly during the summer months. Winter precipitation is highest near the northern limits of the Saharo-Sindian area. This climate has a longer dry season than the Mediterranean; it may last almost all months of the year.

The Irano-Turanian climate, in the southern parts of its range (eastern Syrian Arab Republic and northwestern Iraq), is similar to the Mediterranean, but with lower summer rainfall and a longer dry season. In the northern part of its range (Armenia, Azerbaijan, interior Turkey and northern Iraq), the Irano-Turanian climate is less similar to the Mediterranean, with lower minimum winter temperatures, lower winter precipitation and slightly higher summer precipitation in some areas. In the northwestern parts of the Irano-Turanian area, a significant precipitation phase also occurs during the spring, owing to the westward movement of westerly depressions bearing moisture from the Mediterranean and Black Seas.

Importance of dryland forests, trees and biodiversity

The forests of Western Asia have significant importance in terms of provisioning services (grazing, roundwood and fuelwood, NWFPs), regulating services (land stabilization, watershed protection, desertification control, air quality and microclimate), supporting services (carbon sequestration, biodiversity and soil conservation) and cultural services (recreation and landscape quality) (FAO, 2010; Hadri and Guellouz, 2011). Economically important plants are present in most forests in the region, particularly wild crop relatives such as wheat, rye and barley, as well as nuts and fruits such as pistachio, olive, walnut, chestnut, almond, apricot, pear and apple (FAO, 2010).

Forests and trees provide subsistence for local populations and are deeply integrated into the fabric of rural societies in Western Asia. A wide range of wood and non-wood forest products support the livelihoods of millions of people. As the basis for small-scale enterprises, they provide income and employment for rural people, especially women. In arid countries with low forest cover, trees and shrubs enhance the productivity of crop and livestock systems and provide multiple environmental services that contribute to sustainable rural development (FAO, 2010).

Most of Western Asia's forests are considered globally outstanding and critically endangered from the biodiversity point of view, as represented in three biodiversity hotspots (Mediterranean Basin, Caucasus and Irano-Turanian) (Myers *et al.*, 2000) and four Global 200 ecoregions (Mediterranean forests, woodlands and scrub; Caucasus-Anatolian-Hyrcanian temperate forests; Arabian highland woodlands and shrublands; and Aegean and Western Turkey sclerophyllous and mixed forests) (Olson and Dinerstein, 2002). The Mediterranean forests, woodlands and scrub ecoregion has the highest global rate of plant endemism – about 12 000 species, corresponding to almost 50 percent of the regional flora (Myers *et al.*, 2000). The mountain forest landscapes of the island of Cyprus, the Taurus and Amanus Mountains in Turkey and Mount Lebanon all have plant endemism rates higher than 20 percent (Médail and Quézel, 1997). Lower rates of plant endemism occur in the southern mountains of the Arabian Peninsula (2 750 species), the Irano-Turanian region (2 500 species)

and the Caucasus (1 600 species). The mountains around the Mediterranean Basin are home to 36 endemic conifer species and subspecies with a narrow distribution range. About 15 conifers and 24 broadleaved trees from the Mediterranean portions of the Near East were included in the 1997 IUCN Red List of Threatened Plants (Walter and Gillett, 1998).

Trends and challenges

Communal property rights used to be the dominant type of forest landownership in Western Asia before the colonial era. These systems were based on the organization of specific user groups who agreed on flexible rules, and access was often granted through alliances and socio-political negotiations that served the interest of all partners. Certain communities, in Yemen, for example, still manage forests as common property according to traditional sets of rules and rights (FAO, 2010).

State-controlled regimes for forest and pasturelands and national settlement policies, instituted in many countries in Western Asia after the colonial period, have severely disrupted transhumant and nomadic livelihoods, engendering extensive conflicts between pastoral groups and public administrations (Borrini-Feyerabend *et al.*, 2007). The expropriation of common lands and their distribution among private individuals has led to the conversion of important grazing grounds to agriculture, especially in the lowlands. Herders have been forced to shift to a more sedentary way of life, and the subsequent lack of management of resources previously managed at the communal level has led to the overexploitation of pastoral and forest resources all year round (FAO, 2010). Excessive grazing and forage collection has strongly reduced the overall productivity and species diversity of natural pastures (Schlecht *et al.*, 2004), leading to significant soil erosion and land degradation. In some countries, efforts are being made to revive customary management practices as a means of restoring the landscape (Box 8).

Western Asia is undergoing rapid urbanization, including both seasonal and permanent migration of rural populations to urban areas. In many forest and mountain regions, populations are now earning a significant part of their income from off-farm employment. The trends in urbanization and industrialization are expected to continue and to reduce some of the pressure on rural forests from grazing and fuelwood collection. However, rapid urbanization creates new pressures, such as clearance of forests in the course of urban expansion, localized overcutting in peri-urban areas to supply fuelwood to urban populations, and unplanned and uncontrolled tourism development, particularly around large settlements and in coastal strips.

The absence of adequate management and the unsustainable use of natural resources are having severe negative effects on the natural forests and preventing forest regeneration in large areas. Overgrazing, illegal logging and the irrational collection of fuelwood and forage are major causes of land degradation. In many forested parts of northern Anatolia, Turkey, for example, the lack of alternative energy sources has doubled or tripled fuelwood consumption. The irrational collection of wood often entails mutilating trees and scrub and thus favours the spread of pests, one of the main reasons behind the increase of forest dieback events in recent decades, especially affecting conifers in mixed mountain forests (Allen *et al.*, 2009). National and regional disputes and wars have also been a cause of serious forest resource degradation in some countries of the region (FAO, 1997).

Pressures on wildlife include hunting and capture of animals for sale to zoos and for use in traditional medicine (Lagrot and Lagrot, 1999). The overcollection of plants and wildlife has a major impact on biodiversity. The collection of wild bulbs in the mountains of Turkey, for instance, exceeded 60 million per year in the 1980s, an unsustainable quantity (Atay, 2003).

BOX 8

Reviving customary management through economic incentives, for sustainable rangeland management and restoration

Land stewardship is key to good natural resource governance that supports ecosystem functions, biodiversity conservation and land restoration and contributes to equitable and sustainable development.

Nomads inhabiting Western Asia and Northern Africa, where more than 60 percent of the land is considered drylands, have used traditional institutions of tenure for more than 1 400 years (Klos, undated). Historically, local tribal communities protected their natural resources through the traditional management system known as *hima* in the Mashriq (the Arab countries of Western Asia and the eastern part of Northern Africa) and *agdal* in the Maghreb (the western part of Northern Africa), by which they set aside areas of land, typically pasture and forest, to protect them. However, changes in land use, prioritization of farming activities and settlement of nomads has led to the exclusion of herding communities, resulting in serious environmental degradation and challenges to the livelihoods of pastoral communities. Jordan and Lebanon have been pioneers in reviving the *hima* system.

In Jordan, Prince El Hassan Bin Talal endorsed the Amman Declaration on Innovating *Hima* in May 2014, to support the upscaling of policies and legislation related to this traditional system for managing rangeland, particularly for sustainable management and conservation of rangeland biodiversity, bird conservation and improvement of livelihoods. Following environmental and economic assessments carried out at pilot *hima* sites in 2013 and 2015, assessing the impact of land-use changes on forage availability, groundwater infiltration, carbon sequestration and sediment stabilization, the government updated its rangeland strategy to make *hima* a modality for all grazing sites to ensure the effective integration of natural resource conservation, community livelihoods, ethics and animal welfare. The Jordanian rangeland strategy consequently received a Future Policy Bronze Award in 2017, granted by the World Future Council in partnership with the United Nations Convention to Combat Desertification (UNCCD).

In Lebanon, several municipalities have adopted *hima* to conserve and manage forest in close coordination with local communities. *Himas* have been established at important bird areas through cooperation with the Society for the Protection of Nature in Lebanon. In 2012, *hima* was one of the four categories identified by the country's Ministry of Environment in the protected areas law.

A group of pastoralist communities in Western Asia has established the Arabian Pastoralist Communities Network with the aim to revive, document and develop the traditional knowledge. It operates as a regional body for promoting concern for cultural rights and rights to land and natural resources, combating desertification and conserving threatened biodiversity in the region.

The pilot hima *site Bani Hashem in spring 2019, after four years of communal management*

Habitat loss is a major threat in the Arabian Peninsula, where original mountain conifer forests are now reduced to scattered isolated trees. With the intense use of fire as a management practice in agriculture and livestock grazing, and the increase of neglect and arson as a result of land-use changes and conflicts, uncontrolled fires burn significant amounts of forest every year. This problem is magnified in areas with political tensions, armed conflicts and military operations (FAO, 2010). Land-use and management changes (including the colonization of terraced slopes and grasslands by dense young forests and shrubs, and an increase in tree plantations) have also created fire-prone landscapes with a high risk of difficult-to-control fires, as highly diverse rural landscapes have become more homogeneous landscapes with significant accumulation of biomass and fuel load. Degradation of mature forests also increases disease rates and the accumulation of dry biomass (FAO, 2010).

Changes in agriculture also represent an important threat to Western Asia's forests. The abandonment of traditional agricultural systems, such as mountain terraces, has caused significant problems of soil erosion and hydrologic disruption in many mountain forest areas (e.g. southern Anatolian ranges, Mount Lebanon and the mountains of Yemen). In addition, the conversion of mountain forest areas to subsistence agriculture and the expansion of irrigation in wetlands and steppe forest land are causing significant forest habitat loss, pollution from domestic sewage and agricultural effluents, and severe water and wind erosion problems (FAO, 2010).

Economic difficulties in most of the region's countries represent one of the main constraints to more efficient conservation and sustainable management of natural resources, including forests. Some of the wealthier countries, however (i.e. Kuwait, Oman, Saudi Arabia, the United Arab Emirates), have allocated considerable financial resources to the establishment of areas of green cover. Many countries in the region have afforestation and reforestation and integrated watershed management programmes, while desertification control initiatives are under way, particularly in the Persian Gulf countries.

Women are heavily involved in agriculture, pasturage, fuelwood collection and the harvesting of NWFPs in most of Western Asia. Women are the main labour force in tree nurseries, and their role in forestry and agriculture is expected to grow further owing to population increase, environmental changes and internal and international male migration. Yet the growing role of women in food security, agriculture, natural resource conservation and the overall economy of the region is still broadly under-recognized (FAO, 2010).

DISTRIBUTION OF FORESTS AND OTHER LAND USES

The drylands in Western Asia are for the most part (94 percent) classified in the other land category (Figures 88 and 89). Forest represents only 4 percent of Western Asia's drylands, less than 18 million hectares. Other wooded land spans even a smaller proportion, 2 percent or 6 million hectares.

Dryland forest is mainly found in the northern part of the region (Armenia, Azerbaijan, Georgia, Turkey) and along the Mediterranean Sea, while the drylands in the southern part of the region (the Arabian Peninsula), which are drier, are mainly categorized as other land, with scattered forest and patches of other wooded land.

Other land, with sparse vegetation, dominates the drylands in all aridity zones (from 65 percent of the drylands in the dry subhumid zone to over 98 percent in the arid and hyperarid zones) (Figure 90). The proportion of forest decreases with the aridity level. Most of the forests occur in the dry subhumid zone, where they cover 30 percent of the dryland area, but their presence decreases to less than 1 percent in the arid and hyperarid zones. Other wooded land is almost equally distributed across the aridity zones; it covers 4 percent of the dry subhumid zone, and less than 3 percent of the other zones.

FIGURE 88

Distribution of land uses in Western Asia's drylands ('000 ha)

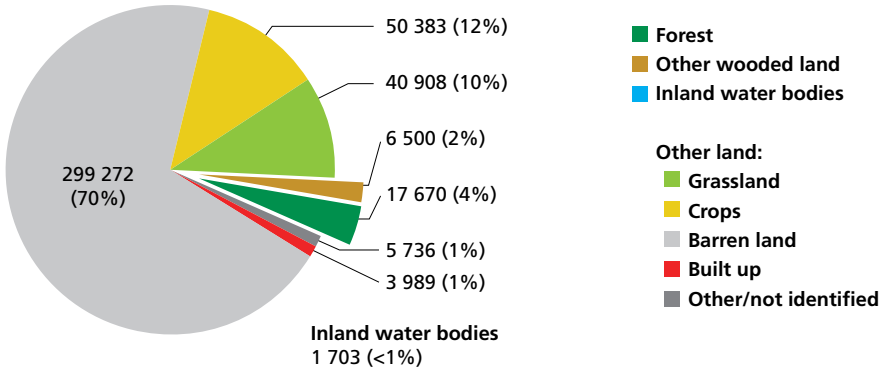
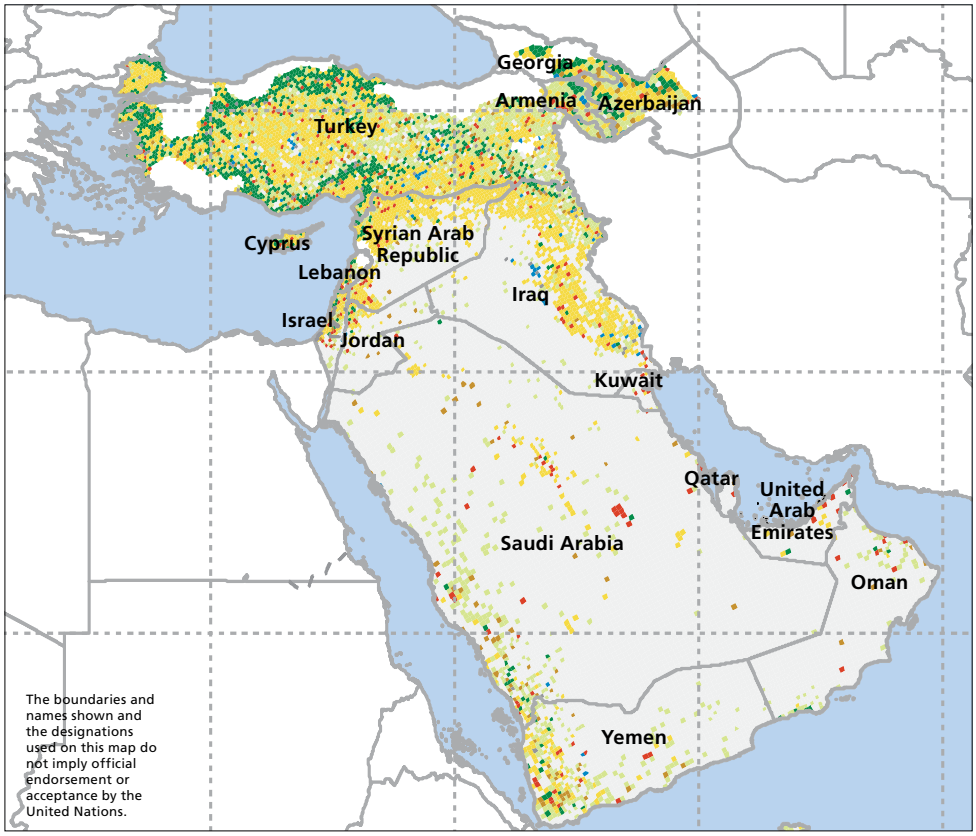


FIGURE 89

Main land uses in Western Asia's drylands



Source: UN Maps, 2019

FIGURE 90

Distribution of land uses by aridity zone

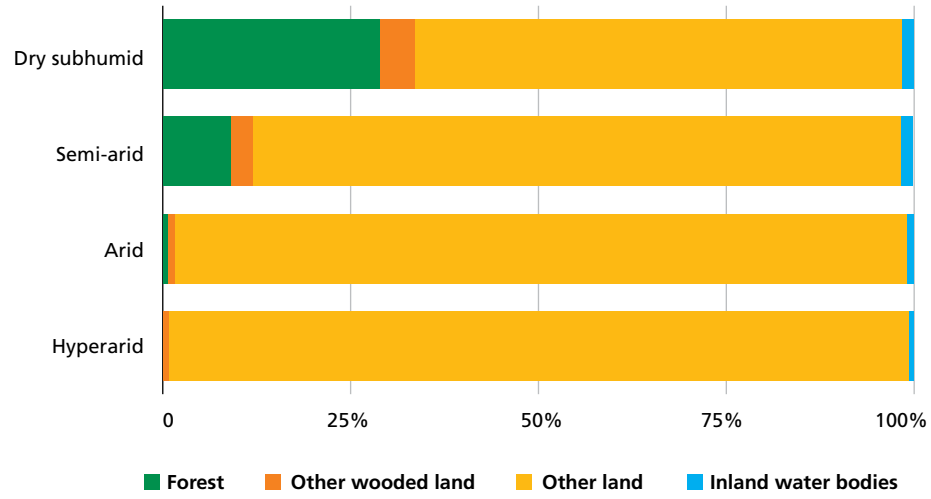


FIGURE 91

Distribution of dryland forest by aridity zone ('000 ha)

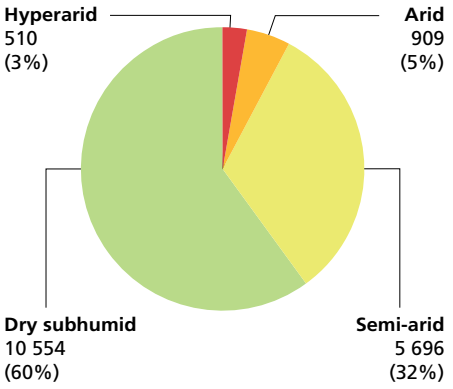
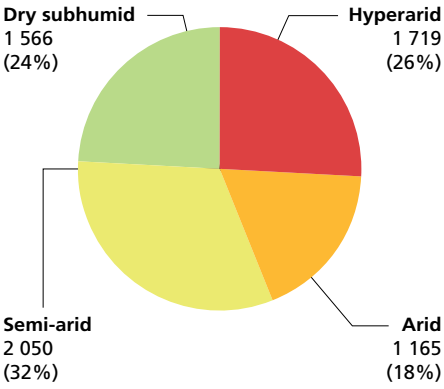


FIGURE 92

Distribution of other wooded land by aridity zone ('000 ha)



Of the 18 million hectares of forest in Western Asia's drylands, a large majority (60 percent) is in the dry subhumid zone, and 32 percent in the semi-arid zone (Figure 91).

Other wooded land area is almost equally distributed across the aridity zones, with 24 percent in the dry subhumid zone, 32 percent in the semi-arid zone, 18 percent in the arid zone and 26 percent in the hyperarid zone (Figure 92).

VEGETATION IN FORESTS AND OTHER WOODED LAND

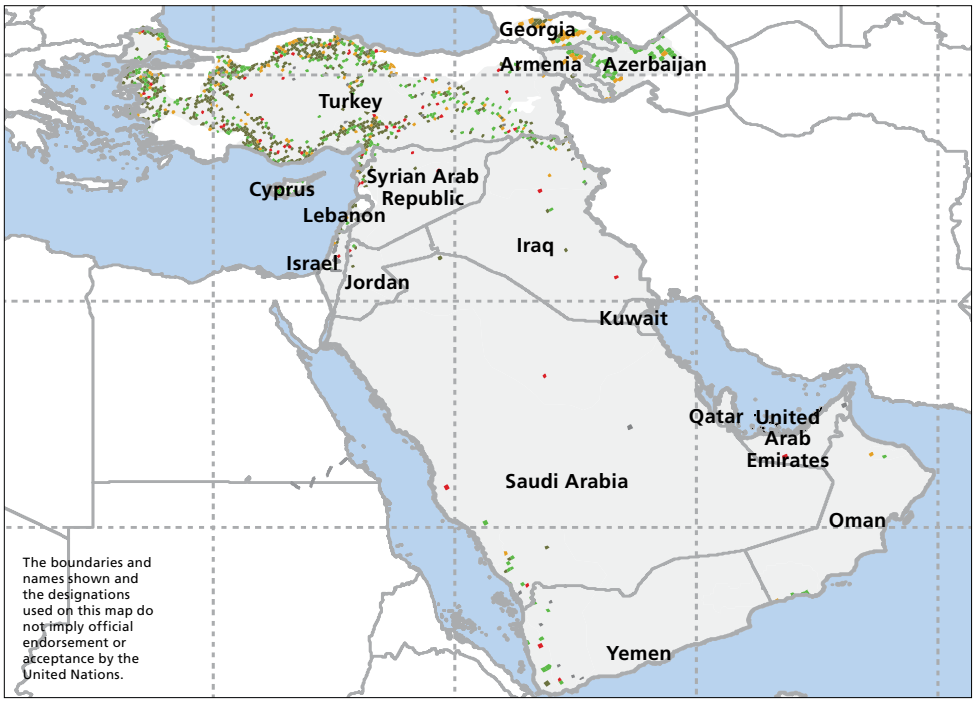
The forests in Western Asia's drylands are classified as 41 percent coniferous, 36 percent broadleaved and 14 percent mixed (Table 28, Figure 93; see also Box 9). The forest type was not specified for 2 percent of forest. Planted forests represent 6 percent of forest.

Other wooded land is mostly dominated by grassland: 50 percent grassland with shrubs, and 29 percent grassland with trees and shrubs (Table 29).

TABLE 28
Type of forest vegetation by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest										
Broadleaved	186	40	419	47	2 117	37	3 685	35	6 407	36
of which riparian	0	0	23	3	78	1	31	0	132	1
Coniferous	93	0	163	18	2 553	45	4 453	42	7 262	41
Mixed broadleaved and coniferous	0	0	70	8	451	8	1 969	19	2 489	14
Other/not identified	46	0	93	11	171	3	93	1	403	2
Planted forest	139	0	140	16	389	7	355	3	1 023	6
Total	**465**	**0**	**886**	**100**	**5 681**	**100**	**10 554**	**100**	**17 585**	**100**

FIGURE 93
Distribution of dryland forest by subtypes



Source: UN Maps, 2019

TABLE 29
Main vegetation types in other wooded land by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	372	0	583	50	1 297	66	920	62	3 171	50
Grassland with trees and shrubs	418	0	373	32	536	27	506	34	1 833	29
Shrubland	93	0	23	2	0	0	0	0	116	2
Other/not identified	790	0	186	16	124	6	62	4	1 162	18
Total	**1 672**	**0**	**1 165**	**100**	**1 957**	**100**	**1 488**	**100**	**6 283**	**100**

BOX 9

Forest and woodland vegetation types in the drylands of Western Asia

Western Asia lies in the transition zone between two major biogeographic units, the Palaearctic and Afrotropical ecozones (Ghazanfar and McDaniel, 2016). In the Near East, the Arabian Desert separates the Palaearctic and Afrotropical ecozones and forms a transition zone between the Afrotropic and Mediterranean Basin to the north. The Mediterranean Basin (of the Palaearctic ecozone) consists of Mediterranean forests, woodlands and scrub.

The northernmost part of the Western Asia region (northern Turkey, Armenia, Azerbaijan and Georgia) corresponds to the southern limit of the Euro-Siberian floristic region. It is dominated by mesophyllic broadleaved deciduous forests, with a substantial component of evergreen shrubs in the understorey. Among them, a dominant role is played by beech (*Fagus orientalis*) (Browicz, 1989).

The Mediterranean floristic region (along the Mediterranean Sea in Western Asia) is characterized by scrubby, dense vegetation composed of broadleaved evergreen shrubs, bushes and small trees, usually of less than 2.5 m. Important tree species of the Mediterranean vegetation in Western Asia are *Quercus ilex*, *Quercus coccifera*, *Pinus halepensis*, *Pistacia lentiscus*, *Olea europea* and *Ceratonia* spp. (Eastwood, 2004).

The Irano-Turanian floristic region (mainly central and eastern Turkey, northeastern Iraq and northern Syrian Arab Republic) mainly consists of steppes with *Prosopis farcta* as a common woody species. In mountainous areas of Turkey and Iraq, forests of *Quercus* spp. are found (Ghazanfar and McDaniel, 2016).

The Saharo-Sindian floristic region, which occupies most of the Arabian Peninsula, Jordan, southern Syrian Arab Republic and southwestern Iraq, has a flora that is poor in species. The southern Arabian woodlands, found mostly in southwestern parts of the Arabian Peninsula (mostly Yemen, parts of western Oman and southwestern Saudi Arabia), include a few permanent and seasonal forests with elements of the Eastern African and Ethiopian floras. Other woodlands, predominantly of juniper or acacia, are scattered and cover small areas (Zohary, 1973; Ghazanfar and Fisher, 1998).

TREE CANOPY COVER

There are no trees on 88 percent or 376 million hectares of the drylands in Western Asia (Figure 94). Tree canopy cover is denser in the northern countries of the region (Armenia, Azerbaijan, Georgia, Turkey), along the Mediterranean Sea, and, to a lesser extent, in the basin of the Tigris River.

Over half of dryland forest (51 percent) has dense tree canopy (at least 70 percent cover) (Figure 95). Almost one-quarter (23 percent) has tree canopy cover ranging from 40 to 70 percent. The remaining 26 percent has an open canopy, with cover below 40 percent.

On average, tree canopy cover in the region's dryland forest is 65 percent (Table 30). It is highest in the subhumid zone (71 percent on average) and below 60 percent in the other, more arid zones.

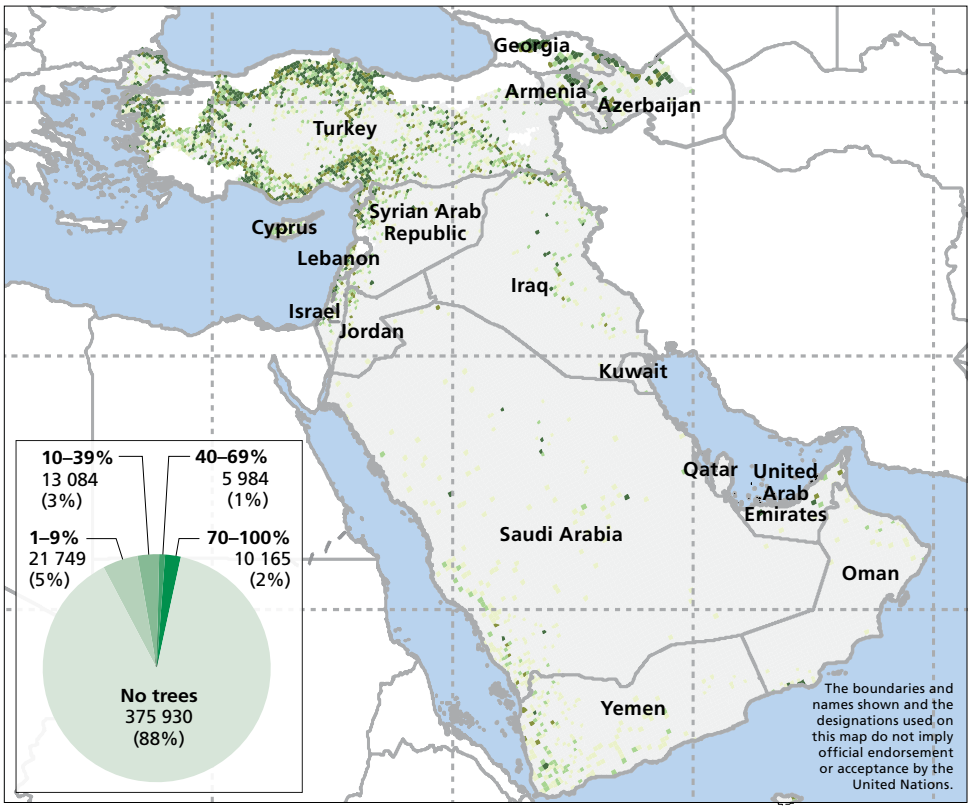
TABLE 30

Average tree canopy cover in Western Asia's drylands by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	50	42	58	71	**65**
Other wooded land	3	4	4	4	**4**
Other land	0	0	3	7	**1**
Inland water bodies	0	0	1	0	**1**
All lands	**0**	**1**	**8**	**26**	**4**

FIGURE 94

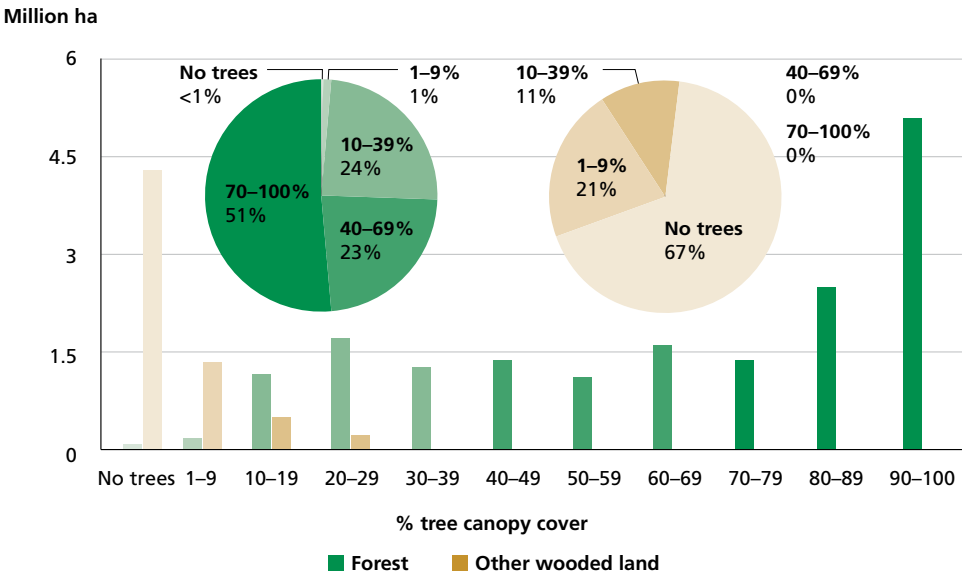
Distribution of tree canopy cover in Western Asia's drylands by tree cover range ('000 ha)



Source: UN Maps, 2019

FIGURE 95

Tree canopy cover in forest and other wooded land



Two-thirds of the other wooded land in drylands, or 4 million hectares, has no tree cover and is predominantly covered with shrubs. The other third has an open canopy (Figure 95). Tree canopy cover in other wooded land is 4 percent on average and is almost the same in all aridity zones (Table 30).

SHRUB COVER

There are no shrubs on 86 percent or 366 million hectares of the drylands in Western Asia, and shrub cover is less than 10 percent on 96 percent or 407 million hectares (Figure 96). The presence of shrubs more or less coincides with the presence of trees (compare Figures 94 and 96). Dense shrubs are found on only 1 percent of the drylands.

Most of the other wooded land in the region is sparsely covered with shrubs: 50 percent has shrub cover ranging from 10 to 39 percent, and 16 percent has shrub cover between 1 and 9 percent (Figure 97). Shrub cover is dense (between 40 and 69 percent) on 16 percent of other wooded land, and very dense and continuous (ranging from 70 to 100 percent) on 12 percent of other wooded land.

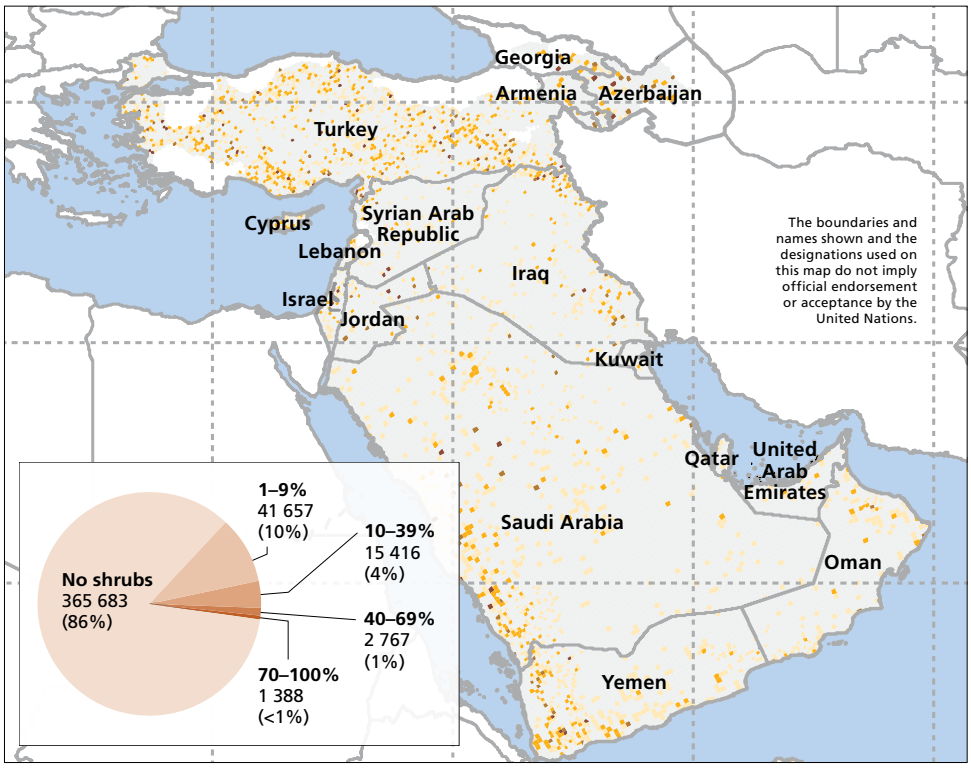
Shrub coverage is 30 percent on average in other wooded land. It is above this average in the arid, semi-arid and dry subhumid zones, and lower (21 percent) in the hyperarid zone (Table 31).

Two-thirds of the region's dryland forest has no shrub cover (or shrubs could not be detected because of dense tree canopy) and an additional 17 percent of forest has little shrub cover (between 1 and 9 percent) (Figure 97). The average shrub cover in forest is estimated to be 5 percent (Table 31). Forest shrub cover is highest in the arid zone (9 percent).

Almost 94 percent (751 million hectares) of other land in the drylands has no shrub cover, while 4 percent (38 million hectares) has shrub cover ranging from 1 to 9 percent (Figure 98).

FIGURE 96

Shrub cover in Western Asia's drylands ('000 ha)



Source: UN Maps, 2019

FIGURE 97

Shrub cover in forest and other wooded land

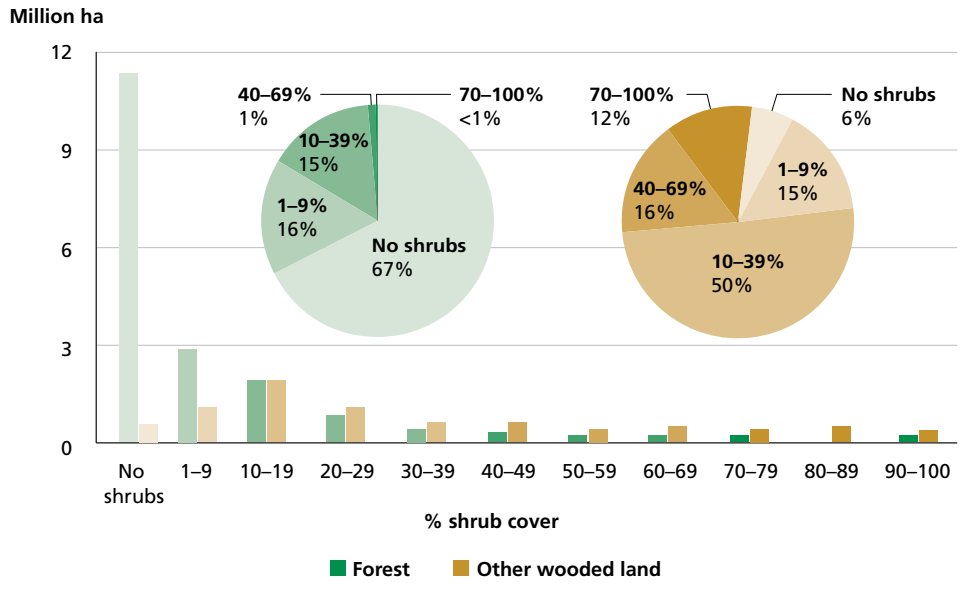


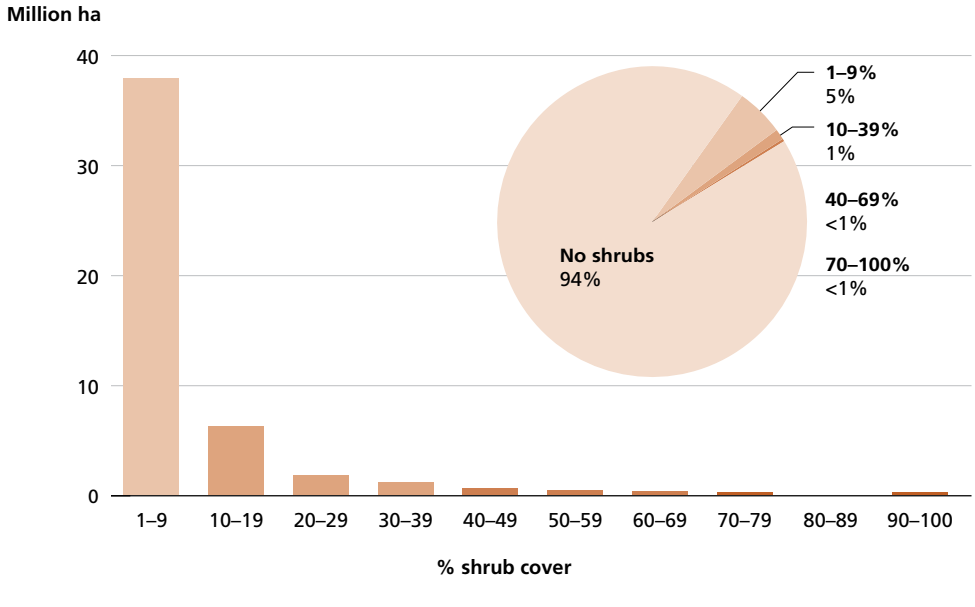
TABLE 31

Average shrub cover by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	2	9	6	4	**5**
Other wooded land	21	35	31	36	**30**
Other land	1	1	2	3	**1**
Inland water bodies	0	0	0	0	**0**
All lands	**1**	**2**	**3**	**5**	**2**

FIGURE 98

Shrub cover in other land



OTHER LAND

Of the 401 million hectares of other land in Western Asia's drylands, 53 percent is found in the hyperarid zone, 27 percent in the arid zone, 14 percent in the semi-arid zone and only 6 percent in the dry subhumid zone (Figure 99). This distribution of other land by aridity zone matches the distribution of total drylands by aridity zone (compare Figures 87 and 99).

The other land category is largely dominated by barren land (75 percent of the total other land area, or 299 million hectares), followed by crops (13 percent of other land or 50 million hectares) and grasslands (10 percent of other land or 41 million hectares) (Figure 100). Settlements and built up areas occupy 1 percent of other land (6 million hectares).

Barren land is located for the most part in the hyperarid zone (197 million hectares) and arid zone (91 million hectares) (Table 32, Figure 101). It is mainly composed of sand and dunes.

FIGURE 99

Distribution of other land by aridity zone ('000 ha)

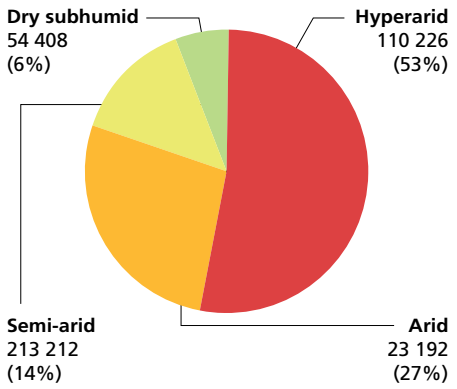


FIGURE 100

Distribution of other land by land use ('000 ha)

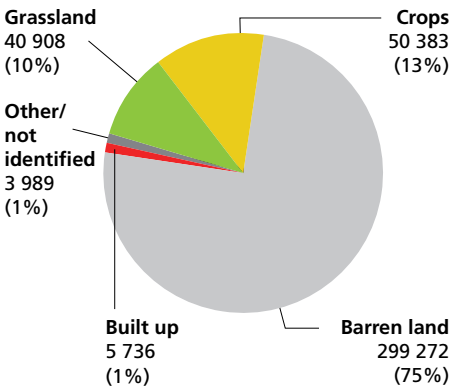


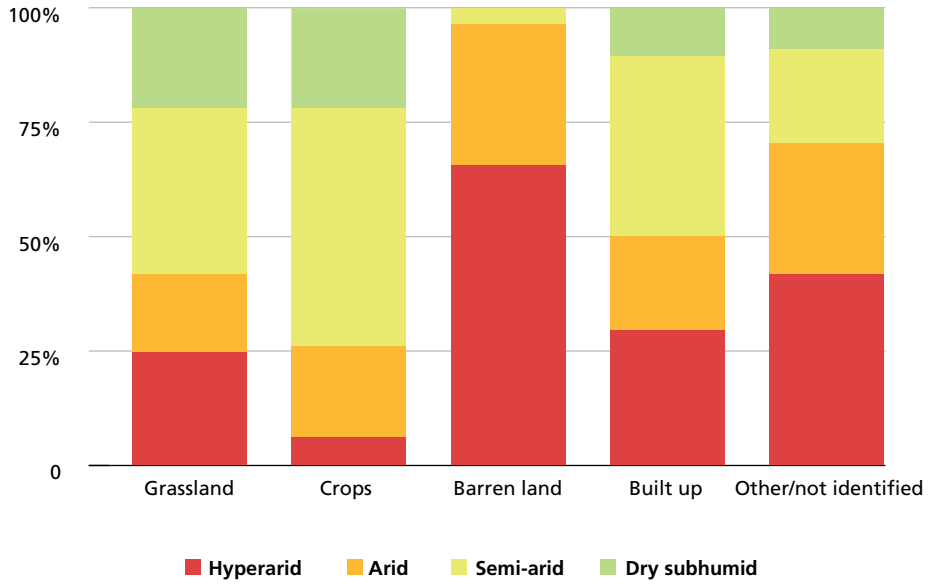
TABLE 32

Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	2 926	9 904	26 241	11 311	50 383	100
Irrigated crops	1 115	4 171	8 207	3 066	16 559	33
Non-irrigated cropland	1 486	5 267	16 302	7 070	30 125	60
Perennial crops (palms, orchards, others)	325	419	1 671	1 109	3 524	7
Cropland fallow	0	47	62	66	175	0
Grass	10 034	7 061	14 597	9 216	40 908	100
Barren land	196 768	90 954	10 306	1 244	299 272	100
Rock or stone	29 636	12 467	3 078	637	45 819	15
Sand and dunes	167 132	78 486	7 197	494	253 310	85
Snow and glaciers	0	0	31	112	143	0
Built up	1 719	1 165	2 222	630	5 736	100
Villages and urban settlements	975	792	1 779	483	4 030	70
Infrastructure	697	373	392	132	1 594	28
Mining	46	0	50	15	112	2

FIGURE 101

Land use in other land by aridity zone



Terracing for prevention of erosion and runoff, Saudi Arabia

©MARVIIKAD

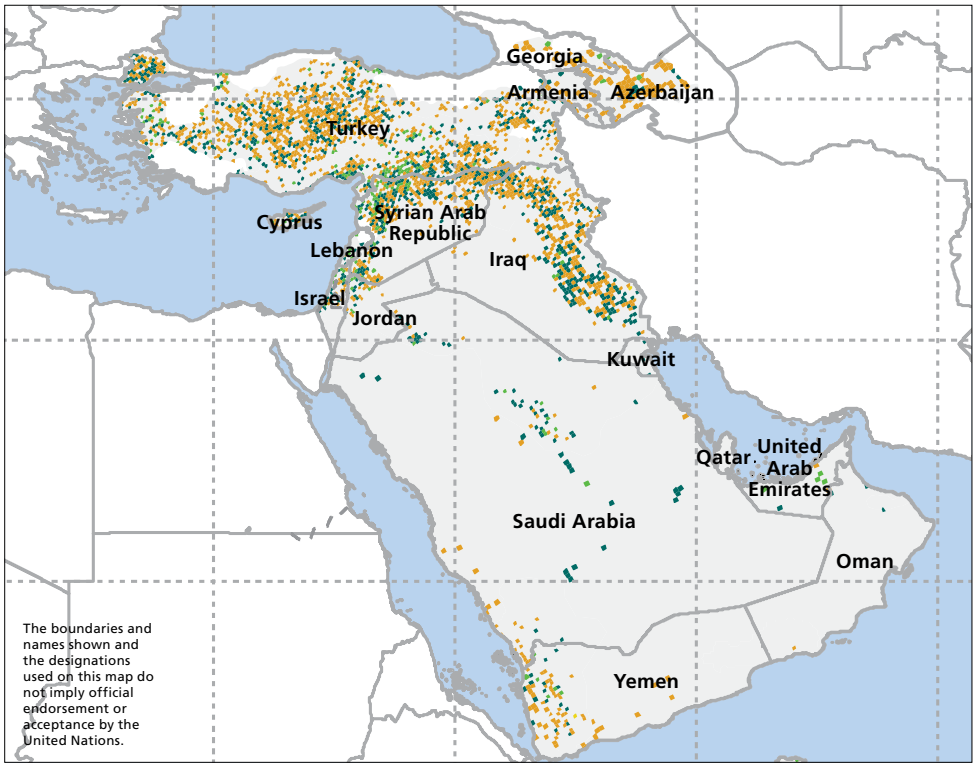
Crops are mainly found in the semi-arid zone (26 million hectares) and dry subhumid zone (11 million hectares). Most of them (60 percent) are non-irrigated annual or mixed crops (30 million hectares). Irrigated crops are estimated to cover 17 million hectares (about one-third of cropland). Most of the cropland is found in the northern part of the region and along the Mediterranean Sea, in the northern Syrian Arab Republic, eastern Iraq and western Yemen (Figure 102).

Grasslands are distributed primarily in the semi-arid zone (15 million hectares), followed by the hyperarid zone (10 million hectares) and are mainly found in the northern part of the region and to a lesser extent in the western part of the Arabian Peninsula (see Figure 89).

Built-up areas, which include urban and rural settlements as well as infrastructure such as roads, are less frequent in the dry subhumid zone (0.6 million hectares) than in the other aridity zones.

FIGURE 102

Distribution of crop types



Source: UN Maps, 2019

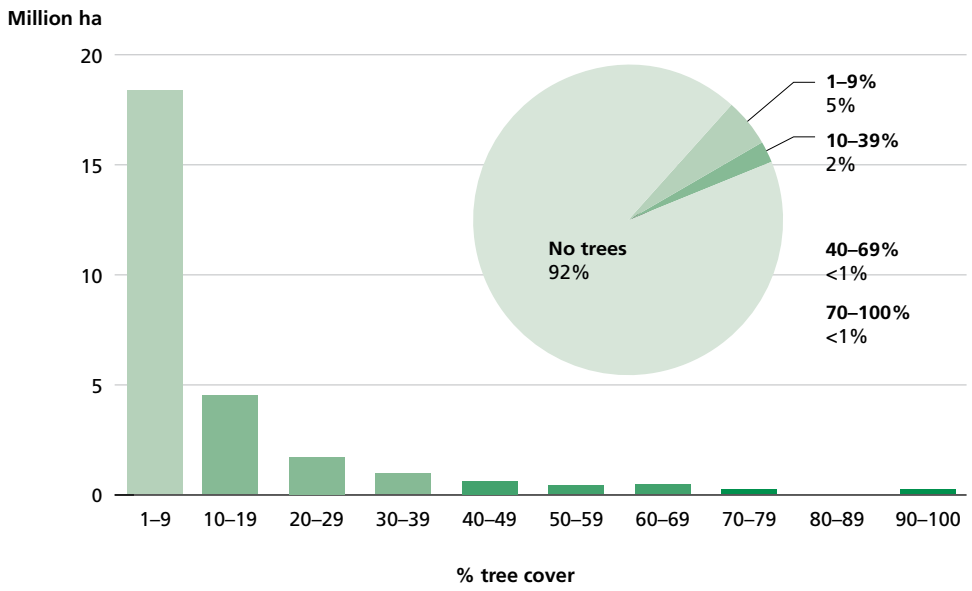
TREES OUTSIDE FOREST

Trees outside forest are present on only 8 percent of other land (31 million hectares). Thus an overwhelming majority of the other land category – 370 million hectares – has no tree cover (Figure 103). Tree canopy cover is below 10 percent on 390 million hectares of other land (97 percent). The area of other land with tree cover above 10 percent is 11 million hectares (3 percent of other land).

Tree canopy cover in other land is 1 percent on average (Table 30) and increases as aridity decreases (from 0 in the hyperarid zone to 7 percent in the dry subhumid zone).

FIGURE 103

Tree canopy cover in other land



Central and Eastern Asia

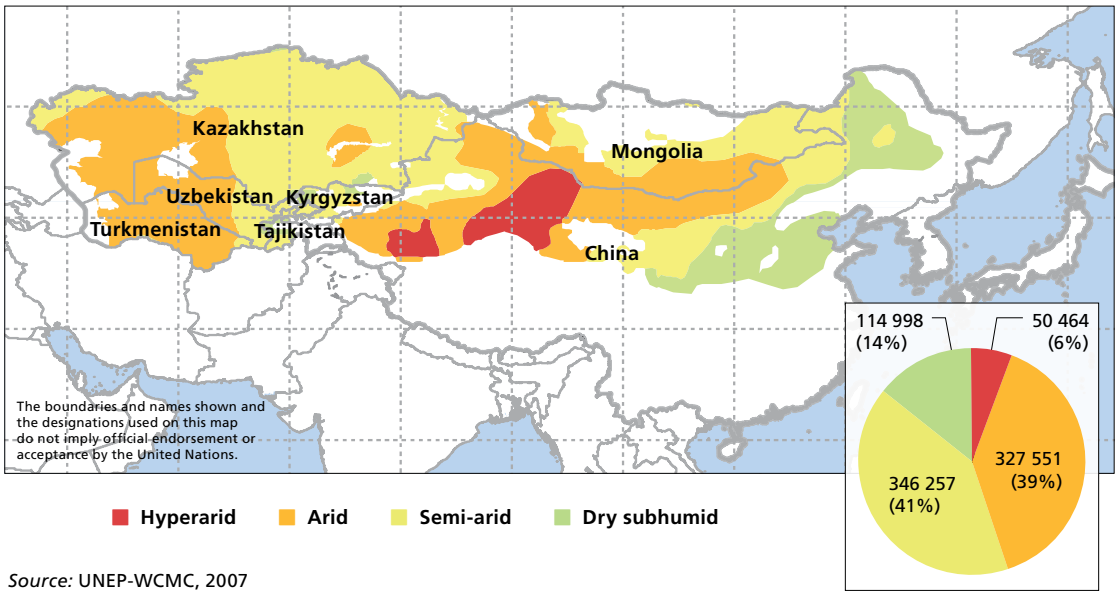
Collecting wild fruits, Uzbekistan

KEY FINDINGS

- The drylands of Central and Eastern Asia consist of 839 million hectares, representing 53 percent of the region's total land area and 14 percent of the global drylands.
- The region's drylands contain 33 million hectares of forest, which is equivalent to 3 percent of the global dryland forest area and about 1 percent of the global forest area.
- Forest covers 4 percent of the region's dryland area, while other wooded land covers less than 1 percent.
- Approximately 69 percent of the forest is located in the dry subhumid zone, 25 percent in the semi-arid zone and 6 percent in the arid zone.
- Approximately 82 percent of the dryland forest in the region has closed canopy (canopy cover greater than 40 percent).
- The drylands in the region are predominantly (95 percent) characterized as other land, mainly comprising grassland (40 percent), barren land (31 percent) and crops (16 percent).
- Trees outside forest are present on 41 million hectares (5 percent of other land in the region). Approximately 72 percent of croplands and 16 percent of built-up lands have some tree cover.

FIGURE 104

Distribution of drylands in Central and Eastern Asia by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

The drylands of Central and Eastern Asia comprise 839 million hectares; around 87 percent of this area belongs to three large countries, China, Kazakhstan and Mongolia. The drylands of Central and Eastern Asia represent 14 percent of the world's drylands.

The semi-arid and arid zones are the largest, covering 346 million hectares (41 percent) and 328 million hectares (39 percent) of the region's drylands, respectively (Figure 104). The dry subhumid zone covers 115 million hectares (14 percent of drylands), mostly on the northeastern side of the region, stretching from the Greater Khingan Range to the Langmusi Mountains in China. The hyperarid zone covers around 50 million hectares (6 percent of drylands) in the Taklimakan Desert and in the Altun Mountains of China, extending to the Mongolian border.

The assessment of the drylands of this region is based on photo interpretation of 19 974 plots, conducted by the Department of Forest and Hunting Inventory of Kyrgyzstan.

BACKGROUND

Climate

The environment of Central and Eastern Asia is characterized by low and variable rainfall and temperature extremes; the landscape is a mixture of mountains, deserts and steppes.

Mean summer temperatures in the region range from 20 °C in the north to above 30 °C in the south (De Pauw, 2008), while winter temperatures are below zero, with extremes below –20 °C in the northern and mountain areas, also known as "cold desert". The mean annual precipitation in the lowlands ranges from about 400 mm in north Kazakhstan to less than 100 mm in some areas of Uzbekistan and Turkmenistan (Lioubimtseva and Henebry, 2009).

Importance of dryland forests, trees and biodiversity

The forests of Central and Eastern Asia offer timber and other non-wood products as well as refuge for wildlife; they also protect soil and help to prevent sand encroachment (Novikov, Simonett and Kirby, 2011). Indeed, most of the forests in the region are protected, with timber felling forbidden. Some of the dryland forests are sparse, such as

the saxaul (*Haloxylon ammodendron*) woodlands, while others are dense forest. They are all important as indicators of species diversity.

Agroforestry is prominent, often with indigenous species such as almond and pistachio, and is significant for food production and economic activities along the value chain.

Trends and challenges

The main threats to forests in recent times have been grazing, trampling, fire and illegal harvesting for fuel and sale (Novikov, Simonett and Kirby, 2011).

Many studies have shown that the drylands in Central and Eastern Asia are especially sensitive and susceptible to climate change and environmental degradation (IPCC, 2001). Continuous increases in temperature have contributed to increased evapotranspiration in the region. Thus, intensified water shortage and aridity are expected (Zhou *et al.*, 2015). While most global drylands experienced stable or increasing precipitation during the period 1988–2008, the Mongolian steppe and northern China were notable exceptions (Andela *et al.*, 2013).

A massive conversion of grassland to cropland in northern Kazakhstan (as well as in the steppes of western Siberia and southern Russia) between 1954 and 1964, the so-called "Virgin Lands" development, expanded the area of arable land in Kazakhstan from 7 to 8 million to 21 to 23 million hectares. This conversion had statistically significant climatic impacts, including changes in evapotranspiration and increases of monthly surface air temperatures by 0.3 to 0.5 °C during the spring, summer and autumn seasons.

The region has approximately 6 000 lakes, most of which are inland, fed by rivers providing mountain snowmelt, with upstream reservoirs used for agricultural irrigation. However, more than half of inland lakes have decreased significantly since 1975 (Bai *et al.*, 2011). These decreases exacerbate serious environmental issues such as soil salinization, pollution of water sources (Saiko and Zonn, 2000), frequent drought and land degradation (Lioubimtseva and Henebry, 2009).

The major driver of desertification in the region has been the conversion of grassland and woodland to cultivated land (FAO, 2002).

In China, desertification is widely recognized as a major environmental hazard. It was the cause of an increasing incidence of sandstorms in the 1990s and early 2000s, which had severe consequences for the environment, agriculture, urban centres and infrastructure. As a consequence of China's forest restoration policy, net tree cover in the country grew by 32 percent from 2000 to 2015, although most of the increase in dryland forest area can be attributed to plantations, including monocultures (Hua *et al.*, 2018).

DISTRIBUTION OF FORESTS AND OTHER LAND USES

Forest covers 33 million hectares in Central and Eastern Asia, or 4 percent of the total dryland area. This area is equivalent to 3 percent of the global dryland forest area and circa 1 percent of the global forest area, estimated at approximately 4 billion hectares (FAO, 2015b).

Other wooded land, covering 2 million hectares, represents less than 1 percent of drylands, mostly located in the steppe ecoregions. Other land, which includes grassland, agricultural land, built-up areas and barren land, is by far the dominant land-use category, encompassing around 800 million hectares (95 percent of drylands) (Figure 105).

The dryland forests are found mainly in northeastern China and on the southeastern edge of the Tibetan Plateau, with a few forested areas scattered in the higher mountains and along the rivers in the desert area of western China and along the border between Kazakhstan and the Russian Federation (Figure 106).

The proportion of forests increases with decreasing aridity, from 1 percent in the arid zone to 20 percent in the dry subhumid zone (Figure 107). The hyperarid zone has no forest or wooded land.

FIGURE 105

Distribution of land uses in the drylands of Central and Eastern Asia ('000 ha)

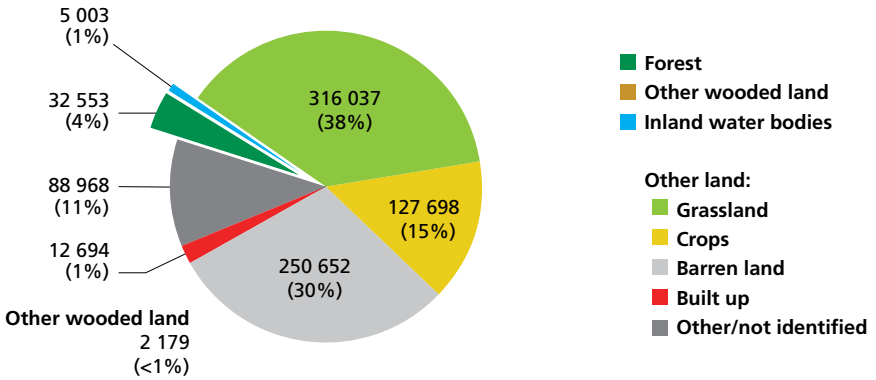
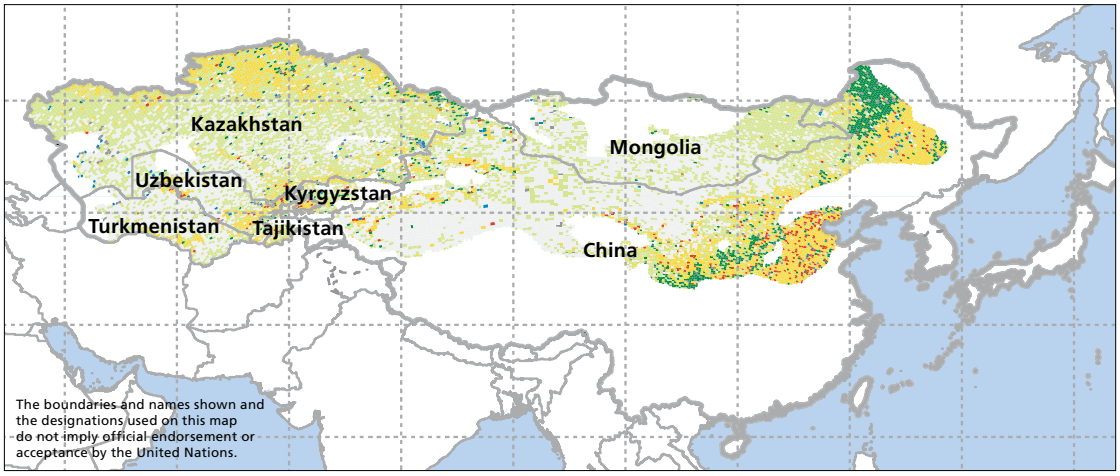


FIGURE 106

Main land uses in the drylands of Central and Eastern Asia



Source: UN Maps, 2019

Almost 70 percent of the forest is located in the dry subhumid zone, and 25 percent is in the semi-arid zone (Figure 108).

Most of the other wooded land (62 percent, or 1 million hectares) is in the semi-arid zone, with the remaining area divided between the subhumid (21 percent) and arid (17 percent) zones (Figure 109).

VEGETATION IN FORESTS AND OTHER WOODED LAND

The major vegetation type in the region's dryland forest is broadleaved (56 percent) (Table 33, Figure 110; see also Box 10). Conifers make up 27 percent of dryland forest.

Other wooded land is mainly composed of grassland with shrubs (44 percent) or with trees and shrubs combined (28 percent) (Table 34).

FIGURE 107
Distribution of land uses by aridity zone

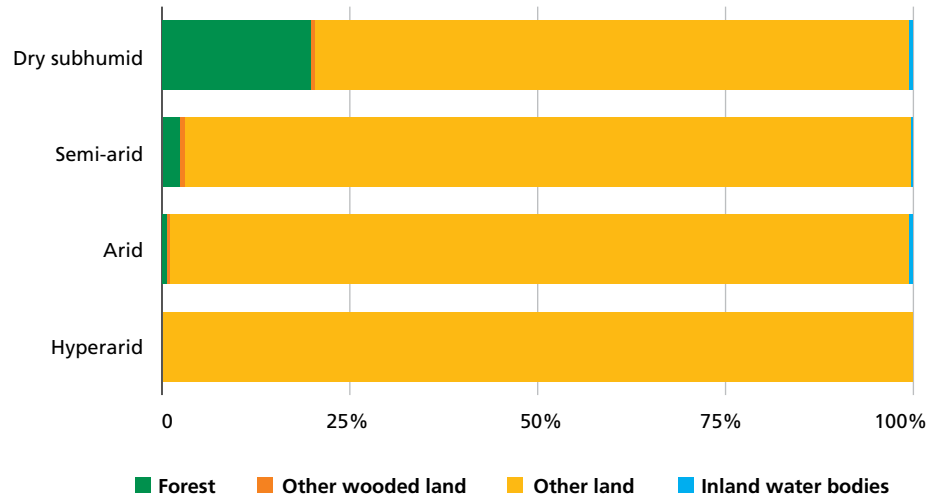


FIGURE 108
Distribution of dryland forest by aridity zone ('000 ha)

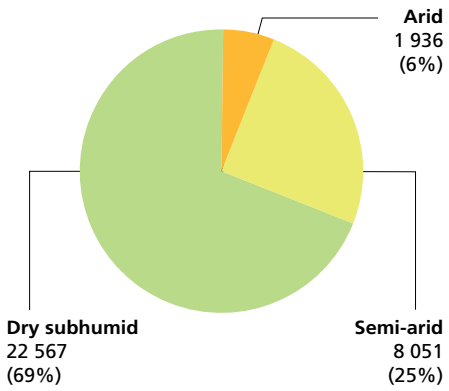


FIGURE 109
Distribution of other wooded land by aridity zone ('000 ha)

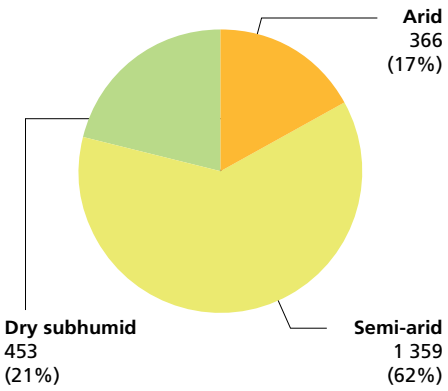
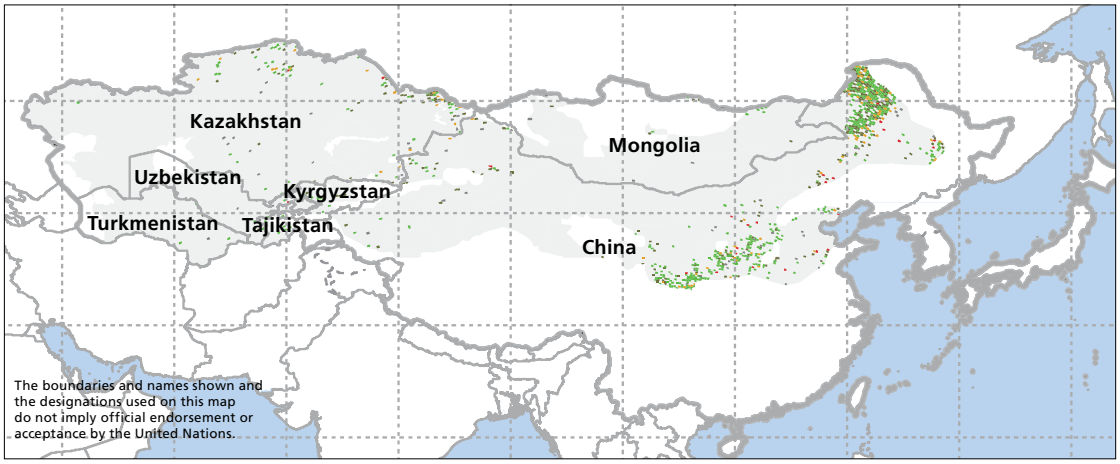


TABLE 33
Type of forest vegetation by aridity zone

Vegetation type	Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest								
Broadleaved	837	46	3 276	41	13 812	62	17 925	56
of which riparian	157	9	279	3	209	1	645	2
Coniferous	628	34	2 962	37	5 162	23	8 752	27
Mixed broadleaved and coniferous	105	6	941	12	2232	10	3 278	10
Other/not identified	209	11	558	7	523	2	1 290	4
Planted forest	52	3	244	3	628	3	924	3
Total	**1 830**	**100**	**7 981**	**100**	**22 358**	**100**	**32 169**	**100**

FIGURE 110
Distribution of dryland forest by subtypes



Natural forest:
Broadleaved | Coniferous | Planted | No forest
Mixed | Other/not identified

Source: UN Maps, 2019

TABLE 34
Main vegetation types in other wooded land by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	209	67	383	37	140	44	732	44	3 171	50
Grassland with trees and shrubs	52	17	244	23	174	56	471	28	1 833	29
Shrubland	0	0	174	17	0	0	174	10	116	2
Other/not identified	52	17	244	23	0	0	296	18	1 162	18
Total	**314**	**100**	**1 046**	**100**	**314**	**100**	**1 673**	**100**	**6 283**	**100**

BOX 10
Forest and woodland vegetation types in the drylands of Central and Eastern Asia

In Central and Eastern Asia, deciduous forest is distributed between 1 200 and 1 700 m in altitude. *Malus sieversii* is one of the notable trees, which grows along the river valleys of Tian Shan. Other temperate tree species are *Prunus armeniaca* and *Acer semenovii*, representing the remnants of broad-leaved temperate forests from the Tertiary period. Species of *Rosa* and *Berberis* are abundant in the region. At higher altitudes, the deciduous forests include *Populus tremula* and *Celtis caucasica*, together with economically important plants such as *Dictamnus turkestanicus*, *Betula tianshanica* and *Hippophae rhamnoides*.

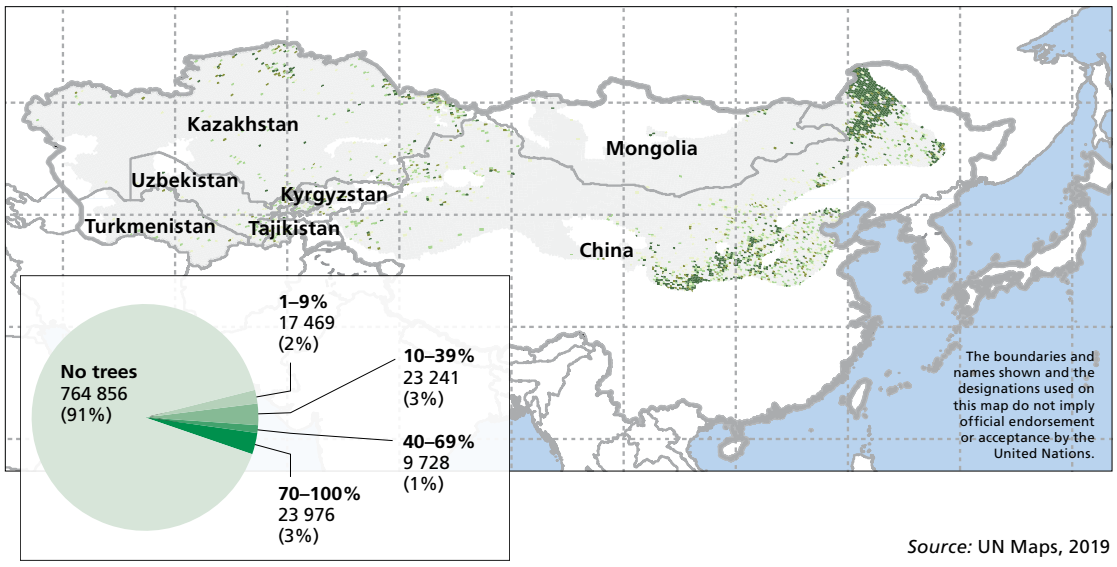
TREE CANOPY COVER

As seen in Figure 111, 91 percent of the region's dryland (765 million hectares) has no trees, while trees are found on 74 million hectares.

Average canopy cover in forest ranges from 50 percent in the arid zone to 79 percent in the dry subhumid zone (Table 35).

FIGURE 111

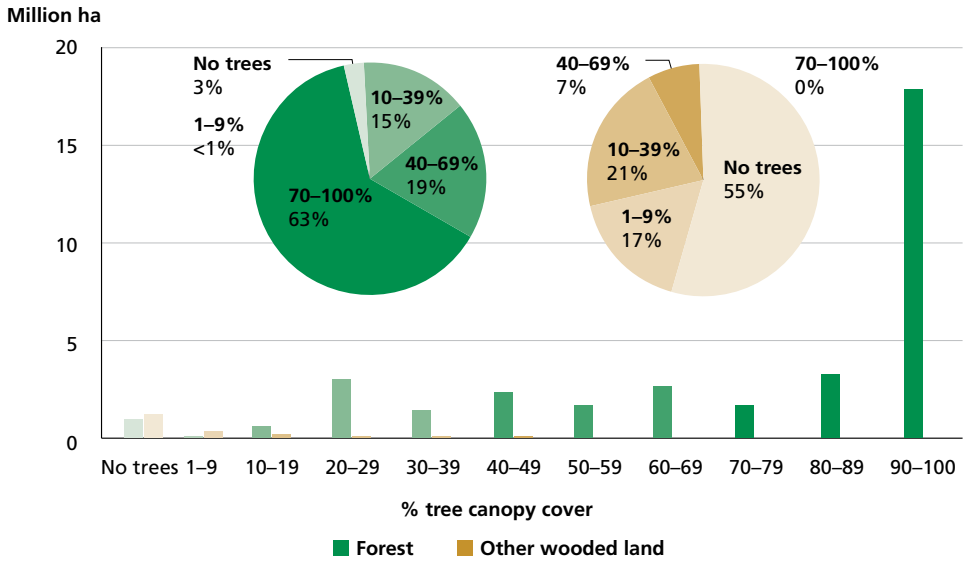
Distribution of tree canopy cover in the drylands of Central and Eastern Asia by tree cover range ('000 ha)



Source: UN Maps, 2019

FIGURE 112

Tree canopy cover in forest and other wooded land



Around 82 percent of forest (almost 27 million hectares) has crown cover density of more than 40 percent and can be considered closed forest (Figure 112), while 63 percent has dense canopy cover of more than 70 percent. An estimated 15 percent is open forest with a tree canopy cover of 10 to 39 percent.

More than half (55 percent) of the other wooded land has no tree cover (Figure 112), and an additional 17 percent has tree cover that is below 10 percent. Almost one-quarter (21 percent) has tree canopy cover of 10 to 39 percent, and only 7 percent has tree cover of 40 to 69 percent.

TABLE 35
Average tree canopy cover in the drylands of Central and Eastern Asia by land use and aridity zone (%)

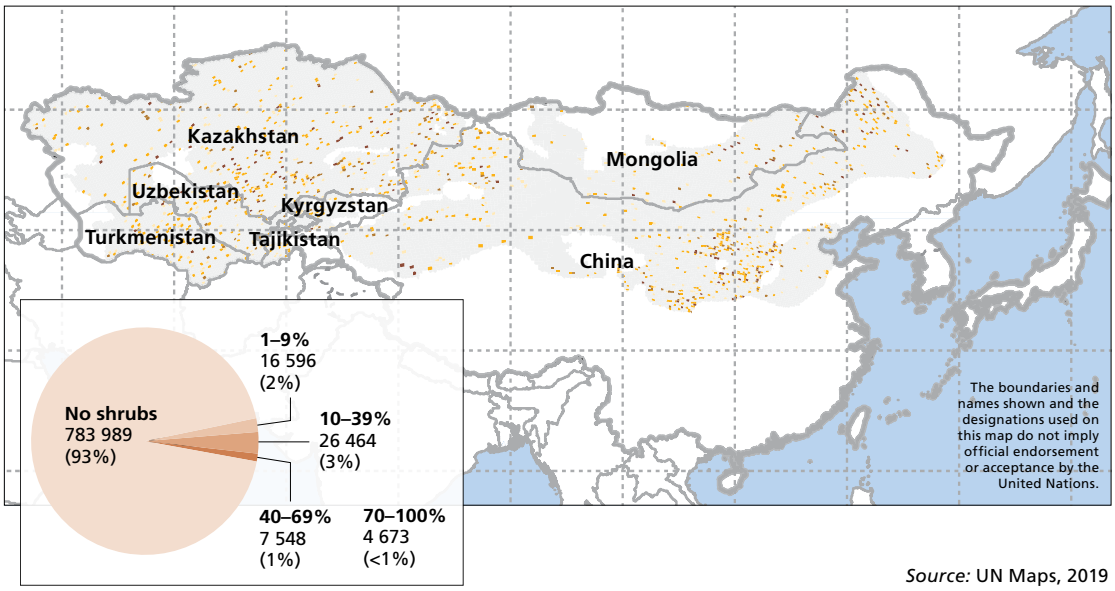
Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest		50	61	79	**73**
Other wooded land		5	8	11	**8**
Other land	0	0	1	6	**1**
Inland water bodies	0	0	1	0	**1**
All lands	**0**	**1**	**2**	**20**	**3**

SHRUB COVER

The majority (93 percent, or 784 million hectares) of Central and Eastern Asia's drylands has no shrub cover (Figure 113). The average shrub cover in other wooded land is 32 percent; it is densest in the arid zone (50 percent), followed by the dry subhumid zone (31 percent) (Table 36). The average shrub cover in forest is 5 percent; it is almost uniform among aridity zones.

Most of the forest (85 percent) has no shrub cover, and most of the rest has coverage ranging from 1 to 39 percent (Figure 114).

FIGURE 113
Shrub cover in the drylands of Central and Eastern Asia ('000 ha)



Source: UN Maps, 2019

TABLE 36
Average shrub cover by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest		5	4	5	**5**
Other wooded land		50	27	31	**32**
Other land	1	1	2	2	**2**
Inland water bodies	0	0	0	1	**0**
All lands	**1**	**1**	**2**	**3**	**2**

FIGURE 114

Shrub cover in forest and other wooded land

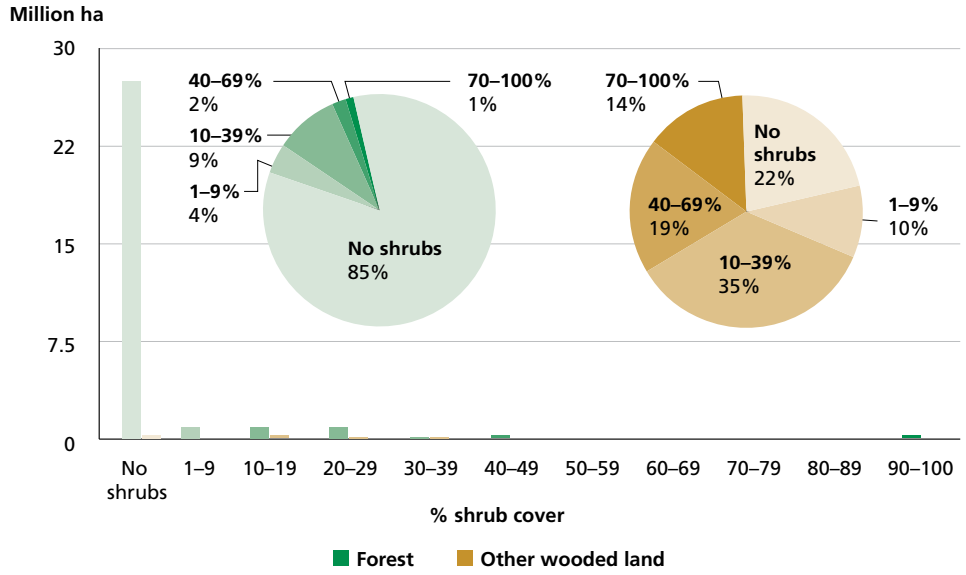
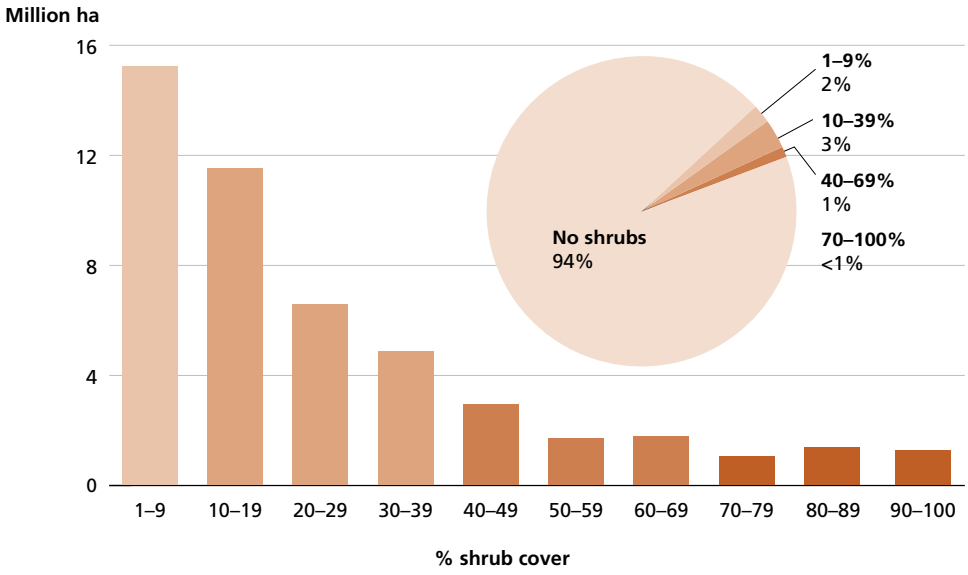


FIGURE 115

Shrub cover in other land



About one-third of other wooded land is densely covered with shrubs, having shrub cover between 40 and 100 percent (Figure 114). Another 35 percent has sparse shrub cover, ranging from 10 to 39 percent, while 10 percent has shrub coverage between 1 and 9 percent.

Most of the dryland classified as other land has little or no shrub cover (751 million hectares, or 94 percent of other land). About 3 percent of other land (22 million hectares) has shrub cover ranging from 10 to 39 percent (Figure 115).

OTHER LAND

Of the 799 million hectares of other land in the region, 42 percent is in the semi-arid zone, 40 percent in the arid zone, 11 percent in the dry subhumid zone and 6 percent in the hyperarid zone (Figure 116).

Grasslands are the dominant land use, covering 316 million hectares or 40 percent of the area of other land (Figure 117, Table 37). They are distributed primarily in the semi-arid and arid zone (175 and 110 million hectares, respectively) (Table 37, Figure 118).

The next largest land use category is barren land, which represents 31 percent of other land (250 million hectares). The largest part (151 million hectares) is located in the arid zone.

Crops represent 16 percent of other land (127 million hectares) and are mainly found in the semi-arid zone (59 million hectares) and the dry subhumid zone (51 million hectares). Most of them are irrigated crops (69 million hectares) (Figure 119). Non-irrigated crops are estimated to cover 35 million hectares.

Settlements and built-up areas occupy only 2 percent or 13 million hectares of other land. They are predominantly found in the dry subhumid and semi-arid zones (8 million and 3 million hectares, respectively).

FIGURE 116

Distribution of other land by aridity zone ('000 ha)

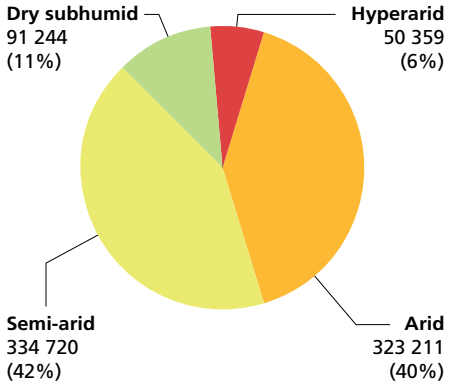


FIGURE 117

Distribution of other land by land use ('000 ha)

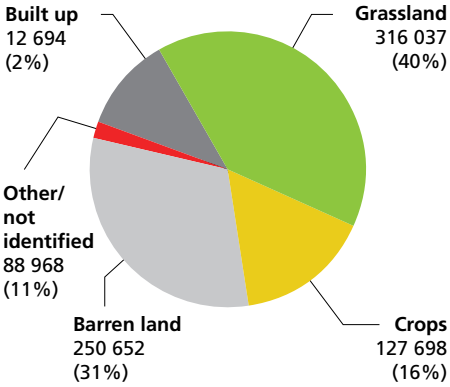


TABLE 37

Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	632	16 474	59 458	51 133	127 698	100
Irrigated crops	105	9 728	29 067	30 345	69 245	54
Non-irrigated cropland	527	4 498	19 378	10 185	34 587	27
Perennial crops (palms, orchards, others)	0	2 092	9 654	10 220	21 966	17
Cropland fallow	0	157	1 359	384	1 900	1
Grass	7 480	109 672	175 446	23 439	316 037	100
Barren land	36 874	151 878	58 273	3 627	250 652	100
Rock or stone	2 423	9 571	7 005	1 151	20 150	8
Sand and dunes	34 135	141 365	50 187	2 197	227 885	91
Snow and glaciers	316	941	1 080	279	2 617	1
Built up	105	1 883	3 137	7 569	12 694	100
Villages and urban settlements	105	1 255	2 335	5 930	9 625	76
Infrastructure	0	575	662	1 639	2 877	23
Mining	0	52	139	0	192	2

FIGURE 118

Land use in other land by aridity zone

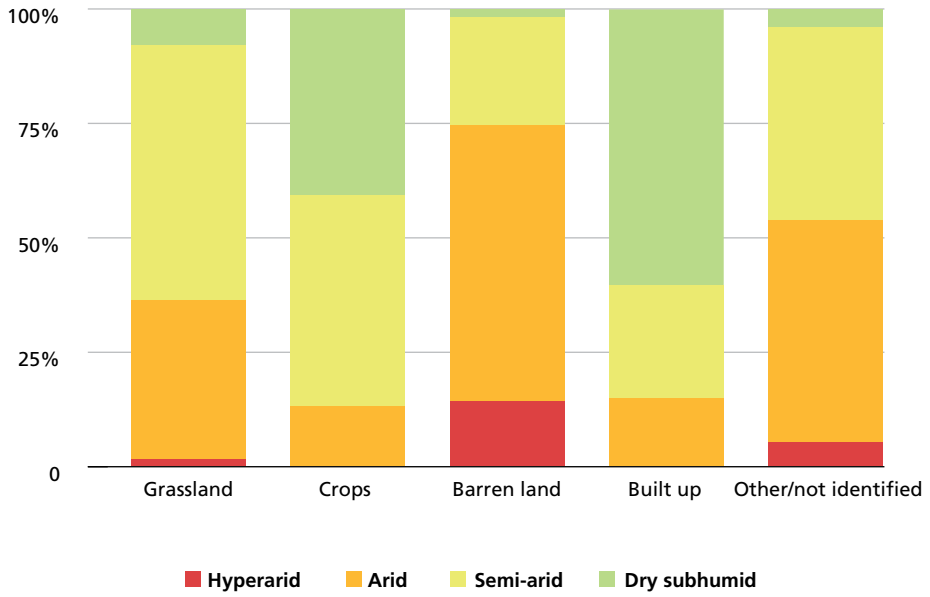
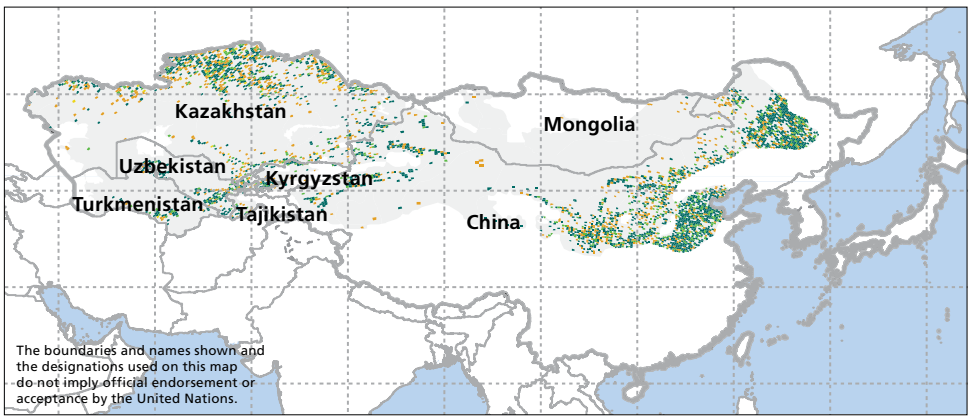


FIGURE 119

Distribution of crop types



Source: UN Maps, 2019

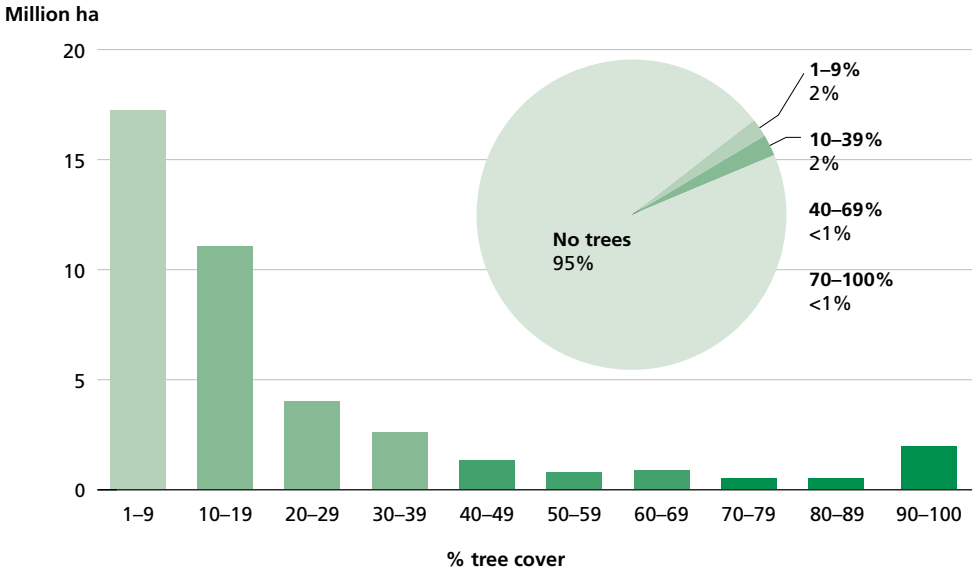
TREES OUTSIDE FOREST

Trees outside forest, which are defined as the trees in other land, are present on only 5 percent of other land (41 million hectares), while 758 million hectares do not have any trees. Trees with canopy cover greater than 10 percent are present on 3 percent of other land (25 million hectares) (Figure 120).

Other land has 1 percent tree canopy cover on average (Table 35), with the highest value in the dry subhumid zone (6 percent on average). Approximately 72 percent of croplands and 16 percent of built-up lands have some tree cover.

FIGURE 120

Tree canopy cover in other land



Southern Asia

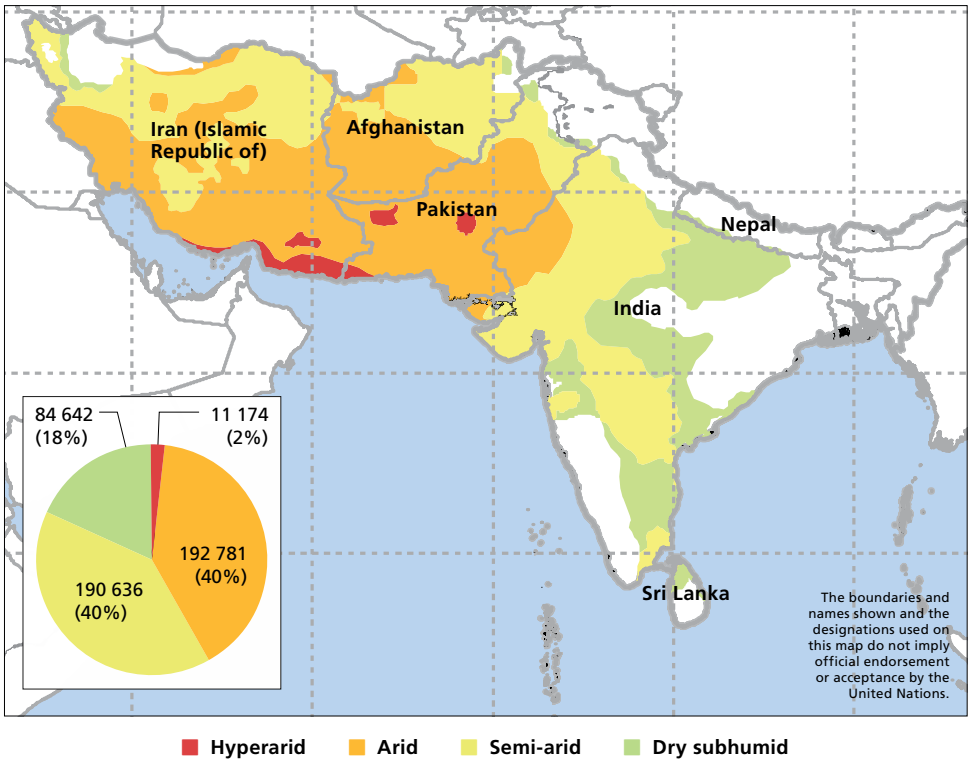
Scattered trees in agricultural land, Afghanistan

KEY FINDINGS

- The drylands of Southern Asia cover a total area of 479 million hectares, including almost all of Afghanistan, the Islamic Republic of Iran and Pakistan, as well as most of India, representing 71 percent of the region's total land area and 8 percent of the global drylands.
- The arid and semi-arid zones each make up 40 percent of the drylands, with the dry subhumid zone occupying another 18 percent and the hyperarid zone covering 2 percent.
- Forest represents 10 percent of the dryland area and other wooded land only 5 percent, while 84 percent of the dryland area is in the other land category.
- The dry subhumid zone has the largest proportion of forest (23 percent), followed by the semi-arid zone (10 percent).
- An estimated 60 percent of the dryland forest is broadleaved, while conifers and mixed stands of conifers and broadleaved trees make up a combined 14 percent.
- The main vegetation types in other wooded land are grassland with trees and shrubs (46 percent) and grassland with shrubs (28 percent).
- Approximately 43 percent of the forest has dense canopy cover of more than 70 percent. Two-thirds of other wooded land has sparse tree cover of less than 10 percent. In both categories, canopy cover decreases as aridity increases.
- In the other land category, crops are the most dominant land use (39 percent) followed by barren lands (29 percent) and grasslands (28 percent).
- Trees outside forest are found on 27 percent of other land.
- In total across all land uses, 35 percent (167 million hectares) of drylands in Southern Asia have some kind of tree cover, including trees in and outside forest.

FIGURE 121

Distribution of drylands in Southern Asia by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

The drylands of Southern Asia cover a total area of 479 million hectares, representing 7.9 percent of the world's drylands. They are primarily arid (193 million hectares, 40 percent) and semi-arid (191 million hectares, 40 percent). The hyperarid zone consists of 11.2 million hectares (2 percent), while the dry subhumid zone covers 84.6 million hectares (18 percent) (Figure 121). The semi-arid and dry subhumid zones are mainly located in India and Nepal, while the arid zone is predominant in Afghanistan, the Islamic Republic of Iran and Pakistan, with pockets of hyperarid zone in the latter two countries.

The regional assessment presented in this report is based on a survey of 20 191 plots. The analysis was completed by a team of 20 students from the Faculty of Environment, School of Geography, Leeds University, United Kingdom, in May and June 2015.

BACKGROUND

Climate

Stretching from the coast to the highest peaks in the world at over 8 000 m above sea level, Southern Asia has a very diverse climate, embracing all five of the broad climatic types under the Köppen climate classification. The climate is influenced by latitude, altitude, landforms, proximity to the sea and the impact of seasonal monsoons. Variations of tropical climate are generally found in the south (southern India, Sri Lanka and Bangladesh). Desert and semi-arid climate are found in western India, Afghanistan and Pakistan. Humid subtropical areas cover a large swathe of northern India and Bangladesh. Northernmost India and the northern Pakistani uplands have a dry subtropical continental climate. Finally, the Himalayas have an alpine climate.

The climate in Southern Asia is generally characterized by monsoons. During the summer, usually from June to September, winds from the southwest bring moist ocean air, resulting in heavy rains, especially in the southwestern portions of the region. This rainfall is crucial to life and agriculture on the subcontinent. On the other hand, the monsoons can cause severe hardship for millions, especially those living in the lowlands of India and Bangladesh.

The most extreme weather pattern of South Asia is the cyclone, which can produce extremely powerful winds and torrential rain.

Importance of dryland forests, trees and biodiversity

In the more arid areas of Southern Asia, rangelands or grasslands and shrubs are the dominant vegetation type. In Afghanistan, the Islamic Republic of Iran and Pakistan, forests cover only 2 to 6 percent of the land area. However, they have an important role in supporting livelihoods and providing environmental services.

Dryland forests provide local communities with timber for building and fuelwood to meet their daily needs. A variety of NWFPs, including pine nuts, walnuts, pistachio, wild almonds, mushrooms, resin, oils, gums, honey and medicinal and culinary herbs, are collected from the forests, mainly by forest-dwelling communities. NWFPs include some important export products, including chilgoza pine nuts in Pakistan and wild pistachio (*Pistacia* spp.) from the deciduous forests of Afghanistan.

Significant tree resources are also found outside the forest areas. Trees on farmlands are an important source of timber, helping to bridge the huge gap between demand and supply in domestic requirements for forest products.

Drylands in Southern Asia contain several biodiversity hotspots, including the Irano-Anatolian region, Western Ghats and the Himalayas, and the forests and trees play a critical role in supporting this rich biodiversity. India is recognized as one of the world's megadiverse countries. Other environmental services of forests, such as their role in environmental protection, climate change mitigation and adaptation, provision of watershed services and recreational value, are also increasingly recognized.

Trends and challenges

Forest cover in Southern Asia has remained relatively stable overall in recent decades. However, even in those countries with stable or increasing forest cover, forest degradation due to unsustainable exploitation of forest resources is a concern. The main drivers of deforestation and forest degradation include conversion of land to agriculture; unsustainable exploitation of forest resources driven by increased demand for timber and fuelwood; and inadequate policies, regulatory framework, governance and institutions to enable sustainable forest management.

Climate change threatens the natural ecosystems in the drylands of Southern Asia, as drier and warmer conditions exacerbate risks of fire, increase risks posed by invasive species, and threaten the survival of plants adapted to specific climatic conditions, particularly in alpine areas. Effects of climate change are already manifest in the Himalayas, where glaciers are retreating, permafrost is melting, and weather patterns are becoming more erratic, with disruption to previously reliable water sources for millions.

The rapid growth in human population in this region presents the major underlying challenge to biodiversity conservation and ultimately to the quality of life. Southern Asia is already the most populous and the most densely populated geographic region in the world. It is also one of the least forested regions in the world in terms of forest area per capita, which implies intense pressure on the forests to meet society's multiple and conflicting demands. With the population expected to increase further, it is inevitable that pressures on dryland forests and associated resources will continue to escalate. Urbanization may help offset some of the pressures by reducing the proportion of rural population, but population growth will likely result in increased demand for land,

energy (including from fuelwood) and water, further intensifying the current threats to dryland forests.

In recent decades, provision of environmental services has become the primary objective of natural forest management in Southern Asia. Issues such as conservation of biodiversity, climate change mitigation and adaptation, and protection of watersheds and other non-use values such as ecotourism are gaining prominence, generating major changes in the way forests are managed. Nonetheless, difficulties persist in establishing appropriate trade-offs between competing objectives, especially in the context of divergent needs of different parts of society (FAO, 2012b).

One of the positive developments in the region's forestry is the expansion of trees outside forest, especially as farmers and other landowners take up tree planting under farm forestry. The declining profitability of agriculture and the growing local demand for timber has encouraged a rapid expansion of tree growing on farms, which is often supported through industry-farmer partnership arrangements. Farm-grown trees have become a major source of wood supply, especially in the context of declining supply from forests (FAO, 2012b).

DISTRIBUTION OF FORESTS AND OTHER LAND USES

The most represented class in Southern Asia's drylands is other land (including agricultural land, meadows and pastures, built-up areas and barren land), which covers 403 million hectares (84 percent of the dryland area). Forest covers 47 million hectares (10 percent of the dryland area), and other wooded land occupies 24 million hectares (5 percent of the drylands) (Figure 122). Dryland forest is mainly located in the dry subhumid and semi-arid zones of India, as well as in the semi-arid zones of northern Pakistan and eastern Islamic Republic of Iran (Figure 123).

Forests are most prominent in the dry subhumid zone, where they account for 23 percent of the land area (Figure 124). In the arid and semi-arid zones, which are the most dominant in Southern Asia, forest represents a small portion of the land cover (4 and 10 percent, respectively). Other land is the main land use class in all aridity zones.

A large majority (82 percent) of the dryland forest is located in the subhumid and semi-arid arid zones, while only 18 percent is found in the arid zone (Figure 125). The hyperarid zone has insignificant forest cover (less than 1 percent of total dryland forest).

Other wooded land, on the other hand, is concentrated in the arid and semi-arid zones (45 and 37 percent, respectively) (Figure 126). The dry subhumid zone has only 16 percent of other wooded land, and the hyperarid zone 2 percent.

FIGURE 122

Distribution of land uses in Southern Asia's drylands ('000 ha)

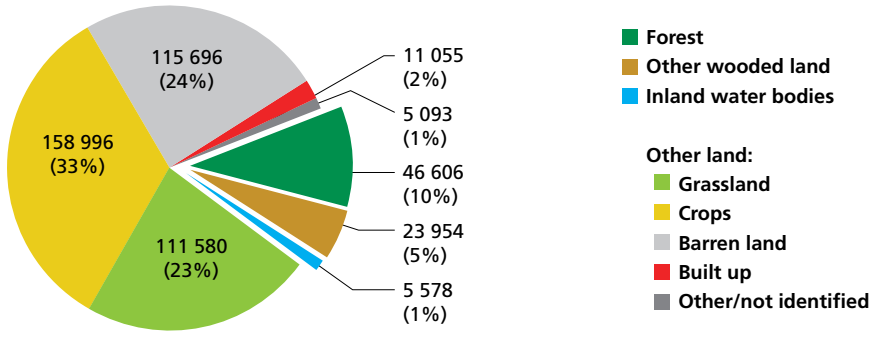
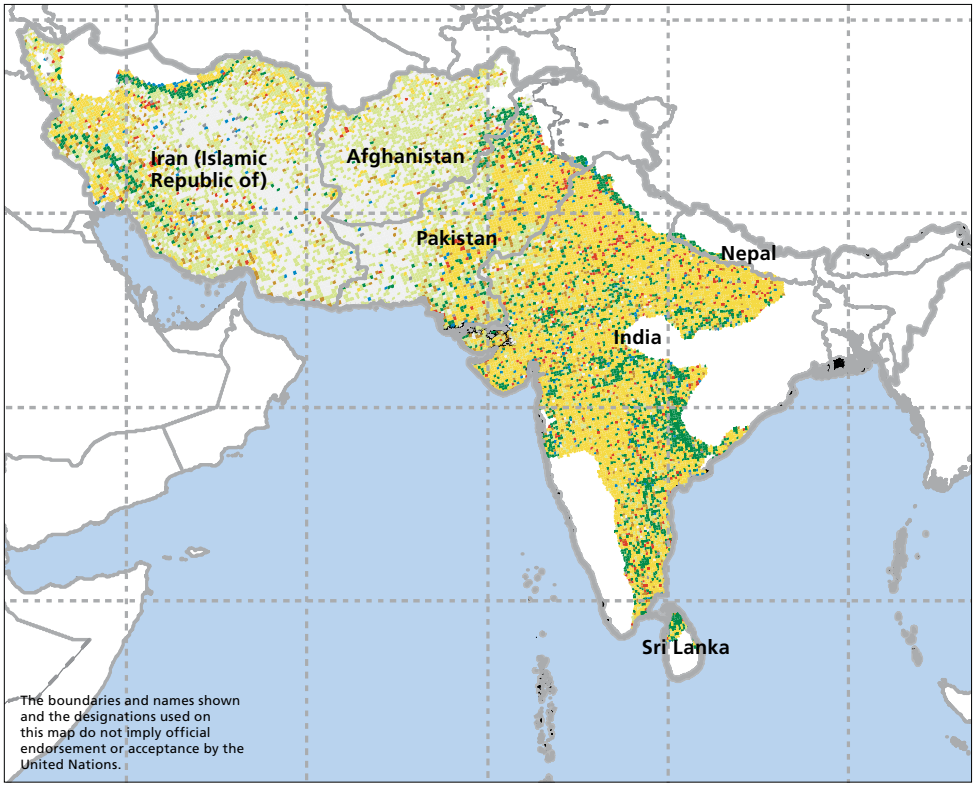


FIGURE 123

Main land uses in Southern Asia's drylands



Source: UN Maps, 2019

FIGURE 124

Distribution of land uses by aridity zone

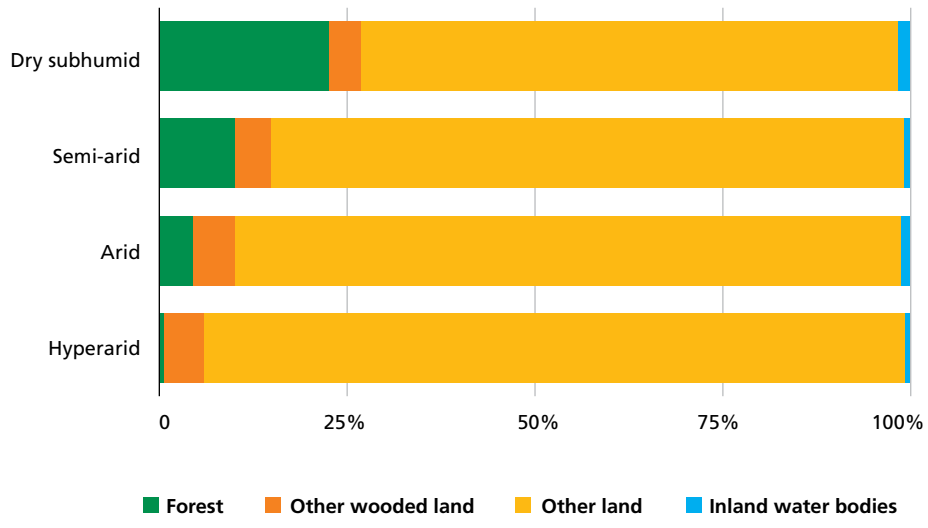


FIGURE 125

Distribution of dryland forest by aridity zone ('000 ha)

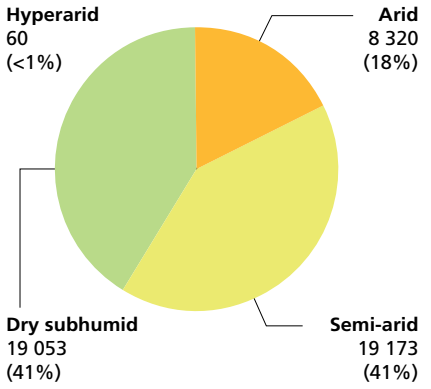
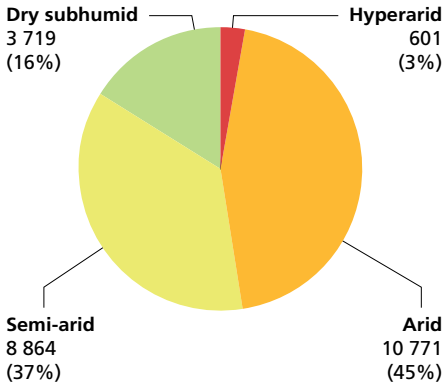


FIGURE 126

Distribution of other wooded land by aridity zone ('000 ha)



VEGETATION IN FORESTS AND OTHER WOODED LAND

An estimated 60 percent of the forest in Southern Asia's drylands is predominantly broadleaved (Table 38, Figure 127). Coniferous forests and forests with a mix of conifers and broadleaves each make up 7 percent of the forest area, while 25 percent is of unidentified type (see Box 11).

Other wooded land is mainly composed of grassland with trees and shrubs (46 percent) or grassland with shrubs only (28 percent) (Table 39).

TABLE 38

Type of forest vegetation by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest										
Broadleaved	60	100	3 691	44	10 994	57	13 191	69	27 936	60
of which riparian	0	0	212	3	423	2	298	2	933	2
Coniferous	0	0	575	7	1 430	7	1 053	6	3 058	7
Mixed broadleaved and coniferous	0	0	272	3	1 612	8	1 288	7	3 172	7
Other/not identified	0	0	3 661	44	4 875	25	3 340	18	11 876	25
Planted forest	0	0	121	1	262	1	182	1	565	1
Total	**60**	**0**	**8 320**	**100**	**19 173**	**100**	**19 053**	**100**	**46 606**	**100**

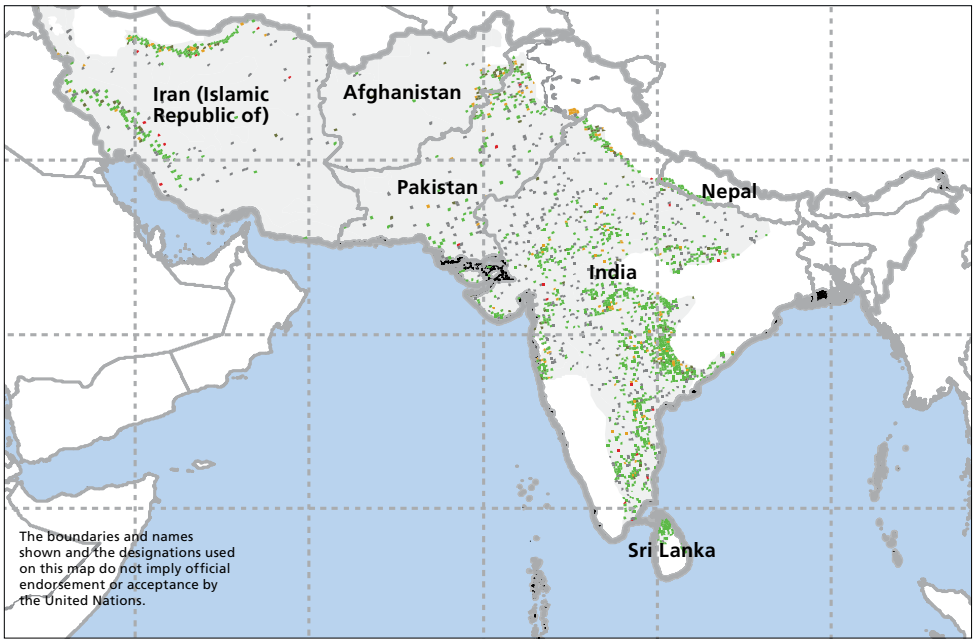
TABLE 39

Main vegetation types in other wooded land by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	60	10	3 661	34	2 317	26	567	15	6 604	28
Grassland with trees and shrubs	481	80	5 779	54	3 405	38	1 371	37	11 035	46
Shrubland	0	0	424	4	201	2	40	1	665	3
Other/not identified	60	10	908	8	2 941	33	1 741	47	5 650	24
Total	**601**	**100**	**10 771**	**100**	**8 864**	**100**	**3 719**	**100**	**23 954**	**100**

FIGURE 127

Distribution of dryland forest by subtypes



Natural forest:

Broadleaved **Coniferous** **Planted** **No forest**

Mixed **Other/not identified**

Source: UN Maps, 2019

BOX 11

Forest and woodland vegetation types in the drylands of Southern Asia

The dry subhumid areas of the highlands of India and Nepal contain subtropical broadleaved hill forests, subtropical pine forests and Himalayan dry temperate forests. Pine (*Pinus* spp.), fir (*Abies* spp.) and other evergreen species (e.g. species of the Fagaceae family) are common.

In the more arid areas of Southern Asia, vegetation becomes sparse and lower in stature. In Pakistan, Himalayan dry temperate forest is the most dominant forest type. Deodar cedar (*Cedrus deodara*), blue pine (*Pinus wallichiana*), chilgoza pine (*Pinus gerardiana*), juniper (*Juniperus excelsa*), fir (*Abies webiana*) and spruce (*Picea smithiana*) are the main timber-yielding species. In Afghanistan, coniferous forests with species of *Pinus*, *Cedrus*, *Picea* and *Abies* are the most dominant.

TREE CANOPY COVER

There are no trees on 65 percent or 312 million hectares of the drylands in Southern Asia. Tree canopy cover is densest in India, northern Pakistan and northern Islamic Republic of Iran (Figure 128).

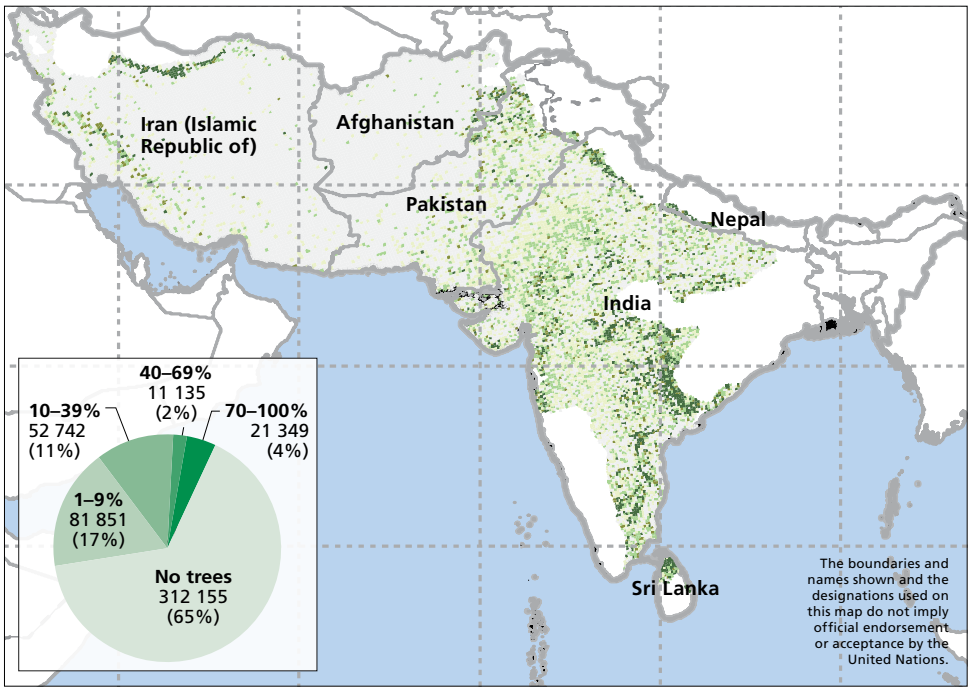
The average tree canopy cover in the region's dryland forest is 55 percent (Table 40). From the dry subhumid to the arid zone, canopy cover decreases as aridity increases.

Nearly half (43 percent) of the dryland forest has dense canopy cover (above 70 percent), occurring mostly in the dry subhumid and semi-arid zones (Figure 129). Approximately 15 percent of the forest area has canopy cover of 40 to 69 percent, while 42 percent of the forest is open, with canopy cover below 40 percent.

Other wooded land has low tree canopy cover; about two-thirds of the land in this category has coverage below 10 percent (Figure 129).

FIGURE 128

Distribution of tree canopy cover in Southern Asia's drylands by tree cover range ('000 ha)



Source: UN Maps, 2019

FIGURE 129

Tree canopy cover in forest and other wooded land

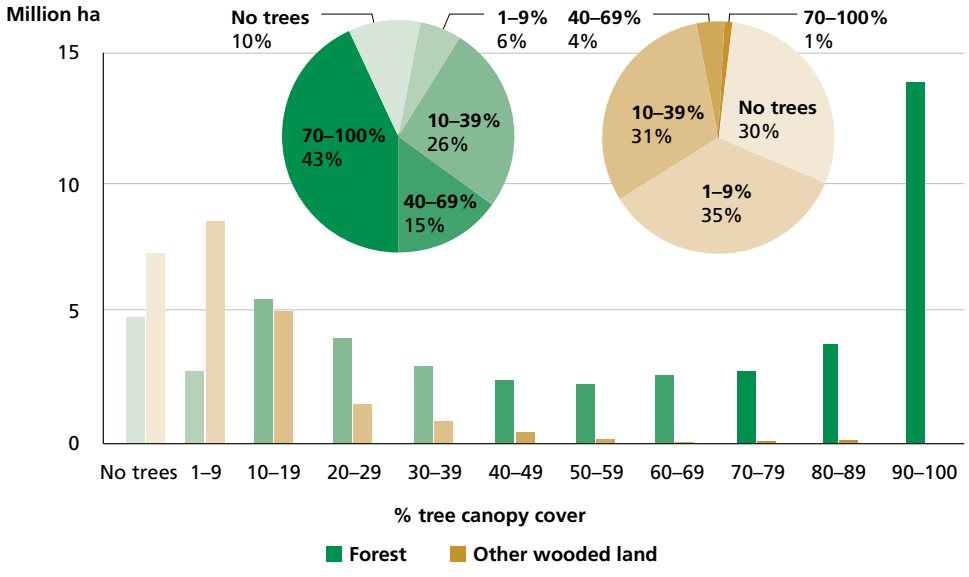


TABLE 40
Average tree canopy cover in Southern Asia's drylands by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	45	30	54	65	**55**
Other wooded land	7	8	11	14	**10**
Other land	1	1	4	7	**3**
Inland water bodies		2	2	1	**2**
All lands	**2**	**3**	**9**	**20**	**8**

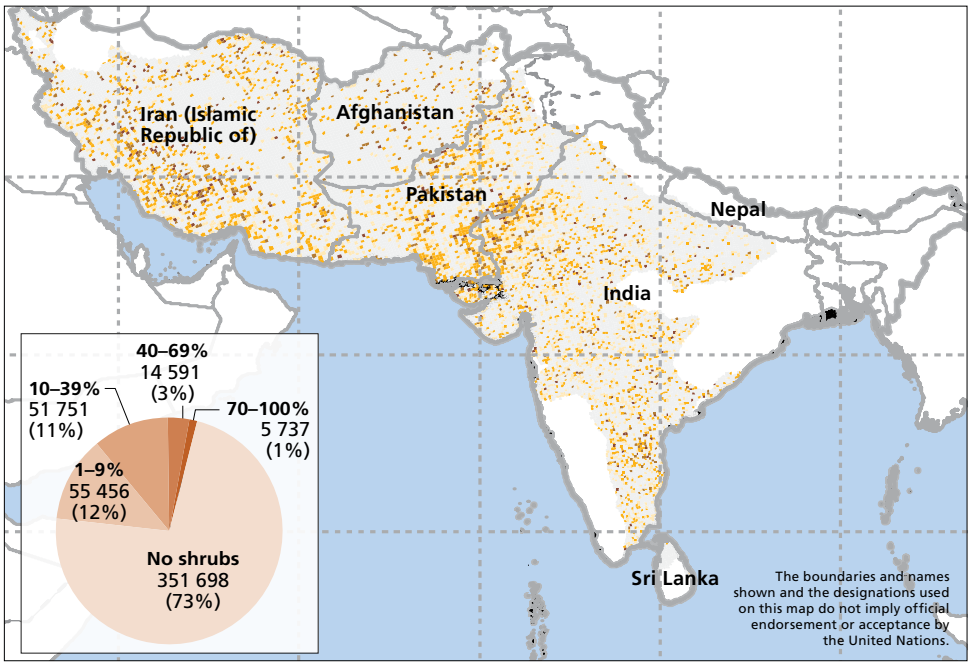
SHRUB COVER

An estimated 27 percent of Southern Asia's dryland, or 128 million hectares, is covered with shrubs. These shrublands are distributed throughout the region (Figure 130).

Most of the other wooded land is sparsely covered with shrubs, with average shrub cover of 27 percent (Table 41, Figure 131).

Most of the forest has little or no shrub cover (or shrubs could not be detected because of dense tree canopy cover); average shrub cover in forest is estimated to be 5 percent. Shrub cover is higher (8 percent) in forests located in the arid zone, owing to their more open canopy (Table 41, Figure 131).

FIGURE 130
Shrub cover in Southern Asia's drylands ('000 ha)



Source: UN Maps, 2019

TABLE 41
Average shrub cover by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	0	8	4	4	**5**
Other wooded land	29	31	25	17	**27**
Other land	4	5	4	4	**4**
Inland water bodies		3	1	1	**2**
All lands	**5**	**7**	**5**	**4**	**6**

FIGURE 131
Shrub cover in forest and other wooded land

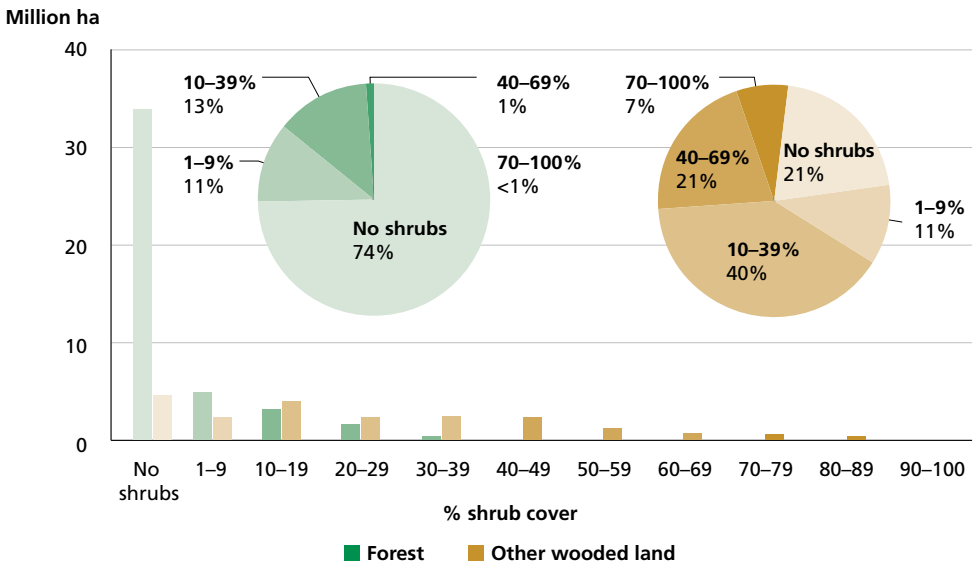
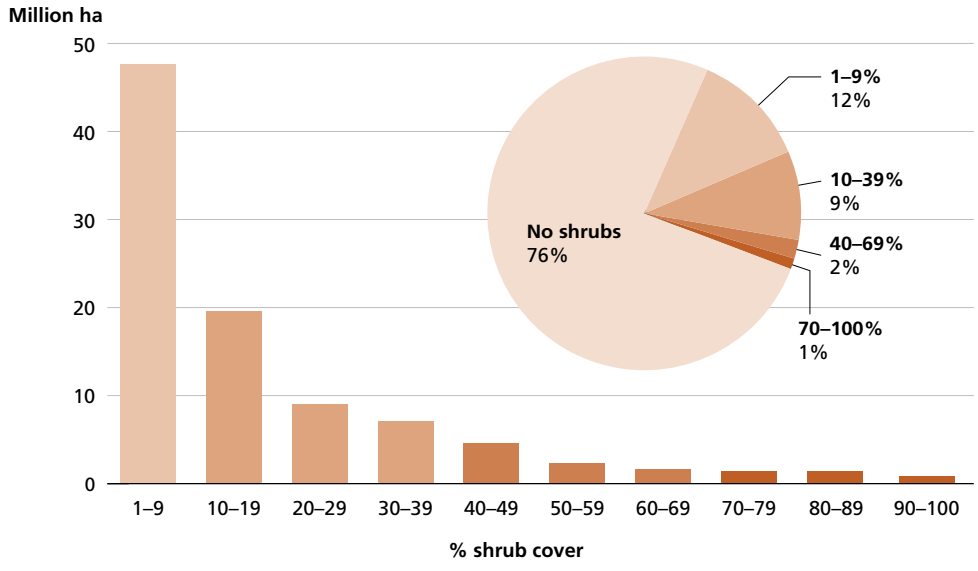


FIGURE 132
Shrub cover in other land



Similarly, most of the other land category has little or no shrub cover. Average shrub cover in these lands is 4 percent (Table 41). 73 percent of other land has no shrub cover, and 23 percent has shrub cover ranging from 1 to 39 percent (Figure 132).

OTHER LAND

Of the 403 million hectares of other land in Southern Asia's drylands, 42 percent is located in the arid zone, 40 percent in the semi-arid zone and 15 percent in the dry subhumid zone (Figure 133). Only 3 percent of these lands are in the hyperarid zone.

FIGURE 133

Distribution of other land by aridity zone ('000 ha)

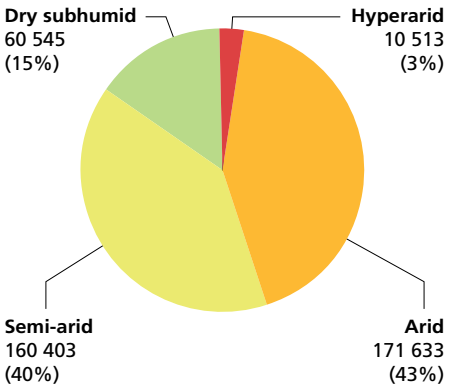
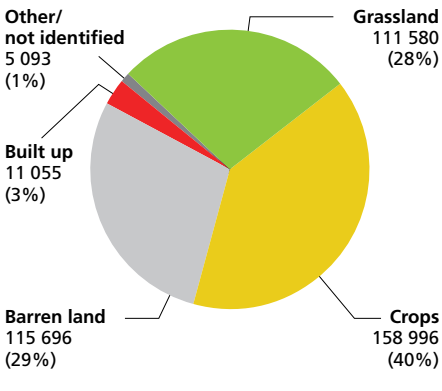


FIGURE 134

Distribution of other land by land use ('000 ha)



Other land comprises mainly crops (159 million hectares), barren land (116 million hectares) and grassland (112 million hectares) (Figure 134, Table 42). Built-up areas represent less than 3 percent of other land (11 million hectares).

Crops are mainly found in the semi-arid zone, followed by the dry subhumid and arid zones (Figure 135). The greatest part consists of perennial crops such as palms and orchards (55 percent), while non-irrigated and irrigated crops represent 22 and 18 percent of the croplands, respectively (Table 42). Crops in the drylands are most extensive in India, followed by Pakistan and the Islamic Republic of Iran (Figure 136).

Barren land is located primarily in the arid zone (77 million hectares) and semi-arid zone (31 million hectares).

Grassland or herbaceous savannah is distributed primarily in the arid zone (60 million hectares) and semi-arid zone (42 million hectares).

TABLE 42

Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	661	30 164	79 420	48 751	158 996	100
Irrigated crops	421	5 869	13 591	8 541	28 422	18
Non-irrigated cropland	180	6 051	16 977	11 873	35 081	22
Perennial crops (palms, orchards, others)	60	15 763	44 702	26 353	86 878	55
Cropland fallow	0	2 481	4 150	1 984	8 614	5
Grass	3 304	60 085	41 983	6 208	111 580	100
Barren land	6 248	76 907	31 124	1 417	115 696	100
Rock or stone	2 583	31 525	15 109	992	50 209	43
Sand and dunes	3 665	45 200	15 794	304	64 962	56
Snow and glaciers	0	182	222	121	525	0
Built up	240	1 936	5 721	3 158	11 055	100
Villages and urban settlements	120	1 089	4 392	2 591	8 192	74
Infrastructure	120	817	1 229	546	2 712	25
Mining	0	30	101	20	151	1

Built-up areas, which include urban and rural settlements, infrastructure and mines, are predominantly found in the semi-arid zone (6 million hectares) and the dry subhumid zone (3 million hectares).

FIGURE 135

Land use in other land by aridity zone

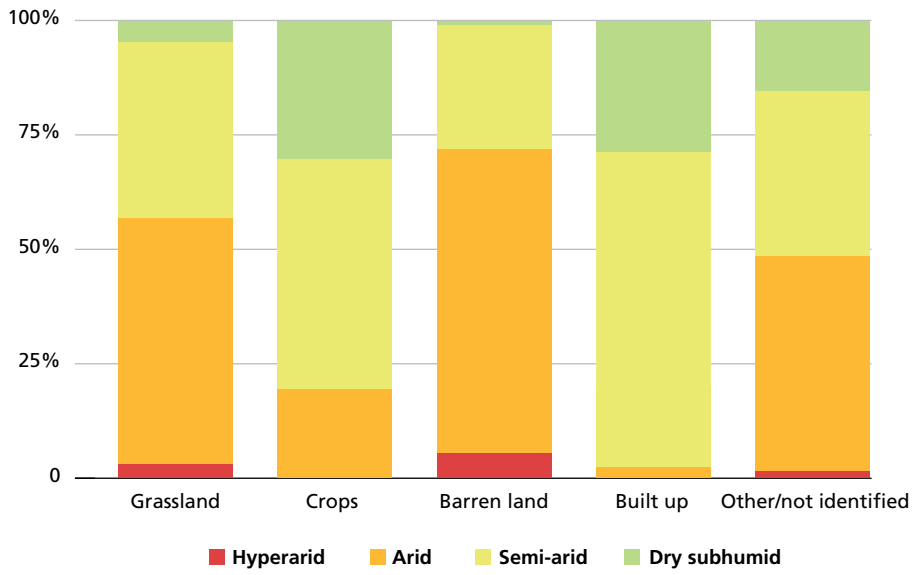
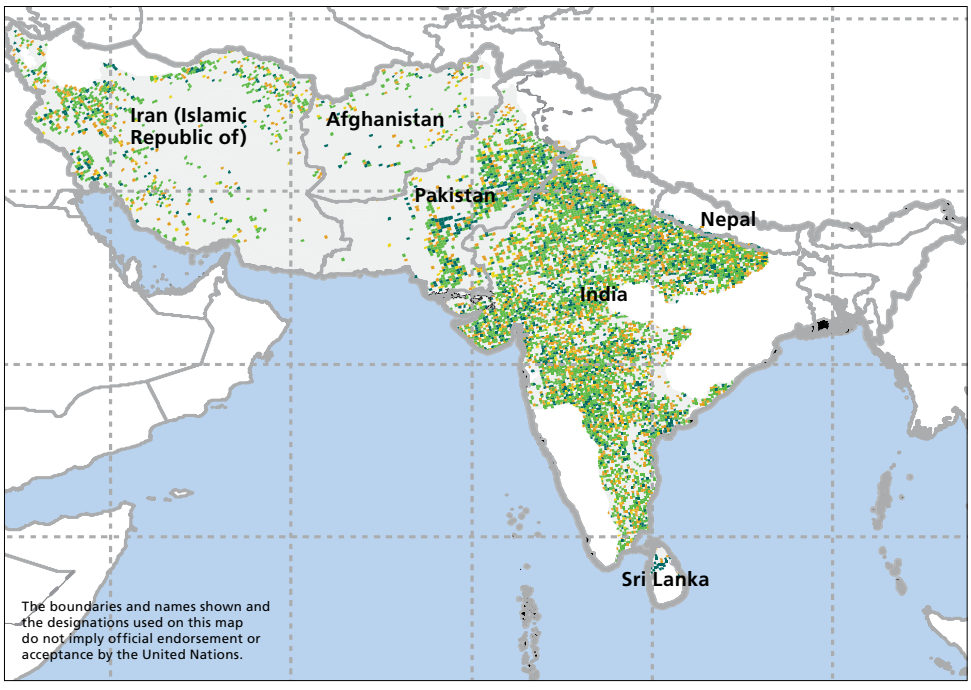


FIGURE 136

Distribution of crop types



Source: UN Maps, 2019

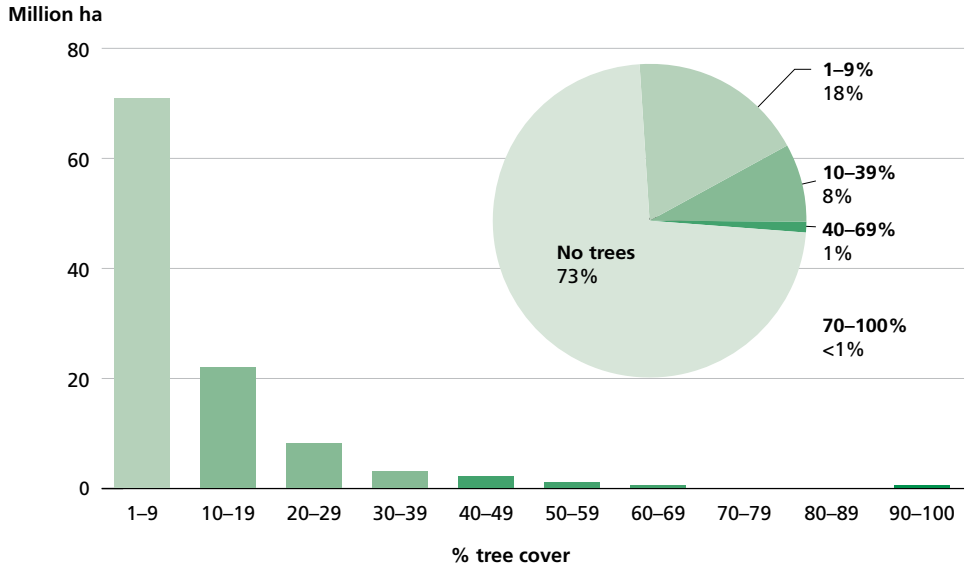
TREES OUTSIDE FOREST

Trees outside forest, which are defined as the trees in other land, are present on 107 million hectares (27 percent of other land). Of this, about one-third (37 million hectares, or 9 percent of other land) has tree cover above 10 percent (Figure 137).

Thus 295 million hectares (73 percent of other land) have no trees, while 366 million hectares (91 percent of other land) have less than 10 percent tree cover. Average tree canopy cover tends to increase as aridity decreases.

FIGURE 137

Tree canopy cover in other land



Oceania

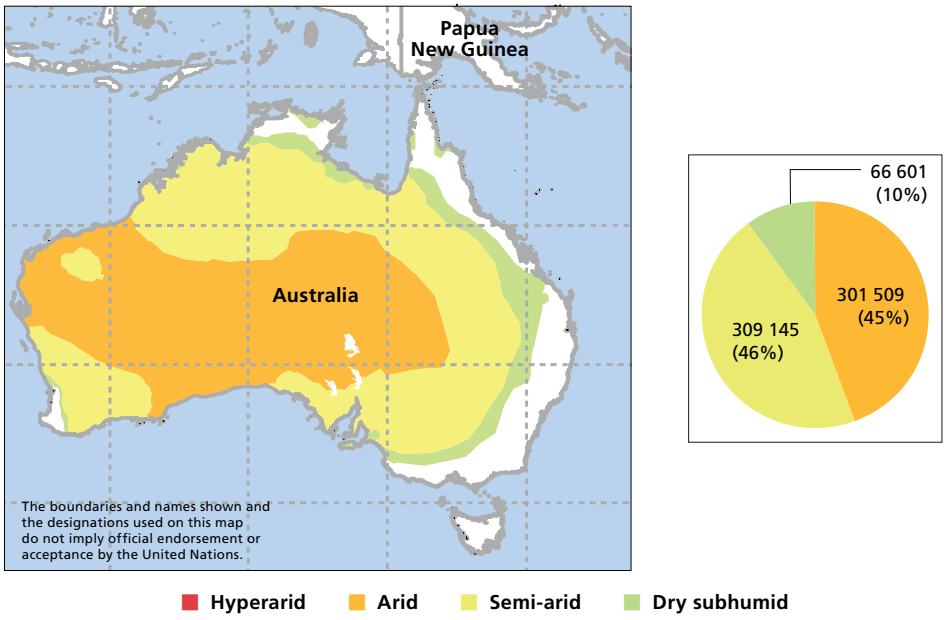
Eucalyptus coolabah *spp.* arida *in Australia*

KEY FINDINGS

- The drylands of Oceania comprise 677 million hectares, almost entirely in Australia, representing 79 percent of the region's total land area and 11 percent of the global drylands.
- The "other land" category constitutes 63 percent of the drylands. Other wooded land constitutes 19 percent, and forest 16 percent.
- Oceania's drylands contain 110 million hectares of forest, which is 10 percent of the global dryland forest area and circa 3 percent of the global forest area, estimated at approximately 4 billion hectares.
- An estimated 55 percent of Oceania's dryland forest is in the semi-arid zone, while about one-quarter is in the dry subhumid zone and 21 percent in the arid zone.
- Almost one-quarter of the dryland forest in the region has closed canopy (canopy cover greater than 40 percent).
- Other land is characterized mainly by grassland (87 percent) and crops (9 percent).
- Trees outside forest are present on 81 million hectares (19 percent of other land in this region). About 59 percent of built-up land and 16 percent of cropland have some crown cover.

FIGURE 138

Distribution of drylands in Oceania by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

The drylands of Oceania comprises 677 million hectares, or 11 percent of the world's drylands. Almost 100 percent of this area belongs to Australia.

The semi-arid and arid zones are the largest, covering respectively 309 million hectares or 46 percent and 302 million hectares or 44 percent of Oceania's drylands (Figure 138). The arid zone occupies the central area of the region, while the semi-arid zone stretches to the northeastern part of the region including Gregory National Park in the north, Carnarvon National Park in the east and Ngarkart Conservation Park in the south. The dry subhumid region covers 67 million hectares on the eastern side of Australia, in a belt stretching from the Gulf of Carpentaria to the Gulf of Saint Vincent.

A small area of drylands is found in Papua New Guinea. This area is all in the dry subhumid zone, except for one plot at Keakoro Bay belonging to the semi-arid zone.

The hyperarid category is not represented in Oceania.

The assessment of the drylands of this region is based on photo interpretation of 14 836 plots, conducted by the Terrestrial Ecosystem Research Network and School of Earth and Environmental Sciences, Faculty of Science, University of Adelaide, Australia, in November and December 2015.

BACKGROUND

Climate

As almost 100 percent of the dryland area belongs to Australia and only 13 percent of Australia is not considered part of the drylands, the climate for this region can be considered equivalent to the climate of Australia. As a consequence of its large area, Australia has different climate zones. The northern areas have a more tropical-influenced climate, hot and humid in the summer and warm and dry in the winter, while the southern areas are cooler, with mild summers and cool, sometimes rainy winters.

Consistent with global trends, Australia's continental average temperature has increased by approximately 0.8 °C since 1910, with minimum temperatures warming faster than the maxima. Rainfall exhibits clear regional and seasonal trends. Also since

1910, an increasing number of wet days as well as heavy rainfall events in summer have brought about a 15 percent increase in average annual rainfall in New South Wales, South Australia, Victoria and the Northern Territory, while the southwest has become 25 percent drier in winter. The drylands weather of this region is also influenced annually by climate and sea-level variability due to the El Niño Southern Oscillation phenomenon and tropical cyclone activity increasing the maximum temperature (Hughes, 2003).

Importance of dryland forests, trees and biodiversity

Australia is one of the most biologically diverse countries on the planet. It is home to more than 1 million species of plants and animals, many of which are found nowhere else in the world.

Trees are extremely important to the Aboriginal community and culture, as they provide a link between the present and the past and between people and the landscape. Traditional Aboriginal societies make sustainable use of timber from certain shrubs and trees to make a wide range of tools and utensils; clubs and boomerangs, for example, are often made from she-oaks (*Casuarina* spp. and *Allocasuarina* spp.) and wattles (*Acacia* spp.). Furthermore, individual trees are sometimes sacred to Aboriginal peoples.

Trends and challenges

Most of the region is subject to desertification. In August 2018, the Australian Government declared that the entire state of New South Wales – the country's most populous state, which is responsible for a quarter of national agricultural production – was affected by drought. Fire and selective logging are additional drivers of forest and biodiversity loss (New, 2018).

Expected ecological consequences of the climate changes described above include encroachment of rain forest into eucalypt woodlands and establishment of trees in subalpine meadows. Long-term changes will also cause shifts in species distributions towards the south (bats, birds), towards higher elevations (alpine mammals) or along changing rainfall contours (birds, semi-arid reptiles) (Hughes, 2003).

DISTRIBUTION OF FORESTS AND OTHER LAND USES

Other land, which includes grassland, agricultural land, built-up areas and barren land, is the most represented class in Oceania's drylands, covering around 426 million hectares (63 percent of drylands) (Figure 139). Other wooded land follows, with 130 million hectares (19 percent of total dryland area).

FIGURE 139

Distribution of land uses in Oceania's drylands ('000 ha)

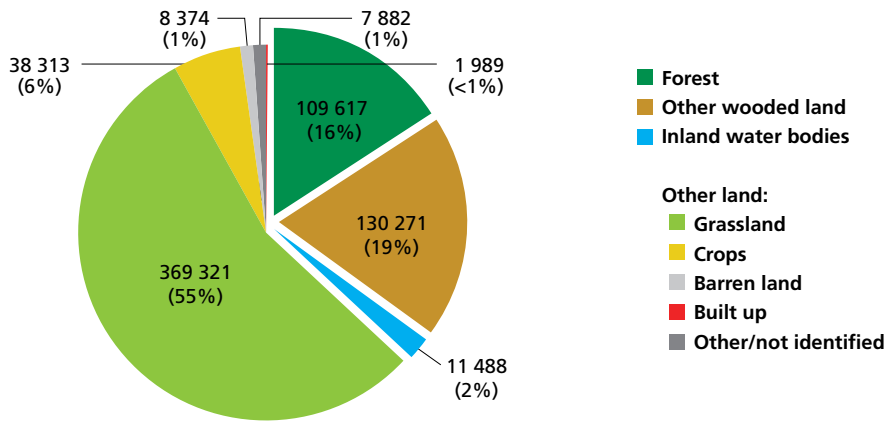
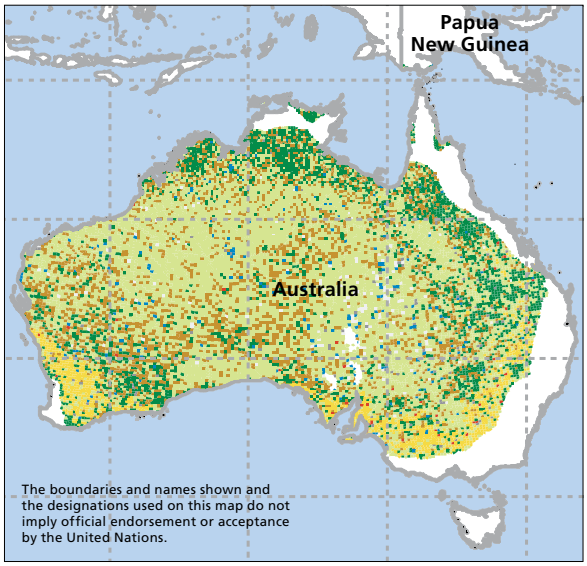


FIGURE 140

Main land uses in Oceania's drylands



Source: UN Maps, 2019

Forest covers 110 million hectares or 16 percent of the dryland area, located mainly in a belt around the edge of the drylands of the region (Figure 140).

The proportion of forest increases from 8 percent in the arid zone to 40 percent in the dry subhumid zone (Figure 141). Other wooded land exhibits the opposite distribution pattern: It makes up 23 percent of the arid zone and only 12 percent of the dry subhumid zone. The proportion of other land decreases with decreasing aridity, from 68 percent in the arid zone, to 62 percent in the semi-arid zone, to 47 percent in the dry subhumid zone.

Of the total dryland forest area, more than half (55 percent) is located in the semi-arid zone, and about one-quarter is in the dry subhumid zone (Figure 142).

More than half (52 percent) of other wooded land is concentrated in the arid zone, with 42 percent falling in the semi-arid zone and 6 percent in the dry subhumid zone (Figure 143).

FIGURE 141

Distribution of land uses by aridity zone

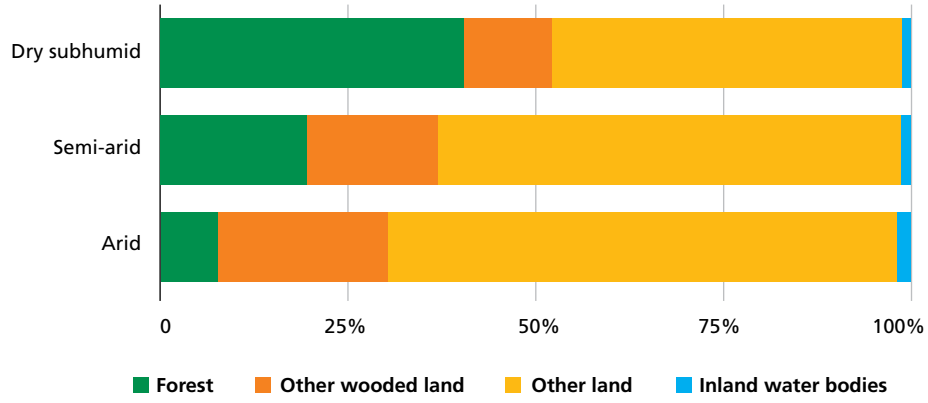


FIGURE 142
Distribution of dryland forest by aridity zone ('000 ha)

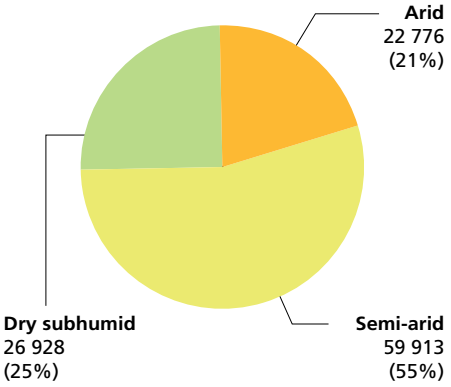
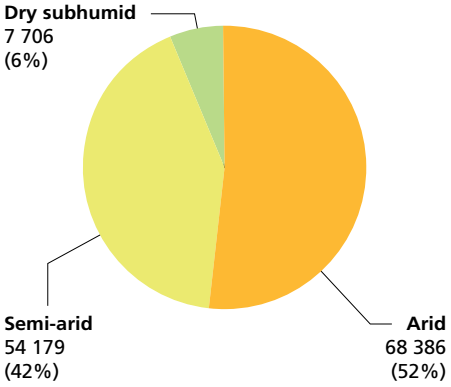


FIGURE 143
Distribution of other wooded land by aridity zone ('000 ha)



VEGETATION IN FORESTS AND OTHER WOODED LAND

Broadleaved forest makes up 85 percent of the region's forest (Table 43, Figure 144), primarily eucalyptus and acacia woodlands, which account for 60 and 21 percent, respectively (see Box 12). As a consequence of the low vegetative reflectance of *Acacia* and *Eucalyptus* species, the forests may not all have been detected, so the 10 percent categorized as other or not identified may also include these types of vegetation (Ringrose *et al.*, 1989; Goodwin, Turner and Merton, 2005).

Other wooded land comprises mainly grassland with shrubs (49 percent) and grassland with trees and shrubs combined (49 percent) (Table 44).

TABLE 43
Type of forest vegetation by aridity zone

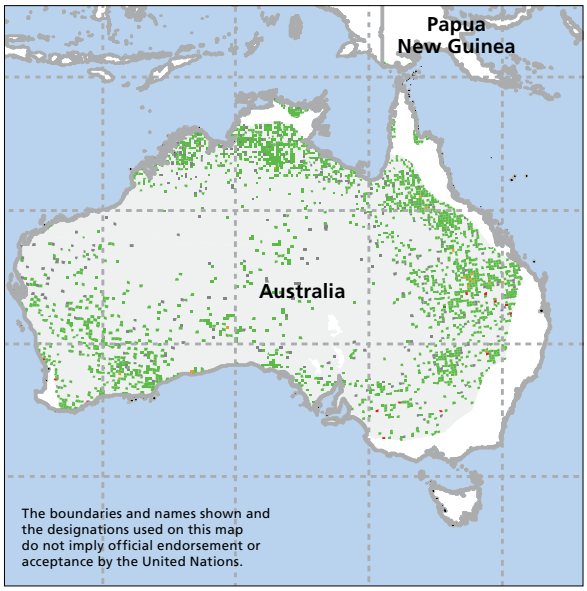
Vegetation type	Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest								
Broadleaved	18 797	83	53 679	90	24 727	92	97 203	89
of which riparian	1 038	5	1 924	3	550	2	3 512	3
Coniferous	0	0	38	0	0	0	38	0
Mixed broadleaved and coniferous	115	1	346	1	212	1	673	1
Other/not identified	3 863	17	5 618	9	1 694	6	11 175	10
Planted forest	0	0	231	0	296	1	527	0
Total	**22 776**	**100**	**59 913**	**100**	**26 928**	**100**	**109 617**	**100**

TABLE 44
Main vegetation types in other wooded land by aridity zone

Vegetation type	Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	36 961	54	24 550	45	2 921	38	64 432	49
Grassland with trees and shrubs	30 791	45	28 667	53	4 573	59	64 031	49
Shrubland	58	0	462	1	42	1	562	0
Other/not identified	577	1	500	1	169	2	1 246	1
Total	**68 386**	**100**	**54 179**	**100**	**7 706**	**100**	**130 271**	**100**

FIGURE 144

Distribution of dryland forest by subtypes



Source: UN Maps, 2019

BOX 12

Forest and woodland vegetation types in the drylands of Oceania

Eucalyptus and acacia woodlands are the primary vegetation types in Oceania's forest. Acacias tend to dominate in drier inland parts of Australia, while eucalypts dominate in wetter parts. The highly diverse flora also includes large numbers of species in ecologically significant genera such as *Melaleuca*, *Grevillea* and *Allocasuarina*.

Eucalypts, also known as gum trees, are the most widespread Australian plant species. They are seen as symbolic of Australia and appear in many iconic paintings and popular songs. About 800 different species of eucalypt are native to Australia. The Tasmanian blue gum (*Eucalyptus globulus*), for example, is an important hardwood resource. Eucalyptus woodlands form a transitional zone between the higher-rainfall, forested margins of the continent and the hummock grasslands and shrublands of the arid interior. They are widespread throughout the mountains and plains west of the Great Dividing Range in eastern Australia and east of the subcoastal ranges in the southwest of Western Australia. Open eucalyptus woodlands cover many plains and downs and some rocky outcrops in the semi-arid interior and the tropics (Australian Government, Department of the Environment and Water Resources, 2007).

TREE CANOPY COVER

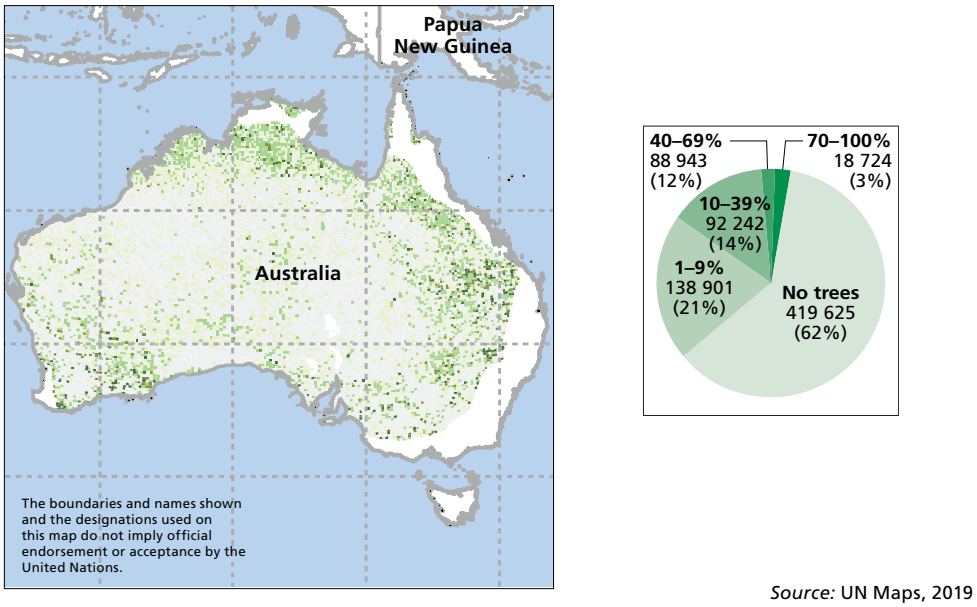
In total, 38 percent of this dryland region has trees (258 million hectares), while 420 million hectares have none (Figure 145).

Average canopy cover ranges from 41 percent in the dry subhumid zone to 23 percent in the arid zone (Table 45).

Almost one-quarter of the forest (25 million hectares) can be considered closed, having a crown cover density of more than 40 percent (Figure 146), while 11 percent has canopy cover that is above 70 percent. More than three-quarters of the forest can be considered open, having canopy cover up to 39 percent.

FIGURE 145

Distribution of tree canopy cover in Oceania's drylands by tree cover range ('000 ha)



Source: UN Maps, 2019

FIGURE 146

Tree canopy cover in forest and other wooded land

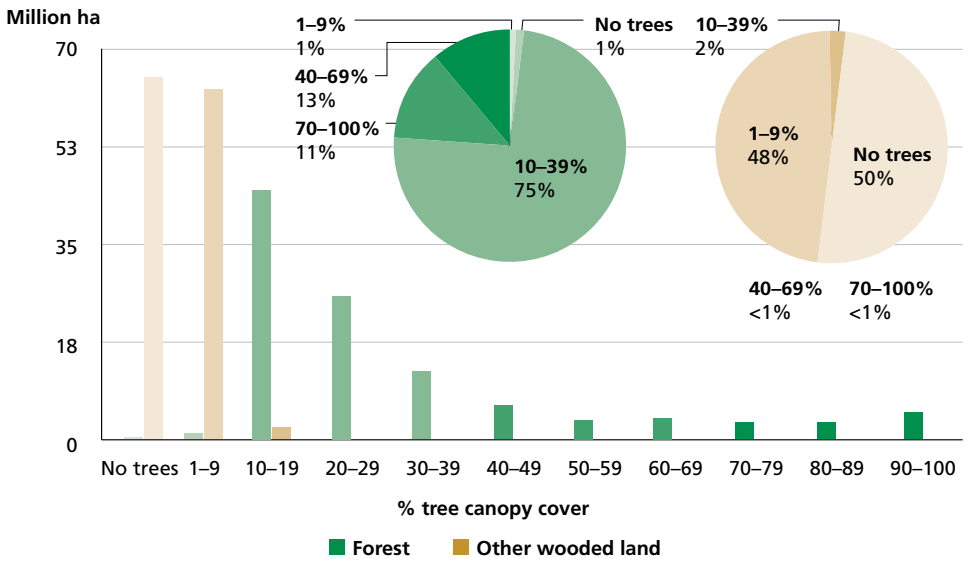


TABLE 45

Average tree canopy cover in Oceania's drylands by land use and aridity zone (%)

Land use	Arid	Semi-arid	Dry subhumid	All zones
Forest	23	31	41	**32**
Other wooded land	3	4	7	**4**
Other land	1	2	3	**1**
Inland water bodies	1	3	7	**2**
All lands	**3**	**8**	**19**	**7**

Half of other wooded land has no trees. Only 2 percent has tree canopy cover between 10 and 39 percent. The remaining 48 percent has less than 10 percent tree cover (Figure 146).

SHRUB COVER

Approximately 57 percent of Oceania's dryland, 384 million hectares, is covered with shrubs (Figure 147).

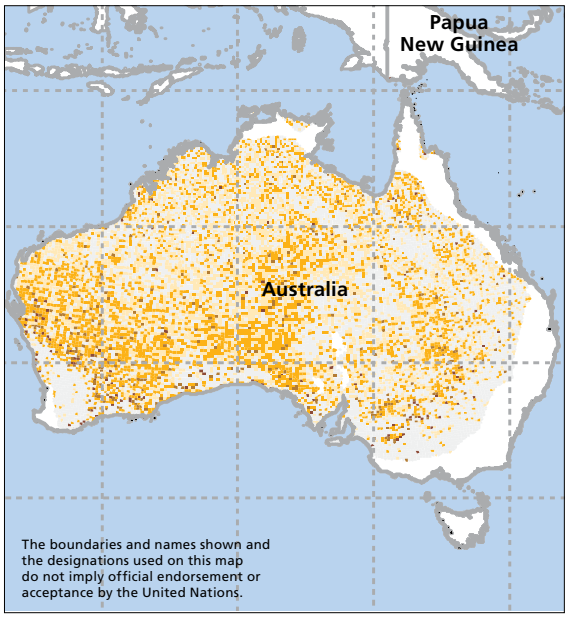
Most other wooded land (86 percent) has sparse shrub coverage ranging from 1 to 39 percent, while 11 percent has dense shrub cover of over 40 percent (Figure 148). Only 3 percent of other wooded land has more than 70 percent shrub cover. The average shrub cover in other wooded land is 22 percent and is nearly uniform across all aridity zones (Table 46).

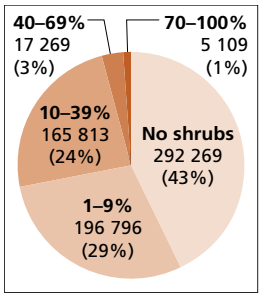
Most of the forest has no shrub cover (52 percent) or between 1 and 39 percent coverage (47 percent) (Figure 148). The average shrub cover in forest is 7 percent (Table 46) and is highest in the arid zone (10 percent).

Most of the other land in dryland has no shrubs (52 percent, 221 million hectares) or very sparse shrub cover ranging from 1 to 9 percent (35 percent, 150 million hectares) (Figure 149).

FIGURE 147

Shrub cover in Oceania's drylands ('000 ha)





Source: UN Maps, 2019

TABLE 46

Average shrub cover by land use and aridity zone (%)

Land use	Arid	Semi-arid	Dry subhumid	All zones
Forest	10	6	5	**7**
Other wooded land	21	22	21	**22**
Other land	6	5	2	**5**
Inland water bodies	3	1	0	**2**
All lands	**10**	**8**	**5**	**9**

FIGURE 148

Shrub cover in forest and other wooded land

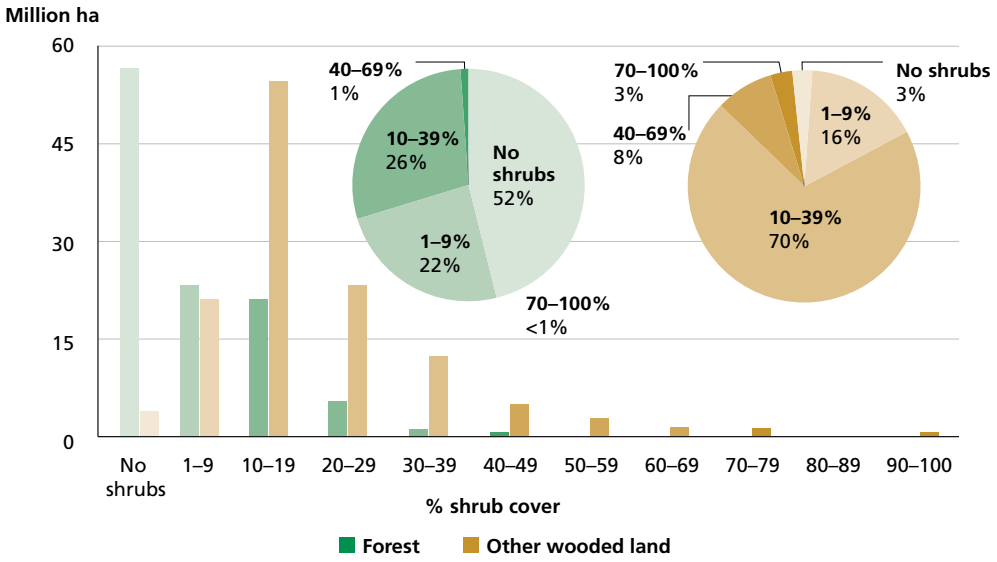
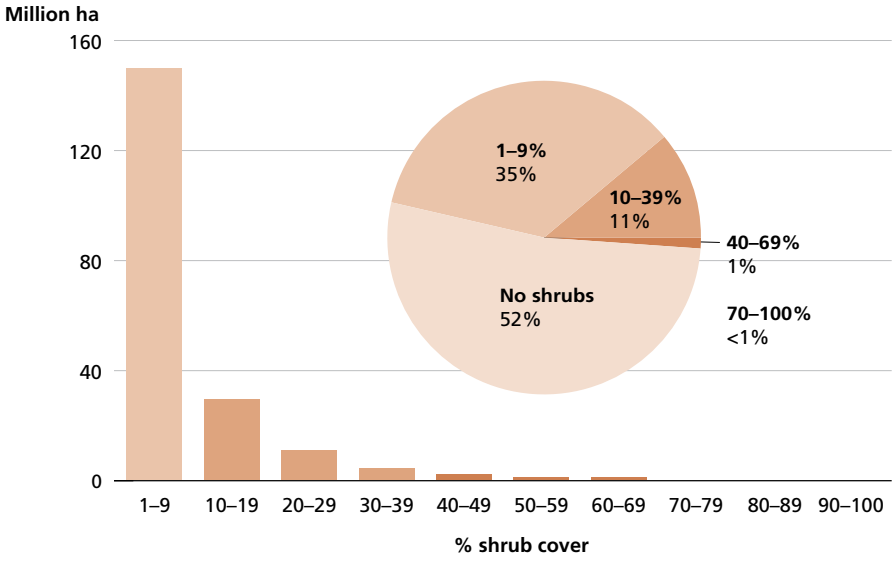


FIGURE 149

Shrub cover in other land



OTHER LAND

The 426 million hectares of other land in the region are almost equally distributed between the arid and semi-arid zones (48 percent and 45 percent, respectively). Only 7 percent is in the dry subhumid zone (Figure 150).

Other land is dominated by hummock and tussock grasslands (87 percent of the total other land area, or 369 million hectares) (Figure 151, Table 47). Grasslands are distributed primarily in the arid zone (194 million hectares), followed by the semi-arid zone (156 million hectares) (Figure 152). Hummock grasslands, typified by *Triodia* and *Plechrachne* species, are arid-land communities characteristic of the Australian outback from the interior to western Australia. Tussock grasslands, found in northern Australia and the temperate grasslands of southern New South Wales and Victoria, contain a broad

FIGURE 150

Distribution of other land by aridity zone ('000 ha)

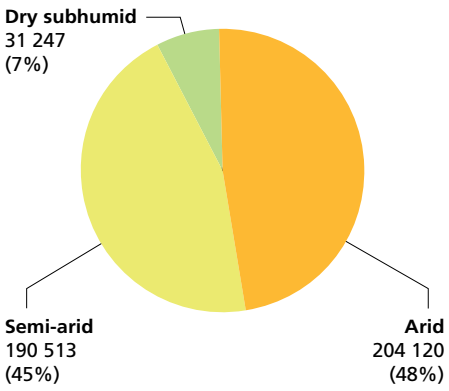
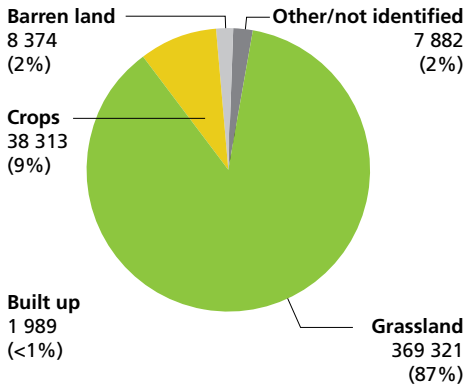


FIGURE 151

Distribution of other land by land use ('000 ha)



range of native grasses including *Dichanthium sericeum* and *Astrebla* spp. (Australian Government, Department of the Environment and Water Resources, 2001).

Crops represent 9 percent of other land (38 million hectares) and are mainly found in the semi-arid zone (28 million hectares) and the dry subhumid zone (10 million hectares). Most of them are rainfed (35 million hectares) (Figure 153). Irrigated crops are estimated to cover 3 million hectares.

Barren land represents 2 percent of other land (8 million hectares). Most of it (almost 7 million hectares) is in the arid zone, while the semi-arid zone has 1 million hectares.

Settlements and built-up areas occupy only 2 million hectares of other land. They are predominantly found in the semi-arid zone (1 million hectares), with the rest about equally distributed between the dry subhumid and arid zones.

TABLE 47

Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Arid	Semi-arid	Dry subhumid	Total	%
Crops	115	27 782	10 416	38 313	100
Irrigated crops	0	1 809	1 313	3 121	8
Non-irrigated cropland	115	25 589	8 891	34 596	90
Perennial crops (palms, orchards, others)	0	308	169	477	1
Cropland fallow	0	77	42	119	0
Grass	194 375	156 189	18 757	369 321	100
Barren land	6 746	1 501	127	8 374	100
Rock or stone	1 096	346	85	1 527	18
Sand and dunes	5 651	1 154	42	6 848	82
Snow and glaciers	0	0	0	0	0
Built up	404	1 077	508	1 989	100
Villages and urban settlements	58	308	339	704	35
Infrastructure	231	654	85	969	49
Mining	115	115	85	315	16

FIGURE 152

Land use in other land by aridity zone

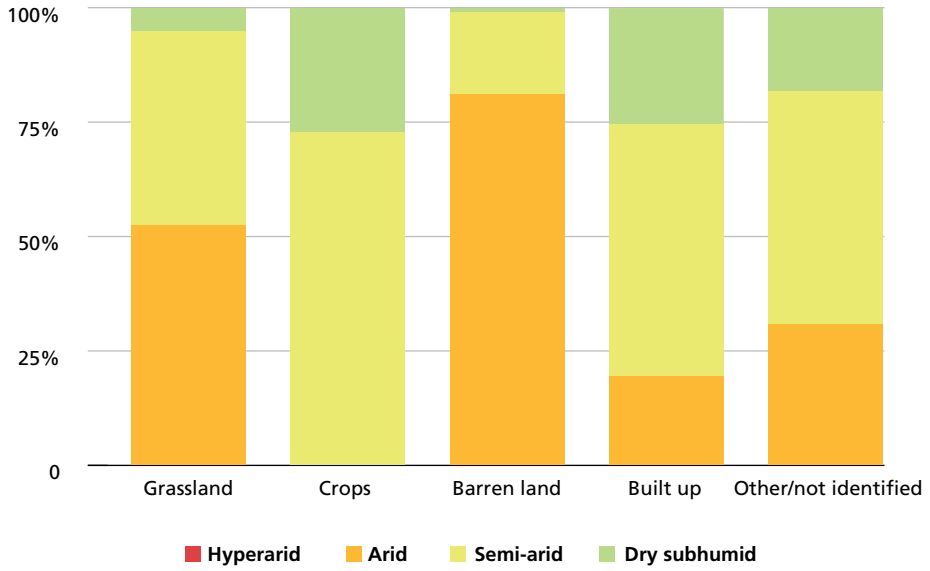
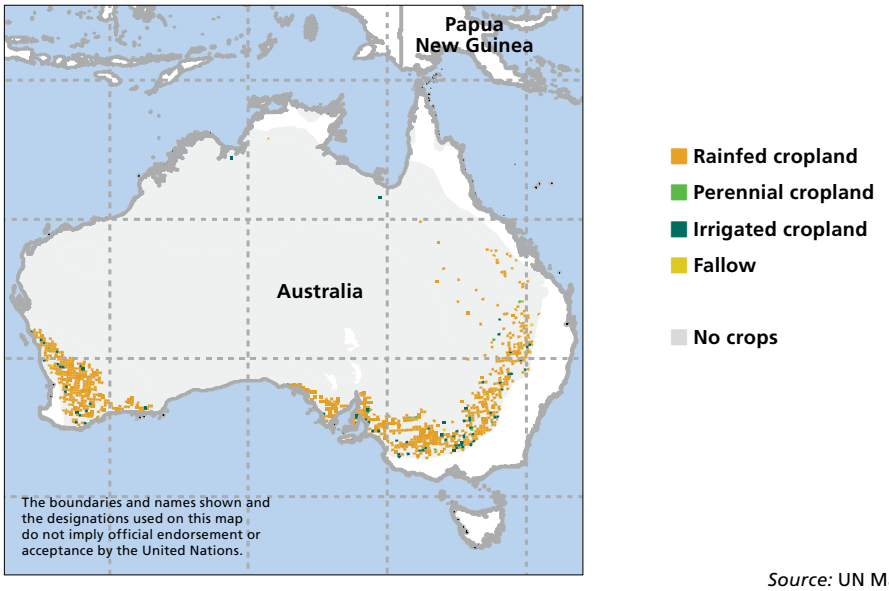


FIGURE 153

Distribution of crop types



Source: UN Maps, 2019

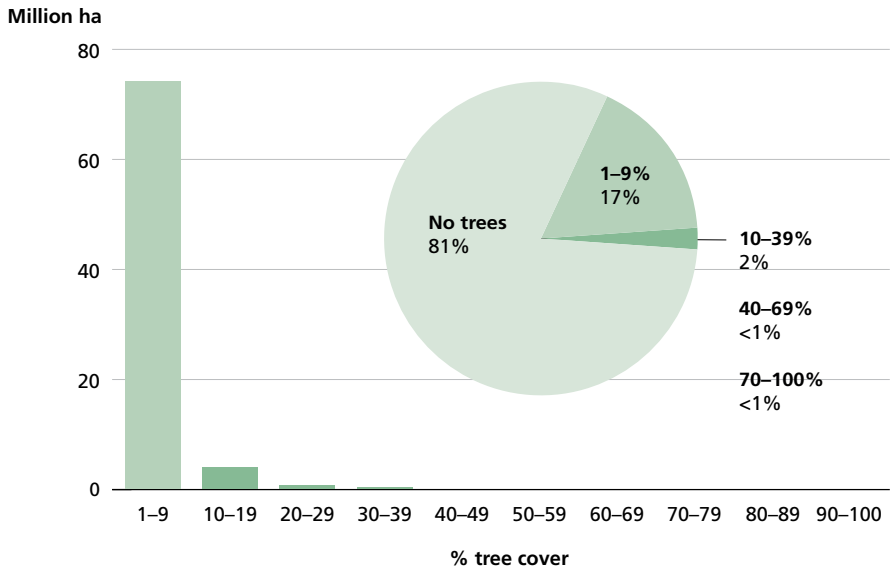
TREES OUTSIDE FOREST

Trees outside forest are present on 19 percent of other land in the drylands (81 million hectares). The rest of the other land category, 344 million hectares, has no trees (Figure 154). About 59 percent of lands classified as built up and 16 percent of cropland have some crown cover.

Other land has 1 percent tree canopy cover on average (see Table 45), with the highest value in the dry subhumid zone (3 percent on average). Tree canopy cover is above 10 percent on 7 million hectares of other land.

FIGURE 154

Tree canopy cover in other land



South America

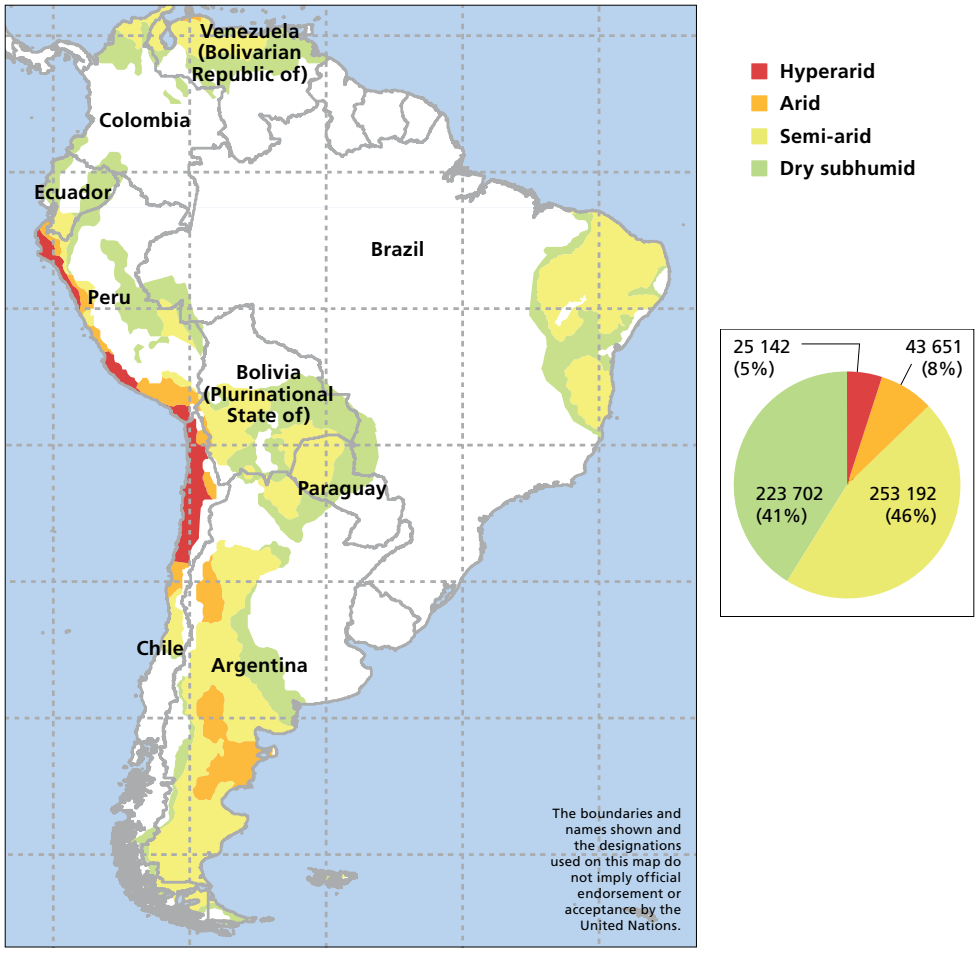
Atacama Desert, Chile

KEY FINDINGS

- The drylands of South America cover almost 545 million hectares, representing 31 percent of the region's total land area and 9 percent of the global drylands.
- The region's drylands contain 199 million hectares of forest, which corresponds to 18 percent of the global dryland forest area and 5 percent of the global forest area, estimated at approximately 4 billion hectares.
- The other land category constitutes 52 percent of the drylands in the region, characterized mainly by grassland (60 percent) and barren land (21 percent).
- Forest covers 37 percent of the region's dryland area, while other wooded land covers 10 percent.
- Forest area follows a clear decreasing gradient as aridity increases. An estimated 61 percent of the dryland forest is in the dry subhumid zone, 38 percent in the semi-arid zone, 1 percent in the arid zone and less than 1 percent in the hyperarid zone.
- Canopy cover in South America's dryland forest is high: 87 percent has a closed canopy, with coverage greater than 40 percent, and 78 percent has a dense canopy of more than 70 percent. The average canopy cover is 80 percent. Coverage is high even for the relatively rare forests of the hyperarid zone (74 percent), suggesting the significant role of these forests as biological corridors.
- Shrub cover in other wooded land is also high, with 66 percent of these lands having shrub cover above 40 percent. Only 3 percent of other wooded land is not covered by shrubs.
- Trees outside forest are present on 46 million hectares (16 percent of other land in the region), while 84 percent of other land (240 million hectares) has no trees.
- In total, 255 million hectares (46 percent) of drylands in South America have some trees. Of this, 29 percent (157 million hectares) has tree cover above 70 percent.

FIGURE 155

Distribution of drylands in South America by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

The drylands of South America cover a total area of 545 million hectares and represent 8.7 percent of the world's drylands. They are primarily distributed in the semi-arid zone (46 percent) and dry subhumid zone (41 percent), with only 8 and 5 percent in the arid and hyperarid zones, respectively (Figure 155).

The regional assessment presented in this report is based on a survey of 30 566 plots. The analysis was completed by a team of 25 data interpreters from the Argentine Dryland Research Institute (IADIZA) and the Instituto Nacional do Semiárido (INSA), Brazil, in July and August 2015.

BACKGROUND

Climate

South America has three main topographical areas – the high mountains of the Andes in the west; the central lowlands, including the Amazon, Orinoco and Paraná Rivers; and the Brazilian and Guiana Highlands in the east – as well as Atlantic and Pacific coastal plains. The climate thus shows large differences, from wet areas to large glaciers to deserts. The coastal belt contains the world's driest desert, the Atacama, and the Colombia Chocó Desert.

South America has four major regions (tropical, temperate, arid and cold) and seven major climate areas: desert, with high temperatures and limited rain; grassland, with hot summers and cold winters; deciduous forest, with four seasons (summer, autumn, winter and spring); Amazon rain forest; savannah, with high temperatures and heavy rains during summer; Mediterranean, with high temperatures and rainfall during autumn and winter; and Andean mountain, with cold winters and snow.

The climatic conditions in the continent are influenced by the fluctuating conditions of the Pacific Ocean and atmosphere, with warming phases known as El Niño and cooling phases known as La Niña. El Niño leads to excessive rainfall along the Caribbean coast and dry periods in the Pacific areas. Rainfall increases in Ecuador and northern Peru, while dry conditions increase in the Andean zones (IICA, 2016).

Northeast and southeast trade winds converge at an area on the equator known as the Intertropical Convergence Zone, affecting the rainfall in the tropics, causing droughts or flooding in nearby areas and cold and warm seasons at higher latitudes (Waliser and Jiang, 2014).

The Humboldt Current, where cool waters from the south interact with the warm tropical waters of the equatorial front, has a permanent cooling influence on Chile, Peru and Ecuador and is responsible for the aridity of the Atacama Desert in northern Chile (Serra *et al.*, 2012).

Temperatures in the tropical wet-dry areas of the Brazilian highlands and Ecuador can reach 18 to 35 °C. Andean areas have dramatic temperature fluctuation and decreasing rainfall from east to west. The high Andes have cold areas in central Peru, Bolivia and Chile with temperatures from –2 to 12 °C and precipitation of 610 to 1 420 mm. In southern Chile, rainfall can reach 2 500 mm.

The warm and cold deserts in Patagonia and northwest Argentina are characterized by an arid climate; average annual rainfall in San Juan Province, Argentina, is 100 to 180 mm. In Patagonia the highest temperature is about 20 °C. Temperatures in the Atacama desert can reach 18 °C, with almost no rainfall in the year. In eastern Brazil, the area around Parnaíba and the São Francisco River is characterized as an interior warm zone, with 100 mm rain.

Importance of dryland forests, trees and biodiversity

Drylands provide global benefits associated with biodiversity, shade, moisture, pollinators and other environmental services that are essential for local communities and their food security. The dry forest of South America is less well known than the tropical rain forest, but according to WRI, 30 percent of the region's population is located in drylands (White and Nackoney, 2003).

Important dry forests in South America include the Tumbes-Piura dry forests in southern Ecuador and northwestern coastal Peru, which have a high level of species endemism; parts of the Tumbes-Chocó-Magdalena biodiversity hotspot in Colombia, Ecuador and northwestern Peru; the dry forests of the Patía, Magdalena and Cauca Valleys in Colombia. Important tree species in these areas include *Loxopterygium huasango* and *Handroanthus billbergii*, used for timber; and *Buresera graveolens*, which provides essential oils and incense and is used in indigenous medicine. Leguminous shrubs of *Cyathostegia* spp. are also found in Ecuador and Peru. Dry forest is also found in the Maranhão Babaçu forest of Brazil as well as in Bolivia, Paraguay and Chaco Province of northern Argentina.

The driest forest in South America is located in the Caatinga (meaning "white vegetation" in the Tupi language) ecoregion of northeastern Brazil. It consists of xeric shrubland and thorn forest. People living in the Caatinga depend on forestry products, extracting the caraiba (*Copernicia prunifera*) for wood products and harvesting local fruits, medicinal plants, forage and palms (Cardoso da Silva, Leal and Tabarelli, 2017).

Grasslands with trees and shrub are important for local communities, providing sources of energy and fodder.

Ecuador

XXXXXXX ©

Trends and challenges

According to MODIS and NASA (United States National Aeronautics and Space Administration) satellite data, 3.8 percent of dry forest cover disappeared between 2001 and 2010, mainly because of soya cultivation and livestock production (Aide *et al.*, 2013). The Caatinga is considered one of the most endangered ecosystems in the world. Slash and burn practices are traditional in this area, and soil salinization is a problem.

In the Gran Chaco, a hot and semi-arid lowland region of the Río de la Plata basin that is home to a variety of indigenous people, fuel crops, soy plantations and illegal logging are having a direct negative impact on the natural habitat (Espinoza *et al.*, 2012).

DISTRIBUTION OF FORESTS AND OTHER LAND USES

Other land, which includes in particular meadows and pastures, barren land, agricultural land and built-up areas, covers 52 percent of South America's drylands or 286 million hectares (Figures 156 and 157). Forests are the next most represented class, with more than 199 million hectares (37 percent of the dryland area). Other wooded land follows, with more than 52 million hectares (10 percent of total dryland area).

The distribution of land uses varies substantially by aridity zone. The proportion of forests increases from 2 percent in the hyperarid zone to 54 percent in the dry subhumid zone (Figure 158). Other wooded land exhibits the opposite distribution pattern; it makes up 22 percent of the arid zone and only 5 percent of the dry subhumid zone. The proportion of other land varies more steadily with aridity, from 94 percent in the hyperarid zone to 72 percent in the arid, 56 percent in the semi-arid and 40 percent in the dry subhumid zones.

The highest proportion of forest is in the dry subhumid zone (61 percent or 121 million hectares) and semi-arid zone (38 percent or 76 million hectares) (Figure 159). The arid and hyperarid zones have only a very small forest area (2 million and 1 million hectares, respectively).

Other wooded land is located primarily in the semi-arid zone (61 percent or 32 million hectares), followed by the dry subhumid and arid zones with 19 and 18 percent, respectively (Figure 160).

FIGURE 156

Distribution of land uses in South America's drylands ('000 ha)

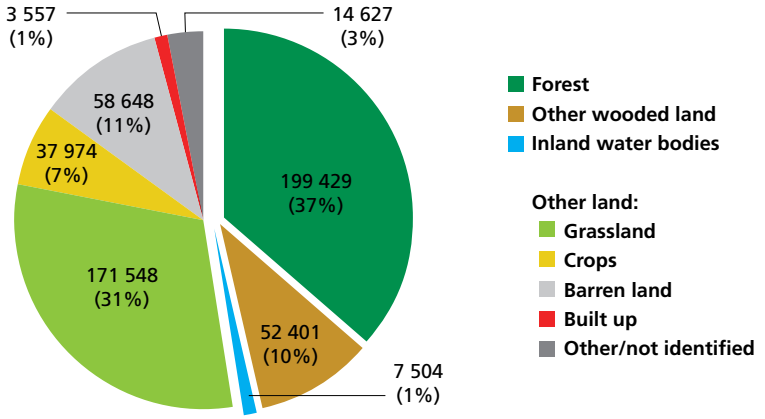
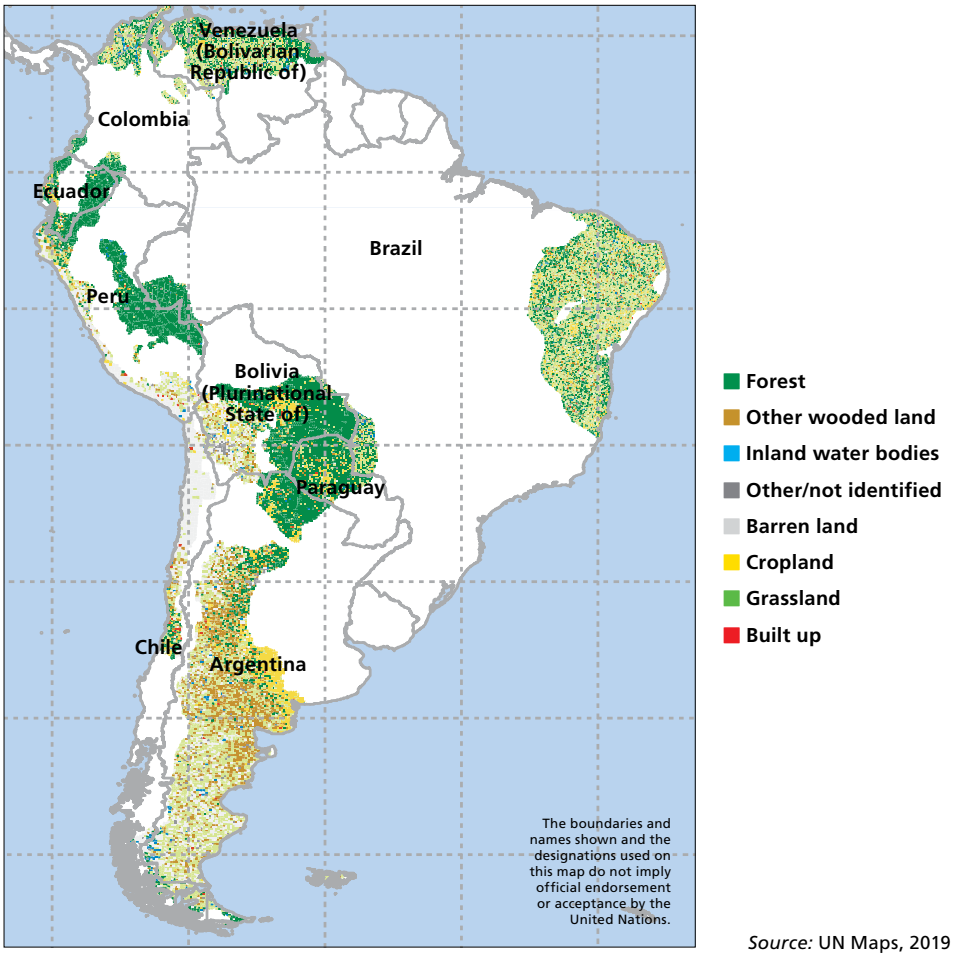


FIGURE 157

Main land uses in South America's drylands



Source: UN Maps, 2019

FIGURE 158

Distribution of land uses by aridity zone

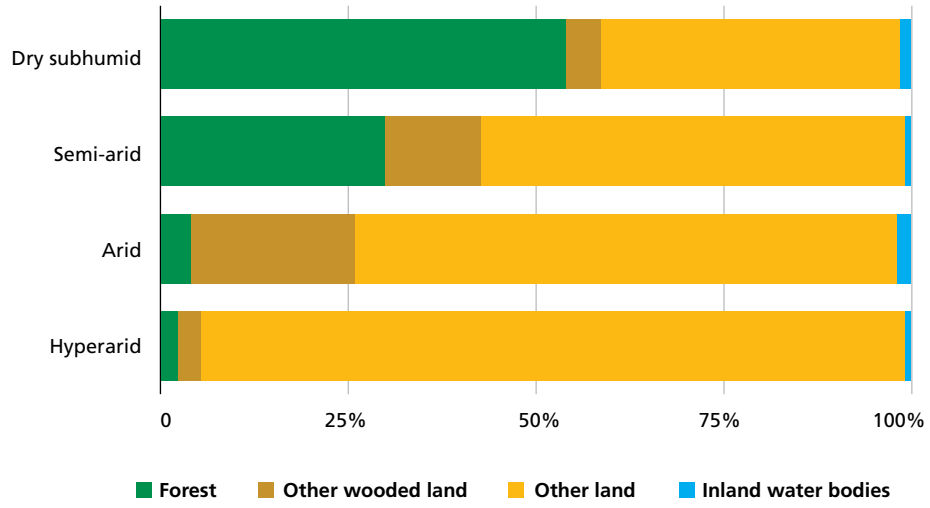


FIGURE 159

Distribution of dryland forest by aridity zone ('000 ha)

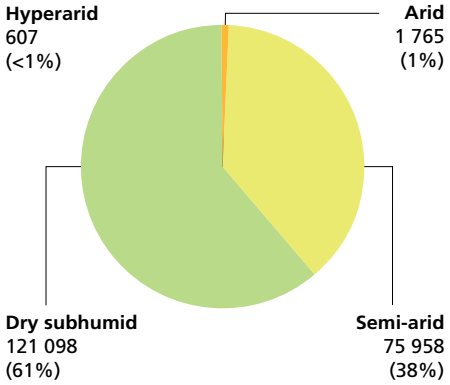
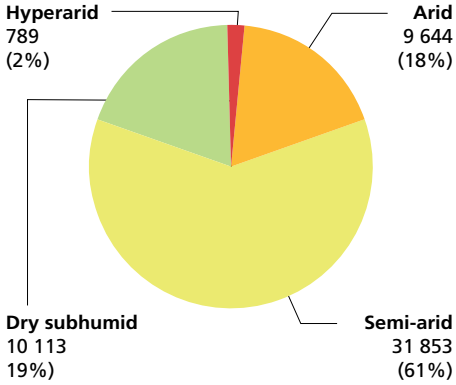


FIGURE 160

Distribution of other wooded land by aridity zone ('000 ha)



VEGETATION IN FORESTS AND OTHER WOODED LAND

Broadleaved forest, including riparian and gallery forest, represents 95 percent of the forest in South America's drylands, with the largest amount found in the dry subhumid zone (Figure 161, Table 48). For 3 percent of the forest area the vegetation type was not identified. Coniferous and mixed forest account for a small proportion of forests. Planted forest makes up 1 percent of the total.

Other wooded land is mainly covered with grass and shrubs (77 percent) or grass with both shrubs and trees (20 percent) (Table 49). Small areas of mangroves were identified in the dry subhumid and semi-arid zones (included under "other" in Table 49).

FIGURE 161
Distribution of dryland forest by subtypes

Source: UN Maps, 2019

TABLE 48
Type of forest vegetation by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest										
Broadleaved	547	90	1 628	92	70 733	93	116 922	97	189 829	95
of which riparian	61	10	78	4	1 542	2	2 788	2	4 468	2
Coniferous	0	0	0	0	171	0	157	0	328	0
Mixed broadleaved and coniferous	0	0	59	3	727	1	789	1	1 575	1
Other/not identified	0	0	48	3	3 309	4	2 276	2	5 632	3
Planted forest	61	10	30	2	1 020	1	955	1	2 065	1
Total	**607**	**100**	**1 765**	**100**	**75 958**	**100**	**121 098**	**100**	**199 429**	**100**

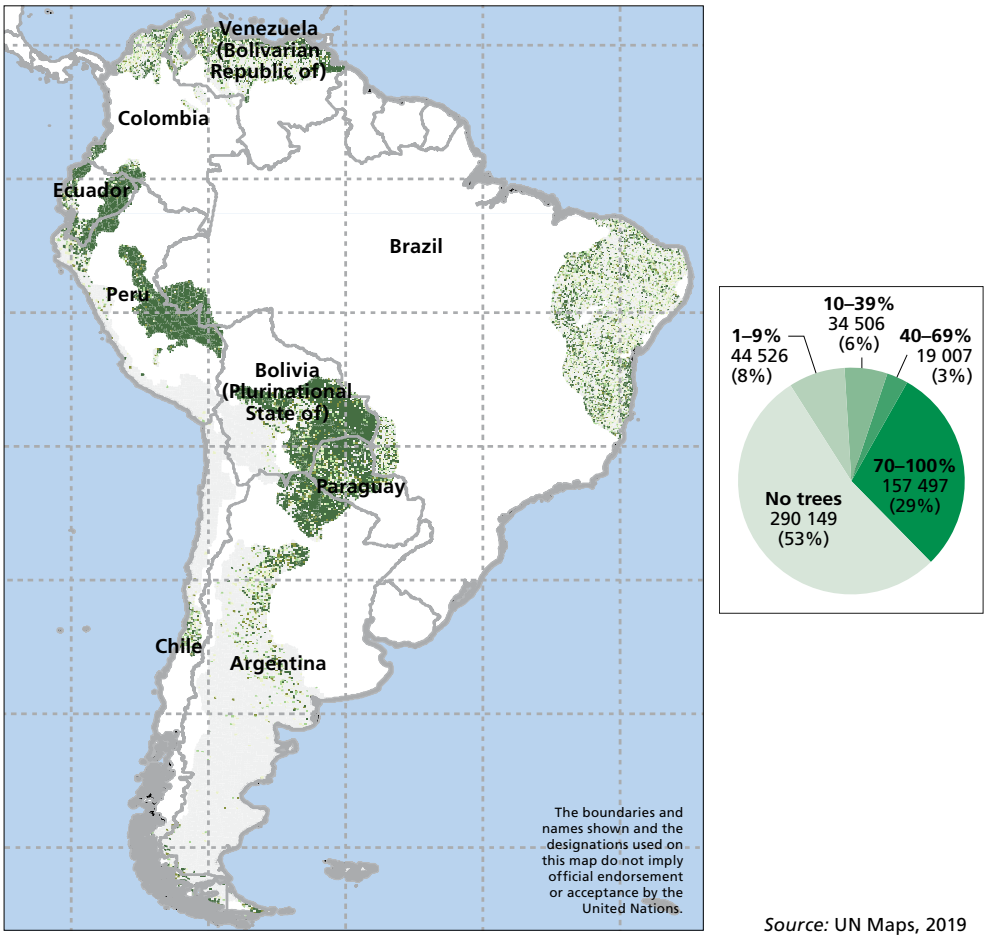
TABLE 49
Main vegetation types in other wooded land by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	607	77	9 270	96	24 104	76	6 196	61	40 177	77
Grassland with trees and shrubs	182	23	345	4	6 714	21	3 272	32	10 513	20
Shrubland	0	0	0	0	326	1	222	2	547	1
Other/not identified	0	0	30	0	710	2	424	4	1 164	2
Total	**789**	**100**	**9 644**	**100**	**31 853**	**100**	**10 113**	**100**	**52 401**	**100**

TREE CANOPY COVER

About 53 percent of South America's drylands has no trees, while 29 percent has a closed canopy, with coverage of 70 to 100 percent (Figure 162).

FIGURE 162
Distribution of tree canopy cover in South America's drylands by tree cover range ('000 ha)

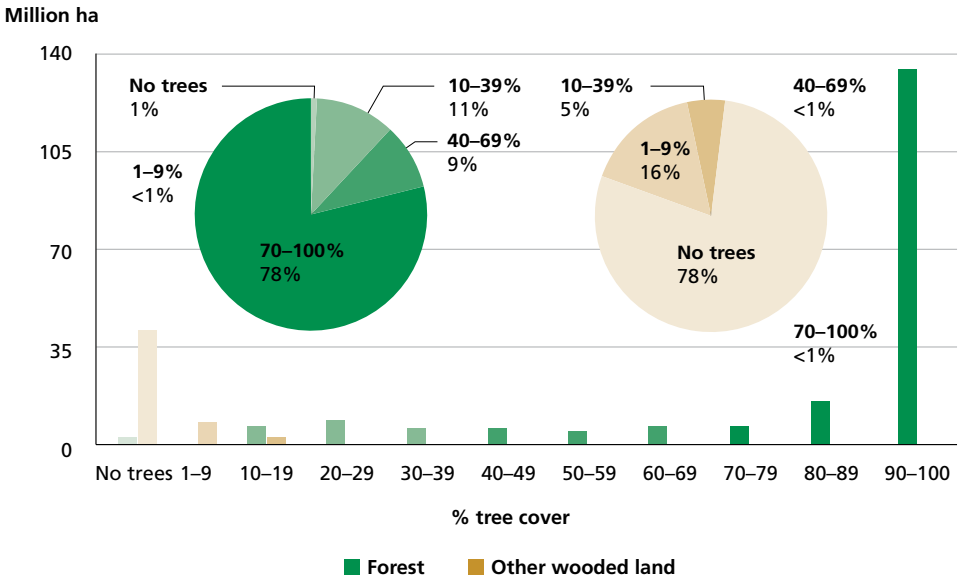


Source: UN Maps, 2019

TABLE 50
Average tree canopy cover in South America's drylands by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	74	65	75	84	**80**
Other wooded land	2	0	2	4	**2**
Other land	0	0	2	3	**2**
Inland water bodies	0	0	0	0	**0**
All lands	**2**	**3**	**24**	**47**	**31**

FIGURE 163
Tree canopy cover in forest and other wooded land



The average canopy cover in South America's dryland forest is high, 80 percent (Table 50). Although the forests in the hyperarid zone account for less than 1 percent of South America's total dryland forest, even these forests have high canopy cover (74 percent); these forests have a high endemism and provide significant ecosystem services as biological corridors.

Approximately 78 percent of South America's dryland forest has canopy cover above 70 percent, while around 20 percent has a tree canopy of between 10 and 69 percent (Figure 163). The area without trees or with canopy cover below 10 percent is small.

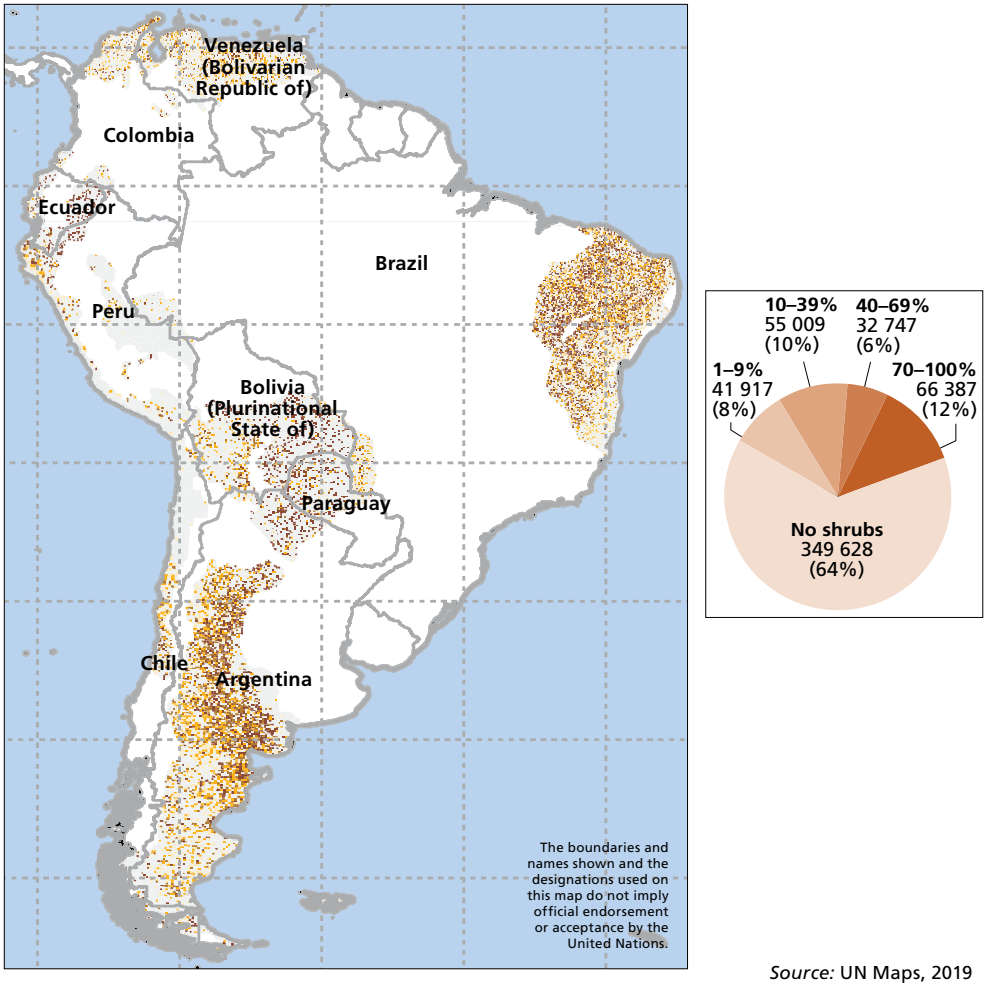
About 78 percent of other wooded land has no tree cover, and the rest has tree cover below 10 percent (Figure 163).

SHRUB COVER

Shrub cover is located mostly in other wooded land (Figure 164). Shrub coverage is 56 percent on average and is similar in all aridity zones, ranging from 53 to 57 percent (Table 51), which is very dense relative to that of other regions. About 40 percent of other wooded land has shrub cover in the range of 70 to 100 percent, while the areas having 10 to 39 percent cover and having 40 to 69 percent cover each account for 26 percent of other wooded land (Figure 165). Only 3 percent of other wooded land has no shrubs.

Most of the forest has little or no shrub cover (or shrubs could not be detected because of dense tree canopy cover). The average shrub cover in South America's dryland forest is estimated to be 13 percent. It is higher in the arid zone (17 percent) than in the dry

FIGURE 164
Shrub cover in South America's drylands by shrub cover range ('000 ha)



Source: UN Maps, 2019

TABLE 51
Average shrub cover by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	7	17	14	12	**13**
Other wooded land	55	53	57	54	**56**
Other land	1	6	17	12	**13**
Inland water bodies	5	7	4	2	**3**
All lands	**3**	**17**	**21**	**14**	**17**

subhumid zone (12 percent), and lowest in the hyperarid zone (7 percent) (Table 51). The data show that 78 percent of the forest area has no shrubs, and just 10 percent of the total area has shrub cover between 70 and 100 percent (Figure 165).

Most of the other land in drylands has little or no shrub cover. About 65 percent of other land has no shrub cover (185 million hectares), and 12 percent has shrub cover ranging from 1 to 9 percent (33 million hectares), while 68 million hectares have shrub cover above 10 percent (Figure 166). Average shrub cover in other land is highest in the semi-arid zone (17 percent) and decreases to 1 percent in the hyperarid zone (Table 51).

FIGURE 165

Shrub cover in forest and other wooded land

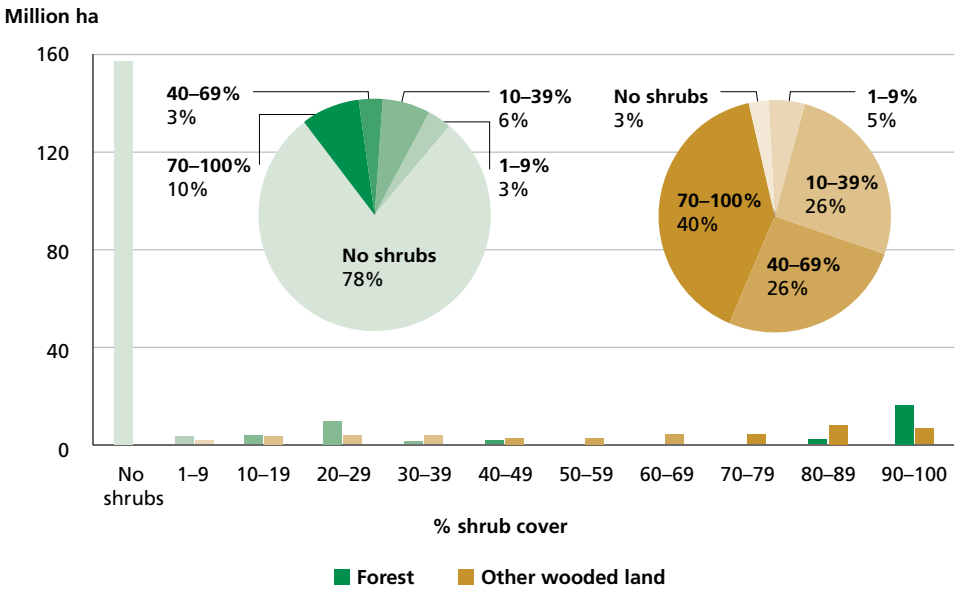
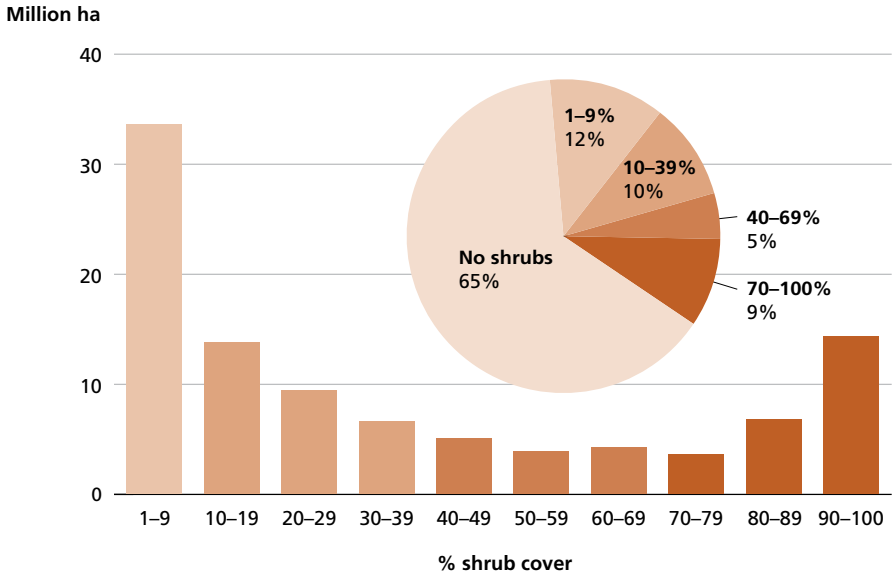


FIGURE 166

Shrub cover in other land



OTHER LAND

The largest part of other land – half of it – is located in the semi-arid zone, while 31 percent is in the dry subhumid zone, 11 percent in the arid zone and only 8 percent in the hyperarid zone (Figure 167). 13 percent to crops and 1 percent to built-up area.

The other lands are mainly composed of grassland or herbaceous savannah (172 million hectares, or 60 percent of other land) (Figure 168, Table 52). Grassland is distributed primarily in the semi-arid zone (97 million hectares), followed by the dry subhumid zone (55 million hectares) (Figure 169).

FIGURE 167

Distribution of other land by aridity zone ('000 ha)

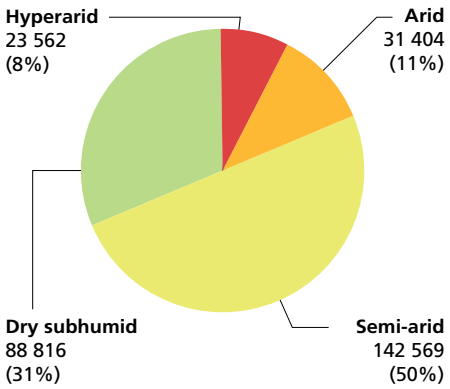


FIGURE 168

Distribution of other land by land use ('000 ha)

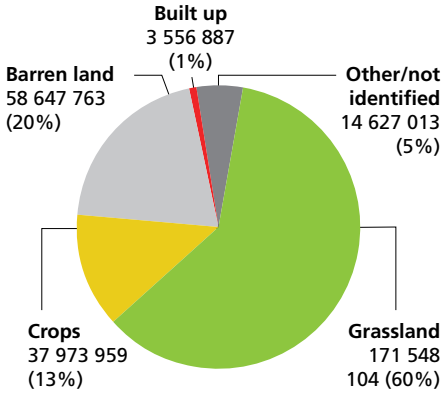


TABLE 52

Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	911	1 008	15 196	20 859	37 974	100
Irrigated crops	364	504	3 057	3 441	7 366	19
Non-irrigated cropland	425	356	8 714	13 455	22 950	60
Perennial crops (palms, orchards, others)	121	59	1 665	1 437	3 283	9
Cropland fallow	0	89	1 760	2 527	4 376	12
Grass	2 733	16 131	97 496	55 188	171 548	100
Barren land	18 644	12 473	20 702	6 829	58 648	100
Rock or stone	6 862	5 782	8 003	3 011	23 659	40
Sand and dunes	11 781	6 601	12 462	2 538	33 383	57
Snow and glaciers	0	89	237	1 280	1 606	3
Built up	243	463	1 774	1 077	3 557	100
Villages and urban settlements	61	226	1 323	811	2 421	68
Infrastructure	121	208	452	243	1 024	29
Mining	61	30	0	22	112	3

Barren land covers 59 million hectares, or 21 percent of other land, and is located for the most part in the semi-arid (20 million hectares) and hyperarid (19 million hectares) zones.

Crops represent 13 percent of other land (or 6 percent of total drylands), with 38 million hectares. They are mainly found in the dry subhumid zone (21 million hectares). Most of them (60 percent) are non-irrigated crops. Irrigated crops cover only 19 percent of the cropland or 7 million hectares, while perennial crops (such as palms and orchards) cover an estimated 3 million hectares (Figure 170).

Built-up areas, which include urban and rural settlements, infrastructure and mines, occupy less than 4 million hectares, predominantly in the semi-arid and dry subhumid zones (2 million and 1 million hectares, respectively).

FIGURE 169

Land use in other land by aridity zone

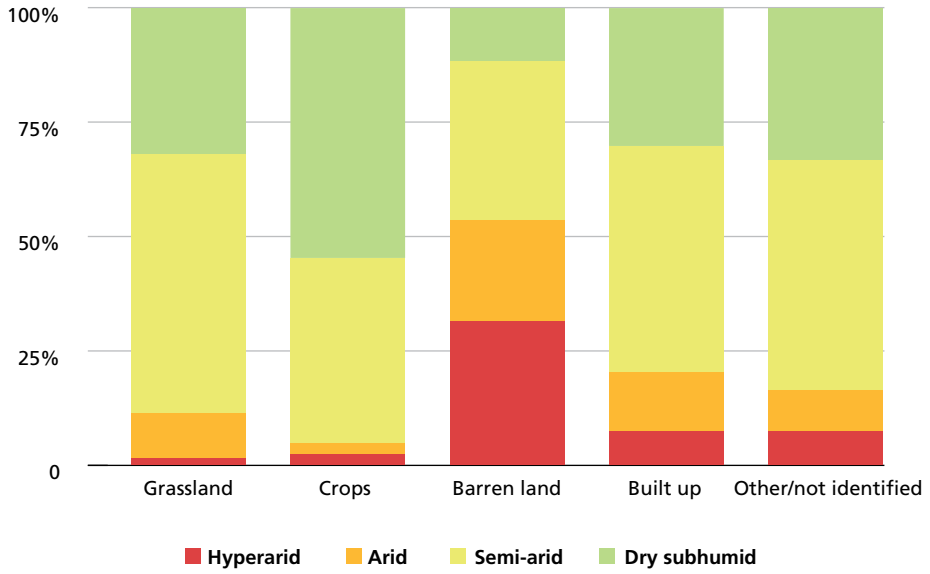


FIGURE 170

Distribution of crop types

Source: UN Maps, 2019

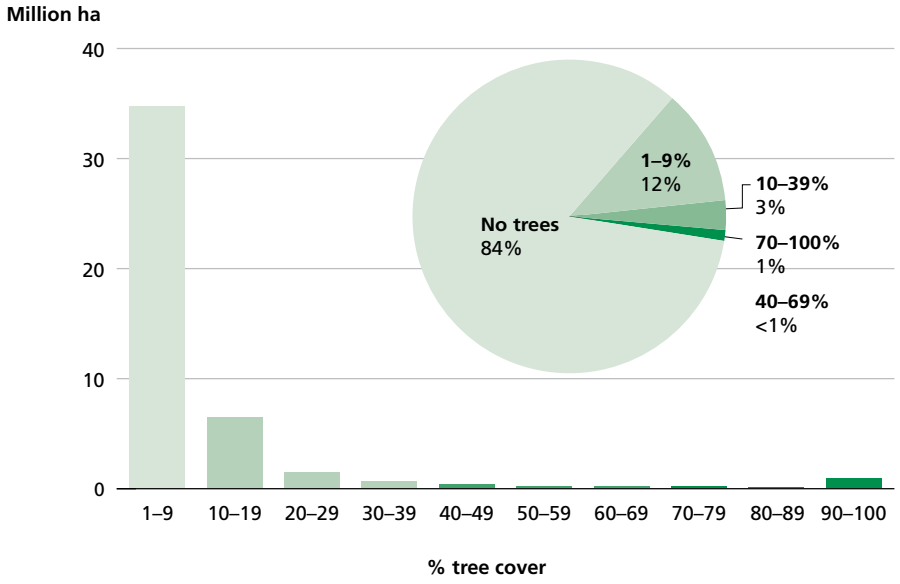
TREES OUTSIDE FOREST

Trees outside forest, which are defined as the trees in other land, are present on 46 million hectares (16 percent of other land) (Figure 171). An estimated 240 million hectares, or 84 percent of other land in South America's drylands, have no trees.

Tree canopy cover is below 10 percent on 96 percent of other land (275 million hectares), while only 12 million hectares have tree cover above 10 percent. Other land has 2 percent tree canopy cover on average (Table 50), with the highest value (3 percent) in the dry subhumid zone.

FIGURE 171

Tree canopy cover in other land



North and Central America and the Caribbean

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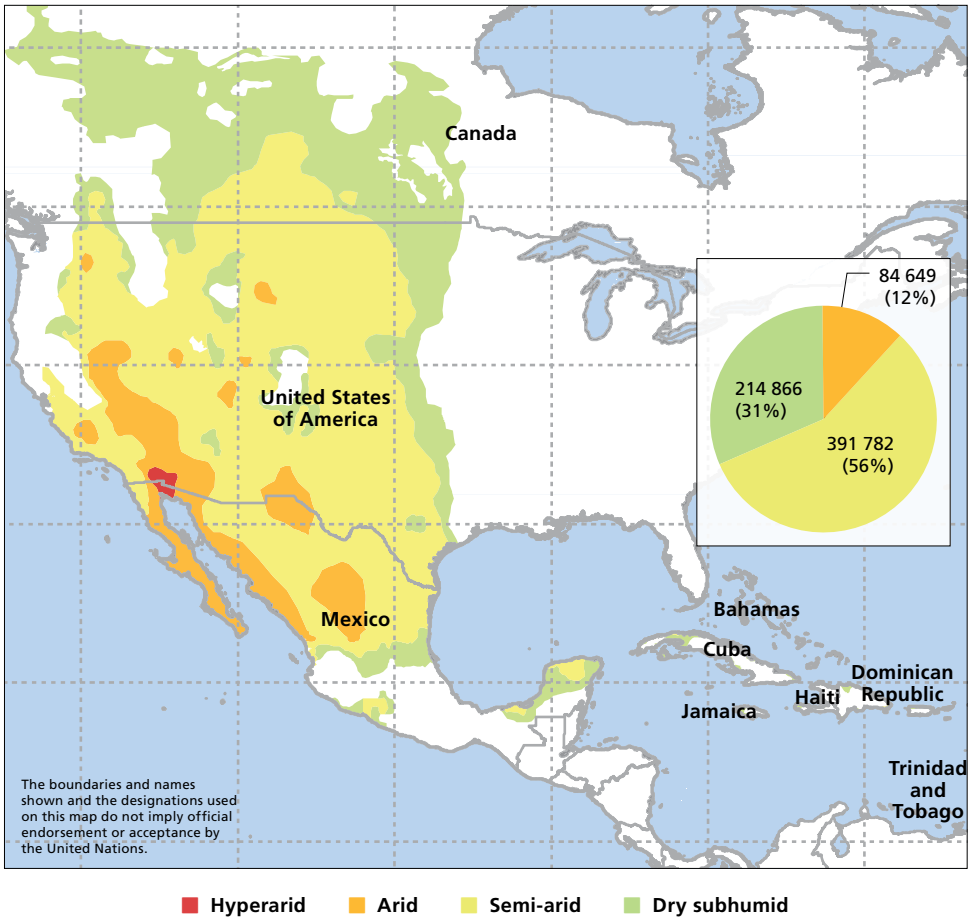
Upstream landscape on the Saskatchewan River, Canada

KEY FINDINGS

- The drylands of North and Central America and the Caribbean cover almost 694 million hectares, representing 32 percent of the region's total land area and 11 percent of the global drylands.
- The region's drylands contain 206 million hectares of forest, which corresponds to 19 percent of the global dryland forest area and 5 percent of the global forest area, estimated at approximately 4 billion hectares.
- Other land is the largest land-use category, constituting 45 percent of the drylands in this region. It is characterized mainly by grassland (47 percent of other land) and crops (39 percent).
- Forest is the second most common land use (30 percent), followed by other wooded land (22 percent).
- Forest follows a clear increasing gradient as aridity decreases, from less than 1 percent of dryland area in the hyperarid zone to 5 percent in the arid zone, 41 percent in the semi-arid zone and 54 percent in the dry subhumid zone.
- An estimated 76 percent of the dryland forest in the region has a closed canopy (canopy cover greater than 40 percent), while 58 percent has a dense canopy of more than 70 percent).
- Trees outside forest are present on 52 million hectares (17 percent of other land). Approximately 62 percent of land classified as built up has crown cover.
- In total, considering all land-use categories, there are trees on 44 percent (305 million hectares) and no trees on 56 percent (390 million hectares) of the drylands of North and Central America and the Caribbean.

FIGURE 172

Distribution of drylands in North and Central America and the Caribbean by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

The drylands of North and Central America and the Caribbean comprise 694 million hectares, representing 11 percent of the world's drylands. They stretch from central Canada to the central and western parts of the United States of America, the entire northern half of Mexico, areas in the Caribbean and the Pacific coast of Central America (Figure 172).

The semi-arid is by far the largest aridity zone, covering 392 million hectares or 57 percent of the region's drylands, for the most part in the central area of the region. The second most prevalent, the dry subhumid zone, covers 215 million hectares (31 percent) along the northern, eastern and southern edges of the drylands. The arid zone occupies 85 million hectares (12 percent), primarily in the interior western part of the United States and the Baja Peninsula and coast of the Gulf of California in Mexico, along with one area in central Mexico and one area straddling the border between Mexico and the United States. The hyperarid zone covers only 3 million hectares, less than 1 percent of the region's drylands, mainly located at the northern tip of the Gulf of California.

The assessment of the drylands of this region is based on photo interpretation of 15 017 plots, conducted by the United States Department of Agriculture – Forest Service and the Remote Sensing and Geographic Information Systems Laboratory, Utah State University, Logan, Utah, United States of America.

BACKGROUND

Climate

Ecological and socio-economic survival in the drylands of North and Central America and the Caribbean is strongly dependent on the current climate, local weather characteristics and the future of the climate. Changes in atmospheric circulation patterns, in combination with the oceanic temperature changes of El Niño and La Niña events, result in annual variations, creating severe drought years or wetter-than-average years throughout the region. The southwestern area of the drylands is also affected by monsoon events, which are localized weather patterns created by seasonal fluctuations in temperature and wind.

Importance of dryland forests, trees and biodiversity

The dryland forests mainly occur in the mountainous areas of the region, particularly the Rocky Mountain range. This mountain range was once heavily exploited by mining, trapping and tree harvesting, but is currently mostly protected public lands. The mountains are important features for the drylands, providing a slow release of water from winter snowpack, carried by streams and rivers to the dry valley bottoms. The wide latitudinal extent of the region's drylands leads to a diverse range of forest ecosystems, with strong influences from climate, local weather patterns and disturbances, while the type of forest and amount of tree cover are strongly correlated with elevational changes, soil moisture content and slope aspect.

Other characteristic forest communities scattered throughout the drylands are on isolated mountains, often referred to as sky islands, surrounded by seas of grassland valleys which act as barriers for biological dispersal and migration paths. These are unique, isolated ecosystems that have a high diversity of vegetation and wildlife species. The Madrean Archipelago Sky Islands in southeastern Arizona are home to more than half of all bird species in the United States of America. Challenges in these ranges include the threat of wildlife extinction from hunting and trapping, encroachment by growing human populations and changing climate patterns (Coe, Finch and Friggens, 2012).

Many groves, tree species and individual trees have spiritual significance to dryland peoples because of their relative rarity, high visibility in the landscape and ability to provide shade. These sacred groves often conserve islands of indigenous ecosystems in a transformed landscape and contribute to unique cultural landscapes such as the historical sites of Native Americans (Williams and Diebel, 1996).

A singular socio-economic asset within the North American drylands are pinyon pine nuts, collected from three main species: Colorado pinyon (*Pinus edulis*), single-leaf pinyon (*Pinus monophylla*) and Mexican pinyon (*Pinus cembroides*). The pine nut crops are mainly protected and harvested by Native Americans, with commercial harvesters scattered throughout the area. Pine nuts offer high nutritional value and have been important to the diet of Native American tribes. Drought, fires and bark beetles have a strong impact on this trade.

Trends and challenges

The region's drylands are subject to desertification, with overgrazing the predominant cause. This degradation began to accelerate in the early nineteenth century through overgrazing in combination with wind and water erosion and salinization of irrigated land. Currently, approximately 90 percent of the region's drylands are moderately to severely affected. Furthermore, over 60 percent of the dryland ecoregions in North America have been characterized with a moderate level of wildlife exploitation (Ricketts *et al.*, 1999).

A slight increase in temperature observed over time across the North American drylands (Hulme, 1996; Hughes and Diaz, 2008; Mote *et al.*, 2005) is expected to lead to an expansion of the arid lands in future years (Feng and Fu, 2013). Rising

BOX 13

Frequent-fire forests of western North America

Ponderosa pine and dry mixed-conifer forests, widely distributed throughout western North America, are also termed "frequent-fire forests" because their fire return interval (the frequency between successive fire events) was historically less than 35 years. Frequent low-severity fires maintained the following key compositional and structural elements in these forests: fire-resistant and shade-intolerant species in the overstorey and understorey; groups of trees with interlocking crowns; scattered individual trees; open grass-forb-shrub interspaces; snags, logs and woody debris; and variation in arrangements of these elements in space and time.

As a result of past forest management, however, especially fire suppression, logging and livestock grazing, these frequent-fire forests have become progressively more susceptible to large-scale severe wildfires and insect pest and disease epidemics. The increasing intensity and geographic scale of these disturbances are the consequences of changes in the vegetation composition and the horizontal and vertical structure of these forests, which diverge from the historical conditions in which the native fauna and flora evolved. Changes include a shift away from shade-intolerant and fire-resistant species to shade-tolerant and fire-sensitive species, large increases in tree densities, reduced structural and spatial heterogeneity of vegetation, losses of small grass-forb-shrub openings, reduction in numbers of old trees, and a reduced diversity and quality of plant and animal habitats, leading to degraded food webs (Reynolds *et al*., 2013).

Climate change models project a warmer and drier environment and extended periods of drought for the southwestern United States of America. Given the unnatural current high tree densities and contiguous tree canopies (lack of small grass and forb openings) in these dry forest types, more catastrophic high-severity forest fires can be expected. Further loss of these forests will have a detrimental impact on the viability of apex predators such as the northern goshawk (*Accipiter gentilis*).

Restoration efforts can be guided by a conservation strategy that addresses all aspects of the forest species: its life history, physical and biological factors that limit its populations, the members (e.g. food species) in its ecological community, and the spatial and temporal dynamics of the ecosystems it occupies. Because they are often sensitive to changes in their environment, apex predators are natural candidates for a conservation strategy. Restoring the natural species composition and structure of these forests will allow for the return of more manageable low-severity fire, thereby keeping them alive by preserving their adaptive capacities, making them more resistant, resilient and responsive to current and future disturbances and climates.

Ponderosa pine actively managed with prescribed fire, Gila National Forest, New Mexico, United States of America

temperatures cause reduced snowpack and earlier snow melts as well as pronounced drought conditions, increased fire activity, and more devastating insect pest and disease infestations affecting the forest communities. The ecological consequences can range from complete stand replacement and die-off to altered plant community composition and stress on individual species (see Boxes 13 and 14). The drylands also face challenges associated with growing human populations, such as encroaching land development and increased pressure on water resources; more frequent and intense drought conditions; and invasion of non-native plant species (Perry *et al.*, 2012).

BOX 14

The disappearing sagebrush habitats of western North America

One of the greatest challenges to resource managers throughout western North America is the accelerated loss of sagebrush (*Artemisia* spp.) habitats. Sagebrush habitats occupied an estimated 63 million hectares in western North America prior to Euro-American settlement, but very little now exists undisturbed (West, 1996; Miller and Eddleman, 2001). For example, an estimated 50 to 60 percent of the native sagebrush steppe has been affected by, or totally replaced by, invasive species. These circumstances make sagebrush habitats among the most imperilled ecosystems in North America (Knick *et al.*, 2003), mostly because of human activities (West and Young, 2000). Factors such as conversion to conifer woodlands, exotic annual and introduced grasses, agricultural development, offroad vehicle use and energy development, especially oil, gas, and wind-driven turbines, have contributed to fragmentation and degradation of sagebrush habitats and reduction of wildlife populations. Perhaps the most significant factor leading to loss of sagebrush habitat is the decreasing fire return interval and increasing fire intensities caused by invasive annual grasses such as cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caput-medusae*).

Pyke *et al.* (2014) suggest that arid sagebrush ecosystems lacking resilience to disturbances or resistance to invasive annual species following prescribed fire or wildfire result in alternative successional states. These successional states typically comprise invasive annual species, which in turn lead to even greater fire risk, and the cycle continues. Invasive annual grasses also negatively affect the productivity and survival of native plant communities, affecting the associated native wildlife. Between 1985 and 1994, on lands managed by the United States Department of the Interior's Bureau of Land Management, the area of invasive annual grasses together with other invasive species such as knapweed (*Centaurea* spp.) and leafy spurge (*Euphorbia esula*) increased from 1.1 million to 3.2 million hectares (Knick *et al.*, 2003). Estimated rates of spread for noxious weeds is approximately 931 ha per day on lands managed by the Bureau of Land Management, and 1 862 ha per day on all publicly owned lands in the western United States of America (Knick *et al.*, 2003). This challenging situation is probably reflective of other similar situations in other vegetation types around the globe. As suggested 40 years ago by Braun *et al.* (1976), efforts to make this issue known and to convince society of the intrinsic value of these sagebrush habitats may be the most effective conservation tool.

*Sagebrush environments are critical for the survival of the greater sage grouse (*Centrocercus urophasianus*)*

DISTRIBUTION OF FORESTS AND OTHER LAND USES

Other land, which includes grassland, agricultural land, built-up areas and barren land, is the most represented class in the drylands of North and Central America and the Caribbean, with around 314 million hectares (45 percent of drylands) (Figure 173). Forest follows, with 206 million hectares (30 percent of total dryland area). Other wooded land covers 22 percent of the region's drylands or 156 million hectares.

FIGURE 173

Distribution of land uses in the drylands of North and Central America and the Caribbean ('000 ha)

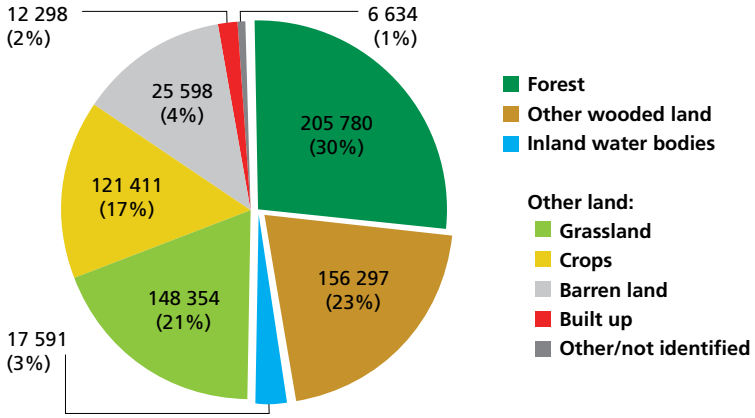
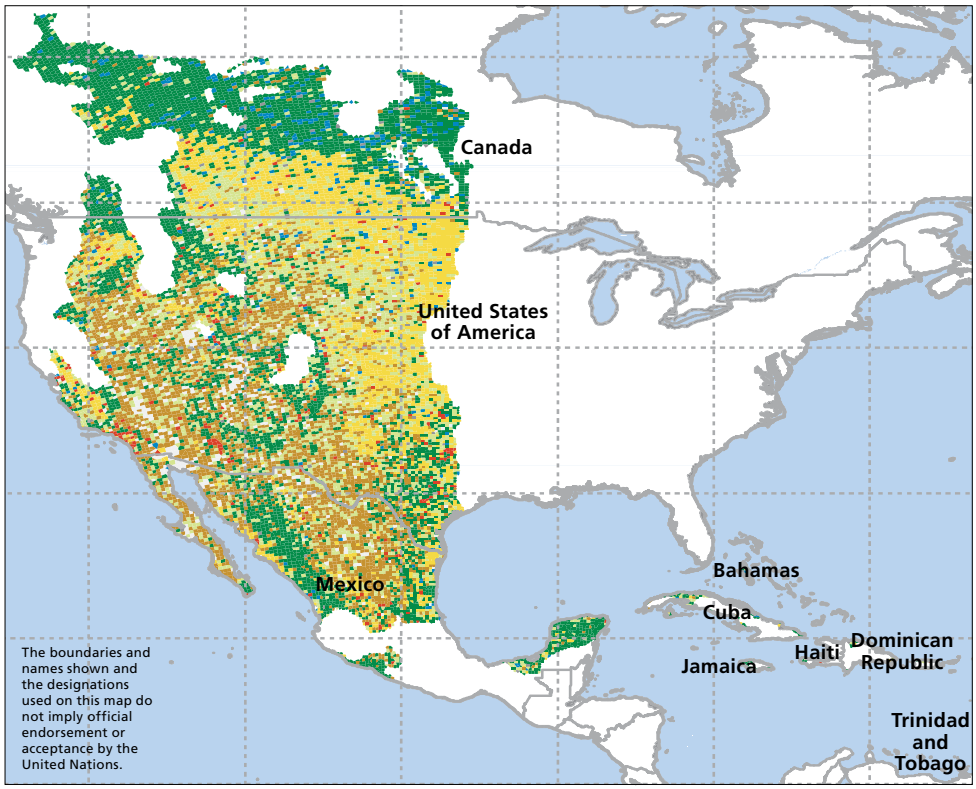


FIGURE 174

Main land uses in the drylands of North and Central America and the Caribbean



Source: UN Maps, 2019

FIGURE 175

Distribution of land uses by aridity zone

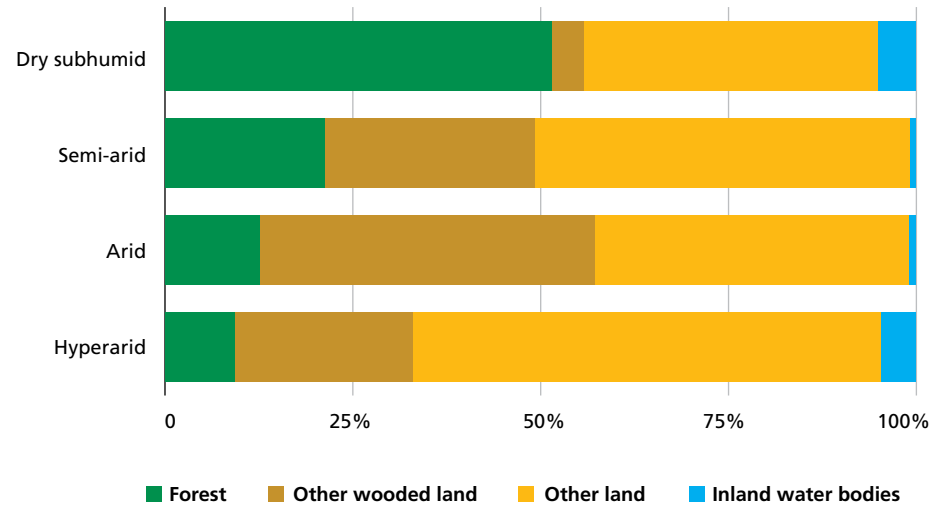


FIGURE 176

Distribution of dryland forest by aridity zone ('000 ha)

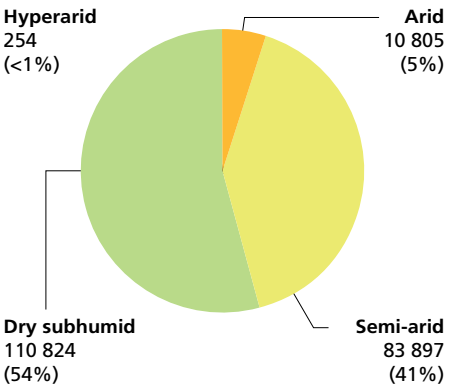
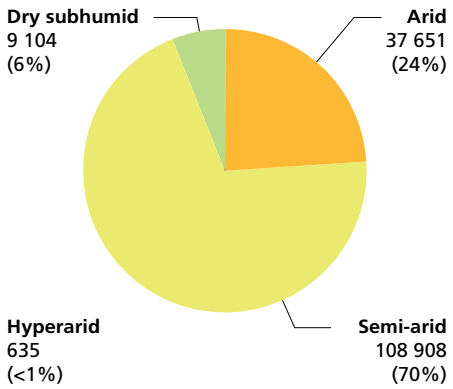


FIGURE 177

Distribution of other wooded land by aridity zone ('000 ha)



Dryland forest is mainly located in the northern part of the region and the Yucatan Peninsula (Figure 174). The northern forests are primarily located in the Rocky Mountains, which stretch more than 4 800 km from the state of New Mexico in the south to the boreal forests of Canada, which are past the northern end of the dryland area.

The distribution of land uses or land cover varies substantially by aridity zone. The proportion covered by forest increases from 10 percent in the hyperarid zone to a majority, 52 percent, in the dry subhumid zone (Figure 175). Other wooded land exhibits the opposite distribution pattern: it makes up 24 percent of the hyperarid zone and only 4 percent of the dry subhumid zone. The proportion of other land is more equally distributed; it is the dominant category in the hyperarid zone, where it accounts for 62 percent of the land, and covers 42, 50 and 39 percent in the arid, semi-arid and dry subhumid zones, respectively.

More than half of the forest (54 percent) is located in the dry subhumid zone, while 41 percent is in the semi-arid zone (Figure 176). A small portion (5 percent) is in the arid zone, and no forest was surveyed in the hyperarid zone.

Most of the other wooded land is concentrated in the semi-arid zone (70 percent), with the remaining area divided between the arid (24 percent) and dry subhumid (6 percent) zones (Figure 177).

VEGETATION IN FORESTS AND OTHER WOODED LAND

The assessment indicated that the dryland forest of North and Central America and the Caribbean is 40 percent coniferous, 38 percent broadleaved and 21 percent mixed coniferous and broadleaved (Table 53, Figure 178; see also Box 15).

Other wooded land is mainly composed of grassland with shrubs (71 percent) or grassland with trees and shrubs combined (28 percent) (Table 54).

TABLE 53
Type of forest vegetation by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest										
Broadleaved	127	50	8 418	78	41 845	50	28 127	25	78 517	38
of which riparian	127	50	199	2	1 903	2	3 580	3	5 809	3
Coniferous	0	0	1 127	10	27 888	33	52 677	48	81 692	40
Mixed broadleaved and coniferous	0	0	862	8	12 837	15	29 300	26	42 999	21
Other/not identified	127	50	199	2	664	1	322	0	1 312	1
Planted forest	0	0	199	2	664	1	398	0	1 261	1
Total	**254**	**100**	**10 805**	**100**	**83 897**	**100**	**110 824**	**100**	**205 780**	**100**

BOX 15

Forest and woodland vegetation types in the drylands of North and Central America and the Caribbean

Pine, spruce, fir and aspen dominate the montane-subalpine elevational zones of the Rocky Mountains in the northern latitudes, and dryer ponderosa pine and mixed conifer forest types in the montane zones of the southwestern United States of America and Mexico. Even dryer forest types of pinyon pine, juniper and oak cover the lower elevations, intruding into the valleys and southwestern desert lands. Recent dynamics and shifting forest types within the Rocky Mountains mainly reflect fire activity and suppression, drought conditions and insect pest infestations, magnified by the changing climate.

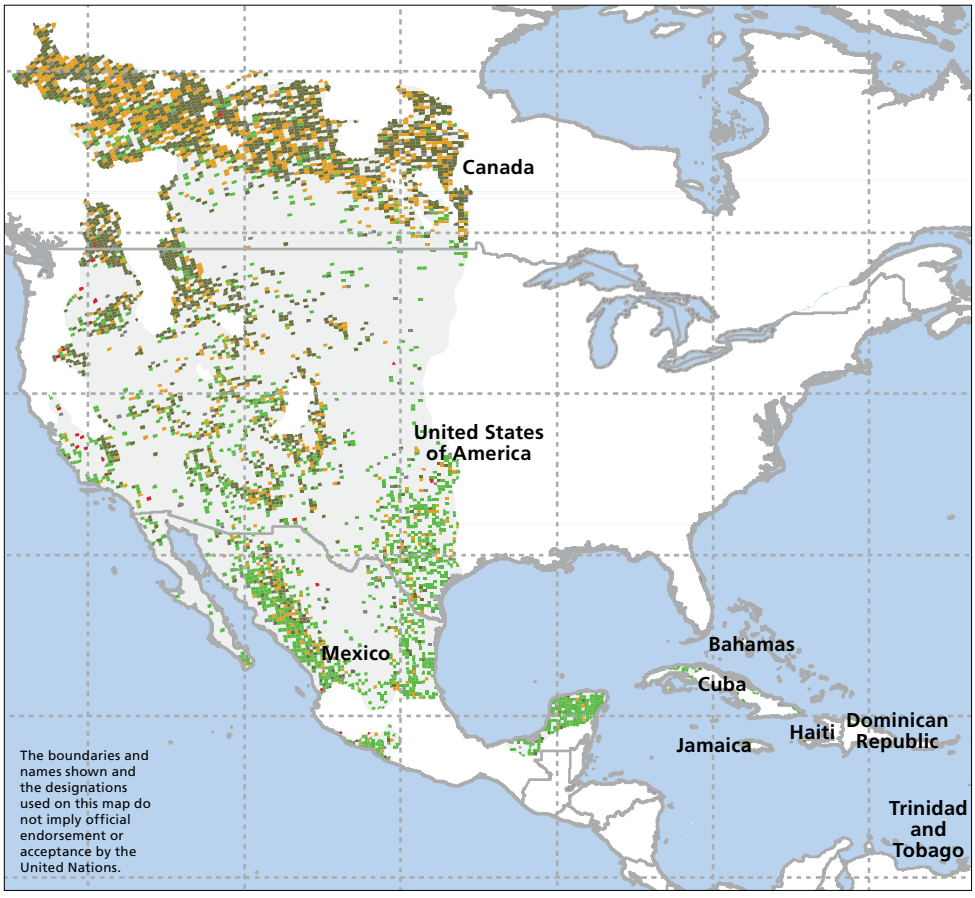
The boreal or taiga forests of Canada are at the most northern extreme of the drylands region and are largely made up of closed coniferous stands intermixed with lakes, rivers and wetlands. Logging, mining and other human activities have had a strong impact on these forests, along with drought, fires and insect pest outbreaks.

Woodlands in the drylands of North and Central America and the Caribbean are dominated by Chaparral and Matorral vegetation types, characterized by woody and drought-hardy shrubs. These ecosystems include California sage scrub, found on south-facing slopes of coastal and inland mountains from southern California into Baja California; Colorado Plateau shrublands, dominated by what is often called a pygmy forest of pinyon pine (*Pinus edulis*) and several species of juniper (*Juniperus* spp.); and the Central Mexican Matorral, situated (as the name indicates) in central Mexico. They are characterized by a distinctive richness in avifauna, herpetofauna and flora and are considered a high-priority area for the conservation of succulents, as well as having several Important Bird Areas.

TABLE 54
Main vegetation types in other wooded land by aridity zone

Vegetation type	Hyperarid		Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	508	80	29 763	79	74 500	68	5 524	61	110 295	71
Grassland with trees and shrubs	127	20	7 292	19	32 372	30	3 314	36	43 105	28
Shrubland	0	0	0	0	221	0	44	0	266	0
Other/not identified	0	0	597	2	1 815	2	221	2	2 632	2
Total	**635**	**100**	**37 651**	**100**	**108 908**	**100**	**9 104**	**100**	**156 297**	**100**

FIGURE 178
Distribution of dryland forest by subtypes



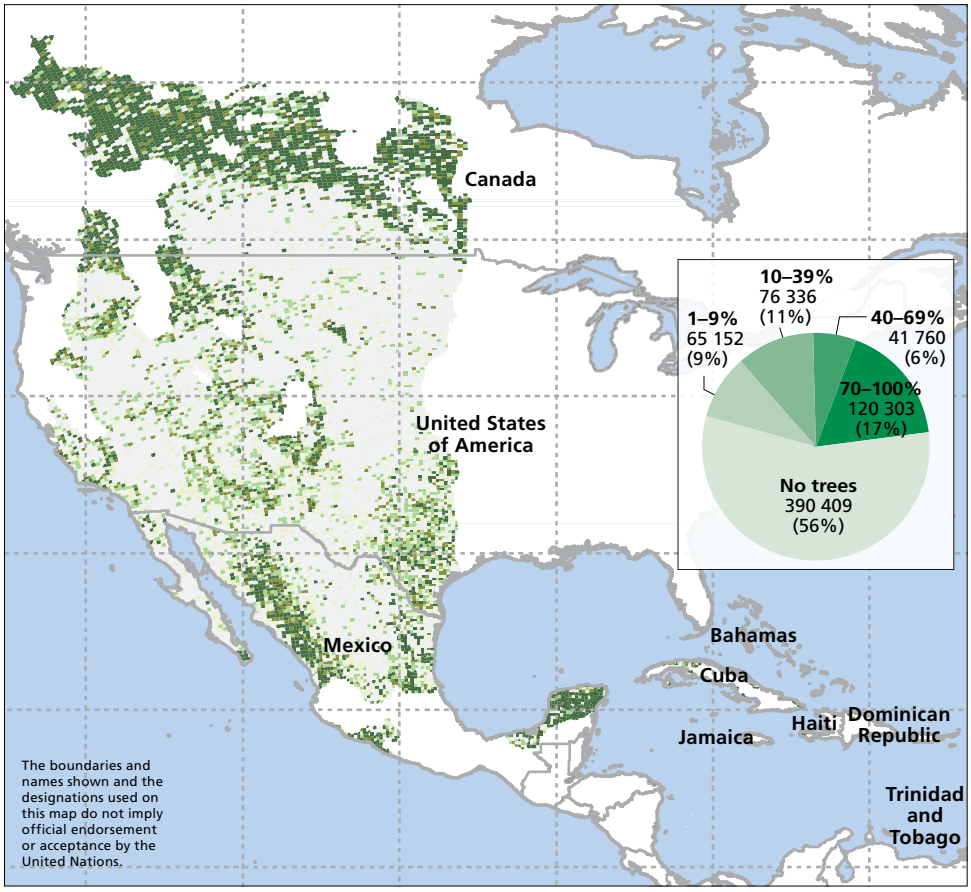
Source: UN Maps, 2019

TREE CANOPY COVER

In total, 44 percent of this dryland region has trees (304 million hectares) (Figure 179). Average tree canopy cover is 68 percent, and forests are relatively dense in all aridity zones, with average cover ranging from 50 percent in the hyperarid zone to 78 percent in the dry subhumid zone (Table 55).

FIGURE 179

Distribution of canopy cover in the drylands of North and Central America and the Caribbean, by tree cover range ('000 ha)



Source: UN Maps, 2019

An estimated 58 percent of the total dryland forest area in North and Central America and the Caribbean has a dense tree canopy cover of more than 70 percent, while slightly more than three-quarters of the total is closed forest with a tree canopy cover above 40 percent (Figure 180). An additional 24 percent has cover ranging from 10 to 39 percent. Less than 1 percent has tree coverage below 9 percent.

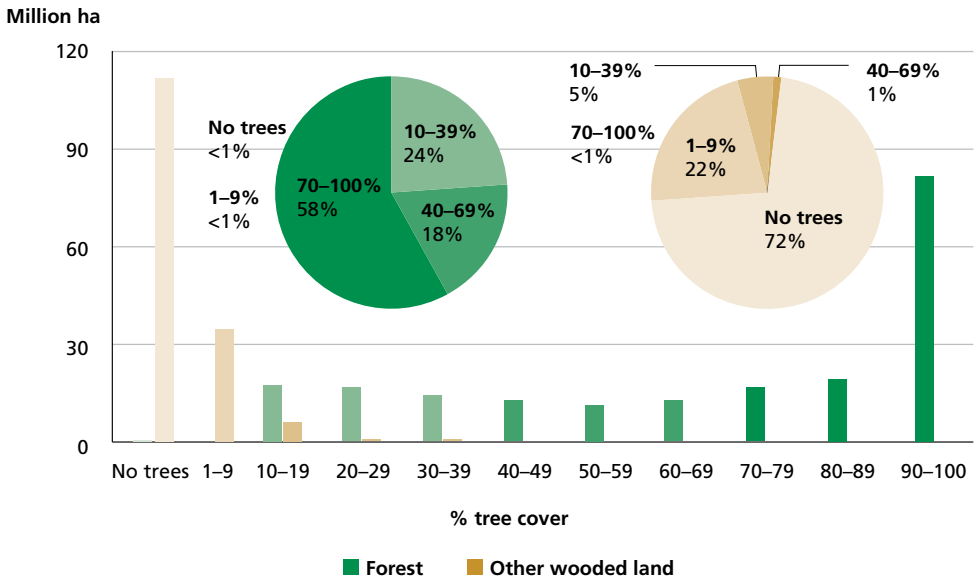
The majority of other wooded land – 72 percent – has no tree cover, while 22 percent has tree cover of 1 to 9 percent and only 5 percent has tree cover of 10 to 39 percent (Figure 180).

TABLE 55

Average tree canopy cover in the drylands of North and Central America and the Caribbean, by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	50	62	56	78	**68**
Other wooded land	1	2	3	4	**3**
Other land	1	1	2	4	**3**
Inland water bodies	0	0	0	0	**0**
All lands	**6**	**9**	**14**	**42**	**22**

FIGURE 180
Tree canopy cover in forest and other wooded land



SHRUB COVER

Shrubs cover 73 percent of the drylands in North and Central America and the Caribbean, or 85 million hectares (Figure 181).

Shrub coverage is 48 percent on average in other wooded land. Average shrub cover is fairly uniform in the arid, semi-arid and dry subhumid zones (46 to 48 percent), and lower in the hyperarid zone (17 percent) (Table 56).

One-quarter of other wooded land has very dense and continuous shrub cover ranging from 70 to 100 percent (Figure 182). Most other wooded land, 54 percent, has dense shrub cover ranging from 40 to 100 percent, while the other 43 percent is sparsely covered with shrubs (coverage below 40 percent, mostly in the range from 10 to 39 percent).

Most forest has little shrub cover (or shrubs could not be detected because of dense tree canopy cover). The average shrub cover in forest is estimated to be 7 percent, with the highest value in the arid zone (13 percent) (Table 56). An estimated 74 percent of forest has no shrub coverage, and 15 percent has coverage of between 10 and 39 percent (Figure 182).

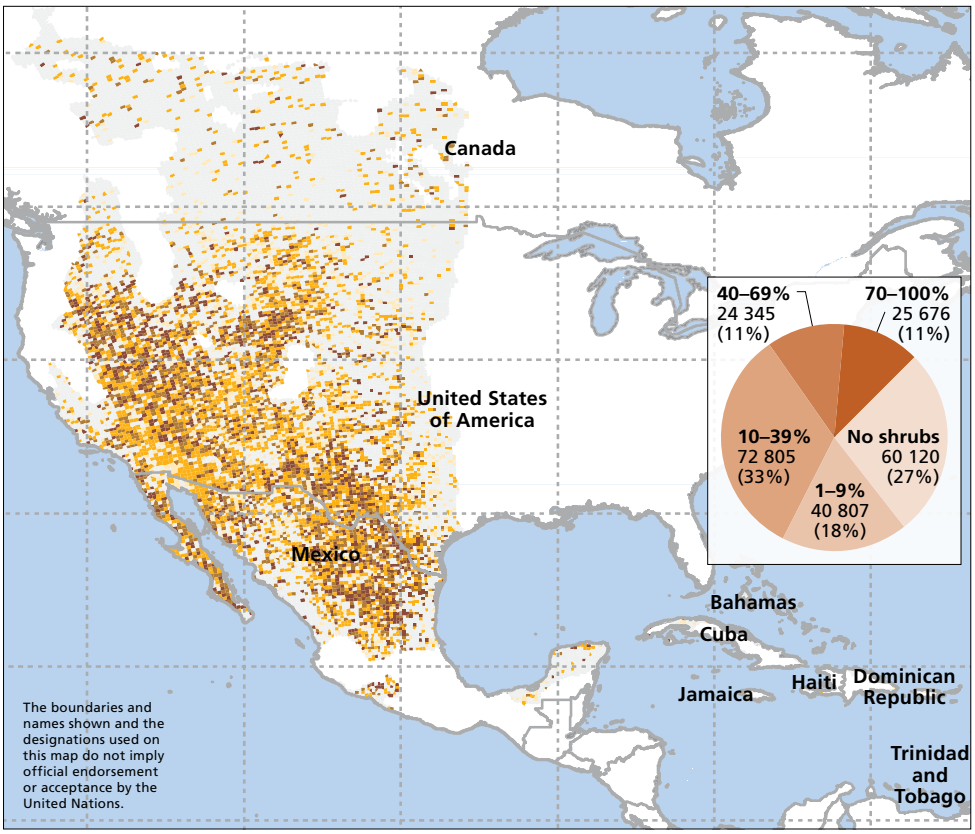
Most of the other land has no shrubs (68 percent or 213 million hectares) or little shrub cover: 12 percent (38 million hectares) has shrub cover ranging from 1 to 9 percent (Figure 183).

TABLE 56
Average shrub cover by land use and aridity zone (%)

Land use	Hyperarid	Arid	Semi-arid	Dry subhumid	All zones
Forest	5	13	10	3	**7**
Other wooded land	17	47	48	46	**48**
Other land	9	19	11	3	**10**
Inland water bodies	0	7	4	1	**2**
All lands	**10**	**31**	**21**	**5**	**17**

FIGURE 181

Shrub cover in the drylands of North and Central America and the Caribbean ('000 ha)



Source: UN Maps, 2019

FIGURE 182

Shrub cover in forest and other wooded land

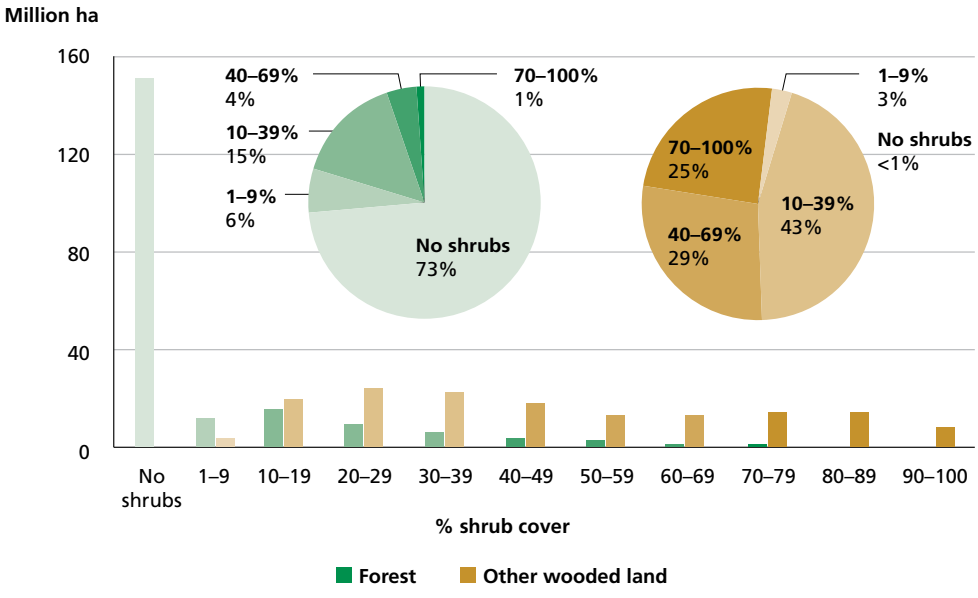
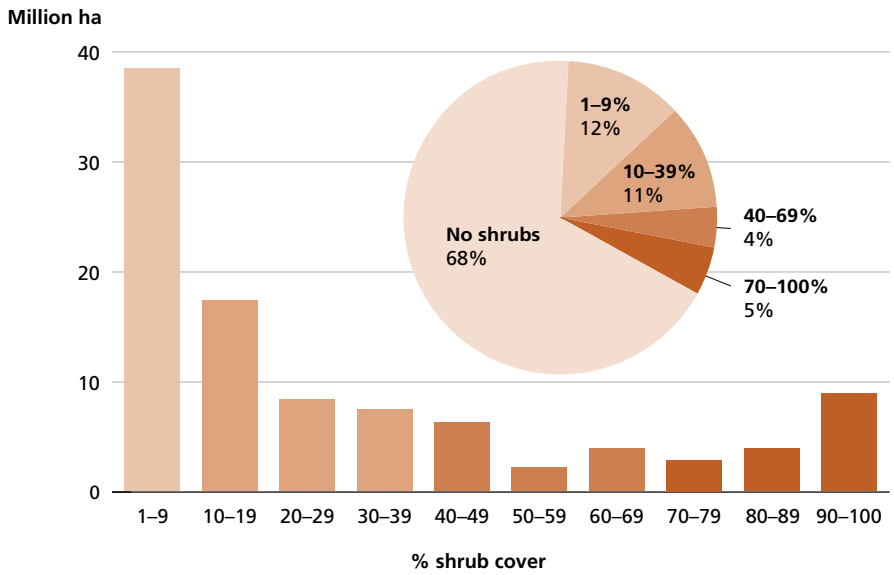


FIGURE 183

Shrub cover in other land



OTHER LAND

Of the 314 million hectares of other land in the region, most – 62 percent – is in the semi-arid zone, while 26 percent is in the dry subhumid zone and 11 percent in the arid zone (Figure 184). Less than 1 percent of other land is in the hyperarid zone.

The largest category of other land is grassland or herbaceous savannah (47 percent of the total other land area, or 148 million hectares) (Figure 185), distributed primarily in the semi-arid zone (102 million hectares), followed by the dry subhumid zone (30 million hectares) (Table 57, Figure 186).

Crops represent 39 percent of other land (121 million hectares), mainly found in the semi-arid zone (68 million hectares) and in the dry subhumid (47 million hectares). Most of them are perennial crops (mainly palms and orchards) (69 million hectares). Croplands also include 17 million hectares of irrigated crops and 20 million hectares of non-irrigated crops (Table 57, Figure 187).

FIGURE 184

Distribution of other land by aridity zone ('000 ha)

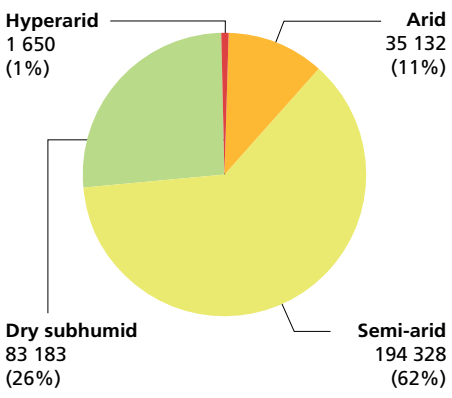


FIGURE 185

Distribution of other land by land use ('000 ha)

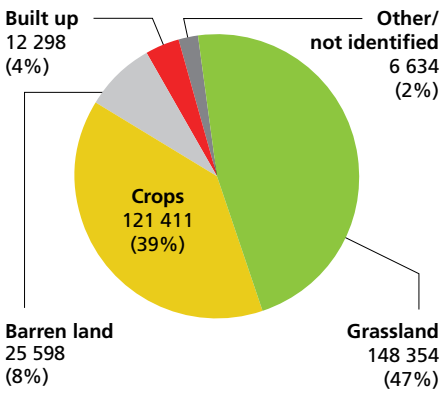
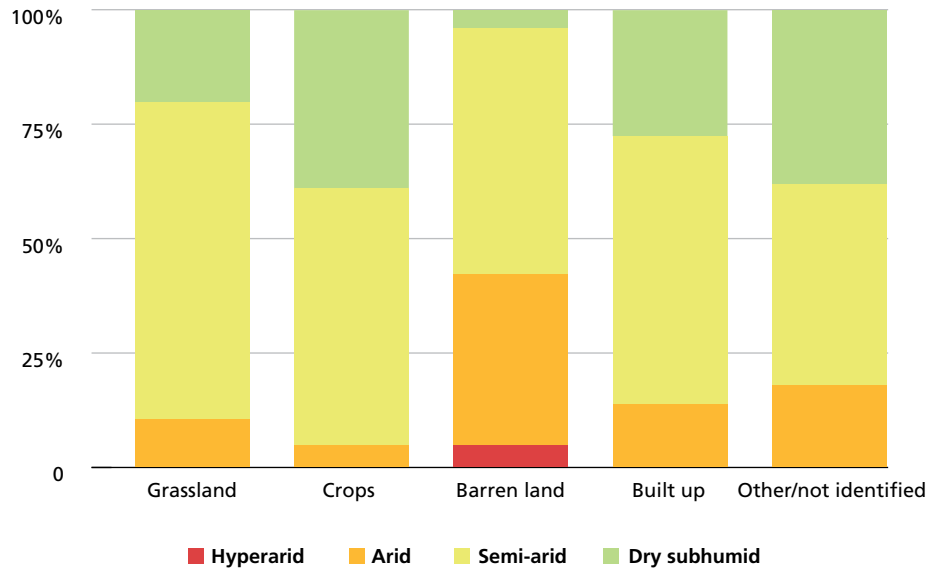


TABLE 57
Other land distribution by main vegetation/land-use type and aridity zone ('000 ha)

Vegetation/land use	Hyperarid	Arid	Semi-arid	Dry subhumid	Total	%
Crops	254	5 966	68 391	46 800	121 411	100
Irrigated crops	254	1 525	11 199	4 331	17 309	14
Non-irrigated cropland	0	133	10 934	9 148	20 214	17
Perennial crops (palms, orchards, others)	0	3 580	37 051	28 460	69 090	57
Cropland fallow	0	729	9 207	4 861	14 798	12
Grass	127	16 572	102 034	29 622	148 354	100
Barren land	1 269	9 678	13 723	928	25 598	100
Rock or stone	127	2 453	4 382	398	7 360	29
Sand and dunes	1 142	7 159	9 163	442	17 907	70
Snow and glaciers	0	66	177	88	332	1
Built up	0	1 723	7 260	3 314	12 298	100
Villages and urban settlements	0	1 127	4 604	1 989	7 719	63
Infrastructure	0	597	2 567	1 282	4 446	36
Mining	0	0	89	44	133	1

FIGURE 186
Land use in other land by aridity zone



Barren lands represent 8 percent of other land (26 million hectares), located mainly in the semi-arid (14 million hectares) and arid (10 million hectares) zones.

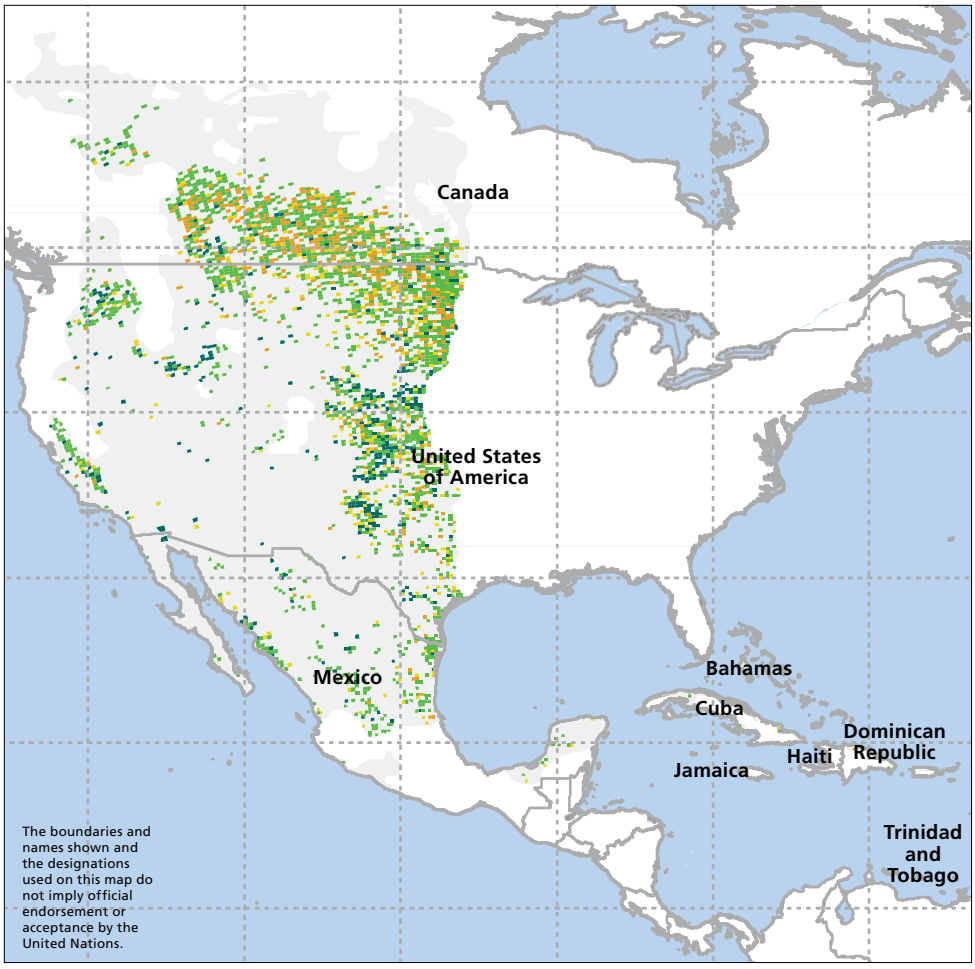
Built-up areas occupy 4 percent (12 million hectares) of other land and are predominantly found in the semi-arid (7 million hectares) and dry subhumid (3 million hectares) zones.

TREES OUTSIDE FOREST

Trees outside forest, which are defined as the trees in other land, are present on 52 million hectares (17 percent of other land). Trees with a canopy cover of more than 10 percent are present on 23 million hectares or 7 percent of other land, while tree canopy cover

FIGURE 187

Distribution of crop types



Source: UN Maps, 2019

Mexico

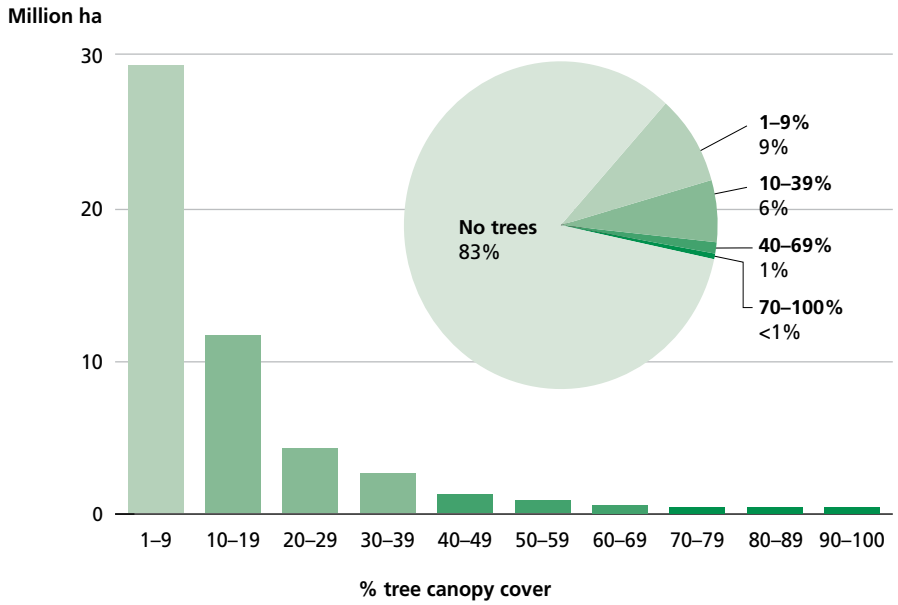
is below 10 percent on the remaining 93 percent of other land (291 million hectares) (Figure 188). An estimated 262 million hectares have no trees.

Other land has 3 percent tree canopy cover on average, here also with an increasing gradient as aridity decreases (from 1 percent in the hyperarid zone to 4 percent in the dry subhumid zone) (see Table 55).

Approximately 62 percent of land classified as built up has crown cover.

FIGURE 188

Tree canopy cover in other land



Europe

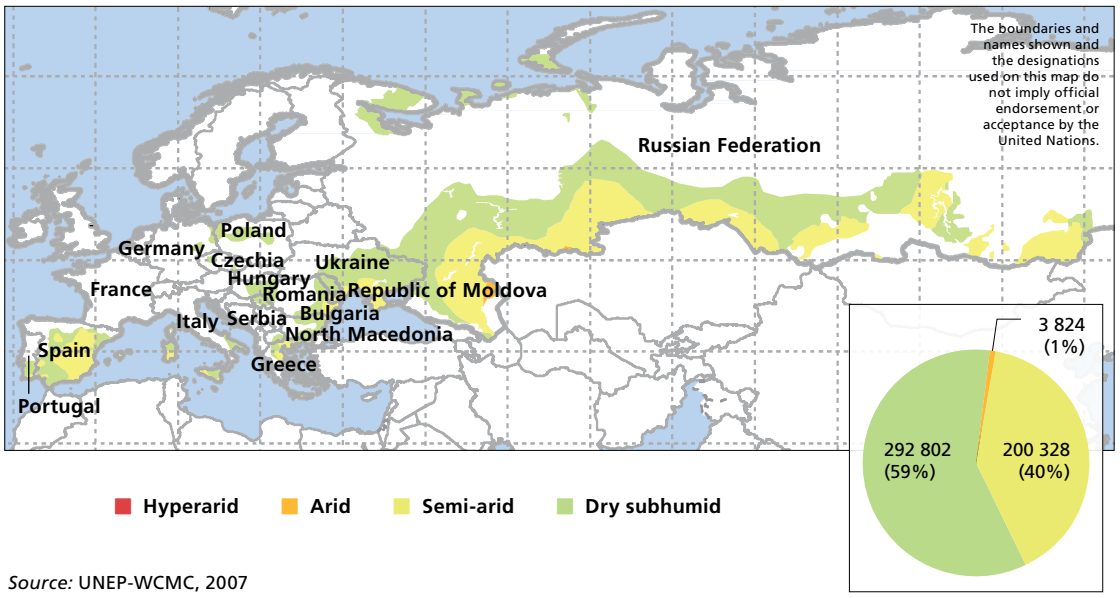
Steppe habitat, Russian Federation

KEY FINDINGS

- The drylands of Europe cover almost 497 million hectares, representing 20 percent of the region's total land area and 8 percent of the global drylands.
- The region's drylands contain 179 million hectares of forest, which is 16 percent of the global dryland forest area and 4.5 percent of the global forest area, estimated at approximately 4 billion hectares.
- Other land is the largest land use class, constituting 59 percent of the region's drylands. It is characterized mainly by crops and grassland (57 and 33 percent of other land, respectively).
- Forest is the second most common land use, accounting for 36 percent of dryland area, while other wooded land accounts for about 2 percent.
- Forest follows a clear increasing gradient with decreasing aridity. The dry subhumid zone has the most forest (65 percent), followed by the semi-arid zone (35 percent). Less than 1 percent of forest is in the arid zone.
- The vast majority of the dryland forest in this region, 92 percent, has a closed canopy, with coverage greater than 40 percent.
- Trees outside forest are present on 57 million hectares (19 percent of other land). An estimated 63 percent of the built-up area (7 million hectares) has tree cover.
- In total, considering all land uses, there are no trees on 51 percent of European drylands (254 million hectares).

FIGURE 189

Distribution of drylands in Europe by aridity zone ('000 ha)



Source: UNEP-WCMC, 2007

The total area of drylands in the European region comprises 497 million hectares, of which 436 million hectares (88 percent) can be found in the Eastern Europe subregion, 58 million hectares (almost 12 percent) in Southern Europe and 2 million hectares (less than 1 percent) in Western Europe (Figure 189). The vast majority of the Eastern European drylands, stretching from Hungary in the west to the far east of the Russian Federation, form part of the dryland belt of Northern Eurasia, the largest contiguous dryland on Earth, which spans the territory of 16 countries (Groisman *et al.*, 2018). Tundra drylands in the far north of the Russian Federation cover 8 million hectares (almost 2 percent of Europe's dryland area). Southern Europe's drylands are situated in the Mediterranean Basin. The drylands of Western Europe are more scattered. Europe accounts for 8 percent of worldwide drylands.

The dry subhumid zone is the largest area by far, covering 293 million hectares or 59 percent of Europe's drylands. The semi-arid zone covers 200 million hectares (40 percent) and the arid category occupies 4 million hectares (1 percent). There is a very small area of hyperarid zone in the Mediterranean Basin, but this zone can be considered insignificant in European drylands.

The assessment of the drylands of this region is based on photo interpretation of 14 958 plots, conducted by the Department of Forest Engineering of the Technical University of Madrid, Spain, in July 2015.

BACKGROUND

Climate

The climate of the Mediterranean Basin is mild and wet during the winter and hot and dry during the summer. Precipitation during the winter is affected by the North Atlantic Oscillation over the western areas of the Mediterranean and by the East Atlantic Oscillation and other patterns over the northern and eastern areas. In the summer, high pressure and descending motions dominate over the region and lead to dry conditions. Some climatic anomalies in the Mediterranean Basin have been reported in the past decades, especially in the warm season. Particular local changes are contradictory, but it is generally agreed that Mediterranean areas are at risk of increased water stress

for agriculture and natural ecosystems and are vulnerable to desertification. Even a relatively small climatic change could begin to transform the Mediterranean drylands from semi-arid to arid, or non-drylands into drylands (Safriel, 2009).

The climate of the dryland belt of northern Eurasia depends primarily on westerlies that move moisture from the North Atlantic Ocean into the Eurasian interior. Disproportionate warming at high latitudes and in the Arctic interferes with the circulation of the westerlies, resulting in the delivery of less moisture to most of northern Eurasia and more frequent atmospheric blocking. These changes in atmospheric circulation lead to unusually variable climatic conditions over all of northern Eurasia in the cold season, and to prolonged periods of days with or without rain in the warm season. Since the mid-1960s, increases in the surface air temperature, the retreat of the cryosphere and changes in precipitation have led to a generalized depletion of available water resources over most of the dryland belt. In the past three decades, warming across the length of the dryland belt has exaggerated dry weather conditions (Groisman *et al.*, 2018).

Trends and challenges

Mediterranean species are adapted to tolerate long, hot summers with little precipitation (UNEP-WCMC, 2007). Overall, the area of Mediterranean forests in the region did not change significantly between 1990 and 2005 (FAO & Plan Bleu, 2013). The main trend in the forests of the northern Mediterranean is unmanaged biomass accumulation.

Factors affecting the northern Eurasian dryland belt include changes in land use such as expansion of croplands and cities, rapid institutional shifts, climatic changes and natural disturbances such as wildfires, floods and dust storms. Furthermore, large-scale unregulated grazing has caused large reductions in biodiversity and productivity and led to degradation and desertification, even in historically productive and stable pasture systems. To meet the challenges to dryland pasture systems from both human activities and climatic changes, feed efficiency must be enhanced in a sustainable way (Groisman *et al.*, 2018).

In general, forest coverage in the dryland belt is not expected to change, because the tundra is likely to vanish and the forest can be expected to shift into the current tundra area. Forest in a dry climate could decrease by about 12.5 percent (Groisman *et al.*, 2018).

DISTRIBUTION OF FORESTS AND OTHER LAND USES

Other land, which includes grassland, agricultural land, built-up areas and barren land, is the most represented class in Europe's drylands, with around 295 million hectares (59 percent of the dryland area) (Figures 190 and 191). Forest follows, with 179 million hectares (36 percent of the total dryland area), of which 86 percent is in the dryland belt of northern Eurasia. Other wooded land covers 2 percent of European drylands, or 11 million hectares.

Land use varies substantially by aridity zone. The proportion of forests increases from 3 percent in the arid zone to 40 percent in the dry subhumid zone (Figure 192). Other wooded land has a relatively low share in all aridity zones: It makes up 2 percent of the area in both the dry subhumid and semi-arid zones and 8 percent in the arid zone. Other land dominates in all aridity zones, from 56 percent in the dry subhumid zone, to 64 percent in the semi-arid zone, to 85 percent in the arid zone.

Of the total forest in Europe's drylands, about two-thirds (65 percent) is located in the dry subhumid zone, and the other 35 percent is located in the semi-arid zone (Figure 193). Virtually no forest was identified in the arid zone.

Similarly, the majority of other wooded land (55 percent) is concentrated in the dry subhumid zone and most of the rest (42 percent) is in the semi-arid zone (Figure 194). Only 3 percent is in the arid zone.

FIGURE 190

Distribution of land uses in Europe's drylands ('000 ha)

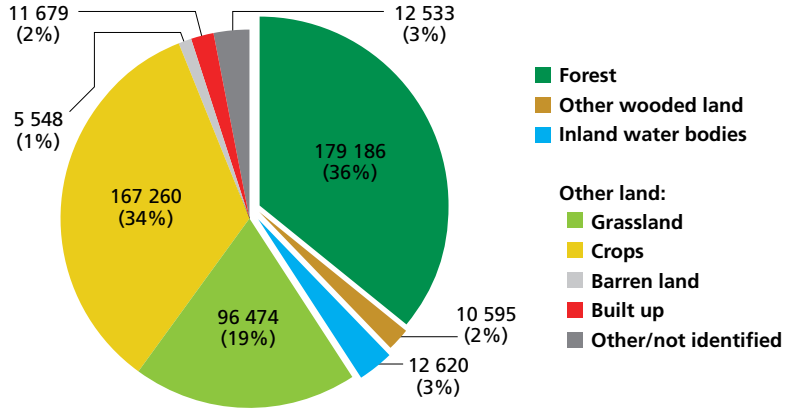
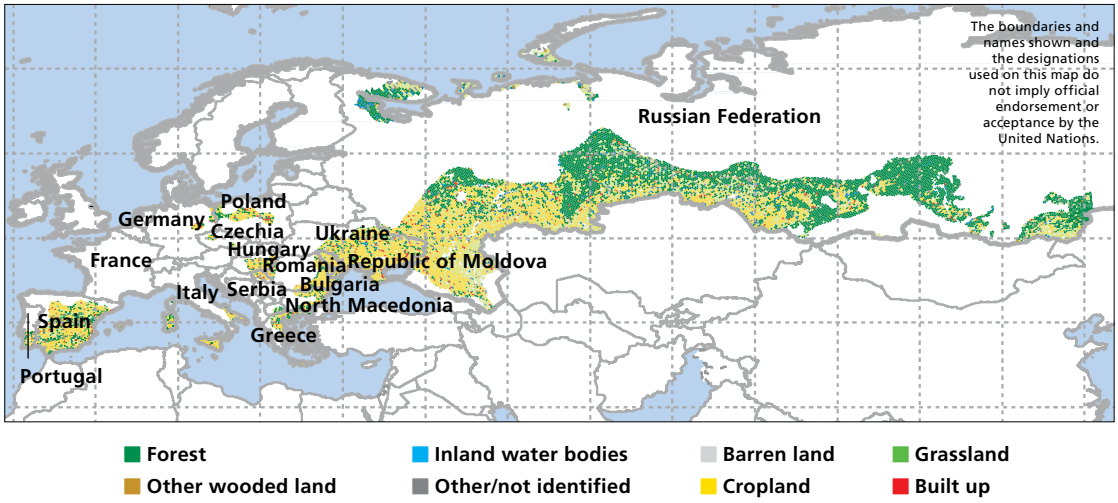


FIGURE 191

Main land uses in Europe's drylands



Source: UN Maps, 2019

FIGURE 192

Distribution of land uses by aridity zone

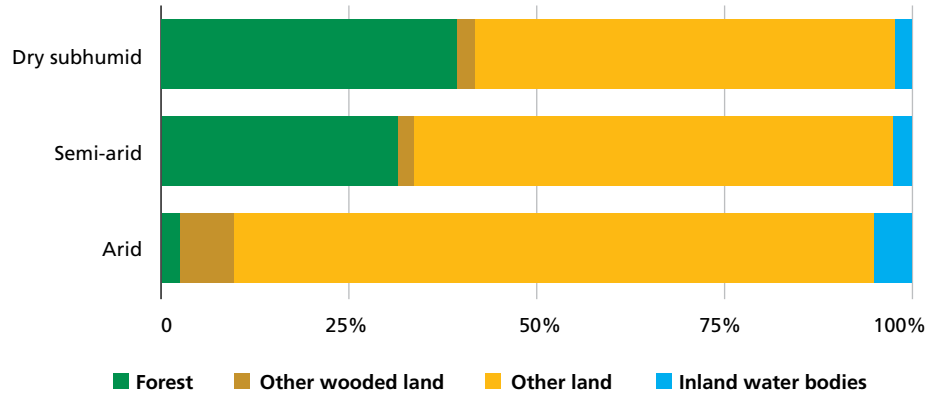


FIGURE 193

Distribution of dryland forest by aridity zone ('000 ha)

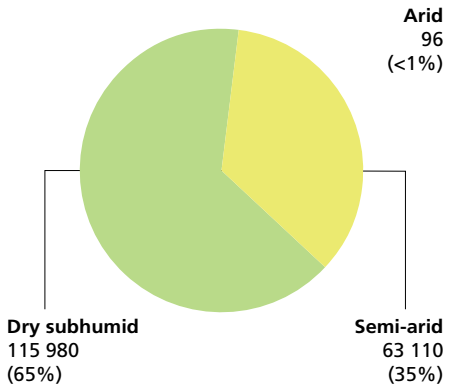
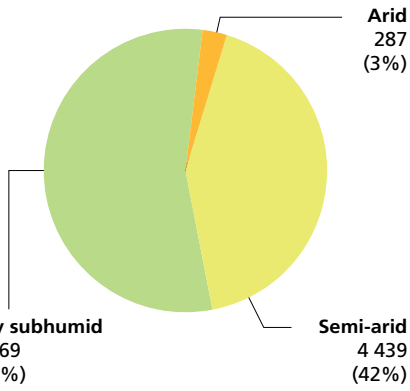


FIGURE 194

Distribution of other wooded land by aridity zone ('000 ha)



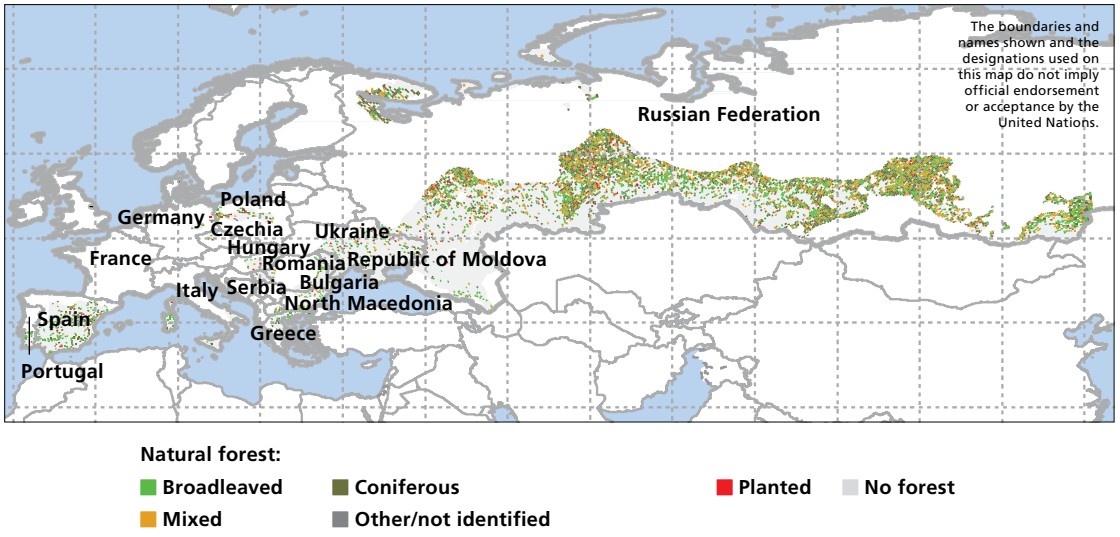
VEGETATION IN FORESTS AND OTHER WOODED LAND

An estimated 38 percent of Europe's dryland forests are broadleaved, while 32 percent are coniferous (Figure 195, Table 58). Mixed forest types account for 26 percent of the forest.

Other wooded land is mainly composed of grassland with trees and shrubs (44 percent) and grassland with shrubs (40 percent) (Table 59).

FIGURE 195

Distribution of dryland forest by subtypes



Source: UN Maps, 2019

TABLE 58
Type of forest vegetation by aridity zone

Vegetation type	Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Natural forest								
Broadleaved	0	0	23 587	37	44 131	38	67 718	38
of which riparian	0	0	530	1	1 857	2	2 387	1
Coniferous	96	100	20 705	33	36 870	32	57 671	32
Mixed broadleaved and coniferous	0	0	16 001	25	30 238	26	46 240	26
Other/not identified	0	0	1 226	2	1 326	1	2 552	1
Planted forest	0	0	1 590	3	3 415	3	5 005	3
Total	**96**	**100**	**63 110**	**100**	**115 980**	**100**	**179 186**	**100**

TABLE 59
Main vegetation types in other wooded land by aridity zone

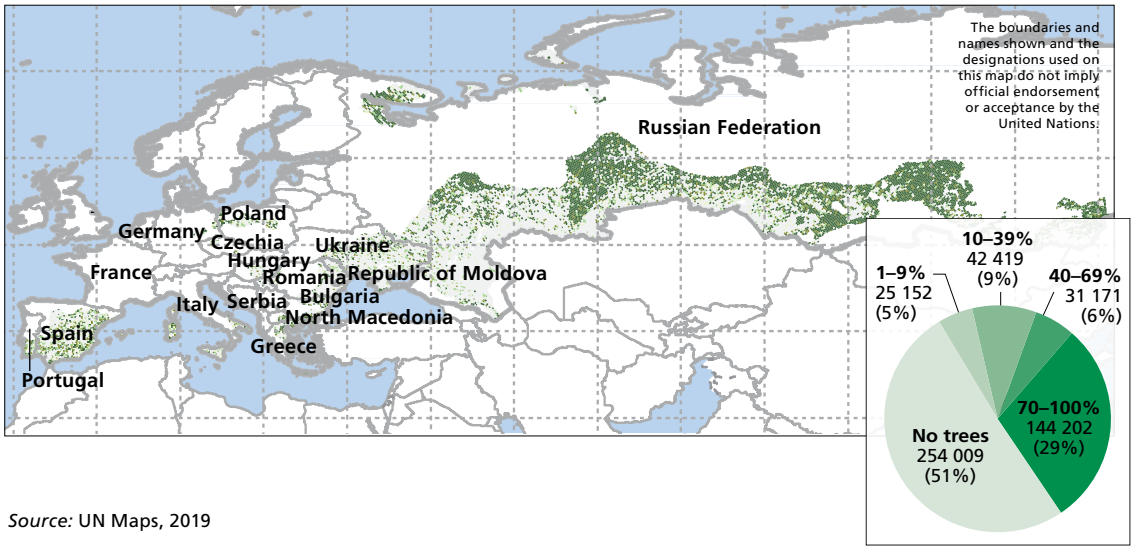
Vegetation type	Arid		Semi-arid		Dry subhumid		Total	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Grassland with shrubs	191	67	1 789	40	2 221	38	4 202	40
Grassland with trees and shrubs	48	17	1 921	43	2 719	46	4 688	44
Shrubland	0	0	0	0	0	0	0	0
Other/not identified	48	17	729	16	928	16	1 705	16
Total	**287**	**100**	**4 439**	**100**	**5 869**	**100**	**10 595**	**100**

TREE CANOPY COVER

In total, 49 percent of this dryland region has trees (243 million hectares), while there are no trees on 254 million hectares (Figure 196).

The average canopy cover in Europe's dryland forest is dense (82 percent), particularly in the dry subhumid and semi-arid zones (83 and 81 percent, respectively) (Table 60).

FIGURE 196
Distribution of tree canopy cover in Europe's drylands by tree cover range ('000 ha)

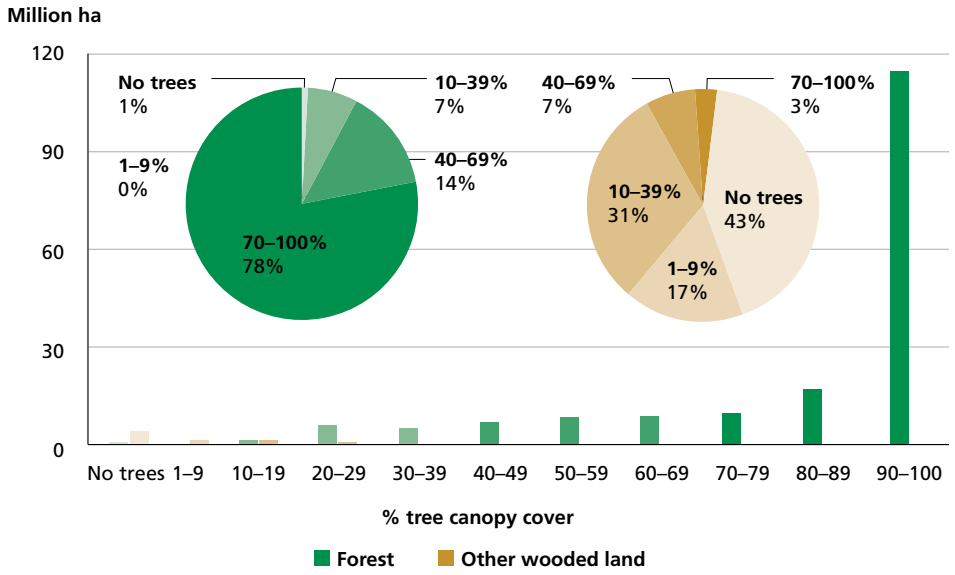


Source: UN Maps, 2019

TABLE 60
Average tree canopy cover in European drylands by land use and aridity zone (%)

Land use	Arid	Semi-arid	Dry subhumid	All zones
Forest	65	81	83	**82**
Other wooded land	2	12	16	**14**
Other land	1	4	5	**4**
Inland water bodies	4	1	2	**2**
All lands	**3**	**28**	**36**	**32**

FIGURE 197
Tree canopy cover in forest and other wooded land



Almost all the forest in European drylands (92 percent) has a closed canopy (more than 40 percent canopy cover), while 78 percent is dense forest, with canopy cover above 70 percent (Figure 197). An estimated 7 percent has canopy cover ranging from 10 to 39 percent, while 1 percent has coverage below 10 percent.

The assessment indicated that 43 percent of other wooded land has no trees. About 31 percent of other wooded land has tree canopy cover of 10 to 39 percent; 17 percent has cover below 10 percent, and only 9 percent has coverage of more than 40 percent (Figure 197).

SHRUB COVER

Only 14 percent of European drylands (70 million hectares) are covered with shrubs. The largest part of the shrub cover is distributed in the Mediterranean Basin (Figure 198).

Average shrub cover in other wooded land is 36 percent, with the densest coverage in the arid zone (44 percent) (Table 61).

An estimated 40 percent of other wooded land has shrub cover above 40 percent, with 24 percent having very dense and continuous cover (ranging from 70 to 100 percent) (Figure 199). About 27 percent of other wooded land has no shrub coverage or less than 9 percent, while 33 percent has sparse shrub coverage of between 10 and 39 percent.

Most forest has little or no shrub cover (or shrubs could not be detected because of dense tree canopy cover). The assessment indicated that 91 percent of forest has no shrubs. The average shrub cover in forest is estimated to be 2 percent (Table 61). Forest shrub cover is slightly higher in the semi-arid zone (3 percent). About 4 percent of forest has shrub coverage of 10 to 39 percent (Figure 199).

FIGURE 198

Shrub cover in Europe's drylands ('000 ha)

Source: UN Maps, 2019

TABLE 61

Average shrub cover by land use and aridity zone (%)

Land use	Arid	Semi-arid	Dry subhumid	All zones
Forest	0	3	2	**2**
Other wooded land	44	37	35	**36**
Other land	4	4	4	**4**
Inland water bodies	0	1	2	**1**
All lands	**7**	**4**	**4**	**4**

FIGURE 199

Shrub cover in forest and other wooded land

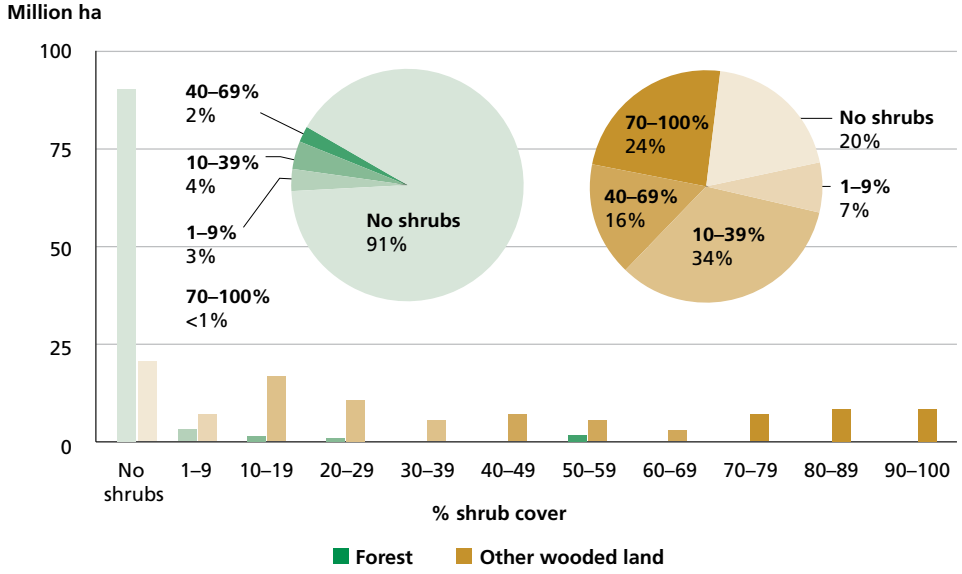
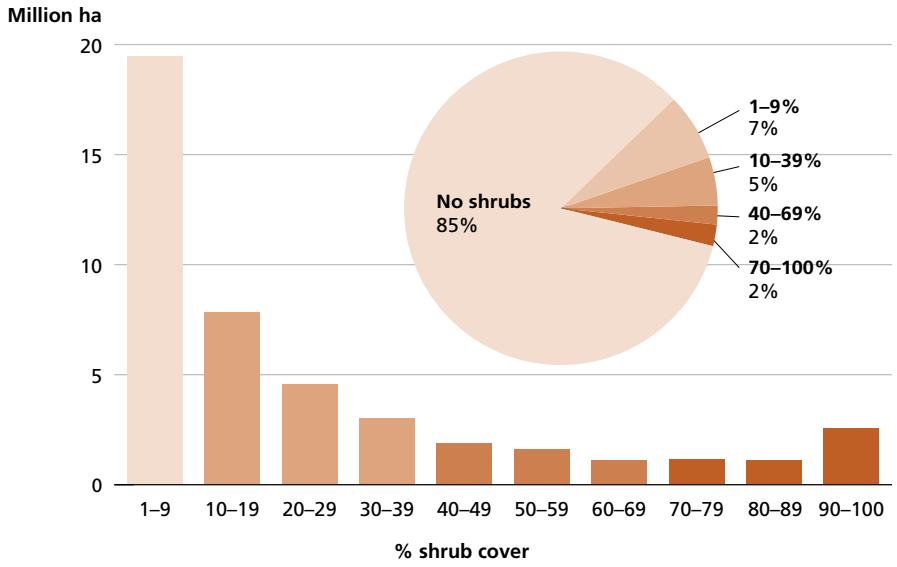


FIGURE 200

Shrub cover in other land



Most of the other land in the region's drylands has little or no shrub cover; shrubs are present on only 15 percent of other land (Figure 200), while 250 million hectares have none. Shrub coverage ranges from 1 to 9 percent on 7 percent of other land (19 million hectares), and from 10 to 39 percent on 5 percent of other land (15 million hectares).

Bardenas Reales Desert, Spain

OTHER LAND

Of the 294 million hectares of other land in the region, the largest part is in the dry subhumid zone (56 percent), followed by the semi-arid zone (43 percent). Only 1 percent of other land is in the arid zone (Figure 201).

The other lands are mainly composed of various types of crops (57 percent of other land, or 167 million hectares) (Figure 202, Table 62). Grassland or herbaceous vegetation represents 33 percent of other land (96 million hectares). Barren lands represent 2 percent of other land (6 million hectares), while built-up areas occupy 4 percent (11 million hectares).

Crops are mainly found in the dry subhumid zone (100 million hectares) and the semi-arid zone (67 million hectares). The vast majority (82 percent of cropland) is non-irrigated crops (138 million hectares) (Figures 203 and 204).

Grassland or herbaceous savannah is distributed primarily in the semi-arid zone (49 million hectares) and the dry subhumid zone (46 million hectares).

FIGURE 201

Distribution of other land by aridity zone ('000 ha)

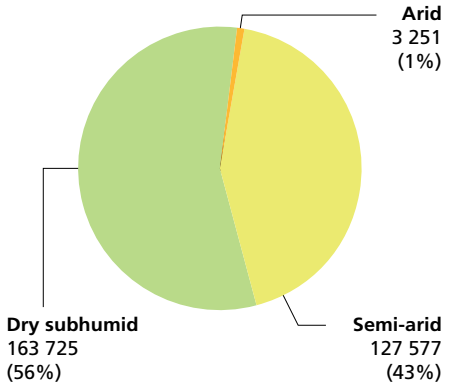


FIGURE 202

Distribution of other land by land use ('000 ha)

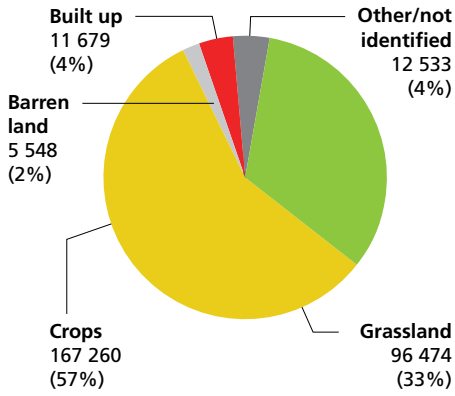


TABLE 62

Other land distribution by main vegetation/land use type and aridity zone ('000 ha)

Vegetation/land use	Arid	Semi-arid	Dry subhumid	Total	%
Crops	574	67 085	99 601	167 260	100
Irrigated crops	96	4 174	10 975	15 245	9
Non-irrigated cropland	335	54 960	82 227	137 522	82
Perennial crops (palms, orchards, others)	0	3 578	3 084	6 661	4
Cropland fallow	143	4 373	3 316	7 832	5
Grass	1 721	48 997	45 756	96 474	100
Barren land	478	3 247	1 824	5 548	100
Rock or stone	96	828	1 094	2 018	36
Sand and dunes	382	2 385	630	3 398	61
Snow and glaciers	0	33	99	133	2
Built up	143	3 810	7 725	11 679	100
Villages and urban settlements	143	2 683	5 802	8 629	74
Infrastructure	0	1 027	1 857	2 884	25
Mining	0	99	66	166	1

Barren lands are mainly found in the semi-arid zone (3 million hectares), followed by the dry subhumid zone (2 million hectares).

Built-up areas, which include urban and rural settlements, infrastructure and mines, are predominantly found in the dry subhumid zone (8 million hectares) and the semi-arid zone (4 million hectares).

FIGURE 203

Land use in other land by aridity zone

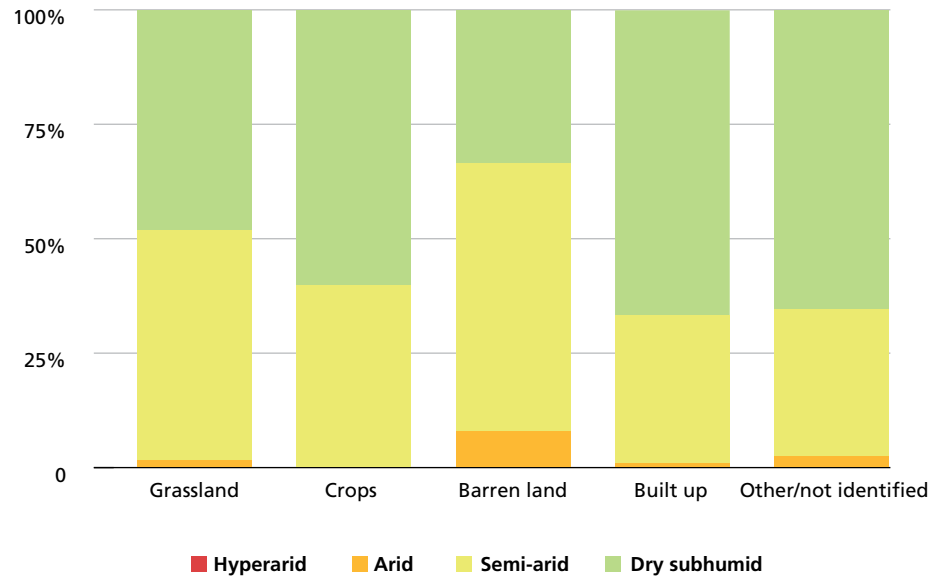
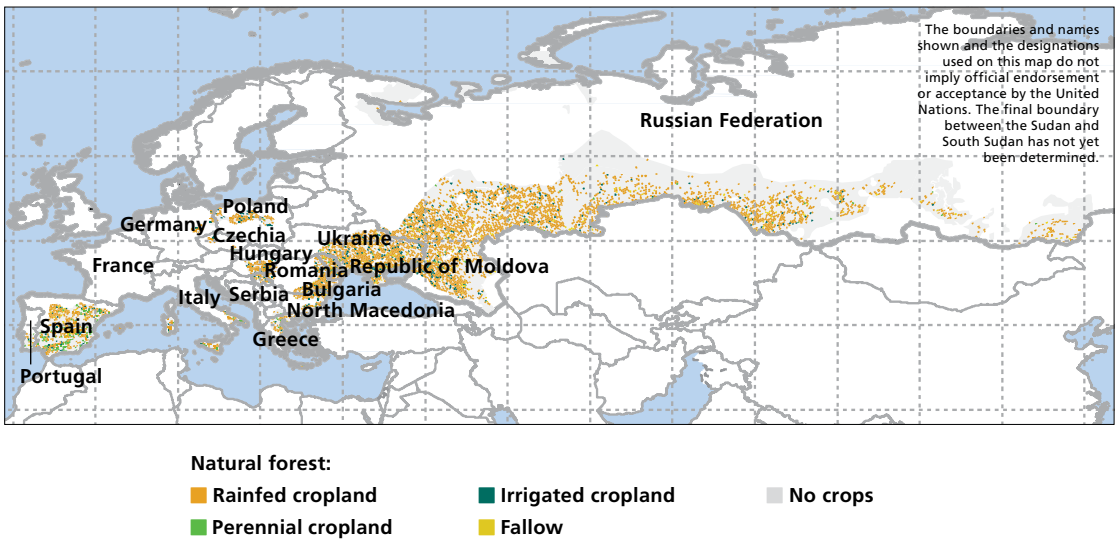


FIGURE 204

Distribution of crop types



Source: UN Maps, 2019

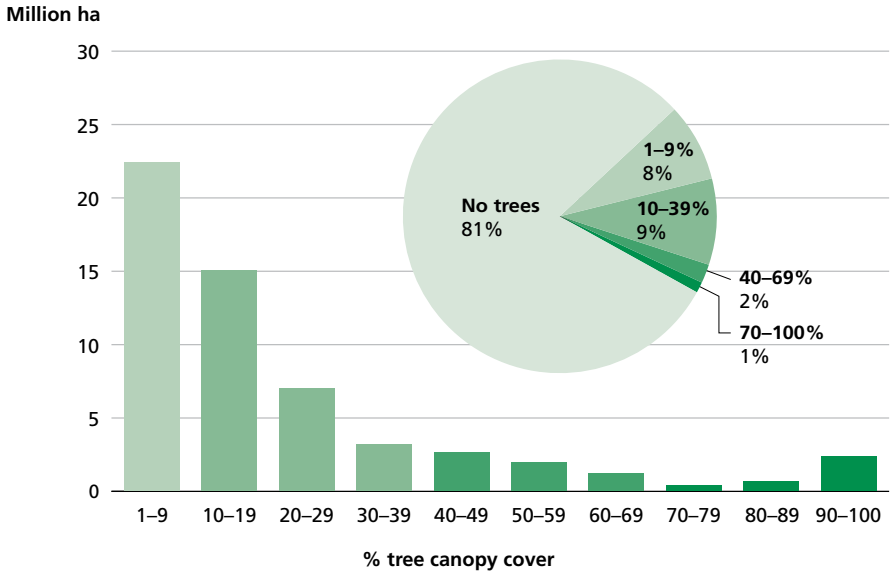
TREES OUTSIDE FOREST

Trees outside forest, which are defined as the trees in other land, are present on 57 million hectares (19 percent of other land); 237 million hectares of other land have no trees. The area of other land with tree cover above 10 percent is 35 million hectares (12 percent of other land) (Figure 205). An estimated 63 percent of the built-up area (7 million hectares) has tree cover.

Other land has average tree canopy cover of 4 percent (see Table 60), ranging from 1 percent in the arid zone to 5 percent in the dry subhumid zone.

FIGURE 205

Tree canopy cover in other land



14. Concluding remarks

The Global Drylands Assessment is the first statistical sampling–based assessment of land use in the world's drylands. It is the first of its kind to provide reliable information (less than ±10 percent error) on the extent and spatial distribution of dryland vegetation, including trees, shrubs, grasses and crops, for all regions. It therefore provides a baseline for monitoring changes in dryland forests, tree cover and land use – globally, regionally and by aridity zone. This information can support decision-making related to land-use planning and strategies to enhance climate change resilience, biodiversity conservation and maintenance of ecosystem services, and can assist in prioritizing and targeting the investments needed for dryland restoration.

THE KEY FINDINGS AND WHAT THEY MEAN

The findings in all regions highlight the importance of conserving and restoring dryland forests and trees in bringing the world towards a sustainable future and zero hunger:

- The global drylands contain 1.1 billion hectares of forest, which is 27 percent of the global forest area, estimated at approximately 4 billion hectares (FAO, 2015b).
- Two-thirds of the dryland forest area has a closed canopy (canopy cover greater than 40 percent), and around 30 percent has canopy cover between 10 and 39 percent.
- Besides barren land, which represents 28 percent of the drylands, the most common land use is grassland (25 percent). Forests are the third most prevalent land use (18 percent), followed by crops (14 percent).
- The least-arid zones have the most forests. The proportion of forest is 52 percent in the dry subhumid zone, 41 percent in the semi-arid zone, 7 percent in the arid zone and less than 1 percent in the hyperarid zone.
- Trees are present on almost one-third of the world's drylands (1.9 billion hectares, or 31 percent of the dryland area). An estimated 60 percent of built-up areas (41 million hectares) and 27 percent of cropland (228 million hectares) have at least some tree cover.

The assessment results highlight the importance of investing in forest and woodland resources in drylands, including trees outside forest, to combat land degradation and desertification, to conserve biodiversity, to support livelihoods and meet the basic demands of rural communities, and to help increase the resilience of landscapes and communities in the face of global changes, especially climate change. The assessment can thus be used to improve planning and implementation of initiatives to enhance land productivity in the different aridity zones, to increase the provision of ecosystem goods and services, and to improve the recognition that drylands are not wastelands, but productive landscapes with considerable economic potential and environmental value.

The Drylands Monitoring Week in 2015 endorsed the creation of a bridge among dryland initiatives, research and funding mechanisms. The assessment findings provide a baseline for monitoring and help in identifying priority intervention areas for restoration and for achieving land degradation neutrality at the global and regional levels.

ADVANTAGES, CAVEATS, LIMITATIONS AND LESSONS

The use or interpretation of high-resolution remote-sensing images has revolutionized the way biophysical data are collected. The approach followed in this assessment has made it possible to obtain accurate and independent information without the need for reality checks on the ground; it has thus been possible to assess areas that would

not otherwise have been covered owing to difficulties of access, scarcity of financial resources or degradation of security in some dryland regions. The continued availability of satellite images and the regular updating of processing tools are greatly aiding such assessment efforts, contributing to providing decision-makers with quality products and results that reflect the realities on the ground.

The assessment has broken new methodological ground through visual interpretation of data collected from publicly and freely available online libraries of satellite images. It was carried out in a participatory and collaborative manner, engaging experts from around the world with experience in systematic data collection and extensive knowledge of the lands and land uses in the regions they assessed. The approach has brought several advantages:

- Individual trees outside forest can be assessed with meaningful precision, thanks to the presence of very-high-resolution imagery in such satellite image libraries as Google Maps and Bing Maps.
- A statistically based assessment of tree, forests, land use and land-use change can be conducted rapidly and inexpensively, as sample plots are inventoried in satellite images rather than in the field.
- A much wider circle of people can be involved in the assessment process, thanks to the ease of use of the interpretation tool (which can be mastered in a few days and does not require familiarity with geographical information systems) and the low cost (as the software tool and the data are both available free of charge).

However, as the method is new, it is still being refined. Like other methods, it has limitations, which must be kept in mind in interpreting results.

A potential source of error is inconsistency, as over 200 people were engaged in data collection and the supply of images was not the same for all of the 213 782 sample plots assessed. The risk of inconsistency was mitigated by supplying all experts with the same training (through the use of the same training modules at all data-collection workshops) and the same tools (Collect Earth, applied in a participatory workshop context).

The global drylands map that underpinned the assessment did not clearly delineate drylands at the regional level. In further assessments, the global map needs to be supplemented by more precise maps available at regional and subregional levels.

Some inconsistencies have been observed between the results of the assessment and corresponding data in FRA 2015, which were collected using different methodology and tools:

- In Southern Africa, the area of forest and other wooded land in drylands reported in the assessment is much higher than the area of forest and other wooded land reported for all lands in FRA 2015.
- In Oceania, the area of dryland forest reported in the assessment is higher than the total forest area reported for all lands in FRA 2015. In addition, the other wooded land area is substantially smaller in the drylands study than in FRA 2015.
- In Northern and Central America and the Caribbean, the area of other wooded land reported for the drylands is substantially higher than the total other wooded land reported in FRA 2015 for all lands.

Explanations for these inconsistencies could include inconsistencies between the FRA definitions of forest and other wooded land and the definitions adopted by countries, which may influence national reporting to FRA; difficulties of differentiating among several dryland vegetation types on satellite imagery (particularly woodland and shrubland); and a lack of reliable and complete national data reported to FRA for some countries, in particular for the area of other wooded land. FAO has consulted with national experts and other stakeholders to share these inconsistencies and to seek advice on the way forward in improving data collection on dryland forests.

The method used in the Global Drylands Assessment can be adapted to accommodate more intensive sampling for addressing specific regional, national or landscape-scale needs. For example, it has been used for the baseline assessment and monitoring of intervention

areas in the FAO-implemented project "Action Against Desertification in support of the Great Green Wall", with funding support from the European Union and the African, Caribbean and Pacific Group of States. It has also been used for a baseline assessment of the entire intervention area of the Great Green Wall of the Sahara and the Sahel initiative, building on data already collected in Northern Africa, the Sahel and the Horn of Africa.

The same approach has also been used to conduct a comparative assessment and analysis of the spatial variability of tree cover and density in protected areas of African savannah, comparing the differences in tree cover and density among three national parks (Kruger, Limpopo and Gonarezhou) to assess the influence of environmental and disturbance factors on woody vegetation (Messina *et al.*, 2018).

LOOKING FORWARD

The United Nations Sustainable Development Goals cannot be achieved without social and economic investment in drylands (Koohafkan and Stewart, 2008). The UN Decade of Ecosystem Restoration 2021–2030 is expected to raise awareness and support for the recovery of damaged drylands. Especially where dryland forest is declining, sound quantitative data on the extent and characteristics of forest, trees and land use are essential to monitor threats and status (deteriorating or improving) and to take action. The Global Drylands Assessment can be used to support countries in developing strategies for the sustainable management of drylands, enabling decision-makers and planners to identify appropriate investments. These might include, for example:

- urgent regreening measures for restoration and preservation of vulnerable and critically endangered natural resources threatened by severe degradation or desertification;
- measures for preventing the expansion of arid lands and the spread of invasive plant species;
- improvements in resource efficiency, including sustainable food systems that restore natural resources and sustain livelihoods;
- encouraging research on and investment in genetic resources that can contribute to adaptation to climate change and to critical conditions associated with drought, high temperatures, pests and diseases;
- the recovery and valorization of local knowledge that can assist adaptation, for the benefit of society.

The assessment should be a step towards regular monitoring of changes in dry landscapes. Monitoring is vital to evaluate the impact of climate change and human activities, the results of adaptation and mitigation measures and progress towards meeting regional targets for land degradation neutrality. It can further support assessment of the impact of different governance frameworks, policies and legislation related to land use, for more effective improvement of the livelihoods and climate change resilience of dryland populations.

As a follow-up to the drylands assessment, multivariable spatial analysis using other datasets could be carried out to study how climate, demography and land-use practices affect vegetation and woodlands, thus supporting development and adoption of more targeted policies.

FAO and its partners continue to develop the tools for assessment of landscape change, including land degradation and deforestation, and monitoring of land cover and land use. Collect Earth has been improved to run online, so users no longer need to worry about software installation and data management; multiple users can collect information simultaneously. This new generation of the software, called Collect Earth Online, also offers further customization, imagery resources and processing capabilities over the desktop version. FAO is also developing a new version of the System for Earth Observation Data Access, Processing and Analysis for Land Monitoring (SEPAL) to increase countries' access to geospatial technologies used to track land-use change, carbon flows and climate mitigation.

Morocco

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Annex 1
Different land-use categories adopted in the assessment

LAND-USE CATEGORIES OF THE GLOBAL FOREST RESOURCES ASSESSMENT 2015 (FAO, 2012a)

Forest

Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use.

Explanatory notes

1. Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 metres.
2. Includes areas with young trees that have not yet reached but which are expected to reach a canopy cover of at least 10 percent and tree height of 5 metres or more. It also includes areas that are temporarily unstocked due to clear-cutting as part of a forest management practice or natural disasters, and which are expected to be regenerated within five years. Local conditions may, in exceptional cases, justify that a longer time frame is used.
3. Includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific environmental, scientific, historical, cultural or spiritual interest.
4. Includes windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 hectares and width of more than 20 metres.
5. Includes abandoned shifting cultivation land with a regeneration of trees that have, or are expected to reach, a canopy cover of at least 10 percent and tree height of at least 5 metres.
6. Includes areas with mangroves in tidal zones, regardless whether this area is classified as land area or not.
7. Includes rubberwood, cork oak and Christmas tree plantations.
8. Includes areas with bamboo and palms provided that land use, height and canopy cover criteria are met.
9. Excludes tree stands in agricultural production systems, such as fruit tree plantations, oil palm plantations, olive orchards and agroforestry systems when crops are grown under tree cover. Note: Some agroforestry systems, such as the "Taungya" system where crops are grown only during the first years of the forest rotation, should be classified as forest.

Other wooded land

Land not defined as "forest", spanning more than 0.5 hectares; with trees higher than 5 metres and a canopy cover of 5 to 10 percent, or trees able to reach these thresholds; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use

Explanatory notes

1. The definition above has two options:
   - The canopy cover of trees is between 5 and 10 percent; trees should be higher than 5 metres or able to reach 5 metres;
     or
   - The canopy cover of trees is less than 5 percent but the combined cover of shrubs, bushes and trees is more than 10 percent. Includes areas of shrubs and bushes where no trees are present.
2. Includes areas with trees that will not reach a height of at least 5 metres and with a canopy cover of 10 percent or more, e.g. some alpine tree vegetation types, arid zone mangroves, etc.
3. Includes areas with bamboo and palms provided that land use, height and canopy cover criteria are met.

Other land

All land that is not classified as forest or other wooded land

Explanatory notes

1. Includes agricultural land, meadows and pastures, built-up areas, barren land, land under permanent ice, etc.
2. Includes all areas classified under the sub-category "Other land with tree cover".

Inland water bodies

Inland water bodies generally include major rivers, lakes and water reservoirs.

LAND-USE CATEGORIES OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC, 2006)

Forest land

Includes all land with woody vegetation consistent with thresholds used to define forest land in national greenhouse-gas inventories. It also includes systems with a vegetation structure that currently falls below, but *in situ* could potentially reach, the threshold values used by a country to define the forest land category.

Cropland

Includes cropped land, including rice fields, and agroforestry systems where the vegetation structure falls below the thresholds used for the forest land category.

Grassland

Includes rangelands and pasture land not considered cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the forest land category. The category also includes all grasslands, from wild lands to recreational areas, as well as agricultural and silvipastoral systems, consistent with national definitions.

Wetlands

Includes areas of peat extraction and land covered or saturated by water for all or part of the year (e.g. peatlands) and that does not fall into the forest land, cropland, grassland or settlement categories. It includes reservoirs as a managed subdivision and natural rivers and lakes as unmanaged subdivisions.

Settlements

Includes all developed land, including transportation infrastructure and human settlements of any size, unless already included in other categories.

Other land

Includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available. If data are available, countries are encouraged to classify unmanaged lands by the above land-use categories (e.g. into unmanaged forest lands, unmanaged grasslands, and unmanaged wetlands). This will improve transparency and enhance the ability to track land-use conversions from specific types of unmanaged lands into the categories above.

Annex 2
Partners involved in the first Global Drylands Assessment

Region	Partner institutions	No. of participants	Focal point
Northern Africa	General Directorate of Forestry Tunis, Tunisia	20	Aloui Kamel
Western and Central Africa	Permanent Interstate Committee for Drought Control in the Sahel (CILSS) Regional Training Centre for Agrometeorology and Operational Hydrology and their Applications (AGRHYMET) Niamey, the Niger	20	Bako Mamane
Eastern Africa	World Resources Institute Washington, DC, United States of America	20	Fred Stolle
Southern Africa	Department of Environmental Biology, Sapienza University of Rome Rome, Italy	20	Fabio Attorre
Western Asia	International Forest Fire Education Centre General Directorate of Forestry Antalya, Turkey	20	Caglar Bassullu
Central and Eastern Asia	Department of Forest and Hunting Inventory of Kyrgyzstan Bishkek, Kyrgyzstan	20	Venera Surappaeva
Southern Asia	Faculty of Environment, School of Geography, Leeds University Leeds, United Kingdom	20	Alan Grainger
Oceania	Terrestrial Ecosystem Research Network and Faculty of Science, School of Earth and Environmental Sciences, University of Adelaide Adelaide, Australia	20	Ben Sparrow
South America	Argentine Dryland Research Institute (IADIZA) Mendoza, Argentina	5	Elena Maria Abrahm
South America	Instituto Nacional do Semiárido (INSA) Campina Grande, Brazil	20	Ignacio Salcedo
Northern and Central America and the Caribbean	United States Department of Agriculture – Forest Service Remote Sensing and Geographic Information Systems Laboratory Utah State University Logan, Utah, United States of America	6	Doug Ramsey
Europe	Department of Forest Engineering Technical University of Madrid Madrid, Spain	20	Luis Gonzaga
Total	**12 partners**	**211**	

FAO FORESTRY PAPERS

1 Forest utilization contracts on public Land, 1977 (E F S)
2 Planning forest roads and harvesting systems, 1977 (E F S)
3 World list of forestry schools, 1977 (E F S)
3 Rev.1 World list of forestry schools, 1981 (E F S)
3 Rev.2 World list of forestry schools, 1986 (E F S)
4/1 World pulp and paper demand, supply and trade – Vol. 1, 1977 (E F S)
4/2 World pulp and paper demand, supply and trade – Vol. 2, 1977 (E F S)
5 The marketing of tropical wood in South America, 1976 (E S)
6 National parks planning, 1976 (E F S)
7 Forestry for local community development, 1978 (Ar E F S)
8 Establishment techniques for forest plantations, 1978 (Ar C E * F S)
9 Wood chips – production, handling, transport, 1976 (C E S)
10/1 Assessment of logging costs from forest inventories in the tropics – 1. Principles and methodology, 1978 (E F S)
10/2 Assessment of logging costs from forest inventories in the tropics – 2. Data collection and calculations, 1978 (E F S)
11 Savanna afforestation in Africa, 1977 (E F)
12 China: forestry support for agriculture, 1978 (E)
13 Forest products prices 1960–1977, 1979 (E F S)
14 Mountain forest roads and harvesting, 1979 (E)
14 Rev.1 Logging and transport in steep terrain, 1985 (E)
15 AGRIS forestry – world catalogue of information and documentation services, 1979 (E F S)
16 China: integrated wood processing industries, 1979 (E F S)
17 Economic analysis of forestry projects, 1979 (E F S)
17 Sup.1 Economic analysis of forestry projects: case studies, 1979 (E S)
17 Sup.2 Economic analysis of forestry projects: readings, 1980 (C E)
18 Forest products prices 1960–1978, 1980 (E F S)
19/1 Pulping and paper-making properties of fast-growing plantation wood species – Vol. 1, 1980 (E)
19/2 Pulping and paper-making properties of fast-growing plantation wood species – Vol. 2, 1980 (E)
20 Forest tree improvement, 1985 (C E F S)
20/2 A guide to forest seed handling, 1985 (E S)
21 Impact on soils of fast-growing species in lowland humid tropics, 1980 (E F S)
22/1 Forest volume estimation and yield prediction – Vol. 1. Volume estimation, 1980 (C E F S)
22/2 Forest volume estimation and yield prediction – Vol. 2. Yield prediction, 1980 (C E F S)
23 Forest products prices 1961–1980, 1981 (E F S)
24 Cable logging systems, 1981 (C E)
25 Public forestry administrations in Latin America, 1981 (E)
26 Forestry and rural development, 1981 (E F S)
27 Manual of forest inventory, 1981 (E F)
28 Small and medium sawmills in developing countries, 1981 (E S)
29 World forest products, demand and supply 1990 and 2000, 1982 (E F S)
30 Tropical forest resources, 1982 (E F S)
31 Appropriate technology in forestry, 1982 (E)
32 Classification and definitions of forest products, 1982 (Ar E F S)
33 Logging of mountain forests, 1982 (E F S)
34 Fruit-bearing forest trees, 1982 (E F S)
35 Forestry in China, 1982 (C E)
36 Basic technology in forest operations, 1982 (E F S)
37 Conservation and development of Tropical forest resources, 1982 (E F S)
38 Forest products prices 1962–1981, 1982 (E/F/S)
39 Frame saw manual, 1982 (E)
40 Circular saw manual, 1983 (E)
41 Simple technologies for charcoal making, 1983 (E F S)
42 Fuelwood supplies in the developing countries, 1983 (Ar E F S)
43 Forest revenue systems in developing countries, 1983 (E F S)
44/1 Food and fruit-bearing forest species – 1. Examples from eastern Africa, 1983 (E F S)
44/2 Food and fruit-bearing forest species – 2. Examples from southeastern Asia, 1984 (E F S)
44/3 Food and fruit-bearing forest species – 3. Examples from Latin America, 1986 (E S)
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60 Monitoring and evaluation of participatory forestry projects, 1985 (E F S)
61 Forest products prices 1965-1984, 1985 (E F S)
62 World list of institutions engaged in forestry and forest products research, 1985 (E F S)
63 Industrial charcoal making, 1985 (E)
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65 Forest legislation in selected African countries, 1986 (E F)
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69 Management of forest industries, 1986 (E)
70 Wildland fire management terminology, 1986 (E F S)
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72 Wood gas as engine fuel, 1986 (E S)
73 Forest products: world outlook projections 1985–2000, 1986 (E F S)
74 Guidelines for forestry information processing, 1986 (E)
75 Monitoring and evaluation of social forestry in India – an operational guide, 1986 (E)
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FAO FORESTRY PAPER

Trees, forests and land use in drylands: the first global assessment

Full report

Drylands cover 41 percent of the Earth's land surface. This publication presents the results of the first global assessment of trees, forests and land use in these lands. The assessment breaks new methodological ground: It relies on the visual interpretation of freely available satellite images, carried out by more than 200 experts in a series of regional workshops. Using a tool called Open Foris Collect Earth, developed by FAO in collaboration with Google, participants gathered and analysed information for more than 200 000 sample plots worldwide.

For each region, the report summarizes the distribution of forests, other wooded land and other land uses including grasslands, croplands, built-up areas and barren land, across all drylands and by aridity zone. It also estimates tree canopy cover, shrub cover, forest type and presence of trees outside forest. Indicating that the global drylands contain more than one-quarter of the world's forest area, and that trees are present on 31 percent of the world's dryland area, the report provides a baseline for future monitoring and will support countries in their efforts to identify appropriate investments for the restoration and sustainable management of drylands.

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