Forest Resources Assessment Working Paper 182

Towards the Assessment of Trees Outside Forests

A Thematic Report prepared in the framework of
The Global Forest Resources Assessment

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Rome 2013

Cover photos:

Left, top to bottom: Trees in an agroforestry parkland (S. Bouju), trees on a farm (H. de Foresta, IRD), linear tree formation (H. de Foresta, IRD)

Centre: trees in the city (H. de Foresta, IRD)

Right, top to bottom: trees in pasture (H. de Foresta, IRD), biodiversity and trees outside forests (H. de Foresta, IRD), forest products and trees outside forests (H. de Foresta, IRD).

Design and layout:

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TOWARDS THE ASSESSMENT OF TREES OUTSIDE FORESTS

A Thematic Report prepared in the framework of The Global Forest Resources Assessment 2010

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 2013

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Comments and feedback are welcome

FOR QUOTATION
Hubert de Foresta, Eduardo Somarriba, August Temu, Désirée Boulanger, Hélène Feuilly and Michelle Gauthier. 2013. Towards the Assessment of Trees Outside Forests. FAO Forestry Paper 164. FAO Rome.

ISBN

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FOREWORD

Trees Outside Forests (TOF) can play important roles in national economies, ecosystems, and international efforts for sustainability – and in many places they already do. At the local level, people have long relied on TOF in various land-use settings for food security, income, and biological diversity. Forest professionals in many countries support local use of trees for these purposes, outside forests as well as in forest settings. More recently, international programmes build on trees' roles in providing essential environmental services to encourage sustainable land management, carbon sequestration to mitigate climate change, and local economic development.

In the 1990s, FAO recognized that TOF are typically splintered among the components of agroforestry, urban and rural forestry, and other disciplines. TOF tend to be left out of forest statistics, natural resource assessments, policy, and legislation. An expert meeting held in Finland in 1996 recommended that FAO address the need for hard data on TOF. As a result, a thematic study on TOF was included in the Global Forest Resource Assessment (FRA) 2000. Along with several publications on the issue, the FAO Forestry Department included TOF in the National Forest Monitoring and Assessment (NFMA) Programme and other country-level reporting efforts.

A major challenge for a better valuation of trees and their services globally remains in better understanding the status and dynamics of all tree resources, including TOF ("Trees Outside Forests: Towards Rural and Urban Integrated Resources Management," 2001)." What little data are available often are entered using methods unlike the ones typically used in forest resource assessments. This may be one reason why TOF are so often invisible in reports about how people use trees and forests.

The objective of this study is to advance toward improved assessments. Navigating the overlapping patterns of trees in landscapes, this report aims to create a more coherent assessment framework compatible with the FRA approach that FAO has refined through FRA 2005 and FRA 2010.

With a view ahead to the 2015 global assessment, the methods in this report and case studies illustrating their use will help provide a more complete picture for international, national, and local efforts to manage trees and land for people's benefits. Different agencies in national and regional governments may have different reasons for why they gather data on TOF and why they report it to FAO. The FRA 2010 provides a starting point, along with other international programmes developed by FAO and its partners (see Chapter 3). This report takes that further, acknowledging where ambiguities remain and clarifying categories and usage where possible.

The report was developed based on recommendations from the Kotka V Expert Consultation on the Global Forest Resource Assessment (June 2006) that a special study on TOF should be included in FRA 2010. An inception workshop for the study was held in Rome (June 2010). During the workshop, 42 experts from 31 institutions in 17 countries defined the objectives, scope and process for developing the study. Considering that quality large area TOF assessments are a sine qua non condition for TOF to be integrated into development policies, the workshop recommended that the main outcome of the thematic study be a report including:

- ✓ A review and comparative analysis of large scale (national and regional) assessments of TOF,
- ✓ A set of methodological and technical options for national-level assessments of TOF, including an operational typology, enabling reporting to international processes such as FRA and IPCC.

A small team was then formed to carry out the study and prepare the report. A first draft was peer-reviewed by the workshop experts

and by FAO officers from various services and departments.

The report is intended to support national agencies responsible for forestry, agriculture, environment, and rural and urban development, by providing adapted tools and methods to assess resources of TOF, as well as their products, uses and economic and environmental functions, at a national level. Through such assessments, local and national decision-makers will be better able to take into account TOF resources and the services they provide. This support to decision-makers and land-use planners is especially important for developing countries as the contribution of TOF to people's livelihoods and national economies is expected to dramatically increase in the current context of climate change, biodiversity crisis, financial crises, and food insecurity.

This report is intended to support national agencies responsible for forestry, agriculture, environment and rural and urban development by providing tools and methods to assess TOF resources, as well as their products, uses and economic and environmental functions, at the national level. Through such assessments, local and national decision-makers will be better able to take into account TOF resources and the services they provide. This is especially important in many developing countries, where the contribution of TOF to people's livelihoods and national economies is likely to increase dramatically if predictions of future climate change, biodiversity loss and food insecurity are accurate.

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ACKNOWLEDGEMENTS

This report on trees outside forests is the result of a multi-institutional collaboration involving specialists from various disciplines worldwide. It was initiated by the FAO-Finland Sustainable Forest Management in a Changing Climate Programme (GCP/GLO/194/MUL).

This document was prepared under the overall leadership of Michelle Gauthier, Forestry Officer of the FAO Assessment, Management and Conservation Division of the Forestry Department, and the guidance of the Coordinator of the Forest Resources Assessment Programme, Kenneth MacDicken. The scientific and technical coordination of the publication was carried out by Hubert de Foresta of the Research Development Institute (IRD) from France. Désirée Boulanger and Hélène Feuilly were indispensable during the first year in assisting researching, collecting and analysing the information contained in parts II and III.

The richness of this report is due to the multistakeholder process that was in place from the beginning of the process to the end of it. The participants of the two inception workshops held at FAO headquarters, Rome, for the development of agroforestry guidelines (7–8 March 2010) and the assessment of trees outside forests (9–10 March 2010) set the participatory process, the objectives, the provisional content of the report and the task force. The authors thank specially those participants: Rik De Vreese (Belgium), Yoshio Shimabukuro (Brazil), Jinlong Liu (China), Chaozong Xia (China), Guillermo Navarro C. (Ecuador), Eduardo Somarriba (Costa Rica), Miguel Adrián Cordero Velásquez (Guatemala), Christian Dupraz (France), Hubert de Foresta (France), Martial Bernoux (France), Denis Gautier (France), Christoph Kleinn (Germany), Michael Koehl (Germany), Stefanie Poepken (Germany), Sebastian Schnell (Germany), Manoj Dabas (India), Prakash Lakhchaura (India), Maria Vincenza Chiriacò (Italy), Piermaria Corona (Italy), Toby Hodgkin (Italy), Angelo Mariano (Italy), Marco Marchetti (Italy), Shantanu Mathur (Italy), Flora De Natale (Italy), Giuseppe Pignatti (Italy), Jésus Quintana (Italy), Fabio Salbitano (Italy), Giovanni Sanesi (Italy), August Temu (Kenya), Jean-Marc Boffa (Malta), Robert J. Zomer (Nepal), Michael Idowu (Nigeria), Labode Popoola (Nigeria), Ignacio Lombardi Indacochea (Peru), El Hadi M. Sène (Senegal), Felician Bakamaza Kilahama (United Republic of Tanzania); John Spears (United States of America), Giorgos Mountrakis (United States of America).

For developing the Part II of the report and for other case-studies, we counted on the valuable contribution of more than 35 experts from national and institutional with expertise at local, national and global level. We would specially like to express our very great appreciation to those participants coming from 28 following countries: Canada, China, Denmark, France, India, Ireland, Morocco, New Zealand, Nepal, Nicaragua, Norway, Philippines, Senegal, Slovenia, Sweden, United Kingdom, Uruguay and USA. The list of these experts is contained in the List of Contributors.

We would like to offer our great appreciation to the following FAO colleagues in various departments who provided their support and valuable advice when necessary, including Moujahed Achouri, Dan Altrel, Caterina

Batello, Louis Bockel, Anne Branthomme, Jim Carle, Julien Custot, Hubert Georges, Theodor Friedrich, Adam Gerrand, Matieu Henry, Amir Kassam, John Latham, Michel Laverdière, Mikko Leppanen, Mette Loyche Wilkie, Doug McGuire, José Antonio Prado, Maria Ruiz Villar, Alberto Sandobal, Christina Seeberg Elverfeldt, Patrice Talla, Marja Liisa Tapio Bistrom, Rebecca Tavani and Julian Thomas. Finally, this interdepartmental work would not have been possible without the support of the Assistant Directors General of three key departments: Eduardo Rojas in the Forestry Department, Modibo Traoré in the Agriculture Department, and Alexander Muller in the Natural Resources Department.

The final peer review has benefited from the advice and contribution from many of the external experts mentioned above.

We express our gratitude to Hubert de Foresta, who for more than two years coordinated the collection of widely scattered information, ensured frequent communication among partners and contributors, and wrote the report. We also wish to acknowledge the dedication of the two task force members and their institutions throughout the whole process: August Temu from ICRAF and Eduardo Somarriba from CATIE. The "Annotated bibliography on Trees Outside Forests" produced by CATIE complements this report and is available in the Thematic Studies page of the FAO Global Forest Resources Assessment web site at http://www.fao.org/forestry/fra/38575/en/

"A picture is worth a thousand words": the challenge was achieved thanks to the dedication of Stéphane Bouju and Hubert de Foresta in selecting the superb illustrations used in this report from their collections of thousands of photographs.

The language editing was provided by David Taylor and graphic and layout services by Corinne Maeght.

CONTRIBUTORS

We express our highest appreciation to the following experts that contributed to the case studies in Part I and Part II

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PRESENTATION OF THE REPORT

This study is organized in three main parts, reflecting the recommendations of experts and country representatives.

Part 1 consists of the report's main text, outlining the purpose of a Trees Outside Forests (TOF) assessment and how to accomplish it. The first chapter presents the background and rationale for the thematic study, and explains the focus on the national and sub-national levels of TOF assessment. Chapter 2 identifies situations in which TOF may be encountered, and analyses the place of land with TOF in FAO's framework of land classification. Chapter 3 reviews large-area assessments regarding TOF with one global assessment, one regional assessment, 33 national assessments, and 3 assessments at the sub-national scale. Based on the previous chapters, Chapter 4 provides options for countries in developing large-area TOF assessments. Selecting among those options depend on quantity, quality and relevance of existing data; the assessment objectives; and available resources. Chapter 5 distills the main conclusions and recommendations.

Part 2 illustrates these methods with case studies and descriptions of international programmes. It synthesizes information on the 38 assessments previously mentioned and on international support programmes.

Part 3, a guide for TOF identification, is a collection of satellite images that further illustrate the various components of Other Land with TOF, the diversity of land uses found, and how to identify them. Seventy high-resolution satellite images, covering all subsets of TOF in various biophysical and human settings, offer examples for classification using the FAO-FRA framework.

ABBREVIATIONS AND ACRONYMS

ASL	above sea level
CATIE	Tropical Agricultural Center for Research and Education
CIFOR	Center for International Forestry Research
CIRAD	Center for International Agricultural Research for Development
COP	Conference of the Parties to UNFCCC
FRA	Global Forest Resources Assessment
GDP	gross domestic product
GEF	Global Environment Facility
GLCN	Global Land Cover Network
ICIMOD	International Centre for Integrated Mountain Development
ICRAF	World Agroforestry Centre, formerly International Centre for Agroforestry

Research

IFAD	International Fund for Agricultural Development
IUFRO	International Union of Forest Research Organizations
LADA	Land Degradation Assessment in Drylands
LCCS	Land Cover Classification System
LUCS	Land-Use/Cover Section
LU/LC	Land-use/Land-cover
MRV	measurement, reporting and verification
NFI	national forest inventories
NFMA	National Forest Monitoring and Assessment
NGO	non-governmental organization
NWFP	non-wood forest product
OLWTC	Other Land With Tree Cover
PES	payment for environmental services
REDD	Reducing Emissions from Deforestation and Forest Degradation
SBSTA	Subsidiary Body for Scientific and Technological Advice
TOF	Trees Outside Forests
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	United Nations General Assembly
UNSD	United Nations Statistics Division
WISDOM	The Woodfuel Integrated Supply/Demand Overview Mapping

GLOSSARY

Agricultural system: An agricultural system is an assemblage of components which are united by some form of interaction and interdependence and which operate within a prescribed boundary to achieve a specified agricultural objective on behalf of the beneficiaries of the system.
(FAO stat, FAO Farm Systems Management Series – 13)

Canopy cover: The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of the foliage of plants. Cannot exceed 100 percent. (Also called crown closure) Same as crown cover.
(IPCC. 2003. Good Practice Guidance for LULUCF - Glossary)

Forest: Land spanning more than 0.5 hectares with trees higher than 5 meters 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 meters in situ.
2. Includes areas with young trees that have not yet reached but which are expected to reach a canopy cover of 10 percent and tree height of 5 meters. 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 5 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 meters.
5. Includes abandoned shifting cultivation land with a regeneration of trees that have, or is expected to reach, a canopy cover of 10 percent and tree height of 5 meters.
6. Includes areas with mangroves in tidal zones, regardless whether this area is classified as land area or not.
7. Includes rubber-wood, 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 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.

(FAO. Guidelines for Country Reporting to FRA 2010)

Inland water bodies: Inland water bodies generally include major rivers, lakes and water reservoirs. (FAO. Guidelines for Country Reporting to FRA 2010)

Other land with no tof: Land classified as Other Land, with no tree and/or no shrub cover or with trees or shrubs but with an area is < 0.05 ha, canopy cover < 5% if trees are present, or < 10% if combined trees, bushes and shrubs, or for linear structures a width < 3 m or length < 25 m.

Explanatory notes:

1. Includes inland water bodies, barren land, stone outcrops, snow caps and glaciers, deserts, peat bogs, meadows without trees, annual crops without trees, etc...
2. Includes large areas with very scattered trees or shrubs

Other land with tof: Land classified as Other Land –i.e. not classified as Forest nor Other Wooded Land-, spanning more than 0.05 hectares with trees higher than 5 meters and a canopy cover above 5 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. It includes land that is predominantly under agricultural or urban use. It also includes some land that is not predominantly under agricultural or urban use".

Explanatory notes:

1. Includes all areas with trees or/and shrubs on land that is predominantly under agricultural use.
2. Includes all areas with trees or/and shrubs on land that is predominantly under urban use.
3. On land that is not predominantly under agricultural or urban use, includes: areas spanning less than 0.5 ha; windbreaks, shelterbelts and corridors of trees and shrubs, with an area spanning less than 0.5 ha or a width of less than 20 m but more than 3 m;

Other land with tree cover (sub-category of Other land): Land classified as Other land, spanning more than 0.5 hectares with a canopy cover of more than 10 percent of trees able to reach a height of 5 meters at maturity.

Explanatory notes

1. The difference between Forest and Other land with tree cover is the land use criteria.
2. Includes groups of trees and scattered trees in agricultural landscapes, parks, gardens and around buildings, provided that area, height and canopy cover criteria are met.
3. Includes tree stands in agricultural production systems, for example in fruit tree plantations and agroforestry systems when crops are grown under tree cover. Also includes tree plantations established mainly for other purposes than wood, such as oil palm plantations.
4. Excludes scattered trees with a canopy cover less than 10 percent, small groups of trees covering less than 0.5 hectares and tree lines less than 20 meters wide.

(FAO. Guidelines for Country Reporting to FRA 2010)

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".

(FAO. Guidelines for Country Reporting to FRA 2010)

Other wooded land: Land not classified as Forest, spanning more than 0.5 hectares; with trees higher than 5 meters and a canopy cover of 5-10 percent, or trees able to reach these thresholds in situ; 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 meters or able to reach 5 meters in situ. 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 5 meters in situ 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.

(FAO. Guidelines for Country Reporting to FRA 2010)

Shifting cultivation: A land utilization method; a particular piece of land is cultivated for some years and then abandoned for a period required to restore its fertility by natural vegetative growth; it is then cultivated again. The distinguishing feature of shifting cultivation is that neither organic fertilizers nor manure are used to retain soil fertility.

(FAO. 1996. Conducting agricultural censuses and surveys. FAO Statistical Development Series, No. 6. Rome.)

Shrub: Woody perennial plant, generally more than 0.5 meters and less than 5 meters in height at maturity and without a definite crown. The height limits for trees and shrubs should be interpreted with flexibility, particularly the minimum tree and maximum shrub height, which may vary between 5 meters and 7 meters.

(FAO. Guidelines for Country Reporting to FRA 2010)

TOF: Trees, bamboos, palms, shrubs and bushes found in Other Lands

TOF-AGRI: TOF-AGRI includes all lands predominantly under an agricultural use with trees and/or shrubs whatever their spatial pattern (in line, in stands, scattered), provided that the area is ≥ 0.05 ha, the canopy cover is ≥ 5% if trees are present, or ≥ 10% if combined trees, bushes and shrubs, the width ≥ 3 m and the length ≥ 25 m.

TOF-URB: TOF-URB includes all lands predominantly under an urban use with trees and/or shrubs whatever their spatial pattern (in line, in stands, scattered), provided that the area is ≥ 0.05 ha, the canopy cover is ≥ 5% if trees are present, or ≥ 10% if combined trees, bushes and shrubs, the width ≥ 3 m and the length ≥ 25 m.

TOF NON A/U: TOF-NON A/U includes all lands not predominantly under agricultural or urban use, with

Subset 1: small tree stands (0.05 ≤ area <0.5 ha), with canopy cover ≥ 5% if trees are present, or ≥ 10% if combined trees, bushes and shrubs.

Subset 2: narrow linear tree formations, (3 m ≤ width < 20 m), with canopy cover ≥ 5% if trees are present, or ≥ 10% if combined trees, bushes and shrubs.

TREE: A woody perennial with a single main stem, or in the case of coppice with several stems, having a more or less definite crown.

Explanatory note

1. Includes bamboos, palms, and other woody plants meeting the above criteria.

(FAO. Guidelines for Country Reporting to FRA 2010)

EXECUTIVE SUMMARY

Background

The concept of "Trees outside Forests" -TOF- emerged in 1995 to designate trees growing outside the forest and not belonging to Forest or Other Wooded Land. The term represents an effort to concentrate attention that had been spread out on components of this rather diffuse resource: agroforestry, silvopastoralism, urban and rural forestry, and other related disciplines. In policy and public discourse, these important resources were overlooked.

The importance of Trees outside Forests for sustainable and integrated land management prompted the Expert Meeting on Global Forest Resources Assessments, held in 1996 in Kotka, Finland (Kotka III), to recommend that FAO and the FRA programme take steps to improve the data on this sector.

In response, the TOF issue was included into the Global FRA 2000 process. An expert consultation on "enhancing the contribution of TOF to sustainable livelihoods", held in FAO-Rome (November 2001), produced various reports and publications, and the synthesis "Trees outside Forests: Towards better Awareness" (FAO conservation Guide 35, 2002). The FAO Forestry Department held regional training workshops such as the workshop on "Assessment of TOF" held in April 2002 in Dehradun, India, and the project on "the role of planted forests and trees outside forests in landscape restoration in low forest cover countries" (FAO 2004).

In parallel with these efforts to raise awareness about TOF, the FAO Forestry Department took two important initiatives to support integration of TOF into national assessments:

✓ Including TOF into the National Forest Monitoring and Assessment Programme (NFMA). As of 2010, the programme has provided direct support to more than 15 countries that have implemented national inventories in and outside forests.

✓ Including information on the extent of a TOF subset –Other Land with Tree Cover (OlwTC)- in the country reporting tables to global FRA. The number of countries and territories that filled the OLwTC line increased from 61 in FRA 2005 to 77 in FRA 2010.

Despite measurable progress, hard data on TOF across large areas (sub-national and national levels) remains scarce. Countries expressed their need for support with methods and techniques for a better assessment of TOF resources. They requested that FAO prepare a thematic report on TOF as part of FRA 2010, including technical guidelines for better integrating TOF into the FRA 2015 reporting process.

Objectives and content

FAO organized an "Inception Workshop of the Thematic Study on TOF", held in Rome in June 2010, attended by 42 experts from 17 countries, coming from governmental organizations, international (CATIE, ICIMOD, ICRAF, IFAD, IUFRO, AU Commission, World Bank) and national institutions (CIRAD, IRD), universities and NGOs.

Through a focus on TOF assessment, this thematic report aims to enable the provision of better information on TOF for informed decisions that optimize tree and forest resources for sustainable development and food security.

As recommended, this study focuses on two main products:

- ✓ **Product 1:** A review of past and current large-area TOF assessments, as a basis for formulating technical and methodological options for new TOF assessments.
- ✓ **Product 2:** A conceptual framework including i) typology and variables for TOF assessment, (ii) on which countries can superimpose their objectives and (iii) select technical and methodological options adapted to their needs and resources.

The Thematic Report follows the Inception Workshop recommendations as far as possible, and consists of three main parts (see Presentation of the Thematic Report):

- ✓ **Part 1 – Towards Assessing Trees Outside Forests: why, what and how:** the report itself presents a rationale for TOF assessment. Building on definitions, it identifies the situations where TOF can be encountered, and analyses the place of land with TOF in the FAO land classificatory framework. It proposes a formal definition of Land with TOF, as a sub-category of Other Land in that framework. It reviews past and current assessments that include or may include TOF. Finally, it puts forward options for countries that want to implement TOF assessments, with options depending on the existing data, and objectives and resources.
- ✓ **Part 2 – TOF assessment case studies:** a compendium of the 38 assessments and the 4 international support programmes analysed as case studies for the review (Part 1, chapter 3). The assessments cover a very large range of environmental and socio-economic conditions, carried out in almost all the major world regions. The assessments also cover the main methods in use and the three TOF sets: agriculture, urban and other land uses.
- ✓ **Part 3 – TOF from the air - a guide for identification:** provides an illustrated guide to TOF, with the aim of facilitating classificatory decisions. A collection of high resolution satellite images, covering all TOF subsets in a variety of biophysical and human settings are presented, analysed, and used as examples for the classification of any piece of land into the FAO-FRA classificatory framework (see Figure 1).

“TOF from the Air - a guide for identification: an exemple from Sumatra, Indonesia”

In the analysis of this satellite image (Sumatra, Indonesia - 3°30’03”N ; 98°49’14”E), the first step of the classification process is the delineation of land units based on a relatively homogeneous land-cover. In the present example, four categories of land units have been identified. Results of the use of the Decision Tree algorithm are detailed for each category.

A: OL*wTOF* - *AGRI* (Ol*wTC*)

B: OL*wNoTOF*

C: OL*wTOF* - *URB* (Ol*wTC*)

D: OL*wNoTOF*

A: Mosaic of large oil palm plots with a regular and very dense tree cover. All trees are TOF *(because the use is predominantly agricultural).*

The whole area is classified as **Other Land *with TOF*** *because the land is predominantly under agricultural use (thus classified as Other Land), tree height is more than 5m, the tree canopy cover is more than 5 percent, and the area is more than 0.05 hectares*. This area can be further classified as **Other Land with Tree Cover** (a sub-category of Other Land satisfying to the same biophysical thresholds as the Forest category), *because the area is more than 0.5 hectares, and the canopy cover is more than 10 percent.*

B: Mosaic of crop fields and houses, with no or scarce isolated trees. All trees are TOF *(because the use is predominantly agricultural).*

The B patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture and housing structures (thus classified as Other Land), and the tree canopy cover is lower than 5 percent, which is the minimum threshold for the Other Land with TOF category.*

C: Settlement area with homegardens, houses, streets, with a dense but heterogeneous cover of trees. All trees are TOF *(because the use is predominantly agricultural and urban).*

The area as a whole is classified as **Other Land *with TOF*** *because the land is mainly used for housing structures and homegardens (thus classified as Other Land), tree height is more than 5m, the tree canopy cover is more than 5 percent, and the area is more than 0.05 hectares*. This area can be further classified as **Other Land with Tree Cover** *because the area is more than 0.5 hectares, and the canopy cover is more than 10 percent.*

D: Area with no or scarce isolated trees, probably a flooded area. All trees are TOF *(because, although the land is not under predominantly agricultural or urban use, the tree canopy cover is lower than 5 percent, which is the minimum threshold for the Other Wooded Land category).*

The area is classified as **Other Land *with No TOF*** *because it satisfies neither the land-use criteria nor the biophysical thresholds of the categories Forest and Other Wooded Land (thus classified as Other Land),* and *because the tree canopy cover is lower than 5 percent, which is the minimum threshold for the Other Land with TOF category.*

Major Findings

TOF are trees that do not fulfill the criteria of Forest, so the TOF realm depends on the definition used for Forest in any country or agency conducting an assessment. TOF can be found in all climates, land types, land uses and regions. They ensure a multitude of ecological, economic, social, and cultural functions, that in many cases are vital for human livelihood.

The TOF set as it is understood in this report, is in the tree realm the complement of the combined two FAO categories, Forest and Other Wooded Land. For clarity, Other Land may be subdivided in two mutually exclusive sub-categories: *with TOF* and *with No TOF*. Based on the presence of TOF at minimum threshold levels, operational definitions are given for the two sub-categories.

Other Land *with TOF* (OL*wTOF*) consists of three sets: lands predominantly under agricultural use; lands predominantly urban; and lands neither urban nor agricultural (small tree stands and narrow linear formations).

These three TOF sets involve a large range of stakeholders: farmers, pastoralists and institutions linked to agriculture and rural development; people living in settlements and cities and institutions linked to urban management and development; environmental organizations, rural and urban planning institutions, etc.

The review of the 38 large-area assessments showed that the TOF concept is just beginning to be considered in national assessments.

Recent progress has included:

✓ One global scale TOF assessment (Trees on Farm, 2009). The results are extremely important and provide an order of magnitude of the global extent of TOF on agricultural land: approximately 10 million km² (or 46% of the total "agriculture land") have more than 10% tree cover.

✓ Many countries have available national assessments that provide (or may provide after data re-analysis) information on some TOF sets.

✓ Countries that have implemented the NFMA approach have successfully integrated TOF and TOF issues into their national forest (and tree) assessments. These countries may provide convincing estimates of the various variables related to the TOF resources, although their precision could be greatly enhanced by an increase in sampling intensity.

✓ Countries have implemented assessments of their tree and forest resource that are so detailed that they may provide estimates of biophysical variables related to TOF. A few countries have undertaken specific TOF assessments. These countries show that assessing TOF at national scale is possible, and that there are no insurmountable technical or methodological obstacles as long as TOF categories are consistent and the assessments organized in a complementary way.

Assessing TOF does not require methods radically different from those used in assessing forests: Low- and high-resolution remote-sensing images are used in the same way. Sampling for inventory proceeds the same way as for forests. Field inventory protocols and survey questionnaires are similar to those used for forest. Sampling, field inventory protocols and survey questionnaires could require adaptation, just as they do for certain kinds of forest in a forest assessment (for instance savannah woodland, rubber plantations and Acacia mangium plantations).

There is no methodological or technical obstacle to large-area TOF assessments. Furthermore, this report sets up a rigorous and operational land classificatory framework that includes TOF.
It is essential to acknowledge the range of land uses that involve TOF for:

- ✓ Building an efficient and legitimate institutional framework. Assessments need an ad hoc multi-sector institutional framework that includes the forest sector and the sectors that are legitimate for the other TOF sets (environment, agriculture, rural development, transportation, city planning, etc.).

- ✓ Setting up a sound land classificatory framework adapted to local reality, so that the land-use/land-cover classes explicitly allow unequivocal assessment of TOF sets and subsets.

Credibility of results requires sound protocols and sampling schemes, pre-evaluated by statisticians, to ensure that they will (1) yield credible results, (2) achieve the desired allowable error estimates for the targeted state and change estimates, (3) permit statistically defensible assessment of uncertainty, and (4) permit assessment of quality assurance and control.

The national TOF assessments reviewed in Chapter 3 provide useful models, much as pioneer national forest assessments were. Still, adaptation to national targets and ecological, social and economic situations are required, keeping in mind that different methods provide different kind of results.

Recommendations

Four major recommendations result:

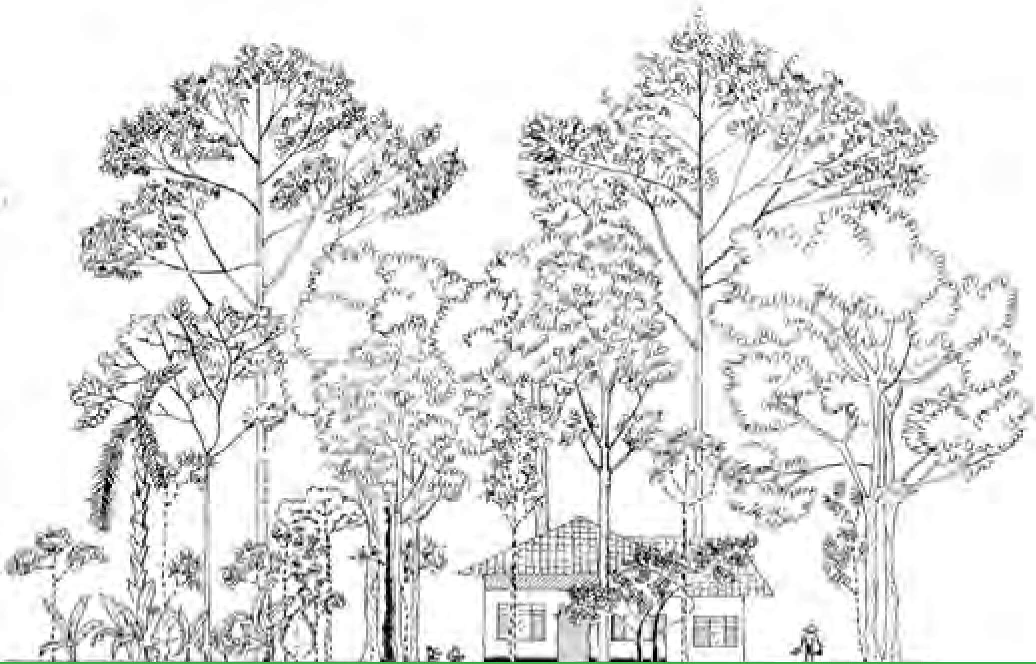
1. Carry out national TOF assessments. This report provides all the practical keys necessary. Due to the importance of the TOF issue for the three international conventions (CBD, UNFCCC and UNCCD), countries that need assistance and guidance can look for support by the international community. If political will is there, no reason can now prevent a country to assess its TOF.

2. Clarify FAO-FRA position regarding global TOF assessments. At FAO, the Agriculture and Consumer Protection department compiles national statistics on major non-timber tree crops (which are TOF), but the FRA programme is currently the only international programme that explicitly compiles national information on TOF. Three options for improving this might be:
   - The FRA programme sets up an ad-hoc multi-sector committee in charge of TOF national reporting,
   - FAO sets up a new ad-hoc TOF Resources Assessment programme including experts from the relevant departments.
   - A combination of the above options, with the initial multi-sector committee under the FRA programme becoming an independent programme once national and international TOF assessments reach a certain threshold.

3. Take action for FRA 2015. It is very important that efforts to integrate information on TOF in the regular assessments of global forest resources be continued in FRA 2015. The FRA programme should refine the definitions of a few terms so that in practice the frontier between Forest, Other Wooded Land, and Other Land with TOF can always be objectively defined. This is urgently needed because remaining ambiguities in terms may spell some doubts on the forest data reported in the last global forest assessments. Three technical improvements are thus recommended for FRA 2015:
   - Reduce subjectivity in national reporting to FAO-FRA: Improve the definitions, especially "agricultural use," "urban use" and "abandoned shifting cultivation."
   - Improve country reporting on the extent of Other Land With Tree Cover. Only a few countries can, at this stage, contribute relevant data to a global TOF assessment that would encompass more than the most basic variables. Rather than add new variables, it is more effective to ensure a higher response rate from countries on the extent of OLwTC. Early involvement of national agricultural and urban services is recommended.
   - Develop a global TOF assessment in the FAO FRA Remote Sensing Survey. The FRA Remote Sensing Survey has been instrumental in improving regional and global data on forests. A pilot study could build on the Global FRA Remote Sensing Survey and on the RSS data already available to do a first approximation of a global estimate of Other Land with TOF.

4. Set the goal and adopt a way forward. In view of the growing importance of TOF issues globally, it is necessary to define clear objectives for a global TOF assessment, like that done for the global assessment of forest resources. This report recommends that the programme responsible for TOF at FAO soon organizes an expert consultation meeting for:

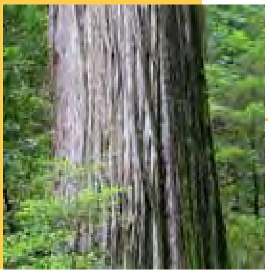
- Refining the seven themes proposed in this report (see Part 1, Table 2) as a basis for the development of a global framework for TOF resources assessment,
- Setting up a step-by-step agenda with realistic targets for further global TOF resources assessments.



Part 1: Towards Assessing Trees Outside Forests: Why, what and how?

Content

1. Background and Rationale



1.1. Trees and Forests: Two facets of the same resource

In human-influenced landscapes where ecological conditions are favourable to tree growth, trees can be found in a wide range of situations and spatial patterns.

This first section builds on a selection of high resolution satellite images freely accessible on the Internet via Google Earth, to help showcase some of the different tree-forest arrangements in relation to their environmental and socio-economic context, along with the various goods and services they provide.

Trees and forest on the same farm

In image 1 above (Normandie, France, 240 m asl), trees on the right side form a forest, a large, compact and dense block of trees. In the agricultural mosaic that spreads on the left side, trees are also present, although at a much lower density than in the forest. Lines of trees have been planted along the road at the far left, and on the borders of cropfields and pastures. Apple trees have been planted on grazing land in the two farms on the left. Trees are present in the private gardens of every farm in the image. Two small woodlots with poplar trees are adjacent to the forest.

In a rural environment like the one depicted above, each farmer manages his/her homegarden and agricultural land. In France about 75 percent of the forest is private, so farmers may also own and manage a piece of forest land. The above example shows trees in four major treed land uses: forest, hedges bordering cropfields and pastures, fruit orchards, and homegardens. Trees in such a mosaic are managed differently according to each land-use. Trees in the forest are managed primarily to produce high value timber and fuelwood, for home consumption or for income. Tree hedges along fields' borders are spatial markers of ownership but are also often managed as living fences and for fuelwood. Apple trees are managed for fruit but also provide shade for cattle. In homegardens, people manage trees for fruit, shade, and aesthetic values.

Trees thus provide a variety of products and services, some of which are independent of land use while others are land-use specific.

In the example above, the forest does not provide apple fruits, but it does ensure certain biodiversity functions, such as niches for some rare herb and bird species, functions that cannot be provided by any other land use. Moreover, although some products and services provided by trees are the same in every land use, their amount or intensity generally depends on the land use. The forest in image 1 provides much more timber and fuelwood per unit-area than the tree hedges.

Trees on farm and restricted access forest

In many rural areas forest is present but inaccessible to farmers, for example along borders of forest concessions, forest reserves or national parks. Therefore farmers can only rely on trees they grow on their agricultural land and in their homegardens.

In image 2 above (Kericho, Kenya, 2040 m asl), the dense and compact tree cover on the left is protected forest. Outside the forest, trees appear in homegardens, isolated or in small groups in some fields, as hedges, in a narrow discontinuous line along the small river, and also along the road. As in the first example, trees accessible to farmers provide a variety of products and services such as ownership boundaries, fencing, shade, fertility maintenance, and erosion control.

In images 1 and 2, trees in forest and trees outside forests under their various spatial patterns provide complementary products and services. In image 1 they are complementary at both farm and landscape level but only at the landscape level in the second image. Trees in forest and trees outside forests may be considered as two facets of the same resource.

No forest but trees on farms: areas with potentially dense tree cover

In many rural areas, forest blocks have disappeared, but trees often are still present in the landscape, and sometimes in large amounts. This is the case in many countries where forest was converted to other land uses with increasing density of human population. The lowlands of Sumatra, Indonesia, were covered by dense tropical rain forest one century ago, but are today a mosaic of agricultural land with lots of trees planted by farmers.

In image 3 below (Tanjung Moravia, North Sumatra, 40 m asl), the left half is the dense tree cover of an oil palm monoculture plantation. Paddy fields on the right are almost devoid of trees. Trees in homegardens and multistrata agroforestry systems form a dense cover between the paddy fields and the oil-palm plantation. This is typical of many areas of the Sumatran lowlands, where trees are found in huge numbers, in monoculture plantations (oil palm, rubber, Acacia), homegardens, and multistrata agroforestry systems (Tomich et al., 2002; Feintrenie et al., 2010; Broich et al, 2011). The trees that replaced the forest provide similar environmental services (e.g. soil protection, water regulation, carbon sequestration) but in lower amounts and with one important exception –biodiversity conservation. Forest conversion led to the disappearance of most forest animal and plant species and loss of diversity (Michon et al., 2007; Fitzherbert et al., 2008; Sodhi et al, 2010; Schroth and McNeely, 2011).

Another land use – agroforest – that replaced the initial forest is worth mentioning, although its area is currently declining in Sumatra (Kusters et al. 2008; Ekadinata and Vincent, 2011). In image 4 below (Muara Bulian, Jambi Province, 35 m asl), apart from the homegardens near houses, the entire landscape is occupied by rubber agroforest plots at various stages of development, with the clearings representing the initial phase of a new cycle expected to lead to the mature and productive agroforest that currently occupies most of the area.

The diverse tree species assemblage established by farmers in agroforests (such as rubber agroforests or damar agroforests) ensures vital economic services. In addition, contrary to the other treed land uses, agroforests provide habitat for many forest animal and plant species, ensuring significant biodiversity conservation (Michon and de Foresta, 1992; Beukema et al., 2007; Bhagwat et al., 2008; Idol et al., 2011).

No forest but trees on farms: areas with limiting tree growth conditions

Trees may also occur in agro-ecosystems with limiting growth conditions (dry lands, cold mountains, highest latitudes), resulting in low tree densities in the landscape. In drylands, trees are always present where environmental conditions allow, and they offer vital economic, environmental and sometimes cultural and religious functions (Boffa, 1999; Faye et al., 2011). In image 5 below (Syoro, Burkina-Faso, 330 m asl), trees either isolated or in small groups are everywhere in this agricultural and settlement landscape. This is representative of the agroforestry parklands that spread all over the Sahelian zone. Often labelled as forest by foresters, these agroforestry parklands are the result of a long intergenerational history of management by local people who selected and favoured the various tree species most adapted to their needs (Boffa, 1999).

Trees in cities

Trees are also commonly found in villages, towns and large cities. According to the United Nations Population Fund (UNFPA), for the first time in history more than half the world population is living in towns and cities. The urban population will likely grow to 4.9 billion by 2030, while the world's rural population is expected to decrease by 28 million by then (UNFPA, 2007). As cities grow they include in their spatial expansion an increasing number of rural areas, sometimes endowed with forests (Yuan Wang et al., 2009; Lugo, 2010; Nowak et al., 2010; Weiqi Zhou et al., 2011). When forest areas become city parks, they lose their production function but keep most of their environmental services function and gain a "greening" function, much valued in areas dominated by buildings and houses (e.g. Konijnendijk et al., 2005). Even cities that do not include forest areas are never treeless (except maybe in the most extreme dry climatic conditions), with trees planted and managed for aesthetic and environmental values: in private gardens, along streets and in public parks. Trees provide vital services to city dwellers such as moderation of microclimate, pollution and flooding, and a "green" environment conducive to good health (e.g. Bowler et al., 2010). On urban peripheries with fewer constraints on space, people also manage trees in private gardens for fruit production (Eriksen-Hamel and Danso, 2010; Lovell, 2010).

Image 6 below (Mexico-city, Mexico, 2230 m asl) shows that even in megacities , trees are present, often in large numbers.

The satellite images presented in this section show that:

- ✓ Trees occur mainly in three land uses: forest and natural woodlands, agricultural lands and urban lands,
- ✓ Trees grow under three main patterns: compact blocks, scattered in the landscape and in linear formations.

Whether trees are part of a forest formation or appear under any of the many spatial patterns found outside forests in rural and urban areas, trees offer numerous environmental, social, cultural, aesthetic, and economic services and vital products - fruit, oil, gum, resin, fodder, medicine, timber, fuelwood - essential for the livelihood of billions of people all over the globe.

1.2. Forest and Non-Forests: A history of dividing the resource

In most countries, a distinction between "Forest" and "Non-Forest" (other land uses) is made. This distinction most often results from a long history, involving production, management, and environmental considerations, but also involving resource control considerations (Ribot, 1999, 2001; Barton, 2002; Williams, 2003; Fay & Michon, 2005; Peluso & Vandergeest, 2011).

This distinction, translated into the legal, policy and institutional framework, generally led to the formalization of various criteria for classifying a given area as forest. These criteria are extremely diverse and their combinations vary from one country to another (Lund, 2002). The combinations usually involve land use or/and land-cover criteria, but may also involve ownership criteria.

One major impact of the line drawn between forest and non forest has been a corresponding divide between institutions dealing with forest resources and institutions dealing with other land uses, even when these land uses include trees (Fay & Michon 2005). A second major impact has been that interests regarding trees and tree products and services have concentrated on the forest side of the divide, with forestry institutions in charge (Van Noordwijk et al 2008). On the other side of the divide, institutions in charge of agriculture, rural development and rural planning historically prioritized crops and livestock and considered trees most often as a minor component, even where trees were vital for the livelihoods of many.

Forestry institutions over time developed ever more sophisticated methods to inventory, assess and monitor trees in forest and the products and services they provide (Tomppo et al., 2010). On the other side of the divide, agriculture institutions developed methods to inventory, assess and monitor crops and livestock, ignoring trees on farmland except when they belong to the quite restricted "tree-crops" category. Many of the maps realized by forestry on one part and by agriculture or rural planning institutions on the other part appear as a caricature of the divide: forests are reported under a number of categories and with a luxury of details in forestry maps, while other land uses appear as "terra incognita" and are often merged into one or a few "black boxes" called "unused land", "agriculture land" or "other land" (Harley, 1988; Vandergeest, 1996; Walker & Peters, 2001;). This is the reverse for maps prepared by agriculture or rural planning agencies, with many different agricultural land-use categories that generally superbly ignore the tree component except for "tree crops", and only one category for forest.

The FAO-FRA land classification system is no exception, with all land uses other than Forest and Other Wooded Land being encompassed in the “Other Land” category (FAO 2010a,2010b).

Only relatively recently has appeared the need to bridge that historical divide, need fueled inter alia by the development of agroforestry with its explicit acknowledgement of the importance of trees on farm and its difficulties in finding its niche because of the institutional divide (Nair,1998; Montambault & Alavalapathi, 2005; Valdivia et al. 2012). Even more recently, the pressure for bridging the divide soared because of rising global issues such as climate change mitigation with the appreciation of the role of trees – inside and outside forests- in carbon sequestration, and poverty alleviation with the acknowledgement of the livelihood importance of tree products and services (Nair, 2011; Schroth et al., 2011; Stringer et al., 2012).

The FAO-FRA programme acknowledged this need to bridge the divide and to better take trees that are not located in forests into account. In particular, its land classification system has evolved since 2005 with the introduction of “Other Land with Tree Cover”, a new subcategory of “Other Land” that includes part of the trees outside forests. The present report is another effort in this direction.

1.3. Reporting for managing, planning and monitoring – Why, Who and How?

The needs for planning, monitoring and evaluating at various levels

Why assess trees and forests at the farm level?

In a farm composed of various land-use units, the farmer consciously or unconsciously integrates in day-to-day management the assessment and monitoring of the state and health of the various farm components, including the trees. This monitoring is crucial to the good functioning of the farm in the short run, allowing the farmer to efficiently plan its activities, for instance the harvesting of a crop, the pruning of trees, or the cutting of trees for fuelwood or timber. Assessing trees and forest resources on a farm is also important for planning and managing the evolution of production in the long run, in accordance with the expected changes in the needs and constraints of the farmer and his/her family. For instance, the farmer could plan to convert one field into a small woodlot with high value timber that would involve less labor and build a patrimony for her/his children.

Why assess trees and forests at sub-national and national level?

In a district, a province or a country, policy and decision-makers at each level need to know the state of the resources present in their constituency in order to plan their management on a sound basis. They need to know the location, amount and production of each resource, and their contribution to the economy and livelihoods of local communities, and their economic, social, cultural and environmental values. They also need to know the past changes in these different parameters, in order to make informed hypotheses regarding expected

trends. With growing appreciation of information and openness in society, policy makers also increasingly need to show voters that their interests are taken into account, that detailed assessments are made, and that results of these assessments are effectively communicated to the public.
In most countries, at sub-national and national levels, forests have a special status that distinguishes them from all other land uses, with the institutional consequences mentioned above. Forestry services assess and monitor the tree resource in forests, with integration of data up to the national level. Agricultural services assess trees on agricultural land (often limiting their assessment to monoculture "tree-crops"). Here also, reports are integrated up to the national level. Trees in cities are generally assessed by municipal services, but in general reports are not integrated up to the national level.

On the basis of these reports prepared by the various sectors, most often with little connection between sectors, sub-national and national governments may take decisions that impact resource management, for example introducing payments for environmental services (PES) to farmers who grow trees in contour lines for controlling erosion and run-off in mountainous areas. They may also take planning decisions such as launching a woodlot development program with the aim of being self sufficient in timber and fiber products in 30 years.

Assessing and monitoring trees and forests at these policy levels uses methods and financial resources that are very different from those used at the individual farm level. The main purposes are however the same in both cases: management and planning.

Reporting to international organizations and international conventions emerged over the last half century as another important reason for assessing and monitoring tree and forest resources at the national level.

Why assess trees and forests at supra national and global level?

Countries do not live in isolation. Adjacent countries often share the same climate and environmental conditions and therefore often share similar problems regarding the management of their tree and forest resources. For instance, countries in the Sahel region share some of the same environmental constraints linked to a hot and dry climate with irregular annual rainfall, which may easily lead to the degradation of fragile socio-agro-ecosystems developed by local communities.

The sustainability of local socio-agro-ecosystems is almost everywhere dependent on the presence of trees and forests and of their wise management. But this dependence is nowhere more intense than in the Sahel where trees can make precious underground water resources accessible to crops (Bayala et al., 2008; Asbjornsen et al., 2011), the starting point for food production and human livelihood. Because they share not only the same environmental constraints and problems, but also the same kind of socio-agro-ecosystems adaptations where trees have a crucial role, it is clear that to understand and manage tree and forest resources, countries in the Sahel would benefit from a regional assessment and/or integration of their national assessments regarding these resources. Based on such a regional assessment, countries could compare their national policies and identify policies that re-enforce the sustainability of socio-agro-ecosystems.

While such regional assessments are still utopian for most regions, almost all countries do join together to carry out regional and global assessments under the auspices of the United Nations. In doing so, they fulfill their obligations as signatories of one or more of the three international conventions that relate directly to forests, trees and other biological resources: the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention on Biological Diversity (CBD), and the United Nations Convention to Combat Desertification (UNCCD). The three conventions underpin the Rio Declaration on Environment and Development, which laid down principles for responsible resource utilization and conservation, and which underlined International cooperation as essential for efficiency and equitable global economy (Keating, 1993).

As demonstrated below, management of forests and trees is important for the implementation of all three conventions.

UNFCCC

The forestry sector (including deforestation and associated land-use change) contributed 17.4 percent of the world's total annual greenhouse gas emissions in 2004 (IPCC, 2007). Natural forests are declining world-wide and especially in the tropics through conversion to agriculture. Recent research has shown that tree cultivation is expanding rapidly on farms and that almost 50 percent of the agricultural land worldwide has at least 10 percent tree cover (Zomer et al., 2009). These trees on agricultural land may not be able to provide all the environmental goods and services that could come from well managed forests. However, they do provide a measure of carbon sequestration, and can inter alia, increase the capacity for farmers not only to adapt to the effects of climate change, but also to contribute to their mitigation. UNFCCC's COP 16 in Cancun Mexico (2010) came up with interesting developments on REDD+ where SBSTA (Subsidiary Body for Scientific and Technological Advice) was asked to develop a work programme on drivers of deforestation, along with MRV (measurement, reporting and verification) protocols (UNFCCC, 2011). One important driver of deforestation is agriculture. Considering that there are global efforts to intensify tree cultivation on agricultural land, the impact of such efforts will have to be included in the MRV protocols. This creates the need to have robust methodology for inventorying and monitoring trees in agricultural and other landscapes. Baseline data are needed to help establish the current status and thereafter periodic monitoring of tree resources would reveal landscape level changes in stocking, leakages, etc.

CBD

Under the Convention on Biological Diversity (CBD), COP 10 in Nagoya Japan (October 2010) adopted the Aichi Target where, by 2020, the world would at least halve the rate of loss of natural habitats, (including forests), protect 17 percent of terrestrial and inland water areas and 10 percent of marine and coastal areas; and restore at least 15 percent of degraded areas (Djoghlaf, 2010). Countries are translating this overarching framework into national strategies and action plans. The latter include the planting of vegetation in different landscapes. Actions to support the Aichi Target are expected largely at sub-national and local levels; this requires measuring and monitoring efforts.

UNCCD

The United Nations Convention to Combat Desertification (UNCCD) includes measures to prevent and /or reduce land degradation, rehabilitate partly degraded land and reclaim desertification areas. Large areas of Africa, Asia, Australasia and the Americas are identified as highly vulnerable to desertification. Among other measures, one strategy is the planting of trees and shrubs in a variety of formations to conserve soil and water and restore ecological functions. Many countries promote the use of leguminous plants to restore soil fertility.

The Great Green Wall for Sahel and Sahara Initiative (GGWSSI) was conceptualized as a green belt of trees and bushes 15 km wide, and up to 8 000 km long, stretching across Africa from Djibouti to Senegal (OSS & CEN-SAD 2008). Eleven Sahelian countries (comprising Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal and the Sudan) and their international partners saw this as way to mitigate desertification along the southern border of the Sahara desert. In practical terms, this 'wall' is planned to be built out of multifaceted international economic and environmental programmes.

> Similar initiatives are taking place in different parts of the world to implement UNCCD programmes and other greening efforts. It is important to be able to monitor the resources generated by these initiatives and to provide guidance on how best to manage them.

Despite the obvious linkages among the three conventions (UNFCCC, UNCBD and UNCCD), their organizational structures and mechanisms for implementation are not closely coordinated. Two interventions that are common to all three conventions are 1) supporting the regeneration of natural vegetation and 2) planting trees in various landscapes. National assessment and monitoring of the tree and forest resources are thus needed to provide statistics that demonstrate response to all three conventions and to measure progress in the management of trees and forests.

UN Member Countries also contribute to global forest and agriculture assessments undertaken on a fairly regular basis by FAO. Data produced through national assessments are used to produce regional and global synthesis on the state of the resources and their evolution. Such regional and global assessments are needed for monitoring the evolution of forest and agriculture resources, for identifying the contribution of each country and region to the objectives of sustainable development at world level, and for planning international support programmes for countries and regions that need assistance from the international community for more sustainable management of these resources. While methods and tools used for the assessments are clearly different from the farm, the sub-national and the national level, the purposes are the same: monitoring and planning.

1.4. FAO-FRA Role regarding Trees outside Forests

FAO-FRA Process for "Forests and Other Wooded Lands" – from 1946 to 2010

The objective of the Global Forest Resource Assessment programme (FRA) is to provide the data and information needed to support policies, decisions and negotiations in all matters where forests and forestry play a role (FAO 2010a). Since 1946, FAO publishes and shares global, regional and country information on the state of forest resources. Most of the data are contributed by member countries. Collating such data at global scale is a huge challenge, and FAO gradually acquired the expertise needed for this challenge, especially regarding consistent definitions, data collection methods and levels of precision. For instance FAO has organized numerous meetings with national and international experts to develop a global consensus regarding the terms and definitions needed for the global forest assessments (FAO, 2003, 2005).

FAO/FRA's assessment objectives, methods and requested information have improved in every successive run. In particular, FRA has adjusted to the evolving needs of countries and the increasing trends of deforestation and plantation forestry in the context of globalization, along with the emergence of biodiversity loss, carbon sequestration and poverty alleviation as global issues. In response to country needs and international needs, FAO has gradually integrated these themes into the FRA reporting framework proposed each five years to countries, and also into forest resource assessment programmes, such as the National Forest Monitoring and Assessment (NFMA) programme (http://www.fao.org/forestry/nfma/en/). FRA has also adjusted to the growing capacity of national institutions for collecting and analyzing the information requested by users, gradually increasing the number of parameters in each theme, in recognition of their complexity.

These changes and improvements may be seen in the FRA 2010 global report, in which:

- ✓ A total of 233 countries and territories, grouped in 12 geographical regions were included.
- ✓ The reporting framework was based, as for FRA 2005, on the concept of sustainable forest management, which encompasses social, economic and environmental dimensions of forest resources that are assessed through 17 key variables (see Table 1).
- ✓ Close collaboration with other reporting processes helped to avoid duplication of effort for variables that are reported to several agencies. For example, further streamlining of reporting to FAO, the International Tropical Timber Organization (ITTO) and the Ministerial Conference for the Protection of Forests in Europe (now Forests Europe) was achieved.
- ✓ New variables enabled the assessment of progress towards the 2010 Biodiversity Target of the CBD and towards the four Global Objectives on Forests of the Non-legally Binding Instrument on all Types of Forests adopted by the United Nations General Assembly at its 62nd Session (UNGA, 2008).
- ✓ Methods for reporting on variables related to forest biomass and carbon were harmonized with the latest specifications and guidelines of the Intergovernmental Panel on Climate Change (IPCC, 2006).
- ✓ Efforts have continued to establish and maintain globally consistent definitions in the FRA process, in order to ensure consistency over time and reduce the reporting burden on countries.

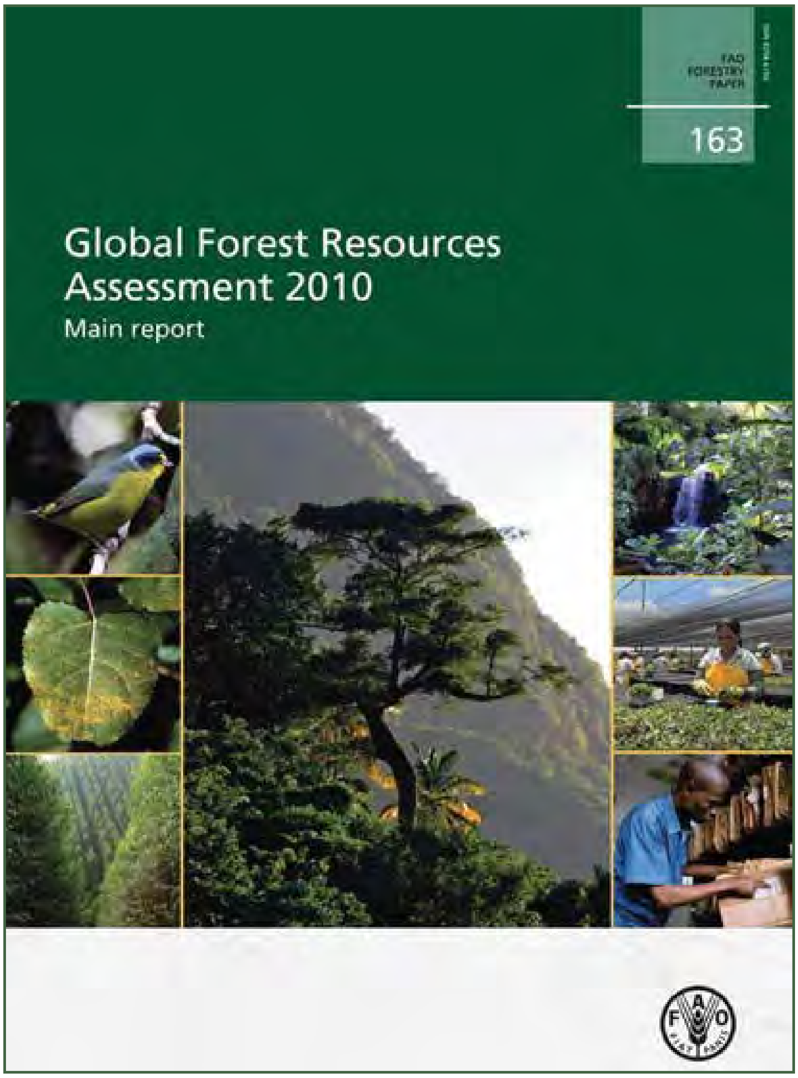


Table 1: FRA 2010 reporting tables and their links to the thematic elements of sustainable forest management (source: FAO 2010a. Table 1.1, p 4)

	Thematic elements						
Table 1	Extent of forest resources	Forest biological diversity	Forest health and vitality	Productive functions of forest resources	Protective functions of forest	Socio-economic functions of forest	legal, policy and institutional framework
1. Extent of forest and other wooded land	✓	✓		✓			
2. Forest ownership and management rights						✓	✓
3. Forest designation and management		✓		✓	✓	✓	✓
4. Forest characteristics	✓	✓		✓	✓		
5. Forest establishment and reforestation	✓	✓		✓			
6. Growing stock	✓	✓	✓	✓			
7. Biomass stock	✓	✓		✓			
8. Carbon stock	✓			✓			
9. Forest fires	✓	✓	✓	✓	✓		
10. Other disturbances affectiong forest health and vitality	✓	✓	✓	✓	✓		
11. Wood removals and value of removal				✓		✓	
12. Non-wood forest products removals and value of removal				✓		✓	
13. Employment						✓	
14. Policy and legal framework							✓
15. Institutional framework							✓
16. Educational framework							✓
17. Public revenue collection and expenditure						✓	

FRA and Trees Outside Forests – 2000, 2005 and 2010.

The concept of "Trees outside Forests" emerged in 1995 to designate trees growing outside the forest and not belonging to Forest or Other Wooded Land (Bellefontaine et al., 2002). At that time, "attention tended to focus on the various components of this rather diffuse resource: agroforestry, silvopastoralism, urban and rural forestry, and other related disciplines. Trees outside forests were also overlooked in natural resource assessments, absent from statistics, policy and legislation, and barely mentioned in the public discourse" (Sène in Bellefontaine et al., 2002).

"The great promise of the sector for sustainable natural resource development and integrated forest, agricultural, pastoral and urban land management" (ibid 2002) prompted the Expert Meeting on Global Forest Resources Assessments, held in 1996 in Kotka, Finland (Kotka III), to recommend that FAO pursue hard data on trees outside forests (ibid 2002).

In response to these recommendations, the Trees outside Forests issue was included into the Global FRA 2000 process. FAO held an expert consultation on "enhancing the contribution of Trees outside Forests to sustainable livelihoods" in Rome in

November 2001, and various reports and publications were produced: an issue of Unasylva (vol 51-200) dedicated to Trees outside Forests, 2000-2001; Trees outside Forests – Towards rural and urban integrated resources management, FAO 2001b; the proceedings of the expert consultation (Sadio et al. eds, 2002); a training manual on inventory of trees outside forests (Rawat et al. 2003); and the FAO Conservation Guide 35, Trees outside Forests – Towards better awareness (Bellefontaine et al., 2002). The FAO Forestry Department also conducted regional training workshops such as a workshop on "Assessment of Trees outside Forests (TOF)" held in April 2002 in Dehradun, India (FSI, 2002), and carried out a project on "the role of planted forests and trees outside forests in landscape restoration in low forest cover countries" (FAO 2004).

In parallel with these efforts to raise awareness about Trees outside Forests, the FAO Forestry Department took two important initiatives that support the integration of Trees outside Forests into national assessments: it included Trees outside Forests into the programme developed to provide support to national forest monitoring and assessment (NFMA); and, In a first attempt to capture information on TOF at the national level, the FRA programme included a line on Other Land with Tree Cover, a subset of Trees outside Forests, –-in the country reporting tables to FRA (FRA 2005 and FRA 2010a).

By 2010, the FAO NFMA programme had directly supported more than 15 countries that have implemented national field inventories inside and outside forests (http://www.fao.org/forestry/17277-0404ecd56baa7684da1943aef014e4029.pdf). The number of countries and territories that filled the Other Land with Tree Cover (OLwTC) line increased from 61 in FRA 2005 to 77 in FRA 2010. In the meantime, research in agroforestry and urban forestry has gradually built a solid scientific corpus that demonstrates the importance of trees outside forests for the environment and for people's livelihoods (Konijnendijk, 2003; Jim and Chen, 2009; Idol et al., 2011; Schroth & MacNeely, 2011). However concerns remain about the scarcity of hard data on Trees outside Forests, especially at sub-national and national levels. For that reason the latest Expert Meeting on Global Forest Resources Assessments (Kotka 5, 2006) renewed its recommendation for more efforts and FAO-FRA included a thematic study on TOF in its FRA 2010 assessment.

1.5. Towards a comprehensive assessment of the tree and forest resources: "Wooded Lands" (Forest + OWL), and "Trees outside Forests" (on Other Land).

With the diversity and quality of data collected for the global forest resource assessments improving over time, the situation for TOF today may be compared to the situation for forests when FAO began its first assessments in 1945 (FAO, 1948). Growing acknowledgement of the potential economic importance of TOF, and recent political interest in their environmental services, could help improve the situation in the same way that forests gained attention. If the right steps are designed and efforts are made, a global assessment of TOF could well take place in a not-so-distant future, a global assessment with the same level of detail and quality as the current assessment of forest and other wooded land.

The themes that structure the FRA for Forest and Other Wooded Land are also relevant to TOF with some adaptations. These themes are embedded in the concept of sustainable forest management, and they encompass the social, economic and environmental dimensions of the forest resources. Similarly, the themes structuring a global TOF assessment should be embedded in the concept of sustainable management and should encompass the social, economic and environmental dimensions of the TOF resources. It is possible to propose a mirror theme for each of the seven themes developed for the FRA 2010 assessment, as in Table 2. For some themes the variables to be reported are straightforward. For instance, for "Extent of TOF resources," one just has to replace "forest" by "TOF" in the three main variables for the FRA 2010: area with TOF, growing stock of TOF, and carbon stock in living biomass. But for other themes such as "Biological Diversity", replacing "forest" with "TOF" in the variable makes no sense. What would be an area with "primary TOF"? It is however possible to find variables with a strong meaning relative to the theme. For instance, agroforestry systems such as agroforests and parklands allow conservation of many plant and animal species; the area covered with such systems could be proposed as an indicator of the contribution of TOF to biological diversity. This is what is proposed in Table 2.

It is important to note that the proposed variables in Table 2 are only indicative of what could be done. A collective effort will need to carve out the most relevant and informative variables for each theme, a collective effort similar to the participatory process implemented for years by FAO to improve the data collected on forests for the global FRA.

Table 2: The 7 FRA 2010 themes, their associated variables, and their proposed equivalent for a future global TOF Assessment (adapted from FAO 2010a. Table 1, p. xxviii)

Themes for FRA 2010	Proposed themes for a global TOF assessment
Extent of forest resources • Area of forest • Growing stock of forests • Forest carbon stock in living biomass	**Extent of TOF resources** • Area with TOF ◦ Area with TOF on agricultural land ◦ Area with TOF on urban land ◦ Area with TOF on non urban/non agricultural land • Growing stock of TOF • Carbon stock in living TOF biomass
Forest biological diversity • Area of primary forest • Area of forest designated primarily for conservation of biodiversity • Area of forest within protected areas	**TOF biological diversity** • Area of TOF systems with high biodiversity value such as agroforests and agroforest parklands • Number of tree species involved in TOF systems
Forest health and vitality • Area of forest affected by fire • Area of forest affected by insects (and diseases?)	**TOF health and vitality** • Area with TOF affected by fire • Area with TOF affected by insects and diseases
Productive functions of forest resources • Area of forest designated primarily for production • Area of planted forest • Total wood removals	**Productive functions of TOF resources** • Total wood removal from areas with TOF • Total non wood removal from areas with TOF (by category: fruit, gum latex and resin, leaf, bark)
Protective functions of forest resources • Area of forest designated primarily for protection of soil and water	**Protective functions of TOF resources** • Area with TOF ensuring protection of soil and water
Socio-economic functions of forests • Area of forest under private ownership • Value of total wood removals • Employment in primary production of goods	**Socio-economic functions of land with TOF** • Area with TOF under private or/and community ownership • Area with TOF under State ownership • Value of total wood removals from TOF • Value of total non-wood removals from TOF • Employment in primary production of goods from TOF
Legal, policy and institutional framework • Forest area with management plan • Human resources in public forest institutions • Number of students graduating in forestry	**Legal, policy and institutional framework** • Area with TOF under disputed ownership status • Human resources in public institutions dealing with TOF • Number of students graduating in agroforestry and in urban forestry

1.6. The Present Thematic Report

Trees Outside Forests (TOF) have important economic, social and environmental implications, at local, national, and international scales. In the current context of change, their importance will increase dramatically for people's livelihoods and national economies, and also for various international processes that address global environmental and economic challenges: carbon sequestration, biodiversity loss, desertification, poverty alleviation. Yet TOF are not consistently considered in national policies and land-use planning decisions. The reason most often cited is that TOF have not been appropriately assessed so that the localization, extent, forms, natures, economic and ecological roles of the TOF resources are generally not well known beyond the local level. Assessing TOF poses different challenges than assessing forests, especially the variability and heterogeneity of TOF systems, their sometimes sparse distribution and limited spatial footprint, and complex ownership and institutional arrangements. In most countries the resulting paucity of TOF data accessible to managers and policy makers limits the choices on tree-related investments at every level from sub-national to national and international levels.

Through the Expert Consultation on Global Forest Resources Assessments (Kotka V, June 2006) countries expressed their need for support with methods and techniques allowing a better assessment of TOF resources. They mandated FAO for undertaking a Thematic Study on TOF as part of FRA 2010, including the formulation of technical guidelines for better integrating TOF into the FRA 2015 reporting process. Through a focus on TOF assessment, this thematic report aims to enable the provision of information on TOF (status and evolution) in time and quality, in order to make informed decisions for the optimization of tree and forest resources for sustainable development and food security.

FAO organized an Inception Workshop on the Thematic Study on TOF, held in FAO headquarters in Rome, Italy in June 2010. In attendance were 42 experts from 17 countries, coming from governmental organizations, international (CATIE, ICIMOD, ICRAF, IFAD, IUFRO, AU Commission, World Bank) and national institutions (CIRAD, IRD), universities and NGOs (Annex 1: List of participants) to define the objectives, the scope and the development process of the study.

The workshop recommended that the study supports national agencies responsible for forestry, agriculture, environment, and rural and urban development, by providing tools and methods to assess resources of trees outside forests, their products, uses and economic and environmental functions, at a national level.

The workshop also recommended:

- ✓ that the Report should provide countries with a typology, a set of variables and a set of assessment methods for TOF that allow reporting compatibility with the main international processes such as the UNFCCC, the CBD, and the FRA;
- ✓ that the typology and list of variables for TOF should be developed through a methodology that facilitates countries to choose the level of detail they want;
- ✓ that methods used for past and current TOF assessment should be evaluated in terms of performances and costs;
- ✓ that the Thematic Study should be developed around two main tasks:

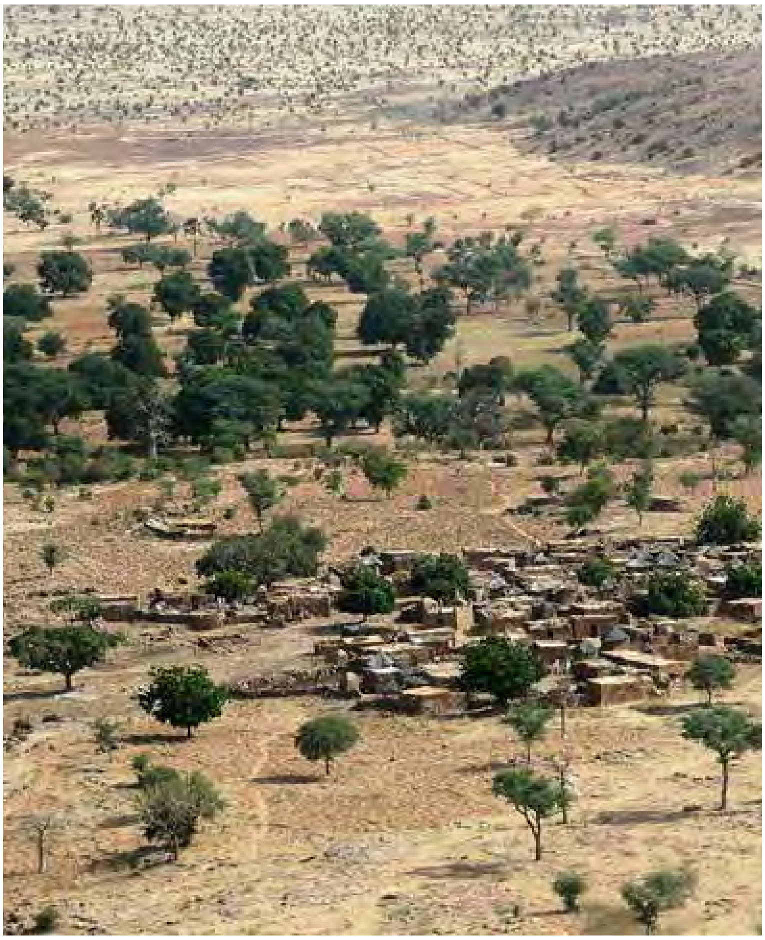
- task 1: Review past and current large-area TOF assessments as a basis for formulating technical and methodological options for countries to undertake their TOF assessments;
- task 2: Develop a conceptual framework for assessing TOF, including a typology and a set of variables on which countries can (i) superimpose their objectives and (ii) select technical and methodological options adapted to their needs and resources.

The present thematic report, written in accordance with the Inception Workshop recommendations, consists of three main parts:

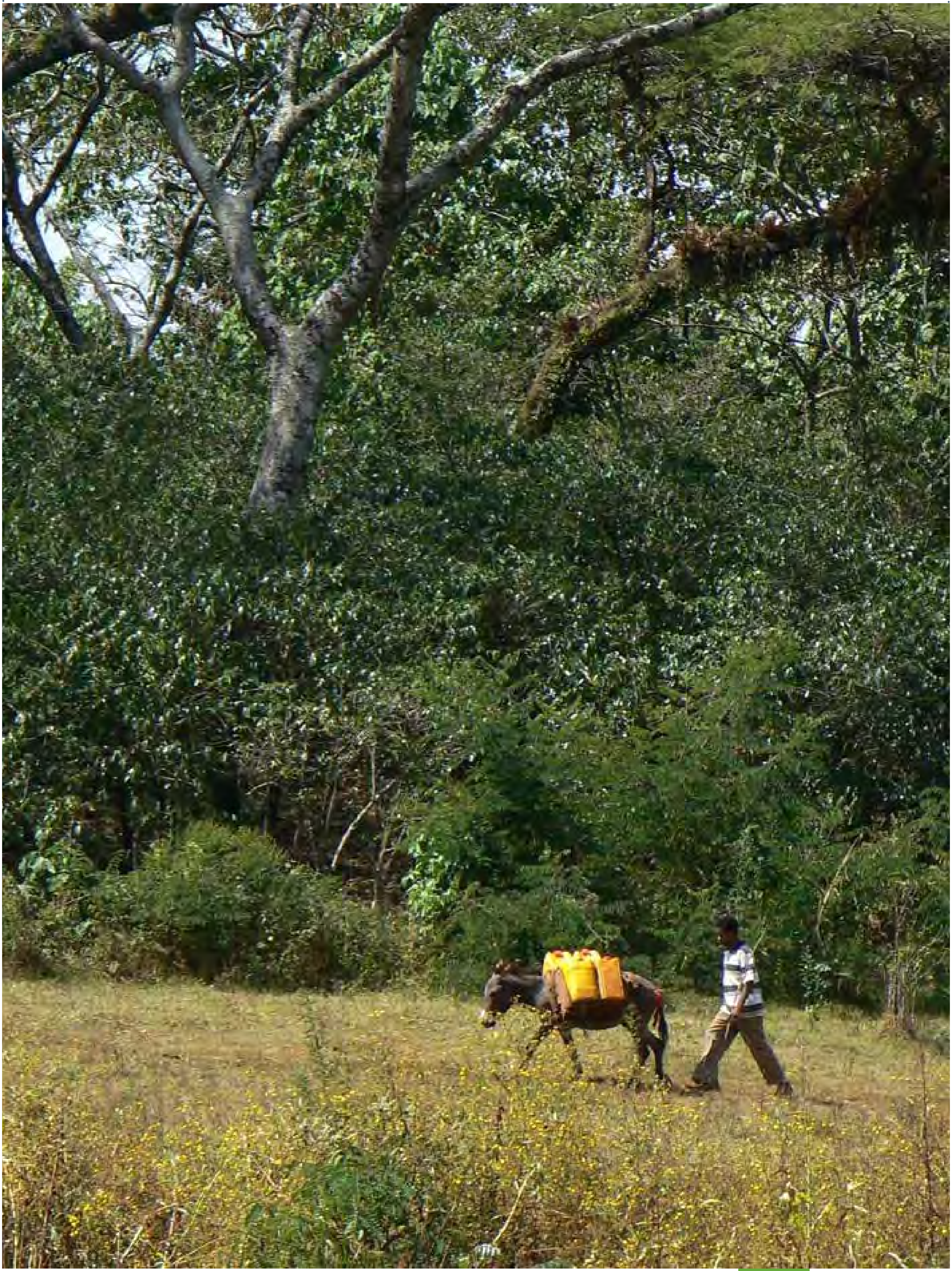
Part One is the report itself. Following this introductory chapter, Chapter 2 discusses the position of TOF and land with TOF in the FAO land classificatory framework. It proposes a formal definition of land with TOF as a subcategory of Other Land called "Other Land *with TOF*". It analyses the various subsets of this sub-category, derives a "natural" typology of land with TOF and proposes an operational definition of TOF and a decision tree tool for easy classification of any piece of land with trees using the FAO classification framework. Chapter 3 reviews a set of large-area assessments that include or may include TOF. Thirty-eight assessments using various methods and targeting different TOF groups have been reviewed including 1 global scale, 1 regional scale, 33 national scale and 3 sub-national scale. Chapter 4 builds on the results and conclusions of chapters 2 and 3 to propose options for countries that would like to implement a large-area TOF assessment, depending on their existing data, their objectives, and their human and financial resources. Chapter 5 presents the main conclusions of the study and some recommendations.

Part Two of this report is a compendium of the assessments and international support programmes that have been collected for case studies for review in Chapter 3 of Part 1. Each assessment is presented in a synthetic standardized format, with most assessments grouped by country. The 38 large area assessments correspond to 19 countries distributed over 10 of the major World regions. In addition, 4 international support programmes that may provide support for TOF assessments are reviewed and presented also in a synthetic format.

Part Three, called TOF illustrated, presents satellite images illustrating the various subsets of Other Land *with TOF* and how they can be identified. This part offers an illustrated guide to TOF, with the aim of facilitating often difficult classificatory distinctions between Forest, Other Wooded Land, and Other land *with TOF*.



2. TOF and Land with TOF



2.1. Introduction

There are many valid ways of classifying land cover into discrete, mutually exclusive categories. Similarly, there are many valid ways of defining a forest, and each country has its own definition. Regardless of which definition is used, the category "forest" never contains all the trees in a landscape. There are always trees growing outside "forest" and thus not counted when forests are inventoried and assessed.

In its endeavour to assess forest resources globally, FAO uses an internationally accepted definition of "forest" that countries likewise use in reporting to the FAO's Global Forest Resource Assessment (FRA). FAO developed another forest-like category for reporting purposes: "Other Wooded Land" (OWL). These two categories together still do not comprise all the trees, in particular trees growing on agricultural land and in settlements. In many countries, these trees fall outside both the "forest" and "OWL" categories yet they represent an important and growing share of the wood resource because of forest conversion. They also form a resource that is increasingly acknowledged as important for livelihood and the environment. Thus for the Global Forest Resource Assessment 2000, FAO - FRA coined the expression "Trees Outside Forests" (TOF) to designate those trees that grew neither in "forest" nor on "OWL".

TOF, or more precisely Land with TOF, as a category, should thus be understood in reference to the FAO-FRA classification scheme (Figure 1), and especially in reference to its two main forestry categories: "Forest" and "Other Wooded Land." The definitions of these two categories have slightly evolved since 2000[1], which means that TOF as a category has also evolved and needs to be clarified, although the definition of TOF given by FAO in Bellefontaine et al. (2002) remains valid: "Trees outside forests refer to trees[2] on land not defined as Forest and Other Wooded Land."

After this short clarification of the TOF concept, the rest of this chapter is devoted to identifying the "Trees Outside Forests" realm. It includes:

- ✓ an analysis of the definitions needed to define TOF;
- ✓ a proposed operational definition of Other Land *with TOF* as a subcategory of Other Land;
- ✓ a definition-derived typology of Land with TOF;
- ✓ the presentation of a practical decision tool for an easy and rigorous classifying of the various types of land cover with trees;
- ✓ a clarification of the position of the only TOF category currently reported in FAO-FRA (Other Land with Tree Cover) in the TOF realm.

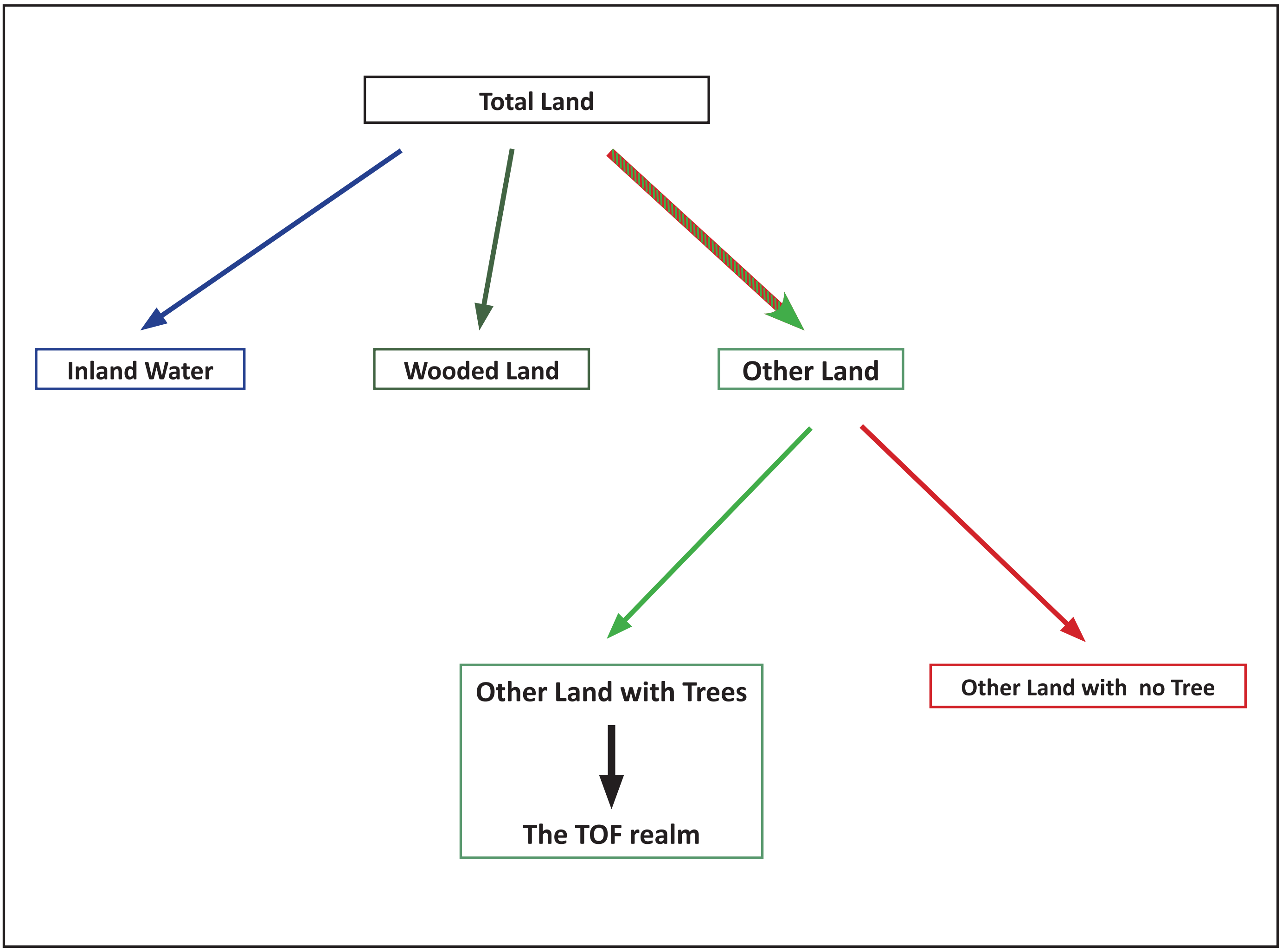
1 The definition of "forest" has strongly evolved since the first FAO international forest assessment. For instance in its 1968 World Forest Inventory, FAO defined "forest land" as "all land with a 'forest cover', that is with trees whose crowns cover more than 20% of the area and that is not used primarily for purposes other than forestry" (Husch, 1968).

2 "Tree" in this definition includes both trees and shrubs.

2.2. Defining TOF and Land with TOF

"Land with TOF" is a category defined as distinct from "Forest" and "Other Wooded Land", but also in relation with "Other Land." Definitions of these three mutually exclusive categories are thus needed to characterize the coverage of TOF and to propose an operational definition.

Figure 1: The FAO-FRA land classification framework and the position of TOF



2.2.a. FAO/FRA Definitions (FAO 2010b)

Forest *(lands) (FOR)*:

Land spanning more than 0.5 ha with trees higher than 5 m 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 m in situ.
2. Includes areas with young trees that have not yet reached but which are expected to reach a canopy cover of 10 percent and tree height of 5 m. 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 5 years. Local conditions may, in exceptional cases, justify that a longer timeframe 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 ha and width of more than 20 m.
5. Includes abandoned shifting cultivation land with a regeneration of grees that have, or is expected to reach, a canopy cover of 10 percent and tree height of 5 m.
6. Includes areas with mangroves in tidal zones, regardless of whether this area is classified as land area or not.
7. Includes rubber-wood, 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 and agroforestry systems where crops are grown under tree cover. Note: Some agroforestry systems such as the Taungya system where crops are grown only during the first five years of the forest rotation should be classified as forest.

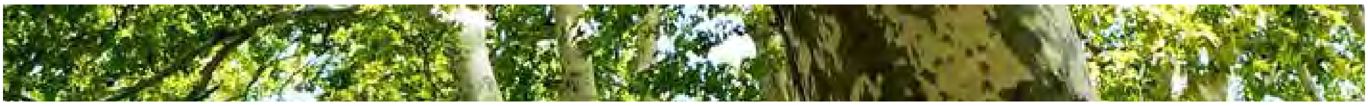
Other Wooded Land (OWL):

Land not classified as Forest, spanning more than 0.5 ha; with trees higher than 5 m and a canopy cover of 5-10 percent, or trees able to reach these thresholds in situ; 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 m or able to reach 5 m in situ.

   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 5 m in situ 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 subcategory “Other land with tree cover.”

Three terms – tree, shrub (or bush, considered here as a synonym) and canopy cover- are extensively used in the above definitions. Defining these terms (FAO-2010b) is also necessary to clarify the concepts of TOF and Land with TOF:

Canopy cover

The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of the foliage of plants. Cannot exceed 100 percent. (Also called crown closure.) Same as crown cover.

Tree

A woody perennial with a single main stem, or in the case of coppice with several stems, having more or less definite crown.

Explanatory note: Includes bamboos, palms, and other woody plants meeting the above criteria.

Shrub

Woody perennial plant, generally more than 0.5 m and less than 5 m in height at maturity and without a definite crown. The height limits for trees and shrubs should be interpreted with flexibility, particularly the minimum tree and maximum shrub height, which may vary between 5 m and 7 m.

2.2.b. Analysis of the FAO-FRA definitions

The six above terms and their definitions are necessary and sufficient to define TOF and where they are located. The following points are direct consequences of these definitions:

- ✓ TOF includes not only trees outside "Forest", but also trees outside "Other Wooded Land".
- ✓ TOF includes not only trees, but also shrubs!. In "Other Wooded Land", the cover may be made-up of shrubs that cannot reach 5 m high, as long as the canopy cover threshold is reached. This inclusion of shrubs in one of the two "forestry" categories comes in strong support of the inclusion of shrubs in TOF.
- ✓ TOF can only be found in "Other Land".
- ✓ Any tree growing in "Other Land" qualifies as a TOF.
- ✓ All trees and shrubs on land under agricultural or urban land use are TOF, including:
    - Trees and shrubs that grow on "land that is predominantly under urban land use" are TOF, because such land is excluded from the definitions of both "Forest" land and "Other Wooded Land".
    - Trees and shrubs that grow on "land that is predominantly under agricultural land use" are TOF, because such land is excluded from the definitions of both "Forest" land and "Other Wooded Land".
    - Bamboos and palms that grow on "land that is predominantly under agricultural or urban use" are TOF (see explanatory note 8, definition of "Forest", note 3, definition of "Other wooded Land", and note 1, definition of "Tree").
- ✓ TOF are also associated to some non-agricultural/non-urban land uses, including:
    - Trees – more than 5m high or able to reach this threshold in situ - that grow on "land that is not predominantly under agricultural or urban use" are TOF if the land spans less than 0.5 ha, whatever the canopy cover (see definition of "Forest").
    - Trees – more than 5m high or able to reach this threshold in situ - that grow on "land that is not predominantly under agricultural or urban use" are TOF if they form windbreak, shelterbelt or corridor less than 20 m width (see explanatory note 4, definition of "Forest").
    - Trees – more than 5m high or able to reach this threshold in situ - that grow on "land that is not predominantly under agricultural or urban use" are TOF if their canopy cover is less than 5 percent, whatever the land area they span on (see definition of "Other Wooded Land").
    - Trees and shrubs that grow on "land that is not predominantly under agricultural or urban use" are TOF if their combined canopy cover is less than 10 percent, whatever the land area they span on (see definition of "Other Wooded Land").

2.2.c. TOF typology: TOF subsets and associated tree-based systems

The TOF realm can now be inferred from the analysis above. Three major and distinct TOF sets collectively make up the TOF realm: TOF on agricultural land (AGRI), TOF on urban land (URB), and TOF on non-urban and non-agriculture land (NON A/U). The last set may itself be subdivided into four TOF subsets (figure 2).

Set 1: TOF on Agriculture Land (TOF-AGRI)

✓ TOF-AGRI includes all lands predominantly under agricultural use with trees and/or shrubs whatever their spatial pattern (in line, in stands, scattered), irrespective of area, height, strip width, and canopy cover level. It includes all agroforestry systems except those which main purpose is forestry; it includes also all non forestry tree crop plantations and orchards.

Set 2: TOF on Urban Land (TOF-URB)

✓ TOF-URB includes all lands predominantly under urban use with trees and/or shrubs whatever their spatial pattern (in line, in stands, scattered), irrespective of area, height, strip width, and canopy cover level. It includes trees in private gardens, in parks, along streets, in parking lots, etc.

Set 3: TOF on Non Agricultural/Non Urban Land (TOF-NON A/U))

✓ TOF-NON A/U includes all lands not predominantly under agricultural or urban use, and outside forests, with:

- Subset 1: small tree stands (area<0.5 ha), irrespective of trees and/or shrubs spatial organization, height and canopy cover level;
- Subset 2: linear tree formations, narrow (width <20 m), irrespective of area, plant height and canopy cover level;
- Subset 3: large stands (area ≥ 0.5 ha), trees (height ≥ 5 m) with low canopy cover level (cc < 5 percent);
- Subset 4: large stands (area ≥ 0.5 ha), shrubs and/or small trees (height <5 m) with low canopy cover level (cc < 10 percent).

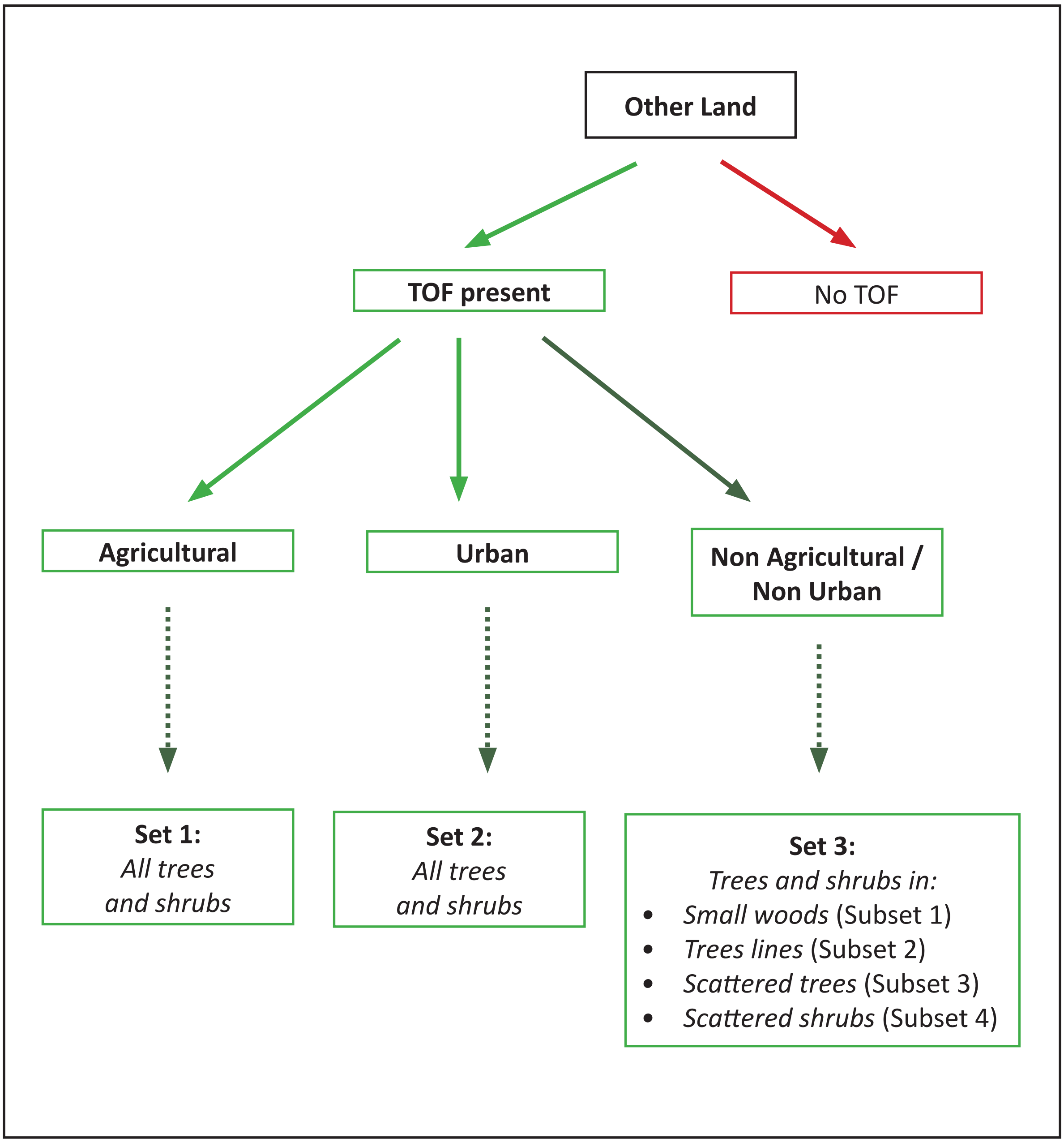
By definition all trees and/or shrubs on agricultural land (TOF-AGRI) and on urban land (TOF-URB) are TOF, irrespective of plant height, patch area, width or canopy cover. Trees on agricultural land and on land under urban use may be planted or not, and may occur with various densities and under various spatial patterns (see part 3: satellite images of examples of TOF AGRI and TOF URB in various countries).

TOF on Non-Agricultural / Non-Urban land may be divided into two groups:

✓ Subsets 1 and 2 are typically small patches, or lines, of trees and/or shrubs. Trees and shrubs may be planted or naturally established, and may be encountered in a large variety of situations, independently from the local environmental tree growth conditions (see part 3: satellite images of small woods, small woodlots, tree lines along roads, hedges, trees along river, for example in Burkina Faso).

✓ Subsets 3 and 4 are made up of large patches consisting exclusively of scattered trees or shrubs. On land that is not under urban or agricultural use, such patches are mainly encountered in natural environments involving harsh growing conditions resulting in low tree and/or shrub height and canopy cover (see part 3: satellite images of examples of scattered trees and bushes, mainly in arid countries).

Figure 2: The formal position of TOF and TOF subsets within Other Land



2.2.d An operational definition of Other Land *with TOF*

In the FAO-FRA classificatory framework, all categories should be mutually exclusive. Integrating TOF or more precisely "Other Land *with TOF*", into the current framework thus requires subdividing "Other Land" into two mutually exclusive sub-categories. It is proposed to call these two sub-categories:

- "Other Land *with TOF*" (OL*wTOF*)
- "Other Land *with No TOF*" (OL*wNoTOF*)

The above analysis (2.2.b) allows formulating a formal –based only on logical inferences- definition of Other Land *with TOF*: Land classified as Other Land, i.e. not classified as Forest or Other Wooded Land, with trees and/or shrubs. It includes land that is predominantly under agricultural or urban use as long as trees and/or shrubs are present. It also includes land that is not predominantly under agricultural or **urban** use when area and/or tree and shrub canopy cover are below the thresholds that define "Forest" and "Other wooded Land".

In land-use classifications, categories must be unambiguous, clear, and operational. It must thus take into account technological limitations and also the balance between time (and cost) efficiency and the degree of precision of the results.

The formal definition of "Other Land *with TOF*" given above is obviously not operational. It would imply that any piece of Other Land supporting some trees and/or shrubs, whatever the density of TOF, whatever the area of Other Land, would be classified as Other Land *with TOF*. The risk is thus quite high of having almost all Other Land classified as Other Land *with TOF*. Although logically correct, the formal definition would in practice result in detrimental ambiguities in selecting the reference area associated with TOF during assessments. For instance, should a one hectare piece of land with one tree be classified as one hectare of Other Land *with TOF*, or should it be divided into two pieces, one classified as Other Land *with no TOF* and one classified as Other Land *with TOF*? And if the latter, how could one decide the area of each piece?

The definitions of Forest and Other Wooded Land are conceived as operational definitions: they include minimum thresholds, for the height of trees, for the area to be considered, for the canopy cover percentage, etc. Minimum values – for area, canopy cover and for length and width of narrow tree lines- are also needed to define Other Land *with TOF* in an operational and unambiguous manner.

The following minimum threshold values for the subcategory Other Land *with TOF* are thus proposed:

✓ Canopy cover threshold: 5 percent if trees only, 10 percent if combined cover of trees and shrubs

The definition of a canopy cover (cc) threshold for Other Land with TOF is absolutely necessary for operational and assessment cost-effectiveness reasons. This threshold would create a distinction between areas where TOF density is sufficient to be labeled as Other Land *with TOF*, and areas where TOF density is not sufficient. Below the cc threshold, the area would be labeled Other Land *with No TOF*, even if TOF are present.

TOF refers to trees and shrubs, so by analogy with what has been done for OWL, it is suggested to adopt the same canopy cover threshold: 5 percent if only trees, 10 percent in case of a combined cover of trees and shrubs.

✓ Area threshold: 0.05 ha
There is no obvious rationale for selecting one minimum area threshold over another. The value 0.05 ha is suggested here to allow classifying most smallholder farmers' woodlots as Other Land with TOF.

✓ Tree line length threshold: 25 m
Some country assessments have used the value 25 m (for example, Italy - see part 2). This value is suggested here by analogy with the length threshold for a tree line to be classified as Forest (see explanatory note 4, definition of Forest).

✓ Tree line width threshold: 3 m
The threshold value of 3 m, used in some country assessments such as in Italy (see part 2) is proposed here as the minimum width for a tree line. Tree lines with a width ≥ 20 m and a length ≥ 25 m are classified as Forest (see explanatory note 4, definition of Forest), if they are not under agricultural or urban use.

The suggested thresholds, combined with the above analysis of the FAO-FRA classificatory categories, allow to propose operational definitions for the two mutually exclusive sub-categories that compose Other Land: Other Land *with TOF* and Other Land *with no TOF*.

Other Land *with TOF* (OL*wTOF*) - subcategory of Other Land:

Land classified as Other Land (i.e. not classified as Forest nor Other Wooded Land), spanning more than 0.05 ha with trees higher than 5 m and a canopy cover above 5 percent, or with trees able to reach these thresholds in situ; or with a combined cover of shrubs and trees above 10 percent.

Explanatory notes:

1. Includes land that is predominantly under agricultural land use if it meets the area and tree/shrub canopy cover thresholds.
2. Includes land that is predominantly under urban land use if it meets the area and tree/shrub canopy cover thresholds.
3. On land that is not predominantly under agricultural or urban use, includes:
   - Areas spanning less than 0.5 ha and more than 0.05 ha
   - Windbreaks, shelterbelts and corridors of trees and shrubs, with an area spanning less than 0.5 ha or a width of less than 20 m but more than 3 m.

Other Land *with No TOF* (OL*wNoTOF*) - subcategory of Other Land:

Land classified as Other Land, but not classified as Other Land *with TOF*.

Explanatory notes:

1. Includes inland water bodies, barren land, stone outcrops, snow caps and glaciers, deserts, peat bogs, meadows without trees, annual crops without trees, etc...
2. Includes large areas with much scattered trees or shrubs (canopy cover < 5 percent if only trees are present; <10 percent if trees and shrubs are combined).
3. Includes very small areas with trees and/or shrubs (area <0.05 ha).
4. Includes very narrow (<3 m width) and very short (<25 m length) tree lines.

It is important to note that by adopting minimum thresholds, the subcategory "Other Land *with TOF*" implicitly leaves out some TOF, just as the category "Forest" does not include all forest patches: it omits those that fall below the 0.5 ha threshold.

The decision tree algorithm in Figure 2.3 can help clarify decisions in classifying any given piece of land into "Forest", "Other Wooded Land", "Other Land *with No TOF*", or "Other Land *with TOF*." This decision tree, based on the sequential application of the criteria in the FAO-FRA framework, suits the particular land use categories, definitions, set of decision criteria, as well as the current thresholds used by FAO-FRA and the proposed thresholds.

The decision tree algorithm is insensitive to changes in the spatial scale (resolution) at which land is being inspected (or mapped). Other countries and institutions using different criteria, sequencing and thresholds can adapt the decision tree concept to their own conditions.

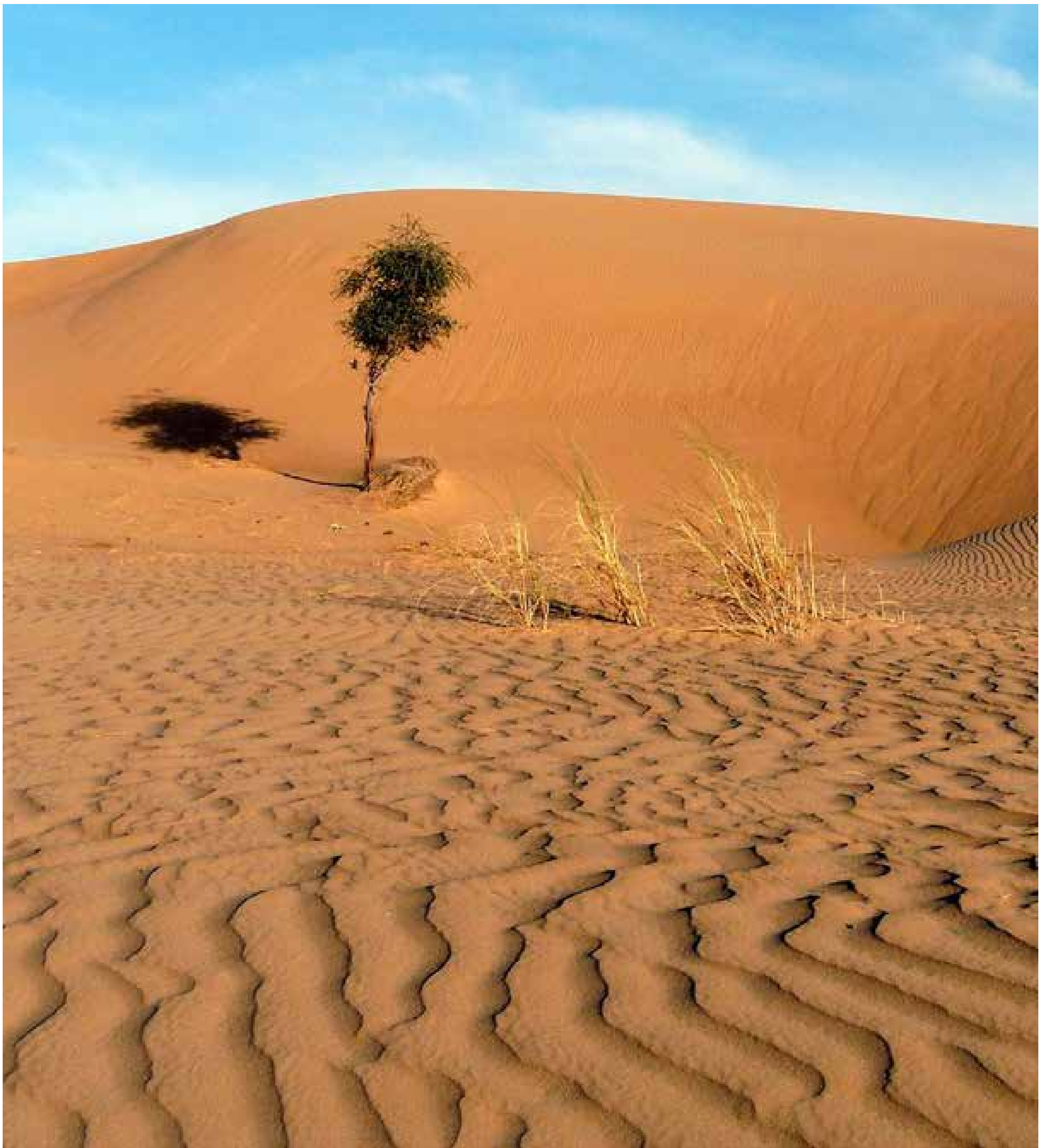
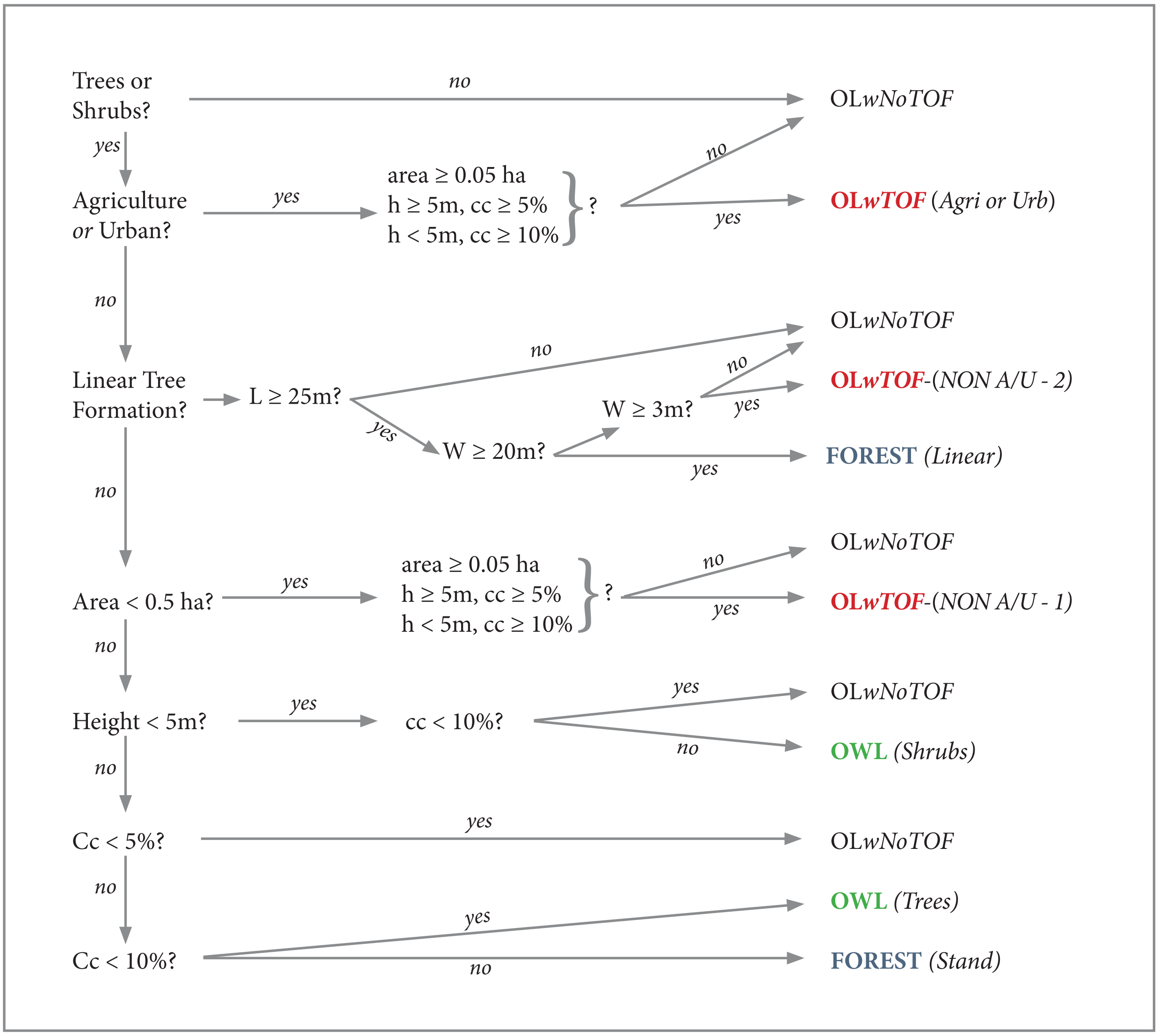


Figure 3: A Decision Tree Algorithm for the identification of Forest, Other Wooded Land, Other Land *with TOF* and Other Land *with No TOF*



Seven (minimal and sufficient) decision criteria were deducted from the FAO-FRA definitions and used to construct the decision tree algorithm for classifying land as
Forest (FOREST),
Other Wooded Land (OWL),
Other Land *with TOF* (OL*wTOF*),
Other Land *with No TOF* (OL*wNoTOF*).

The seven decision criteria (in parentheses the levels for each criterion) were:
1 = Presence of Trees or/and Shrubs on the land (yes/no).
2 = Land Use (Urban [URB] / Agriculture [AGRI] / Other = Non A/U).
3 = Spatial pattern of Trees or/and Shrubs (linear tree formation / other pattern).
4 = For linear tree formations: Length (L, threshold: 25 m) and Width (W, thresholds: 3 and 20 m).
5 = Trees or/and Shrubs patch area (thresholds: 0.05 and 0.5 ha).
6 = Trees or Shrubs height at maturity (threshold: 5 m).
7 = Trees or Shrubs canopy cover (thresholds: 5 % for Trees, 10% for Shrubs and small trees).

2.3. Removing remaining ambiguities

The above definitions are strictly inferred from the proposed thresholds and from the current definitions of "Forest," "Other Wooded Land" and "Other Land." The resulting rigorous framework allows classifying any piece of land in one or another of the classes of the FAO-FRA framework.

Some ambiguities however remain regarding some terms used in the definitions of "Forest" and "Other Wooded Land" and their explanatory notes. These ambiguities complicate the position of a few land-uses/land-covers, such as shifting cultivation, rubber plantations, agroforestry systems, and linear tree formations. Another major remaining ambiguity involves the absence of clear guidelines for a common understanding of the expressions agricultural land-use and urban land-use, which may lead different countries to classify pieces of land with the same land-use/land cover differently.

Problems linked to the above land-uses and the lack of unambiguous identification of agricultural and urban land-uses, are examined below. When possible, keys to help make objective decisions are given, with recommendations to relieve the remaining ambiguities and promote objective classification.

2.3.a. Shifting cultivation.

Since the studies of Conklin on Hanunoo agriculture (1957), shifting cultivation is recognized as an agricultural system in its own right. Conklin (1961) defines shifting cultivation a minima "as any continuing agricultural system in which impermanent clearings are cropped for shorter periods in years than they are fallowed". Many definitions have been proposed since then, along with synonyms such as "swidden cultivation", that complement Conklin's, especially in acknowledging the role of fallow in restoring the fertility of the soil-vegetation complex. It is important to note that all definitions recognize fallow as an integral and necessary part of shifting cultivation systems. It is also important to note the woody character of fallows in the humid tropics, character which has been integrated into some recent definitions: Mertz et al. (2009) for instance "define swidden cultivation in Southeast Asia as a land use system that employs a natural or improved fallow phase, which is longer than the cultivation phase of annual crops, sufficiently long to be dominated by woody vegetation, and cleared by means of fire."

In the FAO-FRA classificatory framework, "Abandoned shifting cultivation land with a regeneration of trees that have, or are expected to reach, a canopy cover of 10 percent and h= 5 m" is currently classified as forest (see definition of Forest, explanatory note 5). It seems simple, but in practice bear in mind that most lands under shifting cultivation are cropped over many crop/fallow cycles. Remember also that it is always very difficult to confirm that shifting cultivation land has been effectively abandoned, since any fallow land may appear abandoned: nothing looks more like abandoned shifting cultivation land than a fallow that will soon be cleared and which is still integral to an active shifting cultivation crop/fallow cycle system. In the humid tropics, this problem is even more difficult because fallow vegetation is usually quickly dominated by pioneer trees that develop as young secondary forests which easily reach the size and canopy cover thresholds of Forest.

It is thus strongly recommended that, in the humid tropics, young secondary forests less than 15-20 years old be classified as "Other Land *with TOF*" by default, provided they meet OL*wTOF* thresholds. It is also strongly recommended that these young secondary forests be classified as "Forest" only if field interviews have demonstrated either that they correspond to abandoned fallows getting out of the shifting cultivation cycle, or that they result from a process other than shifting cultivation.

2.3.b. Rubber plantations.

Rubber plantations are not easy to classify: the explanatory note 7 of the definition of Forest says that the category "includes rubber-wood[1]… plantations", if canopy cover and area thresholds are reached. This is quite ambiguous, since rubber-wood plantations – plantations of rubber for its wood as a primary product - are still quite anecdotal. On the contrary, rubber plantations –plantations of rubber for its latex as a primary product - cover millions of hectares, especially in Asia. These rubber plantations, whether they are monocrop plantations or mixed species agroforest plantations, can all produce rubber-wood as an end product when plantations are regenerated. This rubber-wood is however always a "secondary product." Until 1997, rubber was considered as an "agricultural cash crop" (FAO 1997) and rubber plantations were considered as "non-forest plantations" (FAO 1993). Its status changed with the FRA 2000, when it was decided to include rubber tree plantations into the reporting of the area under Forest, although the 2000 definition of Forest was already loaded with the ambiguity of the term "rubber-wood" (FAO 2001a). In practice, countries now report to FRA their area of rubber plantations under the category Forest, at least for monocrop plantations.

It is strongly recommended to remove the ambiguity still present in the explanatory note accompanying the definition of "Forest", either by changing the term "rubber-wood" into "monoculture rubber" and to conserve monoculture rubber in the "Forest" category, or by returning plantations to agriculture and to consider all land supporting rubber plantations (whatever their management, i.e. including monoculture plantations and agroforests) as "Other Land *with TOF*", provided they meet the OL*wTOF* thresholds.

1 Underlined by the authors

2.3.c. Linear tree formations.

Linear tree formations include shelterbelts, windbreaks, living fences, hedges, tree lines, etc. It is not easy to classify them as Forest or as Other Land, and it is always necessary to consider first the land-use, agricultural, urban, or non agricultural/non urban:

✓ Always associated with an agricultural or an urban use of land, hedges and living fences should all be classified as Other Land, in the subcategory "Other Land *with TOF*" as long as they meet the thresholds.

✓ When they are planted and/or managed for agricultural or urban purposes, shelterbelts, windbreaks, tree lines and corridors of trees, should also be classified as Other Land, in the subcategory "Other Land *with TOF*" provided they meet the thresholds, because the underlying land-use is in that case predominantly agricultural or urban.

✓ When they are planted and/or managed for non-agricultural or non-urban purposes, shelterbelts, windbreaks, tree lines and corridors of trees should be classified either as Forest or as Other Land, in the subcategory "Other Land *with TOF*" as long as they meet the thresholds. It depends on combined [width x area x length] thresholds.

- They should be classified as Forest when their area reaches more than 0.5 ha **and** their width is more than 20 m (in practice their length must thus be more than 25 m).
- They should be classified as "Other Land *with TOF*" when their length is more than 25 m, and their width is between 3 and 20 m.

2.3.d. Agroforestry.

Most land supporting agroforestry systems is classified as "Other Land *with TOF*", because the land is used predominantly for agriculture. However, in a few cases it is classified as "Forest" because the predominant land-use is forest and not agriculture. There are many definitions of agroforestry, which is usually understood as "a collective name for land use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are always ecological and economical interactions between the different components" (Nair 1993). Somarriba (1992) complements this definition: "Agroforestry is a form of multiple cropping that satisfies three basic conditions: 1) There are at least two components of the cropping system that interact biologically; 2) at least one of the components is a woody perennial plant; and 3) at least two interacting species are managed to fulfill the objectives of the land manager." More recent definitions of agroforestry may be found in www.icraf.cgiar.org and www.aftaweb.org.

None of the definitions of agroforestry says anything about the predominant land-use of a given agroforestry system. Whether the land is predominantly used for agriculture or for forestry is a matter of balance between the agriculture and the forestry components of the agroforestry system. Most cases are clear-cut, with the balance bending toward agriculture (such as trees in cropfields or pastures, fruit orchards, coffee or cocoa plantations below a tree cover, pastures under coconut trees, cropfields surrounded by hedges), or toward forestry (such as in systems where livestock is allowed to graze in the undergrowth of a forest or timber tree plantation).

In a few cases of sequential agroforestry systems - such as many agroforests and Taungya systems- where a "mature" phase clearly dominated by trees succeeds an initial phase dominated by crops, the situation is more complex (Sinclair 1999, Wiersum 2004). In these cases, one should take into account the system's objectives and products to decide whether it belongs more to the forestry realm or to the agriculture realm.

Many agroforests belong to this group of sequential agroforestry systems with a mature phase characterized by a "forest" cover (Wiersum 1997, Michon & de Foresta 1999, Belcher et al. 2005). Although agroforests provide the same environmental services as a forest (Bhagwat et al. 2008), the land supporting these agroforests should be classified as "Other land *with TOF*" as long as it meets the conditions for OL*wTOF*, because farmers establish agroforests to generate income through the production of products belonging to the agriculture realm such as fruits and nuts, vegetables, rubber, cocoa, coffee, cinnamon, coconut, oil-palm, etc (Michon & de Foresta 1999). Sometimes items generally considered as non-wood forest products are also produced, such as the damar resin produced by Shorea javanica, a Dipterocarp species, in the damar agroforests planted and cultivated by farmers in the south of Sumatra, Indonesia (Michon et al. 2000). In any case, agricultural products are always present during the whole life of an agroforest, and the landowners' objective is never the establishment of a woodlot or a "forest", but the establishment of a mixed tree-crop plantation.

Taungya systems (Jordan et al. 1992) differ from agroforests mainly by their primary products (wood for timber or fiber) and by the landowners' objective: the establishment of a forestry plantation. They should thus be classified as "Forest". Taungya systems otherwise have many similarities with agroforests in their establishment and their trajectory. In most Taungya systems, farmers grow crops during a few years only alongside young timber or fiber trees until the tree cover becomes dense enough to prevent crop growth. It then becomes a classic forestry plantation. The primary products are clearly forestry products, and the landowner's objective is the establishment of a forest plantation. This is why the explanatory note 9 in the definition of "Forest" (see above) says that "some agroforestry systems such as the Taungya system, where intercropping is reduced to the first 1-2 years of the establishment phase of crops are grown only during the first years of the forest rotation, should be classified as forest."

The "forestry" nature of the land under Taungya is obvious in typical cases where intercropping (concomitant occupancy of the same land by crops and tree species, Huxley 1983) is reduced to the first 1-2 years of the establishment phase of a 30-year rotation forestry plantation. This "forestry" nature is however less evident when (i) crops are selected for shade tolerance and other traits that enable them to be intercropped for a longer fraction of the total forestry rotation time, and (ii) tree species are selected for short-term rotations (e.g. for firewood, stakes, or for fibers), so that the intercrops share the land over a large fraction of – or even all - the forestry rotation. In cases where forestry and agriculture have the same weight, it seems that there is no objective way of classifying the system as "Forest" or as "Other Land *with TOF*".

Although a few agroforestry systems are classified as "Forest" (see the example of "Taungya" above), agroforestry is strongly linked to TOF in agricultural lands (TOF-AGRI), and to a lesser extent to TOF in urban lands (TOF-URB). The overlap between agroforestry and TOF is thus important to note since for all "Other Land *with TOF*" identified as under agroforestry, the rich agroforestry literature provides models, methods and assessments.

2.3.e. Agricultural or urban land-uses.

Both the "Forest" and the "Other Wooded Land" categories exclude land predominantly under agricultural or urban land use. It is thus of crucial importance, not only for identifying TOF and Other Land *with TOF*, but also for identifying Forest and Other Wooded Land, to know precisely how a piece of land may qualify as "predominantly under agricultural or urban land use" or not. The definitions of "Forest" and "Other Wooded Land" do not include any explanatory note on this expression, as if the meaning of this wording was obviously the same for everybody and as if it would be interpreted the same way everywhere in the world. As with the word "Forest", the words "Agriculture" and "Urban" in fact cover very different realities in different countries, which may lead to divergences in reporting.

✓ Agricultural land use. There is no internationally accepted definition of "agricultural land use." However, the FAO-FRA could adopt the definition used by the FAO Statistics Division (http://faostat.fao.org/) and include it in its reporting guidelines. The FAO Statistics Division defines "agriculture area" as "the sum of areas under:

- (a) Arable land - land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for "Arable land" are not meant to indicate the amount of land that is potentially cultivable;
- (b) Permanent crops - land cultivated with long-term crops which do not have to be replanted for several years (such as cocoa and coffee); land under trees and shrubs producing flowers, such as roses and jasmine; and nurseries (except those for forest trees, which should be classified under «forest»);
- (c) Permanent meadows and pastures - land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land)."

✓ Urban land use. Here again, there is no internationally accepted definition of "urban land use." And it seems that there is no consensus among countries even on the definition of "urban." The Demographic Yearbook 2005 published by the United Nations Statistics Division includes the definitions of "urban" used in 101 countries around the world. A rapid analysis shows that eight main criteria are used. They may be grouped in five main sets, listed here in decreasing order of importance:

- Population number (62 percent). A minimum population number is used in 60 national definitions and is by far the most common criterion for defining "urban." The thresholds are extremely variable and range from 200 inhabitants (for instance in Norway) to 50 000 (in Japan). In most countries the thresholds range from 1 000 to 5 000. A threshold population density is also sometimes used (present in 9 definitions: from 400 inh/km^2 in Canada, to 1 500 inh/km^2 in China), as well as a threshold number of dwellings (present in 2 definitions: 100 dwellings in Peru and 300 dwellings in Equatorial Guinea).

- Locality function (31 percent). To be an administrative center (often in relation to a large surrounding rural area) comes second in importance, although far behind the population number criterion. It is cited in 31 national definitions; being a center for commercial activities is also cited in 4 definitions.
- Official designation (27 percent). In 27 countries, governments officially designate which localities are urban.
- Relative importance of agriculture (20 percent). The low importance of agriculture is a criterion in 20 countries. It is sometimes quantified: for instance in Botswana "75 percent of the economic activity is non-agricultural" and in India "at least 75 percent of the adult male population employed in pursuits other than agriculture".
- Urban characteristics (17 percent). In 17 countries, a locality is defined as urban if it has urban characteristics, with a few countries qualifying some of these characteristics: for instance in Panama, these are "streets, water supply system, sewerage system and electric light".

This rapid analysis confirms the UN Statistics Division acknowledgement that "because of national differences in the characteristics that distinguish urban from rural areas, the distinction between the urban and the rural population is not yet amenable to a single definition that would apply to all countries."

Defining "urban" in the expression "urban land use" is important, but it is not sufficient: pieces of land with individual trees, with trees lining streets, canal or railways, with trees in private gardens, with trees on parking lots, etc, located in cities are obviously not "Forest" or "Other Wooded Land", and should thus be classified as "Other Land *with TOF*" when they meet the thresholds. But the ambiguity remains for pieces of land with trees located in hamlets, small villages, and built-up areas located in the countryside such as airports or camping grounds. The ambiguity also remains for large pieces of land supporting forest that are included in the territory of big cities: should they be classified as "Forest" because the local land use - land under the forest - is neither agricultural nor urban? Or should they be classified as "Other Land *with TOF*", because they are embedded into urban areas?

The above examples underscore the urgent need for clear guidelines on what should be considered an urban land use and what should not. This need is even greater for "urban" than for "agriculture", not only because there is less international consensus on what is urban than for agriculture and divergences between countries are more profound, but also because trees in cities are an increasingly important resource for the growing number of people living in cities worldwide.

As with agroforestry in the case of agricultural land, "urban forestry" as a scientific and technical discipline is dedicated to TOF in urban land. Despite the ambiguities in the exact meaning of "urban" land use, it is important to note that for all "Other Land *with TOF*" identified as predominantly urban, there is an ever-growing literature on urban forestry with models, methods and assessment.

The lack of precise and unambiguous definitions of "agricultural land use" and "urban land use" did not prevent the building of the rigorous framework based on mutually exclusive categories presented above in section 2.2. However, when it comes to practice, unambiguous definitions are needed in order to keep subjectivity out of the decision process that leads to the classification of a piece of land with trees as "Forest", "Other Wooded Land", or "Other Land *with TOF*". Until now, countries have used their own definitions of "agricultural land use" and "urban land use" in their national reporting of Forest and Other Wooded Land to FAO-FRA – and most often these definitions are not cited in reports. This has added unknown levels of uncertainty regarding the relevance of national data both for comparisons between countries and also for use at higher geographic scales (region, world).

This report thus strongly recommends that clear and unambiguous definitions for "land predominantly under agricultural use" and "land under predominantly urban use", be prepared and included in the next FA0-FRA.

2.4. TOF and OLwTC

Following-up on the recommendations to include information on Trees Outside Forests into the FRA reporting process, beginning with the Global FRA 2005, the FAO/FRA has added a line in Table T1 "Extent of Forest and Other Wooded Land," asking countries to report the area of "Other Land with Tree Cover" (OLwTC), a subcategory of "Other Land", defined as follows (FAO 2010b):

Other Land With Tree Cover (OLwTC) – subcategory of Other Land:

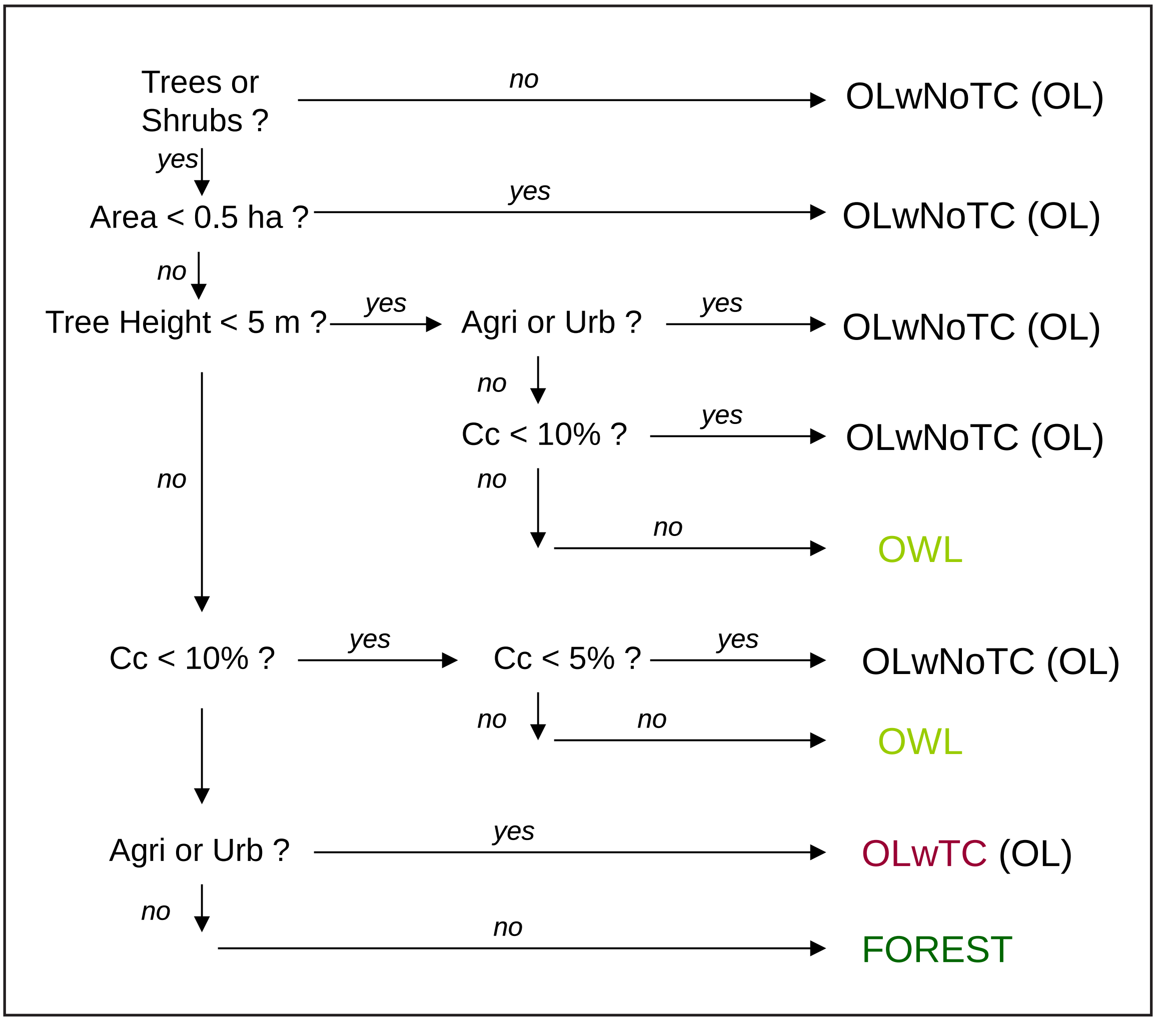
Land classified as Other land, spanning more than 0.5 ha with a canopy cover of more than 10 percent of trees able to reach a height of 5 m at maturity.

Explanatory notes:

1. The difference between Forest and Other land with tree cover is the land-use criteria.
2. Includes groups of trees and scattered trees in agricultural landscapes, parks, gardens and around buildings, provided that area, height and canopy cover criteria are met.
3. Includes tree stands in agricultural production systems, for example in fruit-tree plantations and agroforestry systems when crops are grown under tree cover. Also includes tree plantations established mainly for purposes other than wood, such as oil-palm plantations.
4. Excludes scattered trees with a canopy cover less than 10 percent, small groups of trees covering less than 0.5 ha and tree lines less than 20 m wide.

A decision tree algorithm for distinguishing Other Land With Tree Cover from Forest, Other Wooded Land and Other Land With No Tree Cover, is proposed in Figure 4. It uses the same criteria as those used in Figure 3, except those related to linear tree formations: whatever the tree spatial pattern, what is important here, provided all other thresholds are met, is the area (above 0.5 ha: Forest, Other Wooded Land or Other Land with Tree Cover; below 0,5 ha: Other Land With No Tree Cover).

Figure 4: A decision tree algorithm for OLWTC, Forest, OWL and Other Land With no Tree Cover



Five (minimal and sufficient) decision criteria were deducted from the FAO-FRA definitions and used to construct the decision tree algorithm for classifying land as

- Forest (FOREST).
- Other Wooded Land (OWL).
- Other Land with Tree Cover (OLWTC).
- Other Land with No Tree Cover (OLWNoTC).

The five decision criteria (in parentheses the levels for each criterion) were:
1 = Presence of Trees or/and Shrubs on the land (yes/no).
2 = Trees or/and Shrubs patch area (threshold: 0.5 ha).
3 = Trees or Shrubs height at maturity (threshold: 5 m).
4 = Land Use (Urban or Agriculture/Other).
5 = Trees or Shrubs canopy cover (thresholds: 5 % for Trees, 10% for Shrubs and small trees).

OLWTC has the same thresholds than "Forest" in terms of plant height (≥5 m), canopy cover (≥10 percent) and area (≥0.5 ha). OLWTC is thus a subcategory of Other Land supporting enough trees for being classified as Forest on the criteria of area, canopy cover and tree height. OLWTC is the equivalent of the "Forest" category in the TOF realm (figure 4a and 4b). How does OLWTC fit with the different TOF subsets presented above in section 2.2.c resulting from the definitions of Forest and Other Wooded Land?

It is clear that OLWTC excludes the *Non Agricultural/Non Urban* set and its four subsets. This is underlined by explanatory note 4, which "excludes scattered trees with a canopy cover less than 10 percent" (= subsets 3 and 4 of the TOF typology, section 2.2.c), "small groups of trees covering less than 0.5 ha" (= subset 1 of the TOF typology), "and tree lines less than 20 m wide" (= subset 2 of the TOF typology).

A direct result of these exclusions is that OLWTC only concerns part of agricultural land (set 1: TOF on Agricultural Land – AGRI), and part of urban land (set 2: TOF on Urban Land – URB). Within each of these 2 TOF sets, OLWTC represents the part that meets the same thresholds as "Forest" (see Figure 5a and 5b). This is underscored by explanatory note 1 above, which states that "the difference between Forest and OLWTC is the land-use criteria."

It is important to note that OLWTC is fully embedded into Other Land *with TOF*, but that Other Land *with TOF* is wider than OLWTC (Figure 5b).

Figure 5a: Land not predominantly under agricultural or urban use Position of Forest, Other Wooded Land and Other Land, when land is ≥ 0.5 ha.

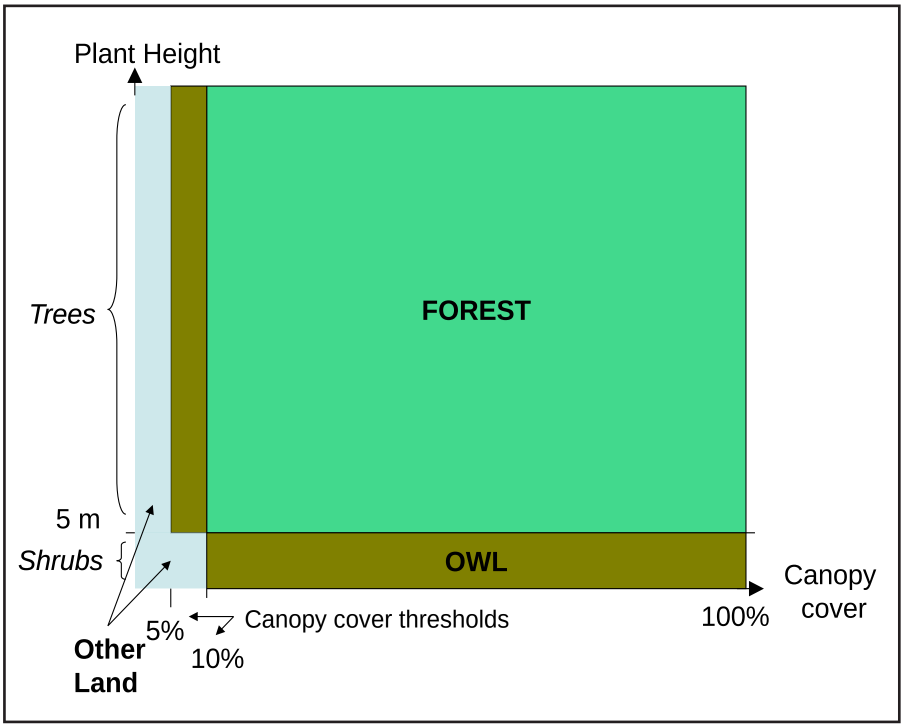
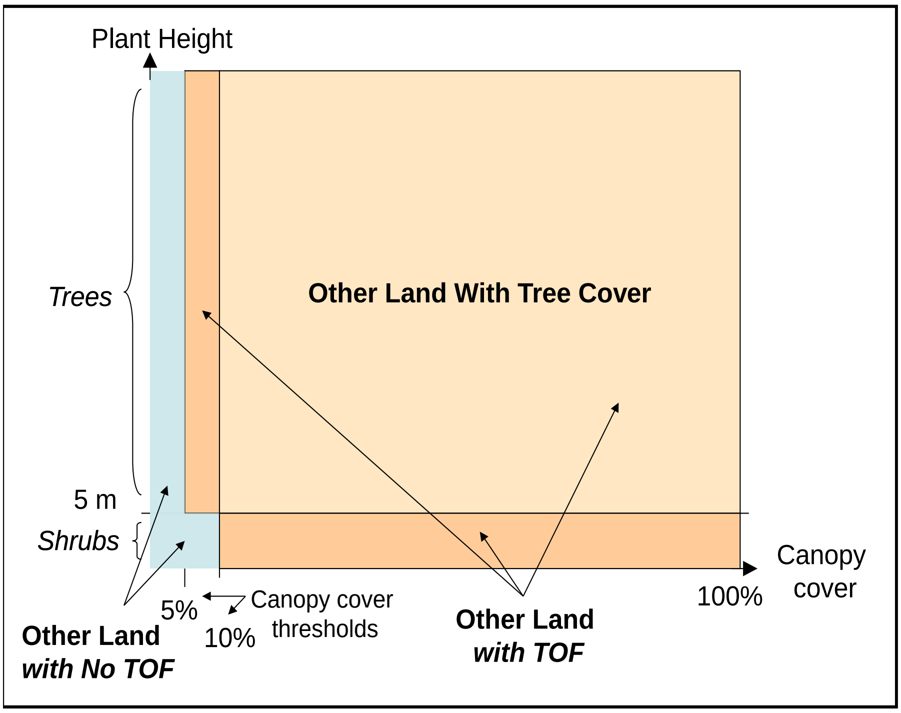


Figure 5b: Land predominantly under agricultural or urban use Position of Other Land with Tree Cover within Other Land *with TOF* when land is ≥ 0.5 ha.



Building upon OLWTC to assess OL*wTOF*?

OLWTC is a subdivision of the subcategory OL*wTOF* based on land cover and land-use criteria. This subdivision introduces a new option for classifying the complement of OLWTC in the TOF realm on a pure land cover basis for at least two subsets. Once OLWTC had been circumscribed, the rest of OL*wTOF*, may be subdivided into four mutually exclusive subsets:

1. Small tree stands or groups (0.05 ha≤area<0.5 ha), with a canopy cover ≥5 percent if only trees and ≥10 percent in case of a combined cover of trees and shrubs. Whether located on agricultural land, urban land or non-agricultural/non-urban land, such small tree stands are classified as Other Land *with TOF* but are not included into OLwTC.
2. Linear tree formations more than 25 m long, narrow (3 m ≤width <20 m), irrespective of area, plant height and canopy cover level. Whether located on agricultural land, urban land or non-agricultural/non-urban land, narrow linear tree formations are classified as Other Land *with TOF* but are not included into OLwTC.
3. Large stands (area ≥ 0.5 ha), shrubs or small trees (height <5 m) with a canopy cover level ≥10 percent, located on agricultural land or urban land. Such stands are classified as Other Land *with TOF* but are not included into OLWTC.
4. Large stands (area ≥ 0.5 ha), trees (height ≥ 5 m) with low canopy cover level (between 5 and 10 percent), located on agricultural land or urban land. Such stands are classified as Other Land *with TOF* but are not included into OLwTC.

The first two above subsets may be translated into two major tree spatial organization patterns - small and relatively dense tree groups, and narrow tree lines -, that may be found on agricultural land, urban land or non-agricultural/non-urban land.The two other sub-categories – large stands with a canopy cover of shrubs ≥10 percent, and large stands with scattered trees (canopy cover between 5 and 10 percent) – should be classified differently according to the land-use: as OWL when the land is not predominantly under agricultural or urban land, and as OL*wTOF* when the land-use is predominantly agricultural or urban. For assessing the extent of TOF by high resolution remote-sensing imagery, this classification based on the spatial structure of trees may be of high interest.

2.5. Conclusions

This chapter used an analysis of the accepted definitions needed to circumscribe the TOF realm as a basis for proposing that Other Land be subdivided into two mutually exclusive sub-categories, based on the presence of TOF at certain threshold levels: Other Land *with No TOF* and Other Land *with TOF*. An operational definition of these two sub-categories is given.

The analysis also provided the basis for a TOF typology including three major TOF sets (Figure 6):

1. TOF on land predominantly under agricultural land use are classified as TOF-AGRI ; part of TOF-AGRI is included in Other Land *with TOF* (OL*wTOF-AGRI*), when the canopy cover and area thresholds are met. OL*wTOF-AGRI* includes all lands predominantly under an agricultural land use with trees and/or shrubs, whatever their spatial pattern (in line, in stands, scattered), provided that the area is ≥ 0.05 ha, the canopy cover is ≥ 5 percent if only trees are present, or ≥ 10 percent in case of combined trees and shrubs, the width ≥ 3 m and the length ≥ 25 m for linear tree formations.

   If the trees are ≥ 5 m high, with a tree canopy cover ≥ 10 percent, the width ≥ 20 m and the area is ≥ 0.5 ha, the land is also classified as Other Land with Tree Cover (OLWTC).

2. TOF on land predominantly under urban land use are classified as TOF-URB; part of TOF-URB is included in Other Land *with TOF* (OL*wTOF-URB*), when the canopy cover and area thresholds are met. OL*wTOF-URB* includes all lands predominantly under an urban use with trees and/or shrubs whatever their spatial pattern (in line, in stands, scattered), provided that the area is ≥ 0.05 ha, the canopy cover is ≥ 5 percent if only trees are present, or ≥ 10 percent in case of combined trees and shrubs, the width ≥ 3 m and the length ≥ 25 m m in case of linear tree formations.

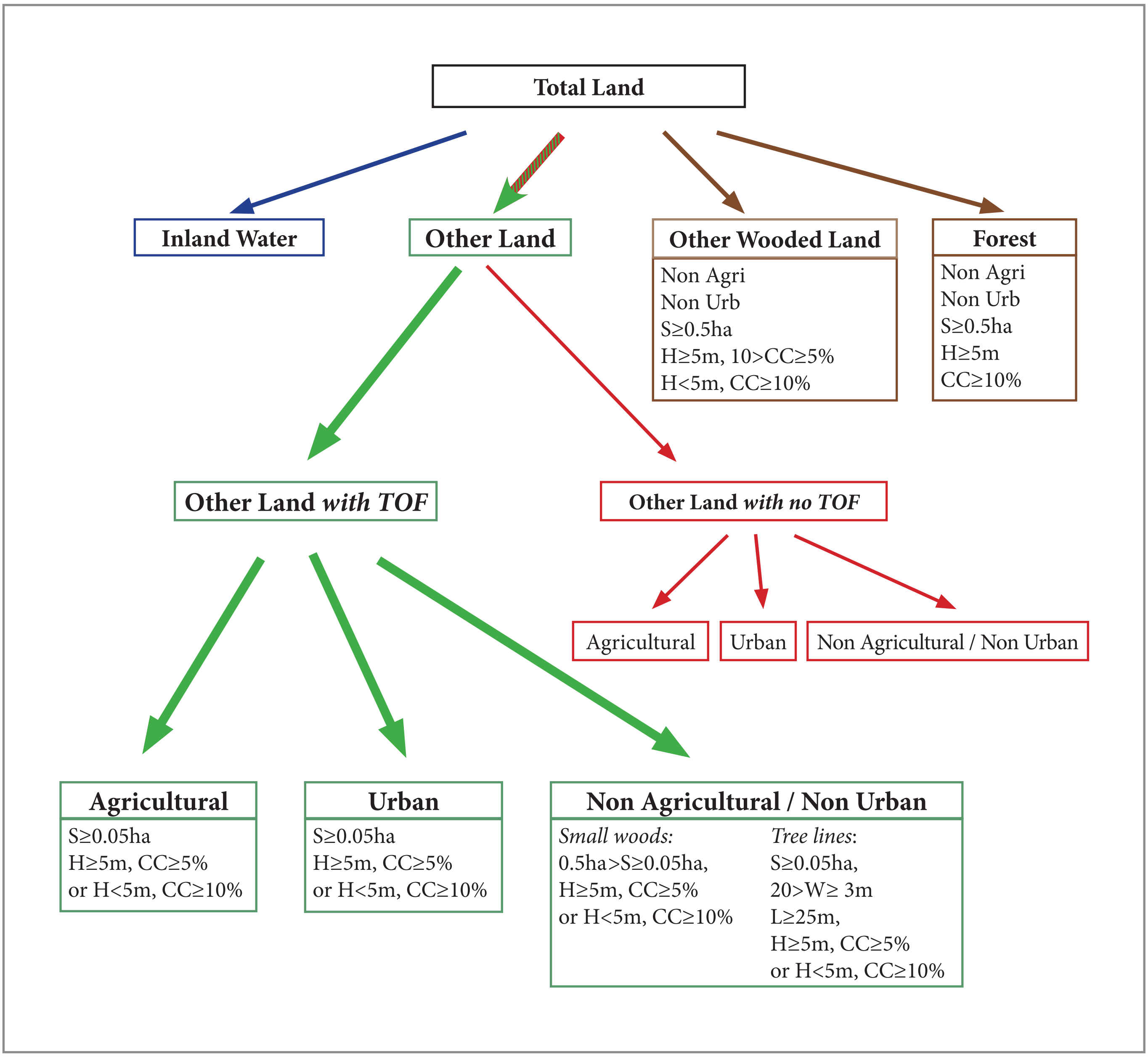
   If the trees are ≥ 5m high, with a tree canopy cover ≥ 10 percent, the width ≥ 20 m and the area is ≥ 0.5 ha, the land is also classified as Other Land with Tree Cover (OLWTC).

3. TOF on land not predominantly under agriculture or urban land use are classified as TOF-NON A/U. Part of TOF-NON A/U is included in Other Land *with TOF* (OL*wTOF- NON A/U*), when the thresholds are met. This is the case for the two following subsets:

   OL*wTOF- NON A/U* - Subset 1: small tree stands (0.05 ≤ area <0.5 ha) with canopy cover ≥ 5 percent if trees are present, or ≥ 10 percent in case of combined trees and shrubs.

   OL*wTOF- NON A/U* - Subset 2: narrow linear tree formations, (3 m ≤ width < 20 m), with length ≥ 25 m, and canopy cover ≥ 5 percent if trees are present, or ≥ 10 percent in case of combined trees and shrubs.

Figure 6: The position of Other Land *with TOF* and its sets within the proposed land classification framework for Other Land



The rigorous framework deriving from this analysis is constrained by a few remaining ambiguities in the terms used for the definition of Forest and Other Wooded Land. In some situations, these ambiguities introduce subjectivity into classifying a piece of land with trees into Forest, Other Wooded Land, or Other Land *with TOF*. Recommendations for removing these ambiguities have been formulated.

The position in the TOF realm of Other Land with Tree Cover, a category recently introduced by FAO-FRA to start to account for TOF, has also been clarified, and its interest, as opening up a new option for classifying the remnants of the Other Land *with TOF* subcategory on an almost pure land-cover basis, underlined.

To conclude, it is important to stress that TOF and Land with TOF have been understood here in the land classification frame of reference of the FAO-FRA, which has a strong focus on forest. The three major TOF sets identified in this chapter correspond to a large variety of stakeholders: farmers, pastoralists and institutions linked to agriculture and rural development; people living in settlements and cities, institutions linked to urban management and development; environmental organizations, rural and urban planning institutions, etc. These extremely diversified stakeholders have objectives and needs that are often very different from those of foresters.

Trees outside Forests provide an opportunity to bridge the divide that sometimes separates foresters from other stakeholders (Dove 1992, 2005, Sood & Mitchell 2009). TOF and the TOF realm, although they are here analyzed through an international forestry-oriented framework, could help in building that bridge.

3. Review of TOF assessments

3.1. Introduction

This chapter reviews the various types of inventory and assessment that may provide data on TOF (hereafter called "TOF assessments" for simplification). Inventory is the process of collecting quantitative and qualitative information on a given resource, while assessment is the process of putting data in context and assigning values to the resource (Kleinn, 2000). The focus is on TOF assessments at scales that are relevant to national policy-makers and the global community: region, country and large area. No attempt was made to collect and analyze case studies involving TOF assessments in small areas. A number of small-scale studies exist, that cover a wide spectrum of TOF systems and a large number of geographical situations, providing a bulk of useful and valuable information on TOF, their use and their management. Despite their interest, these small-scale studies are not presented here because their results and methodologies cannot easily be extrapolated to larger scales.

Various methods and tools can be used to provide relevant information on TOF; three main groups are:

- ✓ Remote sensing and the analysis of aerial photographs and satellite images, combined with ground checking, may provide information on the extent, localization and spatial organization of TOF. Impressive technological progress has made remote sensing an essential tool for measuring these parameters and their change with time.

- ✓ Field inventories that combine sample plots with various tree measurements for information on the tree resource itself: biophysical parameters such as tree density, average height and diameter, volume of timber, tree health, tree species composition and diversity, etc. Provided the sampling scheme is adapted to the area covered, valid statistic estimates of the tree resource over the whole area can be derived, such as the number of trees, the stocking volume, the carbon stock, etc. When combined with interviews, field inventories may also provide information on the use of the trees, their management and their socio-economic value.

- ✓ Survey questionnaires may provide information on various aspects of the TOF resource especially on land used for tree crops in agriculture, but also on urban land. Surveys usually involve interviews with, or questionnaires sent to, local TOF managers (farmers, city staff, etc.), and the information is usually limited to the extent of TOF, various aspects of their production (agricultural land) or their social and environmental services (urban land), and various aspects of their management.

The three groups of methods briefly described above may be used independently or jointly in TOF assessments. Each group provides specific information, different from the others. Assessments collected and analyzed in this chapter consist of these three groups, allowing comparisons.

The information from collected assessments was compiled, analysed and synthesised with the ultimate aim of drawing feasible technical and methodological options for better TOF assessments. In the following, the terms "Forest" and "Other Wooded Land" exclusively refer to their current FAO definitions as presented in chapter 2, unless otherwise stated. Similarly, the term "TOF" exclusively refers to the proposed definition formulated in chapter 2.

The chapter is organized in 3 sections: section 1 (The process) clarifies the process of collecting, analysing and comparing the assessments ; section 2 (TOF Assessments) deals with the review itself, clarifying the pros and cons of each type of assessment for TOF; section 3 highlights the main conclusions (Towards developing options for TOF assessment: major observations).

3.2. The process

Chapter 2 made clear that TOF and land with TOF may be divided into three major subsets: TOF on land used for agriculture, TOF on land used for settlement and TOF on land not used for agriculture nor for settlement. An important consequence of the presence of TOF in these three major land-use types is the fragmentation of TOF issues among the institutions dealing with various sectors including inter alia agriculture, land use and city planning, environment, economy, development, and forestry. This fragmentation is in itself a problem when assessing TOF as a whole because it means that data on TOF subsets may in theory be generated, analysed and held independently by a wide range of institutions. This is true at sub-national and national levels where different ministries (or different agencies from the same ministry) may have different TOF subsets in their mandate. This is true also at the global level where the various TOF subsets fall under the mandates of numerous UN agencies such as FAO, UNEP, and UNSD, or of various departments inside one agency. Despite this fragmentation, at the global level FAO should be the reference for national TOF data as its mandate includes the collection of statistical data on renewable natural resources related to food and agriculture.

3.2.a. Screening and collecting phase

FAO documents and statistics provided the starting point of the screening phase, pointing towards countries where quantitative information on TOF was potentially available, meaning that inventories or assessments were potentially available for these countries.

The recent FAO-FRA 2010 country reports were used to identify countries having reported the OLwTC category ("Other Land with Tree Cover") in Table 1 of their national report ("Extent of Forest and Other Wooded Land"). OLwTC provides information on the spatial importance of relatively large patches (> 0.5 ha) of agricultural and urban land where TOF canopy cover is more than 10 percent (see chapter 2). Although OLwTC does not account for all TOF, the hypothesis was that countries that reported an area as OLwTC would have documents available on large-area TOF assessments. FAOSTAT database was used to identify countries with reportedly large areas of tree crops (that make up part of the agricultural TOF set), whether these countries reported their tree-crop areas in the OLwTC line of the FAO-FRA 2010 report or not. Once countries potentially having TOF assessments were identified, a search for documents pertaining to these assessments was carried out, by contacting FAO national correspondents and by Internet searches.

In parallel to the analysis of the FRA 2010 country reports and the FAOSTAT database, the researchers sent a letter to FAO-FRA national correspondents in 170 countries, requesting their assistance in identifying relevant national assessment documents, originating from the forestry sector or any other sector. The letter included a list of the main tree systems that might include TOF (such as perennial tree crop plantations, hedges and windbreaks, agroforests, parklands). Responses confirmed the interest in TOF expressed by countries that had noted OLwTC in FRA reports, and allowed the integration of a few other countries in the review.

3.2.b. Pre-analysis phase

Through the screening and collection phase, a number of documents from various sources were organized in two main groups. The first group consists of all the assessments (1 global, 1 regional, 33 national and 3 sub-national), that could provide information on one or another TOF set. The assessments included in this review cover the main methods in use and the various TOF sets. They also cover a very large range of environmental and socio-economic conditions, as they have been carried out in countries belonging to almost all the major world regions (see Table 3).

Table 3: World distribution of country case studies (national and sub-national assessments)

World Regions	Countries selected for case study
Eastern and Southern Africa	Zambia
Northern Africa	Morocco
Western and Central Africa	Cameroon, Senegal
East Asia	China
South and Southeast Asia	Bangladesh, India, Philippines
Europe	France, Italy, Norway, Slovenia, Sweden, United Kingdom
Central America	Nicaragua
North America	Canada, USA
South America	Uruguay
Oceania	New Zealand

The second group relates to a few international supporting programmes developed by FAO and partners, programmes that may help in providing information on TOF, although that is not usually a primary objective:

- ✓ LADA: The Land Degradation Assessment in Drylands programme.
- ✓ LCCS: The Land Cover Classification System programme,
- ✓ NFMA: The National Forest Monitoring and Assessment programme
- ✓ WISDOM: The Woodfuel Integrated Supply/Demand Overview Mapping,

The reviewed documents are neither a complete collection of all relevant assessments nor a random sampling of the existing relevant assessments. However, they constitute the largest and most diverse range of assessments related to TOF possible, and they cover all the major assessment categories.

3.2.c. Analysis phase

Each assessment and each supporting programme was systematically analysed for the following points:

- ✓ Objective(s) of the assessment or programme;
- ✓ Institutions involved and coordinating institution(s);
- ✓ Scale (global, regional, national, sub-national);
- ✓ Duration and periodicity (for assessments);
- ✓ Methodology used;
- ✓ Variables recorded related to TOF;
- ✓ Identification of categories that may include TOF;
- ✓ TOF subsets included in the coverage;
- ✓ Main kind of results regarding TOF provided or that may be provided;
- ✓ Main results (for assessments).

Synthetic profile sheets were made for each assessment (Part 2a) and for each supporting programme (Part 2b). National assessments have been organized by country, because in most countries, complementary data on TOF may be gathered from different national inventories, due either to the land-use dispersal of TOF or to differences in the targeted variables. The profile sheets were used as a basis for the comparative analysis of the assessments. All points that were unclear in the available documents were clarified by experts working in the supporting programmes for the global and regional assessments, and by national experts for the countries. Once completed, each profile sheet was as far as possible sent for checking and validation to programme experts or to the relevant contact-person(s) in the countries. This process was considered extremely important: it helped to build a common understanding among specialists who may have very different cultural, technical and conceptual perceptions; it ensured the reliability of the information summarised in the profile sheets; and it allowed the comparative analysis of the selected assessments to be carried out on a sound basis.

3.3.TOF assessments

This section reviews the large area TOF assessments collected as well as the supporting programmes that provide or may provide information on TOF. The synthetic profile sheets synthesizing the information on each assessment and supporting programme are located in part 2 of this report for practical reasons. These profiles are however constantly referred to in this section and are conceived to be read in conjunction with this section.
The direct consequence of the heterogeneity of TOF as a category is the difficulty in developing a comprehensive assessment that would cover all the existing TOF sets and subsets. Indeed, no such assessment could be found in our review and one might question the need to develop such an assessment versus developing selective assessments focusing on specific TOF categories.

Some countries did implement assessments specifically targeted toward one TOF set or another, or toward part of a TOF set (see 3.3.a. below: Assessments focusing on specific TOF sets). Many countries have conducted assessments that provide or may provide information, albeit partial, on at least some TOF sets. Information on the area and location of some TOF sets can be extracted from land-cover and land-use assessments, provided they include such TOF sets as specific land-cover/land-use categories (see 3.3.b. below: Land-cover and land-use assessments including TOF subsets). Biophysical and sometimes socio-economic information on some TOF sets can also usually be extracted from National Forest Inventories, especially when they include sampling in non-forest areas (see 3.3.c. below: National Forest Inventories). The distribution, among these three main groups, of the assessments reviewed in this report, is presented in table 4.

Table 4: Distribution of the assessments between land-use/land-cover (LU/LC) type, national forest inventory (NFI) type, and TOF specific assessments.

Assessment	Type of assessment					
	LU/LC type	NFI type	TOF specific	TOF subset(s) covered or specifically targeted by the assessment		
				AGRI	URB	OTHER
Europe - CORINE LAND COVER	X			X	X	X
India FC/TC Assessment	X			X	X	X
Morocco Globcover LC-mapping 2008	X			X	X	X
New Zealand LCDB2	X			X	X	X
New Zealand LUCAS	X			X	X	X
Senegal Land-Cover mapping	X			X	X	X
US NRI	X			X	X	X
Sweden NILS	X			X	X	X
Bangladesh NFTA		X		X	X	X
Cameroon NFRA		X		X	X	X
Canada NFI		X		X	X	X
China NFI		X		X	X	X
Nicaragua NFI		X		X	X	X
Philippines NFTRA		X		X	X	X
Sweden NFI		X		X	X	X
US FIA		X		X	X	X
Zambia ILUA		X		X	X	X
Morocco NFI		X		X	O	X
Norway NFI		X		X	O	X
Senegal - PROGEDE		X		X	O	X
Slovenia FFECS		X		X	O	X
Uruguay NFI		X		X	O	X
US Great Plain States - Non Forest			X	X	X	X
India TOF inventory			X	X	X	X
Slovenia - WISDOM			X	X	X	X
Italy - Hedgerows and small woods assessment*			X	X	X	X
France - Linear formations*			X	X	O	X
UK - Countryside Survey*			X	X	O	X
UK - Small Woods			X	X	O	X
Global - Trees on Farm			X	X	O	O
Morocco Citrus Census			X	X	O	O
New Zealand APS			X	X	O	O
UK - Fruit and Orchard Survey			X	X	O	O
Uruguay GCA			X	X	O	O
UK - Trees in Towns II			X	O	X	O
Canada - Toronto UTCA			X	O	X	O
US - Urban Forestry			X	O	X	O
Sweden - Urban Forestry			X	O	X	O

Note: * means that the assessment is compiled in the «Inventories of Linear Tree Formations» profile sheet

3.3.a. Assessments focusing on specific TOF categories

The only global-scale assessment related to TOF currently available focuses on agroforestry (the "Trees on Farm" Study – Zomer et al. 2009). All other large-area assessments in this group have been conducted at national and sub-national scale, focusing on trees in part of the non-forest land –with forest land being defined according to national definition, which is very often different from FAO definition (Lund 2002). Non-forest land is usually subdivided into rural areas and urban areas with assessments that are specific to each of these subdivisions and that use different methodologies. In addition to these, some assessments deal with more specific TOF categories, such as commercial non-forest tree crops (all of them TOF), which are included in national agricultural production surveys conducted by many countries, but also "working trees" (USA), small woodlands and trees (UK) or hedges (with examples from France, Italy and the UK).

Trees on Farm - Global extent of agroforestry

The main purpose of the "Trees on farm" study (Zomer et al. 2009) was to quantify and map the extent of agroforestry at the global level, considering only the land used for agriculture, thus excluding land under urban use and land under forest (see Part 2b: Trees on Farm TOF profile). Using remote-sensing derived global datasets at a 1 km resolution, the study produced a series of maps of the tree-cover density on agricultural land. Although results should be considered as rough estimates because of the low resolution of the datasets, they very importantly show that agroforestry is a significant feature of agriculture in all regions, and that at a global level, more than 10 million km^2 (46 percent of the land classified as agriculture land in the global datasets) have more than 10 percent tree cover. No field sampling was undertaken during the study, and consequently its results are limited to spatial information, excluding any biophysical or compositional information.

Assessment of rural TOF

The only nation-wide integrated assessment focusing explicitly on TOF in rural areas has been conducted in India (see Part 2a: India TOF profile). Implemented by the Forest Survey of India as part of the periodic Indian National Forest Inventory, the assessment includes the analysis of high-resolution satellite images and field inventories in randomly selected sampling sites. Rural TOF are subdivided into 3 classes based on their geometrical shape (block: compact group of trees > 0.1 ha, linear tree formation and scattered trees) and different field sampling strategies are developed for each class, according to their respective characteristics. Spatial, biophysical and socio-economic attributes recorded through field sampling are numerous and contribute to the building of a reliable and accurate information base on TOF in rural areas at a national scale. One restriction, however, is that a minor part of the land supporting rural TOF is not taken into account in this assessment because it is classified as "forest" due to uncertainty in locating the exact boundaries of the recorded forest areas.

Assessments of urban TOF

Trees in an urban environment are most often assessed by municipalities at the city or town scale. Many cities in the world have their own urban forestry assessment and monitoring programme (see Part 2a: Canada TOF profile, the example of Toronto). Four countries (India, Sweden, the United Kingdom and the United States of America) have conducted integrated assessments of urban trees at the regional or national scale.

In the USA (see Part 2a: USA TOF profile), "Forest on the Edge" is a long-term program of the US Forest Service devoted to urban forestry. The program released a report including the main results of a country-wide assessment of urban forests, defined as all publicly and privately owned trees within an urban area, including trees along streets and in backyards, as well as stands of remnant forests (Nowak et al. 2010). Using high-resolution, remote-sensing derived data combined with maps of urban areas, the assessment did not include any field measurement and exclusively focused on tree canopy cover and tree density in the urban areas of each county (local jurisdiction).

In India, the "TOF urban" assessment is part of the periodic National Forest Inventory and records different spatial, biophysical and socio-economic attributes in randomly selected "urban block" samples, with the number of field samples increasing with the number of blocks in a city (see Part 2a: India TOF profile). As with the "TOF rural" inventory, the Indian "TOF urban" inventory results in a sound and accurate information base on TOF in urban areas at the national scale.

In UK, the Trees in Town II project (2004-2008) involved local, regional and national organizations and institutions from various sectors under the coordination of the Department for Communities and Local Government. It aimed at providing up-to-date information on England's urban tree stock and urban tree management (see Part 2a: UK TOF profile). The assessment was based on a preliminary stratification (region, town size, land-use type) followed by the random selection of 590 (200 x 200 m) field samples distributed over all the strata. It included a survey questionnaire sent to all local authorities in charge of city trees. A combination of high-resolution, remote-sensing derived data and measurements of spatial, biophysical, managerial and socio-economic attributes in each field sample further ensured high-quality qualitative and quantitative results. The Trees in Town project was partly reproduced in Sweden where a survey of urban forestry was conducted in 2006, based on survey questionnaires sent to local authorities (see part 2a: Sweden TOF profile).

Agricultural production surveys

All countries need statistically relevant data on their agricultural production. Agricultural services in many countries are conducting more or less periodic and detailed surveys on agricultural variables such as the areas under each major commercial crop, the annual production, the number of farmers, the use of fertilizers and pesticides, etc. These surveys usually include inter alia the collection of data on the country major commercial tree crops. Because all tree-crop plantations are TOF (they are made up of trees on land that is used primarily for agriculture), these surveys are an important source of information on TOF. The "Fruit and Orchard survey" in UK (see Part 2a: UK TOF profile) and the "Agriculture Production Survey" in New Zealand (see Part 2a: New Zealand TOF profile) are two examples of such surveys, based on questionnaires sent to tree-crop farmers previously identified through periodic population census. In other countries such as in Morocco with the "National Citrus Census" and in Uruguay with the "General Census of Agriculture", questionnaires are completed by agents of the agriculture services through direct interviews with the farmers. These surveys generally do not provide information on all tree-crop plantations: in New Zealand for instance, the questionnaire is sent to tree-crop farmers having an income above a certain threshold amount; in UK, the questionnaire is sent to farmers having more than 1 ha in tree-crop plantations. With these restrictions in mind, agriculture production surveys provide at least a lower estimate of the country area under various tree-crops[1]. In the best cases they also provide biophysical and socio-economic data that allow estimates of carbon sinks due to tree crops or their economic value at national scale.

Other specific TOF category assessments

Three other types of large-area assessment have been found that focus on specific TOF categories: one sub-national survey focusing on "working trees" (used here partly as a synonym for "agroforestry trees") in the USA, one national survey focusing on small woodlands and trees in the UK and a set of sub-national and national surveys focusing on linear tree formations. In addition to these assessments, two international supporting programmes (WISDOM and LADA) should be mentioned here as they focus on specific categories (the wood for fuel in WISDOM, and the tree resource in degraded land for LADA) that cross-cut all TOF subsets as defined in Chapter 2.

1 The estimate of the extent of the major tree crops in a country is also commonly produced by national land-use/land-cover assessments (see 3.3.a below). Another method commonly used to estimate the area covered by a given tree crop is to extrapolate the average yield to the total country production.

The "Working Trees" study (2008) covered 10 states in the North Central part of the USA. It is a good example of a territory-wide assessment focusing on agroforestry trees in the agricultural landscape (see Part 2a: USA TOF profile). This assessment did not involve new sampling, but built on a comparative analysis of the extent of "working trees" as estimated through data produced by the US Forest Inventory and Analysis (FIA) programme (see Part 2a: USA TOF profile) and through data from the MODIS Vegetation Continuous Field (VCF) global dataset based on low-resolution satellite images (500 m). Among other more specific results, the study showed that the national FIA programme underestimates the importance of some working trees categories such as narrow windbreaks and shelterbelts, which are not included in its inventories.

The "Survey of Small Woodland and Trees" in the UK is a periodic survey involving various organizations and institutions under the coordination of the Forestry Commission. It focuses on the assessment of the tree resources –excluding orchards and urban trees- in individual areas smaller than 2 ha (see Part 2a; UK TOF profile). Four categories are identified: "Small wood" (woodland > 0.1 and <2 ha); "Groups" (group of 2 or more trees with an area < 0.1 ha); "Linear feature", further subdivided into narrow (< 16m wide) and wide (> 16m wide) linear features; and "Individual trees." Various spatial, biophysical and managerial attributes are measured on each of these four categories through the analysis of high resolution remote-sensing based datasets and through measurements in a large number of 250 x 250 m sample plots selected randomly and representing 1 percent of the inland area and 1 percent of the coastal area. No category can be fully assimilated to a TOF category, except the "narrow linear feature" category. Information on three TOF subsets may however be extracted from the original data: narrow linear tree formations, by adding part of the "Wide linear Feature" category (less than 20 m width) to the already mentioned "narrow linear feature category"; woodlands smaller than 0.5 ha are extractable from the "Small wood" category; and areas with scattered trees less than 5 percent cover are extractable through a search for "groups" and "isolated trees" on the remote-sensing datasets.

Three assessments carried out at national scale in European countries specifically targeted linear tree formations. Hedgerows in particular were once very abundant in pasture areas (Burel & Baudry 1990, Deckers et al. 2005, Guillerme et al. 2009, Sklenicka et al. 2009, Plieninger 2012). They progressively disappeared since the 1960's but recent studies highlighted their environmental benefits (e.g. Boughey et al 2011, Paletto & Chincarini 2012), and new policies now support their plantation and maintenance for sustaining biodiversity (http://ec.europa.eu/agriculture/envir/measures/) and for adapting farms to climate change (http://ec.europa.eu/agriculture/climate-change/). The three following assessments have been made in this context (see Part 2a: Linear Tree Formations TOF Assessment Profile).

In France, the "Inventory of Linear Tree Formations," implemented since 2008 by the French National Forest Inventory, has the aim of providing up-to-date information on national tree stock outside forests. "Linear Tree Formations" are here defined as tree lines more than 25 m long and less than 20 m wide. The assessment relies on the systematic 1 km x 1 km grid used by the French NFI and on high-resolution remote-sensing datasets. On remote sensing plots that are selected each year for sampling, a 1-km long, randomly oriented transect is drawn in each non-forest area and linear tree formations intersecting the transect are counted. A sub-sample of these tree lines are then selected for detailed field measurements to provide a reliable and accurate picture at the country scale of the spatial, biophysical and management status of linear tree formations.

In Italy, an assessment of narrow linear tree formations and woodlots was undertaken by the Forest Monitoring and Planning Research Unit of the Agriculture Research Council, in the framework of the National Inventory of Forests and Carbon Sinks (INFC) that began in 2002. During the photo-interpretation phase, all inventory sampling points located outside forests were classified with reference to the two TOF subsets N1 (small woods) and N2 (narrow linear tree formations). Italy used the same definitions as FAO, and the assessed linear tree formations thus strictly correspond to TOF subset N2. The INFC also relies on a 1 km x 1 km grid and on high-resolution remote-sensing datasets, with a slightly different sampling protocol than the NFI in France, and linear tree formations are inventoried in full in each remote-sensing sampling plot. Detailed field measurements were not integrated in the assessment, although a field sampling protocol has been tested in one province.

In the United Kingdom, the Countryside Survey is a periodic country-wide assessment managed by the Centre for Ecology and Hydrology, one of the research centers of the Natural Environment Research Council. It aims at providing up to date information on natural resources in the UK countryside, including a Land Cover map with detailed land cover at a "field by field" scale. The assessment comprises a Field Survey, including inter alia an inventory of linear tree formations, based on a set of 1 x 1 km sample plots distributed all over the country and randomly selected within each of the major habitat types of the country. Although no maximal width threshold is included in the definitions of the assessed linear tree formations, they are assumed to broadly correspond to TOF subset N2.

The Woodfuel Integrated Supply/ Demand Overview Mapping (WISDOM) is an international supporting programme that was initiated in 2003 in the context of FAO country assistance, through collaboration between the FAO Wood Energy Program and the Institute of Ecology of the National University of Mexico (see Part 2b: WISDOM TOF profile). It developed a methodology applicable at various scales (city, country, region) to assess and map the supply and demand of fuel wood as a tool for wood-energy planning and policy. In any given WISDOM project, priority goes to the use of existing sources of information on trees in forest lands and in non-forest lands to assessing the fuel wood supply potential. Data on trees in forest lands are usually available, but data on trees in non-forest lands are often not. Special assessments thus have to be carried out, as in the cases of Rwanda and Slovenia (see Part 2a: Slovenia TOF profile). In Slovenia for instance, the project relied on the Forest & Forest Ecosystem Condition Survey (an NFI type assessment) for data on trees in forest areas, and carried out a specific assessment exclusively focusing on non-forest land.

This assessment began with the identification of all the land-cover classes with trees (10 classes in this case). A systematic sampling of the country's non-forest area was then used for mapping and measuring the area of each class, based on the analysis of high-resolution remote-sensing data sets. Each class was then assessed for its wood potential through measurements in a random sample of field plots.

The Land Degradation Assessment in Drylands (LADA) is another international supporting programme. It involves the United Nations Environment Program (UNEP) and FAO, and it aims at assessing the causes and impacts of land degradation at global, national and local scales (see Part 2b: LADA TOF profile). At national scale, LADA works with a panel of national partners and, after having mapped areas identified as hotspots of land degradation, the project carries out detailed local assessments in a few study sites located in these areas. The areas selected for local assessments may not be representative of the national distribution of TOF subsets and the small number of study sites in each selected area is not sufficient for ensuring statistical reliability and accuracy. However, each LADA local assessment provides locally detailed data on TOF. When combined with the other LADA local assessments, they may represent a complementary source of information on various TOF subsets, especially with regards to TOF management (see Part 2a: Senegal TOF profile).

3.3.b. Land-cover and land-use assessments

The need for spatial information about a country's key geographical features is at the root of the development of geography in general. Mapping is a specific field of geography which long focused on the spatial representation of topography and political boundaries, often including information on the main local uses and production of the land. Along with the technological advances of the 20th century such as high-resolution remote-sensing data and data analysis, capacity for detailed mapping of any geographical feature has become a reality. Many countries have thus developed detailed assessments of their land-use and land-cover, either independently or through collaboration with international programs.

Modern land-use and/or land cover assessments such as the eight assessments belonging to this group in this review (see Table 4) use remote-sensing datasets to produce spatial information with a level of detail that primarily depends on the resolution of the available datasets. This spatial information is translated into maps at various scales from which areas of each considered feature can be estimated. Although these assessments always involve a ground-checking phase, they are usually not associated to field measurements (but there are exceptions such as the National Inventory of Landscapes in Sweden, see Part 2a: Sweden TOF profile) and they thus only inform on the location and area of the land-use/land-cover classes. For TOF, this kind of assessment is extremely useful, both as a direct source of information on the location and area of land-use/land-cover classes with TOF, and as a basis for the identification of areas of interest for conducting detailed TOF assessments. There is however a pre-condition: that land-use/land-cover classes include classes corresponding to the main TOF categories.

All these assessments begin with the identification of all the land-use and/or land-cover classes relevant to the country, usually involving a hierarchy of levels. For instance the first level in the Natural Resources Inventory carried out in the USA (see Part 2a: USA TOF profile) involves two large classes ("developed land" and "rural land"), which are further subdivided up to the last level in ever more specific classes: as an example, "horticultural cropland" is a last-level class which is included into the "Non-cultivated cropland", which itself is part of the "cropland" class, one of the second level classes included in the "Rural land" first level. With regard to the use of the above assessment for getting information on TOF, the situation is quite mixed: some classes contain no TOF at all, some are exclusively composed of TOF, and the others are only partly composed of TOF. In the example above, the "hayland" class, a subclass of "cropland" dedicated to the production of forage crops that are machine harvested, contains no TOF at all. By contrast, the "horticultural cropland" class, also a subclass of "cropland" but dedicated to tree crops, is exclusively composed of TOF. In many cases however, only part of the last-level class includes TOF such as the "rural transportation land" class, a subclass of "developed land" covering transportation corridors in rural areas, which is sometimes associated with narrow lines of trees, which are TOF.

The fact that some land-cover/land-use classes are completely devoid of TOF, while other classes are exclusively composed of TOF and still others partly composed of TOF is typical of the classificatory frameworks used in land-cover/land-use assessments. These assessments are undoubtedly useful as they provide spatial information on classes that are exclusively composed of TOF, therefore allowing the production of some estimates of TOF at country level. However, the fact that some classes only partly contain TOF is problematic, as there is no means to know which parts of such classes contain TOF and which parts do not. Even quite sophisticated assessments such as Corine Land Cover developed at the european scale, and assessments that use the Land Cover Classification System (LCCS, Gregorio & Jansen 2000) developed by FAO and UNEP (see Part 2b: Land Cover Classification System TOF profile) have classes that only partly contain TOF, such as the "Fruit trees and berry plantations" in Corine Land Cover, which could be considered a TOF category except that it includes "permanent florist plantations of roses"; or the "Small Tree Plantation" class in the Land Cover mapping - LCCS project implemented in Senegal, which gathers all forest tree plantations with less than 2 ha in area ("Other Land *with TOF*" for those plantations between 0.05 and 0.5 ha, "Forest" for plantations between 0.5 and 2 ha). In the same Senegal Land Cover Mapping project (see Part 2a: Senegal TOF profile), among the 55 land-cover classes represented in the country, 8 classes could be identified as containing TOF in all the areas they cover (2 classes related to tree-crops, 3 classes related to rain-fed herbaceous crops with a layer of sparse trees, 1 class related to natural herbaceous vegetation with sparse trees and shrubs, 1 class related to urban areas and 1 class related to rural settlements), but 13 classes were identified as containing TOF in parts of the area they cover: 12 classes are subclasses of "Terrestrial Natural Vegetation" and 1 is a subclass of "Aquatic Natural Vegetation", and for these 13 classes, this is either the area of the unit (more or less than 0.5 ha) or the tree cover in the unit (more or less than 5 percent) that determines whether the area does or does not contain TOF.

The Land Cover Classification System, despite the constraints exemplified in the Senegal example above, warrants a special mention here for four reasons:

- ✓ It has been developed through a large range of international collaborative activities by a very diverse panel of national and international experts;

- ✓ After testing in various countries, it has been implemented in a number of countries and it is now used by an increasing number of national, regional and international programs;

- ✓ The land-cover classification approach adopted by LCCS, combining a set of universally applicable levels and 8 optional sets of classifiers, allows levels of detail that are adapted to any country;

- ✓ And the system may be improved in its usefulness for TOF assessments through the adoption of judiciously selected TOF-related classifiers.

3.3.c. National Forest Inventories

Although they usually focus on forests, National Forest Inventories (NFI) or their equivalent may almost always be a source of information on TOF, as shown by the 14 assessments belonging to this group in this review (see Table 4). They often include some TOF categories; they always focus on biophysical information related to trees and their environment; and they sometimes also include socio-economic data.

NFIs sometimes assess TOF that are located in forest areas

The three examples below highlight the fact that national definitions of forest may be different from the FAO definition (Lund, 2002). That suggests that some TOF subsets may be included in NFI assessments and therefore extractable from NFI data.

In Slovenia, national law defines forest as "forest tree stands > 0.25 ha and riverside forest corridors and windbreaks > 0.25 ha, if their widths are at least one tree-height". Small woodlands between 0.25 ha and 0.5 ha were thus considered as forest in the Slovenia "Forest & Forest Ecosystem Condition Survey" (FECS), an NFI equivalent. It was carried out in 2007 at country scale and covered only the country forests (see Part 2a: Slovenia TOF profile). For FAO, since these small woodlands are less than 0.5 ha in area, they are not considered as Forest and the trees are considered as TOF.

In the USA (see Part 2a: USA TOF profile), the Forest Inventory and Analysis program carries out periodic assessments on "accessible forest land," defined among other points as an area that is occupied by trees with at least 10 percent canopy cover, and that meets minimum area (0.4 ha) and width (36.6 m) requirements. These criteria allow (i) small woods between 0.4 and 0.5 ha, and (ii) linear tree formations with a width between 20 and 36.6 m, to be included in these accessible forest lands. For FAO, they are TOF and make up part of the TOF subset N1 and of the TOF subset N2, respectively (see Chapter 2).

In India, TOF are assessed through two specific assessments (the "TOF Urban" inventory and the "TOF Rural" inventory: see II.1.2. and II.1.3. above). Another national assessment, the "Forest Inventory", should also be taken into account for a more complete assessment of TOF (see Part 2a: India TOF profile). The Forest Inventory is a periodic assessment that focuses on forest land. However forest land is not always well demarcated in the field, so that an estimated 10 percent of the area assessed is located on non forest land. It is therefore no surprise that the Indian Forest Inventory includes categories that qualify as TOF, such as "Agricultural Tree Land", "Trees in Line", "Agricultural Lands with Trees in Surround", and "Non Forestry Plantations".

NFIs often encompass non-forest land

Some countries conduct their NFI through a systematic sampling grid that encompasses both forest land and non-forest land, with field and/or remote-sensing sampling in the two components. This means that they collect information on TOF in both their forest land (because of differences between national definitions and FAO definitions) and in their non-forest land, albeit usually with different sampling intensities and sampling protocols.

The National Forest Inventories conducted in Canada (see Part 2a: Canada TOF profile) and in countries that have implemented the National Forest Monitoring and Assessment methodology developed by FAO (NFMA) are good examples of assessments that cover both forest land and non-forest land through different sampling schemes.

The Canada National Forest Inventory is based on a sampling grid that covers the whole country regardless of land cover. Remote sensing sampling plots are assessed whether they are forested or not, but field measurements are carried out only in forested plots.

Countries that used the methodology developed by the National Forest Monitoring and Assessment programme represent other national examples of assessments based on a systematic grid covering the whole country regardless of land use. Here, field sampling and measurements protocols differ depending on whether the sampling unit is located on forest or not (see Part 2b: NFMA TOF profile). Among countries that have implemented NFMA assessments to date, only Cameroon and Guatemala have subdivided their land territory, in 2 and 3 regions respectively that differ in terms of their forest cover. In these cases, forest-dominated regions have twice the sampling intensity of non-forest dominated regions. However as a rule, the measurements protocols in NFMA type assessments are different for forest and non-forest Land-Use/Cover Sections (LUCS), with fewer trees measured on non-forest LUCS because the minimum DBH for tree measurement is higher than on forest LUCS (see Part 2a: Bangladesh TOF profile; Nicaragua TOF profile; Philippines TOF profile; Zambia TOF profile). The originality of the NFMA approach, compared to other NFIs and their equivalent, is that TOF are taken into account right at the onset of the assessment through the constitution of a multi-sector coordination panel, through the multidisciplinary nature of the field teams, and through the inclusion of classes containing TOF in the Land-Use/Cover Classes identification process. This effort allows the mapping and measurement of the sections covered by these classes in field samples, completed by interviews with locals that inform on various management, production and socio-economic issues. NFMA assessments have thus the potential to produce various spatial, biophysical and socio-economic estimates relative to TOF, however with the same constraint as other NFIs: they do not directly provide spatial information on the location of the various TOF classes (although they are often associated with a land-cover assessment that may fill this role). And although they are statistically reliable, they have a relatively low accuracy for TOF due to the low number of field samples including TOF and the high heterogeneity of TOF systems.

The National Forest Inventories in China (see Part 2a: China TOF profile), Norway (see Part 2a: Norway TOF profile) and Sweden (see Part 2a: Sweden TOF profile) represent rare examples of assessments that cover both forest land and non-forest land by using the same sampling scheme for both land-uses. The three countries use quite different methodologies, specific to each country, but they implement the same sampling and measurements schemes regardless of the land-use category, be it forest or not.

NFIs: provider of information on TOF, but also of tools and methods for large-area TOF assessments

Among the data recorded in all NFIs, species identification and dendrometric measures have a special place. Their analysis is of prime importance for assessing the current state of the tree resource in general, for both forest and for trees outside forests. Trees in and outside forests indeed share a number of features, as regards the goods and services they provide. Trees in forests usually produce timber, but in some areas, trees outside forests are a major source of timber, at least for local users (Pandey 2008, Bertomeu 2008). Forests also produce non-timber forest products (NTFPs) but in many cases, they are also collected from trees outside forests that are very often cultivated (Ruiz-Perez et al 2004). Usually the land use of origin of NTFPs is difficult to trace, so that it is often impossible at national scale to know the proportion of a given NTFP coming from forest or from TOF. Trees in and outside forests also provide the same range of environmental services, albeit with varying degrees according to the organisation and composition of the trees.
As shown above and in the country TOF profiles, most NFIs already provide some information on TOF, but considering the functional commonalities between trees in and outside forests, the main utility of NFIs for TOF assessment in large areas may well be as a source of ideas for tools and methods that could be adapted.

3.3.d. Cross-analysis

This section reviews the main characteristics of TOF-related assessments and identifies the major commonalities and differences among the various assessment types (cf Table 5).

Objective(s) of the assessment

Objectives of the assessments always involve a better understanding and knowledge of the targeted resources with the aim of improving planning and resource management. The assessment's land-use coverage clearly depends on the targeted resources: land-use/land-cover (LU/LC) type assessments include all land uses; national forest inventories include forest only or all land uses; and TOF-specific assessments include one, two, or three TOF sets. For a TOF set, inclusion in an assessment does not mean that the TOF set is explicitly taken into account. For instance, many LU/LC assessments do recognize and explicitly take into account tree-crop monoculture plantations, but place pastures with isolated trees into a broader "pasture" category.

Institutions involved and coordinating institution of the assessment

The coordinating institution may belong to the forestry, agriculture, environment or academic sectors. The assessment sometimes involves institutions in other sectors. With the exception –in our sample- of the Sweden NFI (which is coordinated and implemented by an academic institution), national forest inventories are always coordinated by a forestry agency. Other sectors are generally not involved in the implementation of NFIs except when their objectives extend beyond the forest resource and thus include the tree resources outside forests. Most land-use/land-cover assessments are coordinated and implemented by institutions in the environmental sector.

Some LU/LC assessments involve institutions in other sectors during implementation. TOF-specific assessments are generally coordinated by the institution in charge of the targeted TOF set(s): agriculture for the tree-crops census or surveys, forestry for linear tree formations and for small woods, and municipalities for urban tree surveys. However, there are many exceptions. For instance, urban forestry assessments may be coordinated by a forestry agency (India, Slovenia, USA), by a higher education agency (Sweden) or by an inter-sectoral agency (UK).

Table 5: Main characteristics of the assessments analyzed in the review

Assessment	Assessment Type	Institution in charge (a)	Multi sector	Objectives (b)	Scale (c) / land area (x 1000 ha)	Targeted Land-uses (d)	Forest definitions (e)
Europe - CORINE LAND COVER	LULC	E	N	I	R (Europe)	I	NotFRA
India FC/TC Assessment	LULC	F	N	F	N / 297 319	I	NotFRA
Morocco Globcover LC 2008	LULC	I	N	I	N / 44 630	I	NotFRA
New Zealand LCDB2	LULC	E	N	I	N / 26 771	I	NotFRA
New Zealand LUCAS	LULC	E	Y	I	N / 26 771	I	NotFRA
Senegal Land-Cover mapping	LULC	E/I	Y	I	N / 19 253	I	NotFRA
US NRI	LULC	A/E	N	I	N / 916 193	I	NotFRA
Sweden NILS	LULC	E	Y	I	N / 41 033	I	FRA
Morocco NFI	NFI	F	N	F	N / 71 255	F	NotFRA
Uruguay NFI	NFI	F	N	F	N / 17 502	F	NotFRA
Slovenia FFECS	NFI	F	N	F	N / 2 014	F	NotFRA
US FIA	NFI	F	N	F	N / 916 193	F	NotFRA
China NFI	NFI	F	N	F	N / 942 530	I	NotFRA
Norway NFI	NFI	F	N	F	N / 30 427	I	NotFRA
Senegal - PROGEDE	NFI	F	Y	F	N / 19 253	I	NotFRA
Bangladesh NFTA	NFI	F	Y	F/I	N / 13 017	I	FRA
Canada NFI	NFI	F	N	F/I	N / 909 351	I	FRA
Zambia ILUA	NFI	F	Y	I	N / 74 339	I	FRA
Cameroon NFRA	NFI	F	Y	I	N / 47 271	I	FRA
Nicaragua NFI	NFI	F	Y	I	N / 12 140	I	FRA
Philippines NFTRA	NFI	F	Y	I	N / 29 817	I	FRA
Sweden NFI	NFI	H	N	F	N / 41 033	I	FRA
Global - Trees on Farm	TOF specific	H	N	A	G	A	n.a.
Morocco Citrus Census	TOF specific	A	N	A	N / 71 255	A	NotFRA
New Zealand APS	TOF specific	I (A/F)	Y	A	sN / 26 771	A (partly)	NotFRA
UK - Fruit and Orchard Survey	TOF specific	A	N	A	sN / 16 459	A (partly)	NotFRA
Uruguay GCA	TOF specific	A	N	A	N / 17 502	A	NotFRA
US Great Plain States - Non Forest	TOF specific	F	Y	A/U	sN / 79 628	A/U	NotFRA
India TOF inventory	TOF specific	F	N	A/U	N / 297 319	A/U/L	NotFRA
Slovenia - WISDOM	TOF specific	F	N	A/U	N / 2 014	All except F	NotFRA
UK - Small Woods	TOF specific	F	Y	F/A	sN / 22 894	F/A/L	NotFRA
UK - Countryside Survey	TOF specific	E/H	Y	F/A/L	N / 24 250	F/A/L	NotFRA
France - Linear formations	TOF specific	F	N	L	N / 55 010	L	FRA
Italy - Hedgerows / small woods	TOF specific	F	N	L	N / 29 411	L	FRA
UK - Trees in Towns II	TOF specific	I	Y	U	sN / 13 028	U	NotFRA
Canada - Toronto UTCA	TOF specific	U	Y	U	sN / 66	U	NotFRA
US - Urban Forestry	TOF specific	F	Y	U	N / 916 193	U	NotFRA
Sweden - Urban Forestry	TOF specific	H	N	U	N / 41 033	U (partly)	FRA

Legend:

The symbol (a) refers to the sector of the institution in charge: F - forestry, A - agriculture, U - urban, E - Environment, H - Higher Education, I - integrated or multisector.

The symbol (b) refers to the main target of the assessment: F - forest resources, A - tree resource in agricultural land, U - tree resource in urban land,L - tree resource in linear formations, I - tree resource in general

The symbol (c) refers to whether the assessment covers the globe (G), a region (R), a whole country (national: N) or a large fraction of the country (sub-national: SN)

The symbol (d) refers to the land-uses targeted by the assessment: F - forest, A - agricultural land, U - urban land, L - linear tree formations, I - all land-uses

The symbol (e) refers to whether the country uses the same definitions as FAO-FRA (FRA) or not (NotFRA) for forest and related terms

Table 5: Main characteristics of the assessments analysed in the review (continued)

Assessment	Methodology			TOF variables (h)	TOF as categories (i)	Results extractable (j)
	Survey	Remote-sensing (f)	Field sampling (TOF) (g)			
Europe - CORINE LAND COVER	N	WW	N	A/Lo	P	P (re-analysis)
India FC/TC Assessment	N	WW	N	A/Lo	P (A/U)	P (A/U)
Morocco Globcover LC 2008	N	WW	N	A/Lo	P (A)	P (A)
New Zealand LCDB2	N	WW	N	A/Lo	P	P
New Zealand LUCAS	N	WW	N	A/Lo	P	P
Senegal Land-Cover mapping	N	WW	N	A/Lo	P (All)	P
US NRI	N	S	N	A/Lo	N	P (re-analysis)
Sweden NILS	N	S	Sy	D/En/Lu/M/Sp/Tc	P	P (re-analysis)
Morocco NFI	N	S	R/Sy	D/Sp	N	P (re-analysis)
Uruguay NFI	N	WW	Sy	D/En/Lu/Sp/Tc/Ten	P (A/N1/N2)	P (re-analysis)
Slovenia FFECS	N	Y	Sy	D/En/Lu/Sp/Tc/Ten	N	N
US FIA	N	S/WW	R/Sy	D/En/Lu/Sp/Tc/Ten	N	P (re-analysis)
China NFI	N	S	Sy	D/En/Lu/Sp/Tc/Ten	P	P (re-analysis)
Norway NFI	N	N	Sy	D/En/Lu/Sp/Tc/Ten	N	P (re-analysis)
Senegal - PROGEDE	N	S/WW	O	D/Lu/Sp	N	P (re-analysis)
Bangladesh NFTA	Y	WW	Sy	All (- A/Lo)	P (A/U)	P (A/U)
Canada NFI	N	S	N	A	P (A/U)	P (A/U)
Zambia ILUA	Y	WW	Sy	All	P (A/U/L)	P (A/U/L)
Cameroon NFRA	Y	N	Sy	All (- A/Lo)	P (A/U)	P (A/U)
Nicaragua NFI	Y	N	Sy	All (- A/Lo)	P (A)	P (A/N3/N4)
Philippines NFTRA	Y	N	Sy	All (- A/Lo)	P (A)	P (A)
Sweden NFI	N	N	Sy	D/En/Lu/Sp/Tc/Ten	Y	P (re-analysis)
Global - Trees on Farm	N	WW	N	A/Lo/Lu/Tc	Y	Y (A)
Morocco Citrus Census	Y	WW	Sy	A/Lo/Ec/Lu/M/Ten	Y	Y (A)
New Zealand APS	Y	N	N	A/Lo/Ec/Lu/M/Ten	Y	Y (A)
UK - Fruit and Orchard Survey	Y	N	N	A/Lo/Ec/Lu/M/Ten	Y	Y (A)
Uruguay GCA	Y	N	N	A/Lo/Ec/Lu/M/Ten	Y	Y (A)
US Great Plain States	N	WW	R/Sy	D/En/Lu/Sp/Tc	Y	Y (A/U)
India TOF inventory	N	S	Sy/St	D/Lu/Sp/Tc/Ten	Y	Y (A/U)
Slovenia - WISDOM	N	S	Sy	D/Lu/Sp/Tc	Y	Y (A/U)
UK - Small Woods	N	S	Sy	D/En/Lu/Sp/Tc/Ten	Y	P (re-analysis)
UK - Countryside Survey	N	WW	Sy	All (- Ec/TP/TP)	Y	P (re-analysis)
France - Linear formations	N	S	Sy/St	D/En/Lu/Sp/Tc/Ten	Y	Y (N2)
Italy - Hedgerows / small woods	N	S	Sy/ST/R	D/En/Lu/M/Sp/Tc/Ten (l)	Y	Y (N1/N2)
UK - Trees in Towns II	Y	S	R	A/Lo/D/Ec/Lu/M/Tc/Ten	Y	Y (U)
Canada - Toronto UTCA	N	WW	Sy	D/Lu/Sp/Tc/Ten	Y	Y (U)
US - Urban Forestry	N	S/WW	N	A/Lo/Lu/Tc	Y	Y (U)
Sweden - Urban Forestry	Y	N	N	Lu/M/Tc	Y	Y (U)

Legend

The symbol (f) refers to whether the assessment includes the analysis of Remote Sensing images: N - no, S - on a sample of locations, WW - wall to wall mapping (on the whole area covered by the assessment)

The symbol (g) refers to whether the assessment includes a Field sampling phase: N - no, R - random sampling, Sy - systematic sampling, St - stratification per TOF categories, O - other type of sampling

The symbol (h) refers to TOF variables measured or assessed: A - area, D - dendrometrics, Ec - economics, En - environment, Lo - Location, Lu - land-use, M - management, Sp - species composition, TC - tree cover, Ten - Tenure, TP - tree products, TU - tree uses

The symbol (i) refers to whether TOF are Y - fully taken in account, N - not taken in account, or P - partly taken in account, in categories of the assessment,

The symbol (j) refers to whether TOF results are Y - extractable for all TOF subsets concerned by the assessment, N - not extractable for any of the TOF subsets, P - partly extractable, only for some of the subsets concerned by the assessment, or P (data re-analysis) - partly extractable through a re-analysis of the raw data.

Methods used for the assessment,

As expected, the assessments reviewed use remote-sensing analysis usually combined with mapping, field inventories and/or survey questionnaires. The analysis confirms that the three main methods complement each other, with each main method being associated with a different set of variables.

Remote-sensing analysis

All land-use / land-cover assessments use remote-sensing analysis. When the production of LU/LC maps is not among the assessment's expected results, the main objective is the production of statistically valid data at national scale, as in the Sweden NILS and the US NRI. In those cases, the assessment is based on analysis of a set of high-resolution images that are uniformly sampled from a grid covering the entire targeted area. When the assessment results in LU/LC maps, such as in the other LU/LC assessments, the analysis of images covering the entire targeted area ("wall to wall") is necessary. Due to the cost in terms of images and analysis, low-resolution images are used for this wall-to-wall mapping, generally in combination with a sample set of high-resolution images used for reference data creation. Most national forest inventories use existing LU/LC assessments as secondary data, often to check for the presence of forest in samples targeted for field measurements. But some NFIs include an LU/LC assessment in their activities and use remote-sensing analysis, either with wall-to-wall images or with uniformly spaced sample images on a grid. Most TOF-specific assessments include a remote-sensing analysis phase, either with wall-to wall images when maps are to be produced, and/or with uniformly spaced sample images.

The variables related to TOF that are assessed through wall-to-wall remote-sensing are the location and the area of the LU/LC units. The tree cover in each unit may also be assessed, as exemplified at global scale by the "Trees on Farm" assessment. Remote-sensing image samples can be used to estimate at country scale the area and the tree cover of various LU/LC classes and subclasses. Other biophysical variables related to trees in or outside forests, such as biomass and carbon stocks, have been estimated from remote-sensing images, but mainly in relatively homogeneous areas and/or small areas. New remote-sensing methodologies based on Light Detection And Ranging (LiDAR) technology could be of particular importance to TOF assessment. LiDAR technology has numerous applications especially in forestry due to its capability to measure tree heights and in some cases biomass (REF). Remote-sensing is a very active field of research and progress will most likely allow estimation of more variables than area and tree-cover on a routine basis in the near future.

Field inventories

Although all the land-use/land-cover assessments include a ground-checking phase, none of the reviewed assessments includes real field inventories, except the Sweden NILS, which combines analysis of uniformly spaced, high-resolution images with field inventories in the areas covered by these images. By contrast, all the national forest inventories are based on important field inventory campaigns, which in the large majority of cases involve uniformly spaced field samples (systematic sampling), sometimes associated with a certain level of randomization. The situation is more varied in TOF specific assessments. No field inventory is included in agricultural censuses or surveys focusing on tree crops. Field inventories are not included in some urban tree assessments, but they are in others where the location of field samples is chosen through random sampling (UK Trees in Town) or through systematic sampling combined with a degree of stratification (India TOF-urban) or not (Canada-Toronto UTCA). In assessments focusing on TOF groups other than the previous ones, such as narrow linear tree formations, small woods and rural TOF, field inventory is always a major component. Location of field samples is always based on a systematic sampling scheme, which sometimes includes some level of stratification and/or randomization.

The variables associated to TOF that are assessed through field inventories are biophysical variables. The list can be extended almost ad infinitum, but the minimal set consists of the identification of tree species, dendrometric variables such as tree diameter (DBH), tree height, tree cover, environment variables, such as soil characterization, slope, herbaceous components, etc. These variables are used to characterize the structure and composition of the tree component in the field sample. They are further used to derive estimates at national (or other level) level of the tree density, basal area, wood volume, biomass, carbon stocks, etc. The minimum set of variables usually also includes information on land use and land tenure.

Survey questionnaires

Survey questionnaires are not included in any of the land-use/land cover assessments, nor are they included in the national forest inventories, except in NFIs that used the NFMA approach. Survey questionnaires have only been used in TOF-specific assessments that focus on tree- crops, where they make up the main tool for collecting data, and for some urban tree assessments.

The variables related to TOF usually captured through survey questionnaires are socio-economic, production and management variables. The list of such variables usually include basic socio-economic information on the owner or manager of the plot used for sampling, the identification of the various products associated to each tree species, the yield for each product, the quantity of product sold, the sale price, and the management practices (planting, cutting, pruning, etc.) associated with each tree species and the plot.

Identification of categories with TOF in the assessment

Land-use/land-cover assessments generally include LU/LC classes that contain no TOF at all, classes that contain TOF in all the area they cover, and classes that contain TOF only in parts of the area they cover, as exemplified above in the case of the Senegal land-cover mapping (see Chapter 3, 3.3.b). In Senegal for instance, the minimum area and tree cover thresholds are different from those used by the FAO-FRA; that explains the existence of undetermined classes for TOF (classes that may or may not contain TOF depending on the location). In other cases, the class definition does not include the presence (or absence) of trees in its criteria. For instance the class "pasture" often does not differentiate pastures with trees from pastures without trees. National forest inventories often do not include explicit TOF categories but some NFIs do. One example is the Sweden NFI, which developed a very detailed classification; another is the Canada NFI, which uses the FAO-FRA "Other Land with Tree Cover" class; finally there are all the countries that have implemented the NFMA approach and that have explicitly categorized agricultural TOF, sometimes also urban TOF, and but more rarely small woods and/or narrow linear formations. Quite logically, all TOF specific assessments include explicit TOF categories, although none of the reviewed assessments includes all the categories.

TOF sets covered by the assessment

There is an obvious relation between the targeted land-uses of an assessment and the TOF sets that are included into the coverage of this assessment. Land-use/land-cover assessments target all land-uses and very logically include all TOF sets in their coverage. National forest inventories often also target all land-uses which entails that all TOF sets are covered, but a few NFIs more exclusively target forest, which restricts the number of TOF sets that may be found in the assessment coverage with TOF-URB being always excluded. TOF specific assessments very logically show a very close relation between the targeted land-uses and the TOF sets and subsets that are included in the coverage of the assessment. Except for this latest category – TOF specific assessments – it is important to note that the data produced on a given TOF set depend not only from the coverage of the assessment, but also from its objectives and its capacity to distinguish explicitly between the various TOF sets. For a given TOF set to be included in the coverage of an assessment is no guaranty that the assessment produces relevant information on this TOF set. For instance, almost no data can be found on small woods in LU/LC assessments and NFI assessments –because small woods are… too small!-, although this is a TOF subset (N1 in table 5) that is included into the coverage of all the LU/LC assessments and of almost all the NFI assessments.

Main kind of results regarding TOF at the scale of the assessment

The kind of results regarding TOF highly depends on the type of assessment, and within each type, on the targeted land-uses and the combination of methods used. Land-use/land-cover assessments that include mapping, as well as national forest inventories that include a LU/LC phase, provide results on the locations with TOF at least for the TOF categories that have been explicitly defined. All LU/LC and NFI assessments estimate the extent of each explicitly defined TOF category. For mixed categories in which TOF may or not be present, data might be extractable but this would involve a re-analysis of the raw data. National forest inventories mainly provide biophysical and species composition data and information on the main land uses and land-tenure status, again for those TOF categories that have been initially explicitly identified. For these categories, in addition to the area they cover, NFIs may provide estimates at the assessment scale of variables such as the number of trees, the relative proportion of the major tree species, the total tree biomass, the total timber stock, and the total carbon stock. For mixed categories in which TOF may or not be present, the situation is the same as for spatial distribution and area: data might be extractable but this would involve a re-analysis of the raw data. NFIs that used the NFMA approach usually also provide socio-economic results of high importance for TOF issues, such as the use of TOF products and the trends in harvesting these products, or the gender balance in the harvesting and use of TOF products, etc.

TOF-specific assessments are more heterogeneous in all aspects, including the kind of results produced. The global "Tree on farm" assessment produced a number of global and regional maps, including inter alia maps of the tree cover on agricultural land, as well as global and regional estimates of the areas of agricultural land with tree cover according to various thresholds. The national agricultural surveys produce estimates of various socio-economic and management data relative to the producers, estimates of the areas under various tree crops, and estimates of the yield and annual production of the various tree crops. But they generally do not include any dendrometric data so that other biophysical estimates – such as tree biomass and carbon stock -- cannot be provided by these surveys. The other TOF-specific assessments generally provide very detailed results regarding the TOF categories they focus on. In addition to estimates of the extent of the targeted TOF category, results generally include estimates of the same biophysical variables as for national forest inventories (tree number, biomass, carbon stock, composition, etc.), and in some urban forestry assessments, estimates of TOF products, services and management.

Three main observations here involve:

- ✓ The relationship between the kind of assessment and the kind of institution in charge;
- ✓ The relation between the kind of assessment and the sets of methods;
- ✓ The kind of results produced by each kind of assessment.

The institutions involved in the organisation and coordination of the assessments reviewed here are diverse and represent various sectors.

National TOF specific assessments have been implemented by national forest services alone in India (TOF Urban and TOF Rural), France (Linear Tree Features Inventory), and the USA (Great Plain States – Non Forest). In three other cases

(WISDOM Slovenia, the Forest on the Edge project in USA, and the Small Woodland and Tree Survey in UK), the national forest services were coordinators, but the assessment involved many partners from various sectors. In the Trees in Town project in England, the national forest service was one partner in a multi-sector collaborative assessment coordinated by the Department for Communities and Local Government. The Agriculture Production surveys are obviously part of the domain of the national agriculture services. Among the other large-scale assessments that provide information on TOF, National Forest Inventories and their equivalents obviously are the primary domain of national forest services. The "Trees on Farm" global study on agroforestry was carried out by an international research centre (ICRAF), using data produced by Land-cover/ land-use (LC/LU) assessments. LC/LU assessments themselves most often involve international partners such as the Global Land Cover Network (GLCN) and national services related to land-use planning, agriculture, forestry and environment in a multi-sector collaborative process. NFMA-type assessments are usually coordinated by forest services but they always involve a multi-sector collaboration.

Some assessments such as the "Agriculture Production Surveys" in UK and New Zealand or the "Survey of Urban Forestry" in Sweden were exclusively carried out through survey questionnaires sent throughout the country to targeted individuals. The land-cover and land-use assessments all use remote-sensing derived datasets associated with ground-checking, and result in the stratification of a country territory in hierarchically organised land-cover/land-use classes. NFIs and their equivalent, but also the TOF focused assessments, all use a combination of remote-sensing derived datasets and field sampling inventories. They also all use a fairly complex combination of all or part of the following elements, at various stages of their sampling schemes : stratification (e.g., "accessible forest land" vs. "non-forest tree land" in the US FIA, or "block" vs. "linear" vs. "isolated" in the Indian "TOF rural" inventory), systematic grid (e.g., NFI in China, Sweden, USA, and NFMAs), and random sampling (urban blocks in the Indian "TOF urban" inventory, field sub-plots in the UK "Survey of Small Woodland and Trees").

Each kind of assessment yields certain kinds of results. Land-cover/land-use assessments are targeted towards the production of spatial results. For TOF, the usefulness of such assessments is directly related to the identification of unequivocal TOF categories that cover the whole TOF range. The reliability and accuracy of results on TOF classes, as for any LC/LU class then mainly depends on the quality and resolution of the remote-sensing data used. Data are generally presented as maps, and allow the production of estimates of the area covered by each LU/LC class. The usefulness of such data for more detailed TOF assessments is obvious: all patches of each TOF class may be located, allowing the development of adapted sampling strategies that take into account the heterogeneity of each class as well as their geographical distribution and their total area. National Forest Inventories and their equivalents, including NFMA type inventories, in forest land and when the area of isolated stands is recorded, may provide data contributing to an estimation of both the area and the tree attributes of small woodlands less than 0.5 ha in area; in non-forest land, when land use is recorded, they may provide estimates of the area and tree attributes of both trees in an agricultural context and trees in an urban context. Agricultural production surveys provide data that contribute to estimation of the area and attributes of trees in an agricultural context.

TOF-focused assessments provide various kinds of data depending on the objectives set for them. To give one example in an urban context, the Forest on the Edge project in the USA provides data at national scale on the areas of urban land with trees, as well as on the tree density and the tree cover in these areas. The Trees in Town inventory in the UK and the TOF Urban Inventory in India provide the same kind of results, but add solid data on various biophysical, managerial and socio-economic aspects of trees in cities and towns.

3.4. Conclusions

This section highlights the main findings of this review, and examines possible reasons for the small number of large-area TOF assessments.

3.4.a. Highlighting the main results

The review of the 36 national assessments included in this report suggests that the TOF concept has not been fully integrated yet. This is clear from the following facts:

- ✓ Most non-TOF-specific assessments do not explicitly recognize the categories of TOF-covered land.
- ✓ No country has yet implemented an assessment covering all TOF sets.
- ✓ Only a very few countries have conducted assessments that deliberately targeted one or the other TOF set.

However, the review also shows that progress has been made towards the recognition of TOF as a valuable resource worthy of assessment. This is shown inter alia by the following facts:

- ✓ One global-scale TOF assessment has been realised (Trees on Farm). It concerns only TOF on agricultural land, but although its scope is limited to one TOF set, its results are extremely important, especially because they provide an order of magnitude of the global extent of this important set: approximately 10 million km^2 of agriculture area (or 46 percent of the total “agriculture land”) have more than 10 percent tree cover. In other words these 10 million km^2 would have been classified as Forest if the land-use was not agriculture. Compared to the total area of Forest, estimated by the global FRA 2010 at 40 million km^2 (FAO 2010a), this is a very significant figure.
- ✓ One regional scale assessment has been undertaken (Europe - Corine Land Cover). Although it is a land-use/land-cover assessment that does not specifically focus on TOF, it encompasses various classes that contain TOF in their whole or in part of their area. Maps of the various countries are published where the spatial distribution of classes including TOF may be identified and their extent estimated.
- ✓ Many countries have available national assessments that provide (or may provide after some re-analysis of the data) information on TOF sets and subsets. It is possible for such countries to build on these assessments and develop complementary assessments that would fill the gap of information and help these countries get a more complete and accurate picture of their TOF resource. In particular, land-cover/land-use assessments constitute a perfect starting point for complementary TOF assessments based on field inventories, providing the land-cover classes have been judiciously defined so that they unequivocally cover all TOF categories.
- ✓ Countries that have implemented the NFMA approach have successfully integrated TOF and TOF issues into their national forest inventories. These countries are among the few that may provide convincing estimates of the various variables related to TOF resources.

✓ Some countries like Sweden have implemented assessments of their tree and forest resource that are so detailed that these assessments may be used for providing estimates of the main biophysical variables relative to TOF, while a few countries such as India and the UK have undertaken a set of specific TOF assessments with a focus on one TOF set or another. These TOF-specific assessments can be combined and complemented if necessary with other assessments to create a quite complete, reliable and accurate picture of their national TOF situation. These countries show that assessing all TOF at national scale is possible. There are no insurmountable technical or methodological obstacles for doing so, as long as the TOF categories are consistent across the assessments and the assessments organized in a complementary way.

Progress has been made since the previous FAO report on TOF published in 2002. So the time may be ripe for large-area assessments that fully integrate the TOF concept. However the fact that only a very small number of countries have conducted assessments that deliberately target TOF is worth investigating. The first reason is that, despite international and national efforts to focus the attention of policy- and decision-makers on their environmental and socio-economic importance, TOF and TOF assessments have been a low priority for national policy makers, except in a very small number of countries. Other reasons, linked to TOF specificities, are examined in the next section.

3.4.b. TOF specificities and TOF assessments

Chapter 2 underlined the heterogeneity and dispersion of the TOF realm and more precisely of its land-based equivalent -Other Land *with TOF*. This heterogeneity and dispersion needs to be taken into account in any TOF assessment, especially as regards the categorization of Other Land *with TOF*, the methodological and technical aspects, and the institutional framework.

The need for an explicit categorization of land with TOF

The above review shows that many land-use/land-cover and national forest inventory assessments include the whole range or a major part of the TOF sets in their coverage. However, these TOF sets are not explicitly recognized as categories in most of these assessments. The result is that information on TOF is generally not provided by these assessments although some could be extracted, provided data are re-analysed with TOF sets being explicitly taken into account as land categories. The only assessments that provide directly usable information and data on TOF are those that take TOF sets or subsets explicitly into account: TOF specific assessments, some land-use-land-cover assessments and the NFMA type assessments.

Any assessment that includes in its objectives the provision of data on trees outside forests should take into account the heterogeneity of the TOF realm in its planning phase, so that the land-use/land-cover classes defined for the assessment explicitly integrate the variety of TOF covered lands as categories.

The need for a clear and operational land classification including TOF

Any large area forest assessment may in theory have a "trees outside forests" category that encompasses all trees that have not been classified under the Forest category, this being true whatever the definition of Forest that is used. At global scale, the TOF concept, which has mostly been popularized by FAO in the framework of the global Forest Resource Assessment, evolved in response to the growing recognition that a significant part of the tree resource was "outside" the wooded land classes (Forest and Other Wooded Land). But the TOF concept could not be translated into operational terms yet, so that FAO member countries could not refer to any internationally accepted clear and operational definition of the land to be taken into account for the assessment and the reporting of TOF. It is important to note that the FAO-FRA process in general, and in particular its success in the adoption of a consensual standardized classificatory framework, had and still have a stimulating role on the development of national forest assessments in terms of both quantity and quality. A similar stimulating role could be played by FAO-FRA through the integration of TOF into its already existing classificatory framework, as proposed by the present report.

The present report proposes not only a clear definition of what TOF are, but also a clear and operational definition of "Other Land *with TOF*", and of its alter-ego "Other land *with no TOF*", two new sub-categories that complete and complement the FAO-FRA classificatory framework in its endeavour to take into account as much of the tree resource at national and international scales.

Methodological and technical aspects

One of the major conclusions of this review is that countries in various geographical, ecological, and political settings have been able to develop sound TOF assessments based on the judicious use of modern technologies and time-tested field inventory and survey questionnaire methods.

Assessing TOF does not impose radically different methods than assessing forests: low- and high-resolution images are used to identify land with TOF in the same way that pieces of forest are identified. Sampling for field inventory can proceed the same way as for forests. Field inventory protocols and survey questionnaires may be the same as for forest. Sampling, field inventory protocols and survey questionnaires could require an adaptation to the specificities of the targeted TOF sets and subsets, just as these methods would need to be adapted to various kinds of forest targeted in a forest assessment (e.g. savannah woodland, Acacia plantations).

One point may render TOF assessments more complicated than forest assessments: authorization of access to the sampling location could take much longer to obtain for TOF than for forest due to the higher number of stakeholders and the necessity to explain the assessment's objectives. But otherwise, assessing TOF is not more difficult than assessing forests once the TOF classes and sub-classes have been identified. TOF sets are diverse: so are natural and planted forests. Some TOF subsets have low accessibility: so are most natural forests. In fact, two major TOF sets (trees on land predominantly used for agriculture and trees in an urban environment) are much more easily accessible than most natural forests.

There is currently no major technological or methodological obstacle that would prevent or hinder the conception and implementation of large area TOF assessments.

Institutional aspects: Which role for whom?

The heterogeneity of the TOF category has important institutional consequences, as underscored in chapters 1 and 2. TOF realm is under the mandates of various sectors, depending on the TOF sets considered and associated land uses. TOF-AGRI is associated with agricultural land uses and comes under the agricultural and rural development sectors; TOF-URB is associated with settlements and comes under village and city administrations. The other TOF set, on land that is not predominantly under agricultural or urban use, shows a higher heterogeneity in terms of institutional responsibility: small woods (less than 0.5 ha) may come under the forestry, the rural development or the environment and natural resource sectors; narrow linear formations may reside in the same sectors but also in the sector that handles transportation infrastructure when associated with waterways, railways and roads; lands with a low tree or/and shrub cover may fall under the forestry or the environment and natural resource sectors.

This institutional fragmentation of the TOF realm is important for TOF assessments as it represents a difficulty not encountered in forest assessments. It means first, that the sectors above have each legitimacy in undertaking an assessment focused on the TOF set(s) and subset(s) under their mandate. It also means that a holistic TOF assessment, which would target all the TOF sets and subsets, cannot in most cases be undertaken without involving these legitimate sectors. The NFMA-type assessments show this is possible, but considering the difficulties often observed in inter-sector communications, this may partly explain the still low number of TOF assessments.

Another related problem is the unbalanced distribution of know-how relative to assessment of the tree resource. Unlike the forestry sector, other sectors generally have fewer human resources competent in tree assessment.

Indeed, because TOF are trees and shrubs, their assessment has often been viewed as being part of the forest services' domain of competence – which is correct – and also of its responsibility – which is often wrong as they have not always the legitimacy to undertake such assessments alone. In addition, especially when timber production and forest conservation are its main objectives, the forestry sector usually has only a marginal interest in assessing TOF. This is understandable when one considers each TOF set with regards to its potential interest and potential constraints for foresters and forests' services:

✓ Set 1, "trees on land predominantly under agricultural land use" (TOF-AGRI) is a widespread category with important functions crucial for million of farmers, functions such as soil fertility maintenance, carbon sequestration, biodiversity conservation, food and material production, feed for livestock, income generation, livelihood improvement, and contribution to national economies. The timber potential in this category may vary considerably, depending on local ecological conditions and the kind of cropping system, ranging from scattered trees in pastures to agroforests that may form vast forest-like massifs (Michon et al. 2007). Obviously anyhow, the problem of this category for foresters is not the timber potential, but the small or nonexistent role they play in the management of trees grown in these systems: farmers are here the tree managers. The long history of confrontation between farmers and forestry officers has in many places left wounds on both sides, which explains both the reluctance of foresters to consider this category and the reluctance of farmers to see foresters in their fields.

✓ Set 2, "trees on land predominantly under urban land use" (TOF-URB), in settlements and cities, is also a widespread category with important or even crucial functions for people living in villages, cities and towns. Trees in backyards and private urban gardens are part of the private domain where foresters can hardly have any mandate. The situation is different with public parks and trees along streets, waterways and railways, but even though forest services are often involved in their management, they usually do not coordinate this management nor do they have control over the tree resource, which usually is under the control of municipalities.

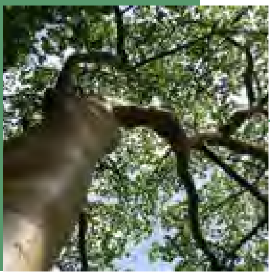
✓ Set 3, "trees on land not predominantly under urban use" (TOF-NON-A/U), may be split into two groups (see section 2.2.c):

- Subsets 1 and 2, "Small isolated woods (less than 0.5 ha) and "narrow lines of trees less than 20 m width", can be encountered almost anywhere. The small individual size of these forest-like patches most often implies low timber and regeneration potential, which, associated with their often private tenure, generally makes these categories a low priority for forest services.
- Subsets 3 and 4, "land more than 0.5 ha with scattered trees less than 5 percent cover (subset 3), or land more than 0.5 ha with shrubs (height <5 m) or a mixed cover of shrubs and trees less than10 percent cover (subset 4)", are mostly restricted to difficult arid or semi-arid conditions with water resources that do not allow rapid tree growth nor more complex tree cover to develop. Trees occur at very low density and they represent extremely low timber resource potential, which makes these TOF subsets of minimal interest for forest services in terms of timber production. However, other functions may be attached to this category, such as biodiversity conservation, that could raise the interest of forest services.

The fact that forest services often have only very limited interest and institutional legitimacy in the three TOF sets that make up the TOF realm does not mean that foresters and forest services are not crucial partners for the implementation of TOF focusing assessments. Indeed they are, because they have the competencies in many aspects related to trees and time-tested methods for assessing trees. In other words, foresters and forest services must be involved in TOF-focused assessments, but they may often not be in the best position to initiate, lead and take responsibility for such assessments.

Assessments targeting the various TOF sets need an ad hoc multi-sector institutional framework that includes the forest sector for its competence and know-how in the assessment of trees, as well as all other legitimate sectors.

4. Keys for TOF assessments



Justifications (the why) and methods (the how) for doing forest assessments are now well known so that in most countries, national policy- and decision-makers have fully integrated national assessment of forest resources into their routine framework of activities. Most countries rely on specialized institutions in forestry to do fairly regular assessments and inform governments about the present and expected forest resource and its economic, social and environmental values. The same is true for agriculture.

As underscored in the introductory chapter, Trees Outside Forests clearly belongs to the non-forest side of the land-use divide, where agriculture is the dominant productive activity. Many if not most policy- and decision-makers now know about TOF resources and their importance (although they often use other names such as agroforestry, tree crops, or urban forests). Still, chapter 3 showed that, apart from a few exceptions, this knowledge has not yet been a sufficient stimulus for officials to initiate national assessments of TOF resources, much less integrate such assessments into their routine framework of activities.

There is thus an urgent need to make the methods and tools available, and to articulate the justification for and utility of national TOF assessments. This chapter presents possible constraints that impede the decision-making process leading to national TOF assessments, and details major justifications for those assessments. The last section is devoted to the methodological and technical options that countries have for the implementation of national TOF assessments once the decision is taken to assess TOF resources.

4.1. Specific constraints on TOF assessments

The analysis of the context and definitions that allow the formal definition of TOF (Chapter 2), and the review of TOF assessments pointed out the main difficulties regarding TOF assessments: namely, semantics and heterogeneity.

- ✓ "Trees outside Forests," as defined in this report, strictly refers to the FAO-FRA land classification framework. Although an unprecedented effort towards harmonization across countries has been undertaken in recent years in relation with the FAO-FRA programme (FAO 2003, 2005), many countries have their own definitions of forest for their forest assessments. This means that many countries have their own criteria regarding what they consider TOF, different from those in the FAO-FRA framework. This is not a difficulty in itself – as shown by examples such as the TOF rural and the TOF urban inventories in India, or the Survey of Small Woodlands and trees in the UK (Chapter 3)- but it is obviously a constraint to reporting harmonized data at supra-national level. This constraint can be overcome, as the success of the FRA reporting for Forest and Other Wooded Land shows, but it means that an effort has to be made for creating bridges or algorithms allowing national reporting to be translated for comparability in international reporting.
- ✓ "Trees outside Forests" in the FAO framework in fact designates "trees and shrubs" outside "Forest and Other Wooded Land". This is not a real constraint since the ambiguity in the terms is relieved through an ad hoc explanatory note.

✓ "Trees outside Forests" as a category has until this report not been translated into terms that would fit the land-use/land-cover classificatory framework for which it was carved. The sub-category "Other land with Tree Cover" (OLWTC), integrated into the FRA reporting framework in 2005, is a major attempt in this direction, as it represents an important part of the TOF resource in many countries. However, OLWTC does not take into account small tree patches (less than 0.5 ha), narrow linear formations, nor very scattered trees on large areas, three TOF-based categories that in some countries may contribute very significantly to the national TOF resource (see Box 1 - Bangladesh). To help solve this problem and translate the TOF concept into its land-based equivalent, this report proposes a subdivision of Other Land into two mutually exclusive subcategories, with the sub-category "Other Land *with TOF*" including most of the TOF resource. For this subdivision to be operational in terms of assessment, this report proposes a set of minimum thresholds, which implies that the sub-category "Other Land *with No TOF*" may include some TOF (especially very scattered trees, which in most countries represent a very minor contribution to the national tree resource).

BOX 1: TOF in Bangladesh

Source: Bangladesh National Forest and Tree Resource Assessment 2005-2007. (see Part 2)

In Bangladesh, the National Forest and Tree Resource Assessment has subdivided "cultivated land with trees" and "rural settlement with trees" into two subcategories each, depending on size: between 0.1 and 0.5 ha, and above 0.5 ha. At the country level, the total area covered by these categories is reported in the following table:

	Total area (ha)	
	0.1 to 0.5 ha	**above 0.5 ha**
Annual crops with trees	784,000	126,000
Perennial crops with trees	8,000	79,000
Rural settlement with trees	1,090,000	1,677,000
Total	**1,882,000**	**1,882,000**

The table shows that in Bangladesh, the total area of land covered with TOF on small land parcels is equal to the total area of land covered with TOF on larger parcels.
In terms of tree resource at national scale, the assessment shows that TOF are of major importance. For instance, the total aboveground wood biomass is estimated at about 846 million tons. Of this total, Forest contributes 33 percent while TOF contributes 67 percent (TOF-AGRI: 17 percent; TOF-URB: 50 percent).
Bangladesh represents a striking example in which the structure of farms and villages is such that following the area threshold used for defining the sub-category "Other Land with Tree Cover" (area ≥ 0.5 ha) would drastically reduce the estimated contribution of TOF, as it would leave a very significant part of the tree resource un-accounted.

Bangladesh is far from being devoid of trees, even in crop-fields dominated rural areas with extreme population density. Trees are planted around houses and in villages where they ensure a forest-like cover.

- ✓ "Trees Outside Forests," or more precisely "Other land *with TOF*," is a category that presents very high heterogeneity. This heterogeneity concerns the spatial pattern of the trees, but it also concerns their functions, values, uses, as well as their dynamics and their management characteristics. "Other land *with TOF*" consists of three main sets corresponding to land uses: predominantly agricultural, predominantly urban, and predominantly non agricultural/ non urban. It thus encompasses land uses as different as coffee plantation, parking lot with shade trees in a city, or narrow linear tree formation along a water stream in an otherwise arid area. A high heterogeneity is in itself a constraint for inventories and assessments, as it entails the need for higher sampling intensity (and thus higher cost) than low heterogeneity for reaching the same precision level.

- ✓ The fact that TOF encompasses land with trees in agricultural, urban and non urban/non agricultural areas means that TOF involve a large range of stakeholders, and that the various parts of the TOF realm are each under the mandates of various institutions. This institutional dispersion may be compared to the institutional concentration that characterizes the forest sector, and is probably one of the major constraints that has prevented most countries from fully integrating TOF assessments and TOF issues into their policy framework. The situation may be relieved through the formal recognition of the different TOF sets and the subsequent recognition and integration of this institutional dispersion right at the outset.

4.2. Why do TOF assessments?

TOF assessments are needed at different levels, with purposes that are basically the same at all levels: management, monitoring and planning (see Chapter 1). At the country level, which is the main focus of this report, TOF assessments are triggered by international and national justifications that correspond to international and national stakeholders.

National policy makers and others need spatial and statistical data with guaranteed credibility on TOF that they can use for development planning and accounting of the services provided by TOF in terms of energy, food diversity and food security, among others. They use this data for identifying TOF "sectors" with high investment potential, for budgeting and allocating funds for the development of economically promising land uses with TOF, and/or land uses with TOF having a patrimonial value. Good quality data are also needed to monitor the congruency of the regulation framework, especially in terms of taxation and tenure, with the development of land-use systems with TOF in order to optimize the contribution of these systems to the national economy and to the national environment.

Farmers' national associations, city dwellers' national associations and environment national associations are other major stakeholders concerned with TOF at the national level. They need quality data on TOF for running their activities but they also can and should be partners in national TOF assessments, as assessments of TOF in agricultural and urban contexts cannot be undertaken without the active participation of farmers and city dwellers, at least when field level data are needed.

The UNFCCC, the CBD, the UNCCD, and FAO, all need much better quality data on TOF than they currently have, and this can only be done through carefully implemented national TOF assessments. This is an important justification for countries to embark on TOF assessments; this is also a major opportunity for countries, as an international emphasis on TOF will one day have to be translated by the international community, through the UN mechanisms and institutions and also through the large international development and environment NG0's, into the allocation of financial and human resources for assisting countries that need support to carry out TOF assessments.

4.3. How to do TOF assessments

TOF-focused assessments covering large areas are still few, but the examples of TOF assessment presented in Chapter 3 show that they are possible and that they do not present insurmountable methodological or technical obstacles.

The following describes the main phases composing a TOF assessment, without detailing the activities in the assessment that are not specific to TOF. It should be clear that securing sufficient funding is a sine qua non condition for implementing a tree resource assessment of any kind, and that the level of funding will condition inter alia the type of assessment to be implemented, as well as the expected type of data and precision of the estimates. It should also be stressed that a good statistical design, coupled with the rigor of subsequent statistical analysis of high-quality data, is needed to guarantee the credibility of TOF estimates. This is a critical component of any successful monitoring and assessment program (e.g. Corona et al. 2011, Fischer et al. 2012).

Preliminary phase 1: Collect and analyse existing data

A national government decision to assess TOF includes the assessment's broad objectives (for example: report to international conventions such as the UNFCCC, integrate TOF into the national accounting framework, evaluate TOF contribution to the national economy). Whatever these broad objectives, the first preliminary phase would always be collecting and analysing existing data related to TOF. It is important at this stage to collect all available assessments that potentially include information on TOF. The following questions should be answered:

- ✓ Is there a land-cover / land-use assessment that covers the whole country?

- ✓ Is there a national forest inventory or an equivalent? If yes, does this inventory cover both "forest land" and "non-forest land" or only "forest land"?
- ✓ Are there national surveys of tree crops?
- ✓ Are there assessments of particular TOF categories such as urban trees or trees on agriculture land?

Once available assessments have been collected, each assessment should be analysed and evaluated for information on TOF. If data on TOF are extractable, these should be extracted. For instance, national agricultural surveys provide data on the extent of large tree-crop areas. (Note that these data are often compiled by the FAO Statistics Division and are available online at the FAOSTAT-Agriculture website: http://www.fao.org/corp/statistics/en/.) This may be used to approximate the extent of TOF-AGRI (see Box 2: FAOSTAT-Agriculture as a source of information on TOF at national scale).

When analysing available assessments, the heterogeneity of TOF should be kept in mind so that no TOF subset is a-priori discarded. As underscored in Chapter 2, a direct consequence of TOF definition is that TOF consist of 4 major TOF sets:

- ✓ TOF-AGRI: trees in agricultural systems, such as hedges, windbreaks, orchards and non forestry tree plantations, trees in pasture, and all the various forms of agroforestry systems;
- ✓ TOF-URB: trees in a urban environment, such as trees along streets and waterways, trees in private and public gardens and parks, trees in agricultural systems located in urban and peri-urban areas;
- ✓ TOF-NON A/U 1: small isolated woods and woodlots, less than 0.5 ha in area;
- ✓ TOF-NON A/U 2 narrow lines of trees less than 20 m wide.

Trees on agricultural land

Trees in city and village

Trees in linear formation

Trees in smallwood

Box 2: FAOSTAT-Agriculture as one source of information on TOF at national scale

National agricultural surveys usually include the major non-timber tree crops. FAO regularly compiles data from these surveys and makes them available to a wide public through the FAOSTAT-Agriculture database (http://faostat.fao.org/site/339/default.aspx).

The total extent of tree crops as given by such national surveys or by FAO may be used during the preliminary phase of a national assessment to estimate the extent of the TOF-AGRI subset. The resulting figure should be considered as an estimate by default (the true extent is much larger than the estimate), because national statistics on tree crops most often do not include (1) tree species with minor economic importance, (2) small farms, (3) multispecies homegardens and agroforests, and (4) agricultural tree fences and hedges.

The two examples below (a temperate country, Spain; and a tropical country, Indonesia) were downloaded from FAOSTAT in May 2012. Data are from 2008 and they reveal a minimum TOF-AGRI extent of more than 3.5 million ha in Spain and almost 14.5 million ha in Indonesia. They show that the use of the FAOSTAT database is always feasible, although the species considered may be different.

SPAIN	
Tree crop (TOF species)	**Area (ha)**
Almonds	566 869
Apples	33 362
Apricots	18 834
Avocados	10 023
Carobs	46 404
Cherries	24 671
Chestnuts	9 800
Citrus fruit	2 242
Grapefruit	1 640
Hazelnuts	15 411
Lemons and limes	46 809
Olives	2 450 470
Oranges	153 429
Peaches and nectarines	75 425
Pears	29 216
Plums	18 695
Tangerines, Mandarines	119 875
Walnuts	7 418
TOTAL	3 630 593

INDONESIA	
Tree crop (TOF species)	**Area (ha)**
Arecanuts	125 500
Avocados	19 786
Cashew nuts, with shell	308 129
Cinnamon (canella)	81 427
Cloves	311 760
Cocoa beans	990 052
Coconuts	2 950 000
Coffee, green	977 356
Fruit, tropical	207 000
Kapok Fruit	132 646
Mangoes, mangosteens, guavas	185 196
Natural rubber	2 897 670
Nutmeg, mace and cardamoms	75 243
Oil palm fruit	5 000 000
Oranges	63 695
Tea	106 948
TOTAL	14 432 408

All documents focusing on one or the other of these categories, even if they are restricted to a limited geographical area, should also be collected. In particular, scientific publications, research reports and project reports may contain relevant information on the occurrence, local extension, etc. of some TOF systems such as treed homegardens, various agroforestry systems, or small woodlots.

Country-scale data on TOF extracted from available national assessments and more localized information on TOF found in other documents will contribute to defining the current state of knowledge related to TOF for the country.

Preliminary phase 2: Develop new data with efficient remote-sensing sampling strategies

Whatever the broad objectives defined by the government for a national TOF assessment, the second step would always consist of gathering or acquiring basic information on the spatial distribution and extent of the various sets of the Other Land *with TOF* (OL*wTOF*) category.

This phase relies on remote-sensing analysis and its associated ground checking, and can thus be fully implemented by an agency specialized in land-use/land-cover assessments. Participation by institutions representing the various sectors involved in TOF would certainly help. The precision level requested, availability of financial and human resources, and the size of the country and climatic conditions will all determine the choice of methods to be used. Technological progress in remote-sensing imagery has made it theoretically possible to identify any TOF subset, including narrow linear tree formations, small tree patches and isolated trees, on high-resolution satellite images. However, the cost of such images, and the cost for analysing all such images for large areas, is generally too high for allowing a wall to wall mapping of TOF covering a whole country. Note that opportunistic sharing and acquisition of remotely sensed data with other organizations can significantly leverage the initial high cost of high-resolution imagery, and/or significantly mitigate the processing costs of coarser, freely distributed imagery.

The recommended option is thus a three-step process beginning with the analysis of low-resolution remote-sensing data allowing a wall to wall mapping and a stratification of the landscape including strata potentially related to TOF. Note that the images needed for this step can now be acquired for free (e.g., MODIS, Landsat). The second step consists of sampling the strata of interest with high-resolution images, analysing these images, and checking the results on the ground for validating the land use (non-Forest and non-Other Wooded Land), which in many cases cannot be ascertained from remote-sensing images of any resolution. The third and final step involves the development of correlations between TOF cover estimates obtained through the analysis of high-resolution images and their equivalent obtained from analysis of low-resolution images. This final step allows the scaling-up of high-resolution data and extrapolation of these data over the entire country. Hansen et al., 2010 successfully implemented a similar approach for a global forest loss assessment.

First phase: Set up an institutional framework and define detailed operational objectives

If the aim of the TOF assessment is simply acquiring information on the spatial distribution, area, and canopy cover of the various TOF subsets, then the results obtained through the preliminary phase presented above would be enough.

But in most cases, governments will identify a much wider range of objectives, which need first to be translated into detailed operational objectives. This "translation" is the first step in the flow chart of a TOF assessment. The example of India shows that it is possible in some countries to implement detailed TOF assessments in rural and urban environments without involving other institutions outside forestry, but it is recommended that the institutions in charge of the various TOF subsets be integrated right at the outset of the assessment and that they collectively define the detailed objectives and organize the distribution of tasks and responsibilities. The examples of national forest and tree resource assessments that used the NFMA approach show that this multi-sector approach is possible and that it is also a highly efficient approach. Early involvement of institutions in various sectors may also be considered as a warranty that the detailed objectives are truly operational, through taking into account not only the financial and human resource constraints related to the planned assessment, but also the institutional, social, economic, spatial and environmental constraints. This early involvement is also important for ensuring the participation of these sectors in later phases of the assessment and for setting up a common understanding of the objectives and methods to be used.

The first objective to decide is whether the assessment will tackle all or some TOF subsets. This report recommends that any national TOF assessment include TOF-AGRI, trees on land under a predominantly agricultural land-use, and TOF-URB, trees on land under a predominantly urban land-use, due to their contribution to rural and urban livelihoods. The decision to include or not the TOF subsets that grow on other lands (not predominantly agricultural or urban) will mainly depend on an inter-institutional consensus regarding the relative importance of these TOF subsets in the country.

Once the contours of the assessment in terms of TOF subset coverage are clarified, the detailed objectives of the TOF assessment can be grouped into layers that will contribute to one or more of the thematic elements linked to sustainable management, in much the same way as what has been done for FRA 2010 (cf Table 2). A major decision will involve which layer(s) will be targeted in the assessment, knowing that the first layer (see below) is absolutely necessary for deriving relevant quantitative and qualitative data regarding the other layers.

The first layer consists of biophysical information on the various TOF subsets included in the assessment. This first layer itself may cover various objectives of increasing complexity, much as in forest assessments: information on tree species composition, tree spatial pattern, tree density, basal area, diameter classes distribution and tree height distribution, forms the basic set of variables needed for assessing TOF biomass, stocking volume, and carbon stock. Information may also be collected on tree regeneration, on dead and cut trees, on tree health, impacts of fire, impacts of pests and diseases, as well as on various environmental parameters that would complement the basic set of variables and allow better predictions in terms of dynamics of the tree resource, its management and planning. This first layer is extremely important as it contributes crucial information not only to the thematic element "Extent of TOF resources" (see Table 6), but also to virtually all of the thematic elements, especially through information on the characteristics and area of the various TOF systems involved in each TOF subset.

Table 6: TOF assessment layers and their links to the elements of sustainable TOF management

TOF assessment layers	Extent of TOF resources	TOF and biological diversity	TOF health and vitality	Productive functions of TOF resources	Protective functions of TOF resources	Socio-economic functions of TOF resources	Legal, policy and institutional framework
Preliminary phase: localization and area of TOF subsets	X	X	X	X	X	X	X
layer 1: Biophysical information	X	X	X	X	X	X	X
layer 2: Production and managerial information			X	X	X	X	X
layer 3: Environmental services		X	X		X	X	X
layer 4: Socio-economic functions						X	X
layer 5: Institutions and regulations							X

The second layer consists of production and managerial information that can help answer such questions as: Are TOF used? What parts are used? What are they used for? What quantities are collected annually? What are the impacts of harvesting on tree growth and on the species population dynamics? Are TOF planted or naturally regenerating, or both?

The third layer consists of complementary information related to the environmental services provided by TOF, which could help answer questions on the importance of the various TOF subsets in such services as inter alia soil fertility maintenance, erosion control, pollination, pest control, and biodiversity corridor.

The fourth layer consists of information related to the socio-economic functions of the targeted TOF subsets, information that can help answer questions such as: Are the collected TOF products sold, and if yes what is their value at different levels of the marketing chain? What is TOF contribution to the economy of households? Are tree propagating materials bought to become established as TOF? If yes, what is the value of the market (important for fruit trees planted in agricultural and urban contexts, but also for ornamental trees, especially in an urban context)?

The fifth layer consists of information on the institutional and regulatory framework related to the TOF subsets and the land on which these TOF subsets grow, such as: What is the tenure status of the land where TOF grow? What is the tenure status of the trees themselves? Are there local institutions that regulate the planting and management of TOF? If TOF products are sold, is there a taxation system?

Second phase: Translate the selected detailed objectives - sampling scheme and data collection protocols.

Now the range of detailed objectives has been tailored to the initial broad objectives. Only operational objectives have been kept for the assessment, objectives that the institutions involved perceive as reachable after considering their knowledge of the nature of the TOF subsets, as well as the human and financial resources they have secured for the assessment.

Data that can be collected by the analysis of remote-sensing images have been collected in the preliminary phase. Data to be collected now require field inventories and interviews. The detailed objectives must be translated into a set of data collection protocols. Many methods can be used for the collection of biophysical data on trees, and the same is true for data on production, uses of tree products and socio-economic functions of tree products.

A sampling scheme has to be defined. This involves many issues, such as the spatial pattern (randomly or systematically spaced), number, and form of the samples. Here also, and for almost each issue, there are a number of possible solutions. The main question in designing a sampling scheme is whether the scheme is based on landscape stratification or not; the answer leads to two main options, which respond to slightly different objectives.

✓ **Option 1.** It is possible to design a sampling scheme which takes Other Land *with TOF* into account globally. That is, the assessment focuses on the tree component outside Forest and Other Wooded Land, whatever the spatial organization of the tree component and whatever general sub-classification is used. No stratification is needed in this option, and samples may be spaced randomly or uniformly. An example is the approach used in many national forest inventories, where

samples are spaced uniformly on a grid that covers the whole country. With a good sampling design ensuring the quality and credibility of data, results in this option will be general estimates on the TOF resource, dendrometric estimates such as wood biomass or volume per ha, average species number and species composition per ha, etc. Results will also include livelihood and economic contribution estimates if the sampling includes survey questionnaires. However, this option has three main constraints that may limit its relevance:

- A very large number of field samples are required to get estimates with a reasonable precision level because Other Land *with TOF*, as a category, shows a very high heterogeneity, as noted in preceding chapters.

- It does not provide any information on the spatial distribution of TOF at the scale of the assessment, where TOF are abundant, where they are rare, where particular species grow and where they do not, etc.

- It does not provide information on the spatial patterns of TOF, which is known to be very often linked to their human context, at least in TOF-AGRI and TOF-URB.

- The two last constraints together prevent the possibility of formulating a hypothesis on the relationships between TOF and the human environment (social, economic, historical, cultural) in which they grow. In other words, this sampling option is perfectly valid for assessing and monitoring the TOF resource and its evolution with time in a purely accountability manner at the assessment scale, but it is of little use for policy and decision-making.

  The last constraint can easily be removed by integrating information on the spatial pattern of TOF and on the link between TOF and the human environment in the samples. Countries that have implemented NFMA type assessments have used this approach. This sub-option still suffers from the two first constraints, but removing the third constraint effectively raises its relevance for policy and decision making.

✓ **Option 2.** The preliminary phase, in which the country area to be sampled -Other Land *with TOF*- has been mapped by TOF subsets, introduces another interesting option: it offers the opportunity to sample each TOF subset independently instead of sampling the Other Land *with TOF* globally. The sampling scheme involves stratification. However, considering the high level of heterogeneity that characterizes the TOF subsets, the first level of stratification operated by the preliminary mapping of the four subsets may not be sufficient for covering significant differences with a non-stratified sampling scheme in terms of cost and precision. Further levels of stratification would most probably be required. Three main stratification levels could usefully be envisaged.

- The first (very classical) level involves a combination of environmental criteria, including inter alia climate, elevation, soil, and topography.

- The second level is more specific to TOF, and would involve three strata representing the three major spatial patterns encountered in TOF:

isolated trees, narrow linear tree formations, and trees in compact patches or blocks.

- The third stratification level would be specific to each TOF subset: it would consist of the major agricultural land uses for TOF-AGRI (such as industrial tree-crop, agroforest parkland, smallholder coffee plantation), the major urban land uses for TOF-URB (such as backyard garden, street, public building, public park), the nature of the associated land for narrow linear formations (such as river, canal, road, railroad), and the planted, natural or mixed origin of the patches in case of small woods. Once final stratification is decided, sampling in each stratum may be spaced either uniformly or randomly.

Note that, for a given precision level, such a detailed stratification would involve more time and effort before the field sampling phase than in a non-stratified sampling scheme, but it would reduce the time and cost of this field sampling phase. For instance, stratifying TOF-AGRI by land uses in a tropical humid country where coffee is a major product would allow distinguishing industrial coffee plantations, smallholder coffee plantations with no shade, two strata smallholder coffee plantations and coffee-based agroforests. Reflecting their degree of heterogeneity, each of these systems needs a different sampling intensity to reach the same precision level of their estimates. In contrast with a non-stratified sampling scheme, stratification allows one to adapt the sampling intensity to the heterogeneity of a given stratum. Stratification also helps avoid the risk of missing TOF categories of reduced extent but of high importance for livelihoods, such as homegardens, or for biodiversity conservation, such as narrow tree corridors.

The stratification option is probably more costly in terms of time and financial resources than non-stratification. With a good sampling design ensuring the quality and credibility of data, stratification will bear the same kind of general estimates as non-stratification. But its high degree of spatialization and its more detailed TOF-land classification allow researchers to derive credible relationships between various TOF and the human context. This ability is of prime importance for policy and decision-making.

The main choice in the design of a sampling scheme is thus between a non-stratified scheme and a stratified scheme that builds on the preliminary mapping of the TOF subsets. In the second option above, further stratification levels adapted to the TOF context and to the requested precision levels have been developed, but other sub-options are possible, which entail lower levels of stratification after the initial differentiation between the TOF subsets.

It would not make sense for this report to recommend one standard method and one sampling scheme design. Instead, this report strongly recommends that the institution in charge of the assessment rapidly forms an ad-hoc multi-sector team including people with experience and know-how in three areas: 1) the design of biophysical sampling schemes and data-collection protocols, 2) the design of socio-economic sampling schemes and data-collection protocols, and 3) the various TOF subsets and their human environment. Such a team would be in charge of designing the protocols and the sampling scheme. Its members' collective knowledge and experience of methods and TOF contexts would ensure that the designed protocols and the sampling scheme would be operational, adapted to the TOF contexts, and efficient with regards to the detailed objectives defined for the assessment.

Whatever the sampling scheme chosen, it must be pre-evaluated by experts, including statisticians, to ensure that (1) it is feasible and it will yield credible results, (2) that it will achieve the desired allowable error estimates for the targeted current state and change estimates, (3) that analysis will permit statistically defensible assessment of uncertainty including all sources of variability (e.g., design, volume and biomass models, measurement and assessment errors), and (4) that it will permit assessment of quality assurance and control. Note that for specific TOF subsets such as scattered trees, narrow linear formations and small woods, choosing a sampling design that fulfills the above conditions is not easy and is currently the subject of active methodological research, as shown by recent publications (e.g., Baffetta et al. 2011a, 2011b, Corona et al. 2011).

Third phase: Conduct field sampling

Once the sampling schemes and sampling protocols have been defined, field sampling phase may begin. There is no fundamental difference regarding the tree variables and their estimation or measurement between field sampling in a forest inventory and in a TOF inventory, except for location (outside forests), which means that different stakeholders are involved. One of the major implications is the necessary involvement of institutions in charge of Other Land (agriculture, local administration, municipality, etc.), so that they can inform owners of the pieces of land chosen for sampling and organize access to the land. Another implication is that field sampling would benefit from being implemented by a multi-sector team.

If the assessment is not limited to the acquisition of biophysical data, then directive and/or semi-directive interviews with local stakeholders are necessary. This means that the field-sampling team would benefit from being multi-sectoral, and also from being multi-disciplinary, much as in the examples given by the countries which have used the NFMA approach.

Further phases: Data treatment, data analysis, reporting

After field sampling has been completed, the next phases resemble other assessments. It is strongly recommended to make public reports that synthesize the collected data widely available, even more so than with forest assessments, due to the wide range of stakeholders involved.

And Monitoring?

Much like what is being done for forests, repeating assessments after a few years is "a must" for monitoring TOF resources and their trends. To facilitate repeated assessments, everything that can be done to ensure an easy retrieval of the sampling plots and the interviewed stakeholders after a few years must be done: record plot coordinates, sketch map of the plot and its surroundings, note names and addresses of respondents, etc.

4.4. Recommendations for country TOF assessments

Some countries have already implemented assessments that cover most TOF subsets and include biophysical and socio-economic variables. For other countries, the recommendations below show what can be done.

Take stock of available information on TOF while designing a TOF assessment

Most countries have information available on TOF, even if they have done no TOF assessment (as noted in Chapter 3), but since this information is generally very uneven and does not cover all TOF subsets, making extraction of coherent TOF data is difficult. It is more efficient, for the many countries that do not have TOF assessments, to design TOF assessments anew on a sound basis. The flow chart above constitutes a reasonable guideline for this endeavor. It does not mean that existing information on TOF must be discarded. On the contrary, all existing information on TOF and their ecological and human context must be used in the design of the TOF assessment so that it will be operational, coherent and adapted to the TOF realities in that country.

Checking existing land-use/land cover assessment potential

One major source of information for a TOF assessment, which may be found in many countries, is a land-use/land cover assessment. This is the very basis of any assessment of natural resources, including TOF, in large areas such as countries. However, most land-use/land-cover assessments have been carried out without TOF as one of their targets, and are thus not directly usable for identifying and mapping TOF subsets and their categories. If these assessments are recent, it is certainly interesting and probably cost efficient to try to retrieve the original data and assess if it is possible to include TOF subsets in a new analysis. If that is possible, it is recommended to conduct this re-analysis and operate a stratification based on the spatial tree patterns (scattered trees, tree stands and tree lines) superimposed on the two major TOF subsets, TOF-AGRI and TOF-URB.

Think operationally, and incrementally

Current forest assessments (which cover scores of variables) did not emerge in one day and they have little in common with the first forest assessments: they are the result of decades of improvement in methods, sampling performances, field work efficiency, etc. As the review of past assessments with information on TOF (Chapter 3) shows, the TOF specific assessments that now exist should be considered the equivalent of the first forest assessments: they are the pioneer assessments for TOF.

When designing an assessment, it is thus important to think operationally and incrementally.

✓ Operationally: most countries do not have the most basic data on TOF, and the recommended target at this stage is for a national TOF assessment to be able to provide at least the following basic data, either for Other Land *with TOF* globally or for each TOF subset:

- Extent and spatial distribution;
- Estimates of the number of trees;
- Estimates of the tree biomass, timber and carbon stocks;
- Tree species composition;
- Estimates of the number of people involved in tree management.

- ✓ Incrementally: new layers of variables may be added later. The above basic data collected in the first assessment will allow assessing the importance of the various TOF subsets in terms of area covered, timber, carbon stocks, etc.

If judged important, it will stimulate the decision to build on this initial baseline and design a new assessment that will be useful for monitoring the TOF resources and for collecting new layers of variables.

5. Conclusions and Recommendations

There is a growing need for sound information on Trees Outside Forests (TOF) at the national level. Land-managers need clear and sound information on the resources they are responsible for, in order to manage and monitor those resources and plan related activities. This need exists at the various levels: farm, city, sub-national, national, regional, and global. International conventions and processes such as the CBD, UNFCC and the UNCCCD recently added to the need for better quantitative information on trees at national level. Important progress has been made in the assessment of forests, but the assessment of TOF is still in its infancy; in most countries the importance of the TOF resource at national level is still not based on evidence.

TOF are trees that are outside the definition of Forest. A tree may always be classified either as belonging to Forest or as a TOF; a tree cannot at the same time be a TOF and belong to Forest: TOF as a set complements Forest in the "tree realm". That means that the definition of Forest (and it varies by country) affects the contours of the TOF realm.

TOF occur in all countries. The examples based on satellite images show that TOF occur in all countries, and that they can be encountered under almost any climate where trees grow: on farms, in cities, in lowlands and mountains, in temperate and tropical regions, in wetlands and in drylands.

TOF fulfill a multitude of functions. TOF fulfill a multitude of ecological, economic, social, and cultural functions that in many cases are vital for human livelihood.

Countries need clarifications for conducting assessments of TOF. A thematic study, carried out in the framework of the FRA 2010, includes the development of an operational definition of TOF, a review of large-area assessments in relation with TOF, and a set of options for countries engaging in a TOF assessment. This report presents those options.

TOF in this report are TOF sensu FAO-FRA. As understood in this report, TOF is in the tree realm the complement of the combined two FAO categories, Forest and Other Wooded Land.

TOF includes trees and shrubs. The word "Trees" in TOF means trees and shrubs.

The TOF realm includes three TOF sets. From an analysis of FAO-FRA definitions, the TOF realm consists of three TOF sets:

1. TOF on land predominantly under agricultural land use or TOF-AGRI;

2. TOF on land predominantly under urban land use or TOF-URB;

3. TOF on land not predominantly under agriculture or urban land use or TOF-NON A/U. This set consists of 4 subsets:

- ✓ Subset 1: small tree stands (area <0.5 ha), irrespective of trees and/or shrubs spatial organization, height and canopy cover level;
- ✓ Subset 2: linear tree formations, narrow (width < 20 m), irrespective of area, plant height and canopy cover level;
- ✓ Subset 3: large stands (area ≥ 0.5 ha), trees (height ≥ 5 m) with low canopy cover level (cc < 5 percent);

✓ Subset 4: large stands (area ≥ 0.5 ha), shrubs (height <5 m) or a mixed cover of shrubs and trees) with low canopy cover level (cc < 10 percent).

Other Land includes two sub-categories: with TOF and *with No TOF*. In the FAO-FRA land classificatory framework, Other Land, in the land realm, complements these combined sets: Forest, Other Wooded Land, and Inland Water. Depending on the presence or absence of trees, Other Land may be subdivided in two mutually exclusive sub-categories.

Minimum threshold values are needed for sub-categories to be operational. This report proposes the following minimum threshold values:

✓ Canopy cover: 5 percent if trees only; 10 percent if combined trees and shrubs
✓ Area: 0.05 ha
✓ Tree line length: 25 m
✓ Tree line width: 3 m

These minimum thresholds result in operational definitions. Based on the presence of TOF at threshold levels, the two Other Land sub-categories are:

✓ Other Land *with TOF* (OL*wTOF*)
✓ Other Land *with No TOF* (OL*wNoTOF*)

Most TOF are included in Other land *with TOF*; by using the minimum thresholds values, some TOF may occur in Other Land *with No TOF*.

Other Land *with TOF* (OL*wTOF*) consists of three sets:

OL*wTOF*-AGRI: includes all lands predominantly under agricultural land use with trees and/or shrubs, whatever their spatial pattern (in line, in stands, scattered), provided that the area is ≥ 0.05 ha, the canopy cover is ≥ 5 percent if only trees are present, or ≥ 10 percent in case of combined trees and shrubs, the width ≥ 3 m and the length ≥ 25 m for linear tree formations.

OL*wTOF*-URB: includes all lands predominantly under an urban use with trees and/or shrubs whatever their spatial pattern (in line, in stands, scattered), provided that the area is ≥ 0.05 ha, the canopy cover is ≥ 5 percent if only trees are present, or ≥ 10 percent in case of combined trees and shrubs, the width ≥ 3 m, and the length ≥ 25 m m in case of linear tree formations.

OL*wTOF*-NON A/U: includes all lands not predominantly under agriculture or urban land use that cannot be classified as Forest or as Other Wooded Land, when the thresholds for Other Land *with TOF* are met. It includes two subsets:

- Subset 1: small tree stands (0.05 ≤ area < 0.5 ha) with canopy cover ≥ 5 percent if trees are present, or ≥ 10 percent in case of combined trees and shrubs.

- Subset 2: linear tree formations, Narrow (3 m ≤ width < 20 m), with length ≥ 25 m, and canopy cover ≥ 5 percent if trees are present, or ≥ 10 percent in case of combined trees and shrubs.

TOF assessments involve a large range of stakeholders. The three TOF sets correspond to a large variety of stakeholders: farmers, pastoralists and institutions linked to agriculture and rural development; people living in settlements and cities and institutions linked to urban management and development; environmental organizations, rural and urban planning institutions. It is very important to take this variety of stakeholders into account when assessing TOF.

Some ambiguities remain. Even with the proposed rigorous land classificatory framework, some ambiguities related to current FAO-FRA definitions remain for classifying some lands. These ambiguities concern the following terms and concepts:

- ✓ Agricultural land-use
- ✓ Urban land-use
- ✓ Shifting cultivation
- ✓ Rubber plantations
- ✓ Linear tree formations
- ✓ Agroforestry.

The Review of TOF assessments in Chapter 3 showed that TOF assessment at large scale is still in its infancy.

Recent progress has been made:

- ✓ One global scale TOF assessment has been realised (Trees on Farm, 2009). It concerns TOF on agricultural land, and its results provide a rough approximation of the global extent of this set: approximately 10 million km^2 (or 46% of total "agriculture land") have more than 10% tree cover.

- ✓ A regional scale assessment included in this review (Europe - Corine Land Cover) does not specifically focus on TOF but includes land-use/land-cover classes that are TOF specific, allowing their spatial distribution and extent to be assessed.

- ✓ Countries that have implemented the NFMA approach have successfully integrated TOF and TOF issues into their national forest (and tree) assessments. These countries may provide convincing estimates of the variables related to TOF resources. Their precision could be enhanced with increased sampling intensity.

- ✓ Many countries have available national assessments that may provide (in some cases after data re-analysis) information on TOF sets. It is possible for those countries to build on these assessments and develop complementary assessments that would, at a lower cost than if no data were available, help in getting a more complete, reliable and accurate picture of their TOF resource. In particular, land-cover/land-use assessments constitute a perfect starting point, provided the land-cover classes have been judiciously defined so that they unequivocally cover TOF categories.

- ✓ Some countries have implemented assessments of their tree and forest resource that are so detailed that they may be used for providing estimates of the main biophysical variables related to TOF. A few other countries have undertaken specific TOF assessments with a focus on a TOF set. These TOF-specific assessments can be combined, and complemented if necessary with new assessments, to allow a quite complete, reliable and accurate picture of their national TOF situation. These cases show that assessing TOF at national scale is possible, with no insurmountable technical or methodological obstacles, as long as the TOF categories are consistent and the assessments organized in a complementary way.

Keys for TOF assessments (Chapter 4) are recognition that:

Assessing TOF is conceptually similar to assessing trees in forest. As in forest assessments, low- and high-resolution remote-sensing images help to identify land with TOF; sampling for inventory proceeds the same way as for forests. Field inventory protocols and survey questionnaires are similar to those used for forest. Sampling, field inventory protocols and survey questionnaires could require adaptation to the specificities of targeted TOF subsets (just as they could need to be adapted to specific forest types).

A prerequisite is acknowledging the range of land-uses that include TOF. The TOF realm includes small woods and linear tree formations when land-use is neither urban nor agricultural. It also includes trees on farms and trees in cities. Any TOF assessment should thus take into account the heterogeneity of the TOF realm at the onset. This helps to identify the sectors that are legitimately involved in the other TOF sets (environment, agriculture, rural development, transportation, city planning, etc.). This can lead to setting up an ad-hoc multi-sector, multidisciplinary team in charge inter alia of refining the detailed objectives of the assessment, as well as identifying the protocols and sampling schemes.

Credible results depend on sound protocols and sampling schemes. Protocols and sampling scheme must be pre-evaluated by statisticians to ensure that they will (1) yield credible results, (2) achieve the desired allowable error estimates, (3) permit statistically defensible assessment of uncertainty, and (4) permit assessment of quality assurance and control.

Pioneer national TOF assessments provide useful models. Pioneer TOF assessments (Chapter 3) offer an important source of inspiration, much as pioneer national forest assessments did. Adaptation to national targets and to country ecological, social and economic situation, are required, keeping in mind that different methods provide different kinds of results (for instance, LCCS may provide maps of the various Other Land *with TOF* sets, while NFMA type assessments may provide reasonable estimates of Other land *with TOF* extent, TOF number, volume, and carbon.).

Recommendations

The following four major recommendations start with a recommendation on national TOF assessments and proceed to other recommendations focused on the international situation and an eventual global TOF assessment, modeled on the global forest resources assessment, and the role of FAO's FRA programme.

Countries should now carry out their national TOF assessments. It is now technically possible to design and implement sound national TOF assessments using the practical keys in this report. Countries that need assistance and guidance in realizing their assessment can now look for support from the international community. If the political will exists, a country can assess its TOF resource.

Clarify FAO-FRA position regarding global TOF assessments. National forest services are often not in the best position to implement national TOF assessments by themselves, because their mandate for two major TOF sets is questionable (land predominantly under agricultural use, and land predominantly under urban use). Agencies in other sectors such as agriculture, environment and urban development should be associated to TOF assessments from the outset. On the other hand, national TOF assessments cannot be implemented without foresters because of their expertise in assessing trees.

The situation is the same at the international level: a global TOF assessment should reflect the variety of TOF and involve a range of international programmes: those dealing with forest, agriculture, environmental and urban issues. At FAO, the Agriculture and Consumer Protection department compiles national statistics on the major non-timber tree crops (which are TOF), but the FRA programme of the Forest department is currently the only international programme that explicitly compiles national information on TOF (extent of Other Land With tree Cover).

In view of the low response rate of countries in the last two Global Forest Resources Assessments, another international effort could be proposed to improve the international reporting of TOF. Two options may be envisaged: (1) The FRA programme sets up an ad-hoc, multi-sector committee in charge of TOF national reporting, (2) FAO sets up a new ad-hoc TOF Resources Assessment programme including experts from the relevant departments.

These two options may also be combined with the initial multi-sector committee under the FRA programme, becoming an independent programme once national and international TOF assessments reach a certain level.

Take action for FRA 2015. In whatever way the FAO FRA programme proceeds in the coming years, it is very important that the efforts already done to integrate information on TOF in the regular assessments of global forest resources be continued in FRA 2015, for two main reasons:

- ✓ FAO-FRA is currently the only legitimate international programme able to gather national information on TOF in a coordinated manner;
- ✓ Before leaving the issue of TOF assessment to another setting, FAO-FRA should still refine the definition of a few terms so that the frontier between Forest, Other Wooded Land, and Other Land *with TOF* can always be objectively defined in practice. This is urgently needed because the current situation may in a number of countries spell some doubts on the forest data reported in the last global forest assessments.

This report thus recommends three technical improvements for implementation in FRA 2015:

✓ Reduce subjectivity in national reporting to FAO-FRA: Improve the definitions[1]. This involves minor modifications of the existing definitions, and defining the terms that allow subjectivity in classifying lands, by:

- Reversing the order of presentation of the land-use and the land-cover criteria in the definitions of Forest, Other Wooded Land and Other Land With Tree Cover. This will help countries better realize the importance of the land-use criterion in these definitions and improve their reporting;

- Defining "agricultural use" and "urban use" in the definitions of Forest, Other Wooded Land and Other Land With Tree Cover, to help countries report in a much more objective and homogeneous way;

- Qualifying the term "abandoned shifting cultivation" in the definition of Forest, so that the sequential nature (crop-fallow cycles) of this agricultural system is respected.

✓ Improve country reporting on the extent of Other Land With Tree Cover (OLWTC)[2]. An analysis of country reporting to FRA 2010 on the extent of OLWTC showed that only a few countries can, at this stage, contribute relevant and relatively precise data to a global TOF assessment on more than the most basic variables. Rather than adding new variables to better qualify OLwTC, it seems more efficient to ensure a much better response from countries on the extent of OLwTC. In addition to improving the definitions (see above), national agricultural and urban services should be involved early, and a few modifications should be made in the Guidelines for Country Reporting.

✓ Develop a global TOF assessment in the FAO FRA Remote Sensing Survey. The FRA Remote Sensing Survey has been instrumental in improving the quality and consistency of regional and global data on the extent of forests. High-resolution images now allow, in most cases, the identification of TOF subsets from the air. A pilot study should build on the Global FRA Remote Sensing Survey and on the RSS data already available to do a first approximation of a global estimate of TOF. That such pilot study should aim to provide regional and global estimates of (1) Other Land With Tree Cover (OLWTC: agriculture AND urban) and (2) Other TOF subsets: small woods and narrow tree lines.

1 A more detailed list has been provided to FAO-FRA at the Expert Consultation on "Long-Term Strategy for Global Forest Resource Assessment", Nastola, Finland, 13-15 September 2011.

2 A detailed list of modifications in the Guidelines for Country Reporting has also been provided to FAO-FRA at the expert consultation in Nastola (2011).

Set the goal and adopt a way forward for global TOF assessment. With a more long-term perspective and in view of the growing importance of TOF issues globally, it is necessary to define clear objectives for a global TOF assessment, much like what has been done for the global assessment of forest resources. This is important to stimulate the implementation of sound national TOF assessments. The programme in charge of TOF at FAO should soon organize an expert consultation meeting to:

- ✓ Finalize the 7 themes proposed in this report as a basis for developing a global TOF resources assessment framework (extent of TOF resources; TOF biological diversity; TOF health and vitality; productive functions of TOF resources; protective functions of TOF resources; socio-economic functions of land with TOF; and legal, policy and institutional framework)
- ✓ Set up a step-by-step agenda with realistic targets for further global TOF resources assessments, on the basis of the finalized framework.

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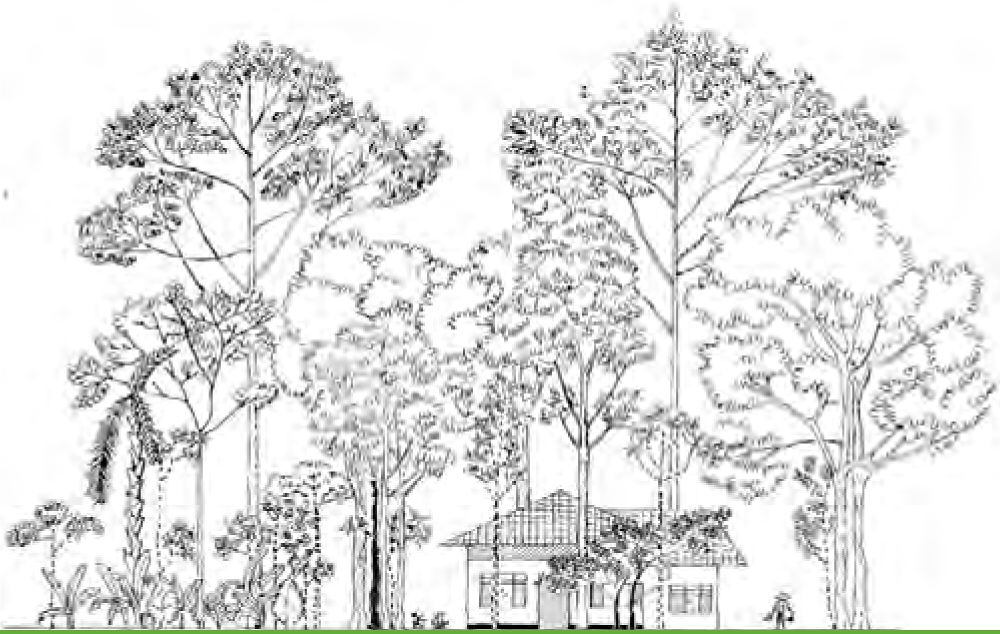
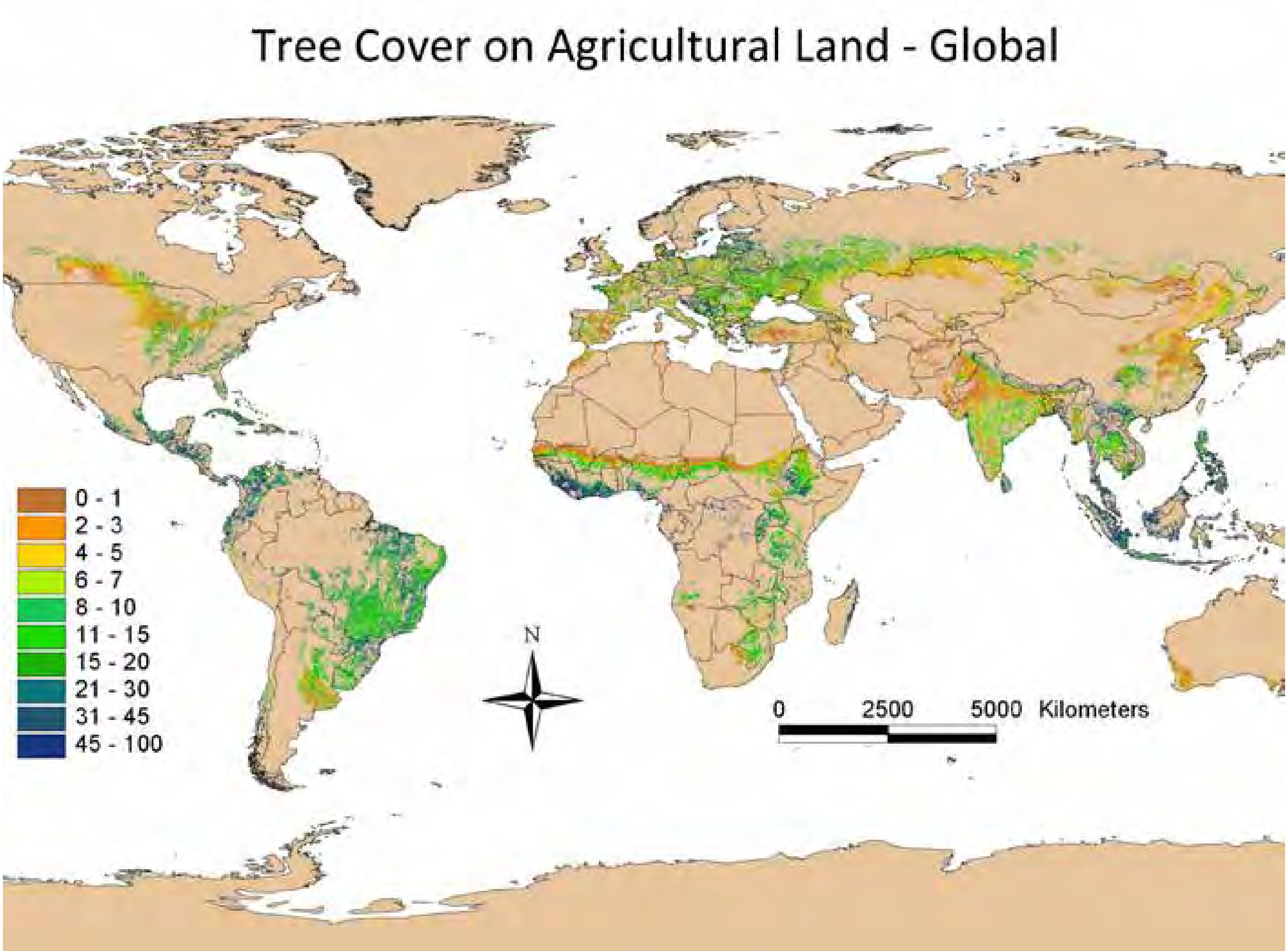


Part 2: Trees Outside Forests Assessments

Introduction

This part consists of the synthetic profile sheets that were made for each assessment and for each supporting programme. Most national assessments have been organized by country, because in most countries, complementary data on TOF may be gathered from different national inventories, due either to the land-use dispersal of TOF or to differences in the targeted variables. The profile sheets were used as a basis for the comparative analysis of the assessments (Part 1, Chapter 3). All points that were unclear in the available documents were clarified by experts working in the supporting programmes for the global and regional assessments, and by national experts for the countries. Once completed, profile sheets were as much as possible sent for checking and validation to programme experts or to the relevant contact-persons in the countries. Any error still remaining is to be attributed to the authors of this report.

Figures in the Assessment Profiles usually follow the International System of Units («metric system»). In some profiles however, figures do not follow the metric system because they have been kept in accordance with the sources used for the profile .



Source: Zomer, R. J., A. Trabucco, et al. 2009. *Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry.* ICRAF Working Paper 89. Nairobi, World Agroforestry Centre: 72.

Content

1. Large area TOF Assessments

Global Trees Outside Forests Assessment

The study "Trees on Farm, analysis of global extent and geographical patterns of agroforestry" represents the first attempt of a TOF assessment at global scale. Focused on trees on land used for agriculture, this assessment highlights the quantitative importance of this kind of TOF worldwide.

Trees on farm: analysis of global extent and geographical patterns of agroforestry	
Objective	To quantify and map the extent of agroforestry at the global level through a remote sensing approach, and to examine the relationships among tree cover, population density and climatic conditions within agricultural land.
Institution in charge	World Agroforestry Center (ICRAF).
Scale, duration, periodicity	Worldwide (Global) Results published in 2009
Data used	Geo-datasets: - VMAP 0 - Country Boundaries - MOD44B MODIS Vegetation Continuous Field Coll. 3– TC - Global Land Cover 2000 database - Global Rural-Urban Mapping Population (GRUMP v. 1) - Aridity Index
Methodology	The geospatial analysis of remote-sensing derived global datasets allowed the production of maps visualizing the relationships among tree cover, population density and climatic conditions within land used for agriculture, at a 1 km resolution. Three data sources were used to obtain cross-sectional information: 1. Global land use. Spatial data layers exist that classify any pixel as agricultural or some other land use. 2. Global tree cover. Remote sensing data has been interpreted to give an estimate of the percentage tree cover in a pixel. 3. Global population. Spatially disaggregated population layers are available, which give an estimate of population in any pixel and can be used to measure the relation between agroforestry and population density. Only the portion of land used for agricultural has been considered. This area was then stratified for each tree canopy cover value (0 to 100) into 20 population density classes, 20 aridity index classes and 13 subcontinents. Within each stratum, or within specific aggregation of strata, zonal statistical values (e.g. mean, sum, total area, percentiles, areal distribution) were summarized to describe: tree canopy cover (percent), total population and population density.
Variables related to TOF	Spatial: location, area covered by each feature Biophysical: Tree cover Background information: Aridity index and population density
Categories that may include TOF	All categories in this assessment are TOF categories (trees on land used for agriculture)

<table>
<tr><td>TOF sets and subsets covered</td><td>Trees in an agricultural land-use context: Set 1 (TOF-AGRI)</td></tr>
<tr><td>Results</td><td>- Agroforestry is a significant feature of agriculture in all regions, with approx 10 million km^2 of agriculture area (or 46 percent of the total “agriculture land” in the survey) having more than 10 percent tree cover.

- Its extent varies significantly across regions (e.g. for agriculture area with a canopy cover above 10 percent, it varies from 9 percent of total agriculture land in North Africa and Western Asia, to 98 percent in Central America).

The resulting information of this assessment is presented in a number of maps (global and regional) and figures, among others :
• Tree canopy cover on agricultural land.
• Agricultural area with tree cover at different thresholds (10, 20 and 30 percent) by major regions.
• Population in agricultural areas with tree cover at different thresholds (10, 20 and 30 percent) by major regions.
• Average tree density on agricultural land by population density for each region.
• Actual and potential tree cover and their difference in Africa.</td></tr>
<tr><td>Comments</td><td>- Even though resolution of images is low, the study allows a good overview of agroforestry resources at global scale. Regional comparison is then available, keeping in mind all the restrictions described in the report document.

- It identifies the actual gaps of agroforestry evaluations and opens the way to other studies on tree cover patterns.

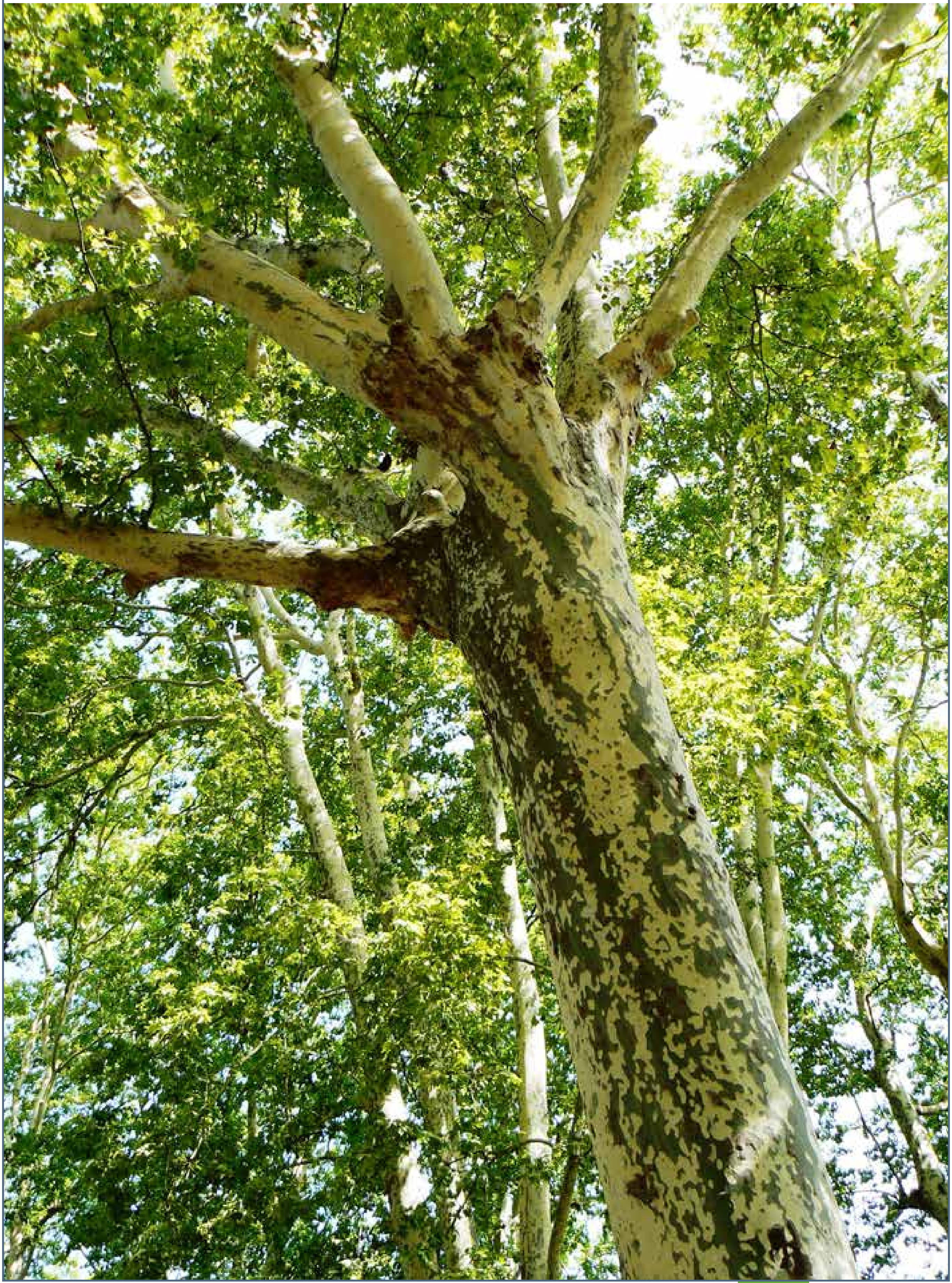
- Due to the low resolution of the images used, the results are rough estimates.

- This assessment is restricted to agricultural lands, and does not thus include all TOF categories. The low resolution allowed only large areas of agroforestry systems and tree crops to be taken into account.

- As it is based on remote sensing only, the usual gaps are implied (e.g. clouds, no data area)</td></tr>
<tr><td>References</td><td>Zomer, R. J., A. Trabucco, et al. 2009. Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry. ICRAF Working Paper 89. Nairobi, World Agroforestry Centre: 72.</td></tr>
</table>

This assessment profile was validated by Mr Robert Zomer (Deputy Programme Manager, Ecosystem Services Program, ICIMOD, Nepal).

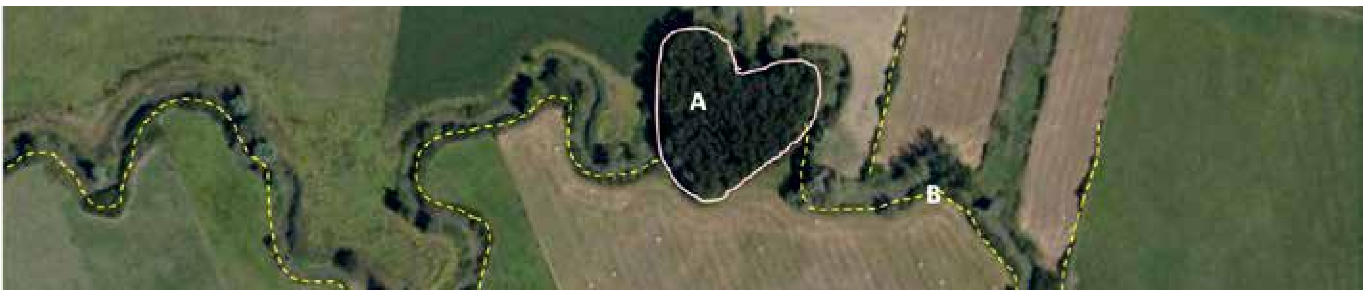
Regional Trees Outside Forests Assessment



Corine Land-Cover

The Corine land cover programme represents the first regional scale assessment that provides information on the area and location of some TOF subsets.

Corine Land-Cover (Co-Ordination of Information on the Environment)	
Objective	To provide information on land cover and land cover changes in Europe, based on the photo-interpretation of satellite images carried out by the national teams of participating countries, the National Reference Centres (NRCs) on land cover of the European Environment Information and Observation NETwork (Eionet).
Institution in charge	Developed by the European Commission and carried out by the European Environment Agency (EEA) and Eionet.
Scale, duration, periodicity	Region-wide: Europe First Corine Land-Cover (CLC) in 1990, Second in 2000, latest in 2006
Data used	Earth observation satellite images
Methodology background	Since 2000, Corine Land-Cover projects (I & CLC2000 and I & CLC2006) are based on 2 components: Image acquisition and interpretation of land cover change. - In 2000: • IMAGE2000: Covering all activities related to satellite image acquisition, ortho-rectification and production of the European and the national mosaics; • CLC2000: covering all activities related to the update of CLC1990 by detection and interpretation of land cover changes (CLC-Changes). It used CLC1990, IMAGE1990 and IMAGE2000 data. Additionally, in order to prevent the propagation of errors into the new update, geometric and thematic mistakes in CLC1990 were corrected. - In 2006, a similar update was done with IMAGE2006 and CLC2006, mapping land cover changes between 2000 and 2006. In order to improve resolution and enlarge environmental monitoring and assessment programs, collaboration was launched between the European Commission, the European Space Agency (ESA) and the European Environment Agency. Now, CLC is part of the land monitoring services of the GMES Initial Operations (GIO) , and the European Topic Centre on Spatial Information and Analysis (ETC-SIA) is supporting the EEA in quality assurance and quality control of the land use/land cover changes.



Methodology	Satellite images interpretation and national land cover inventories are carried out by the national teams, and are further integrated into a seamless land-cover map of Europe by the European Environment Agency (EEA). EEA is also in charge of the updates. The European database thus created is based on standard methodology and nomenclature (see CLC classes). Maps are at a 1:100 000 scale, with a minimum mapping unit (MMU) of 25 ha and a minimum width of linear elements of 100 m for the baseline mapping. Land cover changes are mapped with a MMU of 5 ha and a minimum width of linear elements of 100 m.

Evolution of Corine land cover projects (EEA 2007)

	CLC1990 Specifications	CLC2000 Specifications	CLC2006 Specifications
Satellite data	Landsat -4/5 TM single date (in a few cases Land-sat MSS, as well)	Landsat -7 ETM single data	SPOT -4 and/or IRS LISS III two dates
Time consistency	1986-1998	2000 +/- 1 year	2006 +/- 1 year
Geometric accuracy satellite images	≤ 50 m	≤ 25 m	≤ 25 m
CLC minimum mapping unit	25 ha	25 ha	25 ha
Geometric accuracy of CLC data	100 m	better than 100 m	better than 100 m
Thematic accuracy	≥ 85 % (not validated)	≥ 85 % (validated, see Bûttner, G., Maucha, G., 2006)	≥ 85 %
Change mapping	N.A.	boundary displace-ment min. 100m; change area for existing polygons ≥ 5 ha; isolated changes ≥ 25 ha	boundary displace-ment min. 100 m; all changes > 5 ha have to be mapped
Production time	10 years	4 years	1.5 years
Documentation	incomplete metadata	standard metadata	standard metadata
Access to the data	unclear dissemination policy	free access	free acess
Number of European contries involved	26	32	38

Source : European Environment Agency, 2007

The standard CLC nomenclature includes 44 land-cover classes. These are grouped in a three-level hierarchy. The five main categories of level-one are: 1) artificial surfaces, 2) agricultural areas, 3) forests and semi-natural areas, 4) wetlands, and 5) water bodies.

Variables related to TOF	Spatial: location, area covered by each feature Biophysical: Land cover Background information: Land Use (to a certain extent)

Categories that may include TOF	The following table shows the various Corine categories (level 3 classes) that include or may include TOF :

Corinne Land-Cover Classes			Description and examples of TOF apprehended
Level 1	Level 2	Level 3	
1. Artificial surfaces	1.1. Urban fabric	1.1.2 Discontinuous Urban fabric	Includes private housing estates, residential suburbs made of individual houses with privative gardens and small squares, scattered blocks of residential flats, hamlets, small villages where numerous un-mineralized interstitial spaces (gardens, lawns can be distinguished)
	1.4 Artificial, non-agricultural vegetated areas	1.4.1 Green urban areas	Includes parks, mansions and their grounds, vegetated areas, Green urban areas, Greenery with strips of lanes.
		1.4.2 Sport and lei-sure facilities	Camping ground, sport ground, lei-sure parks, golf courses, zoological gardens, botanical gardens outside urban fabric, forest parks outside built-up areas.
2. Agricultural areas	2.2 Permanent crops	2.2.2 Fruit trees and berry planta-tions	Parcels planted with fruit trees or shrubs: single or mixed fruit species, fruit trees associated with perma-nently grassed surfaces. Includes gro-ves, Ligneous crops: fruit, orchards.
		2.2.3 Olive groves	Areas planted with olive trees, including mixed occurrence of olives trees and vines on the same parcel.
	2.3 Pastures	2.3.1 Pastures	Pastures can be described as exten-sively used grasslands with presence of farm structure. Include areas with hedges.
		2.4.2 Complex cultivation patterns	Juxtaposition of small parcels of diverse annual crops, pasture and permanent crops.
		2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation	Areas principally occupied by agricul-ture, interspersed with significant na-tural areas, such as linear structures of trees organized for truffle producing.
		2.4.4 Agroforestry areas	Annual crops or grazing land under the wooded cover of forestry species.

Source: http://etc-lusi.eionet.europa.eu/CLC2000/classes/index_html

TOF sets and subsets covered	- Trees in agricultural land-use context (set 1: TOF-AGRI, partly covered) - Trees in urban land-use context (set 2: TOF-URB, partly covered)

Results	No data on TOF have been published, but data related to the categories including TOF can be extracted and allow an estimate of the minimum extent of TOF covered land in the various countries of Europe as well as in Europe as a whole. CLC2006 is implemented in the following countries (EIONET 2010): - Completed: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, the former Yugoslavian Republic, Malta, Montenegro, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland and Turkey. - Still in progress: the United Kingdom. - Not initiated yet: Greece.
Comments	- CLC database can be used to give a good overall estimation of the area covered with TOF, in a standardized way across Europe. - CLC database is, in general, compatible with national Land Use / Land Cover assessments that can help to provide more accurate information. For example, some European countries use LUCAS (Land Use / Cover Area frame statistical Survey) or LUCAS derived surveys, as an additional information dataset to implement Corine database. LUCAS, organized by Eurostat, is a European-wide national survey based on photo-interpretation and different types of ground surveys (EUROSTAT 2010). - Different projects use CLC database, among others: • The Land and Ecosystem Accounting (LEAC) project by the European Environment Agency (EEA), which deals with data on changes in land cover and land use and aims to trace the wider environmental, social and economic implications of these transformations; • Land Cover and Forest Indicator Service of the GSE Forest Monitoring, which is a European Space Agency (ESA) funded project. It is part of the Global Monitoring for Environment and Security Services Element (GMSE-GSE), a joint initiative of the European Commission and ESA. - Corine Land-Cover can be to a certain extent compatible with LCCS (see LCCS Profile sheet): "automatic translation from CLC to LCCS doesn't seem feasible at the most detailed level but CLC has potential of interoperability with global land cover activities, (e.g. using the 2nd-level classes, aggregating several classes into a single one or also splitting specific single classes). When coming to concrete mapping, CLC can however be considered as a LCCS version for Europe" (Weber 2009). - Methodology only based on Remote Sensing, no direct field sampling is done, thus no qualitative data on vegetation is provided. - The scale used is quite large as the minimum mapping unit is 25 ha, which is by far too imprecise as it comes to a certain category of TOF (subset N).
References	EIONET. 2010. Corine Land Cover 2006. from http://etc-lusi.eionet.europa.eu/CLC2006. European Environment Agency. 2007. CLC2006 technical guidelines. EEA Technical report 17/2007. Copenhagen, Denmark, EEA: 70 pp. EUROSTAT. 2010. LUCAS — a multi-purpose land use survey. Retrieved November 2010, from http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/LUCAS_%E2%80%94_a_multi-purpose_land_use_survey. Weber. 2009. Land cover classification for land cover accounting. 14th Meeting of the London Group on Environmental accounting, Canberra, Australia. http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster http://www.eea.europa.eu/data-and-maps/data/land-cover-accounts-leac-based-on-corine-land-cover-changes-database-1990-2000.

This profile was validated by Mr Chris Steenmans (Head of Programme Shared Environmental Information System, EEA, Denmark).

Bangladesh

The first National Forest and Tree Resources Assessment 2005-2007 (NFA) of Bangladesh was implemented in both forests and TOF areas whereby earlier management inventories were confined within the designated forest reserves.

First National Forest and Tree Resources Assessment (NFA) 2005-2007	
Objective	To lay out sound foundations for the development of forest policies, forestry programmes, forest management, sustainable development, conservation of the resources, and integrated national policies. (Bangladesh Forest Department, Bangladesh Space Research and Remote Sensing Organization et al., 2007).
Instittions in charge	Bangladesh Forest Department (BFD) of the Ministry of Environment and Forest (MOEF): with assistance from the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) for the remote sensing survey.
Scale, duration, periodicity	Countrywide The NFA was implemented from June 2005 to August 2007
Data used:	- Landsat TM imageries 30 x 30 m (Band 3,4 and 5) - 267 Topo-Sheets at the scale of 1:50 000
Methodology	NFA Bangladesh is based on the NFMA methodology (see NFMA description sheet) Methodology design was issued after the Inception Workshop organized by the Forest Department (FD) in April 2005. Attended and participated by different ministries and divisions of Government of Bangladesh, institutes, herbarium, universities, forest and agriculture departments and FAO. A National Forest Assessment Unit (NFAU) was set within the FD for project implementation (coordination and monitoring of the NFA at national level) under the overall guidance of a National Project Coordinator (NPC). Specific adaptations of the NFMA Bangladesh general methodology: - Systematic sampling grid 15' x 10': 296 sampling points on land (FAO's standard layout for Tracts, Plots and Subplots was adopted but Subplots were not used in non-forest plots) - Development of a national Land Use classification system that corroborates with the Global Land Use classes (GLU) identified by FAO - Socio-economic interviews in sampled areas to assess information related to forest and tree resources management, uses and users: • With external key informants (local forest services, local administrations) • With forest and tree users: individuals or focus groups met during focus group discussions (FGDs) (owners, women, hunters)
Variables related to TOF	Spatial: Plot and tree location, plot orientation, sketch map with property limits, land use/cover sections, watercourses, hedges, proximity to infrastructure Biophysical: Trees assessment if DBH > 10 cm. Tree cover class (<5 percent; 5-10 percent; 10-30 percent; 30-70 percent; >70 percent), shrub coverage, tree species, stem quality, health, number of stumps, tree regeneration, dendrometric characteristics (DBH, total tree height, commercial tree height, year since cut, branch diameter and length), environmental problems (e.g. drought, erosion, burning) Socioeconomic: Land tenure status, Density of population on tract, Tree uses and products (including Non Timber Forest Products (NTFP)) Other background information: Class of protection level, Land use.

Categories that include TOF:	- Other land/ Cultivated Land/ Annual Crops/with trees 0.1-0.5 ha (CA1) - Other land/ Cultivated Land/ Annual Crops/with trees >0.5 ha (CA2) - Other land/ Cultivated Land/ Perennial Crops/ with trees 0.1-0.5 ha (CP1) - Other land/ Cultivated Land/ Perennial Crops/ with trees >0.5 ha (CP2) - Other land/ Cultivated Land/ Wooded Land with shifting cultivation, Fallow (Fa): It includes woody vegetation deriving from the clearing of natural forest for shifting agriculture. - Other land/ Villages/ Rural settlement with trees 0.1-0.5 ha (SR1) - Other land/ Villages/ Rural settlement with trees >0.5 ha (SR2)
Categories that may partly include TOF:	- Other land/ Cultivated Land/ Range Land, Pasture (RL): Land under permanent meadows and pastures - Other land/ Built-up Areas/ Urban settlements (SU) - Other land/ Built-up Areas/ Highways and other artificial areas (HA) - Other land/ Barren Land, Grasslands (BG) - Inland water (W): it appeared in results that 5 percent of this LUC has tree cover of > 5 percent.
TOF sets and subsets covered	All TOF sets and subsets are covered (no exclusion); they are taken into account either in specific TOF categories (see above) or in categories that may include TOF (e.g. trees in urban settlements, trees in pastures, grasslands with less than 5 percent tree cover).
Results	- Data from 296 tracts were collected ultimately all over the country within 10 regions - 27 land use types are distinguished in the maps produced by SPARRSO - 30 percent of the Cultivated land area has tree cover - The area covered with categories that include TOF is 4 091 000 ha (27.72 percent of the total country area, while Forest stands for 9.77 percent and OWL for 1.95 percent). - Total TOF above-ground biomass is estimated to 569 million tons (Forest: 278 million tons). Cultivated lands account for 142 million tons (density: 17 tons/ha), Village lands account for 413 million tons (density: 144 tons/ha), Urban lands account for 10 million tons (density: 93 tons/ha) and Inland water account for 4 million tons (density: 2 tons/ha).
Comments	- In the different LUCs, all woodlots areas measured are more than 0.1 ha: woodlots smaller than 0.1 ha cannot be distinguished from their surrounding land-cover category. - Basic data for categories that may include TOF are accessible in the original NFA sampling forms, and may thus be extractable. - Sampling error is relatively high due to disproportion between the main classes. It is 17 percent for the "Other land" category (FAO, 2008). - There were 10 field teams of 3 members each, and field sampling lasted 5 months (FAO, 2008). The whole project was 33-month long and its cost was US$520 000 (of which 115 000 for fieldwork) (FAO, 2008). - For an unknown reason, the level 2 "Shrub" category, which is fully under the "Other Wooded Land" International Land Use category had been included into the Cultivated Land category for the estimation of all variables except for area.
References	Bangladesh Forest Department, Bangladesh Space Research & Remote Sensing Organization, et al. 2007. *National Forest and Tree Resources Assessment 2005-2007 Bangladesh.* 286. FAO. 2008. NFMA approach and process: an analysis of Cost and Time. *Background Paper prepared for the National Forest Monitoring and Assessment [NFMA] Expert Consultation "Meeting Evolving Needs". Rome - 26-28 November.* Working Paper NFMA 39: 20. FAO. 2010. *Forest Ressources Assessment* 2010 (FRA 2010) - country reporting process. Retrieved October 14, 2010, from http://www.fao.org/forestry/62318/en/.

Cameroon

In order to update the information on forest resource and obtain information on wood resources in non forest areas, the Cameroon government implemented a new comprehensive inventory. This assessment provides information on TOF.

National forest resource assessment 2003-2004	
Objective	To assess national forest resources (timber and non-timber), taking into account woody perennials and trees outside forests, and to implement a monitoring system for forest resources.
Institution in charge	Ministry of Forests and Fauna, with FAO collaboration.
Scale, duration, periodicity	Countrywide Preparation and implementation phase (1) 2002-2003, Implementation phase (2) 2004-2005
Data used	Topographic maps (usually 1:200 000)
Methodology	NFRA Cameroon is based on the NFMA methodology (*see NFMA description sheet*) Specificity within the NFMA general methodology: - Two areas have been distinguished, based on vegetation type and ecological features: 2 strata, northern open area and closed southern area - Systematic sampling grid: for northern area 30' x 30', for southern area 30' x 15'; a total of 207 sampling points have been inventoried - Sampling units: 1 km x 1 km², following the general methodology - Socio-economic interviews with key informants and forest users (individuals or groups) in sampled areas
Variables related to TOF	Spatial: Plot location, tree location, plot orientation and sketch Biophysical: tree number and species, tree measurement if DBH ≥ 10 cm for TOF (DBH, height, health, quality, damages, conservation status, etc.) Socioeconomic: land tenure, land management, products and services (including NWFP) and income generating activity Background information: Land use (LU/LC Sections)
Categories that may include TOF	The categories assessed are the FAO FRA categories. So, as expected, TOF can be found within some of the subcategories of Other Land: - Natural: • Grassland • Wetland - Cultivated: • Perennial Crop • Pasture land - Built-up area

TOF sets and subsets covered	All TOF sets and subsets are covered
Results	- Other land (OL) represents 11 230 928 ha (23.6 percent of the country area) with a total wood volume of 350.5 million m^3 (average density of 31.2 m^3/ha): • Perennial crops cover 1 238 249 ha (11 percent of OL) with a total wood volume of 114.7 million m^3 (92.7 m^3/ha). • Annual crops cover 5 105 665 ha (45.5 percent of OL), and also represent an important wood resource, with 109.7 million m^3 (21.5 m^3/ha). • Wetland: 1 158 866 ha (10.3 percent of OL), with 64.6 million m^3 (55.77 m^3/ha). • Grassland: 1 944 742 ha (17.3 percent of OL), with 40.3 million m^3 (20.7 m^3/ha). • Pastures: 1 308 204 ha (11.6 percent of OL), with 18.6 million m^3 (14.2 m^3/ha). • Built-up areas: 382 402 ha (3.4 percent of OL), with 2.6 million m^3 (4.4 m^3/ha). - Even though almost all categories of OL have wood, very little can be considered as harvestable for timber (5.2 percent of the total) - Other Land had 317 species of trees out of 573 encountered in the whole inventory - "Fallows" represent 2 088 803 ha, with a total wood volume estimated to 110 360 740 m^3 (52.8 m^3/ha) TOF represent a minimum area of 13 319 731 ha (28 percent of the country area), with a total wood volume estimated to 451 million m^3 (6.3 percent of the country estimated total wood volume). Harvestable volume (trees belonging to the "Top 50" species list with a DBH > the minimum legal DBH for cutting) is estimated to 88 million m^3, or 7 percent of the total harvestable volume.
Comments	- No minimal area for Other Land and Other Wooded Land. - Forest fallows (with trees less than 5 m high) in shifting cultivation system with a short cycle (less than 5 years) made-up a sub-class "fallow", integrated into OWL. This whole sub-class is to be considered TOF (part of OL) because land is used predominantly for agriculture. - Data on small woods (< 0.5 ha) cannot be extracted.
References	Branthomme, A. 2002 . *Inventaire forestier national du Cameroun - Manuel de terrain.* Altrell, Saket and Vuorinen. Rome, FAO: 60 pp. Ministère des Forêts et de la Faune. 2007. *Évaluation des Ressources Forestières Nationales du Cameroun 2003 - 2004. FAO. Yaoundé, Cameroun, République du Cameroun*, FAO: 93 pp.

Canada

The National Forest Inventory (NFI) is currently the only available source of information on TOF at country scale. It was established between 2000 and 2006, replacing the CanFI (which was a periodic national compilation of existing provincial and territorial forest inventory information). This new National Forest Inventory takes into account the FAO-FRA categories as a basis (although ignoring the size threshold), including "Other Land with Tree Cover", a subcategory of Other Land with TOF.

Although Canada has no countrywide assessment of its trees and forests in urban environments, many municipalities have their own urban forestry management systems, and some even quantify the economic benefits of maintaining Urban Forests (personal communication: Mike Rosen). Most countries are in the same situation, having city assessments but no countrywide integration of these assessments. The Toronto Urban Tree Canopy Assessment is included here as an example of city assessment.

First National Forest Inventory (NFI), 2000-2006	
Objective	The purpose of the NFI is to assess and monitor the extent, state and sustainable development of Canada's forests in a timely and accurate manner.
Institution in charge	Natural Resources Canada – Canadian Forest Service coordinates the NFI, manages and analyzes the data, and provides the final reports. Provincial and territorial collaborators collect and provide data using jointly developed standards and procedures.
Scale, duration, periodicity	Countrywide NFI follows a 5-year measurement (continuous) and reporting cycle.
Methodology	There are 6 phases in the NFI: 1. A network (grid) of sampling points across the population (Canada); 2. Stratification of the sampling points, with varying sampling intensity among the strata; 3. Estimation of some attributes from remote sensing sources on a primary (large) sample; 4. Estimation of other detailed data from a (small) ground-based sub-sample; 5. Estimation of changes in (3) and (4) from repeated measurements; 6. Compilation of NFI attributes. General sampling design The objective is to survey 1 percent of Canada Land mass. The base for the national network is a 4 km x 4 km grid. Each territory/province can select to a certain extent the sampling intensity according to its own inventory process, but the sampling grid most of the time is 20 x 20 km, nested on the national 4 km x 4 km grid. Sampling intensity varies also with the type of ecozone. All NFI plots are permanent. The stratification is done by terrestrial ecozones (15 ecozones) and territory/province. Data are then aggregated at national level. The NFI Design Document lists a set of 25 key attributes designed to satisfy national reporting requirements for criteria and indicators of sustainable forest management. Individual provinces and territories may decide to include additional attributes.

	Photo-plots They are located generally at the nodes of a 20 km x 20 km sample point grid. Photo-plots have a square shape and a size of 2 km x 2 km. 18 850 Photo-plots (equivalent to 1 plot per 39 000 ha, none in the arctic ecozone) provide information on area coverage and some attributes estimable (e.g. wood volume and tree species) by Remote Sensing (aerial photography, with a minimal scale of 1:20 000 for vegetated areas (forested and non forested) and satellite images for unvegetated areas or with little vegetation). Each Photo-plot contains 4 data layers: Land cover, Land Use, Ownership, Protection Status. Interpretation is done according NFI Land Cover Classification System (LCCS) and the NFI Land Use Classification System (LUCS): - NFI LCCS has 5 levels: land base meaning vegetated or not (5 percent vegetation), land cover type (treed, non treed/water, land) landscape position (Wetland, Upland, Alpine), vegetation type and density class. - NFI LUCS: Industrial, Forestry, Agriculture, Conservation, Infrastructure, Settlement, Re-creation, National Defence, Unknown. Each polygon is recommended to have a minimal size of 0.5 ha and a minimal width of 1 mm at photo scale, but they can be smaller. Ground plots They are a subsample of the photo-plots (10 percent, with a minimum of 50 forested plots/ ecozone), on which measurements, like diversity and biomass are taken. These ground plots are only established on forested locations, and for this reason, they will not be described further here.
Variables related to TOF	Photo-plots Spatial: landscape location (relative to the drainage and elevation), area Biophysical: Land cover, vegetation type, density class, stands structure. For vegetated polygones: stand origin, stand disturbance, stand attributes (species and percent, height, age, crown closure, volume) Background information: Land use, Ownership, Protection status
Categories that may include TOF	OLwTC which is a sub-category of Other Land *with TOF* (S>0,5ha and CC >10 percent), including urban trees and tree crops; Forest may also include TOF (small woods) because of the absence of a size threshold; Other Wooded Land may also include TOF for the same reason.
TOF sets and subsets covered	All TOF sets and subsets are included in the coverage of the assessment
Results	Other Land With Tree Cover spans over 7 773 240 ha.
Comments	- Definitions for forest and other wooded land are the FAO-FRA definitions except for the size threshold (no size threshold). - The NFI covers all lands, but ground sample plots are made only in forested areas. - The NFI provides data on the area of OLwTC but it will be more difficult to enlarge data collection on other TOF, because of the lack of size threshold.
References	NFI Canada. *Canada National inventory/ Inventaire Forestier Canadien*. from https://nfi.nfis.org/index.php.

Toronto Urban Tree Canopy (UTC) assessment 2010	
Objective	- Describe the current composition, structure and distribution of Toronto's Urban forest. - Quantify the ecological services and benefits provided by the urban forest. - Identify opportunities for increasing sustainable tree cover. - Define a baseline forest condition for further monitoring.
Institutions in charge	Project Coordination by City of Toronto, with project advisors from Toronto and Region Conservation Authority (TRCA)Assessment done by Syracuse USDA Forest Service Northern Research Station (NRS) and City of Toronto Urban Forestry staff,Mapping by City Planning and The University of Vermont Spatial Analysis Laboratory.
Scale, duration, periodicity	Municipal boundaries of the City of Toronto (66 140 ha). Field data collection (4 months) and mapping (8 months) in 2008. Periodical re-measurements planned (3-4 years).
Methodology	The project was divided in 5 steps: 1. Study design phase and field data collection based on a two phase sampling: • A grid of 407 squares was laid over the city map and one circular 0.04 ha permanent sample plot (PSP) was randomly selected within each square for field assessment. All trees within each PSP were measured. • A stratification was then realised based on 9 Land Use types 2. Data analysis using the i-Tree Eco model, including Hydro modeling (An urban forest hydrologic model was used to simulate the effects of tree and impervious cover on water flow in the Don watershed). Collected data were sent to Syracuse USDA Forest Service NRS with other data (hourly weather data, air pollution data) for further treatment. 3. Integration of existing City street tree data and City mapping data from the Toronto Maintenance and Management System (TMMS): street tree species composition, size class distribution, tree conditions as well as trends in the rate of planting and tree removals over time. 4. Manual assessment of Land Cover change between 1999 and 2005 based on digital leaf-off aerial orthophotos (1999 and 2005). A total of 9 998 random geo-referenced points sampled on each set. Results post-stratified by land use and change in area assessed for 7 land-cover types (Tree/shrub cover, Grass, Soil, Water, Building, Road, Impervious – other). 5. Automated land cover mapping and Urban Tree Canopy (UTC) assessment based on City land cover mapping using high resolution (0.6 m) QuickBird satellite imagery (leaf-on) acquired in 2007 combined with planimetric data (ownership information, road infrastructure and building footprint data). The UTC assessment provides information describing the amount of current tree canopy currently (Existing UTC) along with the amount of potential tree canopy (Possible UTC).
Variables related to TOF	Spatial: location, distance and direction to space-conditioned buildings Biophysical: Ground and tree cover, individual tree attributes (species, quantity, DBH, tree height, height to base of live crown, crown width, percentage crown canopy missing, crown dieback) Socioeconomic: Ownership Background information: Land use
Categories that may include TOF	All land-use categories of the assessment include trees and are TOF categories as they are all in a urban area

TOF sets and subsets covered	Trees on land that is predominantly urban use: set 1: TOF-URB
Results	- The project is based on the I-tree method. This method has been used in many cities in the USA and elsewhere: http://www.itreetools.org/international-users.html - There is no extra cost for the i-Tree Software Suite, so the global cost is the same as a normal inventory task. - This method requires an existing urban forest staff and city data (city mapping, land tenure, weather and pollution data).
Comments	- Toronto covers 66 140 ha and has approximately 20 percent tree cover representing 10.2 million trees. - Of the total tree population, 0.6 million (6 percent) are street trees, 3.5 million (34 percent) are trees in City parks/natural areas and 6.1 million (60 percent) are growing on private property. - The urban tree canopy has an estimated structural value of CND $7 billion. - Toronto's urban forest provides the equivalent of at least CND $30 million in ecological services each year. - Gross carbon sequestration by trees in Toronto is estimated at 46 700 metric tons of carbon per year with an associated value of CND $1.3 million.
References	This assessment profile is based on personal communications from Mrs. Ruthanne Henry, Urban Forestry Planner (City of Toronto, Canada), and on the following document: City of Toronto - Urban Forestry. 2010. *Every Tree Counts - A Portrait of Toronto's Urban Forest*. Toronto: 106 pp.

China

Various forest assessments are conducted at different levels in China to meet different information needs. We focus on the national forest inventory (NFI) as some data on TOF could be extracted from this countrywide assessment.

Seventh National Forest inventory, 2004-2008	
Objective	To periodically identify the status and functions of forest resources, and provide basic information support for national forestry policies making, planning and management at provincial, regional and national levels.
Institution in charge	State Forestry Administration (SFA), P. R. China. 4 regional inventory institutes are responsible for technical guidance, quality check and data analysis. The field survey is organized by provincial forestry agencies, and undertaken by provincial monitoring institutes.
Scale, duration, periodicity	Countrywide 1/5 of the provinces is inventoried annually 5-year cycle
Methodology	The NFI includes 4 main activities: - Field inventory for all attributes related to forest area and volume estimation (160 factors); - Dynamic analysis based on remote-sensing plots; - Socio-economic investigation; - Mapping of forest distribution using satellite data. Field inventory is based on a two-stage sampling, where the Chinese provinces are the first stage sampling unit. The sampling scheme is then systematic and covers all land cover classes (including deserts and wetlands). Permanent Sample Plots (PSPs) are systematically laid out on the grid dots of x, y coordinates on topographic maps (scale 1:50 000). A total of 415 000 PSP have been established, but the distance between plots, their shape, area and size are flexible, depending on the required estimate precision of variables (forest land area, growing stock, plantation area, amount of growth and consumption, and net timber volume increase), which differs from one province to another. Sampling plots are squares (in general) or rectangles. Distance between plots is 2 km to 8 km, and size is 0.06 ha or 0.1 ha (generally 0.0667 ha, namely 1 mu). PSP data is first set at provincial levels, and then aggregated to be analyzed at national level. Dynamic analysis based on RS-plots. The RS-based plots (RSPs) are set using satellite images with 10 to 30 m resolution (mainly Landsat). Equal-distance systematic sampling is used to set RSPs, but the sampling intensity varies proportionally with the field sampling intensity. The number of RSPs is 4 to 8 times greater than field plots. In total, 2.84 million RS-plots are set at national level. This sampling is used for sampling precision control of main inventory indicators, for the identification of forest distribution in the unreached area, and for the spatial distribution of forest dynamics. Socio-economic investigation This is carried out during field inventory, consisting of a social investigation and a questionnaire to farmers. Its purpose is to collect information on forestry development at provincial and county levels, on tree planting and on forest cultivation, management and utilization in local communities.

	Mapping of forest distribution. The map of forest distribution is drawn using the same satellite data as that of dynamic analysis based on RS-plots. The mapping method is polygon division. The division attributes are forest types including: "coniferous forest", "broadleaves forest", "mixed forest", "bamboo forest" and "national especially designated shrub trees". The map of forest distribution is updated every five years (through NFIs) at national level.
Variables related to TOF	About 160 variables are collected during field inventory. Spatial: plot location , all trees with DBH > 5 cm are individually localized/mapped on the plot. Biophysical: plot land cover, tree-growing environment (including soil and landform), stand characteristic (including average DBH, average height, average age, etc.), health, quality, disturbances, biodiversity, ecological benefits, forest management and disturbance, and individual dendrometrics if DBH > 5 cm (tree species, DBH). Stand features are not recorded in non-standing tree plots. Socio-economic (more than 20 variables, not plot based): statistics on population, forestry employment & GDP, management rights, ownership of trees and land. Tree stand designated functions Background information: plot land use, plantation, afforestation area, wood and products consumption, natural reserve at provincial and county levels
Categories that may include TOF	The results of the NFI are given at different successive levels (forest land type, forest type and characteristics). There are two special subcategories that are made up of TOF: - "Four-side" trees, most of which come from planting. "Four sides" include the areas around houses, roads, rivers and crop lands. The trees are distributed by linear structure and are mainly established for windbreaks, soil conservation and scene purposes. Cover cannot reach the threshold cover and width of stands and open forest, width threshold varying among provinces but generally set around 4 m (Personal communication). - "Scattered trees growing on other non-forestry land (excluding arbour, mangrove stands and open forest) and other land".
TOF sets and subsets covered	- All TOF sets and subsets are included into the coverage of this assessment.
Comments	- The classification scheme seems pretty complex and data on TOF may be difficult to extract even though some categories are completely TOF categories. - The category "scattered trees" has no tree cover limit.
References	FAO.2007. Brief on National Forest Inventory NFI – China. MAR-SFM Working Paper 16/ 2007. Rome. Lei, X., M. Tang, et al. 2010. China. In *National forest Inventories* - Pathways for Common Reporting, eds. E. G. Tomppo, T. Gschwantner, M. Lawrence, R.E. McRoberts. Springer: 113-129 (16). State Forestry Administration, P.R. China. 2004. *Technical Regulation of National Forest Resources Continuous Inventory.* Beijing. (in Chinese) State Forestry Administration, P.R. China. 2009. Supplementary Technical Regulation of National Forest Resources Continuous Inventory. Beijing. (in Chinese)

This Profile was completed in collaboration with Mr. Xia Chaozong, Senior Engineer at the Academy of Forest Inventory and Planning, State Forestry Administration, Beijing, P.R. China.

India

Forest Survey of India (FSI), is a national organization under the Ministry of Environment & Forests. Among the main tasks carried out by the FSI, two are directly related to Trees Outside Forests:

- The National Forest Inventory
- The Forest Cover / Tree Cover Assessment

<table>
<tr><th colspan="2">National Forest Inventory</th></tr>
<tr><td>Objective</td><td>To make the national inventory of forest and tree resources and assess their tree cover, growing stock, biomass, and carbon stock.</td></tr>
<tr><td>Institution in charge</td><td>Forest Survey of India.</td></tr>
<tr><td>Scale, duration, periodicity</td><td>Countrywide
2 years duration
2 years periodicity</td></tr>
<tr><td>Methodology</td><td>The country is first stratified by physiographic zones (14 zones based on tree species composition, physiographic and ecological parameters). Then 10percent (60) districts are randomly selected from the entire country, representing each physiographic zone for a detailed inventory of forest and TOF during a cycle of two years. The inventory of forest is carried out in the recorded forest area, which is mainly owned by the government. Since field boundaries of the recorded forest are not available, the green wash area in the topographic sheet of Survey Of India (SOI) is taken as a proxy to forest area. All area outside the recorded forest area is termed as TOF, which is again divided into rural and urban areas. Separate methodologies are followed for assessment of forest, TOF (rural) and TOF (urban):

- Forest Inventory:
A number of 0.1 ha plots are selected for field sampling:
Each Survey of India (SOI) toposheet map at 1:50 000 scale (15 minutes lat. x 15 minutes long.) is divided into 36 units (called “grids”) of 2 ½’ x 2 ½’. Each “grid” is then subdivided into 4 (1 ¼’ x 1 ¼’) “sub-grids”. Two “sub-grids” per “grid” are then randomly selected. All selected sub-grids falling in the recorded forest (or green wash) area or in any other area declared as forest area are systematically sampled. For each sampled “sub-grid”, data are collected on pre-designed forms in a 0.1 ha sampling plot, centred in the middle of the “sub-grid”.

- TOF inventory: all areas outside the recorded forest area are classified either as water bodies or as TOF areas, and further sub-divided into “TOF Urban” and “TOF Rural”:
• TOF Urban: Urban Frame Survey (UFS) blocks are used as sampling units. UFS blocks are defined by the National Sample Survey Organisation (NSSO) so that each block has well-defined boundaries and a population of 600-800 persons or 120-160 households. In each selected district, UFS blocks are randomly selected according to the following rules:
▪ If the number of UFS Blocks<500, 10 percent are selected for sampling, with a minimum of 20 sampled blocks.
▪ Between 500 and 1000 UFS Blocks, 5percent are selected for sampling; if the number of UFS Blocks>1000, 5percent are selected for sampling, with a minimum of 50 sampled blocks and a maximum of 60 sampled blocks.
▪ The selected UFS blocks are distributed according to town class (which is based on size of population) and data are collected from selected UFS blocks on pre-designed field forms.

• TOF rural: High-resolution satellite data, now mainly LISS-IV Mx (Multispectral 5.8 m) are used for the stratification of rural TOF, based on geometrical shapes corresponding to:
▪ Block (compact group of trees > 0.1 ha)
▪ Linear formation
▪ Scattered trees</td></tr>
</table>

	In each selected district, field sampling plots are randomly selected as follows: • the "Block" stratum: 35 (0.1 ha) plots, • the "Linear formation" stratum : 50 (10 x 125 m) plots, • the "Scattered" stratum is further divided. If non hilly areas: 50 (3 ha) plots, if hilly areas: 95 (0.5 ha) plots.
Variables related to TOF	For forest inventory areas: - Spatial: plot - Biophysical: • size class, regeneration, damages (fire, wildlife) • trees assessment if DBH > 10 cm: number of trees sampled, tree species, dominance, dendrometric characteristics(DBH, crown-width, height) - Socioeconomic: legal status - Background information: land use For TOF areas - Urban TOF : - Spatial: plot location, category of trees (farm forestry, block plantation, railway line, etc.), area of UFS block - Biophysical: • size class • trees assessment if DBH > 10 cm : number of trees sampled, trees species, dendrometric characteristics(DBH, crown-width) For TOF areas - Rural TOF: - Spatial: plot location, category of plot (hilly, plain, irrigated, un-irrigated), category of trees (farm forestry, village woodlots, block plantation, railway, homestead). - Biophysical: trees assessment if DBH > 10 cm: number of trees sampled, trees species, dendrometric characteristics (DBH, crown-width) - Socioeconomic: legal status and ownership - Background information: land use
Categories that may include TOF	- "TOF rural": all trees in this category are TOF sensu FAO - "TOF urban": all trees in this category are TOF sensu FAO - "Green-washed" areas (mainly Recorded Forest) - Forest is not the only land use encountered in this category; some TOF sensu FAO are also included: • Agricultural tree lands, a distinct legal sub-category of Private Recorded Forests (owned by private individuals, communities or corporations), • Trees in line (trees planted along canal banks, along road sides, along railway lines, windbreaks and shelter belts planted under social forestry schemes) • Agricultural lands with trees in surround (all lands under cultivation including fallow lands which are covered with trees along bunds and in the surrounding 2 ha) • Non-forestry plantations (all lands with trees planted primarily for purposes other than forestry such as cashew, coffee, gardens, parks, zoos) However, for the purpose of estimation, plots under such land-uses are excluded from the forest inventory and included in the TOF inventory when located on private forest land.
TOF sets and subsets covered	All TOF sets and subsets are covered by the combination of these two assessments.
Comments	- Area, growing stock and canopy cover of almost all TOF sensu FAO categories are extractable. - The two tree categories assessed by FSI outside "green-washed" areas, TOF Urban and TOF Rural, are TOF sensu FAO, but these two FSI categories do not represent all TOF sensu FAO, as some TOF sensu FAO are also encountered in green-washed areas. However, the area of TOF in green-washed areas is extractable.
References	Forest Survey of India. Forest Inventory. Retrieved November 2010, from http://www.fsi.nic.in/forest_inventory.htm. Lakhchaura, P. 2010. Assessment of TOF in India. Inception workshop on TOF for FRA 2010. Rome.

Forest Cover / Tree Cover assessment	
Objective	Have an accurate and complete view of the forest/tree cover in the country and its evolution.
Institution in charge	Forest Survey of India.
Scale, duration, periodicity	Countrywide 2 years duration 2 years periodicity
Data used	Satellite data used is IRSP6- LISS-III (Multispectral 23.5 m)
Methodology	The country land cover is divided into 4 classes: "forest cover", "tree cover", "scrub cover" and "non-forest cover". - Forest Cover includes all lands located inside and outside Recorded Forests with a tree canopy cover > 10 percent and an area ≥ 1ha. This class is further subdivided into 3 sub-classes according to the density of their tree canopy cover. It is assessed only by wall-to-wall mapping and Digital Image Processing. - Scrub Cover includes all lands located mainly inside Recorded Forests with a tree canopy cover < 10 percent. It is assessed only by wall-to-wall mapping and Digital Image Processing. - Non Forest Cover includes all lands that are not included in the above classes. Its area is obtained by subtracting areas of forest cover and scrub cover from the total country area. • Tree Cover is a sub-category of "Non Forest Cover". It includes all lands located outside Recorded Forests with tree patches < 1 ha. It is assessed by using TOF data from the NFI: ◊ for rural tree patches between 0.1 and 1 ha, cover of the block and linear strata is estimated through remote sensing only for the sampled districts; ◊ for rural scattered trees and urban (UFS) blocks, cover is estimated using field-recorded crown diameter, converted to correspond to a 70 percent canopy density. Data for both components are aggregated at the district level, then at the physiographic level, and finally at the national level to give the total Tree Cover estimate for the country.
Variables related to TOF	Spatial: location and area of each cover category
Categories that may include TOF	- Forest Cover • TOF systems, such as large orchards, non-forestry tree plantations and agroforestry systems, may be found in this category (if area > 1 ha and tree cover > 10 percent). - Scrub Cover • This category may include the following TOF sensu FAO category: scattered trees (less than 5 percent cover) on land that is not under agricultural nor under urban use. - Non-Forest Cover • This category includes Tree Cover and thus includes TOF. - Tree Cover • Tree Cover may include woodlands and woodlots with an area between 0.5 and 1 ha, which fall into the Forest sensu FAO category. Otherwise, Tree Cover is exclusively made up of TOF sensu FAO.
TOF sets and subsets covered	All TOF sets and subsets are covered in this assessment
Results	In 2009, estimation of Forest Cover area was 69.09 million ha, Scrub Cover was 4.15 million ha and Non-Forest Cover was 255.5 million ha. Tree Cover area was 9.3 million ha.

Comments	TOF sensu FAO are included in all the four FSI categories of this assessment. It is impossible, in the current state of this assessment, to estimate the part represented by TOF sensu FAO in the "Forest Cover" and "Scrub Cover" categories. However, an estimate of the TOF area can be generated from the experience of states which have already digitised their forest boundaries. The "Non-Forest Cover" category includes TOF sensu FAO only in the "Tree Cover" sub-category. The "Tree Cover" category is almost exclusively made up of TOF sensu FAO. It would be relatively easy to modify this category so that it would exclusively consist of TOF sensu FAO, by distinguishing, in units with an area between 0.5 and 1 ha, those in which the land is predominantly under agricultural or urban use, from those in which the land is not predominantly under agricultural or urban use (woodlands and woodlots) which are Forest under FAO definition. This assessment does not bring in new information on TOF except integrated information on the areas occupied by the "TOF Rural" and the "TOF Urban" categories. However, in association with the National Forest Inventory, this assessment is used for national reporting to international processes such as FRA and the UNFCCC.
References	Forest Survey of India. 2010. India State of Forest Report 2009. Retrieved from http://www.fsi.nic.in/sfr_2009.htm.

This country profile was realized in collaboration with Mr. Prakash Lakhchaura, Deputy Director, Forest Inventory, Forest Survey of India, Ministry of Environment and Forests, Dehradun, India.

Morocco

Trees outside forests are an important resource for Morocco. Fruit tree crops such as Olive, Citrus, Almonds, and Date Palms are considered as an integral part of agriculture. Other TOF, such as the Argan trees in sylvopasture or sylvoarable areas are considered part of the forest lands. Three large area assessments are presented below that can provide information on TOF at national scale: the Land-use mapping under GlobCover 2008, the National Forest Inventory, and the Citrus Census 2006.

National Forest Inventory	
Objective	To provide information (maps and statistics) on wood resources per administrative unit To facilitate the design of forest policy and forest management
Institution in charge	National forest inventory (under the High Commission for Water, Forests and the Control of Desertification - Ministry in charge of Forests).
Scale, duration, periodicity	Countrywide 1990-2005 10- to 15-year cycle
Data used	- Satellites and aerial images - Topographic maps
Methodology	NFI includes two phases, both carried out in areas of forest covering more than 10 ha: Forest mapping: Forest maps (1:100 000 and 1:500 000) are issued after an interpretation of aerial photos at 1:20 000, and involves a stratification (124 strata) based on tree species, canopy cover, height and management type of the dominant species. Minimum mapping unit is 10 ha. Field survey: Based on a method called oriented random sampling, with clusters selected at random and plots (5-6 per cluster) systematically laid out in each cluster. A total of 3 635 sampling plots were established. Plots are temporary, have a circular shape and a variable size depending on the relative quantity of selected species (should contain at least 15 to 20 trees surveyed). Minimal and maximal radii are 10 m and 30 m, respectively. All trees with a DBH >7.6 cm were measured.
Variables related to TOF	Biophysical: dendrometrics (DBH, height), species
Categories that may include TOF	Argan tree formation
TOF sets and subsets covered	Trees in an agricultural context (sylvo-arable and sylvopasture systems): set 1: TOF-AGRI, Trees in low-tree cover areas: set 3: TOF-Non A/U, subsets 3 and 4.
Results	Argan tree formations cover 871 210 ha, representing 18.1 percent of the total forest area. Argan tree standing wood volume is estimated at 17 339 536 m^3, representing close to 11 percent of the total standing wood volume in Morocco.
Comments	Argan tree can be considered TOF, this species being used for different purposes (fodder, nuts) and occurring mostly on land predominantly used for agriculture (cropping and pasture). Due to the lack of information on canopy cover (cc), other TOF areas may be included in the forest strata (areas with trees and a cc of less than 5 percent, and area with a combined cover of trees and shrubs of less than 10 percent).
References	IFN. 2000. Inventaire forestier national - Rapport de synthese. Rabat-Chellah, Morocco: 42.

Citrus Census 2006	
Objective	To provide detailed information on Citrus in the framework of the Agriculture general census.
Institution in charge	Direction des programmations et des affaires économiques - Division des statistiques et de l'informatique.
Scale, duration, periodicity	Countrywide Assessment started in June 2006, lasted 6 months
Data used	- Topographical maps and aerial photos
Methodology	1. Aerial photography and mapping a. First topographical maps (1:50 000) were used to delineate the main Citrus areas in order to identify where aerial photos were needed (679 487 ha). b. An aerial photography (1:17 500) campaign was carried out. c. Orthophoto-maps were made at the scale of 1:5 000 for approximately 500 000 ha in order to delineate precisely each orchard and its plots d. Identification of the owner, citrus variety and plantation date for each plot, for reporting on the orthophoto-maps. 2. Census questionnaire, conducted by specialized interviewers in each farm, based on 2 forms: a. The Farm survey b. Plot information 3. Data processing using the CSPro (Census and survey program) and implementation of the GIS database on citrus called the SIGAG combining cadastral data, data from the survey and water resource data.
Variables related to TOF	Spatial: localization of the farm and the plot, localization of the wells Biophysical: Species, Variety, production and yield Social: Ownership, cooperatives, social data Background: irrigation, sanitary aspects, grafting, plantation prospects for 2010 and destruction program, fertilization, investments. In the plot form, technical aspects and productivity
Categories that may include TOF	All categories in this assessment include TOF (trees on land used for agriculture).
TOF sets and subsets covered	Part of set 1: TOF-AGRI
Results	A total of 12 820 citrus orchards, representing 81 550 ha.
Comments	This census was the first agricultural survey using aerial photographs as a support. Other surveys following the same methodology are expected for the other fruit crops.
References	Direction des programmations et des affaires économiques. 2007. Recensement général des Agrumes 2006. Rabat: 155 pp.

Land use mapping under Globcover 2008	
Objective	To provide a land use map compatible with international standards.
Institution in charge	Global Land Cover Network.
Scale, duration, periodicity	Countrywide
Methodology	See LCCS template sheet Land cover of Morocco was derived from the GlobCover program for Africa, using the 46 regional classes.
Variables related to TOF	Spatial: localization and area Biophysical: Land cover in 2005 Background information: Land Use
Categories that may include TOF	- Categories that contain TOF (FAO 2009) • Irrigated shrub or tree crops (class 12) • Rainfed shrub or tree crops (class 16) - Many other categories might contain TOF at least in some areas, but information is not precise enough as far as TOF are concerned.
TOF sets and subsets covered	All TOF subsets are included into the coverage of this assessment (no exclusion)
Comments	- The resolution is 300 m and minimum mapping unit is 10 ha. - Only the tree crop category can be strictly attributed to TOF; TOF in the other categories is merely speculation. - The threshold for tree cover in many classes of Globcover Africa is 15 percent cover, above the current threshold of 5 percent for TOF in land used neither for agriculture nor for settlement.
References	FAO. 2009. «Land cover of Morocco - Globcover Regional.» From http://www.fao.org/geonetwork/srv/fr/metadata.show?currTab=simple&id=37195. Mhirit, O. & Et-Tobi, M. 2002. Trees outside forests: Morocco. *In Trees outside forests - Towards a better awareness*,eds. R. Bellefontaine, S. Petit, M. Pain-Orcet, P. Deleporte and J.-G. Bertault. FAO: Rome. CAHIER FAO - CONSERVATION 35. Ministère de l'Agriculture et de la Pêche Maritime. Répartition de la superficie totale nationale. Retrieved 08/02/2011, from http://www.vulgarisation.net/sol.htm.

New Zealand

The Land Cover Database (LCDB), the Land Use and Carbon Analysis System (Lucas) and the Agricultural Production Survey (APS) are available online and may be used for getting data on Trees Outside Forests.

Land Cover DataBase 2 (LCDB2)	
Objective	To establish and maintain a consistent land cover classification of known accuracy at national level in order to provide a basis for better resource management decisions, more effective use of natural resources and improved environmental management.
Institution in charge	New Zealand Climate Change Office (Ministry for the Environment). Consultants are involved in field checking (AgriQuality), image analysis and GIS processing (Terralink International Ltd).
Scale, duration, periodicity	Countrywide LCDB2 was completed in June 2004 and lasted approximately 2 years. Advised periodicity for the updates is 5 years (LCDB1 was completed in 2000). LCDB3 is proposed to provide a LC map for 2007/08.
Data used	Landsat 7 ETM+ (from 2001/02), aerial photography and ancillary data
Methodology	The LCDB classification is harmonized with international land cover mapping initiatives (FAO/UNEP Land Cover Classification System, see LCCS description sheet). Landsat 7 ETM+ sensor is used as the primary data source to define polygons for areas with similar land cover types. Minimum Mapping Unit (MMU) is 1 ha but resolution for LCDB2 is 15 m (1 pixel = 15 m). There are 43 classes in LCDB2. The classification is hierarchical: 7 classes at the 1st level based on physiognomy of the land cover, and more detailed classes at lower levels based on phenology, flora or other characteristics. For each polygon, data are edited and aerial photography and ancillary data are acquired to complete the work. For each class, a sampling intensity is decided and followed by field checking.
Variables related to TOF	Spatial: Location and area of each Land Cover class unit Biophysical: Field notes on the signatures of land cover Other Backgrund information: Name of Territorial authorities, Name of Regional Councils
Categories that may include TOF	Categories that include TOF: - 2/ Urban Parkland / Open Space includes parks with scattered trees, playing fields, cemeteries, airports, golf courses, and river sides. - 32/ Orchards and Other Perennial Crops: Orchards and areas cultivated less than annually, and used for producing tree crops. - 60/ Minor Shelterbelts: Minor Shelterbelts are visible as linear features in the imagery. Shelterbelts longer than 150 m are mapped if 15 m (1 pixel) in width. If the signature of a shelterbelt exceeds 30 m (2 pixels) it is captured as a polygon and assigned to Class 61 – Major Shelterbelts (not TOF). Categories that may partly include TOF: - 1/ Built-up Area: includes horticultural sites dominated by structures and sealed surfaces. - 5/ Transport Infrastructure: includes artificial surfaces such as roads, railroads, airport runways where these features are discernable and exceed the 1 ha MMU. - 30/ Short-rotation Cropland: Due to MMU of 1 ha, this class may include TOF as scattered trees or small groups of trees. - 40/ High Producing Exotic Grassland: Due to MMU of 1 ha, this class may include TOF as scattered trees or small groups of trees. - 41 Low Producing Grassland: Due to MMU of 1 ha, this class may include TOF as scattered trees or small groups of trees.

	- 50 Fernland: This class includes areas of dominant ferns often associated with shrubs, such as manuka or kanuka (up to 6 m) and may thus include TOF.
TOF sets and subsets covered	All TOF sets and subsets are included in the coverage of this assessment.
Comments	- Although all TOF systems are taken into account, only three categories are fully TOF categories. Other categories that may partly include TOF are not detailed enough regarding TOF presence or absence. - Minimum mapping area is 1 ha, so all units that qualify as TOF areas but are less than 1 ha are not mapped.
References	Grüner, I. & Gapare, N. 2004. «Fieldwork Procedures used for LCDB 2.» 8. Ministry for the Environment. 2009. «The New Zealand Land Cover Database.» Retrieved December 2010, from http://www.mfe.govt.nz/issues/land/land-cover-dbase/index.html. New Zealand Climate Change Office. 2004. «New Zealand Land Cover Database 2 - User Guide.» S. T. a. Partners; 24 pp. Thompson, S., Grüner, I., et al. 2003. «Illustrated Guide to Target Classes.» *New Zealand Land Cover Database Version 2*. Auckland, Ministry for the Environment, version 4: 62.

New Zealand's Land Use and Carbon Analysis System (Lucas)	
Objective	To measure and monitor carbon stocks and stock change held in NZ's land categories and carbon pools (such as forestland, cropland, grassland and and soils).
Institution in charge	Ministry for the Environment, in partnership with Ministry of Agriculture and Forestry and other government departments
Scale, duration, periodicity	Countrywide Land-use mapping for 1990, 2008 and 2012. Planned periodicity is 5 years.
Data used	161 SPOT 5 scenes acquired in 2006–2007 and 2007–2008 (resolution: 10 m)
Methodology	LUCAS programme consists in 6 workstreams on: - Database and reporting system (on Carbon and Land-use): data used in this workstream are stored and manipulated within 3 systems: • the geospatial system, using images and land-use maps; • the gateway, with forest plot data, soil data, parameters used to validate data from imagery; • the calculation and reporting application for LULUCF Analysis and reporting. - Method development to improve imagery techniques to inventory trees; - Land-use mapping: Minimum Mapping Unit (MMU) is 1 ha and Land-Use categories are IPCC categories; - Soils; - Natural forests; - And planted forests (pre-1990 planted and post-1989 forest). Sampling design: used for forests and soils. A single grid (8 x 8 km) has been established across New Zealand to collect data on forests on permanent sample plots from NZ's National Forest Inventory. It is not detailed here because this field assessment provides no information on TOF.
Variables related to TOF	Spatial: Area, location of each Land-Use unit
Categories that may include TOF	Categories that include TOF: - Cropland – perennial : all orchards and vineyards, and linear shelterbelts associated with cropland Categories that may partly include TOF: - Grassland – with woody biomass: may include scattered tall trees, riparian vegetation, linear shelterbelts > 30 m in width, and/or erosion control plantings, scattered areas of shrubland; - Grassland – high producing: grassland with high quality pasture species mostly in intensive dairying areas (may include linear shelterbelts with width < 30 m); - Grassland – low producing: low fertility grassland (may include linear shelterbelts with width < 30 m); - Cropland – annual : includes linear shelterbelts associated with cropland; - Settlements : include recreational areas within 'settlements', and urban parklands and open spaces which do not meet the forest definition; - Wetlands – vegetated non forest : includes Scattered patches of tall tree-like vegetation to be included as wetlands and estuarine/tidal areas including mangroves.
TOF sets and subsets covered	All TOF sets and subsets are included into the coverage of this assessment.
Comments	- Although all TOF systems are taken into account, one category only is a fully TOF category. Other categories that may partly include TOF are not detailed enough as regards TOF presence or absence. - Minimum mapping area is 1 ha, so all units that qualify as TOF areas but are less than 1 ha are not mapped.

References	Ministry for the Environment. 2010a. Land Use and Carbon Analysis System (LUCAS). Retrieved December 2010. Ministry for the Environment 2008. Looking at Lucas - Data description. l.-v. nz-data-description. Wellington, New Zealand.. Ministry for the Environment 2010b. Land Use and Carbon Analysis System: Satellite Imagery Interpretation Guide for Land-use Classes. ME1024: 28. Beets, P. N., Brandon, A., et al. 2010. New Zealand. *National Forest Inventories*: 391-410.

Agricultural Production Survey 2009 (APS)	
Objective	To produce up-to-date, robust statistics on livestock and arable farming (including Livestock, Horticulture) and forestry activity in New Zealand.
Institution in charge	Statistics NZ, in partnership with the Ministry of Agriculture and Forestry (MAF).
Scale, duration, periodicity	Countrywide. Started in 2002. Annual postal survey.
Methodology	Agricultural Production Survey is a direct survey of all businesses engaged in 'agricultural production activity' (including livestock, cropping, horticulture, and forestry) or owned land that was intended for agricultural activity. The target population includes business engaged in agriculture or forestry production as a secondary activity. Since 2002, a national census is carried out every 5 years, which includes all units identified in the relevant categories (a total amount of 80 000 units). In the years between, specific surveys are carried out alternating between a 'livestock, arable, and forestry' survey and a 'horticulture-focused' survey. In 2005 and 2009 horticulture-focused surveys were held. All farms classified as horticulture and with a minimum income of NZ$ 60 000 were included in the postal survey.
Variables related to TOF	Spatial: Farm location, area of planted fruit trees, area of other horticulture crops Biophysical: Trees species and variety, age and number of trees planted, yield Background data: Farm practices and detailed land-uses on the farm
Categories that may include TOF	Horticulture: Orchards and tree crops
TOF sets and subsets covered	Part of set 1: TOF-AGRI
Results	APS 2009 on horticulture provides updated results on the area covered by the areas of main fruit tree species: Apples (9,280 ha), Avocadoes (4,120 ha) and Cherries (600 ha). The general Agriculture Production Survey 2007 includes Olives (2,173 ha).
Comments	- The estimated proportion of eligible businesses that responded to the 2009 Agricultural Production Survey on horticulture was 84 percent. - The survey focuses on only one category of TOF: tree crops. - People with income <NZ$60,000 (hobby farms) are not sampled.
References	Millar, R. 2009. «Environmental certification and the small forest grower.» F. E. L. New Zealand Farm Forestry Association, MAF; 75 pp. Ministry of Agriculture and Forestry. 2010. «National Exotic Forest Description.» Retrieved December 2010, from http://www.maf.govt.nz/mafnet/publications/nefd/. Statistics New Zealand. 2007. Area planted in outdoor fruit as at 30 June, from 1982. O. Fruit. Wellington, New Zealand, Ministry of Agriculture an Forestry. Statistics New Zealand. 2009a. «Agriculture, Horticulture, and Forestry Domain Plan 2009.» 151 pp. Statistics New Zealand. 2009b. Area planted in outdoor fruit by region. agprod-finaljun09-tables.xls. Wellington, New Zealand, Ministry of Agriculture an Forestry.

Nicaragua

Nicaragua designed, with FAO assistance, a new National Forest Inventory based on the National Forest Monitoring and Assessment methodology.

National Forest Inventory 2007-2008	
Objective	To realize a National Forest Inventory that contributes to the sustainable management and use of natural resources, improvement of uses and costs of forest activities, and improvement of the rural population's standards of living.
Institution in charge	Instituto Nacional Forestal (INAFOR).
Scale, duration, periodicity	Countrywide The NFI was implemented from October 2007 to October 2008, with a first follow-up monitoring planned for 2010-2014.
Data used	- Topographic maps at 1:50 000 and 1:5 000 scale - Cobertura forestal/Forest Cover Maps for 1981-83, 1992, and 2000
Methodology	NFI Nicaragua is based on the NFMA methodology (see NFMA description sheet) Methodology design was issued after a multi-sectoral consultation (forestry services, agricultural services, regional governments, universities, technical centers, NGO's, community leaders, etc.). A Technical Unit was then established with the following tasks: project planning and execution, inter-institutional collaboration and field implementation. Specific adaptations of the NFMA general methodology: (Instituto Nacional Forestal 2009) - Systematic sampling grid 10' x 10': 344 sampling points on land. - Sampling units : 500 m x 500 m^2. - Socio-economic interviews in sampled areas: • with government (mayors' offices) and indigenous territories authorities: on forest and non forest area local management capabilities; • with inhabitants: about land ownership, employment, reforestation, management capabilities, production activities, uses, and products derived from forests and trees.
Variables related to TOF	Spatial: plot and tree location, plot orientation, sketch map with property limits, land use/ cover sections, watercourses, hedges. Biophysical: trees assessment if DBH > 10 cm. Tree species, bole quality, health and damages (fire, hurricane), seed source potential, dendrometric characteristics (DBH, total tree height, commercial tree height), canopy cover. Socioeconomics: Land use, Land tenure status, Tree uses and products (including NTFP).
Categories that may include TOF	Other lands/ Agroforestry (level 2 National class): area over 0.5 ha, classified as other lands, with tree cover over 10 percent, with potential height of mature trees above 7 m. Level 3 classes: - Coffee under tree shadow - Cacao - Fruit crops - Silvopasture - Non-traditional crops with trees - Annual crops with trees - Orchards - Extensive pasture land with trees Other lands/ Without trees (level 2 National class): area over 0.5 ha, classified as other lands, with tree cover under: - 10 percent in agricultural or urban areas, - 5 percent in natural ecosystems. (Instituto Nacional Forestal 2008)

TOF sets and subsets covered	All TOF sets and subsets are covered.
Results	- Agroforestry land represents 2 099 127 ha, a gross wood volume of 68 444 829 m3 (32.61 m3/ha), a commercial volume of 25 580 445 m3 (3.76 m3/ha). - The dry biomass is 44 224 637 tons (21.07 T/ha) and carbon biomass is 20 788 021 tons (9.9T/ha). - Other lands Without trees represent 4 264 548 ha, a gross wood volume of 50 584 006 m3 (11.86 m3/ha), a commercial volume of 10 617 870 m3 (2.42 m3/ha). - The dry biomass is 13 821 522 tons (3.24 T/ha) and carbon biomass is 6 496 106 tons (1.52T/ha).

Comments	- No direct data on trees in:
	  - Urban areas,
	  - Linear structures,
	- Basic data for trees in urban areas and linear structures are however accessible in the original sampling forms (linear structure length and width, tree species, dendrometric data).
	- Small areas (<0.5 ha) with trees (TOF) can not be distinguished as the Minimum Mapping Unit was 0.5 ha.

References	Instituto Nacional Forestal. 2008. *Manual de campo - Inventario Nacional Forestal de Nicaragua 2007-2008*. C. R. Zea. Managua, INAFOR, MARENA, FAO, GTZ, MAGFOR. 193 pp. Instituto Nacional Forestal. 2009. Resultados del Inventario Nacional Forestal, Nicaragua, 2007-2008. FAO. Managua, INAFOR, MARENA, FAO, GTZ, MAGFOR. 232 pp.

Norway

Assessments focusing on TOF have never been carried out in Norway. Some raw data can however be extracted from the National Forest Inventory (NFI) database.

National Forest Inventory 9 (2005-2009)	
Objective	Provide data on natural resources, mainly timber resources and the environment for forest land in Norway.
Institution in charge	Norwegian Forest and Landscape Institute.
Scale, duration, periodicity	Countrywide, except the Finnmark county; however Finnmark will be surveyed during the present five-year cycle. 5-year cycle.
Data used	- Topographic maps at 1:50 000 and 1:5 000 scale. - Cobertura forestal/Forest Cover Maps for 1981-83, 1992, and 2000.
Methodology	Systematic sample plot field inventory based on a 3 km x 3 km grid, covering forest and non forest areas. NFI is based on circular permanent plots inventory (16 000 permanent sample plots, of which about 10 500 are located on productive forest and other wooded land. Re-sampling of permanent plots is based on a 5-year cycle: every year 20 percent of the permanent plots are randomly selected to be re-sampled. The survey forms the basis for forest statistics at regional and national scale. Sampling design (Eid, Brunner et al. 2010): 1. For forests (productive and non-productive), other wooded land, and other land-use classes where trees are assessed, the circular sample plot for tally trees has an area of 250 m². This plot type has been used since 1994 for measuring trees with DBH ≥ 50 mm. 2. For all permanent plots with tree assessments, data for trees with DBH < 50 mm are collected in four sub-plots of 1.3-m radius with centres located 5 m from the plot centre in directions north, east, south, and west. 3. Circular sample plots of 17.84 m radius (1 000 m²) are used to assess area-related data such as land-use class, crown cover, development class, and site-quality class. Data on land cover, land use and land use change are provided.
Variables related to TOF	Spatial : Tree location Biophysical: Stand conditions, Development class, Site quality class, Crown cover, Operating conditions and biodiversity. Trees assessment if DBH > 5 cm: number of trees sampled, tree species, dendrometric characteristics (DBH, height) Socioeconomic: Land ownership, Land use
Categories that may include TOF	Categories are based on land cover, with sub-categories based on land use (see table below): Both productive and non-productive forest land (Land cover) in urban areas and along roads (Land use). Grazing land as it may partly be covered with trees, bushes. Arable land regularly cultivated (Agricultural land) as it may partly be covered with trees, bushes. Other areas as may partly be covered with trees, bushes.
TOF sets and subsets covered	All TOF sets and subsets are covered.
Results	No results on TOF are published.
Comments	- Assesses all timber resources (growing stock) on forest and non forest areas. - Land cover and land use criteria are taken into account, so some data on TOF could probably be extracted thanks to the land use subcategories. - Permanent plots enable change estimations.

References	Statistics Norway. 2008. Forestry Statistics 2008. Official Statistics of Norway Oslo–Kongsvinger, Statistics Norway: 53 pp. Climate and Pollution agency. 2010. National Inventory Report 2010 - Norway. Greenhouse Gas Emissions 1990–2008. Oslo: 330 pp. Eid, T., A. Brunner, et al. 2010. Estimation, availability and production of tree biomass resources for energy purposes – a review of research challenges in Norway. INA fagrapport 15 Ås, Norway, Department of Ecology and Natural Resource Management , Norwegian University of Life Sciences , Oslo.

National Forest and Tree Resources Assessment (NFA) 2003-2005	
Objective	To "enhance the social, economic and environmental functions of forest and trees resources through their sustainable management on the basis of better knowledge of their qualitative and quantitative importance. The project also aims at improving contribution of these resources in the national economy."
Institution in charge	Project coordination by Forest Management Bureau (FMB) Field data collection by the Department of Environment and Natural Resources (DENR) Mapping by National Mapping and Resource Information Authority (NAMRIA)
Scale, duration, periodicity	Countrywide 3 years (2003-2005)
Data used	- Topographic map (usually 1:50 000) - Regional and provincial maps
Methodology	NFA Philippines is based on the NFMA methodology (see NFMA description sheet) Compliance with the NFMA general methodology: - Systematic sampling grid 15' x 15': 351 sampling points inventoried - Sampling units : 1 x 1 km squares - Socio-economic interviews in sampled areas to external key informants and forest users (individuals or groups)
Variables related to TOF	Spatial: plot and tree location, plot orientation, land use/cover sections Biophysical: TOF assessment if DBH > 10 cm. Tree species, timber quality, health and damages (fire), dendrometric characteristics (DBH, total tree height, commercial tree height), regeneration Socioeconomics: Land tenure status, user rights, Tree uses and products (including NTFP) Background information: Land use, Management system, Protection status, Ecological zones, silvicultural treatments & technology used
Categories that may include TOF	Other Lands (level 2 national class), Perennial crop (PCr) (level 3 national class) includes orchards, palm plantation and tree crops All the following level 3 subclasses of Other Land might also include TOF to a certain extent: - Grassland (Gl) - Marshland (Ml) - Annual crop (AC) - Pastures (Pa) - Built-up area (BUA)
TOF sets and subsets covered	All TOF sets and subsets are covered
Results	- Other Land surface is 18,423,641 ha, being 61.4 percent of the total surface of the country. - Other Land wood Gross volume (DBH ≥10 cm) is 365 030 730.40 m^3, (82.1 percent of the total volume) and Commercial volume (DBH≥ 50 cm) of 24 080 987.47m^3 (63.2 percent). - 77.1 percent of the 426 tree species recorded are found in Other Land. - Based on the perception of the respondents, grazing is the highest value service provided by TOF (in Other Land and Other Wooded land) at 12.6 percent and windbreaks (in Other Land and Other Wooded land) amount to 1 935 927 ha.

Comments	- TOF are fully taken into account as opposition to "Wooded Land", so that the whole category "Other Land" can provide information on TOF but it is not possible to make distinction between the different TOF categories. - Only very basic data is accessible in the original sampling forms (land use code and linear structures type) to suggest TOF subcategories. - No minimal size is given for the Other Land & Other Wooded Land category; so some TOF (S < 0.5 ha) might be included in Other Wooded land. - No tree cover indication is given for the Other Land category. - Small woodlots in Other Land (< 0.5 ha) can not be distinguished.
References	Forest Management Bureau, Department of Environment and Natural Resources. 2005. *National Forest and Tree Resources Assessment 2003-2005, Philippines*. Department of Environment and Natural Resources, FAO. Quezon City, Philippines.

Senegal

Two projects have been reviewed that provide information on TOF at country scale in Senegal:

- PROGEDE: the Sustainable and Participatory Energy Management Project
- Senegal Land Cover Mapping, within the West Africa programme of GLCN with Land Cover Classification System (See LCCS description sheet)

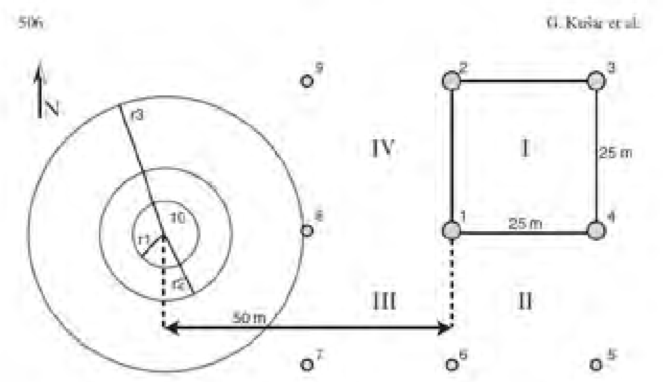
Sustainable and Participatory Energy Management Project (PROGEDE)	
Objective	To contribute to the supply of households in traditional biomass fuels (fuelwood, charcoal) in a regular and sustainable way, by preserving environment and offering choice and comfort opportunities to consumers.
Institution in charge	Ministry of Environment and Ministry of Energy from the Government of Senegal Other organizations involved: Dutch Co-operation (DGIS) and the World Bank for financial support, "Direction des Eaux et Forêts, Chasse et Conservation des Sols" and the ''Direction de l'Energie" for fieldwork (Utria, Seck et al. N.D.).
Scale, duration, periodicity	Countrywide Implemented between 1997 and 2004 PROGEDE II is planned for June 2010 to November 2016.
Data used	1 100 aerial photos covering 1 500 000 ha, country-wide satellite data (Landsat 7 ETM)
Methodology	Methodology : 1. Photo-interpretation of aerial photos and satellite images 2. Field inventory (3 levels) : a. Intervention area : 1 284 forest plots and 570 pasture plots , on 840 000 ha of forest land, in order to acquire valid information on forest potential for the management plan ; b. National level : 1 788 forest plots, covering 5 out of the 6 existing eco-geographic zones in order to estimate the timber potential for the supply management plan of the main cities; c. Follow up of the permanent plots (PSP), carried out on 57 PSP clusters (a cluster being 4 PSP), that is a total of 228 PSP (Government of Senegal, 2009) to evaluate vegetation trend at country scale. Main steps of this inventory were (Dieng, 2005): 1st: to distinguish agro-ecological units; 2nd: to stratify those units in 2 or 3 homogenous sites; 3rd: to determine for each site a number of sample units (at least 3) depending on its homogeneity and its forest cover importance; 4th: to inventory trees above 3 cm DBH on circular plots (r = 16 m) in each sample unit. On each plot, circular subplots of r = 1 m are also inventoried for trees below 3 cm DBH.
Variables related to TOF	Spatial: plot location, plot orientation, altitude and slope, distance to nearest road. Biophysical: Number of trees for diameter >3 cm, tree species, threats (fire, grazing species), dendrometric characteristics (DBH, density cover, height), regeneration, average height of trees . Background information: Land use.
Categories that may include TOF	Agricultural land Forest with low potential.
TOF sets and subsets covered	All TOF sets and subsets were included into this assessment, except set 2: TOF-URB: (trees in urban environment).
Results	PROGEDE provides no data on TOF, although a re-analysis of raw data could probably provide some information on the two categories that include or may include TOF.

Comments	PROGEDE data are still used in 2010 (FAO, 2010). For instance, FRA 2010 data for Senegal are extrapolated from PROGEDE data. Data are not easily accessible.
References	Dieng, C. 2005. «Suivi des impacts environnementaux de l'exploitation des ressources forestières dans les bassins d'approvisionnement en bois-énergie des villes sahéliennes.» *Choix d'un protocole régional de suivi écologique et environnemental sur le terrain RAPPORT DU SENEGAL*. Programme régional de promotion des énergies domestiques et alternatives au Sahel (PREDAS); 47. Dieng, C. 2008. «Le SIEF, Un Outil nouveau et une approche nouvelle pour la gestion des ressources naturelles au Sénégal.» 7. FAO. 2010. «FRA 2010 - country reporting process.» Retrieved October 14, 2010, from http://www.fao.org/forestry/62318/en/. Government of Senegal. 2009. «Pochette PROGEDE.» Ministère de l'Environnement de la Protection de la nature des Bassins de rétention et des Lacs artificiels; 12. Ministère de l'Environnement de la Protection de la nature des Bassins de rétention et des Lacs artificiels. 2009. «PROGEDE - Projet de gestion durable et participative des énergies traditionnelles et de substitution.» Retrieved 12 2010, from http://www.environnement.gouv.sn/article.php3?id_article=25. Utria, B. E., Seck, A., et al. N.D. «Senegal PROGEDE: Traditional Biomass Energy and Poverty Alleviation.» *Senegal: Sustainable and Participatory Energy Management Project (PROGEDE) - IDA/GEF/DGIS ($20 Million)*. 4.

Senegal Land Cover Mapping within West Africa programme of GLCN (with LCCS) (See LCCS description sheet)	
Objective	To set-up an accurate Land-Cover data base for Senegal.
Institution in charge	GLCN and Centre de Suivi Écologique (CSE)
Scale, duration, periodicity	Countrywide
Data used	- Landsat ETM 2005 and 1999-2001 satellite images, - aerial photos, - high resolution images available in Google Earth
Methodology	A land cover database (2005) was created, with 55 LCCS classes (171 field verifications, and 706 extra observations with GPS coordinates, a photo and a short description) (Leonardi, 2008b). The spatial resolution is 30 m and the Minimal Mapping Area is 10 ha. Then, a selection of 477 polygons randomly extracted, and assessed through GLCN's Mapping Accuracy Program (MAP). A Land cover change analysis was then performed.
Variables related to TOF	Spatial: Location and area
Categories that may include TOF	Terrestrial agriculture: - Large to Medium Tree crops - Small Tree crops - Small Rainfed Herbaceous crops with a layer of Sparse Trees - Small Rainfed Herbaceous crops with a layer of Sparse Trees – Isolated - Large to Medium Rainfed Herbaceous crops with a layer of Sparse Trees Terrestrial natural vegetation: - Closed Gallery Forest - Open Gallery Forest - Very Open Trees in Mare Environment - Open Shrubs with emergent Trees - Very Open Shrubs with emergent Trees - Closed to Open Herbaceous vegetation with Sparse Trees and Shrubs Aquatic natural vegetation: - Open Trees temporarily flooded – Gonakie Artificial surfaces: - Urban areas - Rural settlement
TOF sets and subsets covered	All TOF sets and subsets are covered
Results	A map providing information on land cover for 21 238 polygons covering 19 659 000 ha.
Comments	- Scattered trees are in classes such as "Open shrubs with emergent trees" but tree cover in these classes can be >10 percent, so it would then be counted as OWL and not TOF."Rural settlements" are non-linear, built-up areas. - The Mapping Accuracy Program is based on Google Earth high-resolution images that cover 1/3 of Senegal. This program confirmed the accuracy of the Land-Cover database.
References	Leonardi, U. 2008a. Senegal classes description. FAO, Dakar. Leonardi, U. 2008b. Senegal Land Cover Mapping. FAO Downloaded from: http://www.glcn.org/downs/prj/senegal/Sen_lc_report_dec08.pdf.

Slovenia

Two assessment projects can be used to extract TOF data in Slovenia: (i) the Forest & Forest Ecosystem Condition Survey (FECS) 2007, and (ii) the WISDOM Slovenia project.

Forest & Forest Ecosystem Condition Survey (FECS) 2007	
Objective	Ensuring essential and reliable data on forests and forest ecosystems conditions at national level, with data usable for national and international reports.
Institution in charge	Slovenia Forest Institute for the 16 km² grid (test period) and Slovenia Forest Service for the 4 km² grid
Scale, duration, periodicity	Countrywide Survey lasted from July to August 2007 Variable periodicity (1- to 10-year cycle), see below
Data used	Systematic sampling covering the whole country with a 4 x 4 km sampling grid. Satellite images, orthophotos and maps of the Actual Agriculture and Forest Land Use (MAFF 2002) are checked for dominance of forest. FECS field samples are implemented only on forest-dominated areas.
Methodology	Different grid scales and periodicities, according to expected information: - 4 km x 4 km (780 clusters): with a 5- to 10-year periodicity (last data from 2000 and actual in 2007) - 16 km x 16 km (44 clusters): every year to detect a changes - 8 km x 16 km, 8 km x 8 km: special surveys (soil, litter, forest functions) Sampling unit is a sampling cluster with (see diagram below): - 2 “M6 ” plots (4 x 4 km grid) or 4 “M6” plots (16 x 16 km grid) where only the 6 trees closest to the centre of each plot are taken into account (species, measurement); - 1 concentric permanent sampling plot (“CPSP”): tree identification and measurement only in the 3 inner circles: cpsp1 (30m²): if DBH > 0 cm and H ≥ 1.3 m, cpsp 2 (200m²) if DBH ≥ 10 cm, cpsp 3 (600 m²) if DBH ≥ 30 cm; in the outer circle (cpsp1 4: 2000 m²), site description and land use assessment. 
Variables related to TOF	In the CPSP: - Spatial: tree location. - Biophysical: site and stand spatial structure, health, tree species, status (living, dead), damages, dendrometrics (height, DBH), soils, canopy cover, regeneration. - Socioeconomic: forest functions and roles, ownership, management type. In the M6 plots: tree species, social status and damages are measured for the 6 selected trees.
Categories that may include TOF	“Forest”: according to the national definition, forests are forest tree stands > 0.25 ha and riverside forest corridors and windbreaks > 0.25 ha, if their widths are at least one tree-height (Forest Law: Official Journal of the Republic of Slovenia, nr. 30/1993 with amendments in 2007).

TOF sets and subsets covered	Part of the small woods category: set 3 TOF-Non A/U, subset 1
Comments	Data on small woodlands covering between 0.25 and 0.5 ha can probably be extracted from the raw data.
References	This country profile is based on personal communications from Mr Janez ZAFRAN (Forestry division, Republic of Slovenia) and on the following documents: Kušar, G. & P. Simončič. 2010. Slovenian forest inventory data. *JRC technical workshop on LULUCF issues under the Kyoto Protocol*. Brussels, Belgium. Kušar, G., M. Kovac, et al. 2010. Slovenia. *National Forest Inventories*. E. Tomppo et al., eds.: 21 pp.

Woodfuel Integrated Supply / Demand Overview Mapping methodology (WISDOM) in Slovenia

Objective

To acquire the knowledge base and the planning tools necessary for the formulation of a national bioenergy strategy and to contribute to the creation of the Slovenia Wood Energy Information System (SWEIS), applying the Woodfuel Integrated Supply / Demand Overview Mapping methodology (see WISDOM project sheet).

Institution in charge

Slovenian Forest Service (SFS). Assessment led within the Project, "Supply and Utilization of Bioenergy to Promote Sustainable Forest Management", TCP/SVN/2901, 2003 /2004.

Scale, duration, periodicity

Countrywide, based on a sample of 2696 Cadastral Communities (KO).
July 2003 to June 2004.

Data used

For wood-energy resource in forest-dominated areas, data are compiled from the SFS database aggregated to the KO level (see table above: Forest & Forest Ecosystem Condition Survey).

Methodology

For wood-energy resource in non-forest-dominated area, a specific survey was carried out:

phase 1: on the 2002 LU Map, systematic sampling, using the same 4 km x 4 km grid as FECS, but covering only the non-forest-dominated areas (471 sampling points) to estimate the canopy cover of woody vegetation, using available ortophotos;

phase 2: field measurement in randomly selected samples of the non forest dominated areas (227 sampling points), to relate canopy cover to woody biomass stocking and increment.

During phase 1, 10 categories of cover type, including forest types, were identified. The sampling plot size in phase 2 varied with the cover type within each land use class (see below).

Code	Cover type	Variable sampling plot size
1	Bushes and young trees (vegetation below 7 m height)	20 m x 20 m
2	Intensive orchard	30 m x 30 m
3	Extensive orchard	30 m x 30 m
4	Young forest stand (up to the pole stand)	20 m x 20 m
5	Middle-age forest stand (small to medium tree crown size)	30 m x 30 m
6	Mature forest stand (medium to large tree crown size)	40 m x 40 m
7	Individual (isolated) trees – crown area < 50 m^2 (diameter < 8 m)	-
8	Individual (isolated) trees – crown area > 50 m^2 (diameter > 8 m)	-
9	Lines of trees (e.g. roadside trees, hedges) with crown diameter < 8 m	30 m
10	Lines of trees (e.g. roadside trees, hedges) with crown diameter > 8 m	30 m

In all woody cover types, trees and bushes with a diameter ≥ 5 cm were measured.

Variables related to TOF

For the non-forest-dominated area assessment:
Spatial: location, cover type category area
Biophysical: Tree species, DBH, Height (for some individual trees)

Categories that may include TOF

Forest: tree stands between 0.25 ha and 0.5 ha

Land Use Classes considered as Non-Forest areas:

- Fields and gardens
- Orchard (Intensive , Extensive)
- Meadow (Intensive , Extensive)
- Re-growth on old farmland
- Mixed use (Agric/Forestry)
- Urban and built up areas, roads.

TOF sets and subsets covered	All TOF sets and subsets are covered.
Results	The standing volume in non-forest areas (including meadows, abandoned agriculture, agroforestry, urban areas, orchards, etc.) amounts to some 11.5 million m^3, with an estimated annual increment of some 400 000 m^3. From this resource, approximately 300 000 m^3 are believed to be used as fuel every year" (FAO, 2006). For comparison, the same report estimates the annual woodfuel extracted from forests at 1 million m^3.
Comments	- Good overview of the total area, crown cover, stocking volume and increment in various TOF categories, but estimations are rough due to low sampling intensity. - Seems replicable in other countries, not only for fuelwood assessment purposes but for non–forest biomass in general. - Need for a preexisting data on land use and land cover. - The study could be realized in a short time (1 year) thanks to a relatively small country area, preexisting data on forests (representing approximately 60 percent of the country area) and preexisting good land use/land cover mapping system.
References	FAO. 2006. WISDOM – Slovenia. R. Drigo and Ž. Veseli. Rome: 69.

Sweden

The three following projects contribute information on Trees Outside Forests in Sweden:

- National inventory of Landscapes in Sweden (NILS)
- Swedish National Forest Inventory (NFI)
- A Survey of Urban Forestry in Sweden

National inventory of Landscapes in Sweden (NILS)	
Objective	To provide national-level data and perform analyses of landscape biodiversity conditions and changes in terrestrial environments in Sweden. To measure the occurrence of different landscape elements such as solitary trees.
Institution in charge	Swedish University of Agricultural Sciences (SLU)
Scale, duration, periodicity	Countrywide Planned periodicity: 5 years First cycle began in 2003 and ended in 2007. Second cycle began in 2008
Data used	infrared aerial photos
Methodology	Various partner institutions were involved (Universities, Swedish Environmental Protection Agency, Swedish Board of Agriculture, National Heritage Board, etc.) The National Inventory of Landscape in Sweden (NILS) has been developed building upon the Corine Land Cover (CLC) Program, the Landscape inventory and monitoring (LIM), the Swedish National Forest Inventory and other approaches. the country was divided into 10 geographical strata, and 631 (5 x 5 km) sampling units were selected following a random-systematic pattern with stratum-dependent densities. NILS focuses on all terrestrial land cover types: alpine areas, forest, mires and peatlands, coastal areas, agriculture-dominated areas and populated areas. General aerial photo interpretation is conducted within all sampling units. The 1 x 1 km central square in each sampling unit is mapped by detailed colour infrared (CIR) aerial photo interpretation (resolution is 0.5 m and minimum mapping unit is 0.1 ha). If located in land with growing crops, in water, in built-up areas, or areas that are not physically or legally available, plots are not visited. Otherwise, field-inventories are carried out in the central square in 12 permanent sample plots at a distance of 250 m from each other, and along 12 lines (each 200 m long) with line-intercept sampling for linear structures. Each sample plot consists of several concentric circular plots of different radius (20 m, 10 m, 3.5 m and 0.28 m). About 120 (1 km x 1 km) squares all over Sweden's land base are assessed each year by field crews of 2 persons (from late May to September). The number of crews varies between years (8 to 13) depending on planning and logistics, and on the load of supplementary inventory on top of the original NILS-inventory.
Variables related to TOF	356 variables are assessed (269 in the field and 87 in aerial photo interpretation) and selected to be useful for a posteriori classifications such as the European Environment Agency EUNIS habitat type classification, the Biohab approach, and the LCCS classification. Spatial: plot location, site description Biophysical: Number of trees > 10 cm on plots with r=10 m and < 10 cm on plots with r=3.5 m, vertical structure of the Tree layer (no trees, scattered trees, one-layered tree stand, 2-layered tree stand), Shrub layer, Tree canopy cover, Tree species, Habitat type, dendrometric characteristics (DBH, tree height), tree aggregation pattern, grazing impact, Proportion of Dead trees, etc.

Categories that may include TOF	The extremely detailed land-use/land-cover classification allows the grouping of all TOF objects into more general TOF categories. For instance, the 'trees on land predominantly used for agriculture' category is made up of the following NILS classes: - Fruit orchard cultivation - Grazing - Enclosure for reindeer - Berry bush cultivation - Other cultivation - Vegetation strips - Broadly crowned solitary tree - Biotope islets with trees and shrubs - Mound of stones/boulder/bedrock outcrop with trees and shrubs - Ponds with trees and shrubs - Wetlands in agricultural land with trees and shrubs
TOF sets and subsets covered	All TOF sets and subsets are covered
Results	- Provides national statistics for conditions and changes (natural or anthropogenic) on land cover, land use and landscapes for all terrestrial habitats. - Provides a detailed Land-use/land-cover map for the central 1 km x 1 km central square plot.
Comments	- Field inventory provided by NILS developed a specific classification that is compatible with other classifications such as LCCS. - Adjustments of the classification are continuously made to improve the data without compromising the variables and variable groups. - Aerial photo interpretation's method is still under development. - Aerial photo interpretation phase is very accurate: even if results provided by NILS may not seem to focus on all TOF categories, information provided in NILS manual for photo interpretation shows that land cover and land use classifications used are detailed enough to extract information on areas for special TOF categories, such as: agricultural built-up areas, parks, golf courses, camping sites, fruit orchard cultivations, etc.. - Data is used by other surveys, including Swedish Bird Survey, a climate change monitoring project. - Other inventory is integrated with or supplemented with the NILS inventory, including a specific assessment of grasslands and pastures where also fauna are recorded, patch habitats in agricultural landscapes, and Natura 2000 habitats, according to the species and habitats directive.
References	Allard, A., Nilsson, B., et al. 2003. «Manual for Aerial Photo Interpretation in the National Inventory of Landscapes in Sweden.» 81 pp. Esseen, P.-A., Glimskär, A., et al. 2007. «Field Instruction for the National Inventory of the Landscape in Sweden.» 239 pp. Ståhl, G., Allard, A., et al. 2010. National Inventory of Landscapes in Sweden (NILS)—scope, design, and experiences from *establishing a multiscale biodiversity monitoring system*. Environmental Monitoring Assessment: 17 pp. Swedish University of Agricultural Sciences. 2003. National Inventory of Landscapes in Sweden. NaturVårdsVerket Swedish Environmental Protection Agency. Wikströms, Sweden 4 pp.

National Forest Inventory in Sweden (NFI)	
Objective	To describe the state and changes in Sweden's forests.
Institution in charge	Swedish University of Agricultural Sciences (SLU)
Scale, duration, periodicity	Countrywide Annually (the Swedish NFI uses running 5-year mean values, where the interval of re-measurement of permanent plots is 5 years).
Methodology	There are both temporary and permanent tracts, laid out on both forest and non-forest lands. Permanent tracts are laid out on a systematic grid (with varying sizes of meshes and measurements depending on type of tract and region assessed: trees are callipered on all classes except Alpine areas, Urban land and water); temporary tracts are selected at random. Tracts are square or rectangular in shape. They are approximately 7,000 in Sweden (1/3 are temporary and 2/3 are permanent). Each tract is made up of 4 to 12 circular plots (r=7 to 10 m) spread around the cluster. There are 2 sorts of plots: plots (r= 7–10 m) for which tree counts are conducted if H > 1.3 m, and plots for which only stump counts (if stump diameter is > 5 cm) are conducted.
Variables related to TOF	Spatial: Plot location, tree location. Biophysical: Tree species, type of forest, Number of trees, Mean diameter, dendrometric characteristics (DBH, tree height, stem volume), vegetation cover, maturity class, age, site quality, dead wood, nesting holes and woodpeckers traces, stand structure. Socioeconomic: Ownership category. Background information: Forestry management, land use.
Categories that may include TOF	Other Land (definitions of "Forest", "OWL" and "Other Land" are the same as FAO definitions); the following subcategories may include TOF: - agriculture land; - road/railroad; - alpine areas; - urban land.
TOF sets and subsets covered	All TOF sets and subsets are covered except set 2: TOF-URB (trees in a urban context).
Results on TOF	- Area, volume and potential wood production estimates. - NFI is used for reporting to all major international processes, such as UNCCC: Greenhouse gas emissions and biomass.
Comments	- National Forest Inventory is only available in Swedish, except the information provided online. - Data on TOF may be extractable for all TOF categories.
References	Axelsson, A.-L., Ståhl, G., et al. 2010. Sweden. *National forest Inventories - Pathways for Common Reporting. E. G. Tomppo, Th.; Lawrence, M.; McRoberts, R.E., Springer: 555-565* (11). Swedish University of Agricultural Sciences. 2010. «Swedish National Forest Inventory.» from http://www.slu.se/en/collaborative-centres-and-projects/swedish-national-forest-inventory/inventory-design/.

A Survey of Urban Forestry in Sweden	
Objective	Provide a picture of the state of the management of publicly owned street and park trees in Sweden.
Institution in charge	Myercough College (Britain's national centre for education and training in arboriculture and urban forestry)
Scale, duration, periodicity	Countrywide Assessed once in 2006
Data used	National census of 2004 (from Sweden Statistics)
Methodology	(Based on Trees In Town II methodology) - The 107 towns and cities >10,000 inhabitants are assessed. - Postal questionnaires are sent to each local authorities to get factual data on urban tree resource. - The 39 questions are related to urban trees: staff involved, budgets, inventories, planning and management. - Statistical analyses complete the gathering of data.
Variables related to TOF	Spatial: location of the city assessed, town size class, area of the city. Biophysical: type of urban trees (street or park), number of street trees, number of park trees, percent of urban area with a tree cover. Socioeconomic: none. Background data: maintenance cost per tree in 2004 on various actions (planting, felling), frequency of inspections of trees.
Categories that may include TOF	Street and park trees
TOF sets and subsets covered	Part of set 2: TOF-URB: trees in urban areas - excluded: private gardens
Results	Response rate is 58 percent (62 local authorities out of 107); 73 percent of the respondents were responsible for street, park and woodland trees, 13 percent were only responsible for park trees, and 2 percent only for street trees in public domain (12 percent did not answer this question) On average, 51.53 percent of the urban area has trees, and average tree cover in urban areas is 9.67 percent.
Comments	- Methodology of this survey is close to the one used in Trees In Town II (See Trees In Town description sheet).
References	Saretok, L. 2006. A Survey of Urban Forestry in Sweden. Billsborough, U.K., Myerscough College, 170 pp.

Note: This Sweden TOF assessment profile was completed with personal communications from Mr Jonas FRIDMAN, Head of the Swedish National Forest Inventory, Swedish University of Agricultural Sciences (SLU), jonas.fridman@srh.slu.se ; Mr Karl DUVEMO, Swedish Forest Agency, karl.duvemo@skogsstyrelsen.se ; and Dr Johan SVENSSON, Director of the National Inventory of Landscapes in Sweden, Swedish University of Agricultural Sciences (SLU), Faculty of Forest Sciences, johan.svensson@slu.se.

United Kingdom

Surveys on trees in the United Kingdom are conducted by four institutions:

- Forestry Commission is responsible for the National Inventory of Woodlands and Trees,
- Department for Communities and Local Government manages the Trees in Town program,
- Department of Agriculture and Rural Development inventories fruit trees and orchard trees,
- The Centre for Ecology and Hydrology is in charge of the Countryside Survey (not treated here, see "Inventory of Linear Tree Formations" profile sheet).

These four projects provide information on most of Trees Outside Forests in the United Kingdom.

Survey of Small Woodland and Trees (integrated into the National Inventory of Woodlands and Trees)	
Objective	To realize a national inventory of forest and tree resources for areas up to 2.0 ha.
Institution in charge	Forestry Commission: the Woodland Surveys Branch of Forest Research is responsible for the inventory. Other partners, such as the Macaulay Land Use Research Institute, are involved in the different counties and regions of GB.
Scale, duration, periodicity	Territory-wide (GB only: England, Wales, Scotland) Planned periodicity for sampling is 5 years
Data used	Aerial photographs at 1:25 000 scale
Methodology	Land area is divided into a 1 km x 1 km grid, with 2 strata (inland and coastal land), and 1 km^2 sample plots are randomly selected to represent 1 percent of the inland area and 1 percent of the coastal area. Feature types are identified in each sample plot. For field data collection, each sample plot is divided in 16 (250 m x 250 m) subplots and 2 subplots are randomly selected (field sampling on 2 382 plots (Wright, 1998).
Variables related to TOF	Spatial: location, area covered by each feature. Biophysical: Spatial structure (upper, lower, shrub, field and ground layers), Forest type, Tree species, Number of trees per group, Dead trees (proportion of deadwood over 15 cm), health and damages, Natural regeneration, dendrometric characteristics (DBH, tree height, commercial tree height), Underwood species. Socioeconomic: Land tenure status. Background information: Thinning history.
Categories that may include TOF	All feature types used: - "Small wood" (woodland > 0.1 and <2 ha); - "Groups" (group of 2 or more trees with an area < 0.1 ha); - "Linear feature": feature with a length of 25 m or more, and at least four times as long as it is broad. It can be up to 50 m wide or as narrow as a single line of trees. Two types are recognised: Narrow Linear Features (with a width of 16 m or less); and Wide Linear Features (with a width greater than 16 m); - "Individual trees" (at least 2 m tall).
TOF sets and subsets covered	- Small Stands, < 0.5 ha (set 3: TOF-Non A/U, subset 1). - Narrow Linear Formations, < 20 m width (set 3: TOF-Non A/U, subset 2). - Patches > 0.5 ha, with low tree cover (set 3: TOF-Non A/U, subsets 3 and 4).
Results	- Woodlands from 0.10 to 0.25 ha represents a total woodland area of 13 419 ha (0.5 percent of the total GB woodland area and 0.05 percent of total GB land area). - Woodland from 0.25 to 2 ha (including TOF sensu FAO up to 0.5 ha) represents a total woodland area of 107 075 ha (4.0 percent of the total GB woodland area and 0.47 percent of total GB land area). Total TOF woodland area in GB thus stands between 0.05 and 0.52 percent of total GB land area, while total woodland area is estimated to 11.6 percent of the total GB land area.

Comments	- Exact data on the extent of the woodland TOF sensu FAO covered by this assessment may be extracted from the original data set: "Woodland size" being recorded, data on woodlands under 0.5 ha are extractable. - Orchards and urban woodland are excluded. - Not implemented in Northern Ireland.
References	Forestry Commission. 2003. *National Inventory of Woodland and Trees Great Britain*. Edinburgh, Scotland, Forestry Commission: 68 pp. Wright, D. 1998. The National Inventory of Woodland and Trees, information note. F. Commission, Forestry Practice: 8 pp.

Trees in Towns II	
Objective	To provide up-to-date information on England urban tree stock and urban tree management and recommend good practice.
Institution in charge	Department for Communities and Local Government Various interested parties involved in this project included the Office of the Deputy Prime Minister, research contractors, arboriculture organizations, colleges, the national urban forestry unit, associations, and the Forestry Commission. A Project Advisory Group (PAG) gathered regularly to provide support and advice to the project, gathering representatives of the arboricultural industry and local government organisations. Especially, PAG helped to set up the Local Authority questionnaire.
Scale, duration, periodicity	Territory-wide (England only) Commissioned in 2004, results published in 2008
Data used	Aerial photographs (1:25 000 - 1:10 000 and some with a 25 cm resolution)
Methodology	TT II is structured into 3 distinct but interrelated phases: - Strand 1: A national tree survey, with aerial photos and field sampling. - Strand 2: A survey of Local Authorities (LA), through questionnaires, which aims at providing an insight into and identify good and innovative practices in urban tree management by Local Authorities (including all County, Metropolitan, London Borough, Unitary, and District Councils in England, Transport for London, Parish and Town Councils). - The integration of Strands 1 and 2 using statistics. Sampling design: - Strand 1: National tree survey • Three levels of stratification: 9 regions, 3 town sizes (3-10,000; 10-80,000; over 80 000 population), land-use type (6 classes or "groupings": low, medium and high-density residential, town centre/commercial, industrial, open space; and sub-categories, e.g. for "open spaces": (1) Formal and informal open space (parks, gardens and informal amenity land), (2) Institutional open space (school and hospital grounds, cemeteries and crematoria), (3) Derelict, vacant and neglected land, (4) Areas of enclosed remnant countryside (low input agriculture, pony grazing, etc.). Land Class Types were initially identified from 1:25 000 and 1:10 000 scale mapping and aerial photography. • 147 towns and cities were surveyed: originally the plan was to look at 15 towns per region, with 5 from each town category (small, medium and large), plus 10 London Boroughs. Target towns were randomly selected from each of the Government regions and town size classes, and the survey plots were selected through an on-screen analysis of both aerial photography and digital mapping. • A total amount of 590 plots surveyed on the ground (up to 4 plots of 4 ha for each land use type in each town), measuring 200 m x 200 m. At least one plot per land use type was supposed to be sampled in each town, but not all of the six land use types were present in sufficiently large and uniform areas to allow even one survey plot to be identified in some towns. A sampling tool was developed (within ArcView) to randomly generate up to four 4-ha sample squares per land class polygon. • Aerial photographs (at a resolution of 25 cm) on 1 783 plots were also used to measure the extent of tree canopy cover. • Data were recorded on every clearly visible tree or group of trees and all visible shrubs >2.5 m tall. - Strand 2: Local Authorities survey • A detailed questionnaire sent to all local authorities in England: 389 in total, of which 258 were returned (66 percent). The questionnaires were sent to the LA officers in charge of the management of the LA's publicly-owned tree resource. The content of the questionnaire developed in consultation with the Project Advisory Group included seven sections dealing mainly with strategies, programmes, legal aspects and management of urban trees.

Variables related to TOF	Spatial: location, area Biophysical: Land cover, Tree species and variety/form, age, maturity, condition, dendrometric characteristics (DBH, tree height, crown spread, canopy cover). Socioeconomic: Land use, contribution to urban environment, visual contribution, density of inhabitants in the area, tree ownership status, management and the uses and values of urban trees. Background information: Thinning history.
Categories that may include TOF	All categories of the assessment are part of the Urban TOF sensu FAO category: "Trees on land that is predominantly under urban use", whatever the size and shape of the stands.
TOF sets and subsets covered	Trees in urban areas (set 2: TOF-URB)
Results	- Distribution of trees in species groups and in classes of: diameter, height, crown spread, age, maturity, etc. - Tree density per city/town and per land-use category. Average density of urban trees and shrubs is 58.4 trees/ha, but densities ranged widely from 1 tree/ha to 886 tree/ha. Town size had no effect on tree density. A total number of 137 863 trees were recorded out of the 2 360 ha of urban areas inventoried.
Comments	- All trees in urban areas are considered, even in private property (mainly in gardens) or less accessible public land (e.g. schools, churchyards, allotments, etc.). - Cost to the Department was £296 683 (approx US$470 000 in total and US$800 per plot), which may hinder the replicability of such study in other countries. - Through comparison with TT I, results of TT II provided data on changes.
References	Britt, C. & Johnston, M. 2008a. Trees in Town II, A new survey of urban trees in England and their condition and management. Queen's Printer and Controller of Her Majesty's Stationery Office; Research for Amenity Trees no. 9: 647. Britt, C. & Johnston, M. 2008b. Trees in Town II, A new survey of urban trees in England and their condition and management - Executive Summary. Queen's Printer and Controller of Her Majesty's Stationery Office; Research for Amenity Trees no.9. 36 pp. CLG. 2004. Project: Trees in Town (2). CLG Research Database Communities and Local Government. Retrieved December 2010 from http://www.rmd.communities.gov.uk/project.asp?intProjectID=11590. CLG. 2008. «Planning, building and the environment.» Communities and Local Government. Retrieved December 2010 from http://www.communities.gov.uk/publications/planningandbuilding/treesintownsii.

Fruit and orchard survey	
Objective	To have statistics on the fruit tree cover and its evolution at country level.
Institution in charge	Economics and statistics Division of the Department of Agriculture and Rural Development (DARD) for Northern Ireland Department for Environment, Food and Rural Affairs (DEFRA) for England and Wales
Scale, duration, periodicity	Territory-wide (England, Wales, Northern Ireland) Assessment based on a 5-year cycle. Last survey published on March 2010
Methodology	Questionnaires sent to all growers having commercial orchards > 1 ha: - 580 responded in England and Wales (response rate of 72 percent) (National Statistics 2010) - 204 responded in Northern Ireland (Economics and Statistics Division of the Department of Agriculture and Rural Development 2002)
Variables related to TOF	Orchard area, Tree species, Fruit varieties, Productions
Categories that may include TOF	All categories in this assessment are TOF categories (orchards > 1 ha).
TOF sets and subsets covered	Trees on agriculture land (set 1: TOF-AGRI, partly covered)
Results	Total fruit orchard area for the UK is estimated as 24 000 ha (orchards > 1 ha). Results of the Orchard Fruit Survey 2009 dealt only with England and Wales, where the fruit orchard area (excluding orchards < 1 ha) is estimated at 16 788 ha.
Comments	- Orchards covering less than 1 ha are not taken into account. - Data resulting from this assessment may constitute a lower estimation of the Other Land with Tree Cover (OLwTC) FRA category as all orchards covered by this assessment are included into OLwTC. - Other small surveys provide data on orchards at the region scale (i.e. The Forth Valley Orchard Regeneration Initiative).
References	Department for Environment Food and Rural Affairs, Department of Agriculture and Rural Development (Northern Ireland), et al. 2009. Chapter 3: The Structure of the Industry. Agriculture in the United Kingdom 2009. 3: 146. Economics and Statistics Division of the Department of Agriculture and Rural Development. 2002. *Survey of Orchard Fruit Production in Northern Ireland: Results for 2002*. Northern Ireland, Department of Agriculture and Rural Development. National Statistics. 2010. Survey of Orchard Fruit - October 2009 - England & Wales Department for Environment Food and Rural Affairs. 4 pp.

This UK TOF assessment profile was completed with personal communications from Mr Mark Johnston, Research Fellow on Arboriculture and Urban Forestry at Myerscough College, and Mr Simon Gillam, Head of Economics and Statistics at Forestry Commission.

Uruguay

Two main sources can provide information on TOF at country scale in Uruguay: the first National Forest Inventory, and the General Agriculture Census.

First National Forest Inventory	
Objective	To contribute to sustainable forest management, thanks to a continuous forest resources monitoring and assessment of biophysical, ecological, economical, social aspects of all forests. To assess forest cover change using remote sensing; to assess the wood volume and the conservation status of forests using field sampling. To involve public and private institutions related to forest resources in the project process and to improve the technical capacity for a Permanent Monitoring System of forest resources.
Institution in charge	Dirección General Forestal (MGAP). Field data collection was subcontracted but supervised by DGF.
Scale, duration, periodicity	Countrywide Started in 2008, preliminary results of the first assessment have been published in August 2010. Continuous over a 5-year cycle for the planted forest and 10-year cycle for native forest.
Methodology	2 phases: Forest Map (Phase) Based on the 2006 forest map, stratification was done using Landsat-5 TM images. This new forest map is divided in 8 strata: 1.Native Forest; 2. Eucalyptus grandis, saligna, dunnii ; 3. Eucalyptus globulus ssp.globulus, ssp. maidenii, ssp. bicostata ; 4.Eucalyptus other species ; 5. Pinus ; 6. Salicaceas ;7. Atlantic coastal Forest; 8. Mixed native and planted forest. An actualization of the Forest map will be done this year (2012). 1. Sampling grid of 1.9 km x 1.9 km covering the whole country. 2. Watershed with the most representative forests were selected. 3. Within each selected watershed, a sampling point was assigned at the centre of each square, as long as the point fell on a forest area (sensu NFI). If the sampling point fell in a non forest area, then it was discarded. 4 769 permanent sampling plots (1PSP/361 ha approx) were then established countrywide. Field sampling (Phase) So far, out of the 4 769 PSP, 1 242 PSP have been sampled in the first year of inventory (392 on native forests and 850 on planted forest), representing an area of forest inventoried of about 450 000 ha (26 percent of the country). Sampling plot design: - Sampling plots on planted forest are concentric circles, where different measurements are taken: 113 m^2 (6 m), all trees with a height above 1.30 m are considered 314 m^2 (10 m), all trees with a diameter above 10 cm are considered 616 m^2 (14 m), all trees with a diameter above 25 cm are considered 1.018 m^2 (18 m), all trees with a diameter above 35 cm are considered - Sampling plots on native forest have a rectangular shape, 20 m x 10 m (200 m^2), oriented perpendicular to major physical features.
Variables related to TOF	Different variables are taken for planted and native forest, but for both the following variables are collected: Spatial: Localization; surface area estimated from satellite images, topographical situation exposition, slope. Biophysical: station quality, tree density, dendrometrics (DBH, height),growth, regeneration, treatments, vegetation, sanitary aspects. Socioeconomical: ownership. Background information: characteristics and vocation of the production.

Categories that may include TOF	Planted Forest subclasses: - Windbreaks and "Service Forest", if less than 20 m width or less than 0.5 ha - Agroforestry and sylvopasture systems
TOF sets and subsets covered	All TOF sets and subsets are covered except trees in urban context (set 2: TOF-URB)
Results	- Planted forest in Uruguay cover an estimated area of 969 500 ha, representing 56 percent of all national forests (1 721 658 ha). - - 53 percent of the PSP made on planted forests could be considered as TOF areas because the predominant use of the land was "agriculture". Primary land uses in the PSP made on planted forests were: - 47 percent: forestry use - 28 percent: agroforestry use - 18 percent: pastoral use - 3 percent: agricultural use - 2 percent: agro-pastoral use - 1 percent: sylvo-agricultural use and - 1 percent: sylvo-pastoral use
Comments	- Since land use is provided, all land-use types involving human activities can be distinguished and evaluated separately. - No minimal width is set for linear structures, but they could probably be extracted (windbreaks and "Service Forest").
References	This assessment profile is based on personal communications from Mr. Ricardo D. Echeverría (Dirección General Forestal-MGAP, Montevideo, Uruguay) and on the following documents: Dirección General Forestal MGAP & FAO. 2010. Monitoreo de los Recursos Forestales - Inventario Forestal Nacional - Resumen de Resultados. R. D. Echeverría: 32 pp. Echeverría, R. 2008a. Inventario Forestal Nacional - Prueba Metodológica - Cuenca Río Negro, Subcuenca Río Tacuarembó Montevideo, Uruguay.

General Census of Agriculture 2000- Censo General Agropecuario	
Objective	To provide basic data on the structure of the farming sector, at different levels: national, departmental and enumeration area. (The enumeration area is the smallest territorial division within departments. There are 637 enumeration areas in the country.) To update the sampling frame for continuous or occasional surveys in the farming sector. To provide a baseline for the improvement of the farming sector statistics, and contribute to the consolidation of an Integrated Farming Statistical System.
Institution in charge	Dirección de Estadísticas Agropecuarias DIEA (MGAP)
Scale, duration, periodicity	Countrywide Data collection 08/2000 - 11/2000 10-year cycle, next one in 2011
Methodology	- This census is a complete enumeration and survey of all farms of more than 1 ha. No sampling has been done. - A census map that corresponds as much as possible to other population censuses was first developed in collaboration with the National Institute of Statistics (INE). The geo-statistical units were defined using the digital geographical database (Primera Base de Datos Geográfica Digital, or BDGD), which provided geographical limits, transportation axes, etc. The 2000 census map was at 1:200 000 scale while the 2010 map is at 1:50 000 scale. A field survey was then carried out in all farms > 1 ha. The survey consisted in field visits and interviews based on questionnaire forms, including the following TOF related sections: - Farm area as of 30 June, 2000: • Planted and Natural Forest • Fruit trees and Vineyards • Land use - Household composition and labour force - Source of income (from farm activities) Farm and farmer main characteristics (e.g. gender, age, education) All individual data on areas come from the questionnaire and are then totaled.
Variables related to TOF	Spatial: area, location Biophysical: irrigation, tree density Socioeconomics: Labour and social parameters, income, production, yield
Categories that may include TOF	All Fruit tree crops: - Citrus - Fruit trees with deciduous leaves: Apples, Pears, Peaches, Prunes, Nectarines and Quince
TOF sets and subsets covered	Part of set 1: TOF-AGRI (trees on agricultural land)
Results	- Citrus cover 21 659 ha, representing 0.1 percent of the operated surface (being the total surface of all farms censused). - Other Fruit trees cover 10 490 ha, representing less than 0.1 percent of the operated surface (being the total surface of all farms censused).
Comments	- A web page provides interactive maps and information on the results. The census is regularly complemented by more specific surveys (livestock, plant production, and fishery). Within the crop section, citrus, tree crops and forest are assessed by specific censuses. Citrus surveys and Fruit tree surveys are carried out on a yearly basis. - Small farms < 1 ha encountered during the census were not surveyed but were recorded on the field forms. They represent a very low number and a small area. - Windbreaks are included in the cultivated land surface declaration (for farms > 1 ha). - Another census, in 2011, was designed following the new FAO recommendations for the decennial World Agricultural Census.

References	This assessment profile is based on personal communications from M. Alfredo Hernández (DIEA Director, Montevideo, Uruguay) and on the following documents: Abayian, A. 2008. Definición de áreas geográficas en los censos de población y vivienda. Santiago, Chile. Dirección de Estadísticas Agropecuarias. 2000. Censo Agropecuario 2000. From http://www.mgap.gub.uy/portal/hgxpp001.aspx?7,5,296,O,S,0,MNU;E;28;5;MNU;,.

The United States of America

Four large-area surveys provide information on TOF in the United States of America:

- The Forest Inventory and Analysis National Program (FIA),
- The Natural Resources Inventory (NRI) program,
- The Inventory of Trees in Non-forest Areas in the Great Plains States,
- The "Forest on the Edge project": an assessment of urban trees.

Forest Inventory and Analysis National Program (FIA)	
Objective	To provide the information needed to assess America's forests and project how forests are likely to appear 10 to 50 years from now (USDA Forest Service, 2010)
Institution in charge	USDA Forest Service
Scale, duration, periodicity	Countrywide Annual survey based on a 5-year cycle in the eastern U.S. and 10-year cycle in the West. Last national report was published in 2007.
Data used	Satellite imagery ranging from 1-m USDA NAIP imagery to Landsat at 30-m and MODIS at 250-m resolution.
Methodology	Forest Inventory and Analysis, previously known as Forest Survey, is a statistically based, systematic random sample. It has evolved to address diverse topics such as forest health, carbon storage, wildlife habitat, air pollution, and invasive plants. Spacing at the field plot level is one plot every 5 km (McRoberts et al, 2010). It uses a double-sampling design including a preliminary stratification phase, and two phases of sampling: 1. Remote sensing phase aims at stratifying forest areas in roughly homogeneous strata. 2. The second phase begins with setting sample locations. FIA applies a nationally consistent sampling protocol using a quasi-systematic design covering all ownerships in the entire country. This sampling design is based on a tessellation of hexagons, each hexagon representing approximately 2 403 ha. The base federal sample consists of one sample in a randomly selected location in each hexagon. High resolution aerial imagery is then used to check that the sample qualifies as "forest": an area that is occupied by trees with at least 10 percent canopy cover, and that meets minimum area (0.4 ha) and width (36.6 m) requirements (Liknes at al. 2010). Tree-covered areas in agricultural production and in urban settings are not considered forest land (Smith et al. 2009). If the sample qualifies as forest, a 0.4 ha permanent plot is established for field measurements and observations. 3. The third phase consists in a subset of plots from Phase 2. Additional measurements on phase 3 plots relate to forest ecosystem function, condition and health.
Variables related to TOF	Spatial: plot location Biophysical: Phase 2 samples: Forest type, Number of trees, Dead trees, Regeneration status, dendrometric characteristics (for trees > 12.7 cm DBH), species composition Stand age, Disturbance, Plant association, Ground cover, Stand size class. Phase 3 samples: crown condition, soil erosion potential, soil fertility and/or toxicity, lichens, ozone bioindicators, vegetation structure, and down woody material. Socioeconomic: Ownership status Background information: Present land use, treatments and thinning history
Categories that may include TOF	All categories may potentially include TOF in the form of smallwoods, between 0.4 ha (the minimal threshold size for a forest in FIA assessment) and 0.5 ha (the minimum threshold size for a forest by FAO-FRA definition).

TOF sets and subsets covered	Part of set 3: TOF-Non A/U, subset 1 (the Small woods subset)
Results	These areas include windbreaks, shelterbelts, other agricultural land and farmsteads with trees, and riparian wooded strips. There are also another 1 million ash trees in the urban areas of South Dakota.
Comments	The list of research applications using FIA data is growing as more scientists become familiar with the program. For instance, a study carried out in a few counties of Maryland concluded that 30 - 50 percent of the FIA non-forest samples contained trees and were located in urban, suburban, industrial, and rural areas (Riemann, 2003). Another example is the "Working Tree" study (Perry et al., 2008) that assessed the woody resources in 11 Midwestern states, suggesting that substantial areas of working trees (which mostly qualify as TOF) are not inventoried because of the focus of FIA on "forest". Recently, Liknes et al. (2010), using various satellite image datasets concluded that satellite-derived estimates of tree cover area (including non-forest lands) differed from FIA estimates (including only forest land) by as much as 200 000 ha in both North Dakota and South Dakota.
References	Liknes, G.C., Perry, C.H., & Meneguzzo, D.M. 2010. *Assessing tree cover in Agricultural Landscapes Using High-Resolution Aerial Imagery*, Journal of Terrestrial Observation: 2(1): Article 5. Available at: http://docs.lib.purdue.edu/jto/vol2/iss1/art5 McRoberts, R.E., Hansen, M.H. and Smith, W.B. 2010. United States of America (USA). *National Forest Inventories - Pathways for Common Reporting*,eds. E. G. Tomppo, Th.; Lawrence, M.; McRoberts, R.E., Springer: 567-581 (15). Perry, C. H., Woodall, C. W.,Liknes G.C. & Schoeneberger, M.M. 2009. Filling the gap: improving estimates of working tree resources in agricultural landscapes. *Agroforestry Systems* 75 (1): 91-101. Riemann, R. 2003. *Pilot Inventory of FIA plots traditionally called «nonforest»*. Newton Square, PA, US Dept. of Agriculture, Forest Service, Northeastern Research Station. Smith, W. Brad, tech. coord.; Miles, Patrick D., data coord.; Perry, Charles H., map coord.; Pugh, Scott A., Data CD coord. 2009. *Forest Resources of the United States, 2007*. Gen. Tech. Rep. WO-78. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 336 pp. USDA Forest Service. 2010. «Forest Inventory and Analysis National Program.» Retrieved January 2011 from http://www.fia.fs.fed.us/.

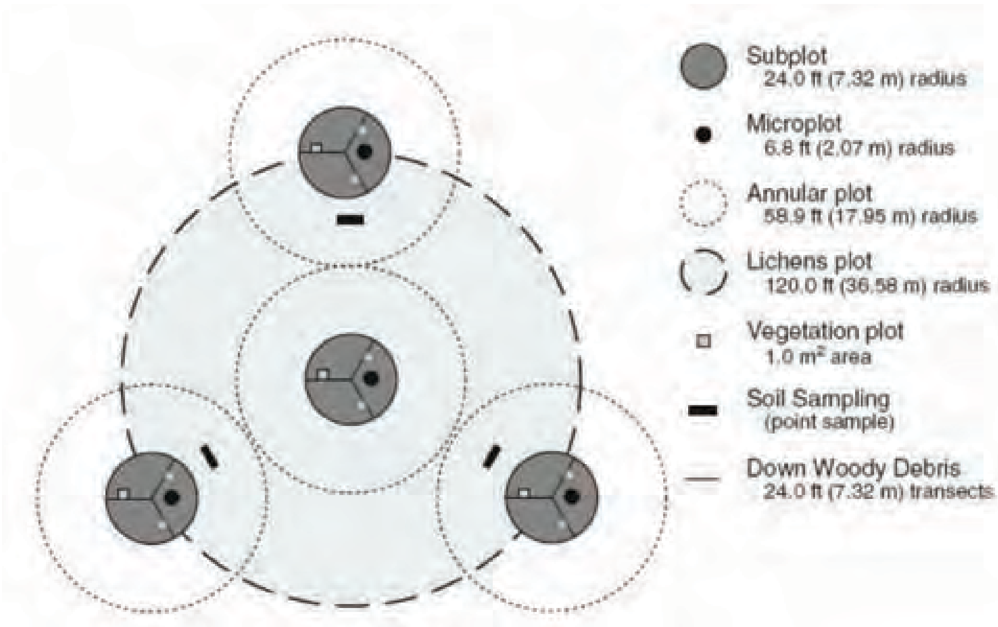
<table>
<tr><th colspan="2">National Resources Inventory (NRI)</th></tr>
<tr><td>Objective</td><td>To assess conditions and trends for soil, water, and related natural resources (including trees and land use) on non-federal lands in the United States.</td></tr>
<tr><td>Institution in charge</td><td>Natural Resources Conservation Service (NRCS) of U.S. Department of Agriculture
In collaboration with Iowa State University's Center for Survey Statistics and Methodology (ISU-CSSM)</td></tr>
<tr><td>Scale, duration, periodicity</td><td>Countrywide
5-year cycle
Last NRI (2007) was released in 2010</td></tr>
<tr><td>Data used</td><td>High resolution remote-sensing images</td></tr>
<tr><td>Methodology</td><td>NRI is a statistically based sample of land use, natural resource conditions and trends on U.S. non-federal lands. Non-federal lands include privately owned lands, tribal and trust lands, and lands controlled by state and local governments and represent about 75 percent of the total land area in the USA.

(1) Geospatial technologies and remote sensing, to monitor natural resource conditions and trends, based on the collection of data using photo interpretation for an annually observed core sample of 42 000 "primary sampling units" (PSUs) and a rotating sample (31 000 PSUs) each year.
(2) Inventory on sample points and segments (see below)
(3) Statistical analysis and production of national and state estimates (Farmland Information Center, 2010)

Sampling design (USDA, 2009):
The basic design of NRI surveys is a stratified, two-stage area sample that can be modified for specific national survey objectives and used as a frame for special studies.

(1) In the first stage of sampling, a county (standard-sized county is a square ~38.6 km on a side) is divided in equal size townships. A township is split into 3 strata (3.2 x 9.6 km), which are further divided up into "segments". A "segment", also called "Primary Sampling Unit" or PSU, is an area of land (typically square to rectangular) that is usually 64.7 ha in size. Its size is based on the shape, size, and complexity of the resources being inventoried (Figures 1 and 2).

An approximate 4 percent sampling rate is obtained by selecting 2 PSUs within each stratum.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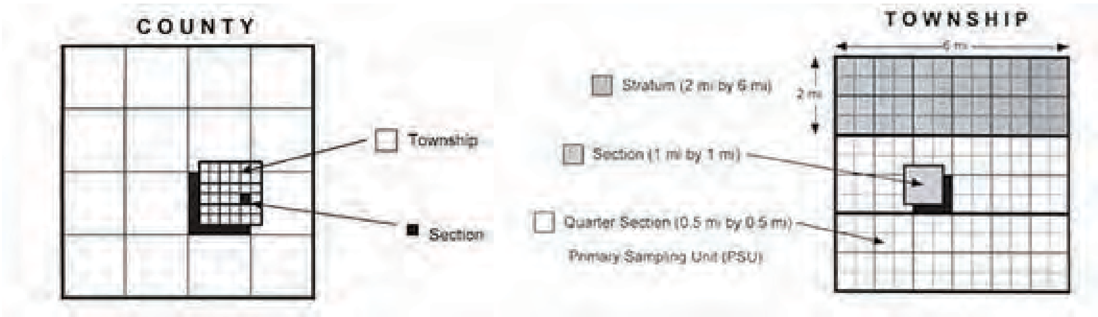


(2) The second stage of sampling consists in choosing randomly three sample points within each PSU. Some data are collected for the entire segment, while others are collected at the segment sample points.
Sampling rates across the US generally range from 2 to 6 percent of the land area: NRI sample contains approximately 300 000 sample segments for 800 000 sample points.

Variables related to TOF	Spatial: plot location, surfaces inventoried Biophysical: Land cover, Tree canopy cover Background information: ownership, land use, agricultural history, irrigation practices, conservation practices, regional natural resource classifications
Categories that may include TOF	Two main classes: "Developed land" and "Rural land". Both may contain TOF: 1. Developed Lands: These are areas of intensive anthropogenic use. Much of the land is covered by structures and impervious surfaces (to identify which lands have been permanently removed from the rural land base). It is further divided into 3 categories, each containing TOF in part of their area: - Large tracts of urban and built-up land; - Small tracts of built-up land (< 4 ha); - Land in a rural transportation corridor. 2. Rural Lands: further divided into 6 categories based on land cover/use criteria. They all may include TOF in part of the area they cover: - Cropland - CRP (Conservation Reserve Program) Land - Pastureland - Rangeland - Forest land - Other rural land
TOF sets and subsets covered	All TOF sets and subsets are covered.
Results	Data on TOF may be extractable for some categories, but only through a re-analysis of raw image data.
Comments	A special study focused on Rangelands. It included a field inventory of trees (USDA, 2004).
References	Farmland Information Center. 2010. «2007 National Resources Inventory: Changes in Land Cover/Use.» ennifer Dempsey; Northampton, MA: American Farmland Trust; FIC Fact Sheet and Technical Memo; 4 pp. Perry, C. H., Woodall, C. W., and Schoeneberger M.M. 2005. Inventoring Trees in Agricultural Landscapes : Towards an Accounting of Working Trees. 9th N.Am. Agroforestry Conference, Rochester, Minnesota. USDA. 2004. National Resources Inventory Rangeland Field Study—Introduction. National Resources Inventory Rangeland Field Study. Chapter 1: 3. USDA. 2009. «Summary Report: 2007 National Resources Inventory.» Natural Resources Conservation Service (NRCS) and Center for Survey Statistics and Methodology; Iowa State University, Ames, Iowa. 123 pp.

Inventory of Trees in Non forest Areas in the Great Plains States	
Objective	To characterize the tree resource in non-forest areas (and supplement FIA inventory), to develop and conduct statistically valid regional inventories of rural agroforests and urban and community forests.
Institution in charge	National Inventory and Monitoring Applications Center (NIMAC) , US Forest Service NIMAC partnered with state co-operators from various sectors (Higher Education, municipalities, Farmers associations, etc.) to implement this study.
Scale, duration, periodicity	Region-wide (the Plains States = North Dakota, South Dakota, Nebraska, and Kansas) Set up once in 2008, 2 years long
Data used	FIA's field inventory methodology and RS analysis with Landsat 30 x 30 m (1 pixel).
Methodology	Great Plains are approximately 97 percent non-forest, and consist mostly of agricultural and grassland vegetation communities. This inventory of non forested areas is the first phase of the Great Plains Tree and Forest Invasives Initiative (GPI). It includes rural and urban lands NIMAC extended traditional FIA plot and sample design methodology to the Plains States Non Forest Trees inventory. It is a stratified, two-phase sample design. Per pixel, land cover category, percent impervious surface, and percent canopy cover are estimated. Then: (1) Step 1 consists in stratifying the four-state area into two strata (canopy and no canopy using a derivative of the National Land Cover Dataset (NLCD) (2) Step 2 is the first phase of the two-phase sample. It consists in selecting elements within each stratum. Photo-interpretation plots (PI plots) from the FIA were used. (points covering the whole national territory). Each PI plot consists in 21 uniformly spaced points (within a circle of 674 m^2). The land use of each of the 21 points is assessed (using FIA classification and field data) and the count of points falling in the Non Forest Trees (NFT) land use category is recorded for each PI plot. For economical reasons a sampling intensity of 18 000 PI plots/State was predetermined. The number of PI plots with Non Forest Trees in each stratum was counted, allowing to find out the representative quantity of PI plots per stratum. (3) Step 3 is the second phase of sampling. A subsample of the PI plots was selected randomly in a spatially balanced manner for field inventory. For each PI plot, three substratum classes were assigned depending on the number of NFT land-use points (n/21). No ground plots were sampled in the first substratum of each stratum (the substrata with no NFT "points").
Variables related to TOF	Spatial: location of tree resource Biophysical: Tree species, Number of trees, dendrometric characteristics (DBH for trees > 2.54 cm, tree height), health (percentage of canopy dieback), function (e.g. windbreaks, shelterbelts, wildlife areas, narrow riparian tree belts). Socioeconomic: Land use.
Categories that may include TOF	All trees outside forests are assessed, but there is no attempt to categorize the trees.
TOF sets and subsets covered	All TOF sets and subsets are covered by this assessment.

Results	As an example of the kind of results: In South Dakota, Ash tree is the fifth most abundant forest land tree species, with an estimated 21 million ash trees (2.5 cm diameter or greater). But the measurement plots in non-forested land show that the greatest percentage of the ash resource (28 million trees) is in rural, non-forested areas. These areas include windbreaks, shelterbelts, other agricultural land and farmsteads with trees, and riparian wooded strips. There are also another 1 million ash trees in the urban areas of South Dakota.
Comments	Built on the statistically valid FIA sample set, the adopted sampling design is a trade-off between a desire for compatibility with FIA methodology and cost effectiveness in the field.
References	Josiah, S. 2008. Great Plains Tree & Forest Invasives Initiative. National S&PF Leadership Team, US Forest Service, Charlotte, NC, USA. Lister, A., Scott, C. & Rasmussen, S. 2008. Inventory of trees in nonforest areas in the Great Plains States. Forest Inventory and Analysis (FIA) Symposium, Park City, UT, USA. Piva, R. J., Lister, A. J., & Haugan D. 2009. «South Dakota's forest resources, 2007.» (Research Note NRS-32), U.S. Department of Agriculture, Forest Service, Northern Research Station; 4 pp. Western Forestry Leadership Coalition. 2009. Great Plains Tree and Forest Invasives Initiative. A multi-state cooperative effort for education, mitigation and utilization, U.S. Forest Service: 2 pp.

“Sustaining America’s Urban Trees and Forests” study: an assessment of urban trees and forests	
Objective	To assess the cover of Urban Trees in the USA by: - providing an overview of the current status and benefits of America’s urban forests, - comparing differences in urban forest canopy cover among regions, - discussing challenges facing urban forests and their implications for urban forest management.
Institution in charge	Forest Service of the U.S. Department of Agriculture
Scale, duration, periodicity	Countrywide (except Alaska and Hawaii that provided incomplete data) First report in 2010
Data used	- National Land Cover Database (NLCD) estimates of 2007 based on Landsat satellite imagery from 2001 (resolution is 30 m) - U.S. Census Bureau data for delimitation of urban areas and population data - Satellite images (Google Earth) - High resolution Aerial photo (at 1 m)
Methodology	This assessment is part of The Forests on the Edge project that aims at increasing public understanding of the contributions of and pressures on US forests, and at creating new tools for strategic planning. The main results (on Urban Tree Cover and Tree Canopy Cover) are provided at county scale and then gathered to provide results at a National scale. Two main variables were assessed, using different methods: 1. Tree canopy cover at county scale was directly extracted from NLCD. Tree canopy cover per capita was calculated as tree canopy cover (m^2) divided by the county population. 2. The National Urban Tree Cover estimate. Because NLCD tends to underestimate tree cover, tree cover in urban areas was photo-interpreted using imagery from Google Earth. A total number of 9 436 points, randomly located in urban areas over the whole country, were photo-interpreted in relation to tree cover. Urban tree cover was calculated as the percentage of total points that fell upon tree canopies and then, urban tree cover within each state was weighted by total urban land in the state to calculate national urban tree cover.
Variables related to TOF	Spatial: location of tree resource (Western Forestry Leadership Coalition, 2009) Biophysical: Tree canopy cover, density of trees Background information: Land use
Categories that may include TOF	The assessment covered all urban trees. But there was no further categorization.
TOF sets and subsets covered	Trees in urban areas, set 2: TOF-URB
Results	- Maps on the percent of urban areas per county, urban canopy cover per person, etc. - A little more than 3 percent of the conterminous USA was classified as “urban”. This small percentage of land supports 79 percent of the population, or more than 220 million people. - Average tree cover in urban areas of the conterminous USA was estimated at 35 percent. - Nationally, urban forests in the United States are estimated to contain about 3.8 billion trees, with an estimated structural asset value of US$2.4 trillion.
Comments	- Provides important qualitative results in addition to tree cover data - Provides no data on most biophysical aspects such as species composition and volumetric data.
References	Nowak, D.J., Stein, S.M., et al. 2010. «Sustaining America’s Urban Trees and Forests.» *A Forests on the Edge report*, NRS-62: 28.

Zambia

Many forest inventories and wood resources assessment programs were carried out at different levels in Zambia. The national assessment reported here is the first comprehensive Land use assessment; it is based on the ILUA/NFMA (National Forest Assessment and Monitoring System) project.

Integrated Land Use Assessment 2005-2008	
Objective	To assess forestry and other related resources and land use practices. To provide up-to-date qualitative and quantitative information on the state, use, management and trends of these resources (FAO 2005; FAO and Zambia Forest Department 2008).
Institution in charge	Zambia Forestry Department (MTENR)
Scale, duration, periodicity	Countrywide 3 years (2005-2008) ILUA II, a 4-year project, was launched in 2010. Its main purpose is to support implementation of Sustainable Forest Management (SFM) and REDD (FAO 2010).
Data used	Field measurements, observations and local interviews
Methodology	ILUA is based on the FAO National Forest Assessment and Monitoring System (NFMA) methodology (see NFMA description sheet), with in-depth analysis and policy dialogue. Sampling: - Systematic sampling grid (30' x 30' equivalent to 50 x 50 km) leading to 248 plot clusters called "tracts" or "sampling units" of which only 221 were accessible and finally inventoried. - The sampling scheme followed the NFMA methodology: 1 km² tracts with 4 field plots (250 m x 20 m) and sub-plots specific to forest measurements. Mapping: - The Land Use/Land Cover Map was done by the Survey Department of the Ministry of Lands, using Landsat 5TM and ETM+ donated by the Global Land Cover Network. The interpretation was done at a 1:50 000 scale with a minimum mapping unit of 30 m (for linear structures) and followed the FAO FRA categories of Land Use. (FAO and Zambia Forest Department 2008)
Variables related to TOF	Spatial: Plot location, tree location, plot orientation and sketch Biophysical: Tree number and species, for the trees outside forests with DBH ≥ 7 cm: tree measurements (DBH, Height, health, quality, damages), Tree canopy cover Socioeconomic: Land use (LU Section), land ownership, products and services (including NWFP) Background information: land management
Categories that may include TOF	TOF can be found within some of the subcategories of Other Land: - Natural: • Grassland • Marshland - Managed • Perennial Crop • Pasture • Fallow (H < 5 m) - Built-up area • Rural
TOF sets and subsets covered	All TOF sets and subsets are covered by this assessment (no exclusion)

Results	- A Land Use/Land Cover map was done. - 21 percent (15 771 081 ha) of the country surface is classified as Other land representing 3 percent of the growing stock (97 Millions of m^3)(FAO and Zambia Forest Department 2008)
Comments	- Since ILUA followed the FAO classification recommendations, information on TOF can be easily gathered. - Urban areas being relatively small, no sampling units fell on urban LU, and this category was not sampled. With the denser sampling scheme of ILUA II, urban trees may be better assessed. - Since there is no minimal area limit for the Other Land, there is no way of extracting information for woodlots with Forest or OWL characteristics but smaller than 0.5ha.
References	FAO. 2005. *Integrated Land Use Assessment - Zambia - Field Manual*. 5th Edition. M. Saket, D. Altrell, P. Vuorinenet al. Rome, Italy, FAO: 98. FAO. 2010. FRA 2010 - country reporting process. Retrieved October 14, 2010, from http://www.fao.org/forestry/62318/en/. FAO & Zambia Forest Department. 2008. *Integrated Land Use Assessment 2005-2008*. Republic of Zambia. J. Mukhosha and A. Siampale. Rome, Italy.

Narrow tree linear formations assessments: Examples in France, Italy and the UK

Hedgerows, scattered trees, and shelterbelts play an important role for biodiversity. For Europe, these elements are part of the new environmental aspects of European Common Agricultural Policy (Guillerme, Alet et al. 2009)

In most European countries, tree lines forming hedgerows are found in pasture areas. Since the 1960s, a large part of these linear structures have disappeared but recent environmental problems highlighted the benefits provided by such tree lines and new policies now support their planting and maintenance. The majority of research in the last 2 or 3 decades concerns western France and Britain, even though hedgerows have been recognised as important in other countries such as Belgium, Germany, Italy, Poland and Switzerland. Outside Europe, studies are scarce but exist in Africa, China, the USA, Canada, Ecuador or Bolivia (Baudry, Bunce et al. 2000). Unfortunately, these researches are mostly based on qualitative analysis or provide results only at a local scale.
This profile sheet presents three examples of national assessments of tree linear formations. These examples all use remote-sensing derived datasets and field sampling. They show that different sampling strategies can be implemented for assessing the same TOF category:

- France: a national inventory of linear tree formations, based on the sampling of transects intercepting hedgerows;
- Italy: a national inventory of linear tree formations, based on a stratified 3-phase sampling;
- The United Kingdom: a national survey of linear tree formations, based on a random sampling of permanent plots in the framework of a systematic grid.

France: "Inventaire des Formations linéaires arborées"(Inventory of Linear Tree formations)	
Objective	To provide up-to-date information on national tree stock outside forests within the linear formations.
Institution in charge	The National Forest Inventory (IFN), in partnership with regional forestry services
Scale, duration, periodicity	Countrywide Periodicity for sampling is 10 year
Data used	Aerial photographs and satellite images with a 50 cm resolution: BD ortho® (RGE), produced by the National Geography Institute (IGN).
Methodology	For IFN, a linear tree formation ("Formation Linéaire Arborée", FLA) consists of trees with a potential height >1.3 m, forming a line > 25 m length with no gap > 10 m and a width <20 m. In practice IFN distinguishes 3 types: - tree line ("alignement"): made up of at least 4 trees, with a regular diameter of trees and a regular space between the trees, - wooded corridor ("cordon boisé"): a line of trees and/or shrubs with 80 percent of the biomass not concentrated on 2 m width, - hedgerow ("haie"): line of trees and/or shrubs irregularly spaced, of various species, heights and diameters, with a concentration of 80 percent of the biomass on less than 2 m width. The inventory is structured into 2 main interrelated phases. The amount and location of FLA are determined in phase 1, through photo-interpretation for tree lines and in phase 2 through field assessment for the 2 other types. Biophysical, managerial and other variables are recorded in phase 2 through a field inventory: - Phase 1: Remote-sensing analysis • The country land area is divided into a 1x1 km grid. • On each 1 km square, a "main point" is randomly selected within the square for inventory. • a 1-km long transect, centred on the "main point" is established and oriented randomly within each square, • In non-forest areas, tree lines intersected by the transect are counted and measured. • Each year, 10 percent of the "main points" are sampled this way.

Methodology	- Phase 2: Field Inventory • A sub-sample of the FLA, intercepted by the transect is inventoried to get detailed data on species, volumes, density. • Sample plots are 50 m long (whenever possible: 25 m on each side of the "interception point") and follow the axis of the FLA (even when this axis is not straight). • Tree lines in densely urbanised areas and tree lines made up of cultivated species are excluded from this inventory.
Variables related to TOF	Spatial: GIS geo-reference of every tree or group of trees, proximity to river or road, banks or stonewall. Biophysical: type, width and length of the FLA, dead trees, tree species, abundance per species, tree cover, dimension category of trees (small, medium, large, very large), dendrometric characteristics for one tree per dimension category (total height, commercial height, tree crown shape, stem shape, DBH, dead branches, diameter class). Background data: Land-use, maintenance (use of chemicals, thinning, etc).
Categories that may include TOF	The three main FLA categories (Tree line, Forest String and Hedgerow) are all TOF categories.
TOF sets and subsets covered	Narrow Linear formations (set 3 TOF-Non A/U, subset 2)
Results	Some results are available at sub-national scale. Results at national scale are planned to be available soon.
Comments	An IFN field team of 2 persons inventories between 3-4 and 6-8 intersection plots per day. A very large number of variables are measured or estimated (Inventaire Forestier National, 2010), which raises the question of the cost efficiency of the assessment, and the question of how this enormous amount of accumulated data can be efficiently analysed and used…
References	Baudry, J., Bunce, R. G. H., et al. 2000. Hedgerows: An international perspective on their origin, function and management. *Journal of Environmental Management*(60): 7-22. Bélouard, T., Vidal, C., et al. 2005. *Le nouvel inventaire forestier de l'IFN - Un sondage systématique et annuel*. De l'observation des écosystèmes forestiers à l'information sur lla forêt, Paris. Guillerme, S., Alet, B. et al. 2009. L'arbre hors forêt en France. Diversité, usages et perspectives. *Revue Forestière Française* 61: 543-560. IFN. 2010. *La forêt française - Pour bien comprendre les résultats publiés*. Nogent-sur-Vernisson, France. Inventaire Forestier National. N.D. Les haies et les alignements d'arbres. 50-51 (2). Inventaire Forestier National 2009a. Inventaires des haies et nouveau protocole. *Rapport d'activités 2008 de l'Inventaire forestier national*: 16 (1). Inventaire Forestier National. 2009b. La Carte des haies de Vendée, IFN; Région Pays de la Loire; FRCPL. 4. pp Inventaire Forestier National. 2010. Les Formations linéaires arborées. *Campagne d'inventaire 2009*: 173-214 (42).

Italy: The assessment of hedgerows and woodlots	
Objective	To assess the importance of narrow linear tree formations and small woods at national scale, in the framework of the National Forest Inventory.
Institution in charge	The Forest and Range Management Research Institute (ISAFA), known as the Forest Monitoring and Planning Research Unit of the Agriculture Research Council (CRA-MPF).
Scale, duration, periodicity	Countrywide The first Italian NFI was carried out between 1983 and 1986. The second NFI (INFC), was implemented in 2002 and its results were published in 2007.
Data used	Digital ortho-photos
Methodology	INFC used the FAO definitions of forest, other wooded land, etc. "Small woods" and "linear tree formations" considered in this inventory thus respectively correspond to TOF set 3 (TOF NonA/U), subset 1 - small wood < 0.5 ha, and subset 2 - narrow linear formation < 20 m width (De Natale, Chincarini et al. 2011). The INFC used a one phase design with photo-interpretation of unaligned systematically distributed photopoints. The country was divided into a 1 km x 1 km grid made up of approximately 301 000 cells. In each cell, a sampling point was set randomly (unaligned systematic sampling), which was associated to a 150 m x 150 m sampling plot. The two TOF subsets were present in 4 521 sampling plots. At sub-national level, in one administrative region (Veneto province) a field inventory was also carried out, to set-up and test a sampling protocol for linear tree formations: 105 sampling plots were selected randomly among the photo-interpretation sampling units intercepting linear tree formations associated with agricultural landscape and water courses. Two different sample plots were used, a 15 m x 5 m plot to measure tree attributes and a smaller inner 10 m x 1.25 m sub-plot for floristic surveys.
Variables related to TOF	Photo-interpretation: surrounding land-use, width, length, size, distance from forest, closeness to other hedgerows or woodlots. Field survey: stand structure, dendrometric characteristics, deadwood, and vegetation composition.
Categories that may include TOF	The two categories considered in this inventory, small woods and linear tree formations, are specific TOF categories.
TOF sets and subsets covered	- Set 3 (TOF NonA/U), subset 1 (0.1ha≤small wood < 0.5 ha) - Set 3 (TOF NonA/U), subset 2 (3m width≤narrow linear formation < 20m width).
Results	- The combined area covered by small wood and linear tree formation is estimated to 452 000 ha, or 1.5 percent of the country area. For comparison, the percentage of forested area (Forest + Other Wooded Land) is 34.7 percent. - 299 500 ha are covered by linear tree formations; 152 600 ha are covered by smallwoods. - Most small woods and linear tree formations are located in agriculture dominated landscapes (82 percent of the total area). - The field survey in Veneto allowed, inter alia, to estimate the mean crown cover for linear tree formations at 82.1 percent.
Comments	This inventory shows that, in countries where NFI covers both forest and non-forest land, it is possible to build up on the framework of the NFI and integrate the two TOF subsets -"small woods" and "Narrow Linear Features"- in the photo-interpretation phase to provide reliable estimates of these two subsets at relatively low cost.
References	De Natale, F., Chincarini, M., Gasparini P, Morelli S., Paletto A. & Tosi, V. 2011. The assessment of hedgerows and woodlots in Italy. Agricultural Research Council; 9. Gasparini, P., Tosi, V. & Di Cosmo L. 2010. Italy. In *National forest Inventories - Pathways for Common Reporting*, eds. E. G. Tomppo, T. Geschwantner, M. Lawrence, & R.E. McRoberts. Heidelberg, Germany. Springer. Chapter 19: 311-331.

The United Kingdom: the Countryside Survey	
Objective	To gather information on natural resources and identify trends in changes in the UK countryside at a countrywide level, across England, Scotland and Wales. To provide data on woody linear features such as tree lines or hedgerows.
Institution in charge	Countryside Survey team, part of the Centre for Ecology and Hydrology (CEH) The 2007 Countryside Survey represented a partnership of nine government funded bodies led by the Natural Environment Research Council (NERC) and the Department for Environment, Food and Rural Affairs (DEFRA). It also involved the support and advice of many dedicated individuals from these and other organisations (farmers, scientists, landowners).
Scale, duration, periodicity	Countrywide (England, Wales, Scotland, Northern Ireland) Assessment based on an approx 8-year long cycle. Last survey published in 2008
Methodology	The first Countryside Survey (CS) was realised in 1978. The CS has developed and expanded every time it was carried out, in 1984, 1990, 1998 and 2007 (at intervals of about 8 years). Countryside Survey (CS) is made up of two main independent parts: 1. The Field Survey focuses on habitats, vegetation, soils and freshwater. CS includes all lands except urban lands (Scott, 2008). CS 2007 results were released in 2008 and only part of the inventoried data is related to TOF, the "Linear Features Category", which includes the following categories: • "Hedges": line of woody vegetation that has been subject to management so that trees no longer take their natural shape. Hedges may be present with any feature below. These are also known as 'managed' hedgerows, • "Lines of trees/shrubs and relict hedge and fence": line of trees or shrubs, in which trees/shrubs take their natural shape, including those originally planted as hedges with a fence. • "Lines of trees/shrubs and relict hedge": line of trees or shrubs, in which trees/shrubs take their natural shape, including those originally planted as hedges. Includes avenues of trees. May also include banks/grass strips. CS Field Survey data comprises information collected from a stratified random sample of squares at the intersection of a 15-km grid covering Great Britain (Scott, 2008). For CS 2007, the sample consisted of a set of 591 (1 km x 1 km) 'sample squares', randomly selected from this grid within the various Land Classes representing the variations in the climate and geology of England, Scotland and Wales. The individual squares are chosen so that they represent all major habitat types in the UK and enough squares are selected for each type to make sure that the statistical analysis for that habitat is robust and reliable (Countryside Survey, 2010). A similar approach was used within the Northern Ireland Countryside Survey (NICS), based on 288 squares, 0.5 km x 0.5 km (Scott, 2008). Within each sample square, woody species in linear tree formations were inventoried on up to 10 plots of 1 m x 30 m for each of the following habitats: hedgerows, roads and tracks, streams, ditches and riversides. woody species of hedgerows. 2. The Land Cover Map – intended to be published in 2011 – uses satellite data to form a digital map of the different types of land and vegetation across the UK. The classification process is carried out by 'training' a computer to recognize certain values of ground surfaces and vegetation types in the satellite data and assign them to a Land Cover type, equivalent to one of the UK's Broad Habitats (Countryside Survey, 2010). The CS uses the "Broad Habitat Classification" developed as a part of the UK Biodiversity Action Plan and containing classes including TOF. CS also identifies "Priority Habitats" as the ones at risk, and "Hedgerows" is one of them. The two surveys are undertaken separately but the results are brought together where possible in the CS report for the UK.

Variables related to TOF	Spatial: plot location, area covered by each feature, length and position of the linear feature (GIS) Biophysical: Vegetation type (belt of scrubs or trees), Species, Cover, absence of non-native species, Dead trees, dendrometric characteristics (total height, height of the base of the hedge canopy, average DBH, Crown shape - natural or managed), health and vigor condition, Line of stumps, Gaps between trees Background data: Land use, maintenance, management evidence
Categories that may include TOF	In the Field Survey: - Linear features / Hedges - Linear feature / Lines of trees/shrubs and relict hedge and fence - Linear feature / Lines of trees/shrubs and relict hedge In the Land Cover Map: - Agricultural crop / Orchard - Wide linear feature - Structures / Agricultural cartilage, Allotments, Car-park, Garden Centre/nursery Garden/ grounds with or without trees, or Public open space - Recreation / Camp site, Golf course, Other playing fields, or School playing fields
TOF sets and subsets covered	By the Field Survey: - - Narrow linear tree formations : set 3 (TOF Non A/U), subset 12 By the Land Cover Map: - All TOF sets and subsets except "Trees on land under a predominantly urban use" (set 2: TOF-URB)
Results	- The data collected enables estimates of estimates of the stock of hedgerows in kilometers for 2007 and estimates of change in stock between 1998 and 2007; - Trends give a clear signal that the vegetation of linear features became taller, more shaded and less diverse, reinforcing a long-term trend over the period 1978 to 2007. The length of 'managed' hedges decreased by 6 percent in Great Britain between 1998 and 2007, and there were corresponding increases in the length of remnant and relict hedges and in the length of lines of trees. This finding suggests a reduction in the management and maintenance of some hedgerows (Scott 2008), - There were on average 3.7 woody species per 30-m section of hedge in Great Britain in 2007, with no detectable change between 1998 and 2007,
Comments	Information from CS 2007 will be used to update a range of biodiversity indicators, including: UK BAP Priority Habitats, Plant Diversity (specifically open habitats, woodlands and boundary habitats), Ecological Impacts of Air Pollution (specifically areas affected by acidity and nitrogen), Invasive Species, and River Quality (biological and chemical).
References	Barr, C.J. & Gillespie, M.K. 2000. Estimating hedgerow length and pattern characteristics in Great Britain using Countryside Survey data. *Journal of Environmental Management* 60: 23-32. Carey, P.D., Wallis, S., et al. 2009. *Countryside Survey: UK Results from 2007*. Bailrigg, GB, Centre for Ecology and Hydrology. Countryside Survey. 2010. Measuring change in our countryside. Retrieved January 2011, from http://www.countrysidesurvey.org.uk. Maskell, L.C., Norton, L.R., et al. 2008. CS Technical Report No.1/07 - Field Mapping Handbook. *Countryside Survey, Annex 5*. Centre for Ecology and Hydrology. 143 pp. Scott, W.A. 2008. CS Technical Report No.4/07 - Statistical Report. Countryside Survey, Annex 5. Centre for Ecology and Hydrology. 15 pp. Tansey, K., Chambers, I., et al. 2009. Object-oriented classification of very high resolution airborne imagery for the extraction of hedgerows and field margin cover in agricultural areas. *Applied Geography* 29: 145-157.

2. Support Programmes Profiles

Land Degradation Assessment in Drylands (LADA)

LADA is being implemented by United Nations Environment Programme (UNEP) and executed by FAO with the support of partners

Purpose:

To assess the causes and impacts of land degradation at global, national and local scales in order to detect hot spots and identify remedial measures.

Historical background:

LADA is a 4-year long project providing data on land degradation that started in 2006. It is based on WOCAT (World Overview of Conservation Approaches and Technologies) classification, which is another project providing global database on Sustainable Land Management (SLM).

LADA and WOCAT's aims and missions are complementary.

Methodology:

LADA follows a participatory, decentralized, country-driven and integrated approach. It makes ample use of participatory rural appraisals, expert assessment, field measurements, remote sensing, GIS, modelling and other modern means of data generation, networking and communication technologies for sharing of information at national and international levels.

Methods and indicators have been selected and adapted for use across the main land use/ecosystems in dryland areas. The assessment addresses a number of different elements (soil, vegetation, water resources, agriculture and socio-economic assessment) and requires synthesis, analysis and output production in addition to data collection.

At a national scale, LADA is implemented in 6 pilot countries: Argentina, China, Cuba, Senegal (see Senegal TOF assessment profile, South Africa and Tunisia). Tools and methods are developed through regional training in these countries. Satellite images provide information on land cover change and hot spots of land degradation.

At a local scale, each country implements local assessments in 2 to 6 areas. Each local assessment compiles biophysical information, historic context, socio-economic factors and local perception and behaviour.

Sampling design:

The following sampling strategy is recommended. For each country, select 2 to 6 Geographic Assessment Areas (GAA). These areas of significant land degradation activity should be representative of at least one important land use system (LUS) and could be anything from a single watershed to a region of several hundred km². Logistics, existing activity and other factors may influence the choice of GAAs but it is essential that they remain in areas of national priority concern and interest with respect to land degradation or SLM.

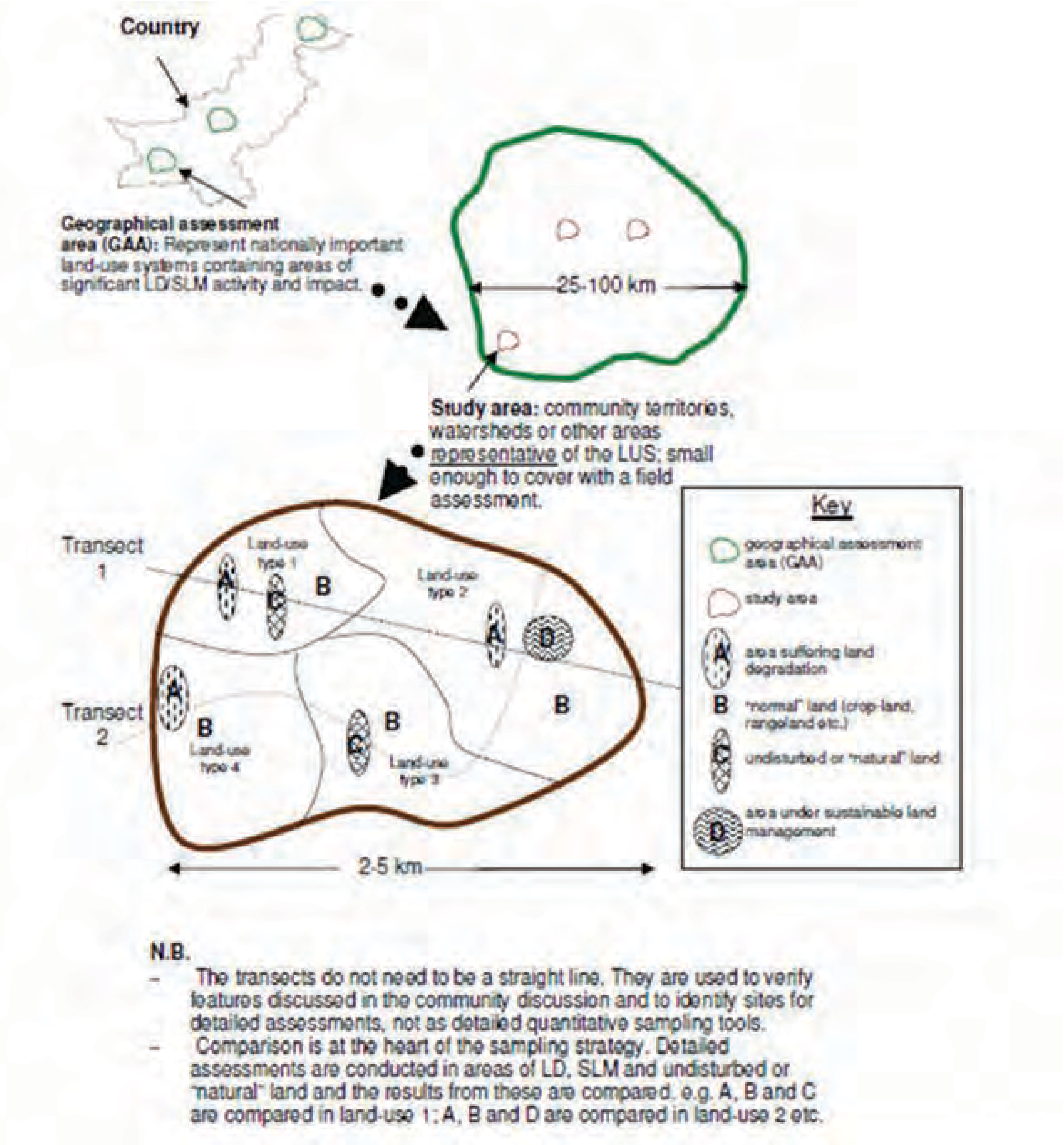


Figure 1: Sampling units, plot and subplot design example (McDonagh, Bunning et al., 2009a).

Within each GAA, choose a few study areas (2 to 3 of variable size) for the field-level assessments. Study areas must be representative of the GAA, containing as many of the main land uses and forms of land degradation present in the GAA as possible. A study area may be a community and the territory it occupies.

On each study area, characterize a number of representative transects, and choose 3 pairs of field plots per Land Use Type for detailed assessments. (see Senegal TOF assessment sheet).

Variables related to TOF and assessed in the GAA of LADA:

There are two stages in the vegetation assessment: a rapid assessment of vegetation and land use, and a more detailed vegetation assessment, on selected sites in the study area.

1. Vegetation quality and composition on study area: Vegetation height, average diameter and vigour for the main perennial species (shrubs, trees) and herbaceous species (grasses, legumes)

2. Detailed assessment includes the identification of vegetation and land-use type, of vegetation cover, composition and species diversity, tree and shrubs measurements, plant health and quality, especially in terms of grazing for pasture and rangelands.

Land-use categories that include or may include tof:

To assess land degradation, LADA uses a detailed classification system adapted from WOCAT 2008.
Land-use categories that include TOF are the following:
- Tree and shrub cropping (sub-category of Cropland): permanent woody plants with crops harvested more than once after planting and usually lasting for more than 5 years (e.g. orchards / fruit trees, coffee, tea, vineyards, oil palm, cacao, coconut, fodder trees).
- Agroforestry (sub-category of Mixed): cropland and trees
- Agro-silvopastoralism (sub-category of Mixed): cropland, grazing land and trees

Land-use categories that may partly include TOF are the following:

- Natural forests (sub-category of Forests/woodlands): woods of indigenous trees, not planted by man, including riparian forests.
- Plantations, afforestation, woodlots (sub-category of Forests/woodlands): forest stands established by planting or seeding (including plots and wider belts, wind-/shelterbelts).
- Extensive grazing land (sub-category of Grazing lands): grazing on natural or semi-natural grasslands, grasslands with trees/shrubs (savannah vegetation) or open woodlands for livestock and wildlife.
- Silvo-pastoralism (sub-category of Mixed): forest and grazing land.
- Settlements, infrastructure networks (sub-category of Other land-use): roads, railways, pipe lines, power lines.
- Waterways (sub-category of Other land-use), drainage lin.

Funding process:

LADA projects are funded through various partnerships, including contributions of involved countries, or FAO, Global Environment Facility (GEF), United Nations Environment Programme (UNEP), Global Land Cover Network (GLCN), Water Soil Information (ISRIC), University of East Anglia, UNCCD, United Nations University (UNU), University of Sassari, WOCAT, etc.
Potential Data on TOF provided by LADA:
- At national level, production of land-use maps;
- At local level, LADA may be used for illustrating various features of each land use class identified as including TOF and provide more specific data, such as species composition, tree density, average DBH, tree volumes, etc.

Comments on TOF:

LADA focuses on land degradation, thus the geographical areas selected for the assessment may not be representative of the considered region or country. In each GAA, the small number of study sites may not be sufficient for ensuring statistical representativeness. However these study sites provide locally detailed illustrations of situations involving TOF.

References

McDonagh, J., Bunning, S., et al. 2009a. LADA-L Part 1: Methodological Approach, Planning and Analysis. 76 pp.

McDonagh, J., Bunning, S., et al. 2009b. LADA-L Part 2: Tools and Methods for Fieldwork. 76 pp.

Land Cover Classification System (LCCS)

Developed by the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP)

Purpose:

To set up a reference classification system that encompasses all possible land cover classes to respond to the need for harmonized collection of data.

To be a reference base for applications ranging from forest and rangeland monitoring through production of statistics, planning, investment, biodiversity, climate change, to desertification control.

Historical background:

In 1994, the Africover Programme aimed at mapping land cover for the whole Africa and led to the development of the Land Cover Classification System (LCCS). The initial concept, based on existing classifications, nomenclatures and FAO documents, was discussed by various working groups and was finally operational for the Africover – East Africa project (1995-2002).

There is currently no internationally accepted land cover classification system. However, FAO has submitted LCCS for approval to become an international standard, and several studies already used LCCS to map their land cover (see paragraph Comments).

Methodology:

LCCS implementation is in two successive phases:

The Initial Dichotomous Classification Phase, which consists of three classification levels, defining 8 major land cover classes in the third level as indicated below (classes that may include TOF are coloured):

First level	Second level	Third level
PRIMARILY VEGETATED AREA(S)	TERRESTRIAL	CULTIVATED AND MANAGED TERRESTRIAL AREA(S)
		NATURAL and SEMI-NATURAL TERRESTRIAL VEGETATION
	AQUATIC or REGULARLY FLOODED	CULTIVATED AQUATIC OR REGULARLY FLOODED AREA(S)
		NATURAL and SEMI-NATURAL AQUATIC OR REGULARLY FLOODED VEGETATION
PRIMARILY NON-VEGETATED AREA(S)	TERRESTRIAL	ARTIFICIAL SURFACES AND ASSOCIATED AREA(S)
		BARE AREA(S)
	AQUATIC or REGULARLY FLOODED	ARTIFICIAL WATER BODIES, SNOW and ICE
		NATURAL WATER BODIES, SNOW and ICE SNOW and ICE

(source: FAO GLCN, 2010)

- The Follow-up Modular-hierarchical Phase, that uses 8 other different classifier sets (optional ones) to extend the classification in subcategories adapted to each country or region. A given land cover class is defined by the combination of a set of independent diagnostic attributes, the so-called classifiers. The more classifiers are used, the more precise and specific the land cover class and subclasses are. The classification can be stopped at any time and the corresponding land cover class determined. Each land cover class is described by three codes:
  - A boolean formula, consisting of the string of classifiers used for class definition (e.g. A3A10B2),
  - A standardized name of land cover class (e.g. "high closed forest"),
  - A unique numerical (GIS-friendly) code (e.g. 20006).

Two other sets of optional classification attributes provide additional description of land cover characteristics:

- Environmental attributes, which influence land cover but are not essential for its definition, e.g. climate, landform, altitude, soils, lithology and erosion.
- Specific technical attributes, which relate to specific applications. They include the description of crop types in managed terrestrial areas, floristic aspects of natural and semi-natural terrestrial and aquatic vegetation, salinity of artificial and natural water bodies, etc.LCCS is an a priori classification. Therefore all the classes must be defined before any data collection. LCCS uses a basic physiognomic-structural classification to describe cultivated areas but it ensures a high degree of compatibility with existing agricultural classification systems. Depending on the level of detail reached, some of the LCCS classes thus include TOF by definition, while some others may include TOF (see Senegal TOF assessment profile). For instance, class A11 (cultivated and managed lands) may include TOF systems such as tree crop plantations, orchards, agroforests and parkland agroforests. To be sure that these TOF systems are taken into account, the system has to be taken a level of detail further and the dominant life form identified. Where this dominant life form is "trees" (code A1 in class A11) then the user can be sure that the TOF systems quoted above are included in the class.

Data on TOF provided by LCCS:

- Spatial information on classes that by definition include TOF and on classes that may include TOF.
- Areas of TOF classes.

Comments:

Main Advantages as regards TOF:

- LCCS has inherent flexibility. It is applicable to all climatic zones and environmental conditions, and is compatible with the existing classification systems,
- If well used, defined with enough classes in the Modular-hierarchical Phase, this classification is detailed enough to extract TOF categories one by one (see Senegal TOF assessment profile),
- LCCS is the only universally applicable system in operational use at present; it enables a comparison of land cover classes regardless of data source, economic sector or country.
- LCCS is used in many countries
- It inspired other systems (at regional or international scales), such as:

  - The North American Land Change Monitoring System (NALCMS), which aims at depicting information about land cover and land cover change in a seamless, consistent, and automated way across North America at regular intervals. Its classification legend is designed in three hierarchical levels using the FAO Land Classification System LCCS.
  - GLC2000, which provides accurate baseline land cover information to the International Conventions on Climate Change, the Convention to Combat Desertification, the Ramsar Convention and the Kyoto Protocol. It was designed by the European Commission's Joint Research Centre (EC-JRC) with an LCCS compatible legend allowing global standardization of land cover classification.
  - Globcover (project from the European Space Agency), that aims to produce a new global land cover database using images with a spatial resolution of 300 m (see Morocco TOF assessment Profile).

Main Limitations as regards TOF:

- Despite its flexibility, LCCS has also an inherent rigidity since all the classes have to be pre-defined in advance, which imposes a good preliminary knowledge of the landscapes to be mapped.
- Although LCCS may be linked to projects including field inventories, data directly provided by LCCS are restricted to localization and area of land cover classes.

Reference

FAO and United Nations Environment Programme (UNEP). 2010. GLCN Global land cover network. Retrieved November 2010, from http://www.glcn.org.

National Forest Monitoring and Assessment (NFMA)

NFMA has been developed by FAO since 2000 in response to the needs of member countries for adequate forest and tree data at national level

Purpose:

To assess and monitor forest and other natural resources (including trees outside forests), land uses and management practices in order to provide new qualitative and quantitative data on the state, use, management and trends of these resources and the ecosystems.

Historical background:

Few countries in the world today generate systematic data on the changing characteristics of their forest resources and trees outside forests (TOF). FAO estimated in 2005 that only 15 percent of the forest in developing countries was covered by regular, field-based forest inventories (Branthomme, 2010). To support member countries to carry out national forest monitoring and assessment activities, FAO designed its NFMA programme. This assessment model enlarges the information collected on tree resources by including systematic data collection on trees outside forests, identification of forest products and services and their beneficiaries, property rights and policies associated with such products and services, as well as the socioeconomic and institutional characteristics of forest use and users.
As of 2010, FAO has worked with over 50 countries in all regions of the world in addressing National Forest Monitoring and Assessment needs. Direct support has been provided in over 20 countries that have implemented national field inventories in collaboration with FAO and 20 more countries are expected to follow suit.

By the end of 2010, NFMA had been completed in 9 countries (FAO, 2010):
Bangladesh (see Bangladesh TOF assessment profile), Cameroon (see Cameroon TOF assessment profile), Costa Rica, Guatemala, Honduras, Lebanon, Philippines (see Philippines TOF assessment profile), Zambia (see Zambia TOF assessment profile), Nicaragua (see Nicaragua TOF assessment profile)

Methodology:

- Based on nationwide systematic sampling, local interviews and field data collections as well as remote sensing
- Applied through National Forest Inventories
- Made up of a set of 1st level predefined variables, definitions and options, and a set of sublevels that may be modified according to country specifications
- Developed through a multi-stakeholder process and by examining data needs according to information required for enhancement & monitoring of specific forest-related policies

NFMA may be completed with an ILUA (Integrated Land Use Assessment) that gathers more socio-economic data and a field sampling integrating all land uses. At present, just Zambia (see ZambiaTOF assessment profile) and Kenya have carried out NFMA/ILUA studies.

Sampling design:

The inventory phase of the assessment starts from a systematic sample grid covering the entire country. Remote sensing is used for determining the preliminary land-use classification for the sampled sites.

The sampling units (SU) are selected at least at the intersection of every degree of latitude and longitude. The number of SU and the sampling frequency of monitoring are determined according to the required statistical reliability of the data and available financial and human resources.

Each sampling unit (SU) is a 1 km x 1 km square. Each SU contains 4 field plots.
Field plots are rectangles (20 m x 250 m) starting at each corner of an inner 500 m square and numbered clockwise from 1 to 4 (see Figure 1).

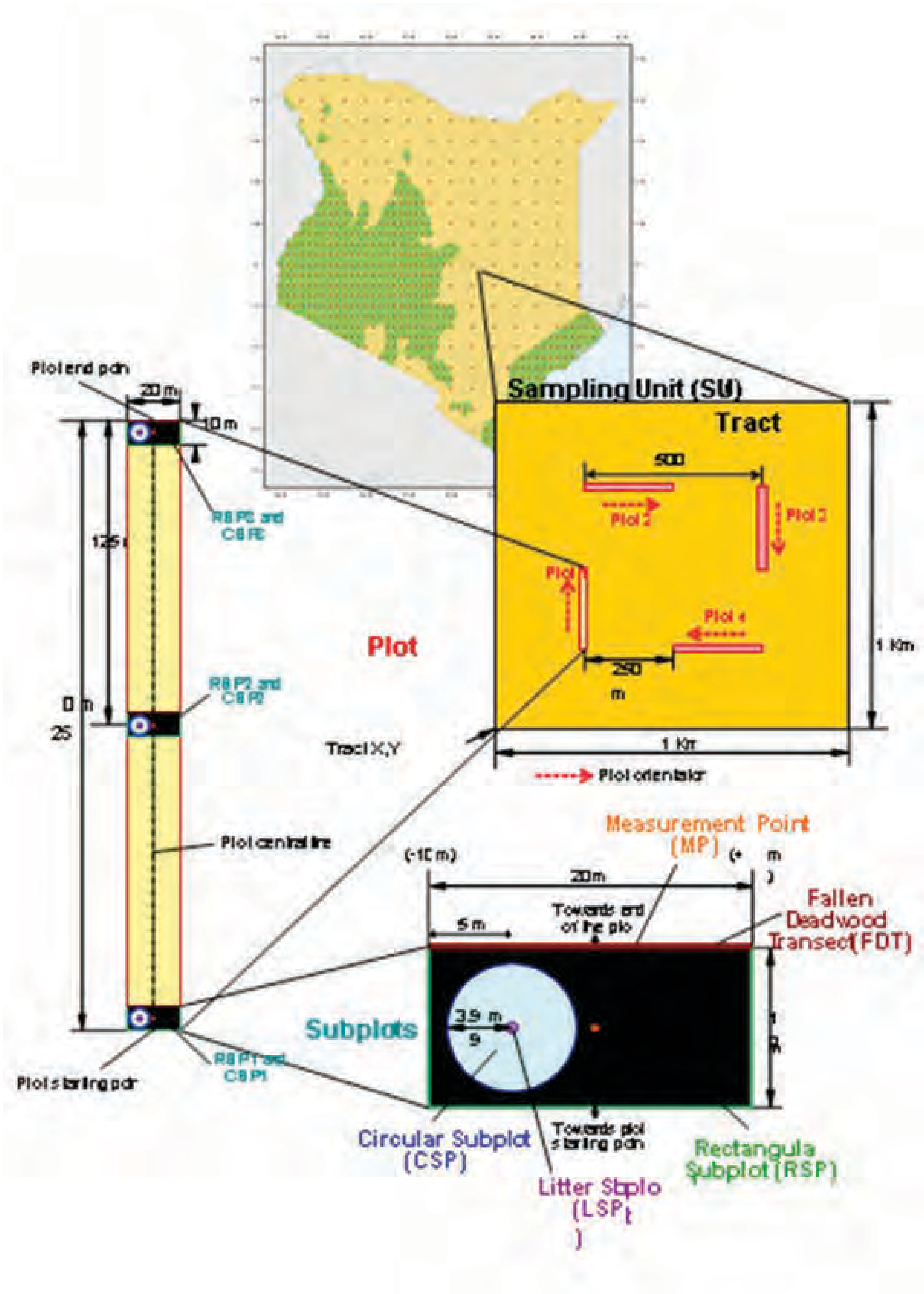


Figure 1: Sampling unit, plot and subplot design example. (Branthomme, 2009)

Each plot contains 3 sets of 3 subplots used for measuring litter, deadwood, soil condition and topography and is divided into Land Use / Cover Sections (LUCS), representing homogenous land use and vegetation units. The number of LUCS on a plot is thus variable.

Classification of LUCS is based on the Land Use / Cover Classes (LUCC) (see Figure 1):

- At the first level (global class level), LUCC are: 'Forests', 'Other wooded land', 'Other land' and 'Inland water', categories developed by the FAO global FRA to ensure harmonisation between countries.
- At other levels (national class levels), LUCC subclasses are country specific and meet national and sub-national information needs (see the various NFMA country TOF assessment profiles).

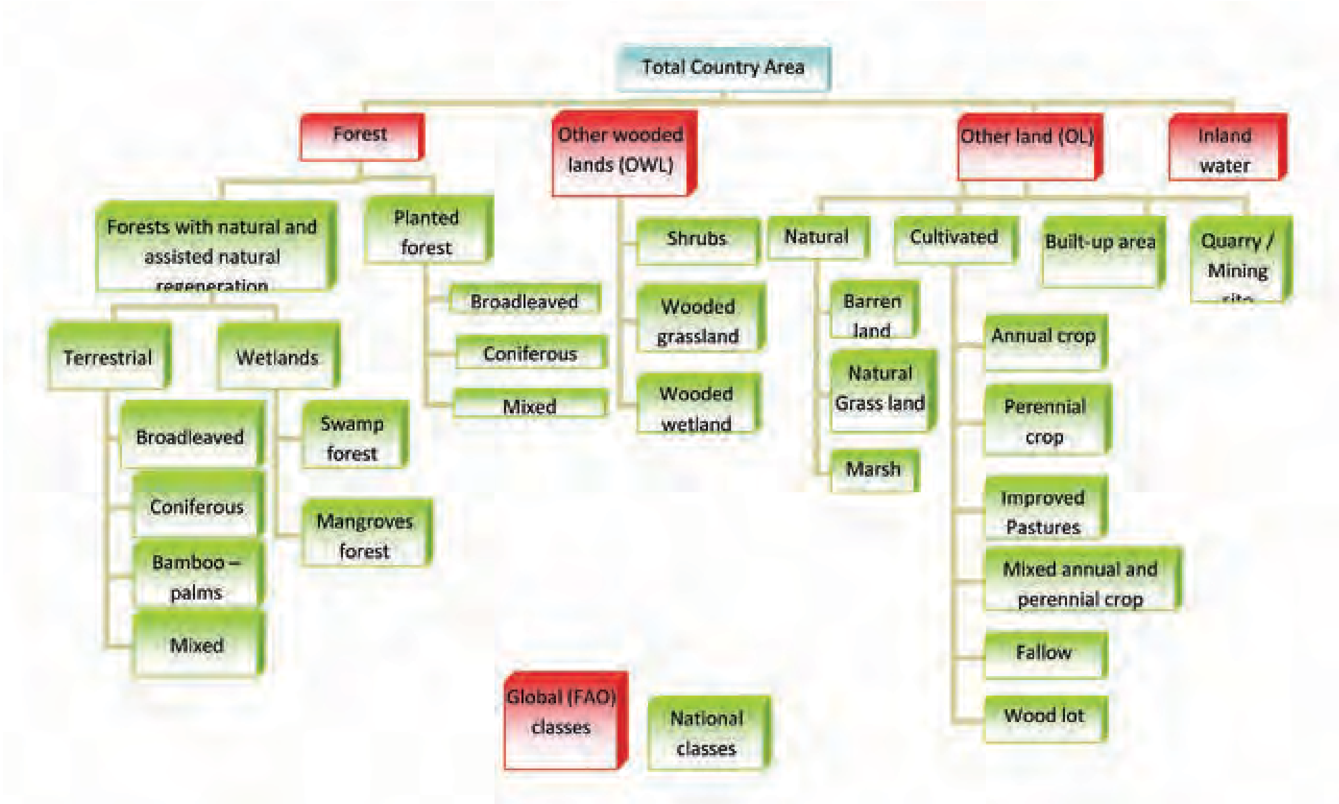


Figure 2: Example of Land use / cover classification diagram (Branthomme, 2009)

Variables related to TOF and assessed in NFMA:

- Qualitative data on the LUCC including TOF are extractable from the classification
- Areas of LUCC including TOF (see Nicaragua TOF assessment profile)
- For each LUCC including TOF, data provided are:
  - in Form F3: tree number, LUCS number, species scientific name, dbh, health, stem quality, etc.
  - in Form F5 on LUCS: vegetation cover, tree canopy cover, TOF distribution or shrub cover, services provided by the forest and trees, soil and water conservation, stand origin and structure,
  - in Form F6 on LUCC: products harvested in the LUCC, services provided by trees (soil protection, soil fertility, water conservation, shade, etc.),

Definitions, field forms and guidelines for measurements and data collection are available in annexes of NFMA reports to ensure that countries using NFMA will grant homogeneous data.

Implementing process:

NFMA structure varies from country to country, but the main organisation is common, involving:
- a National Project Coordinator (NPC), who is referent for the country;
- the Project Technical Unit (PTU), which aims at coordinating, executing and monitoring the NFMA at a national level;
- field teams, which are responsible for data collection, recording and transmission to the PTU. One field team contains 4 to 8 persons, specialized in key disciplines as forestry, botanic, sociology, wildlife, crop, soil, water, etc.

Potential Data on TOF provided by NFMA (at national level):

(See the various NFMA country TOF assessment profiles)
For each Land Use/Cover class identified as including TOF, results comprise: area by land use class, tree volumes, volumes per ha for major LUCs, growing stock, products and services from TOF, biomass, aboveground carbon, species composition, etc.

Comments on TOF:

Main advantages as regards TOF:
- It provides both qualitative and quantitative data on TOF.
- It is a complete assessment since it reports sets of spatial, biophysical and socio-economic data.

- It has a high reliability level at sample plot scale as each sample plot is assessed through remote sensing, biophysical measurements and, interviews.
- Its cost is relatively low, estimated to approx US$1000 per sample unit (Saket, Branthomme et al., 2008),It is adaptable to any country, even those that already have national LUC classes.
- It is adapted to national reporting to internal processes such as FRA or the UNFCCC
- It has a detailed enough LUC classification so that all classes including TOF can be identified, even when a national class (2nd or 3rd level) is put in a wrong global class (1st level) (see Bangladesh TOF assessment profile).

Main limitations as regards TOF:

- Some TOF categories may not be distinguished separately: e.g. in Nicaragua, hedgerows, and small woodland areas (<0.5 ha) are not put in a special category.
- Precision at which global classes are produced is generally acceptable, but it can be low for some countries where there are disproportions between classes: then, sampling error is higher (FAO, 2008).

References:

This assessment profile was validated by Mr. Dan Altrell (FAO Forestry Officer - National Forest Inventory, Italy). It is based the following documents:

Branthomme, A. 2009. National Forest Monitoring and Assessment - Manual for integrated field data collection. Rome, FAO.

Branthomme, A. 2010. Monitoring Trees Outside Forests through national field inventory. FAO Support to National Forest Monitoring and Assessment. Rome, FAO.

FAO. 2008. NFMA approach and process: an analysis of Cost and Time. Background Paper prepared for the National Forest Monitoring and Assessment [NFMA] Expert Consultation "Meeting Evolving Needs". Rome, 26-28 November. Working Paper NFMA 39: 20.

FAO 2010. FAO support to national forest monitoring and assessment. Monitoring the world's forest resources. FAO. Rome. 4 pp.

FAO. 2010. National Forest Monitoring and Assessment (NFMA). FAO Support to National Forest Monitoring and Assessment Retrieved December 2010 from http://www.fao.org/forestry/nfma/fr/.

Saket, M., Branthomme, A., et al. 2008. Decision-making is informed, better coordinated across sectors, transparent and participatory. GEO Forest Monitoring Symposium, Foz do Iguaçu, Brazil, FAO Support to National Forest Monitoring and Assessments (NFMA).

····Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM)····

Spatial analysis of Woodfuel flow,
developed by the Food and Agriculture Organization and National University of Mexico

Purpose:

WISDOM is a spatially explicit method for visualizing woodfuel priority areas or "hot spots", enabling a potential wood energy planning and policy development. It is based on geographic information system (GIS) technology, which offers new possibilities for combining, or integrating, statistical and spatial information about the production (supply side) and consumption (demand side) of woodfuels (fuelwood, charcoal and other biofuels).

Historical background:

WISDOM methodology was developed in the context of FAO country assistance, by collaboration between FAO's Wood Energy Programme and the Institute of Ecology of the National University of Mexico (UNAM), in 2003.

The WISDOM approach was further defined at the:
- City level: Bangui, Dar-es-Salaam, Arusha-Moshi, Kampala, Khartoum, Phnom Penh, Battambang, Vientiane, Luang Prabang, Maputo and on-going for N'Djamena
- Sub-national/Regional level: Purepecha in Mexico, Castilla y León in Spain, Niger Delta in Nigeria, Emilia Romagna in Italy and Darfur in Sudan
- Country level: Slovenia, Mexico, El Salvador, Senegal, Argentina, Italy, Rwanda, Mozambique, Croatia, Brazil and Central Africa Republic
- Subregional level: East Africa (10 countries), South East Asia (7 countries)

Methodology:

WISDOM is based on:
- Geo-referenced data bases.
- Minimum administrative and spatial unit of analysis. The spatial resolution is defined at the beginning of the study, on the basis of the desired level of detail and as constrained by the main parameters or proxy variables that will be used to "spatialize" the information. The spatial level of analysis (i.e. the size of the pixel in GIS raster data) is usually determined by the mapping detail of the available land use/land cover data.
- Modular and open structure. Once the common spatial base of reporting is defined, each module is developed in total autonomy using existing information and analytical tools and is directed to the collection, harmonization, cross-referencing and geo-referencing of relevant existing information for the area of study.
- A comprehensive coverage of woodfuel and biofuel resources and demand from different energy users.

The methodology may be divided into two sequential phases/contexts of analysis: WISDOM Base, which includes the analysis over the entire territory of the study area, and Woodshed analysis, which uses the result of the WISDOM Base to delineate the sustainable supply zone of selected consumption sites.

The WISDOM Base involves five main steps:
1. Definition of the spatial base (minimum administrative spatial unit of analysis)
2. Development of the DEMAND module (spatial distribution of woodfuel consumption)
3. Development of the SUPPLY module (a spatial representation of all natural and planted woodfuel sources)
4. Development of the INTEGRATION module (develop variables that integrate the information from the demand and supply modules)
5. Selection of the PRIORITY areas or woodfuel "hot spots" under different scenarios

The Woodshed analysis involves two additional steps:

6. Mapping of potential "commercial" woodfuel supplies suitable for urban, peri-urban and rural markets
7. Definition of woodshed, or potential sustainable supply zones, based on production potentials and physical accessibility parameters

Data on TOF provided by WISDOM:

WISDOM gives high relevance to TOF because these are often a major source of woodfuels serving local demand. Lack of data on TOF is a serious constraint that WISDOM can overcome by undertaking ad-hoc TOF surveys or rapid appraisals, as in the Slovenia and Rwanda case studies, or by providing best estimates based on available references. Surfaces, woody biomass growing stock and productivity can be extracted for TOF categories, with reliability depending from the used reference data.
WISDOM can act as incentive for national resource assessment as in Slovenia, where the national inventory considers the non forest wood resource as a specific category to be assessed (see Slovenia TOF assessment profile).

Comments:

Main advantages as regards TOF:
- It provides a consistent and holistic vision of the wood energy sector over an entire country or region; including an estimation on TOF resources.
- It constitutes an open framework and a flexible tool meant to adapt to existing information related to woodfuels demand and supply patterns.
- It allows the definition of critical data gaps resulting from the thorough review and harmonization of wood energy data.
- It promotes cooperation and synergies among stakeholders and institutions (Forestry, Agriculture, Energy, Rural Development, etc.).
- It enhances the political recognition of the real inter-sectoral role of wood energy.
- It contributes essential information for the promotion of sustainable management of forests, other wooded lands and trees outside forests.
- It encourages the establishment of national inventories in forest and non forest areas.

Main limitations as regards TOF:

- Non-forest area productivity is generally roughly estimated (unless ad-hoc TOF surveys are carried out), because data mostly come from forest focusing inventories such as most NFI.
- Based on pre-existing GIS data, with a very variable precision.

References:

FAO. 2003. «Woodfuels integrated supply/demand overview mapping-WISDOM.» from http://www.fao.org/docrep/005/y4719e/y4719e00.htm#TopOfPage

Drigo, R. & Salbitano, F. 2009. WISDOM for cities: Analysis of wood energy and urbanization using WISDOM methodology. Eds. M. A. Trossero & M. Gauthier. Rome, FAO Forestry Department. Urban forestry – Wood energy: 126.http://www.fao.org/fileadmin/templates/FCIT/PDF/WISDOM.pdf

WISDOM case studies where TOF surveys were undertaken: Drigo, R. & Veselič, Ž. 2006. Woodfuel Integrated Supply / Demand Overview Mapping (WISDOM) - Slovenia - Spatial woodfuel production and consumption analysis. FAO Forestry Department – Wood Energy Working Paper.

FAO link (chapter-wise) http://www.fao.org/docrep/009/j8027e/j8027e00.HTM

Full paper: http://www.WISDOMprojects.net/global/csdetail.asp?id=8

Drigo, R. & Nzabanita, V. 2011. WISDOM Rwanda - Spatial analysis of woodfuel production and consumption in Rwanda applying the WISDOM methodology. Working Paper of Project "Rationalisation de la filière bois-énergie" (TCP/RWA/3103). (available from FAO Wood Energy website)

Non-FAO WISDOM publications are available at: http://www.WISDOMprojects.net/global/index.asp

This assessment profile was validated by Mr. Rudy Drigo (FAO Consultant, Wood Energy Programme).

PART 3: Trees Outside Forests from the air: A guide for identification

The following guide has two main objectives:

Provide practical examples of how to interpret any situation in terms of the various classes currently used by the FAO-FRA and the complementary subclasses that are proposed in this report to take into account the existence of Trees Outside Forests.

Provide a wide range of illustrations to underline the fact that TOF and Other Land with TOF are encountered almost everywhere on earth, from the humid tropics to the boreal zone through the arid and temperate areas of the middle latitudes, in rich economically developed countries as in poor developing countries.

Practical considerations:

The images are extracted from Google Earth. The analysis has been executed without GIS analysis software. Width and length, area, and tree cover percentage are estimated at the scale of the image but are based on visual appreciation.

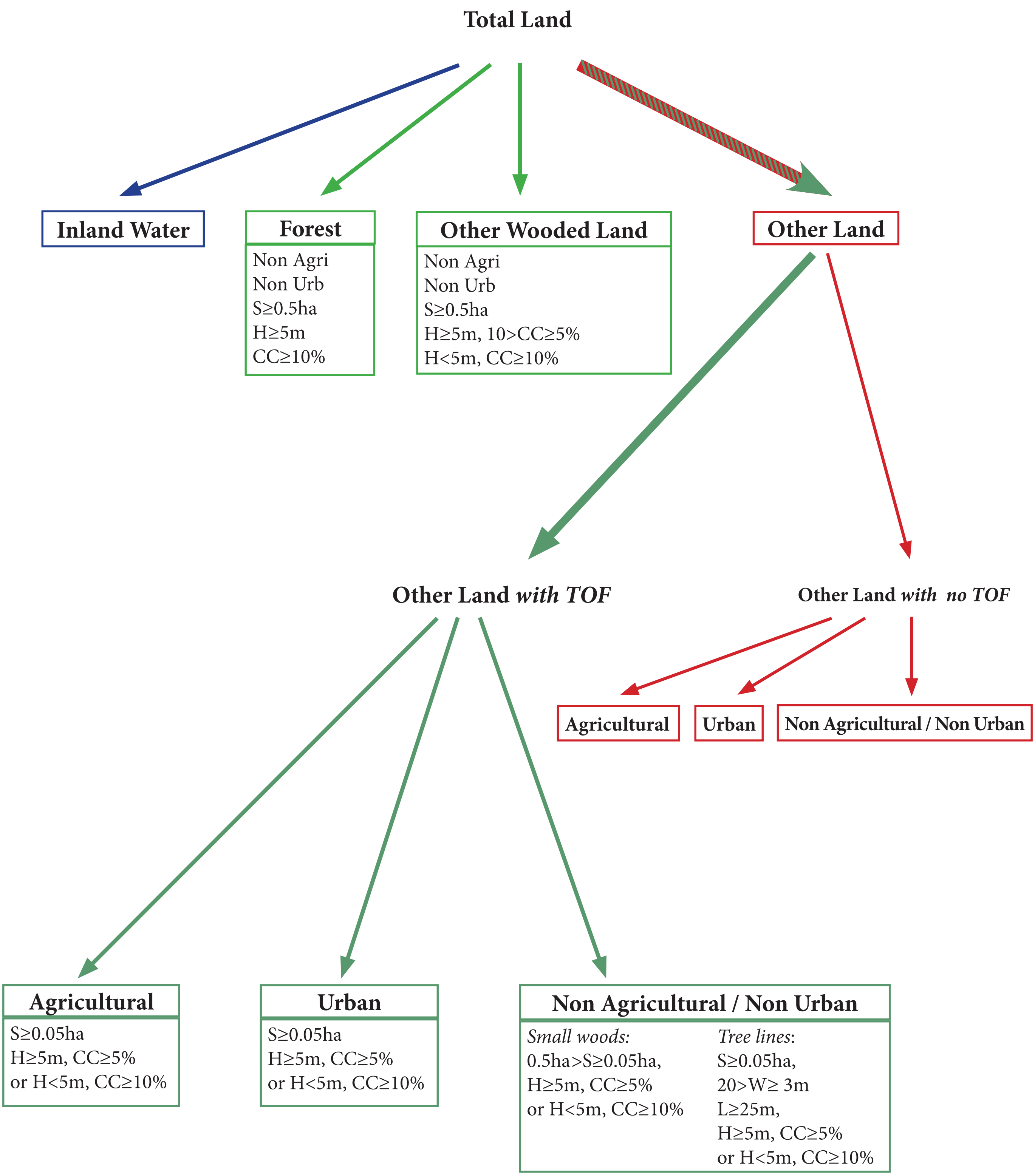
For each image, and unless stated otherwise, the analysis does not take into account the land-use / land-cover areas outside the image.

For some illustrations, when appropriate, two interpretations are provided. Generally one interpretation focuses on the image as a whole, while the second focuses on details to allow the identification of specific OLwTOF subsets. The choice between these two interpretations is a choice of resolution / scale targeted for the assessment. In practice, this choice will mainly depend on the time and financial constraints of the assessment.

When trees and shrubs are present, the tree presence is generally considered first for the thresholds.

TOF:
Trees and shrubs on land that is NOT:
FOREST
or
OTHER WOODED LAND

OTHER LAND *with TOF (OLwTOF):*
Other Land *with TOF – AGRI (OLwTOF - AGRI)*
Other Land *with TOF – URB (OLwTOF - URB)*
Other Land *with TOF Non AGRI/ URB (OLwTOF – Non A/U):*
OL*wTOF – Non A/U subset 1: small woodlands*
OL*wTOF – Non A/U subset 2: linear tree formations*



Content

TOF AGRI

1.1. Agroforestry parklands

Case 1: Agroforestry parkland, Niger (13°27'28"N ; 7°01'28"E)

A: OLw*TOF - AGRI* (OLw*TC*)

B: OLw*TOF - URB* (OLw*TC*)

A: Mosaic of crop fields and pastures with a relatively low cover of trees and shrubs (canopy cover: ca. 20%). All trees and shrubs here are TOF.

The area is classified as **Other Land *with TOF*** *because land is mainly used for agriculture; trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

In addition the area is also classified as **Other Land with Tree Cover** *because trees are ≥ 5m high, the tree canopy cover is ≥ 10% and the area is ≥ 0.5 ha.*

B: Urban area with houses and home gardens with trees (canopy cover: ca. 25 %). All trees here are TOF.

The area is classified as **Other Land *with TOF*** *because land is under urban land-use; trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

In addition the area is also classified as **Other Land with Tree Cover** *because trees are ≥ 5m high, the tree canopy cover is ≥ 10% and the area is ≥ 0.5 ha.*

Case 2 : Agroforestry parkland, Burkina Faso (12°13’37”N ; 1°41’05”W)

OLw*TOF* - *AGRI*
(OLw*TC*)

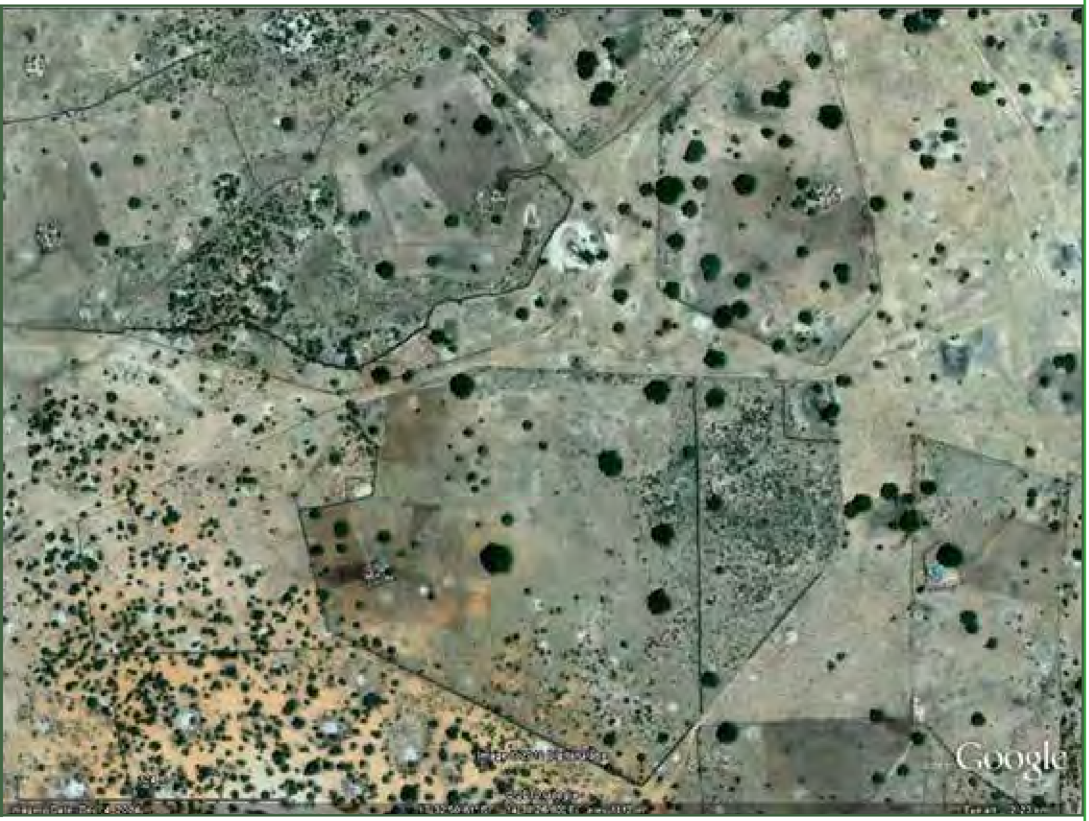
Mosaic of crop fields, scattered houses, pastures and paths, with trees and shrubs homogeneously distributed in small groups or isolated (canopy cover: ca. 20 %) . All trees and shrubs here are TOF.

The whole area is classified as **Other Land *with TOF*** *because the land is mainly used for agriculture and housing structures, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

In addition the area is also classified as **Other Land with Tree Cover** *because trees are ≥ 5m high, the tree canopy cover is ≥ 10% and the area is ≥ 0.5 ha.*

Case 3: Agroforestry parkland, Namibia (17°32'50"S ; 14°39'26"E)

OLwTOF - AGRI
(OL*wTC*)



Mosaic of crop fields, houses, pastures and paths, with scattered trees and shrubs (canopy cover: ca. 20 %). All trees and shrubs here are TOF.

The whole area is classified as **Other Land *with TOF*** *because the land is mainly used for agriculture and housing structures, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

In addition the area is also classified as **Other Land with Tree Cover** *because trees are ≥ 5m high, the tree canopy cover is ≥ 10% and the area is ≥ 0.5 ha.*

Note: Different zones can be identified based on their appearance and tree density, but they all belong to the same category (Other Land *with TOF – AGRI)*, so there is no need to separate them.

Case 4: Agroforestry parkland, Senegal (15°06'02"N ; 16°24'51"W)

OLwTOF - AGRI
(OLwTC)

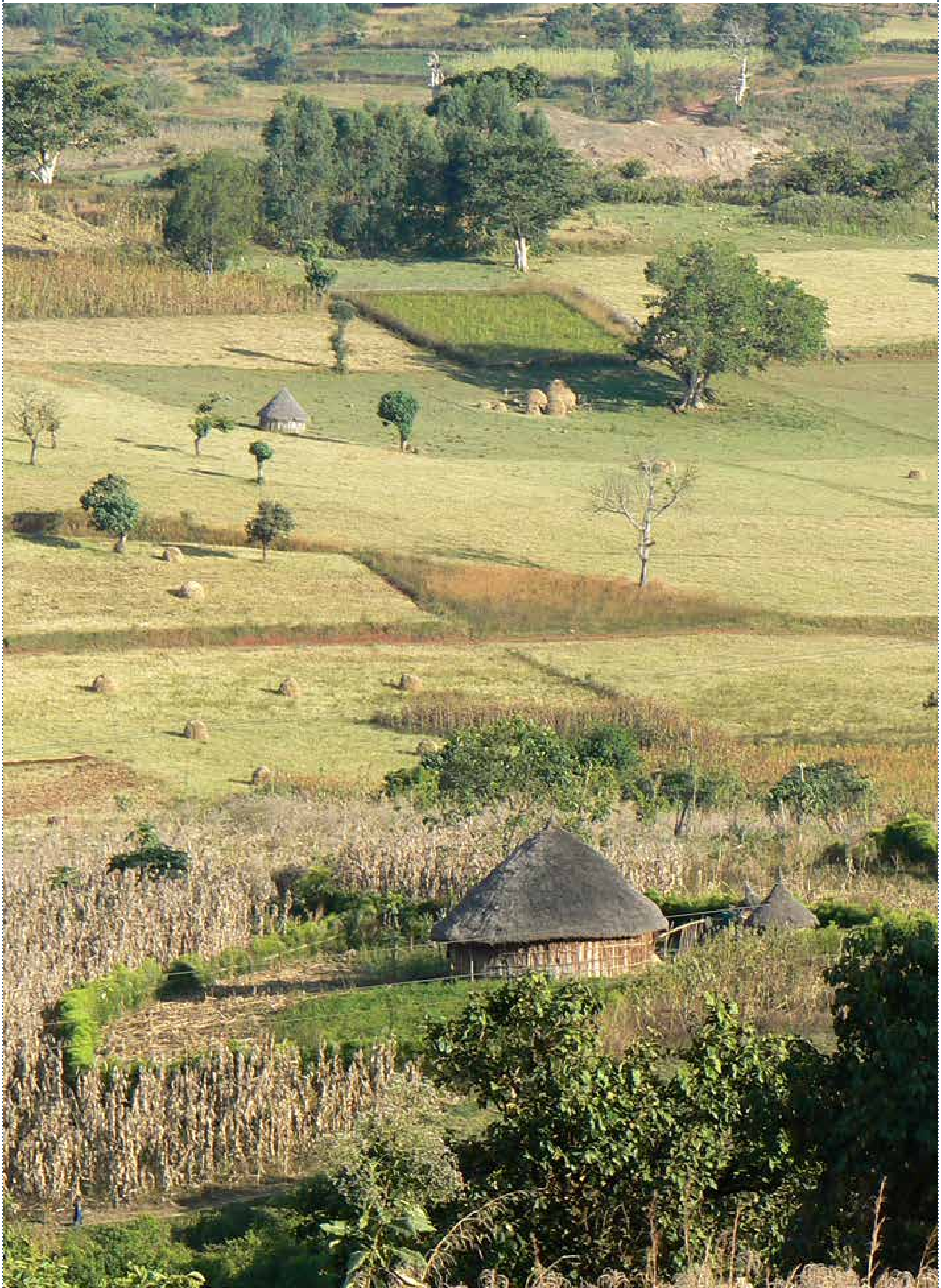
Mosaic of crop fields, pastures and paths, with isolated trees or shrubs homogeneously distributed. There is also a village with home gardens and large trees. All trees here are TOF.

The whole area is classified as **Other Land *with TOF*** *because the land is mainly used for agriculture, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

In addition the area is also classified as **Other Land with Tree Cover** *because trees are ≥ 5m high, the tree canopy cover is ≥ 10% and the area is ≥ 0.5 ha.*

Note: Different zones can be identified based on their appearance and tree density, but they all belong to the same category (Other Land *with TOF – AGRI)*, so there is no need to separate them.

1.2. Trees scattered in mixed cropping systems



Case 5: Trees scattered in mixed cropping systems, Northern India (24°29'04"N ; 82°28'12"E)

Interpretation 1:

OLwTOF - AGRI

(OLw*TC*)

Mosaic of crop fields, houses, roads and pastures with trees in small groups or isolated (canopy cover: < 5 %). All trees are TOF.

The whole area is classified as **Other Land *with TOF*** *because the land is mainly used for agriculture, the combined trees and shrubs canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

Interpretation 2:

A: OLw*NoTOF*

B: OLw*TOF - AGRI*

A: Mosaic of crop fields, houses, roads and pastures with no or rare isolated trees or shrubs. All trees are TOF.

The area is classified as **Other Land *with No TOF*** *because the land is mainly used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.*

B: Mosaic of crop fields with isolated trees and shrubs (canopy cover: > 5 %). All trees and shrubs are TOF.

The area is classified as **Other Land *with TOF*** *because the land is mainly used for agriculture, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

Case 6: Trees scattered in mixed cropping systems, Ethiopia (9°00'54"N ; 34°33'57"E)

Interpretation 1

A: OL*wTOF* - *AGRI*

B: OL*wTOF* - *AGRI*
(OL*wTC*)
or FOREST

C: OL*wTOF* - *AGRI*
or *NON A/U*
subset 2

A: Mosaic of crop fields, houses, and pastures with trees in small groups or isolated (canopy cover: < 5%). All trees are TOF.

The area is classified as **Other Land *with* TOF** *because the land is mainly used for agriculture and housing structures, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

B: Large and dense patches of trees with an irregular mixed tree cover (canopy-cover: ca.95 %). *Because the patches are large (≥ 0.5ha) and there are no obvious signs of field activity,* ***field checking*** *is necessary to identify the land-use.*

If **agricultural** use is predominant, all trees are TOF and B patches are classified as **Other Land *with* TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* The largest B patches can be further classified as **Other Land with Tree Cover**, *because their area is ≥ 0.5 ha, and their tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the smallest B patches are classified as **Other Land *with* TOF** (OL*wTOF - Non A/U* subset 1) *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha,* while the largest B patches are classified as Forest *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*
In this particular case, **field checking** reveals that B patches are made up of coffee agroforest plots (agriculture); all trees are thus TOF and all B patches are classified as **Other Land *with TOF***, the largest patches being also classified as **Other land with Tree Cover.**

C: Trees and shrubs in linear tree formation. Trees here are TOF, either *because they have a predominant agricultural use or, if they have a predominant non agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with* TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

Interpretation 2:

A+: OL*wTOF - AGRI*
(OL*wTC*)

A-: OL*wNoTOF*

B: OL*wTOF - AGRI*
(OL*wTC*)
or FOREST

C: OL*wTOF - AGRI*
or *NON A/U*
subset 2

A is further divided :

A+: Patches of trees in crop fields and pastures, or in gardens around houses with trees in small groups or isolated (canopy cover: > 20 %). All trees are TOF.

The A+ patches are classified as **Other Land *with TOF*** *because the land is mainly used for agriculture and housing structures, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

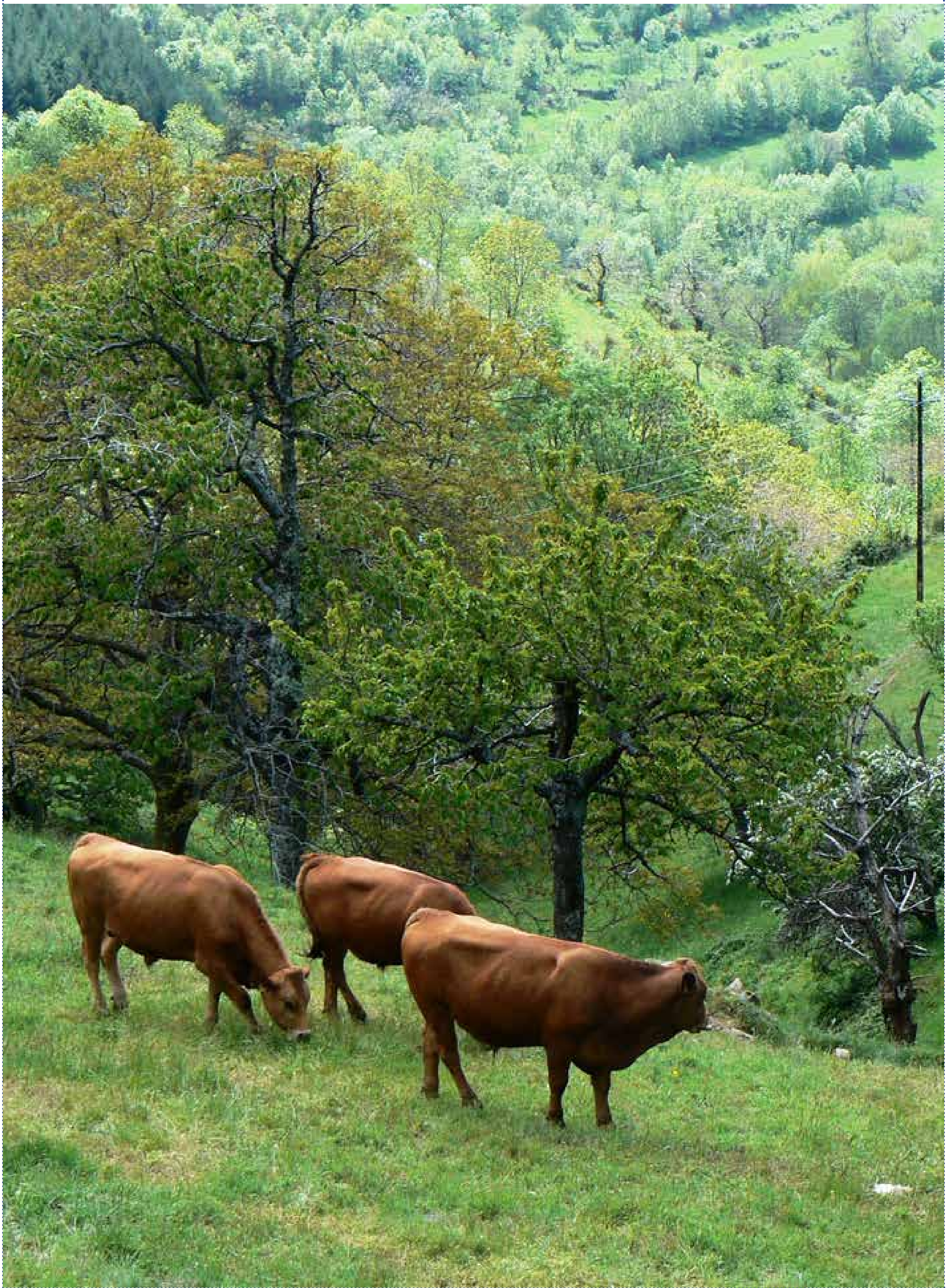
The largest A+ patches can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

A-: Mosaic of crop fields and pastures, with no or scarce isolated trees. All trees are TOF.

The A- patches are classified as **Other Land *with No TOF*** *because the land is mainly used for agriculture and housing structures (thus: Other Land), but the tree canopy cover is <5 %.*

B and **C** are similar to interpretation 1.

1.3. Trees on pasture land



Case 7: Trees on pasture land, Burkina Faso (11°03'38"N ; 3°46'29"W)

A: OLw*TOF - AGRI*
(OLw*TC*)
or FOREST
or OWL

B: OLw*TOF - AGRI*
(OLw*TC*)

C: OLw*TOF - Non A/U*
subset 2

A: Large area with no obvious human use, with a dense and irregular shrub cover and some trees. Because the area is large (≥ 0.5ha), has no obvious main use, and the tree and shrubs combined canopy cover is high (ca. 70 %), **field checking** is needed to identify the land-use and the canopy cover of trees *(that reach 5m high, or that are able to reach 5 m high in situ):*

If the *tree canopy cover≥ 10%.*

If **agricultural use** predominant, all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because the tree canopy cover is ≥ 10% and the area is ≥ 0.5 ha.*

If **non-agricultural use**, the area is classified as **Forest**, *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

If the *tree canopy cover is between 5 and 10%.*

If **agricultural use** predominant, all trees and shrubs are TOF and the area is classified as **Other Land *with* TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

If **non-agricultural use**, the area is classified as **Other Wooded land**, *because trees are ≥ 5m high, the combined tree and shrub canopy cover is between 5 and 10 %, and the area is ≥ 0.5 ha.*

B: Mosaic of crop fields, paths and houses with trees in small groups or isolated (canopy cover: ca. 20 %). All trees are TOF.

The area is classified as **Other Land *with TOF*** *because the main use of the land is agriculture, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

C: Wild trees forming a narrow corridor along a stream. All trees are TOF because the tree line width is < 20 m.

The area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, the area is ≥ 0.05 ha, and the linear formation width is ≥ 3m with a length ≥ 25m.*

Case 8: Trees on pasture land, Missouri, USA (39°31'21"N ; 93°06'15"W)

Interpretation 1

A: OLw*TOF - AGRI* (Olw*TC*)

B: OLw*TOF* or FOREST

C: OLw*TOF* or FOREST

D: OLw*TOF – AGRI* or *NON A/U*, subset 2

E: OLw*NoTOF*

A: Large patches of trees (≥0.5 ha), in small groups in garden and pastures. All trees are TOF.

The area is classified as **Other Land *with TOF*** *because the land is mainly used for pasture (thus: Agriculture) and housing structures, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover,** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Large areas with dense tree canopy cover, following a linear pattern; because the width is ≥ 20m and there are no obvious signs of field activity even though the surrounding area is mostly pasture and agriculture, **field checking** is necessary to identify the land-use.

If **the trees have a predominant agricultural use**, then all trees are TOF and the land is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, the area is ≥ 0.05 ha and the length is ≥ 25 m.* It can be further classified as **Other Land with Tree Cover,** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **the trees do not have a predominant agricultural use**, the B areas are classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

C: Large and dense patches of trees with an irregular mixed tree cover; *because the patches are large (≥ 0.5ha), the canopy cover is dense and there are no obvious signs of field activity,* **field checking** is necessary to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the land is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the C areas are classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

D: Trees and shrubs in narrow linear formation. Trees here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with* TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25m.*

E: Mosaic of crop fields, roads and pasture, with trees isolated or in small groups (canopy cover slightly above 5 %). All trees here are TOF.

The land is classified as **Other Land *with* TOF** *because the land is mainly used for agriculture and housing structures, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

Interpretation 2

A+: OL*wTOF - AGRI*
(Olw*TC*)

A-: OL*wTOF* – *AGRI*
or *NON A/U*, subset 1

B: OL*wTOF* or FOREST

C: OL*wTOF* or FOREST

D: OL*wTOF* – *AGRI*
or *NON A/U*, subset 2

E: OL*wNoTOF*

E has been further divided to extract small woods (A-). B, C and D are similar to interpretation 1. A has been renamed to A+.

A+: identical to A in interpretation 1

A-: Small patches of trees (<0.5 ha) more or less scattered in crop fields and pastures. All trees are TOF, either because their use is predominantly agricultural, or if not predominantly agricultural, because patches do not reach the area threshold for Forest and Other Wooded Land.

If **the trees have a predominant agricultural use**, then the A- patches are classified as **Other Land *with* TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

If **the trees do not have a predominant agricultural use,** A- patches are also classified as **Other Land *with* TOF**, but this time this is because their tree canopy cover is ≥ 5%, and their area is < 0.5 ha and ≥ 0.05 ha.

B, C, D are similar to interpretation 1

-E: Mosaic of crop fields, roads and pastures with some rare isolated trees or shrubs. All trees are TOF.
The area is classified as **Other Land *with No* TOF** because the land is mainly used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.

Case 9: Trees on pasture land, Spain (39°14’56”N ; 6°35’35”W)

A: OL*wTOF - AGRI*
(Ol*wTC*)

B: OL*wNoTOF*

A: Pastures with an homogenous tree cover. This is a typical landscape of the so-called “Dehesa” agroforestry system. All trees here are TOF.

The whole area is classified as **Other Land *with TOF*** *because the land is mainly used for pasture (thus: Agriculture), the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

In addition, the area can be further classified as **Other Land with tree cover** *because the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

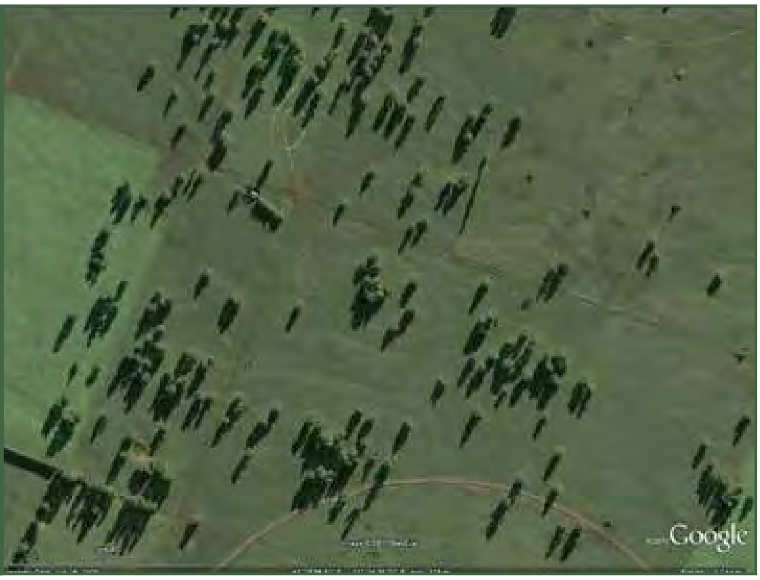
B: Area with houses, pasture and crop fields, with no or scarce isolated trees. All trees are TOF.

The area is classified as **Other Land *with No TOF*** *because the land is used for agriculture and habitation (thus: Other Land), and the tree canopy cover is < 5%.*

Case 10: Trees on pasture land, New Zealand (43°25’56”N ; 174°14’35”E)

Interpretation 1

OLwTOF - AGRI
(OlwTC)



Mosaic of pastures, with trees isolated or in small groups (canopy cover slightly below 10 %). All trees are TOF.

The whole area is classified as **Other Land *with* TOF** *because the land is mainly used for pasture (thus: Agriculture), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

Interpretation 2

A: OLwTOF - AGRI
(OlwTC)

B: OLwNoTOF

A: Mosaic of pastures with trees isolated or in small groups (canopy cover: ca. 15 %). All trees are TOF.

The area is classified as **Other Land *with* TOF** *because the land is mainly used for pasture (thus: Agriculture), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

The area can be further classified as **Other Land with Tree Cover,** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Mosaic of pasture and crop fields, with no or scarce isolated trees. All trees are TOF.

The land is classified as **Other Land *with No* TOF** *because the land is used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.*

Case 11: Trees on pasture land, France (49°17’52”N ; 0°02’31”E)

A: OLwTOF - AGRI or FOREST

B: OLwTOF –AGRI or Non A/U subset 2

C: OLwTOF – AGRI (OLw*TC* pro-parte: C+)

D: OLwNoTOF

E: OLwTOF - AGRI or FOREST

A: Large dense tree patches; because patches are large (≥ 0.5ha) and the canopy cover is dense, **field checking** is necessary to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the area is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

B: Trees in lines (in yellow on the picture). Trees here are TOF, either because they have a predominant agricultural use or, if they have a predominant non-agricultural use, because the line width is < 20m.

The area is in any case classified as **Other Land *with TOF*** *because the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

C: Pastures and crop fields with scattered trees (C) or with a high density of trees (C+). All trees are TOF.

All C patches are classified as **Other Land *with TOF*** *because the land is mainly used for agriculture, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

In addition, all C+ patches can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

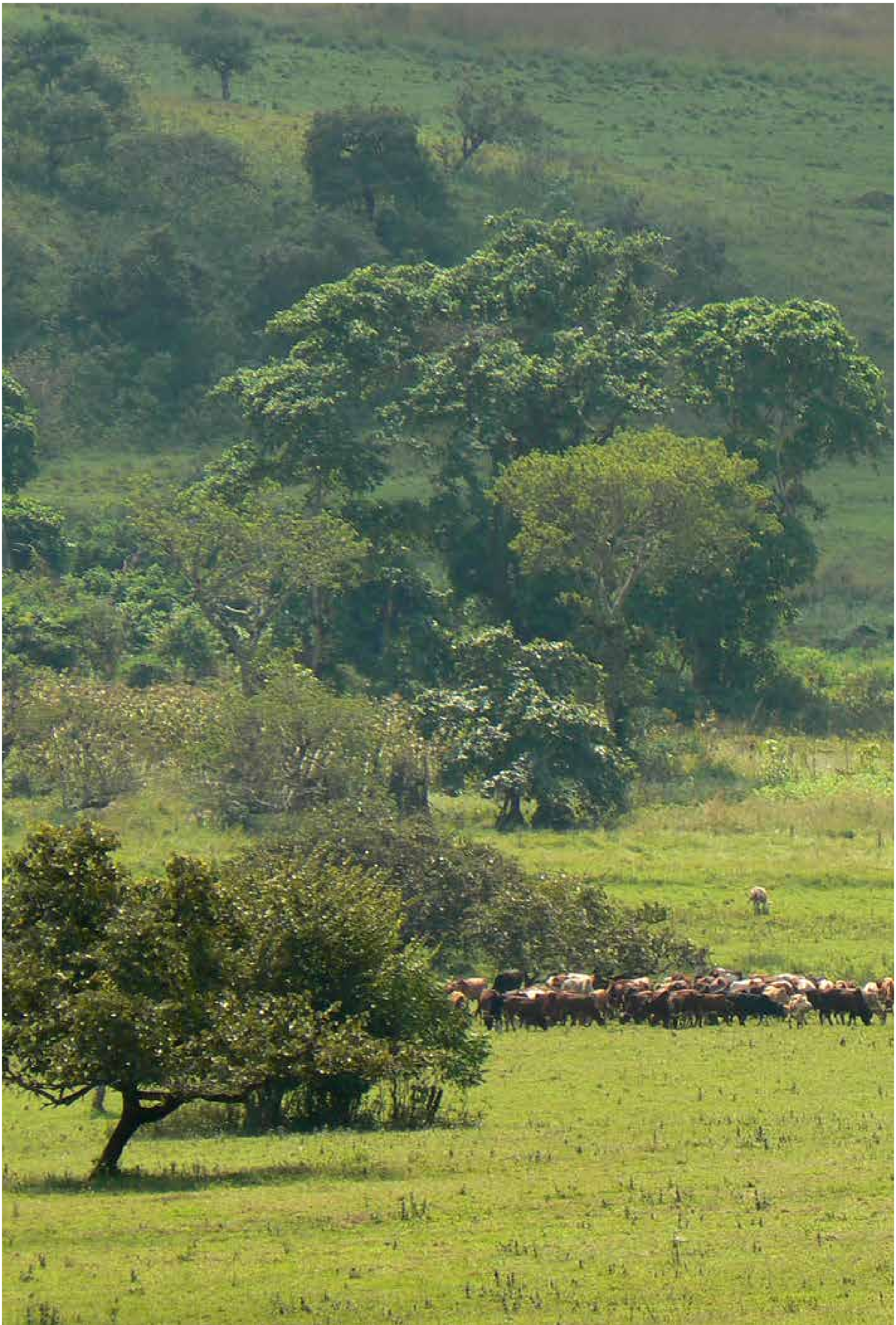
D: Patches of pasture and crop fields, with no or scarce isolated trees. All trees are TOF.

All D patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture and housing structures (thus: Other Land), but the tree canopy cover is < 5%.*

E : Large (width ≥ 20m) linear tree formation (red line on the picture); **field checking** is necessary to identify the land-use.

If trees have a predominant **agricultural use**, then all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, the area is ≥ 0.05 ha and the length is ≥25 m*. It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If trees have a predominant **non-agricultural use**, then the area is classified as **Forest** because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.



1.4. Trees in hedges

Case 12: Trees in hedges, Kerry County, Ireland (53°05'41"N ; 7°18'37"W)

A: OL*wNoTOF*

B: OL*wTOF - AGRI* or *NON A/U*, subset 2

Mosaic of crop fields, houses, roads, and pastures, with trees, either isolated or in linear formation.

A: Mosaic of pasture and crop fields, with no or scarce isolated trees. All trees are TOF.

All A patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture and housing structures (thus: Other Land), but the tree canopy cover is < 5%.*

B: Trees and shrubs in linear formation forming hedges around fields and pastures, or along small paths and roads (yellow line in the picture). Trees here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the combined trees and shrub canopy cover is ≥ 10%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

Case 13: Trees in hedges, Guinea (11°13’15”N ; 12°25’23”W)

A: OLw*NoTOF*

B: OLw*TOF*

C: OLw*TOF -- AGRI*
or *URB*
or NON A/U,
subset 2

Mosaic of crop fields, houses, paths and pastures with trees isolated or in linear formation.

A: Mosaic of pasture and crop fields, with no or scarce isolated trees. All trees are TOF.

The A patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture and housing structures (thus: Other Land), and the tree canopy cover is < 5%.*

B: Mosaic of small patches of houses, pasture and home gardens with scattered trees (canopy cover: ca. 10-15 %). All trees are TOF.

All B patches are classified as **Other Land *with TOF*** *because the land is mainly used for agriculture and housing structures(thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

C: Trees and shrubs in linear formation forming hedges around fields, pastures, or houses. Trees here are TOF, either because they have a predominant agricultural / urban use or, if they have a predominant non-agricultural / non-urban use, because the line width is < 20m.

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the combined trees and shrubs canopy cover is ≥ 10%, and the linear formation width is ≥ 3m with a length ≥ 25m.*

Note: If we consider the settlement as a whole (delineated by a blue line on the picture), merging B patches and C tree lines, its area can not only be classified as **Other Land *with TOF*** (a mix of TOF-AGRI and TOF-URB), but also as **Other Land with Tree Cover,** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

1.5. Tree crops in monoculture plantations

Case 14: Tree crops in monoculture plantations, India (30°12’16”N ; 77°19’40”E)

A: OL*wTOF* - *AGRI* or NON A/U, subset 1

B: OL*wTOF* or FOREST

C: OL*wTOF* - *AGRI* or *NON A/U* subset 2

D: OL*wTOF* - *AGRI* or *NON A/U* subset 2

E: OL*wNoTOF*

A: Small patches of trees. All trees and shrubs are TOF, *either because their use is predominantly agricultural or, if their use is predominantly non-agricultural, because the patches are too small to qualify as Forest (< 0.5 ha).*

The area is in any case classified as **Other Land *with* *TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha, but less than 0.5ha*

B: Large and dense patches of trees with regular tree cover; *because the patches are large (≥ 0.5ha) and the canopy cover is dense,* **field checking** is necessary to identify the land-use.

If **trees have a predominant agricultural use**, then all trees are TOF and the B patches are classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover,** because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.

If **trees have a predominant non agricultural use,** then B patches are classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

In this particular case, it seems that most of these patches are poplar plantations, so these patches have to be classified as Forest.

C: Trees in linear pattern forming hedges around crop fields and plantations. Trees here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non-agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with* *TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

D: Scattered trees following a discontinuous linear formation along the main roads. Trees here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non-agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with* *TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

E: Crop fields and building areas with no or scarce isolated trees. All trees are TOF.

All E patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture and housing structures (thus: Other Land), and the tree canopy cover is < 5%.*

Case 15: Tree crops in monoculture plantations, Orchards, Spain (39°39’25”N ; 0°30’19”W)

A: OL*wTOF* - *AGRI*
(Ol*wTC*)

B: OL*wTOF*
or OWL

C: OL*wTOF* - *URB*
(Ol*wTC*)

A: Mosaic of orchards. All trees are TOF.

The area is classified as **Other Land with *TOF*** *because the main use of the land is agriculture, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover,** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Relatively large areas with no obvious human use, with an irregular shrub cover and with some isolated trees (tree canopy cover < 5%). *Because the area is large (≥ 0.5ha),* has no obvious main use, and the tree and shrub combined canopy cover is higher than 10 %, **field checking** is needed to identify the land-use:

If **agricultural use** (pasture) predominant, all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree and shrub canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

If **non-agricultural use** predominant, the area is classified as **Other Wooded Land**, *because trees are ≥ 5m high, the combined tree and shrub canopy cover is above 10 %, and the area is ≥ 0.5 ha.*

C: Urban area with trees around houses and roads.

The land is classified as **Other Land *with TOF*** *because the land is predominantly used for housing structures, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover,** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Case 16: Tree crops in monoculture plantations, Chiapas, Mexico (39°39'25"N ; 0°30'19"W)

A: OL*wTOF - AGRI* **(OL*wTC*)** **or FOREST**

B: OL*wNoTOF*

C: OL*wTOF* **or FOREST**

D: OL*wTOF - AGRI* **or** *NON A/U* **subset 2**

A: Large and dense mosaic of tree plantations with regularly distributed tree cover; *because the patches are large (≥ 0.5ha) and the tree cover is dense,* **field checking** is necessary to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the area is classified as **Other Land *with* TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover,** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, classified as Forest because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha

In this case, **field checking** shows that the area is covered by mango orchards. The area is thus classified as **Other Land *with* TOF** and as **Other Land with Tree Cover.**

B: Crop fields with no or scarce isolated trees. All trees are TOF.

All B patches are classified as **Other Land *with* No TOF** *because the land is used for agriculture and housing structures (thus: Other Land), but the tree canopy cover is < 5%.*

C: Large and dense patch of trees with an irregular mixed tree cover (canopy cover: ca. 60 %); *because the patches are large (≥ 0.5ha) and the tree canopy cover is dense (≥ 10%),* **field checking** is necessary to identify the land-use.

If **agricultural use** predominant, all trees are **TOF** and the land is classified as **Other Land *with* TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover,** *because area is ≥ 0.5 ha, and tree ≥ 10%.*

If **non-agricultural use**, classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

In this case, **field checking** reveals that the area is an agroforest all trees here are TOF because the area is a complex agroforest with fruit trees, coffee and cocoa trees. The area is then classified as **Other Land *with* TOF** and as **Other Land with Tree Cover**.

D: Trees and shrubs in linear formation along the road. They are TOF, *either because they have a predominant agricultural use or, if they have a predominant non-agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with* TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

Case 17: Tree crops in monoculture plantations, Crete (35°14’33”N ; 25°05’10”E)

A: OL*wTOF - AGRI*
(Olw*TC*)

B: OL*wNoTOF*

C: OL*wTOF - AGRI*
(Olw*TC*)
or FOREST

A: Mosaic of orchards. All trees are TOF.

The area is classified as **Other Land *with TOF*** *because the main use of the land is agriculture, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Crop fields with no or scarce isolated trees. All trees are TOF.

All B patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture and housing structures (thus: Other Land), and the tree canopy cover is < 5%.*

C: Area with an irregular tree and shrub canopy cover (canopy cover between 25 and 50 %). In this case, the image quality is not good enough to determine the content of the area, whether it consists of old orchards or natural areas.

If the use is **predominantly agricultural**, the C patches are classified as **Other Land *with TOF*** *because the main use of the land is agriculture, trees are ≥ 5m high, the combined tree and shrub canopy cover is ≥ 10%, and the area is ≥ 0.05 ha.* They can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If natural areas with **no predominant agricultural** use such as pasture, the C patches are classified as **Forest**, *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

Case 18: Tree crops in monoculture plantations, Sumatra, Indonesia (3°30’03”N ; 98°49’14”E)

A: OL*wTOF - AGRI* (Ol*wTC*)

B: OL*wNoTOF*

C: OL*wTOF - URB* (Ol*wTC*)

D: OL*wNoTOF*

A: Large mosaic of oil palm trees with a regular and very dense tree cover. All trees are TOF.

The whole area is classified as **Other Land *with* *TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree ≥ 10%.*

B: Crop fields with no or scarce isolated trees. All trees are TOF.

All B patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture and housing structures (thus: Other Land), but the tree canopy cover is < 5%.*

C: Settlement area with homegardens, houses and roads.

The area as a whole is classified as **Other Land *with TOF*** *because the land is mainly used for housing structures and homegardens, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

D: Area with no or scarce isolated trees, probably a flooded area. All trees are TOF.

The area is classified as **Other Land *with No TOF*** *because the tree cover is below the canopy cover threshold and cannot be classified as Forest or Other Wooded Land (thus: Other Land), and the tree canopy cover is < 5%.*

1.6. Trees in homegardens

Case 19: Homegardens, Karnataka, India (14°01'54"N ; 74°30'59"E)

A: OL*wTOF - AGRI*
(Ol*wTC*)
or FOREST

B: OL*wNoTOF*

C: OL*wTOF - AGRI*
OR *NON A/U*
subset 2

A: patches of trees with a dense, irregular tree cover, with small grassland patches and houses. Because the patches are large (≥ 0.5ha) the canopy cover is dense, even though human activity signs are present, **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the land is classified as **Other Land *with TOF*** because *trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the land is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

Field checking reveals that A patches are made up of a juxtaposition of homegardens, thus agricultural use, so that A patches should be classified as **Other Land *with TOF***. They can be further classified as **Other Land with Tree Cover**.

B: Crop fields, pastures and houses with no or scarce isolated trees. All trees are TOF.

All B patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture and housing structures (thus: Other Land), but the tree canopy cover is < 5%.*

C: Trees and shrubs in linear formation forming hedges around fields or pastures. Trees here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

Case 20: Homegardens, truffle orchards, France (45°17'58"N ; 0°52'30"E)

A: OLwNoTOF

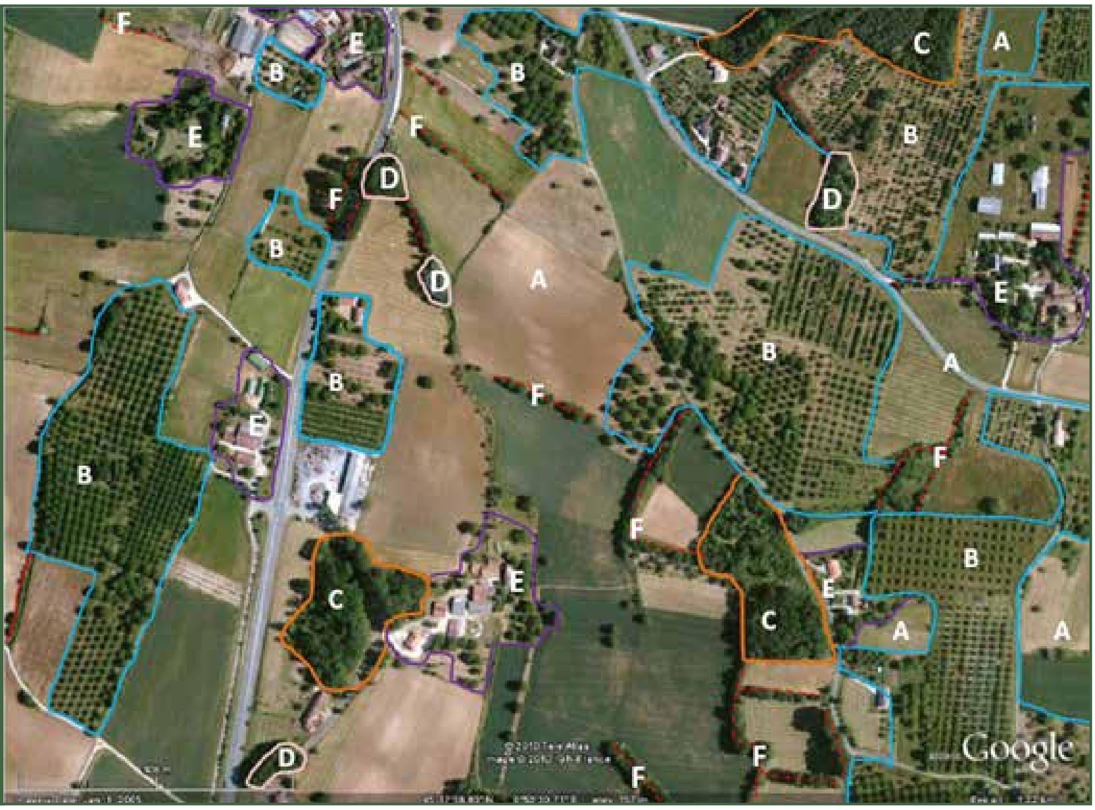
B: OLwTOF - AGRI (OLwTC) or FOREST

C: OLwTOF - AGRI (OLwTC) or FOREST

D: OLwTOF - AGRI or NON A/U subset 1

E: OLwTOF - AGRI - URB

F: OLwTOF - AGRI or NON A/U subset 2



A: Mosaic of crop fields with some houses, with no or scarce isolated trees (canopy cover below 5 %). All trees are TOF.

All A patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture and housing structures (thus: Other Land), and the tree canopy cover is < 5%.*

B: Large patches with dense and very regular tree canopy cover. Because the patches are large (≥0.5ha), the canopy cover is dense and even though human activity signs are present, **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the land is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the land is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

Field checking reveals that B patches are truffle orchards, thus agricultural use, so in this case the B patches should be classified as **Other Land *with TOF***.

They can also be further classified as **Other Land with Tree Cover.**

C: Large patches with dense and irregular tree canopy cover. *Because the patches are large (≥ 0.5ha), the canopy cover is dense,* **field checking** is needed to identify the land-use.

If agricultural use predominant, all trees are TOF and the C patches are classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* They can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the C patches are classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

D: Small patches of trees (<0.5 ha) with dense tree canopy cover, in crop fields. All trees are TOF, *either because their use is predominantly agricultural, or if not predominantly agricultural, because patches do not reach the area threshold for Forest and Other Wooded Land.*

The D patches are in any case classified as **Other Land *with* TOF** *because their tree canopy cover is ≥ 5%, and their area is <0.5 ha but ≥ 0.05 ha.*

E: Patches of houses and buildings with trees isolated or in small groups. All trees are TOF.

The E patches are classified as **Other Land *with TOF*** *because the land is mainly used for agriculture and housing structures (thus: Other Land), the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

They can be further classified as **Other Land with Tree Cover**, *because their area is ≥ 0.5 ha, and their tree canopy cover is ≥ 10%.*

F: Trees and shrubs in linear formation forming hedges around fields. Trees here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non-agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

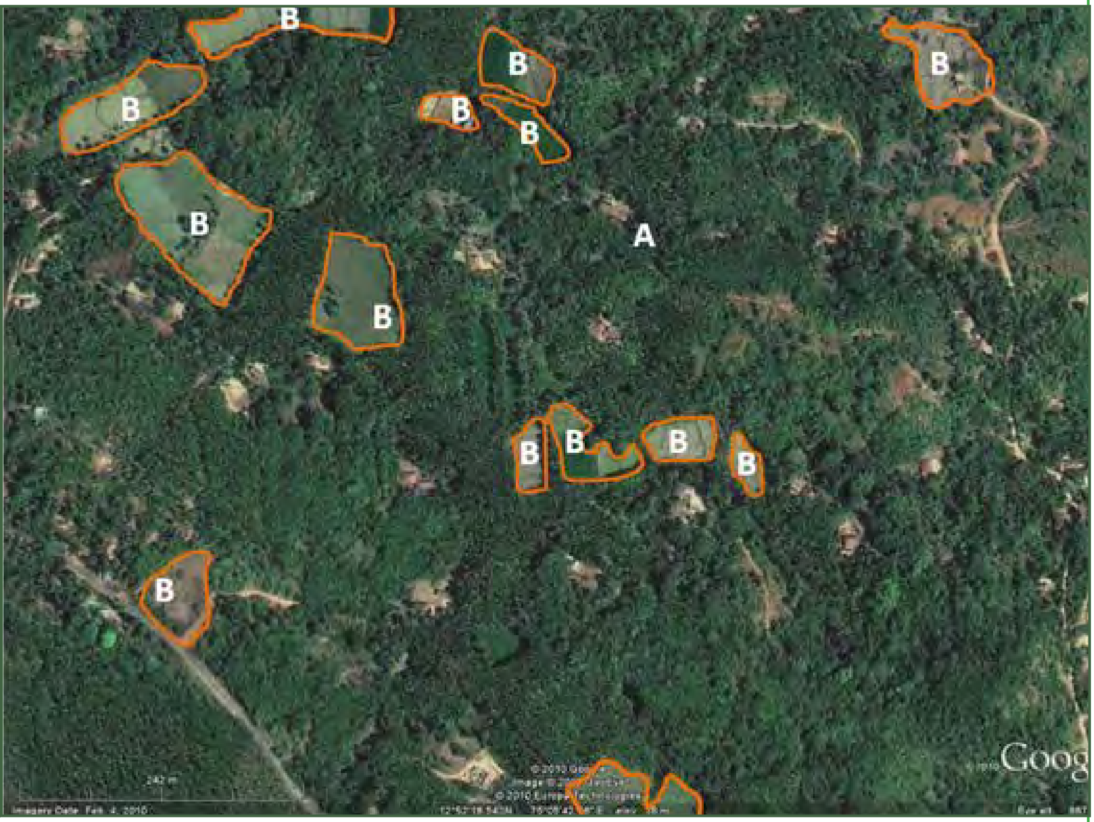
1.7. Trees in agroforests of the Humid Tropics

Note: because of their tree density and their more or less irregular canopy cover, agroforests in the humid tropics most often cannot be distinguished from forests using only the land-cover criterion. Field checking or an expert knowledge of the land-use in the assessed area is absolutely needed

Case 21: Trees in agroforests, India (12°52’18”N ; 75°05’42”E)

A: OLw*TOF* - *AGRI*
(OLw*TC*)
or FOREST

B: OLw*NoTOF* - *AGRI*
or NON A/U
subset 2



A: A matrix with a dense, irregular tree cover, with some small crop fields, grassland patches and houses. Because the area is large (≥ 0.5ha), and the canopy cover is dense; **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the whole area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the area is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

Field checking reveals that the area is a juxtaposition of coffee agroforest plots, thus agricultural use, so in this case the area should be classified as **Other Land *with TOF*** and as **Other Land with Tree Cover**.

B: Patches of crop Fields with no or scarce isolated trees. All trees are TOF.

The B patches are classified as **Other Land *with No TOF*** *because the land is used for agricultural activities and housing structures (thus: Other Land), and the tree canopy cover is < 5%.*

Case 22: Trees in agroforests, Guinea-Bissau (11°59’11”N ; 16°13’16”W)

A: OLw*TOF - AGRI*
(OLw*TC*)
or FOREST

B : OLw*TOF - URB*

C: OLw*NoTOF*

A: A large treed patch with a dense, irregular tree and palm cover, with some bare soil (canopy cover: ca. 80 %). *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are obvious signs of human activity interlinked with the trees,* **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF, and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the area is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

Field checking reveals that it is an oil palm agroforest, thus agricultural use, so in this case the area should be classified as **Other Land *with TOF*** and **Other Land with Tree Cover**.

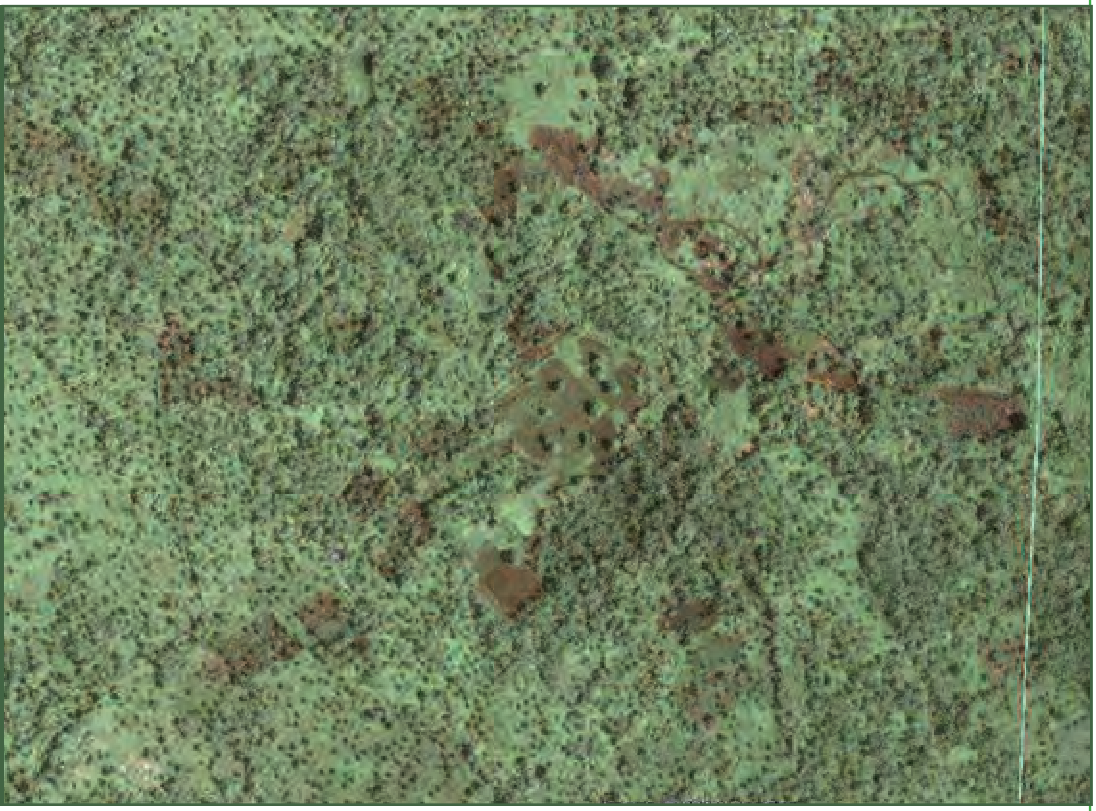
B: Houses and buildings with isolated trees. All trees here are TOF, and the area is classified as **Other Land *with TOF*** *because the land is in an urban context, where trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

C: Area with mostly bare soil or herbaceous vegetation, with no or scarce isolated trees. All trees are TOF.

The area is classified as **Other Land *with No TOF*** because the tree canopy cover is < 5%.

Case 23: Trees in agroforest, Sulawesi, Indonesia (1°26'16"N ; 125°05'18"E)

OLw*TOF - AGRI*
(OLwTC)
or FOREST



Area with relatively dense and irregular palm tree cover with some small grassland patches. *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are obvious sign of human activity interlinked with the trees,* **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the land is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

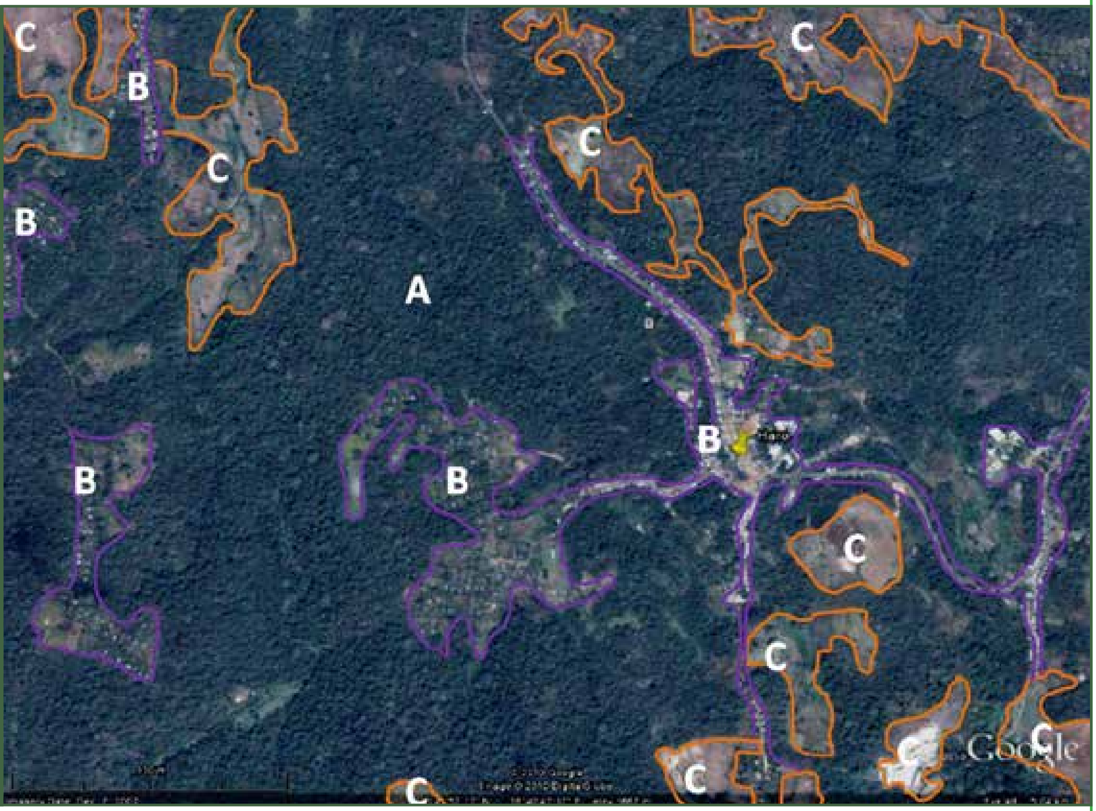
Field checking reveals that it is an area of coconut agroforestry, thus agricultural use, so in this case the area should be classified as **Other Land *with TOF*** and as **Other Land with Tree Cover**.

Case 24: Trees in agroforest, Haro, Jima zone, Ethiopia (7°48’52”N ; 36°40’47”E)

A: OLwTOF - AGRI (OLwTC) or FOREST

B : OLwTOF - URB - AGRI

C: OLwNoTOF



A: Large treed area with dense, irregular tree cover with a few bare soil patches. *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are obvious signs of human activity interlinked with the trees,* **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF, and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the area is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

Field checking reveals that it is a coffee agroforest, thus agricultural use, so in this case the land should be classified as **Other Land *with TOF*** and as **Other Land with Tree Cover**.

B: Houses, roads and paths with trees, isolated or in small groups. All trees here are TOF.

The B patches are classified as **Other Land *with TOF*** *because the land is in an urban and agricultural context, where trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* They can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

C: Crop fields and paths with no or scarce isolated trees. All trees are TOF.

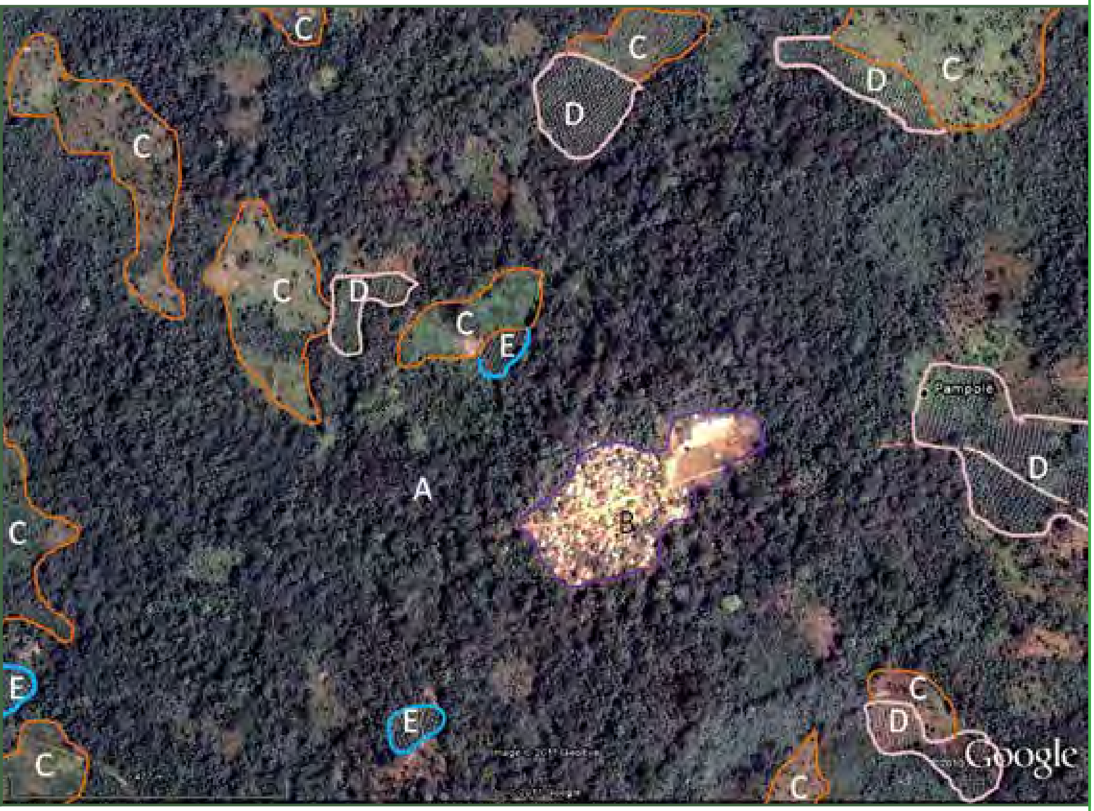
The C patches are classified as **Other Land *with No TOF*** *because the land is used for urban activities and housing structures (thus: Other land), and the tree canopy cover is < 5%.*

Case 25: Trees in agroforest, Guinea (7°26'58"N ; 9°06'21"W)

A: OLw*TOF* - *AGRI* (OLw*TC*) or FOREST

B : OLw*TOF* - *URB* - *AGRI*

C: OLw*NoTOF*



A: A matrix with a dense, irregular tree and palm cover with some bare soil and herbaceous vegetation patches. *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are signs of human activity (houses and fields) interlinked with the trees,* **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the land is classified as **Other Land *with* TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the land is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

Field checking reveals that it is a mixed agroforest (coffee, cocoa, kola nut, etc), thus agricultural use, so in this case the area should be classified as **Other Land *with* TOF** and as **Other Land with Tree Cover**.

B: Village with houses and roads, with some trees, isolated or in small groups. All trees here are TOF and the area is classified as **Other Land *with* TOF** *because the land is in an urban and agricultural context, where trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

C: Crop fields and paths with isolated trees. All trees here are TOF and the C patches are classified as **Other Land *with* TOF** *because the land is mainly used for agriculture, where trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

D: Large patches with a dense cover of palm trees. *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are obvious signs of human activity interlinked with the trees,* **field checking** is needed to identify the land-use (same possibilities than in A).

Field checking reveals that D patches are Oil-palm plantations, thus agricultural use, so that D patches should be classified as **Other Land *with* TOF** and as **Other Land with Tree Cover**.

E: Small patches of palm trees (<0.5 ha) with dense tree canopy cover close to crop fields. All trees are TOF.

The E patches are classified as **Other Land *with* TOF** *because the land is mainly used for agriculture, the tree canopy cover is ≥ 5%, and the area is <0.5 ha but ≥ 0.05 ha.*

Case 26: Trees in agroforest, Sumatra, Indonesia (1°46'16"S ; 103°12'48"E)

A: OLw*TOF - AGRI*
(OLw*TC*)
or FOREST

B : OLw*NoTOF*

C: OLwTOF - URB

A: A matrix of treed vegetation with a dense and irregular tree canopy cover and some small grassland patches. *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are obvious signs of human activity interlinked with the trees,* **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

In this particular case, field checking reveals that the whole area is a rubber agroforest, so this area should be classified as **Other Land *with TOF*** and as **Other Land with Tree Cover**.

B: Large patches of crop fields with no or scarce isolated trees. All trees are TOF.

The B patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture activities (thus: Other Land), and the tree canopy cover is < 5%.*

C: Village with houses along a main road with trees, isolated or in small groups.

All trees here are TOF and the land is classified as **Other Land *with TOF*** *because the land is in an urban and agricultural context, where trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Case 27: Trees in agroforest, Sumatra, Indonesia (5°00’40”S ; 104°06’32”E)

Interpretation 1

OLwTOF - AGRI
(OLw*TC*)

The image can be interpreted in two different ways, depending on the resolution chosen for the assessment.

Complex mosaic of crop fields, houses and coffee agroforestry plantations. The coffee agroforestry system in this case is based on a cycle made up of two phases. The first phase is a plantation of vegetables with young coffee and Erythrina trees. The second phase is the mature coffee-Erythrina plantation. Because of the predominantly agricultural and urban use of the area, all the trees here are TOF.

The whole area is classified as **Other Land *with TOF*** *because the main use of the land is agriculture, the trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

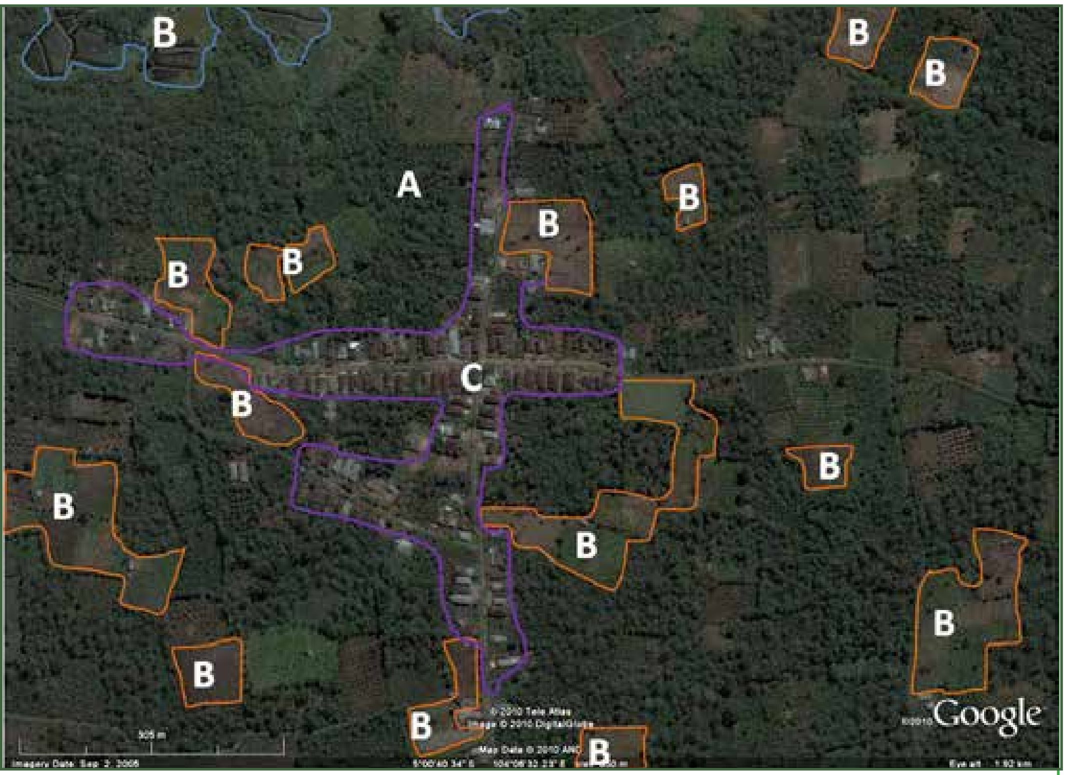
It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Interpretation 2

A: OLw*TOF - AGRI*
(OLw*TC*)
or FOREST

B: OLw*NoTOF*

C: OLw*TOF - URB*



A: A matrix of treed vegetation with a dense, irregular tree canopy cover and some small bare soil and small crop field patches. *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are obvious signs of human activity (houses and fields) interlinked with the trees,* **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If ***non-agricultural use***, the area is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

Field checking reveals that it is a coffee agroforest, thus agricultural use, so in this case the land should be classified as **Other Land *with TOF*** and as **Other Land with Tree Cover.**

B: Large area of crop fields and paths with no or scarce isolated trees. All trees are TOF.

The B patches are classified as **Other Land *with No TOF*** *because the land is used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.*

C: Village with houses and roads with isolated trees or in small groups. All trees here are TOF.

Area C is classified as **Other Land *with TOF*** *because the land is mainly used for housing, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Case 28: Trees in agroforest, Mexico (15°03’46”N ; 92°20’12”W)

A: OL*wTOF - AGRI*
(OL*wTC*)
or FOREST

B : OL*wTOF - URB*

A: Matrix of treed vegetation with a dense and irregular tree canopy cover and some scattered houses. *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are obvious signs of human activity (houses) interlinked with the trees,* **field checking** is needed to identify the land-use.

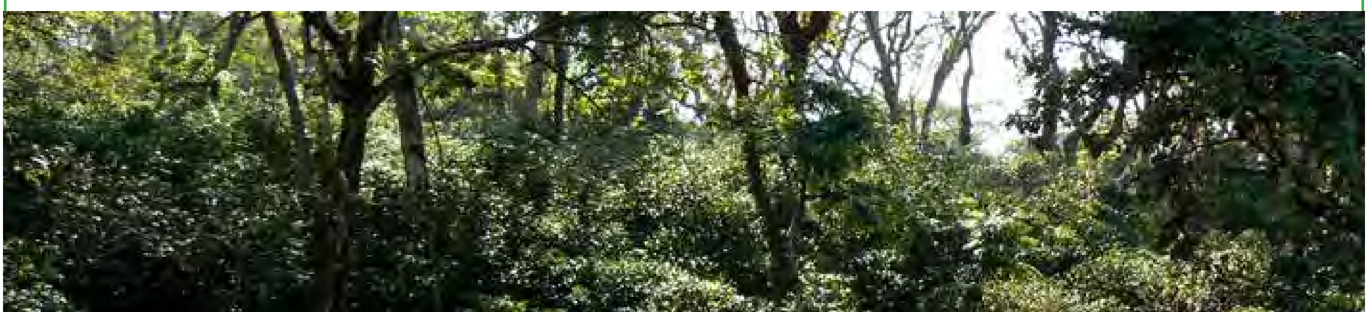
If **agricultural use** predominant, all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, the area is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

Field checking reveals that it is a coffee agroforest, thus agricultural use, so in this case the area should be classified as **Other Land with *TOF*** and as **Other Land with Tree Cover.**

B: Village with houses and roads, with trees isolated or in small groups (canopy cover: ca.30 %). All trees here are TOF and the area is classified as **Other Land *with TOF*** *because the land is in an urban and agricultural context, where trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*



Case 29: Trees in agroforest, Sumatra, Indonesia (5°03’15.86»S 103°50’02.15»E)

A: OLw*TOF - AGRI*
(OLw*TC*)
or FOREST

B : OLw*NoTOF*

A: A matrix of treed vegetation, with a dense and irregular tree canopy cover and some small grassland patches. *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are obvious signs of human activity interlinked with the trees,* **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

In this particular case, **field checking** reveals that this is a Damar agroforestry system, thus agricultural use, so this area should be classified as **Other Land *with TOF*** and as **Other Land with Tree Cover**.

B: Large crop fields with no or scarce isolated trees. All trees are TOF.

The B fields are classified as **Other Land *with No TOF*** *because the land is used for agriculture (thus: Other land), and the tree canopy cover is < 5%.*

1.8. Trees in shifting cultivation systems (Humid Tropics)

Shifting cultivation in the humid tropics produces an ever changing landscape. If looked at a certain time, there are areas with trees and areas without trees, but the system is dynamic and interlinked, and this has to be taken into consideration when mapping areas with TOF or without TOF.

Case 30: Trees in shifting cultivation system, Guinea (10°06’47”N ; 12°13’04”W)

OLw*TOF* - *AGRI*
(OLw*TC*)
or FOREST

An intricate and complex matrix of crop fields, housing structures, areas with irregular tree cover and grassland patches. This is a typical pattern of shifting cultivation in the humid tropics. Trees are dominant in the fallow part of the system, which alternates crops and fallows. Trees are thus an integral part of this agricultural system.

The first option that comes to mind is delineation of the treed areas, the crop field areas, the herbaceous fallow areas, the bare soil areas, and the village area.
However this option would miss the fact that except for the village area, all these land cover categories are constantly moving their location and borders – a given area is a crop field this year, a herbaceous fallow the year after, a tree fallow two years after, a bare soil patch 15 year after, and again a crop field 16 years after. This is much as in a “Forest” where timber harvesting is followed by a bare soil phase and then by a young treed vegetation - that does not satisfy the canopy cover thresholds of a “Forest” but is still considered as a “Forest”.

The second option, the only option that respects the dynamic nature of shifting cultivation as an agricultural systems is to consider the area as a whole. This report thus fully supports this second option.

The whole area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* Moreover, it should be classified as **Other Land with Tree Cover**, *because the area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

TOF-URB

2.1. Trees in large urban centers

Case 31: Trees in large urban center, Darwin, Australia (12°30'04"S ; 130°58'46"E)

OLwTOF - URB
(OLw*TC*)

Treed residential urban matrix, with abundant trees planted in private gardens, along houses and along streets. All trees here are TOF *because the land has a predominant urban land-use.*

The whole area is classified as **Other Land *with TOF*** *because the land is in an urban context, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

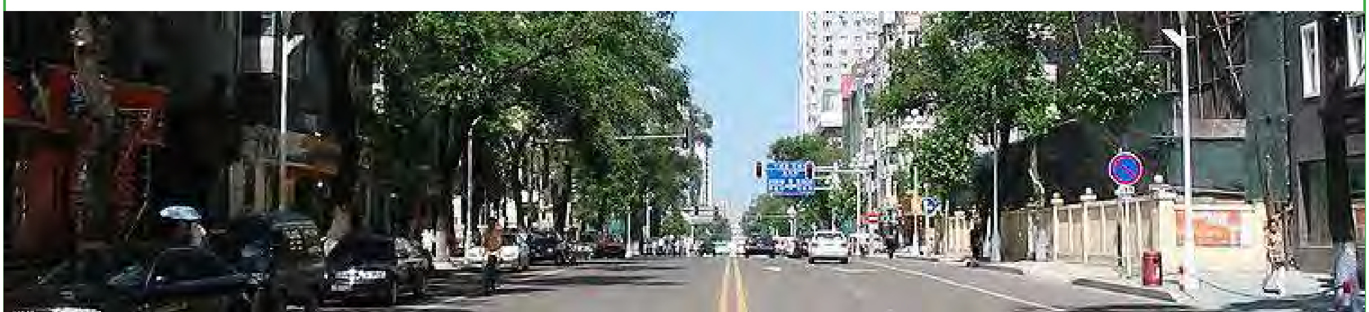
Case 32: Trees in large urban center, Harbin, China (45°44’56”N ; 126°38’05”E)

OLwTOF - URB
(OLw*TC*)

Urban matrix with scarce trees planted along buildings and streets, in a linear structure or in small groups. All trees here are TOF, because the land has a predominant urban land-use.

The whole area is classified as **Other Land *with TOF*** *because of its urban context, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*



Case 33: Trees in large urban center, Montpellier, France (43°37'23"N ; 3°52'01"E)

A: OLw*TOF – URB* (OLw*TC*)

B: OLw*TOF – URB* (OLw*TC*)

C: OLw*NoTOF*

Urban matrix made up of houses, buildings, roads and residential green areas. Trees are planted in linear structure along buildings, parking lots and streets, in small groups in green areas or more or less isolated in gardens. All trees are TOF *because the land has a predominant urban land-use*. The whole area may be interpreted as **Other Land *with* TOF** (and as **Other Land with Tree Cover**). If needed, a finer resolution may also lead to the following interpretation:

A: Large tree patches with dense and irregular tree cover. The main use of the land is recreational, so all trees here are TOF.

The A patches are classified as **Other Land *with TOF*** *because of their urban land-use, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

They can be further classified as **Other Land with Tree Cover**, *because their area is ≥ 0.5 ha, and their tree canopy cover is ≥ 10%.*

B: Urban area with trees planted along building and streets. Trees, isolated or in small groups, are planted in small green areas. All trees here are TOF.

The area is classified as **Other Land *with TOF*** *because of its urban context, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

C: Large area (≥0.5ha) with no trees.

This area is classified as **Other Land *with No TOF*** because of its urban context (thus: Other Land), and the tree canopy cover is < 5%.

Case 34: Trees in large urban center, Hamburg, Germany (53°34'33"N ; 9°56'54"E)

Interpretation 1:

OLwTOF – URB
(OLw*TC*)

Treed urban matrix, with abundant trees planted along houses, buildings and along streets, in linear formation or in small groups in urban parks. All trees here are TOF, *because the land has a predominant urban land-use.*

The whole area is classified as **Other Land *with TOF*** *because the land is in an urban context, trees are ≥ 5m high, tree canopy cover is ≥ 5%, and area is ≥ 0.05ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Interpretation 2:

A: OLw*TOF – URB* (OLw*TC*)

B: OLw*TOF – URB* (OLw*TC*)

C: OLw*NoTOF*

A: Treed urban matrix, with abundant trees planted along buildings, houses and along streets, in linear structure or isolated in urban plots. All trees here are TOF *because the land has a predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Large patches (≥*0.5 ha*) with dense and irregular tree cover. The main use of the land is recreational. All trees here are TOF *because the land has a predominant urban land-use.*

The B patches are classified as **Other Land with TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

They can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

C: Large area *(≥0.5 ha)* with no or scarce isolated trees. All trees are TOF.

The C patches are classified as **Other Land *with No TOF*** *because the land is used for urban activities (thus: Other land), and the tree canopy cover is < 5%.*

Case 35: Trees in large urban center, Christchurch, New-Zealand (43°31'33"S ; 172°35'39"E)

A: OL*wTOF – URB*
(OL*wTC*)

B: OL*wTOF – URB*
(OL*wTC*)
or FOREST

C: OL*wNoTOF*

A: urban matrix, with abundant trees along streets, in private gardens, on parking lots. All trees here are TOF, *because the land has a predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Large forest-like patch with dense, irregular tree cover. *Because the patch is large (> 0.5ha) and the canopy cover is dense, even though there is human activity nearby,* **field checking** is needed to identify the land-use.

If **urban use** predominant (recreational), all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-urban use**, the area is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

C: Sport ground with no trees.

The area is classified as **Other Land *with No TOF*** *because the land is used for urban activities (thus: Other Land), and the tree canopy cover is < 5%.*

Case 36: Trees in large urban center, Western Malaysia (5°30'33"N ; 100°25'44"E)

A: OLw*TOF – URB*
(OLw*TC*)

B: OLw*TOF – URB*
(OLw*TC*)

C: OLw*NoTOF*

A: Treed urban matrix, with abundant trees planted along buildings, houses and along streets, in linear structure or isolated in urban plots. All trees here are TOF *because the land has a predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Large patches *(≥0.5 ha)* with dense and irregular tree cover. The main use of the land is recreational. All trees here are TOF, *because the land has a predominant urban land-use.*

The B patches are classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

They can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

C: Large area *(≥0.5 ha)* with no or scarce isolated trees. All trees are TOF.

The C patches are classified as **Other Land *with No TOF*** *because the land is used for urban activities (thus: Other land), and the tree canopy cover is < 5%.*

Case 37: Trees in large urban center, Marrakech, Morocco (31°37’42”N ; 8°00’04”W)

A: OL*wTOF – URB* (OL*wTC*)

B: OL*wTOF – URB* (OL*wTC*)

A: Treed urban matrix, with abundant trees planted along buildings, houses and along streets, in linear structure or isolated in urban plots. All trees here are TOF *because the land has a predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Large patch *(≥0.5 ha)* with dense and irregular tree cover. The main use of the land is recreational. All trees here are TOF *because the land has a predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.

Case 38: Trees in large urban center, Namibia (17°47’05”S ; 15°41’35”E)

OLwTOF – URB

Urban matrix with scarce trees scattered along buildings and roads, isolated or in small groups. All trees here are TOF *because the land has a predominant urban land-use.*

The whole area is classified as **Other Land *with TOF*** *because of its urban context, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

A precise evaluation of the canopy cover would be necessary to know if the area qualifies as **Other Land with Tree Cover** or not…

Case 39: Trees in large urban center, Nicaragua (13°29’01”N ; 86°34’45”W)

A: OLw*TOF – URB*
(OLw*TC*)

B: OLw*TOF – AGRI*
(OLw*TC*)
or FOREST

C: OLw*NoTOF*

A: Treed urban matrix, with abundant trees planted along buildings, houses and roads, in small groups or isolated. All trees are TOF *because of the predominant urban land-use.*

All trees here are TOF and the land is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: A large patch with dense and irregular tree cover. *Because the area is large (≥ 0.5ha) and the canopy cover is dense, even though there are obvious signs of human activity interlinked with the trees,* **field checking** is needed to identify the land-use.

If **agricultural or recreational urban use** predominant, all trees are TOF and the patch is classified as **Other Land** *with TOF because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural and non recreational urban use**, the patch should be classified as **Forest** *because trees are ≥ 5m high, canopy cover is ≥10 %, and area is ≥ 0.5 ha*

C: Large patches with no or scarce isolated trees and shrubs. All trees and shrubs are TOF, *because of the predominant urban land-use.*

The C patches are classified as **Other Land *with No TOF*** *because the land is used for urban activities (thus: Other Land), and the tree canopy cover is < 5%.*

Case 40: Trees in large urban center, Niger (13°30’09”N ; 7°46’32”E)

A: OL*wTOF – URB*
(OL*wTC*)

B: OL*wNoTOF*

C: Inland Water

A: Urban area with trees and shrubs along buildings, houses and streets, either isolated or in small groups (canopy cover: ca. 20 %). All trees are TOF *because of the predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Patches of urban area with no or scarce isolated trees. All trees are TOF, *because of the predominant urban land-use.*

The B patches are classified as **Other Land *with No TOF*** *because the land is used for urban activities (thus: Other Land), and the tree canopy cover is < 5%.*

C: A water reservoir, classified as Inland Water.

Case 41: Trees in large urban center, Senegal (12°33'55"N ; 16°17'45"W)

A: OL*wTOF – URB*
(OL*wTC*)

B: OL*wNoTOF*

Urban matrix of houses, buildings and roads. Trees are planted scattered among the buildings, and roads, in small groups in green areas or isolated in gardens. All trees are **TOF**.

A: Urban area with trees and shrubs along buildings, houses and streets, either isolated or in small groups (canopy cover: ca. 25 %). All trees are TOF *because of the predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Patches of urban area and crop fields with no or scarce isolated trees. All trees are TOF, because of the predominant urban land-use.

The B patches are classified as **Other Land *with No TOF*** *because the land is used for urban activities or agriculture (thus: Other Land), and the tree canopy cover is < 5%.*

Case 42: Trees in large urban center, Singapore (1°19’05”N ; 103°47’46”E)

OLwTOF – URB
(OLw*TC*)

Treed urban matrix, with abundant trees planted along houses, buildings and streets, in linear formation or in small groups in urban parks and gardens (canopy cover: ca. 35 %). All trees are TOF because of the predominant urban land-use.

The area is classified as **Other Land *with TOF*** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Case 43: Trees in large urban center, Los Angeles, USA (33°48’17”N ; 118°05’20”W)

A: OLw*TOF – URB*
(OLw*TC*)

B: OLw*TOF – URB*
(OLw*TC*)

C: OLw*NoTOF*

A: Treed urban matrix, with abundant trees planted along houses, buildings and streets, in linear formation or in small groups in urban parks and gardens (canopy cover: ca. 35 %). All trees are TOF, *because of the predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: A golf course on the left and a urban park on the left, forming a large “green area” with a relatively dense tree cover (canopy cover: ca. 50%). The main use of the land is recreational, in an urban context, so all trees here are TOF.

The area is classified as **Other Land *with TOF*** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

C: Relatively large patches (≥0.5 ha) with no or scarce isolated trees. All trees are TOF *because of the predominant urban land-use.*

The C patches are classified as **Other Land *with No TOF*** *because the land is used for urban activities or agriculture (thus: Other Land), and the tree canopy cover is < 5%.*

Note: A and B are obviously different. However they belong to the same category and could thus have been merged…

Case 44: Trees in large urban center, Los Angeles, USA (33°46'30"N ; 117°59'38"W)

A: OLw*NoTOF*

B: OLw*TOF – URB* (OLw*TC*)

A: Urban matrix with no or scarce isolated trees. All trees are TOF *because of the predominant urban land-use.*

The area is classified as **Other Land *with No TOF*** *because the land is used for urban activities (thus: Other Land), and the tree canopy cover is < 5%.*

B: Parking lot with homogeneously distributed trees (canopy cover: ca. 15 %), mainly for shading. All trees are TOF, *because of the predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as O**ther Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Case 45: Trees in large urban center, South Western, India (12°51’57”N ; 74°51’00”E)

Interpretation 1:

OLwTOF – URB
(OL*w*TC)

Treed urban matrix with a few bare soil patches and with abundant trees and palms in small groups close to houses, buildings and streets (canopy cover: ca. 60%). All trees are TOF *because of the predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Interpretation 2:

A: OL*wTOF – URB* (OL*wTC*)

B: OL*wTOF – URB* (OL*wTC*) or FOREST

A: Treed urban matrix with a few bare soil patches and with abundant trees and palms in small groups close to houses, buildings and streets (canopy cover: ca. 45%). All trees are TOF *because of the predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.

B: Large patches with dense and irregular tree and palm cover. *Because the area is large (≥ 0.5ha) and wide (≥ 20m), and the canopy cover is dense, even though it is in an urban context,* **field checking** is needed to identify the land-use.

If **agricultural use or urban use** predominant, all trees are TOF and the B patches are classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* They can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If the use is predominantly **non-agricultural/non-urban**, the B patches are classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

Case 46: Trees in large urban center, San Diego, California, USA (33°11'23"N ; 117°12'50"W)

OL*wTOF* – *URB*
(OL*wTC*)

Urban landscape with buildings, houses and streets, with trees and shrub isolated, in small groups in gardens or in a small orchard (Oranges).

All trees and shrubs here are TOF and the land is classified as **Other Land *with TOF*** *because the land is used for urban activities, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

2.2 Trees in small urban centers

Case 47: Trees in small urban center, China (35°40’04”N ; 119°47’02”E)

A: OL*wTOF – URB*
(OL*wTC*)

B: OL*wNoTOF*

A: Urban matrix with trees along houses and streets, isolated or in small groups (canopy cover: ca. 30 %). All trees are TOF *because of the predominant urban land-use.*

The area is classified as **Other Land with TOF** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: A mosaic of crop fields with no or scarce isolated trees. All trees are TOF *because of the predominant agricultural land-use.*

The area is classified as **Other Land *with No TOF*** *because the land is used for agricultural activities (thus: Other Land), and the tree canopy cover is < 5%.*

Case 48: Trees in small urban center, Eastern India (25°08'42"N ; 86°35'23"E)

A: OLw*TOF – URB*
(OLw*TC*)

B: OLw*NoTOF*

C: OLw*TOF – AGRI*
(OLw*TC*)

D: OLw*TOF – AGRI*
or Non A/U,
subset 2

A: Treed urban matrix, with scattered crop fields and ponds, and with abundant trees, isolated or in small groups, along houses, forming hedges of crop fields, or close to the streets (tree canopy cover: ca. 20 %). All trees are TOF *because of the predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because of its urban context (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Crop fields with no or scarce isolated trees. All trees are TOF *because of the predominant agricultural land-use.*

The area is classified as **Other Land *with No TOF*** *because the land is used for agricultural activities (thus: Other Land), and the tree canopy cover is < 5%.*

C: Home-gardens and orchards forming independent and relatively large (> 0.5 ha) treed patches in the agricultural matrix, with a relatively dense tree cover (canopy cover: ca. 20 to 50 %, depending on the considered patch). All trees are TOF *because of the predominant agricultural land-use.*

The C patches are classified as **Other Land *with TOF*** *because the land is used for agricultural activities (thus: Other Land), trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

They can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

D: Trees in linear formation. All trees here are TOF, either because they have a predominant agricultural use or, if they have a predominant non agricultural use, because the line width is < 20m.

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

Case 49: Trees in small urban center, Chiapas, Mexico (14°58’39”N ; 92°15’55”W)

A: OLw*TOF – URB* (OLw*TC*)

B: OLw*NoTOF*

C: OLw*TOF – AGRI* (OLw*TC*)

D: OLw*TOF – AGRI* or Non A/U, subset 2

A: Matrix with a dense, irregular tree cover, with small grassland patches, and a road bordered by houses. *Because the area is large (≥ 0.5ha), and the canopy cover is dense, even though there are obvious signs of human activity (houses, paths and grasslands),* **field checking** is needed to identify the land-use.

If **agricultural use** predominant, all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. It can be further classified as **Other Land with Tree Cover**, *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If the use is predominantly **non-agricultural**, the area is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

Field checking reveals that area A is a juxtaposition of coffee agroforest plots, thus agricultural use, so in this case the whole area should be classified as **Other Land *with TOF*** and as **Other Land with Tree Cover**.

B: Large area (≥0.5ha) with no trees, classified as **Other Land *with No TOF***.

C: Treed urban matrix, with abundant trees, isolated or in small groups scattered along houses (gardens) and streets (canopy cover: ca. 45 %). All trees are TOF *because of the predominant urban land-use.*

The area is classified as **Other Land *with TOF*** *because of its urban context, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Case 50: Trees in small urban center, Namibia (43°35’16”N ; 5°11’24”E)

A: OLw*TOF – AGRI*
or FOREST
or OWL

B: OLw*TOF – AGRI*
(OLw*TC*)

C: OLw*TOF – URB*
(OLw*TC*)

D: OLw*NoTOF*

A: Large area with no obvious human use; dense and irregular shrub cover with some trees. Because *the area is large (≥ 0.5ha)*, has no obvious main use, and the tree and shrubs combined canopy cover is dense (≥ 10%), **field checking** is needed to identify the land-use:

If **agricultural use** predominant, all trees are TOF and the area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because the tree canopy cover is ≥ 10% and the area is ≥ 0.5 ha.*

If **non-agricultural use**, the area is classified as **Forest** because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.

B: Pasture area with shrubs and scattered trees (canopy cover: ca. 15 %). All trees and shrubs are TOF, *because of the predominant agricultural land-use.*

The area is classified as **Other Land *with TOF*** *because, trees are ≥ 5m high, the combined tree and shrub canopy cover is ≥ 10%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

C: Urban matrix made up of houses, buildings and streets, with abundant shrubs and scattered trees (canopy cover: ca. 30 %). All trees and shrubs are TOF, *because of the predominant urban land-use.*

The land is classified as **Other Land *with TOF*** *because the land is used for urban activities, trees are ≥ 5m high, the combined tree and shrub canopy cover is ≥ 10%, and the area is ≥ 0.05 ha.*

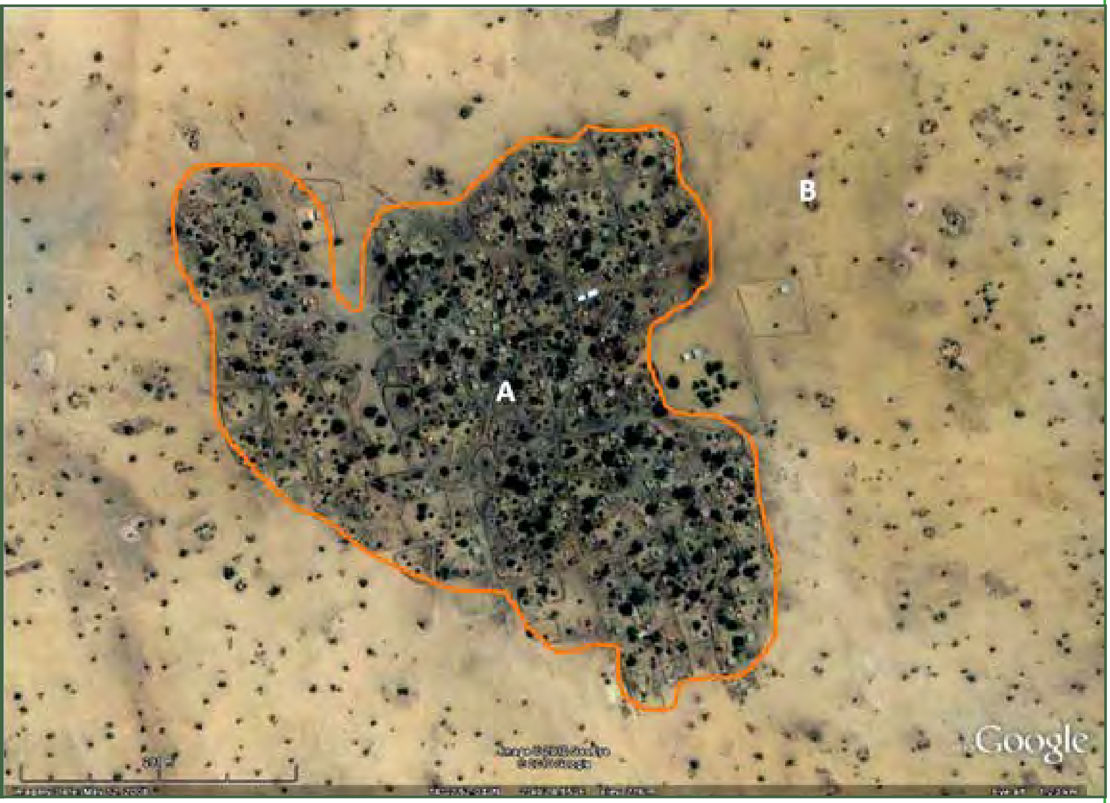
It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and the tree canopy cover is ≥ 10%.*

D: Two large patches (≥0.5ha) with no trees, classified as **Other Land *with No TOF***.

Case 51: Trees in a small urban center, Niger (14°02'52"N ; 2°49'28"E)

A: OLwTOF – URB (OLwTC)

C: OLwTOF – AGRI



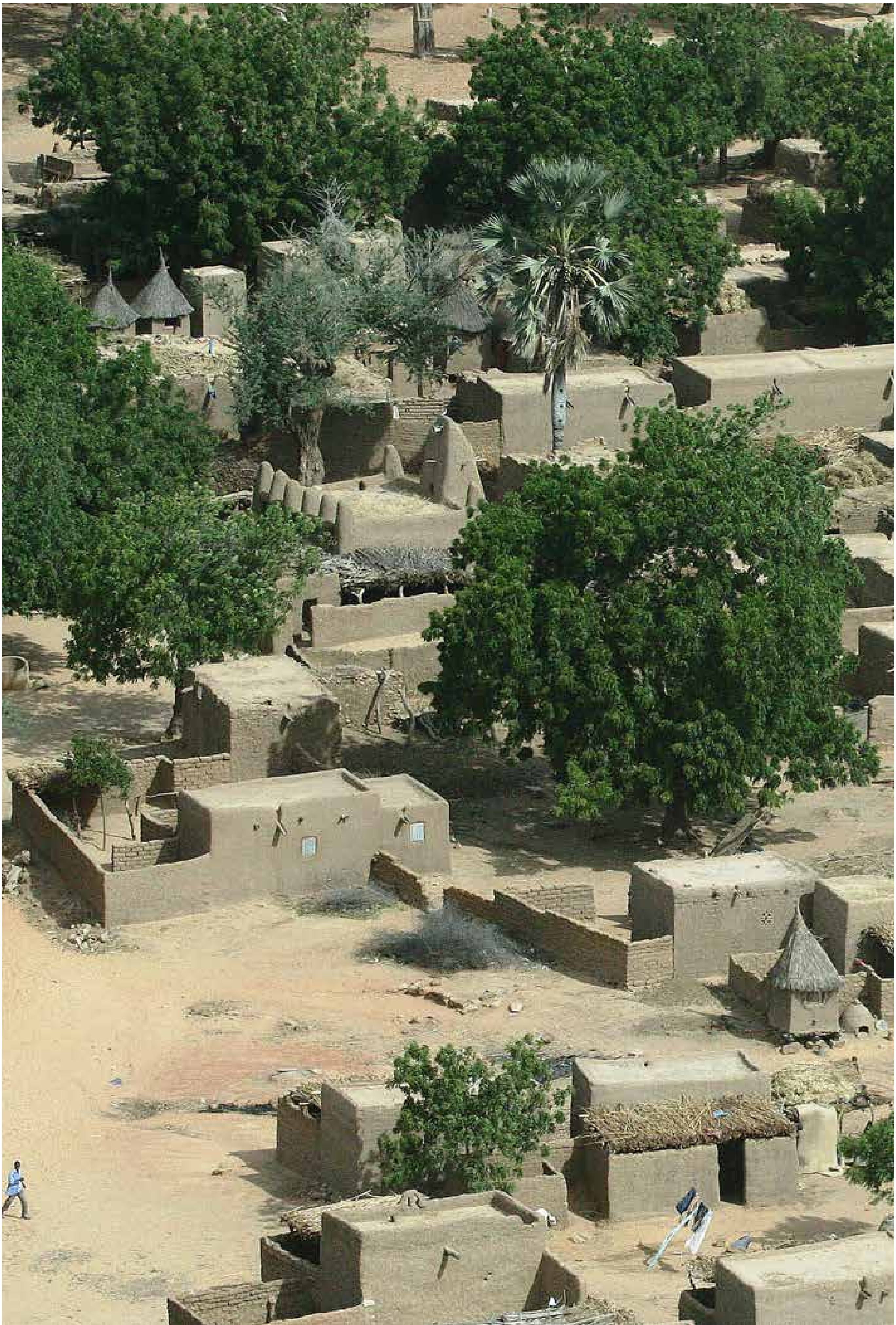
A: Small urban matrix of houses, gardens and paths with shrubs and trees (canopy cover: ca. 20 %). All trees and shrubs are TOF *because the predominant use of the land is urban.*

The area is classified as **Other Land *with TOF*** *because the land is used for urban activities, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and the tree canopy cover is ≥ 10%.*

B: Pasture area with shrubs and scattered trees (canopy cover between 5 and 10 %). All trees and shrubs are TOF *because the predominant land use is agriculture.*

The land is classified as **Other Land *with TOF*** *because the land is used for pasture (agriculture), trees are ≥ 5m high, the tree and shrub canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*



2.3. Trees in "R-urban" Area

When the human habitat is scattered, each house being associated to a large plot of land, it is sometimes difficult to identify the urban nature of an area. This is expressed here in the neologism "rurban" or "r-urban" which takes this hesitation between "rural" and "urban" into account.

Case 52: Trees in “R-urban” areas, Darwin, Australia (12°32’50”S ; 131°02’27”E)

OLw*TOF* – *AGRI* – *URB* (OLw*TC*)

This image illustrates a transition between a forest and a treed urban area.

Mosaic of housing structures (houses and gardens), roads, crop fields with abundant trees in large groups and orchards. All trees here are TOF, *because the land is in an urban and agricultural context.*

The land is classified as **Other Land *with TOF*** because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Another interpretation could be devised if a finer scale / resolution of the assessment is needed: a matrix with houses and gardens -OLwTOF - AGRI - URB (OLwTC)-, crop fields with no or rare trees -OLwNoTOF-, and patches with a dense tree cover and no house -FOREST.

Case 53: Trees in "R-urban" areas, France (50°41'20"N ; 3°07'19"E)

OLwTOF – URB

R-urban landscape with buildings, houses, road and parking lot, with trees isolated, in small groups or in linear formation (width <20m). All trees and shrubs here are TOF.

The whole area is classified as **Other Land *with TOF*** *because the land is used for urban activities, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.

Case 54: Trees in "R-urban" areas, France (47°52'37"N ; 4°03'08"W)

A: OL*wTOF - AGRI*
(OL*wTC*)
or FOREST

B: OL*wTOF - URB*
(OL*wTC*)

C: OL*wTOF - AGRI*
or NON
A/U subset 2

D: OL*wTOF - AGRI*
(OL*wTC*)
or FOREST

E: OL*wNoTOF*

A: Large treed patches with a dense, irregular tree cover, small grassland areas and a few housing structures. *Because the area is large (≥ 0.5ha), and the tree canopy cover is dense, even though signs of human activities are obvious,* **field checking** is needed to identify the land-use:

If **agricultural use** predominant, all trees are TOF and the A patches are classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. They can be further classified as **Other Land with Tree Cover** *because their areas are ≥ 0.5 ha, and their tree canopy cover is ≥ 10%.*

If **non-agricultural** use, the A patches are classified as **Forest** *because trees are ≥ 5m high, tree canopy cover is ≥10 %, and areas are ≥ 0.5 ha.*

B: Mosaic of small crop fields, orchards, houses, roads and grassland patches with abundant trees and shrubs. All trees are TOF *because of the predominant urban land-use.*

The B patches are classified as **Other Land *with TOF*** *because the land is used for agriculture and housing structures, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

They can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

C: Trees in linear formation forming hedges around crop fields, or along roads. All trees here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

D: Large patches of dense and regular tree cover. *Because the patches are large (≥ 0.5ha), and the tree canopy cover is dense (≥ 10%), even though signs of human activities are obvious,* **field checking** is needed to identify the land-use:

If **agricultural use** predominant, all trees are TOF and the D patches are classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. They can be further classified as Other **Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, B patches are classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha*

In this case **field checking** shows that B patches are fruit orchards, so they should be classified as **Other Land with TOF** and as **Other Land with Tree Cover**.

E: Patches of crop fields and houses with gardens, with no or scarce isolated trees. All trees are TOF, *because of the agricultural or urban land-use.*

The E patches are classified as **Other Land *with No TOF*** *because the land is mainly used for agriculture and for a few housing structures (thus: Other Land), and the tree canopy cover is < 5%.*

Case 55: Trees in “R-urban” areas, Montpellier, France (47°52’37”N ; 4°03’08”W)

A: OL*wTOF - URB* (OL*wTC*)

B: OL*wTOF - URB* (OL*wTC*) or FOREST

C: OL*wTOF - URB* (OL*wTC*) or FOREST

D: OL*wNoTOF*

E: OL*wTOF - AGRI* or *NON* A/U subset 2

A: Mosaic/matrix of houses and gardens, some small crop fields, orchards, streets and roads, and grassland patches, with abundant trees and shrubs (canopy cover: ca. 30 %). All trees are TOF *because of the predominant urban land-use.*

The A patches are classified as **Other Land *with TOF*** *because the land is predominantly used for housing structures, trees are ≥ 5m high, tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

They can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Large corridor of trees, with a dense, irregular tree cover, along a river. *Because the area is large (≥ 0.5ha), and the tree canopy cover is dense (≥ 10%),* **field checking** is needed to identify the land-use:

If **agricultural use** or **urban use** predominant, all trees are TOF and the land is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha;*

C: Large patches of dense and irregular tree and bush cover, with a few houses. *Because the patches are large (≥ 0.5ha), and the tree and bush canopy cover is dense,* **field checking** is needed to identify the land-use:

If **agricultural use** or **urban use** predominant, all trees are TOF and the land is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.* It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha;*

D: Mosaic of crop fields, with no or scarce isolated trees. All trees are TOF.

The D patches are classified as **Other Land *with No TOF*** *because the land is mainly used for agriculture and some housing structures (thus: Other Land), and the tree canopy cover is < 5%.*

E: Trees in linear formation forming hedges around crop fields, or along roads (yellow dotted lines on the picture). Trees here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land with TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25m.*

Case 56: Trees in “R-urban” areas, Potsdam, Germany (52°23’49”N ; 13°1’25”E)

A: OLwTOF - URB (OLwTC)

B: OLwTOF - AGRI - URB (OLwTC)

C: OLwTOF - URB (OLwTC)

A: Recreational urban park with buildings, a small lake, large tree patches with an irregular tree cover and grassland patches (average canopy cover: ca. 60 %). All trees are TOF *because of the predominantly urban use of the land.*

The area is classified as **Other Land *with TOF*** *because the land has a predominantly urban use, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

B: Mosaic of small houses, roads and grassland patches with abundant trees and shrubs, isolated or in small groups along buildings and roads. All trees are TOF *because of the predominantly urban and agricultural use of the land.*

The B patches are classified as **Other Land *with TOF*** *because the land is used for agriculture and housing structures, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

They can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

C: Dense matrix of houses, streets and urban kitchen gardens with abundant trees and shrubs, along streets and in gardens. All trees are TOF *because of the predominantly urban use of the land.*

The area is classified as **Other Land *with TOF*** *because the land is used for agriculture and housing structures, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Case 57: Trees in “R-urban” areas, Nicaragua (12°08’35”N ; 86°20’14”W)

OLw*TOF* - *AGRI* - *URB* (OLw*TC*)

Mosaic of housing structures (houses and gardens), streets and roads, crop fields; abundant trees in groups (gardens and orchards). All trees are TOF *because of the predominantly urban and agricultural use of the land.*

The land is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

Case 58: Trees in "R-urban" areas, Montpellier, France (43°28'53"N ; 3°41'02"E)

A: OLwNoTOF

B: OLwTOF - AGRI (OLwTC)

C: OLwTOF - AGRI or NON A/U subset 2

D: OLwTOF - AGRI

E: OLwNoTOF

F: OLwTOF - URB (OLwTC) or FOREST

G: OLwTOF - URB or NON A/U subset 1

A: Crop fields and highway with no or scarce isolated trees. All trees are TOF *because the land is used for agriculture and urban (the highway is considered as a corridor linking urban centers) activities.*

The area is classified as **Other Land *with No* TOF** *because the land is used for agriculture and urban activities (thus: Other Land), and the tree canopy cover is < 5%.*

B: Patches of trees isolated or in small groups, on crop fields and in house gardens.

The B patches are classified as **Other Land with TOF** *because the land is used for agriculture and housing structures, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

C: Trees in continuous and discontinuous linear formation (width <20m), mostly along roads. All trees and shrubs here are TOF, e*ither because they have a predominant agricultural or urban use or, if they have a predominant non agricultural – non urban use, because the line width is < 20m.*

The area is in any case classified as **Other Land with TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25m.*

D: Patch of tree crop (olive tree).

The area is classified as **Other Land with TOF** *because the land is used for agriculture, trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha.*

E: Vineyards with no or scarce isolated trees. Grapevine is a vine, not a tree nor a shrub.

The E patches are classified as **Other Land *with No* TOF** because the land is used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.

F: Large patches (> 0.5 ha) with dense, irregular tree cover. *Because the patches are large (≥ 0.5ha) and the canopy cover is dense, even though there is human activity nearby,* **field checking** is needed to identify the land-use.

If **urban** or **agricultural use** predominant, all trees are TOF and the land is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. It can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-urban** or **non-agricultural use**, the land is classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

In the present case, the **definition of "urban"** is the key, at least for the patch located in the lower left quarter of the picture: this patch is managed by the highway authority and if the highway is considered as "urban" because it links urban centers, then this patch has a urban use and should be classified as **Other Land *with TOF*** and as **Other Land with Tree Cover**.

G: Small (<0.5 ha) and dense patches of trees. All trees here are TOF, *either because the land has a predominantly urban or agricultural use, or if the land use is not predominantly urban or agricultural, because the area of each patch is lower than 0.5 ha.* In the present case, the 3 G patches are managed by the highway authority and should be considered as "urban" if a highway is considered as "urban".
The G patches are in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is<05 ha but ≥ 0.05 ha.*

TOF NON A/U

3.1. Trees in smallwoods (area less than 0.5 ha) – subset 1

Case 59: Trees in small woods - Namibia (18°17'53"S ; 23°36'59"E)

Interpretation 1

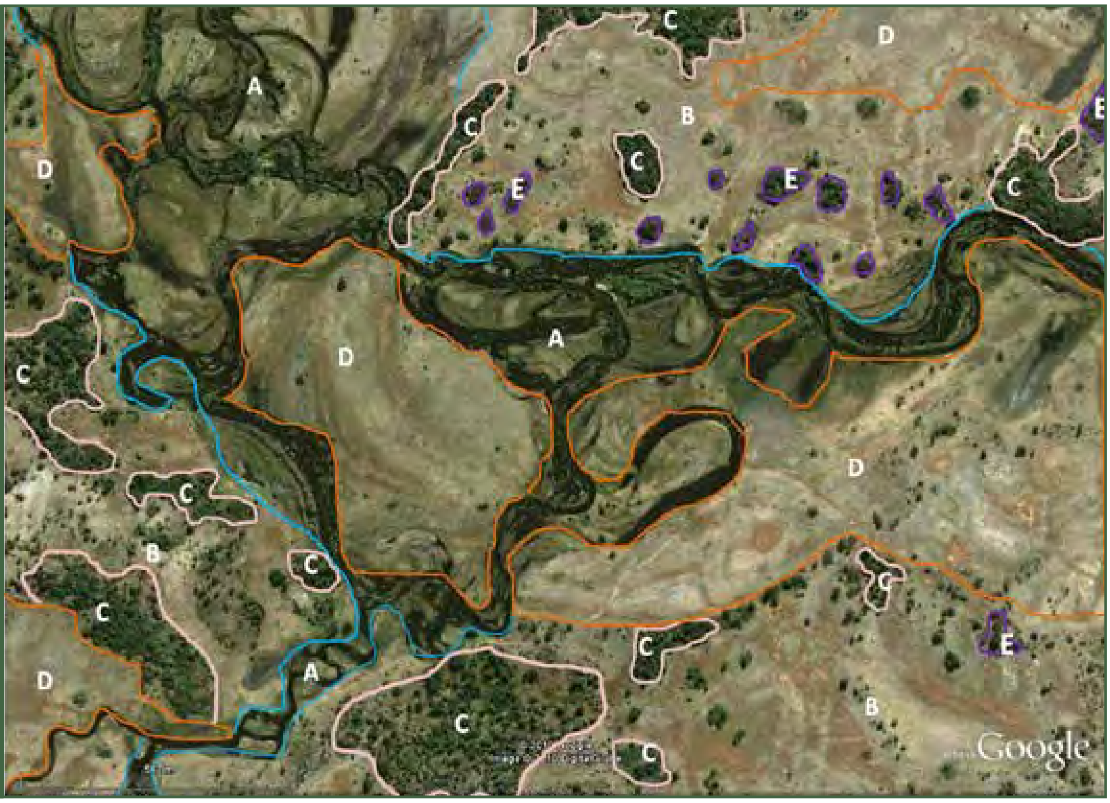
A: OLw*NoTOF*

B: OWL

C: OLw*TOF - AGRI*
(OLw*TC*)
or FOREST

D: OLw*NoTOF*

E: OLw*TOF -*
***NON* A/U**
subset 1



Riverbed surrounded by natural areas and paths. Some agricultural activity is visible on the right top corner but is not the predominant land use.

A: Large riverbed with a few shrubs along river streams.

With a tree canopy cover below 5%, and a combined tree and shrub canopy cover below 10%, the area is classified as **Other Land *with No TOF*** *because it does not satisfy the minimal canopy cover thresholds, neither for* Forest *and* Other Wooded Land, *nor for* Other Land *with TOF*. All trees and shrubs in the area are TOF.

B: Large area with scattered shrubs and small groups of trees (small woods with individual area <0.05 ha).

The land is classified as **Other Wooded Land** *because the land is not predominantly under agricultural or urban use, nor classified as Forest, and because canopy cover is ≥ 10%, and area is ≥ 0.5 ha.*

C: Large tree patches with a dense and irregular tree cover. *Because the area is large (≥ 0.5ha), and the tree canopy cover is dense (≥ 10%)*, **field checking** is needed to identify the land-use:

If **agricultural use** predominant (pasture), all trees are TOF and the C patches are classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area of each patch is ≥ 0.05 ha.* They can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, C patches are classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area of each patch is ≥ 0.5 ha.*

D: Large patches with no or scarce isolated trees.

With a tree canopy cover below 5%, and a combined tree and shrub canopy cover below 10%, the D patches are classified as **Other Land *with No TOF*** *because they do not satisfy the minimal canopy cover thresholds, neither for* Forest *and* Other Wooded Land, *nor for* Other Land with TOF. All trees and shrubs in the D patches are TOF.

E: Small patches (<0.5ha) of trees and shrubs.

The E patches are classified as **Other Land with TOF** *because they do not satisfy the minimal area threshold for Forest and Other Wooded Land, and because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area of each patch is ≥ 0.05 ha but < 0.5ha.* All trees and shrubs are TOF.

Interpretation 2

A: OLw*NoTOF*

B: OWL

C: OLw*TOF - AGRI* (OLw*TC*) or FOREST

D: OLw*NoTOF*

In this interpretation, the small **E** patches (**Other Land *with TOF***) are considered as an integral part of the **B** patches (**Other Wooded Land**). The areas under **A**, **C** and **D** are not modified. **B** becomes:

B: Large area with scattered shrubs and small groups of trees (small woods with individual area <0. 5 ha).

The land is classified as **Other Wooded Land** *because the land is not predominantly under agricultural or urban use, nor classified as Forest, and because the combined tree and shrub canopy cover is ≥ 10%, and the area is ≥ 0.5 ha.*

Case 60: Trees in small woods - Germany (48°37’06”N ; 11°25’55”E)

A: OLw*TOF - AGRI* (OLw*TC*)

B: OLw*NoTOF*

C: OLw*TOF - AGRI* or *NON* A/U subset 2

D: OLw*TOF - AGRI* or *NON* A/U subset 1

E: OLw*TOF* - *NON* A/U subset 2

A: Large patches of dense and irregular tree cover. *Because the area is large (≥ 0.5ha), and the tree canopy cover is dense (≥ 10%),* **field checking** is needed to identify the land-use:

If **agricultural use** predominant, all trees are TOF and the A patches are classified as **Other Land with TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha*. They can be further classified as **Other Land with Tree Cover** *because area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

If **non-agricultural use**, A patches are classified as **Forest** *because trees are ≥ 5m high, the tree canopy cover is ≥10 %, and the area is ≥ 0.5 ha.*

B: Agricultural matrix forming a mosaic of crop fields, with no or scarce isolated trees. All trees are TOF.

The area is classified as **Other Land *with No TOF*** *because the land is mainly used for agriculture and some housing structures (thus: Other Land), and the tree canopy cover is < 5%.*

C: Trees in linear formation (hedges) around crop fields. Trees here are TOF, *either because they have a predominant agricultural use or, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

D: Small patch (<0.5ha) of trees with dense and irregular tree cover. All trees here are TOF, e*ither because the land has a predominantly agricultural use, or if the land use is not predominantly agricultural, because the area of the patch is lower than 0.5 ha.*

In any case the D patch is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha, but <0.5 ha.*

E: Forest-like corridors of dense and irregular tree cover, following a river on both sides. All trees are TOF, because each corridor has an average width <20m.

The area is classified as **Other Land with TOF** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, the area is ≥ 0.05 ha, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

Cas 61: Trees in small woods - France (46°57’39”N ; 4°57’17”E)

A: OLw*TOF* - *NON* A/U subset 1

B: OLw*TOF* - *NON* A/U subset 2

C: OLw*NoTOF*

A: Small patch (<0.5ha) of trees with a dense canopy cover.

The patch is classified as **Other Land *with TOF*** *because it does not satisfy the minimal area threshold for Forest and Other Wooded Land, and because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the area of the patch is ≥ 0.05 ha but < 0.5ha*. All trees and shrubs are TOF.

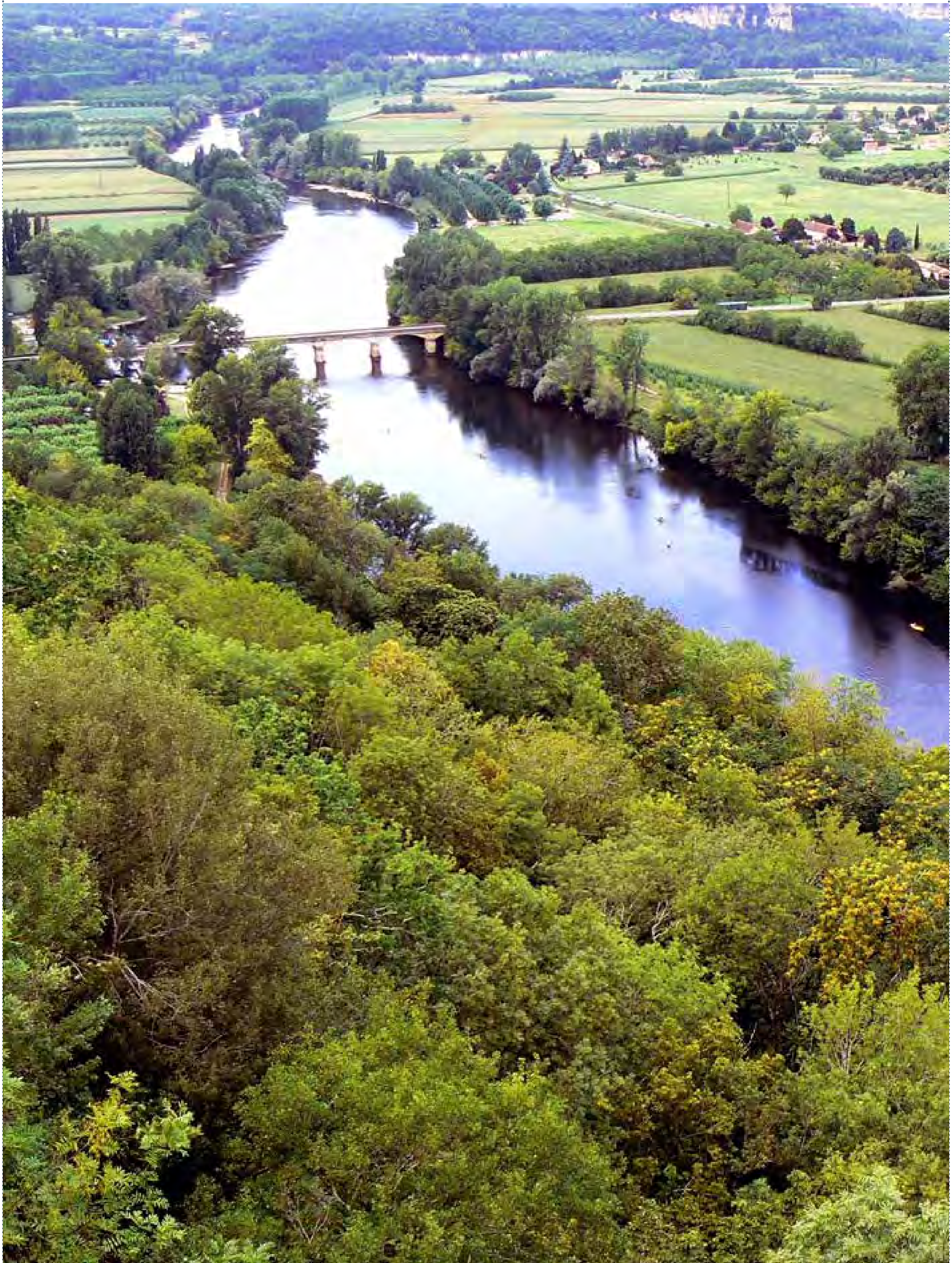
B: Trees and shrubs in narrow discontinuous linear formation, forming hedges around crop fields or a corridor along the river. All trees and shrubs here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

C: Agricultural matrix composed of a mosaic of crop fields with no or scarce isolated trees.

The area is classified as **Other Land *with No TOF*** *because the land is used for agriculture (thus: Other Land), and the tree canopy cover is < 5%. All trees and shrubs here are TOF.*

3.2. Trees in narrow linear formations – TOF NON A/U subset 2



Case 62: Trees in narrow linear formations – Turkey (41°25’26”N ; 27°10’57”E)

A: OL*wNoTOF*

B: OL*wTOF* -
***NON* A/U**
subset 2

A: A mosaic of crop fields, with no or scarce isolated trees.

The area is classified as **Other Land with *No TOF*** *because the land is used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.* All trees are TOF.

B: Two parallel tree corridors with a dense and irregular canopy, following a river on both sides. All trees are TOF *because each corridor has a width <20m.*

The area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25m.*

Case 63: Trees in narrow linear formations – Australia (32°20'01"S ; 115°52'37"E)

A: OLw*TOF* - *NON* A/U subset 2

B: OLw*NoTOF*

C: OLw*TOF* - *AGRI* or *NON* A/U subset 2

D: OLw*TOF* - *AGRI* or *NON* A/U subset 1

A: Trees and shrubs in narrow discontinuous linear formation, along a river. All trees and shrubs here are TOF *because the width of the tree line is <20m.*

The area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25m.*

B: Mosaic of crop fields, with no or scarce isolated trees.

The area are classified as **Other Land with No TOF** *because the land is used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.* All trees are TOF.

C: Trees and shrubs in narrow discontinuous linear formation, following the road or forming hedges. All trees and shrubs here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non-agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

D: Small and dense patches of trees. All trees here are TOF, *either because the land has a predominantly agricultural use, or if the land use is not predominantly agricultural, because the area of the patch is lower than 0.5 ha.*

In any case the D patches are classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and their individual area is ≥ 0.05 ha, but <0.5 ha.*

Case 64: Trees in narrow linear formations – France (48°25’10”N ; 7°33’44”E)

A: OL*wNoTOF*

B: OL*wTOF - AGRI* or *NON* A/U subset 2

C: OL*wTOF - AGRI* or *NON* A/U subset 1

A: Mosaic of crop fields, with no trees.

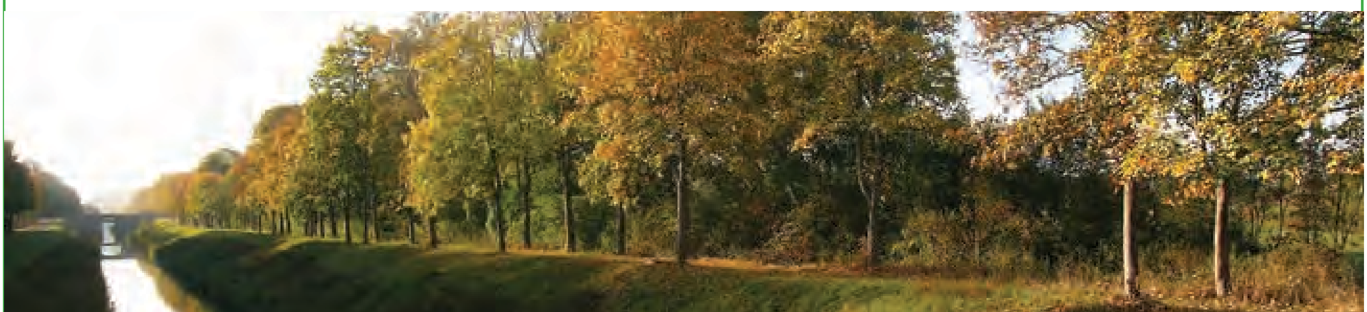
The area is classified as **Other Land *with No TOF*** *because the land is used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.*

B: Trees along roads or forming hedges around crop fields, in narrow continuous linear formation (width <20m). All trees and shrubs here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non-agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

C: Small patch (<0.5 ha) of linear formation (width > 20m) with a dense tree cover. *Even though the width is >20m, all trees here are TOF, either because they have a predominant agricultural use or, if they have a predominant non-agricultural use, because the area of the patch is < 0.5 ha.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the patch area is ≥ 0.05 ha, but <0.5 ha.*



Case 65: Trees in narrow linear formations – China (46°13'39"N ; 127°04'03"E)

A: OL*wNoTOF*

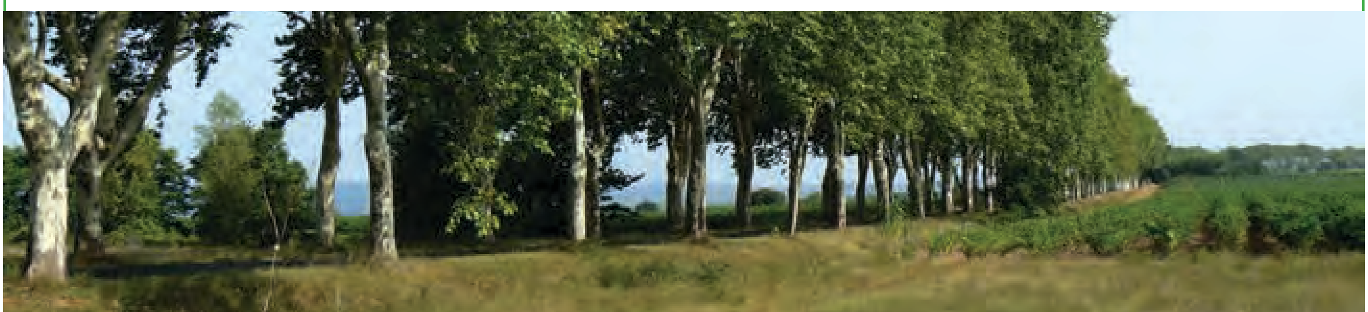
B: OL*wTOF* -
***NON* A/U**
subset 2

A: Mosaic of crop fields, with no trees.

The area is classified as **Other Land *with No TOF*** *because the land is used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.*

B: Trees along roads, in narrow continuous linear formation (width <20m).

The area is classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.* All trees are TOF.



Case 66: Trees in narrow linear formations – Morocco (29°46'52"N ; 9°48'21"W)

A: OL*wNoTOF*

B: OL*wTOF - AGRI* or *NON* A/U subset 2

C: OL*wNoTOF*

A: Mosaic of crop fields, with no or scarce isolated trees.

The area is classified as **Other Land *with No TOF*** *because the land is used for agriculture (thus: Other Land), and tree canopy cover is < 5%. All trees are TOF.*

B: Trees in continuous and discontinuous linear formation (width <20m), forming hedges around crop fields. All trees and shrubs here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non-agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*

C: Pasture lands and village with houses and roads, with no or scarce isolated trees.

The area is classified as **Other Land with No TOF** *because the land is used for agriculture or housing structures (thus: Other Land), and the tree canopy cover is < 5%.* All trees are TOF.

Case 67: Trees in narrow linear formations – Namibia (18°08’23”S ; 21°34’57”E)

A: OLwNoTOF

B: OLwTOF - AGRI

C: OLwTOF - AGRI (OLwTC)

D : OLwTOF - AGRI or NON A/U subset 2

A: Mosaic of crop fields or pasture, with no or scarce isolated trees.

The area is classified as **Other Land *with No TOF*** *because the land is used for agriculture (thus: Other Land), and the tree canopy cover is < 5%.* All trees are TOF.

B: Large patches, with a dense and irregular shrub cover, and with some trees. *Because the area is large (≥ 0.5ha), and has an obvious agricultural use*, all trees and shrubs are TOF.

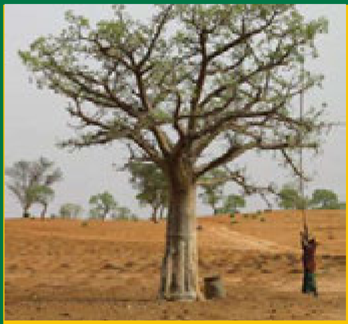
The B patches are classified as **Other Land *with TOF*** *because the combined tree and shrub canopy cover is ≥ 10%, and the area is ≥ 0.05 ha. Note that the B patches do not qualify as Other Land with Tree Cover because their tree canopy cover is below 10%.*

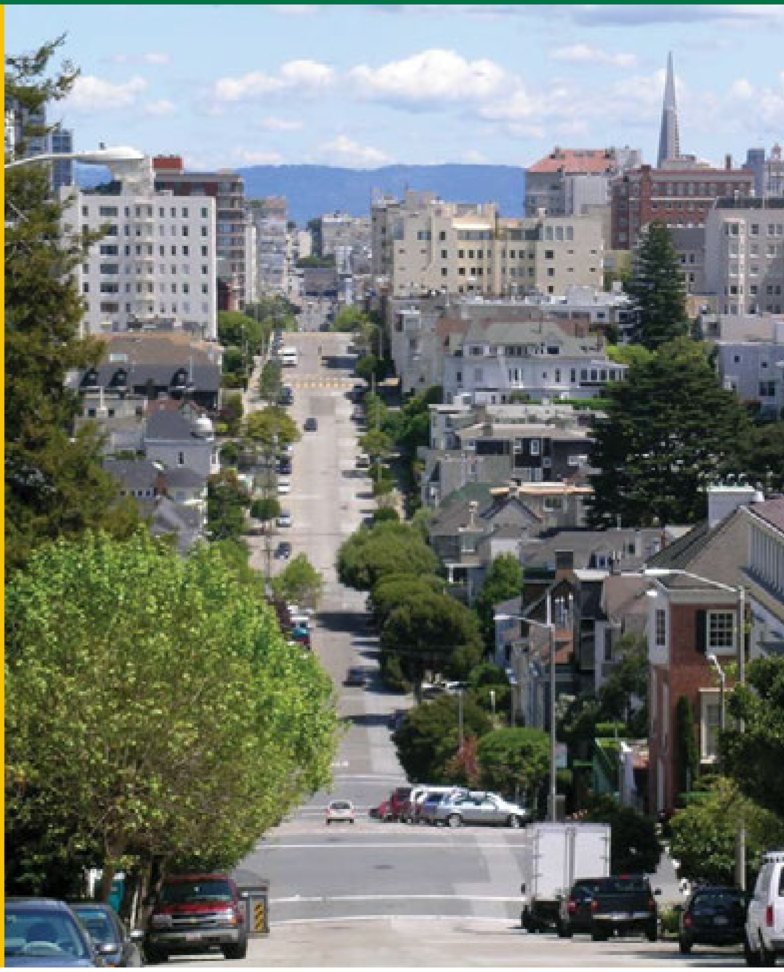
C: Large patch, with dense and irregular tree cover. *Because the area is large (≥ 0.5ha), and has an obvious agricultural use*, all trees and shrubs are TOF.

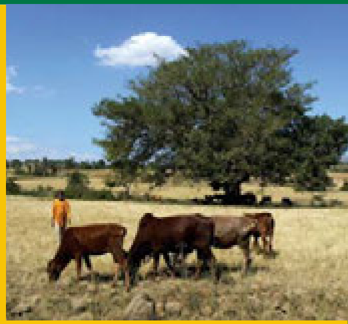
The area is classified as **Other Land with TOF** *because, the tree canopy cover is ≥ 5%, and the area is ≥ 0.05 ha. It can be further classified as Other Land with Tree Cover, because the area is ≥ 0.5 ha, and tree canopy cover is ≥ 10%.*

D: Narrow continuous and discontinuous linear formation (width <20m) composed of trees and shrubs forming hedges around crop fields. All trees and shrubs here are TOF, *either because they have a predominant agricultural use or, if they have a predominant non agricultural use, because the line width is < 20m.*

The area is in any case classified as **Other Land *with TOF*** *because trees are ≥ 5m high, the tree canopy cover is ≥ 5%, and the linear formation width is ≥ 3m with a length ≥ 25 m.*







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FAO, in cooperation with its member countries, has monitored the world's forests at 5 to 10 year intervals since 1946. These global assessments provide valuable information to policymakers in countries, to international negotiations, arrangements and organizations related to forests and to the general public. The Global Forest Resources Assessment (FRA) is the most comprehensive assessment on forest that examines the status and trends for all types of forests in the world.
Reliable and comprehensive information on "Trees outside Forests" - TOF - across large areas (sub-national and national levels) remains scarce. Recognizing the importance of all tree resources, FRA has included activities for the assessment of trees outside forest in the process since FRA 2000.
The Thematic Report "Towards the Assessment of Trees Outside Forest" responds to the request made by FAO member countries to support identifying methods and techniques for TOF assessment on large areas that promotes harmonization between countries, quality data and respond to the requirements related to global processes such as the CBD, UNCCD and UNFCCC.
The Thematic Report consists of three parts:

- Part I – Towards Assessing Trees Outside Forests
- Part 2 – Case Studies on Trees Outside Forests Assessment
- Part 3 – Trees Outside Forests from the air (satellite photos interpreted).

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