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Where are the trees outside forest in Brazil?

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Abstract - Trees outside forests (ToF) is often a misunderstood category. This is the case in Brazil as shown by the lack of data on ToF reported until now by the country. In this article, ToF are understood in relation to the FAO definition of forest because it is the definition used in Brazil for the National Forest Inventory. I provide a definition of ToF, detail the main sets as inferred from this definition, propose to focus on a category of ToF as an efficient and realistic first step towards the assessment of ToF countrywide, and I illustrate the diversity of ToF-based systems in Brazil, from relatively isolated trees in agroforestry fields to dense mixed tree formations that cannot be distinguished from forests on satellite images. A recent publication has placed Brazil as the world leader in terms of the total biomass carbon stored by one ToF set, trees on agricultural land. This result could stimulate the desire for Brazil to better assess not only trees on agricultural land but also trees on urban land, the two major sets of trees outside forests. The present paper can help those who will undertake this challenging and exciting task.

Onde estão as árvores fora da floresta no Brasil?

Resumo - Árvores fora das florestas (AFF/Trees outside Forests - ToF) é um conceito frequentemente mal compreendido. Esse é o caso no Brasil, como demonstra a falta de dados do país sobre AFF, até o momento. Neste artigo, AFF é entendida conforme a definição de floresta da FAO, porque é a mesma utilizada pelo Brasil, no contexto do Inventário Florestal Nacional. Este artigo propõe uma definição de AFF e detalha seus principais agrupamentos, determinados a partir dessa definição; propõe também concentrar-se em um agrupamento de AFFs como um primeiro passo - eficiente e realista - para a avaliação de AFFs em todo o país. Além disso, é ilustrada a diversidade dos sistemas que envolvem AFF no Brasil, desde árvores relativamente isoladas em sistemas agroflorestais a densas formações de árvores heterogêneas que não podem ser distinguidas das florestas nas imagens de satélite. Uma publicação recente colocou o Brasil como líder mundial em termos de carbono total de biomassa armazenado por um conjunto de AFFs em áreas agrícolas. Esse resultado poderia estimular o país a reportar não apenas as árvores em áreas agrícolas, mas também as árvores em áreas urbanas, os dois principais agrupamentos de árvores fora da floresta. Espera-se que o presente artigo contribua com aqueles que empreenderão essa tarefa desafiadora e excitante.

Introduction

A recent global study demonstrated the importance of trees on agricultural land and their significance for carbon sequestration at a global level (Zomer et al., 2016). Using remote sensing data, the authors showed that 43% of the 22.2 million km^2 of agricultural land globally had a tree cover of at least 10% in 2010, an increase of 2% since 2000. A tree cover of 10% is the minimum threshold for a tree vegetation to qualify as "forest" according to FAO definition (when on land whose predominant use is not urban and not agricultural). The figure cited above thus means that 43% of all agricultural land globally, or about 9.5 million km^2, has a "forest" cover (according to FAO definition)! Zomer et al. (2016) also estimated the biomass carbon stored in trees on agricultural land globally: about 33 gigatonnes in 2010. This figure is impressive, although it is almost two orders of magnitude smaller than the amount of carbon stored in the soils, as stated by the same author , and one order of magnitude smaller than the amount of carbon stored in the above and below-ground biomass of trees in forests (FAO, 2015).

In a recent study, de Foresta et al. (2013) showed that trees on agricultural land form a major set of trees outside forests (hereafter abbreviated as ToF). As seen before, trees on agricultural land is indeed an important ToF set in terms of the amount of trees, their cover and the carbon they store in their biomass. Moreover it is a set of trees of prime importance for the livelihood of millions of people in terms of the various products and services they provide (Bellefontaine et al., 2002). As noted by Zomer et al. (2016), trees on agricultural land are not systematically accounted for in either global carbon budget or national carbon accounting. This low accounting of trees on agricultural land may be extended to all ToF indeed, so that our knowledge about ToF in general, be it at global or at regional level is close to nil. It is the same at national level, except for a small number of countries which have relatively good knowledge of their ToF because they have developed national assessments that include ToF (de Foresta et al., 2013).

Brazil included the assessment of ToF in its National Forest Inventory (hereafter called BNFI). However assessing ToF was not a main priority until now, and this is quite understandable: the BNFI is quite recent (Freitas et al., 2010), the territory it has to cover is enormous and the means allocated are not proportionate yet to the magnitude of its tasks. In addition Brazil is endowed with an enormous forest estate covering more than half of the country and characterized by an impressive diversity in terms of forms of forest as well as in terms of species. The size and the diversity of the forest estate, its importance nationally and globally in terms of biodiversity, its importance nationally in terms of resources and services, the limited resources of the National Forest Service, all concur to make Forest, not ToF, the number one priority for the BNFI.

The level of knowledge on ToF is thus still very low in Brazil. However the recent publication by Zomer et al. (2016) brings in new extremely relevant information. The authors did not restrict their study to the global level: they also detailed the tree cover on agricultural land, and its associated biomass carbon, country per country. And their results certainly came as a surprise to many in Brazil who learned that their country had the highest total biomass carbon (understand tree biomass) on agricultural land (Zomer et al., 2016). It is well known for years that Brazil is a leading country in terms of forest area, with the second largest forest estate globally. But these authors just revealed that Brazil is also a leading country in terms of the area covered by trees outside forests!

This revelation may stimulate better assessment of ToF in the country, a necessary condition for Brazil to be able to sustainably manage ToF and maximize the benefits they can provide. In this context, the following represents an attempt to help those involved in the assessment of ToF in Brazil better understand the basic concepts linked to ToF so as to be able to recognize ToF when they encounter them, which may not be so easy. Assessing all ToF in a country appears unrealistic. I thus propose, as a first step, to focus on a category of ToF, already identified and proposed years ago by FAO, but with very limited success, to countries collaborating to the Global Forest Resources Assessments run every five years. This category includes the main bulk of the trees outside forests and could be assessed efficiently at minimum cost. I conclude with some thoughts about where to look for ToF in the Brazilian context.

(Trees in) Forests and Trees outside Forests

It is extremely rare to encounter a landscape with no trees, except in areas such as deserts where climatic conditions are so harsh that trees cannot grow, or in areas covered with industrial plantations of agricultural crops where management does not allow the establishment

of trees. Most landscapes on earth indeed harbor trees, either in "forest" or not. This is precisely those trees that are not in "forest" that are called "trees outside forests". Belonging to a "forest" or not thus allows the distinction of two mutually exclusive categories of trees: (trees in) "Forest" and "Trees outside Forest" ("ToF"). The only conceivable situation in which there would be no ToF would be one where the definition of "forest" would allow a forest to be composed of only one tree, in other words when forest is synonym with tree.

A "forest" is generally conceived as a local cluster of trees. Where trees are so distant one from the other that there is no discernable cluster, trees do not form a forest and consequently they are ToF. Many foresters in the world still equate ToF to such isolated trees, probably because, being made up of trees which do not form distinct clusters and which thus cannot by any means be confused with a forest, isolated trees form the easiest ToF set to understand and to accept.

There are situations however where trees form clusters but are not classified as forest. Fruit trees in orchards or in estate plantations form dense clusters but are not generally conceived as forest. Similarly, trees in various agroforestry systems such as shade trees in coffee or cocoa plantations form clusters of trees but are not conceived as forest. In cities, trees along streets, trees in private gardens and in parks, also form clusters, but they are not conceived as forest either. These examples show that not all clusters of trees have all the qualities required to be qualified as "forest". These required qualities are embedded in the national and international definitions of the term "forest", which very generally exclude clusters of trees when they are on agricultural or urban land.

This is the case with the international FAO definition of forest, which had been adopted by Brazil for its National Forest Inventory: land whose predominant use is urban or agricultural is not classified as forest, even though it harbors clusters of trees.

There are still other situations where trees form clusters but are not classified as forest. A very small cluster of trees is not generally conceived as a forest, and each language has its own words to qualify such small clusters of trees. Similarly a piece of land with very sparse trees with a canopy cover that occupies only a tiny fraction of the land is generally not conceived as a forest, but as a savanna or grassland with sparse trees. Shape of the cluster of trees may also have a role: a line of trees in an area otherwise devoid of trees is not generally conceived as a forest, but simply as a tree line.

Thus, in addition to the land-use criteria which prevent clusters of trees on agricultural or urban land from being classified as Forest, definitions generally include minimum area, canopy cover (or tree cover) and linear tree cluster width thresholds for a piece of land to be classified as forest. FAO definition of forest, and thus also BNFI definition, uses 0.5 ha, 10%, and 20 m as its minimum area, canopy cover and linear tree cluster width thresholds, respectively.

Defining trees outside forests

There is no universal definition of ToF, and in fact most countries have no definition of ToF. However, ToF and land with ToF may be defined in any country through an analysis of the definition used for forest. In Brazil, the definition used by the BNFI is the FAO definition and thus in the following, ToF and land with ToF should be understood in reference to the FAO classification scheme (Figure 1), and especially in reference to its two main forest classes: "forest" and "other wooded land" (hereafter abbreviated as OWL). Definition of these two classes and of the complement to these two classes, "other land", where ToF are to be found, are all needed to define ToF.

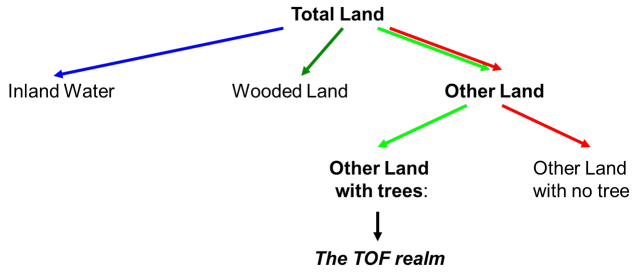

Figure 1. The FAO land classification framework and the position of TOF (adapted from de Foresta et al., 2013)

Forest is defined (FAO 2012) as: "Land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10%, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use".

In its explanatory note 4, it is also specified that Forest "includes windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 ha and width of more than 20 m".

Other wooded land is defined (FAO 2012) as: "Land not defined as "forest", spanning more than 0.5 ha; with trees higher than 5 m and a canopy cover of 5-10%, or trees able to reach these thresholds; or with a

combined cover of shrubs, bushes and trees above 10%. It does not include land that is predominantly under agricultural or urban land use."

Other land is simply defined (FAO, 2012) as: "All land that is not classified as forest or other wooded land."

These definitions have logical consequences which allow identifying where ToF may be encountered. ToF cannot be located in Forest and in OWL. ToF can only be located in Other Land, and indeed all the trees in Other Land are ToF. Forest and OWL are restricted to land which use is not predominantly urban or agricultural. It means that all agricultural land and all urban land are classified as Other Land. It also means that all trees located in agricultural or urban land are ToF.

Where the land use is not predominantly urban or agricultural, Forest and OWL are restricted by the area, canopy cover and linear tree formation width thresholds, so that trees are ToF if the land spans less than 0.5 ha (definition of Forest), if the canopy cover is less than 5% (definition of OWL), and if they form windbreak, shelterbelt or corridor whose width is less than 20 m (explanatory note 4, definition of Forest). In addition, trees and shrubs are TOF if their combined canopy cover is less than 10% (definition of OWL).

Three major ToF sets may thus be distinguished: ToF on agricultural land, ToF on urban land, and ToF on non-urban and non-agricultural land (Figure 2).

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

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

ToF on Non Agricultural/Non Urban Land includes all lands not predominantly under agricultural or urban use which do not satisfy the criteria of forest or OWL. This set is made up of four subsets, in which subset 1 includes small woods with trees either planted or not, subset 2 includes shallow tree lines along road or river, hedges, etc, and subsets 3 and 4 are mainly restricted to harsh environments where trees and shrubs can grow but only at very low density.

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

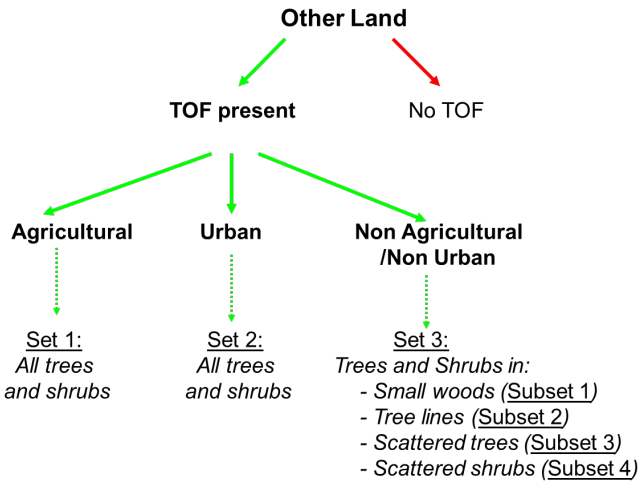

Figure 2. The formal position of TOF and TOF sets within Other Land (adapted from de Foresta et al., 2013).

Being able to recognize that a given tree is a tree outside forest is fundamental but it is only a first step towards being able to undertake an inventory or an assessment of ToF in an efficient and realistic manner. The ToF realm should be further divided to allow realistic assessments, that would not include all ToF, but that would include most of the ToF.

Towards the assessment of Trees outside Forest

In their report, de Foresta et al. (2013) proposed a division of the ToF realm on the basis of minimum area (0.05 ha), linear tree formation width (3 m) and canopy cover (5% if trees only, 10% if combined cover of trees and shrubs) thresholds. Although these thresholds would allow undertaking an inventory of ToF in an efficient

way, it seems that they would be too demanding for most countries at the present stage, in view of both their limited resources and their very low level of knowledge of their ToF.

Considering the above limitations, it seems that better assessing Other Land with Tree Cover (hereafter abbreviated as OLwTC), a subcategory of Other Land proposed by FAO some years ago would be a more realistic first step towards the assessment of ToF in most countries. OLwTC would let more ToF out of the assessment than the division of the ToF realm proposed by de Foresta et al. (2013). Every five years the United Nations Food and Agriculture Organization publishes a Global Forest Resource Assessment (Global FRA) report. This report compiles information provided by the member countries on the state of their forest and more generally on the trends of their forestry sector. With the Global FRA 2005, FAO introduced OLwTC as a subcategory of Other Land in Table 1 of the reports that countries had to provide. This table compiles the area of the three classes used in the Global FRA framework (Forest, OWL and Other Land), and the new line informs on the area occupied by OLwTC as estimated by the country. OLwTC is defined (FAO, 2012) as: "Land considered as Other Land, that is predominantly agricultural or urban land uses and has patches of tree cover that span more than 0.5 ha with a canopy cover of more than 10% of trees able to reach a height of 5 m at maturity. It includes both forest and non-forest tree species" This subcategory of Other Land has thus exactly the same characteristics as Forest (area $\geq$ 0.5 ha, canopy cover $\geq$ 10%) except that the predominant use of the land is agricultural or urban (thus not Forest).

The OLwTC line is the only information on ToF asked to countries by FAO and the Global FRA. It has been included in three reporting processes (FRA 2005, FRA 2010 and FRA 2015) until now, with both a very low level of country response and a high level of confusion in their responses for most of the countries who responded (de Foresta, 2011).

For instance the analysis of the country reports to the Global FRA 2010 (FAO, 2010) showed that 163 countries (including Brazil) did not fill the OLwTC line (or responded "not available", or "zero"), and that only 68 countries responded with values different from zero (de Foresta, 2011). Among those 68 countries, 56 included land-use categories based on agriculture (albeit not all relevant categories) and only 16 included urban based land-use categories (albeit not all relevant categories). Among the same set of 68 countries, many did not provide any information on their canopy cover or area thresholds while filling the OLwTC line, while most of those who provided such information could not comply with the area and canopy cover thresholds used for OLwTC, either because they have different national thresholds, or because they have no thresholds for agricultural and urban lands. There is thus a great uncertainty regarding the congruency of the given figures with the OLwTC thresholds, except for a few countries (de Foresta, 2011).

A quick analysis of the country reports for the Global FRA 2015 shows that the situation did not improve, confirming that the proposal made by de Foresta et al. (2013) of a more demanding division of the ToF realm was way ahead of what could be expected from the forest services in most countries. This is why I reiterate here the proposal I made to FAO (de Foresta, 2011; de Foresta et al., 2013), that efforts be, as a first step, focused on the assessment of OLwTC. This category is easy to understand and to assess because it is the exact equivalent of Forest, but located on agricultural and urban land (Figure 3). These characteristics would allow foresters to use the same remote sensing tools that they use to assess Forest, combined with the same field measurements methods. This being said, the assessment of ToF is different from the assessment of Forest, in particular, the assessment of OLwTC necessarily entails a multi-sectoral approach, and a process of authorization (which is also often the case for the assessment of Forest in Brazil, but may or not be the case in other countries depending on the status of Forest) because the trees targeted are located in cities and in agricultural land, and thus generally subjected to clear private property rights that have to be taken into account.

There is no doubt that the Forest Service and its various partners who undertake the National Forest Inventory in Brazil have all the necessary competences in terms of both remote sensing and field work to either include the assessment of ToF in the inventory or to develop a specific ToF assessment, especially if the focus is put on OLwTC. In this perspective it may be useful to explore some of the tree-based systems that would potentially fall into the OLwTC sub-category.

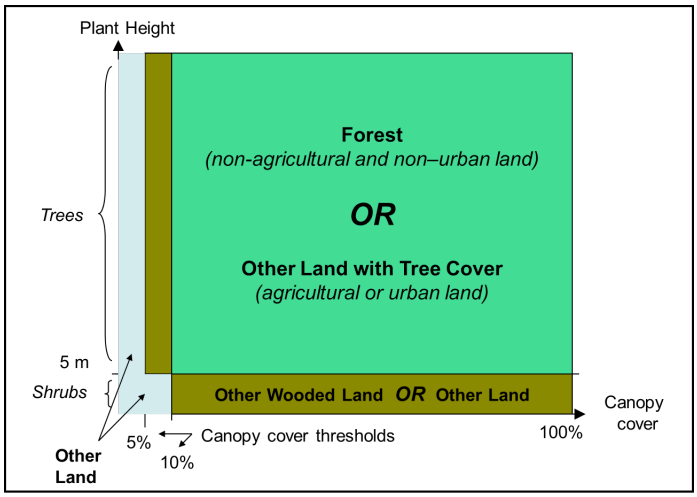

Figure 3. Comparing forest and other land with tree cover. Where land has trees (height ≥ 5 m) with a canopy cover ≥ 10% (the large rectangle), it is classified as FOREST if the use of the land is not predominantly urban and agricultural, OR it is classified as OTHER LAND with TREE COVER if the use of the land is predominantly urban or agricultural (adapted from de Foresta et al., 2013).

Potential candidates for OLwTC in Brazil

The following is certainly not an exhaustive inventory of the tree-based systems that could be classified as OLwTC in Brazil. I do not have enough knowledge about this so diverse country to be able to propose such an inventory, and my modest objective is here to screen the range of possibilities on the basis of the systems that could be identified on satellite images available on Google Earth.

Trees often make up a substantial proportion of the urban areas. This is the case in many large cities and Brasilia is one of the best examples in the world, where almost the whole city may be classified as OLwTC (Figure 4). This is also the case in many smaller cities located in more rural areas, in which parts may also be classified as OLwTC (Figure 5). In rural landscapes, houses often have tree-based home gardens and when houses form relatively dense settlements, the juxtaposition of home gardens often satisfy the criteria for being classified as OLwTC (Figure 6), in which cases they somehow form a transition between trees in an urban context and trees in an agricultural context.

Trees on agricultural land can be encountered in diverse arrangements. Some arrangements make them obvious candidates for OLwTC. This is the case indeed with all industrial fruit tree crop plantations such as mango or avocado plantations (Figure 7), and with all palm plantations.

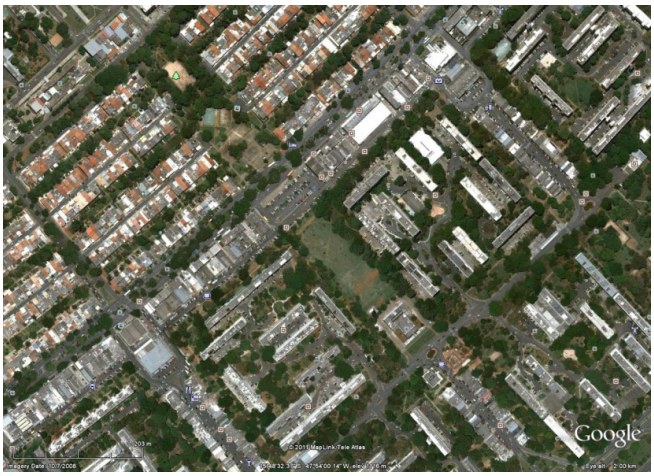

Figure 4. Trees in large cities often satisfy the criteria for OLwTC (here in Brasilia, DF, Brazil). Photo credit: Image©2017 Digital Globe, Google.

Figure 5 . Trees in rural cities often satisfy criteria for OLwTC (here in Rio Branco, Acre, Brazil) Photo credit: Image©2016 Digital Globe, Google.

Figure 6 . In villages, home gardens may often satisfy criteria for OLwTC (here in Cruzeiro do Sul, Acre, Brazil). Photo credit: Image©2016 CNES/Astrium, Google.

However, it is not always obvious to distinguish on satellite images a fruit tree plantation (to be classified as OLwTC) from a timber plantation (to be classified as Forest), and field checking may often be necessary in case of doubt. Simple agroforestry systems such as coffee or cocoa plantations under a monospecific cover of shade trees may also be included into this group of obvious tree arrangements that qualify as OLwTC. Some arrangements may require canopy cover measurements to ensure that they satisfy the canopy cover criterion of OLwTC. This is often the case for pastures with trees. In Cerrado region for instance, when farmers converted the forest to pasture, they often preserved, and sometimes planted, some trees for shading cattle, so that at least some parts of their farms may satisfy criteria to be classified as OLwTC.

Figure 7. Industrial fruit tree and palm tree plantations are to be classified as OLwTC (here, fruit trees, in Juazeiro, Bahia). Photo credit: Image©2016 Digital Globe, Google.

Still in other arrangements, characterized by a dense and sometimes diverse tree cover, it is not the tree canopy cover threshold that causes difficulties, but the similarity between the ToF cover and a Forest cover. In such cases, satellite images are not enough to identify the use of the land, which is the only distinction between Forest and OLwTC, and field checking, including sometimes interviews with the land users, is thus necessary.

Traditional shifting cultivation systems in the humid tropics are one of these cases. In these systems, the short (generally about 2 years) swidden phase of cultivation is followed by a longer (generally about 15 years) fallow phase usually made up of a forest-like regrowth. Fallow allows the reconstitution of the fertility of the field (soil plus reduction of weeds) and it is thus considered an essential and integral part of this agricultural system since the seminal work of Conklin commissioned by FAO and published in 1957 (Conklin, 1957). Fallow, even though it has a forest-like cover, should thus be considered as agricultural land. This is not currently the position of the FAO-FRA which, in its latest "guide for country reporting" to Global FRA 2015 (FAO-undated), explains that: "Long fallows, in which the woody fallow period is longer than the cropping period and trees reach at least 5 m in height should be considered as "forest". Short fallows in which the cropping period is greater or equal to the fallow period and/or woody vegetation does not reach 5 m during the fallow period should be classified as "other land" and, when relevant, as "other land with tree cover" since the main land use is agriculture." This conception of fallow in shifting cultivation systems represents a denial of shifting cultivators livelihood which is not shared by all sectors at FAO, as exemplified by the recent book " Shifting cultivation, livelihood and food security" published by FAO, the International Work Group For Indigenous Affairs and the Asia Indigenous Peoples Pact (Erni, 2015). The FAO-FRA conception however probably reflects the dominant perception of most foresters in the humid tropics, but it is not sure it reflects the perception of shifting cultivation practitioners in the humid tropics, among which the indigenous communities in the amazon region. As a temporary measure, fallow land could deserve a special category in forest and ToF assessments so that it could be assigned either to forest or to OLwTC according to the evolution of the understanding of the shifting cultivation system. If fallow is understood as an integral part of the agricultural system, then fallow (be it short or long) land should be classified as OLwTC (Figure 8).

The other case for which satellite images are not enough to identify the land-use is complex agroforests (Michon et al., 2007), which mimic the natural forest ecosystem in terms of structure and processes, but which are based on the establishment and management of a large range of useful tree species. Most trees in complex agroforests have been chosen by farmers for their production of fruits, latex or resin, generally all of commercial value, so that agroforests often represent the main income generating part of farmers land. Although established and managed by farmers, complex agroforests are often confused with natural forests.

Figure 8. Mosaics of swiddens and fallows generally satisfy criteria for OLwTC (here in Papaïchton, French Guiana) Photo credit: Image©2016 CNES/Astrium, Google.

Figure 9. This area, on the eastern bank of the Tapajos river is known for its rubber agroforests, some of which have been cultivated for more than a century. Distinction between Forest and OlwTC can only be made through field checking. Photo credit: Image©2016 CNES/Astrium, Google.

In countries where forest is a legal category considered as state property, confusing agroforest with forest may result in the denial of the rights of agroforest farmers, as was the case for the damar agroforests in Sumatra, Indonesia (Kusters et al., 2007). Even when forest is not considered as a state property, confusing agroforest with forest may have dramatic consequences, because forests often represent easy targets for agricultural development projects while agroforests are indeed already developed areas. There are agroforests in Brazil (Figure 9), some of which have been reported and studied, such as the rubber-based agroforests east of the Tapajos river (Schroth et al., 2003), or the cocoa-based agroforests near Bahia (Sambuichi et al., 2012). These agroforest systems show that ToF can occur not only in the form of isolated trees or in dense monoculture plantations whose area is easy to classify as OLwTC, but also in dense multi-specific plantations which may be quite difficult to distinguish from natural forests.

The National Forest Inventory of Brazil takes into account all forest and non-forest land-uses in non-urban areas, so that all the various tree-based systems on agricultural land described above, as long as they are identified as such could be assessed as parts of the OLwTC subcategory. However, first a whole part of OLwTC (trees on urban land) is not covered, and second, the systematic sampling protocol used by the BNFI, based on a 20 km x 20 km grid, may not be the most appropriate method for assessing OLwTC efficiently. Including the assessment of OLwTC in the BNFI or developing another assessment specific to OLwTC is a matter of choice for Brazil. However considering the enormous task already represented by the assessment of its forests, it may be interesting to devolve another set of resources and envisage a specific assessment dedicated to OLwTC. Such assessment could begin with a stratification of the landscape based on the analysis of remote-sensing images which, in combination with the necessary field checking, would allow mapping and measuring the OLwTC areas. This could be combined with a categorization of OLwTC (with urban and agricultural as first obvious categories, to be further detailed) that would lead to the development of ad hoc sampling protocols that would be best adapted to the dual nature of OLwTC, urban or agricultural, and that would efficiently capture the information needed on the trees themselves, their diversity, their uses, and the services they provide.

Conclusions

This paper tried to provide a better understanding of the different sets of trees outside forests and of where they have to be looked for in Brazil. It also tried to forward the idea that assessing Other Land with Tree Cover (OLwTC), a subcategory of Other Land in the FAO land classification framework used by countries to report every five years on the state of their forests, should be considered a major first step in the assessment of ToF, as it would already provide an extremely useful

and much needed information, not on all the existing ToF, but on the main bulk of ToF.

The recent publication by Zomer et al. (2016) positions Brazil as a leader in terms of the total biomass carbon from trees on agricultural land. The same publication however shows that Brazil lags far behind many countries in terms of the average biomass carbon per hectare, and that there is thus ample room in the country for a tremendous increase in the tree cover on agricultural land. A countrywide assessment of OLwTC would allow the country identifying agricultural areas where tree cover could be increased for ecological and economic reasons, and targeting such areas for agroforestry development.

That the country, despite its low average tree cover on agricultural land, is the world leader in terms of the total agricultural area covered with trees, will certainly stimulate the desire for Brazil to better assess not only trees on agricultural land but also trees on urban land, the two major sets of trees outside forests that make up the OLwTC category. I do hope that the present paper will be of some help to those who will undertake this challenging but exciting task, so useful for the future.

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References

Bellefontaine, R. et al. **Trees outside forests**: towards better awareness. Rome: FAO, 2002. 234 p. (FAO conservation guide, 35). Available from: <http://www.fao.org/DOCREP/005/Y2328E/Y2328E00.HTM>. Access on: 20 June 2017.

Conklin, H. C. **Hanunoo agriculture**: a report on an integral system of shifting cultivation in the Philippines. Rome: FAO, 1957. 209 p. (FAO forestry development paper, 2).

De Foresta, H. et al. **Towards the assessment of trees outside forests**: a thematic report prepared in the Framework of the Global Forest Resources Assessment 2010. Rome: FAO, 2013. 368 p. (FAO. Forest resources assessment working paper, 183). Available from: <http://www.fao.org/forestry/fra/2560/en/>. Access on: 26 June 2017.

De Foresta, H. For a better integration of trees outside forests in FRA 2015 and beyond. In: Expert Consultation on the Long-Term Strategy for Global Forest Resource Assessment, 2011, Nastola, Finland. Rome: FAO, 2011. 34 p.

Erni, C. (Ed.). **Shifting cultivation, livelihood and food security**: new and old challenges for indigenous peoples in Asia. Rome: FAO, 2015. 415 p.

FAO. **FRA 2015**: terms and definitions. Rome, 2012. 32 p. (Forest Resources Assessment working paper, 180). Available from: <http://www.fao.org/docrep/017/ap862e/ap862e00.pdf>. Access on: 26 June 2017.

FAO. **Global Forest Resources Assessment 2010**: main report. Rome, 2010. 340 p. (FAO forestry paper, 163). Available from: <http://www.fao.org/docrep/013/i1757e/i1757e.pdf>. Access on: 26 June 2017.

FAO. **Guide for country reporting for FRA 2015**. Rome, [2015]. 103 p. (FRA 2015 working paper, 184). Available from: <http://www.fao.org/3/a-au190e.pdf>. Access on: 26 June 2017.

Freitas, J. V. et al. National forest inventory reports: Brazil. In: Tomppo, E. et al. (Ed.). **National forest inventories**: pathways for common reporting. London: Springer, 2010. p. 89-95.

Kusters, K. et al. Towards solutions for State vs. Local Community conflicts over Forestland: the impact of formal recognition of user rights in Krui, Sumatra, Indonesia. **Human Ecology**, v. 35, n. 4, p. 427-438, 2007. DOI: 10.1007/s10745-006-9103-4.

Michon, G. et al. Domestic forests: a new paradigm for integrating local communities forestry into tropical forest science. **Ecology and Society**, v. 12, n. 2, 2007. Available from: <http://www.ecologyandsociety.org/vol12/iss2/art1/>. Access on: 26 June 2017.

Sambuichi, R. H. et al. Cabruca agroforests in southern Bahia, Brazil: tree component, management practices and tree species conservation. **Biodiversity and Conservation**, v. 21, n. 4, p. 1055-1077, 2012. DOI: 10.1007/s10531-012-0240-3.

Schroth, G. et al. Rubber agroforests at the Tapajós River, Brazilian Amazon: environmentally benign land use systems in an old forest frontier region. **Agriculture, Ecosystems & Environment**, v. 97, n. 1, p. 151-165, 2003. DOI: 10.1016/S0167-8809(03)00116-6.

Zomer, R. J. et al. Global tree cover and biomass carbon on agricultural land: the contribution of agroforestry to global and national carbon budgets. **Scientific Reports**, v. 6, article 29987, 2016. DOI: 10.1038/srep29987.