ecosystem services, and that species or ecosystems that are rare, endemic or threatened with extinction should be identified, protected and monitored. It implies that the REDD+ Programme will protect natural forests from degradation and conversion to other land uses, including to forest plantations, and that it shall also promote and use indigenous species to restore degraded areas. Furthermore, it states that the REDD+ Programme shall analyse the possible impacts on biodiversity and other ecosystem services when considering options for REDD+ actions.

2. Planning for REDD+ multiple benefits and safeguards

When identifying potential zones for REDD+ action, several considerations are likely to be relevant (Figure 2). First, the goals of REDD+: to reduce forest carbon emissions, maintain or enhance forest carbon stocks, as well as to deliver the other benefits that REDD+ is expected to bring. The aim is to achieve an overall reduction in forest carbon stock losses and overall gain in carbon stocks compared to those in an anticipated non-REDD+ future; whilst applying the agreed safeguards for REDD+. This means that, second, the drivers of forest loss and degradation need to be tackled in order to avoid leakage and ensure persistence of the achieved results. This implies an identification of the pressures that forests may be subject to in future, and the vulnerability of forest carbon stocks to those pressures. Third, decision-makers will need to consider feasible actions that can be used to achieve the goals, and evaluate them in terms of what benefits they can provide, under what conditions they will be effective, and what risks they may carry. These actions and their effects should be consistent with the REDD+ safeguards. For example, the draft Tanzania REDD+ Safeguards expect the REDD+ Programme to analyse the possible impacts on biodiversity and ecosystem services when considering options for REDD+ actions.

The maps in section 2 of this report aim to assist decision-makers in this process of identifying potential zones for REDD+ action. Some relevant themes are also identified for which spatial information is not yet available.

2.1 Biomass carbon stocks of Tanzania

The central value that REDD+ is intended to protect and enhance is forest carbon, in biomass and potentially also soils. Spatial planning for REDD+ implementation therefore needs to include a consideration of existing carbon stocks and their rate of loss; to inform decisions on which stocks will be maintained, which will be enhanced, and which may be lost even in the context of REDD+ implementation.

The NAFORMA inventory has resulted in a new, field-based map of woody biomass for Tanzania, at 5 km resolution. Another, higher resolution map which will account for all above ground biomass is in preparation by NAFORMA, building on a multi-source approach, combining the field based survey and remote sensing. This map will be available in late 2013.

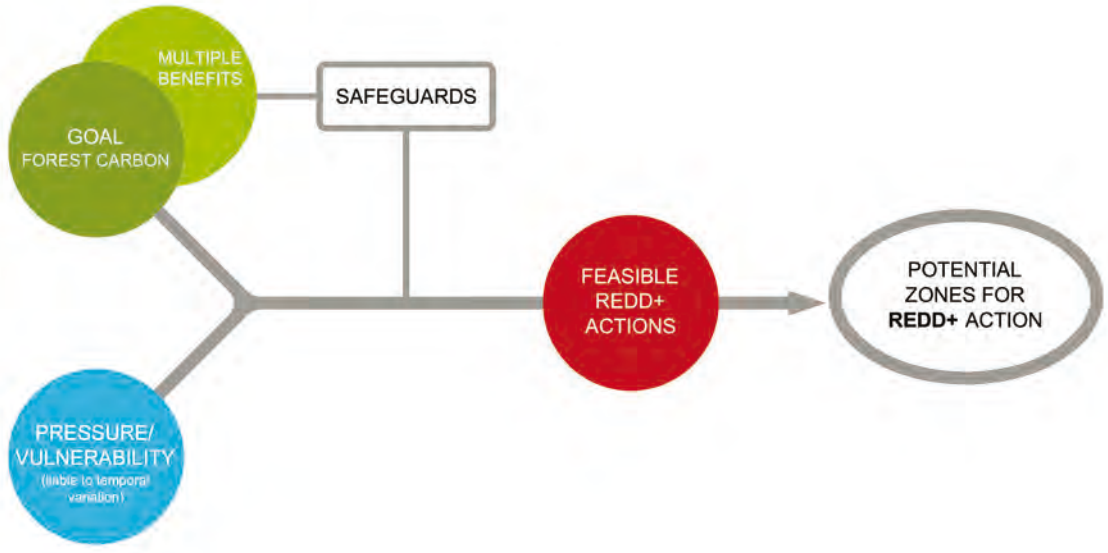


Figure 2: When identifying potential zones for REDD+ action, several factors are likely to be relevant. Identifying the current and desired spatial distribution of forest carbon stocks and multiple benefits (the goals of REDD+) is a first consideration. Current and future pressures on forests determine what additional value REDD+ actions can bring. Feasible actions in different locations is a third consideration. These actions should be consistent with the REDD+ safeguards, which intend to ensure that REDD+ actions promote multiple benefits and avoid harm.

When the NAFORMA woody biomass carbon map is compared with two other datasets on above-ground biomass carbon developed for the tropical regions of the world (Saatchi et al. 2011; Baccini et al. 2012), differences in the pattern of biomass distribution are notable (Map 2). Furthermore, the field plot-based mapping methodology applied here results in lower biomass estimates than reported in Saatchi et al. (2011) and Baccini et al. (2012). Some of these differences can be explained by differences in the definition. While above-ground biomass consists of all living biomass (including stem, stump, branches, bark, seeds and foliage), the applied definition of woody biomass in the initial NAFORMA analysis refers to the stems of the trees only. However, as the tree stems constitute the major part of above-ground biomass carbon in the dominating Tanzanian vegetation types, the differences observed here are larger than expected.

In addition to the carbon stored in biomass, there is a pool of carbon stored in the soil. Removing vegetation can cause the release of soil carbon stocks. In some cases it may therefore be important to take soil carbon stocks into account in forest land-use planning. Map 3 shows soil organic carbon down to 1 m depth in Tanzania, and is based on a global dataset (Scharlemann et al. in prep). A national soil carbon map for Tanzania is being developed based on the NAFORMA field inventory and sources of soil data, and can replace Map 3 when it becomes available. In addition, Map 4 shows a sum of woody biomass carbon, below ground biomass and soil organic carbon to illustrate the combined amounts of carbon in these different pools.

Deciding which carbon map is most appropriate to use for decision making depends on what REDD+ action is under consideration, and what carbon pools it will influence. For example, where the aim is to reduce forest clearing or unsustainable forest management, which can lead to release of soil carbon, a combined map of biomass and soil carbon can be useful for understanding where soil carbon stocks will significantly influence emissions. The maps in this report that include a carbon layer use the NAFORMA woody biomass map, because it is the most recent dataset available, and because the inclusion of soil carbon stocks in all analyses may lead to an over-estimate of the likely impacts of REDD+. Furthermore, the accuracy of national scale soil carbon assessments is much lower than equivalent assessments for above-ground biomass.

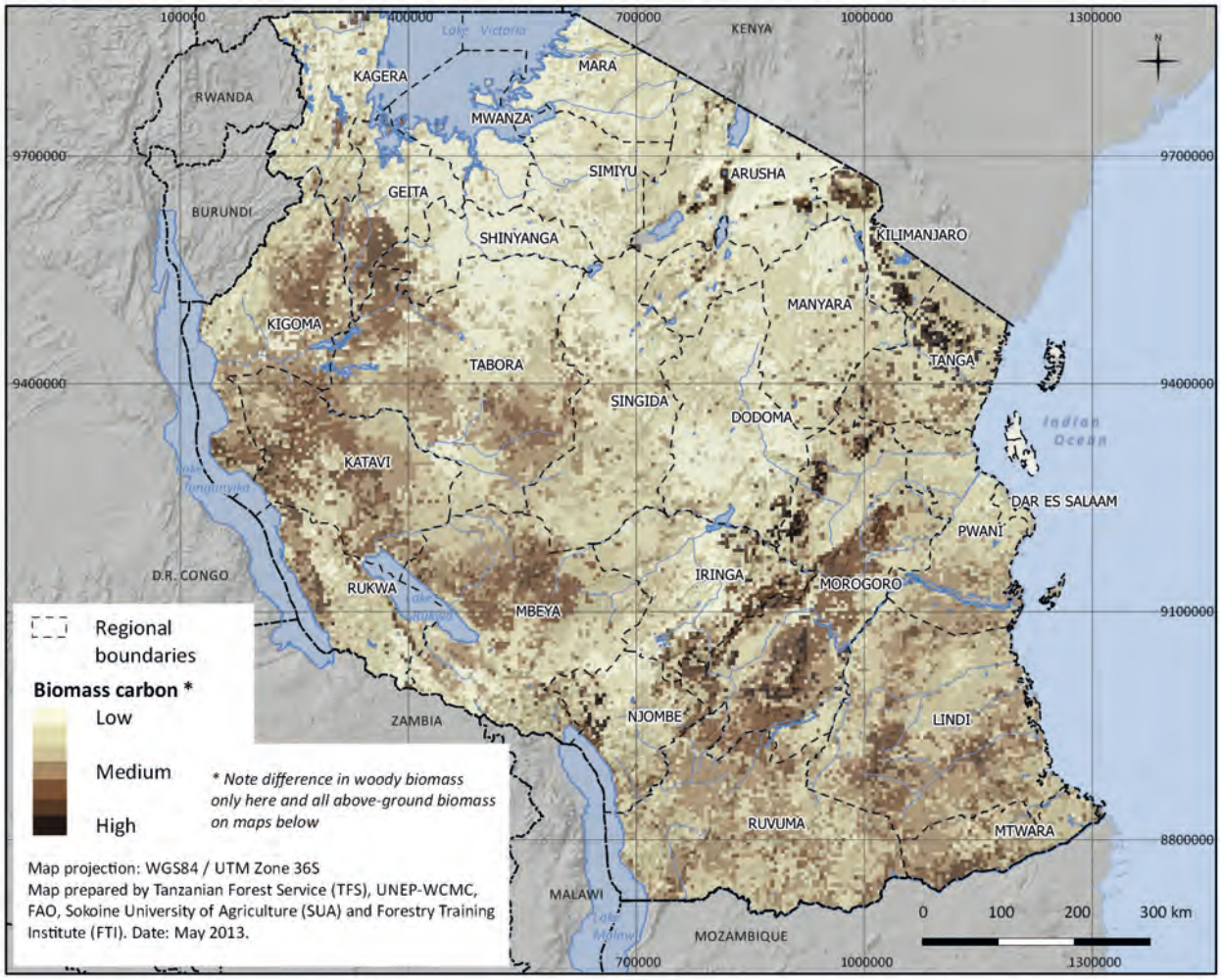
2.2 Natural forest

The definition of *forest* in the first negotiations on REDD under the UNFCCC did not distinguish between natural and plantation forest. This led to the concern that REDD could result in the conversion of natural forests to plantations or other non-forest systems, such as agroforestry (Harvey et al. 2010). To address this, the Cancun Safeguards[4] defined at the UNFCCC

Map 2: Woody biomass carbon compared with above-ground biomass carbon (three different datasets)

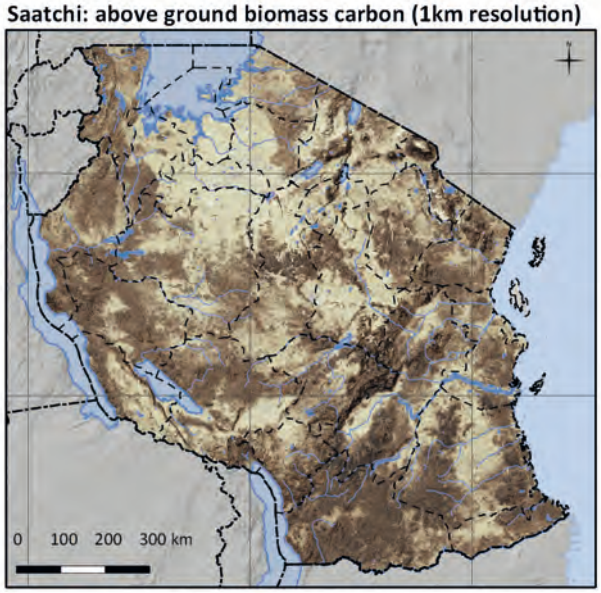
This map shows the NAFORMA woody biomass carbon map (top), compared with above-ground biomass carbon maps based on data from Saatchi et al. (2011) (below left) and Baccini et al. (2012) (below right). The maps are displayed using the same carbon value categories, and are therefore comparable. Current carbon stocks will be needed to inform many decisions in spatial REDD+ planning. For many REDD+ decisions, above-ground biomass is the most important carbon pool (woody biomass constituting the bulk of this).

NAFORMA: Woody biomass carbon only (5km resolution preliminary dataset based on field data)



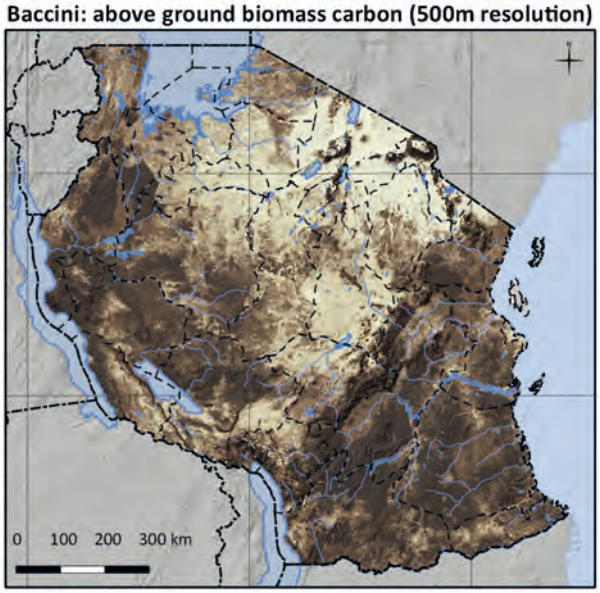
Data sources: Woody biomass carbon: NAFORMA. 2013. NAFORMA woody biomass. 5km preliminary dataset based on field data. Regional boundaries: Ministry of Lands, Housing and Human Settlements Development. 2011. Administration Map of Tanzania. Surveys and Mapping Division, Dar es Salaam Tanzania.

Saatchi: above ground biomass carbon (1km resolution)



Data source: Saatchi S, Harris NL, Brown S, Lefsky M, Mitchard ET, Salas W, Zutta BR, Buermann W, Lewis SL, Hagen S, Petrova S, White L, Silman M, Morel A. 2011. Benchmark map of forest carbon stocks in tropical regions across three continents. Proceedings of the National Academy of Sciences USA. Jun 14;108(24):9899 -904.

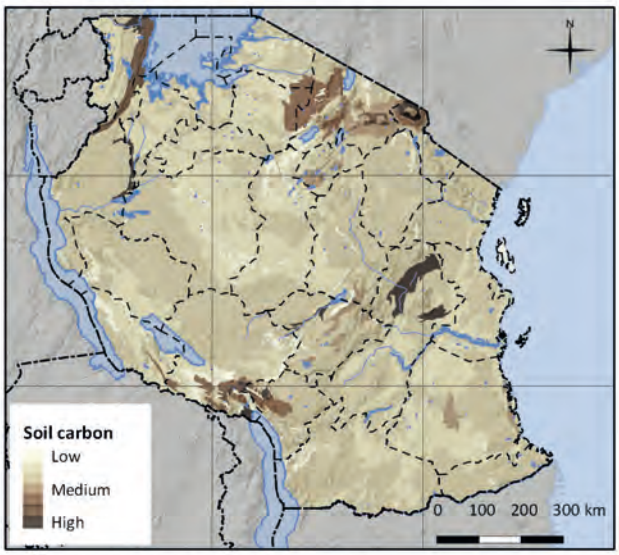
Baccini: above ground biomass carbon (500m resolution)



Data source: Baccini, A., Goetz, S.J., Walker, W.S., Laporte, N.T., Sun, M., Sulla-Menashe, D., Hackler, J., Beck, P.S.A., Dubayah, R., Friedl, M.A., Samanta, S., Houghton, R.A. 2012. Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. Nature Climate Change 2 182-185.

Map 3: Soil organic carbon

This map shows soil organic carbon to a depth of 1 metre. Soil carbon stocks can be relevant to account for in some REDD+ decisions.



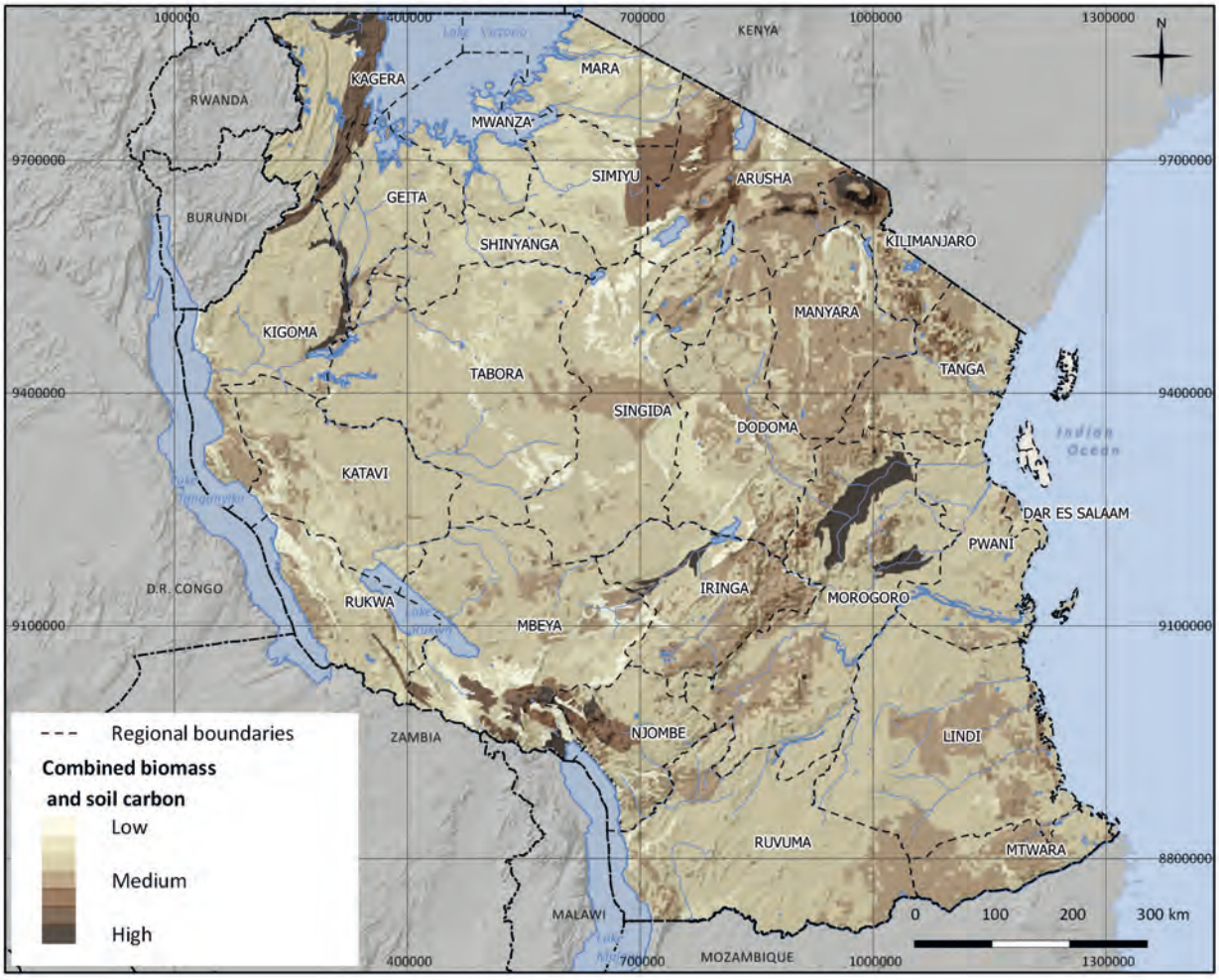
Map projection: WGS84 / UTM Zone 36S
Map prepared by Tanzanian Forest Service (TFS), UNEP-WCMC, FAO, Sokoine University of Agriculture (SUA) and Forestry Training Institute (FTI). Date: May 2013.

Data sources:
Woody biomass carbon: NAFORMA. 2013. NAFORMA woody biomass only. 5km preliminary dataset based on field data.
Below ground biomass conversion factors: IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 4 Agriculture, Forestry, and Other Land Use. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds).
Published: IGES, Japan. Accessed: March 2013 at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html
Ecological zones: FAO. 2001. Global Forest Resources Assessment 2000. FAO Forestry Paper 140. Food and Agriculture Organization of the United Nations, Rome, Italy.
Soil organic carbon: Scharlemann JPW, Hiederer R & Kapos V. in prep. Global map of terrestrial soil organic carbon stocks. A 1-km dataset derived from the Harmonized World Soil Database. UNEP-WCMC & EU-JRC, Cambridge UK.
Regional boundaries: Ministry of Lands, Housing and Human Settlements Development. Surveys and Mapping Division. Administration Map of Tanzania. Dar es Salaam Tanzania, 2011

Methods:
Above ground woody biomass was taken from NAFORMA (2013). Ecosystem-specific conversion factors (IPCC 2006) were used to add below-ground biomass, with the factors allocated to FAO ecological zones (FAO 2001). Where an ecological zone was not listed in IPCC 2006, the tropical shrubland factor was used. These values were multiplied by 0.5 to convert from biomass to carbon. This was added together with soil carbon (Map 3) to form the combined carbon map (Map 4).

Map 4: Combined carbon map

This map shows the sum of above-ground woody biomass carbon, below-ground carbon and soil organic carbon. In some cases it may be preferable to base REDD+ decisions on a combination of carbon pools, rather than only above-ground or woody biomass.



Conference of Parties in 2010 state that REDD+ actions should be: "consistent with the conservation of natural forests and biological diversity, ensuring that [REDD+] actions (...) are not used for the conversion of natural forests, but are instead used to incentivize the protection and conservation of natural forests and their ecosystem services, and to enhance other social and environmental benefits". The Government of Tanzania, through its draft REDD+ Safeguards document, has identified the protection of natural forests from degradation and from conversion to other land uses (including plantations) as a priority.

Since no common definition of natural forest has yet been agreed under the UNFCCC, a national definition of natural forest is useful in this context. The Tanzania REDD+ Strategy defines natural forest as: "Forest composed of indigenous trees, not planted by man". This further requires a definition of forest, and Tanzania is currently using multiple definitions of forest in parallel. The REDD+ Strategy and NAFORMA follows the FAO Forest Resources Assessment (FRA) definition, which defines forests as "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." (FAO 2010). The Tanzanian Government has also submitted a national definition of forest to the Clean Development Mechanism (CDM) under the UNFCCC, defining forest as having a minimum tree crown cover value of 10 per cent, a minimum land area value of 0.05 ha, and a minimum tree height value of 2 metres. If the CDM definition is applied, bushland and thicket vegetation could in many cases fall under the definition of forest, while these land cover categories are likely to be excluded using the FAO/REDD+ Strategy/NAFORMA definition. Including thickets and bushlands as forest, could expand the area of natural forest by as much as 38 per cent (an additional 6 369 000 ha), and hence also the areas that are covered by draft safeguard 7.3 (Table 1).

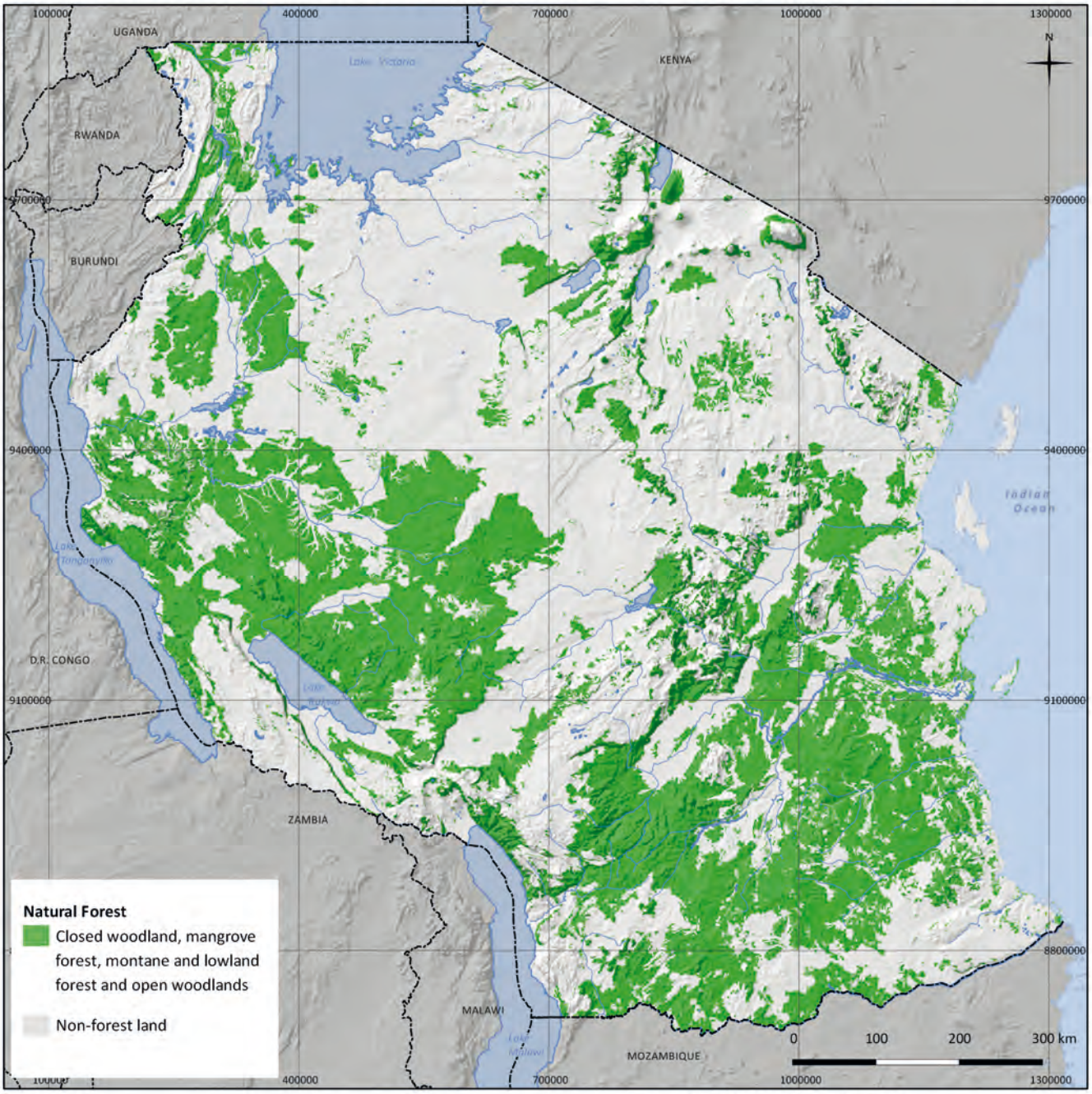
Map 5 shows an estimate of the difference between these two forest definitions, based on the categories in the NAFORMA land-use land-cover map. Whilst the map is not a perfect representation of the two definitions, it does show that definitions of forest and natural forest can have a strong influence on the extent of the area to which the safeguard would apply. Some of the limitations of this map are: first, the vegetation classification used to produce the remote sensing-based land-use land-cover map may include stands shorter than the 2 m or 5 m minimum tree height in various forest definition categories, which would hence not fit the forest definition. Second, a strict interpretation of the natural forest definition would exclude areas that have been invaded by (or deliberately planted with) non-native species. This possibility is not accounted for in these maps. Third, that same strict interpretation could also exclude high carbon forests where enrichment plantings have been carried out in the past; these are also not distinguished on the maps.

The national natural forest definition applied to REDD+ is likely to be important, as it on the one hand places constraints on the areas that might be available for specific REDD+ actions, for example the development of plantations; but on the other hand also provides an important safety mechanism to protect natural forest.

[4] FCCC/CP/2010/7/Add.1 Appendix I

Map 5: Natural forest estimations based on the NAFORMA land-use land-cover map.

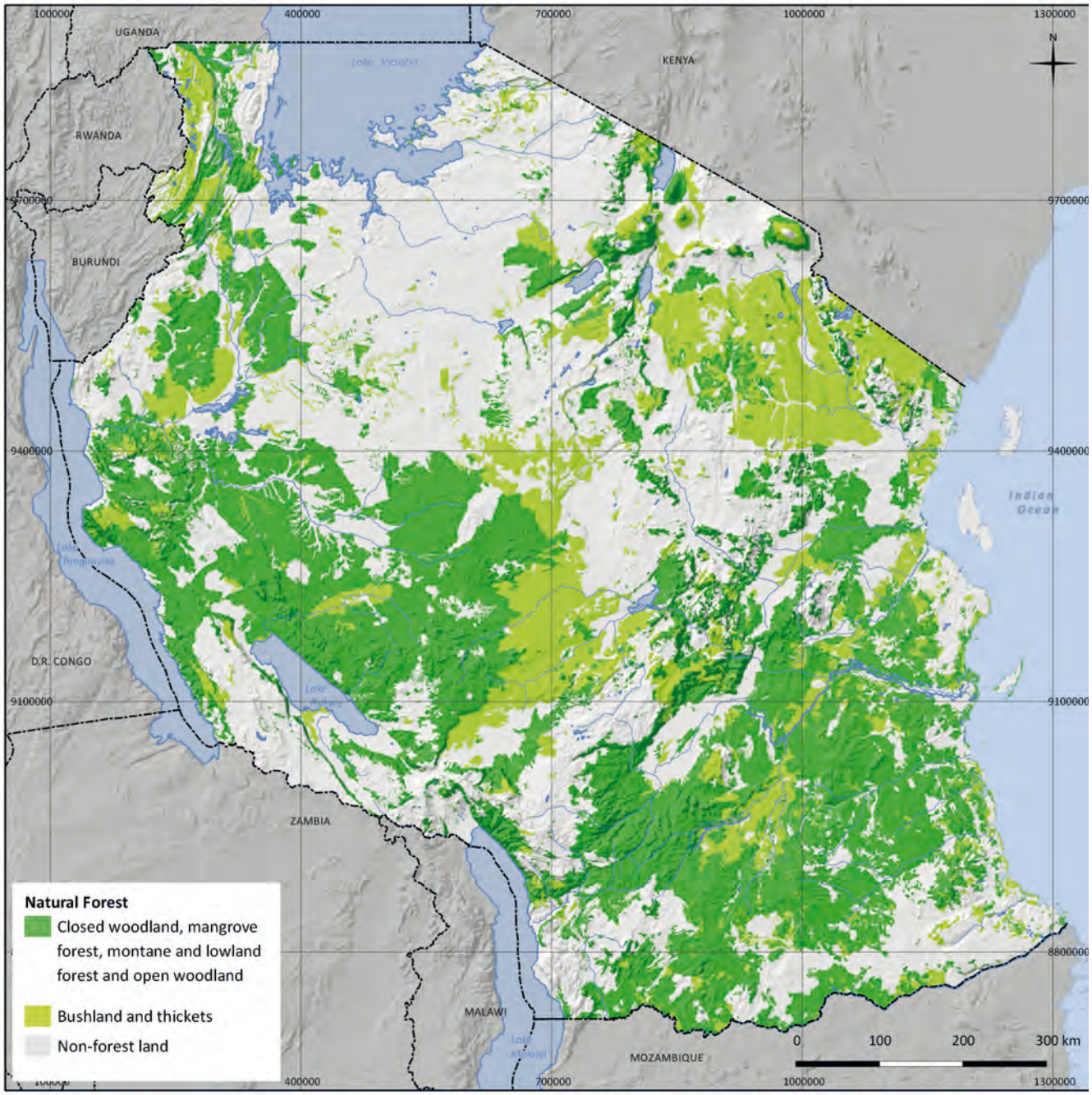
Defining natural forest is necessary to be able to apply key parts of the REDD+ safeguards, which state that "the REDD+ programme [should] protect natural forests from degradation and conversion to other land uses including forest plantations" (draft safeguard 7.3 in table 1). In Tanzania, different definitions of natural forest are possible, as the country has several definitions of 'forest' in use. Two key examples are: (1) The REDD+ Strategy/NAFORMA/ FAO FRA definition: minimum tree crown cover of 10 per cent, minimum land area of 0.5 ha and minimum tree height of 5 meters. (2) The national UNFCCC CDM definition: minimum tree crown cover of 10 per cent, minimum



Data sources:
Natural forest: NAFORMA. 2013. NAFORMA land-use / land-cover Map 2010.

Map projection: WGS84 / UTM Zone 36S
Map prepared by Tanzanian Forest Service (TFS), UNEP-WCMC, FAO, Sokoine University of Agriculture (SUA) and Forestry Training Institute (FTI). Date: May 2013

land area of 0.05 ha and minimum tree height of 2 meters. The REDD+ Strategy/NAFORMA/FAO FRA definition includes the vegetation categories montane and lowland forest, open and closed woodlands, and mangroves, but excludes thickets and bushlands (the map on the left). The CDM definition is also likely to include thickets and bushlands in addition to the other vegetation categories (the map on the right). Including thickets and bushlands may expands the area of natural forest by up to 38 per cent (an additional 6 369 000 ha), and hence also the areas that are covered by draft safeguard 7.3.



Data sources:
Natural forest: NAFORMA. 2013. NAFORMA land-use / land-cover Map 2010.

Map projection: WGS84 / UTM Zone 36S
Map prepared by Tanzanian Forest Service (TFS), UNEP-WCMC, FAO, Sokoine University of Agriculture (SUA) and Forestry Training Institute (FTI). Date: May 2013

2.3 Biodiversity

Biodiversity is not distributed evenly across space, and because of its complexity, is difficult to capture in a single indicator. For this reason, different approaches for identifying areas of importance for biodiversity exist. To examine key aspects of biodiversity for Tanzania, and how these relate to the distribution of biomass in-country, a number of datasets were used for this report.

First, an analysis of tree species diversity using the NAFORMA inventory was undertaken, to investigate the spatial distribution of tree species richness (Map 6), and the NAFORMA inventory clusters where threatened tree species were observed (Map 7). It should be noted, however, that the NAFORMA survey was not designed to accurately sample rare phenomena tree species diversity, and so may not give a representative result. Still, the threatened tree species identified in the survey were largely found in the Eastern Arc Mountains, which is a known global plant biodiversity hotspot (Mittermeier et al. 2004), in coastal forest and in remote locations of the miombo woodlands. For further details on mapping tree species richness and threatened tree species, including on the methodology employed, please refer to Annex I of this report.

Map 8 presents the distribution of animal species richness (mammals, birds and amphibians), and threatened species of the same categories. This information has been combined with woody biomass carbon to allow for identification of areas that are high in both carbon and animal species richness. The compilation of maps in Map 9 shows the same type of information but separated for the different taxa. 'One map show the frequency of threatened species and the other frequency of all assessed species, including species that are not considered threatened. These maps have been developed based on extent of occurrence[5] data from the IUCN Red List of Threatened Species (IUCN 2013). As can be seen from both Map 8 and Map 9, the Eastern Arc Mountains stand out as being among the few areas that have particularly high values of both threatened species richness and carbon. Such forests may be appropriate for REDD+ actions to conserve natural forests, and reduce human disturbances.

Map 10 shows the location of major wildlife corridors in Tanzania, and how they relate to protected areas and natural forest. Wildlife corridors are vital for the long term viability of wildlife populations and stability of protected ecosystems, but are in many cases subject to pressures such as forest degradation or land-use change (Jones et al. 2012). If wildlife corridors were to become the subject of forest rehabilitation or increased protection under REDD+, carbon stocks could be enhanced at the same time as benefiting key areas for biodiversity.

Together, maps 6-10 provide a range of biodiversity information that can be considered for different REDD+ purposes. REDD+ actions to maintain natural forest could provide additional benefits for biodiversity if they were implemented in areas that have high biodiversity values, or areas that have such values nearby and could serve as buffer zones. Forest areas which have been degraded but still hold high biodiversity values, or land that function as a wildlife corridor, could be appropriate for forest restoration using appropriate methods.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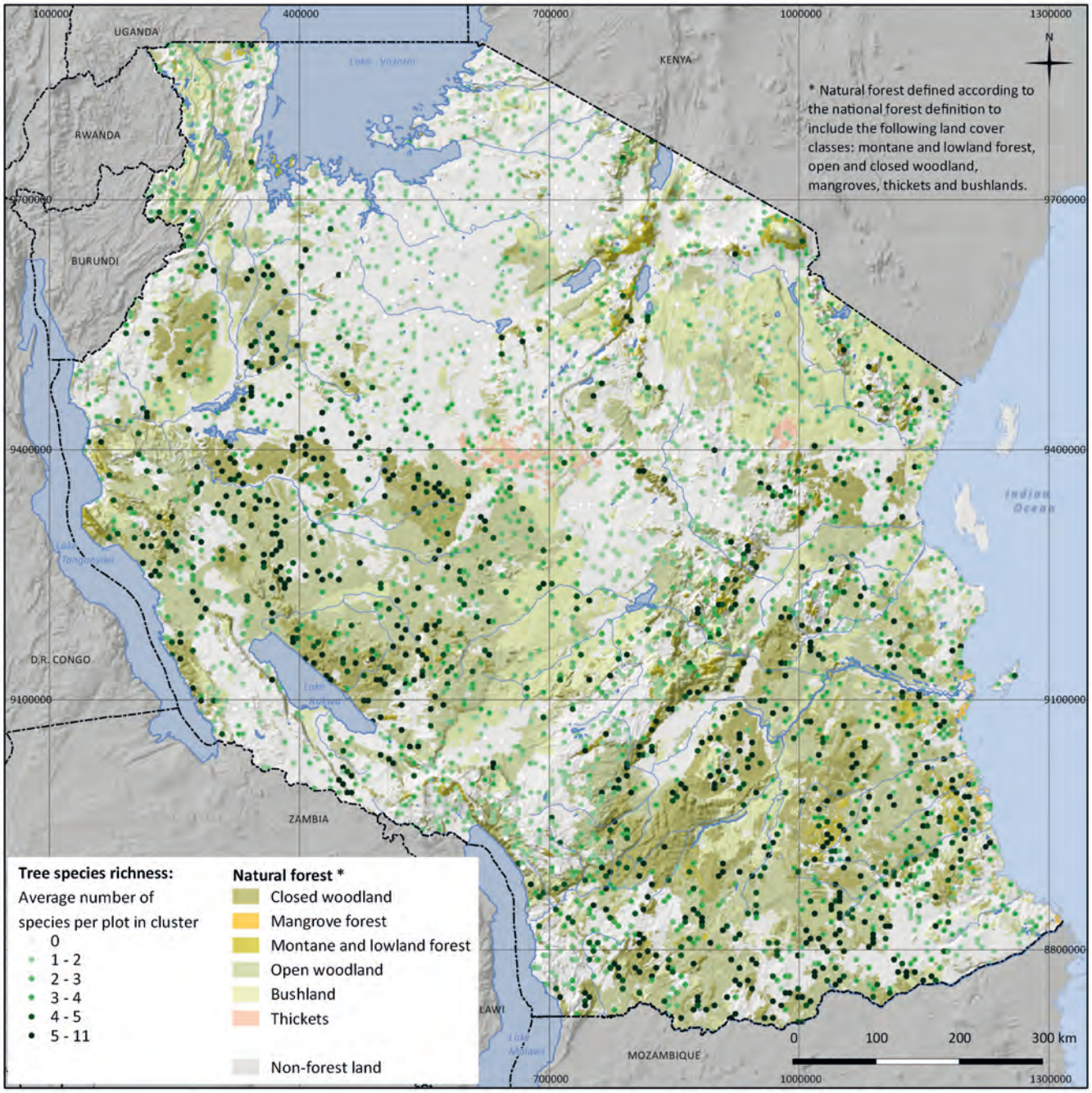
[5] Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy (IUCN 2000).

[6] This map has been created based on the information at http://www.tzwildlifecorridors.org (accessed May 2013). The map includes five types of wildlife corridors, including three categories covering areas that have been either confirmed or suspected to be active movement routes, but which were data deficient. A fourth category covers proposed or potential corridor areas linking fragmented or threatened habitat patches (usually forest), and the final category is defined by "known animal movement between two protected areas" (Jones et al. 2012).

Map 6: Average tree species richness in NAFORMA plots

This map shows the average (mean) tree species richness per plot for each cluster in the NAFORMA inventory. Box 1 further explains what the NAFORMA inventory can say about tree species richness in Tanzania. The average values are generally higher in lowland forest, montane forest, and closed woodland, indicating the high biodiversity value of these forests.

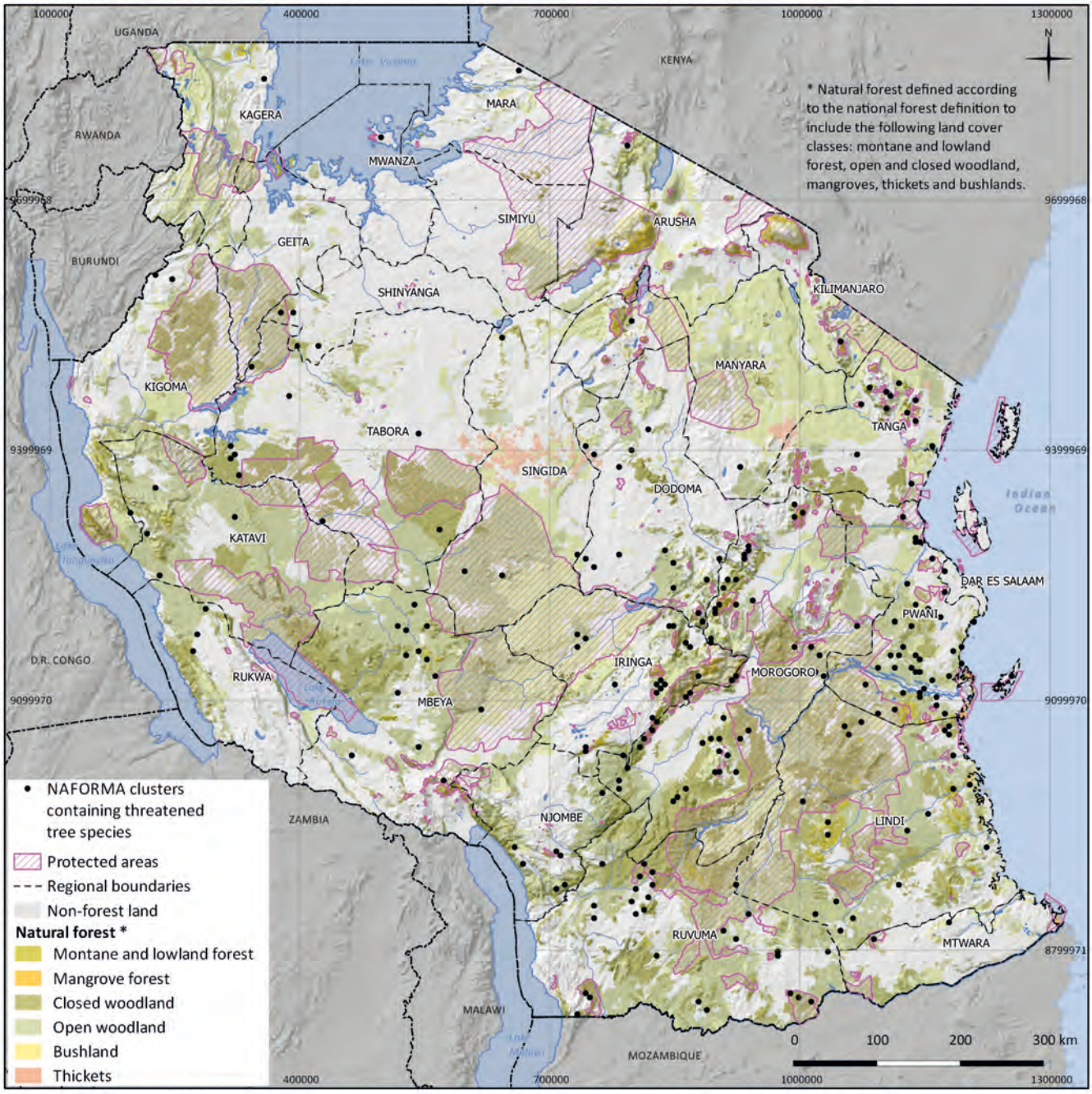


Data sources:
Natural forest: NAFORMA. 2013. NAFORMA land-use / land-cover Map 2010.
Tree species richness: NAFORMA. 2013. NAFORMA biophysical survey 2013.

Map projection: WGS84 / UTM Zone 36S
Map prepared by Tanzanian Forest Service (TFS), UNEP-WCMC, FAO, Sokoine University of Agriculture (SUA) and Forestry Training Institute (FTI). Date: May 2013

Map 7: Observed threatened tree species in the NAFORMA inventory

The map shows the NAFORMA inventory clusters where threatened tree species were observed, in relation to natural forest* and protected areas. Concentrations of threatened species are found in particular in and around the Eastern Arc Mountains and in the coastal forest of Tanzania. This information may be helpful for defining areas where actions can be implemented to conserve forests and reduce deforestation and forest degradation.

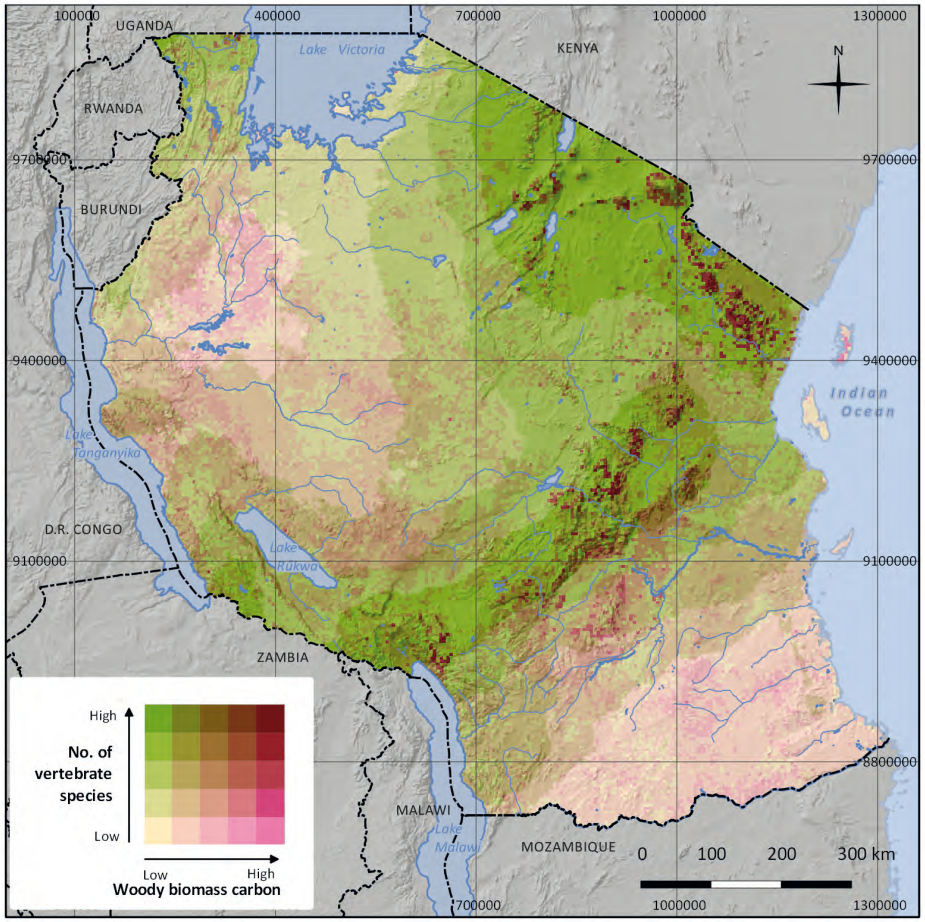


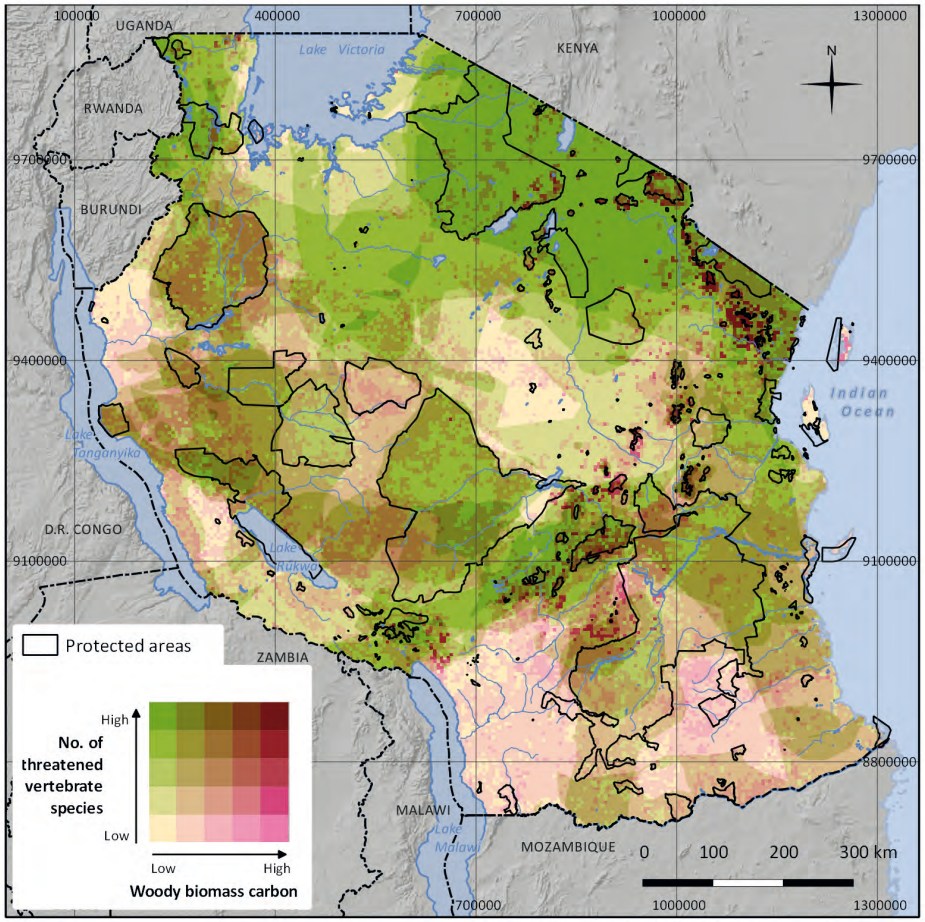
Data sources:
Natural forest: NAFORMA. 2013. NAFORMA land-use / land-cover Map 2010.
Threatened tree species: IUCN-SSC East African Plant Red List Authority. 2013.
Forest Reserves: Tanzanian Forest Service. 2013. Forest Reserves of Tanzania.
Protected Areas: IUCN and UNEP-WCMC. 2013. The World Database on Protected Areas (WDPA) Cambridge, UK. Available at: www.protectedplanet.net.
Regional boundaries: Ministry of Lands, Housing and Human Settlements Development. 2011. Administration Map of Tanzania. Surveys and Mapping Division, Dar es Salaam Tanzania.

Map projection: WGS84 / UTM Zone 36S
Map prepared by Tanzanian Forest Service (TFS), UNEP-WCMC, FAO, Sokoine University of Agriculture (SUA) and Forestry Training Institute (FTI). Date: May 2013

Map 8: Animal species (mammals, birds, amphibians) richness in relation to above-ground woody biomass carbon

These maps shows areas that are important for both biodiversity and carbon (dark red) where it may be a priority to ensure that the forest is not degraded, areas with low carbon but high biodiversity (green), and areas with high carbon but low biodiversity (light pink). Different REDD+ actions may be appropriate for these different combinations of values. The map on the left includes all vertebrates assessed by IUCN, while the map on the right includes threatened animal species only, displayed with protected areas.



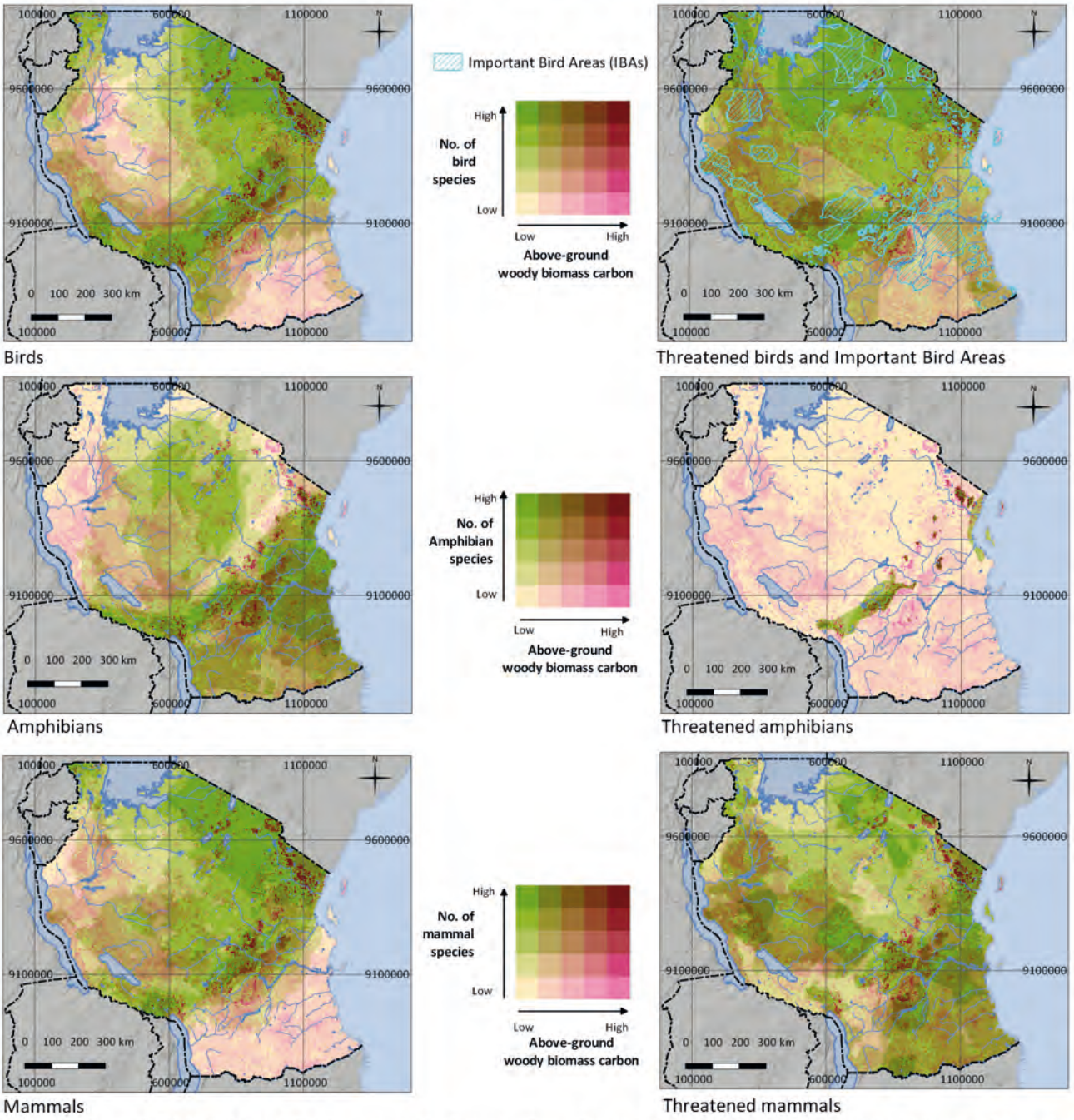


Data sources:
Woody biomass carbon: NAFORMA. 2013. NAFORMA woody biomass only. 5km preliminary dataset based on field data.
Vertebrates: IUCN. 2013. The IUCN Red List of Threatened Species. Version 2012.2. Downloaded March 2013 at http://www.iucnredlist.org
Forest reserves: Tanzanian Forest Service. 2013. Forest Reserves of Tanzania.
Protected areas: IUCN and UNEP-WCMC. 2013. The World Database on Protected Areas (WDPA) Cambridge, UK. Available at: www.protectedplanet.net.

Map projection: WGS84 / UTM Zone 36S
Map prepared by Tanzanian Forest Service (TFS), UNEP-WCMC, FAO, Sokoine University of Agriculture (SUA) and Forestry Training Institute (FTI).
Date: May 2013

Map 9: Animal species (mammals, birds, amphibians) richness in relation to above-ground woody biomass carbon

Areas that are particularly important for both biodiversity and carbon are shown in dark red, which for all taxa, including threatened species, are largely found in the Eastern Arc Mountains. Threatened species are those species regarded as threatened with extinction by IUCN. IBAs, indicated on the map of threatened birds, are important bird areas, assessed by BirdLife International.

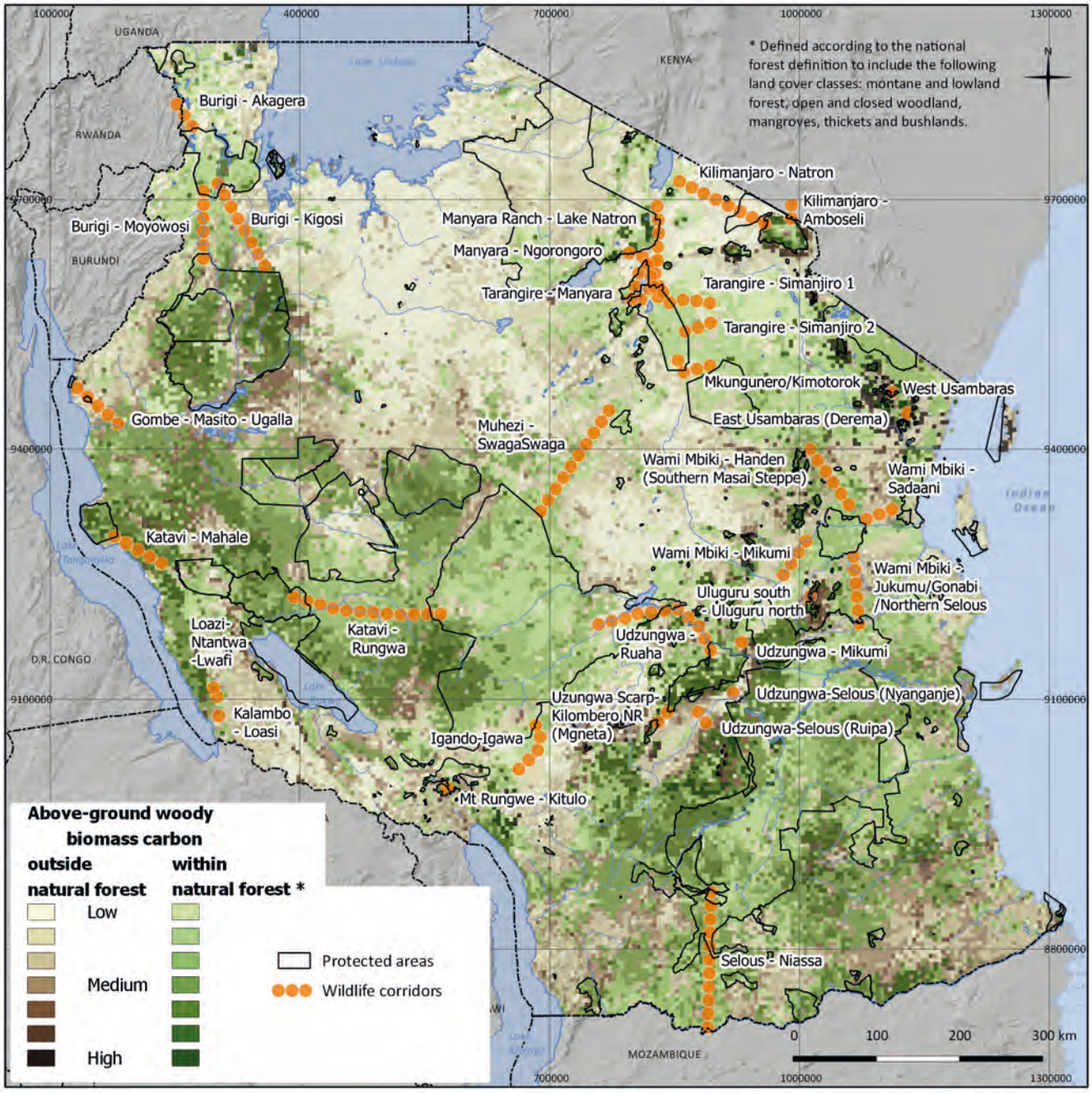


Map projection: WGS84 / UTM Zone 36S. Map prepared by Tanzanian Forest Service (TFS), UNEP-WCMC, FAO, Sokoine University of Agriculture (SUA) and Forestry Training Institute (FTI). Date: May 2013.

Data sources:
Woody biomass carbon: NAFORMA. 2013. NAFORMA woody biomass only. 5km preliminary dataset based on field data.
Vertebrates: IUCN. 2013. The IUCN Red List of Threatened Species. Version 2012.2. Downloaded March 2013 at http://www.iucnredlist.org
Forest reserves: Tanzanian Forest Service. 2013. Forest Reserves of Tanzania.
Protected areas: IUCN and UNEP-WCMC. 2013. The World Database on Protected Areas (WDPA) Cambridge, UK. Available at: www.protectedplanet.net.
Important Bird Areas: BirdLife International. 2013. Important Bird Areas in Tanzania (GIS data). Birdlife International, Cambridge, UK. Accessed May 2013. For further information please visit www.birdlife.org.

Map 10: Important wildlife corridors in relation to protected areas, natural forest and woody biomass carbon stocks.

This map shows the location of some important corridors in Tanzania where natural vegetation facilitates the movement of wildlife between protected areas. Wildlife migration corridors enable long-term health of protected ecosystems, extending the habitat of species and allowing the gene pools of different populations to mix. Many of the corridors on the map are threatened from agriculture, livestock keeping and other activities (Jones et al. 2012). REDD+ activities for forest rehabilitation or protection could help to preserve these crucial areas.



Data sources:
Natural forest: NAFORMA. 2013. NAFORMA land-use / land-cover Map 2010.
Woody biomass carbon: NAFORMA. 2013. NAFORMA woody biomass only. 5km preliminary dataset based on field data.
Wildlife corridors: based on information provided at tzwildlifecorridors.org. Accessed May 2013.
Forest reserves: Tanzanian Forest Service, 2013. Forest Reserves of Tanzania.
Protected areas: IUCN and UNEP-WCMC (2010), The World Database on Protected Areas (WDPA) Cambridge, UK: UNEP- WCMC. Available at: www.protectedplanet.net.

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Map prepared by Tanzanian Forest Service (TFS), UNEP-WCMC, FAO, Sokoine University of Agriculture (SUA) and Forestry Training Institute (FTI).
Date: May 2013