MINISTRY OF ENVIRONMENT AND TOURISM

REDD+ MONGOLIA

USING SPATIAL ANALYSIS TO EXPLORE POTENTIAL FOR MULTIPLE BENEFITS FROM REDD+ IN MONGOLIA

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Mongolia

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This report is produced as an output of the Mongolia UN-REDD National Programme. The UN-REDD Programme is the United Nations collaborative initiative on Reducing Emissions from Deforestation and Forest Degradation (REDD+) in developing countries. The Programme was launched in 2008 and builds on the convening role and technical expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and UN Environment. The UN-REDD Programme supports nationally-led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including indigenous peoples and other forest-dependent communities, in national and international REDD+ implementation.

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Acronyms and abbreviations

AFOLU	Agriculture, Forestry and Land Use sector
ALAGAC	Administration of Land Affairs, Geodesy, and Cartography
CO2	Carbon dioxide
DEM	Digital Elevation Model
EIC	Environment Information Center
EOC	Extent of Occurrence
FAO	Food and Agriculture Organisation of the United Nations
FRDC	Forest Research Development Centre
GHG	Greenhouse gas
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GSV	Growing Stock Volume
IBA	Important Bird Area
INDC	Intended nationally Determined Contribution
IPCC	International Panel on Climate Change
IRIMHE	Information and Research Institute of Meteorology, Hydrology and Environment
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
MEGD	Ministry of Environment and Green Development
MEGDT	Ministry of Environment, Green Development and Tourism
Mha	Million hectares
MNFI	Multipurpose National Forest Inventory
MNT	Mongolian Tugrik
MRTT	Ministry of Roads, Transport and Tourism
NASA	National Aeronautics and Space Administration
NTFPs	Non-timber forest products
REDD+	Reducing Emissions from Deforestation and Forest Degradation; 'plus' Conservation of forest carbon stocks, sustainable management of forests; and enhancement of forest carbon stocks
RSD	Relative stock density
Spp	Species
UNDP	United Nations Development Programme
UNEP-WCMC	UN Environment World Conservation Monitoring Centre
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD Programme	United Nations Collaborative Programme Initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries

Executive Summary

Deforestation and forest degradation play a crucial role in climate change by making a significant contribution to anthropogenic carbon dioxide (CO_2) emissions. Parties to the United Nations Framework Convention on Climate Change (UNFCCC) are beginning to address this issue through REDD+, with the aim to significantly reduce emissions from deforestation and forest degradation, and to increase the removal of CO_2 from the atmosphere through forests, while promoting sustainable development. REDD+ has the potential to deliver multiple benefits, including a wide range of social and environmental benefits in addition to climate change mitigation. Mongolia, a signatory to the UNFCCC, the Kyoto Protocol and the Paris Agreement, has committed to a green development pathway, which includes the implementation of REDD+. REDD+ has the potential to contribute to green development by protecting forest carbon stocks and biodiversity, helping to prevent and reverse land degradation, promoting the improvement of rural livelihoods and aiding adaptation to climate change.

This report presents the outcomes of a collaboration that took place under the auspices of the Mongolia UN-REDD Programme during 2015-2016, involving the Ministry of Environment and Tourism of Mongolia (MET), the Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE) and the UN Environment World Conservation Monitoring Centre (UNEP-WCMC), with support from the UN-REDD Programme. The partners worked together to develop in-country capacity to use spatial decision support tools to inform REDD+ planning that enhances benefits and reduces risks. Identifying areas where specific REDD+ actions may yield significant multiple benefits can help to inform decision-making on land use and to increase the overall positive impact of the REDD+ programme. Generated through a series of consultations and technical working sessions, the maps presented in this report can serve as decision support tools to aid land-use planners, policy-makers and stakeholders to identify priority areas for REDD+ implementation.

The analyses have been undertaken at both a national (or boreal forest zone) and aimag (province) level, focusing on the two aimags of Khovsgol and Tov. Mongolia's forests are a critical resource for the country, covering an estimated 9 million hectares in the northern boreal forest zone. They are valuable to society in multiple ways. The boreal forest zone analyses in this report map forest resources, carbon storage in aboveground biomass and biodiversity, and explore pressures on forests and their values. These pressures include fire, unsustainable levels of exploitation, pests and pressure from grazing. Fire is highlighted as probably the most important threat, and it is clear that forest within protected areas is not immune to this and other drivers, including climate change. The results also highlight the potential vulnerability of biodiversity, with some areas rich in threatened species falling outside of any official protection.

Analyses undertaken at local (aimag) scale highlight the differing environmental conditions and, through consultation workshops, reflect how these environmental factors are perceived, valued and prioritized by local stakeholders. At the aimag level, this report analyses additional values from forests, as prioritized through consultations in Khovsgol and Tov. Using the best available datasets, these maps include the status of forest resources in the two aimags and show the distribution of the provision of a range of forest values. In modelling the contribution of forests to water yield, a considerable proportion is shown to be due to fog capture by the trees. By mapping the presence of natural springs and ger camps as tourism and recreational sites, these are shown to intersect with forested areas, particularly in the case of Khovsgol. Fuelwood provision is an important forest value for both aimags, as well as timber and non-timber forest products for Khovsgol. Maps of extraction pressure show that forests providing these products are often under more pressure the nearer they are to roads and town centres.

Overlaying these maps also highlights areas that are significant in terms of supporting multiple values, and where REDD+ activities could therefore bring about multiple benefits. We compared the distribution of such areas in Tov and Khovsgol for the three values of carbon stocks, biodiversity and water yield. Potential areas for forest restoration (including reforestation) were mapped for Tov aimag. These were further prioritized based on the potential to provide multiple benefits, showing about 2,500 km^2 with high potential for forest restoration, with a degree of concentration of such areas along water courses.

The work described in this report has aimed to support REDD+ planning in Mongolia, in particular the opportunity to promote multiple benefits, and to progress towards a more integrated use of forest landscapes. In addition to the analyses produced, we have worked to build capacity in spatial planning, including accessing relevant spatial datasets and using decision support tools. We encourage follow-up work to build on the analyses presented here and to capitalise on the enhanced in-country capacity for spatial analysis and use of decision support tools. This additional work should include:

- Wider stakeholder analysis of the priority values of forests (and therefore potential multiple benefits of REDD+ that could be targeted);
- Field validation of the modelled priority areas for forest conservation and restoration;
- Extension of the finer-scale analyses to other aimags in Mongolia; and
- Translation of the spatial analysis and mapping into firm area targets for REDD+ implementation at national and aimag levels.

Such activities will further increase the overall positive impact of Mongolia's future REDD+ programme and inform decision-making on sustainable land use more widely.


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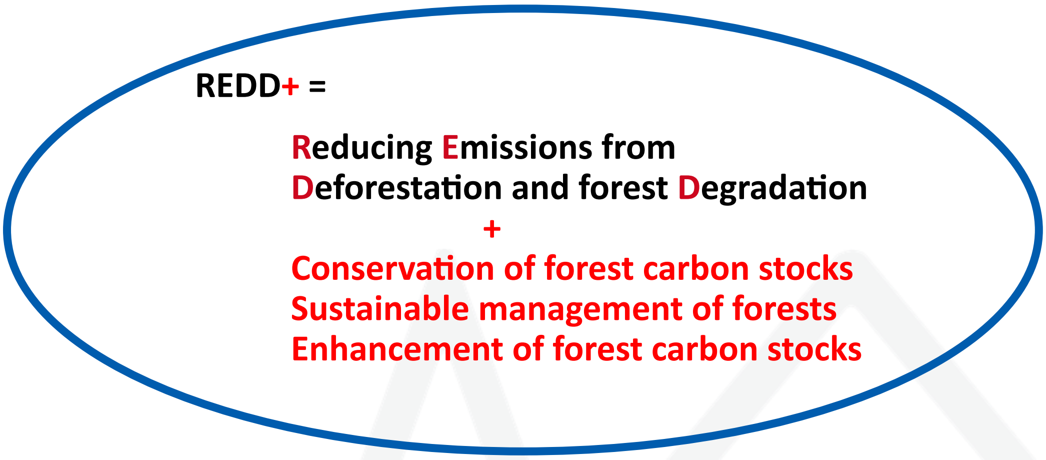
1. Introduction

1.1 REDD+

Deforestation and forest degradation play a crucial role in exacerbating climate change by making a significant contribution to anthropogenic carbon dioxide (CO_2) emissions. Deforestation and other land-use changes are estimated to have provided a net contribution of around 12% of global emissions during 2000-2009 (Smith *et al.* 2014). Parties to the United Nations Framework Convention on Climate Change (UNFCCC) are beginning to address this issue through REDD+, with the aim to significantly reduce emissions from deforestation and forest degradation, and to increase removals of CO_2 from the atmosphere by forests, while promoting sustainable development. REDD+ is expected to provide incentives for developing countries to implement actions relating to five main activities (Figure 1.1).

Figure 1.1: REDD+ activities agreed under UNFCCC



1.2 REDD+ multiple benefits and risks

REDD+ has the potential to deliver multiple benefits, including a wide range of social and environmental goods and services in addition to climate change mitigation. These multiple benefits are also sometimes referred to as 'non-carbon benefits' (e.g. in the 2015 Paris Agreement of the UNFCCC). Social benefits from REDD+ implementation can include enhanced forest governance and increased participation in local decision-making on land use and, in some cases, financial improvements to livelihoods. Environmental benefits from securing the many ecological functions of forests can include biodiversity conservation and the provision of ecosystem services on which people depend (Box 1).

Well-planned REDD+ implementation should secure or enhance forest ecosystem services while reducing risks. By reducing deforestation and forest degradation, REDD+ can ensure that ecosystem services are retained when they may otherwise have been lost. Through reforestation and forest restoration, REDD+ can restore ecosystem services that have previously been lost or degraded. As the importance of forests for providing different ecosystem services varies across the landscape, decisions about how and where REDD+ is implemented will influence the resulting benefits to people.

Box 1: Ecosystem services

Ecosystem services are usually classified into the following main groups: provisioning services, regulating and supporting services, and cultural services (Millennium Ecosystem Assessment 2005). While provisioning goods are tangible and can be easily quantified and valued, other ecosystem services (e.g. climate regulation, soil protection, nutrient cycling, pollination) are more difficult to value but are of crucial importance for human well-being.

Provisioning services

These services are often tangible with clear monetary value. Forest goods include timber, which is still the most highly valued economic product from most forests in the world, fuelwood (a significant part of the world's energy comes from biomass) and non-timber forest products such as food, fibre and medicinal plants. For example, a study by Vedeld *et al*. (2007) of 51 case studies from 17 developing countries found that forest environmental income on average makes up 22% of total household income in rural communities (in Hicks *et al*. 2014).

Regulating and supporting services

These services arise from the natural function of healthy ecosystems, and include climate regulation, soil and water services, and carbon storage. Forests regulate water quality and quantity, and they are a moisture source for downwind/downstream ecosystems. Forests serve as a carbon sink: as much as 45% of the carbon stored on land is found in the world's forests (NASA Earth Observatory, 2012). Forests also give shade and shelter, and help to preserve soils and permafrost.

Cultural services

Forests have non-material cultural, spiritual, religious and recreational values, which can be described as cultural services. Some forests are sacred sites, and others have recreation and amenity values. Living near to forests can improve people's physical and mental wellbeing. Forests support nature tourism, camping, hiking and horse-trekking. For example, Nielsen *et al*. (2007) cite a number of studies from across Europe showing that forests are the most popular environments for outdoor recreation.

Depending on how REDD+ is implemented, it also carries potential risks, such as pressures on forests being displaced from one area to another, or local communities' access rights to forests being reduced. The Cancun safeguards were specifically developed by the UNFCCC to address such potential risks of REDD+ and encourage its benefits. Indeed, the UNFCCC requests developing countries to promote and support the Cancun safeguards and to provide information on how they are being addressed and respected throughout implementation of REDD+ activities. A REDD+ programme that delivers multiple benefits and avoids social and environmental risks can contribute to a range of policy goals beyond climate change mitigation.

1.3 REDD+ in Mongolia

Mongolia is a signatory to the UN Framework Convention on Climate Change (UNFCCC, in 1992), the Kyoto Protocol (1997) and the Paris Agreement (2016). The Government of Mongolia is also committed to a green development pathway to help navigate the environmental challenges of rapid economic growth and expansion of the mining sector, with associated threats to forests and other ecosystems. REDD+ has the potential to contribute to green development by protecting forest carbon stocks and biodiversity, helping to prevent and reverse land degradation, promoting the improvement of rural livelihoods and aiding adaptation to climate change. For this reason, in June 2011, Mongolia became a partner country of the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme[1]). It is the first country with significant boreal forest cover to do so. It is estimated that Mongolia has more than 18 million hectares of forests, covering 11-12% of the national territory (FAO, 2014). These fall into two broad forest types: the northern boreal forests; and the southern saxaul forests.

A National Programme Document (MEGDT and UN-REDD Programme, 2015) describes how the UN-REDD Mongolia has since taken steps towards developing REDD+. A National REDD+ Readiness Roadmap produced in 2014 sets out its planned 'readiness activities' (Ministry of Environment and Green Development (MEGD) 2014). The Roadmap has four main outcomes:

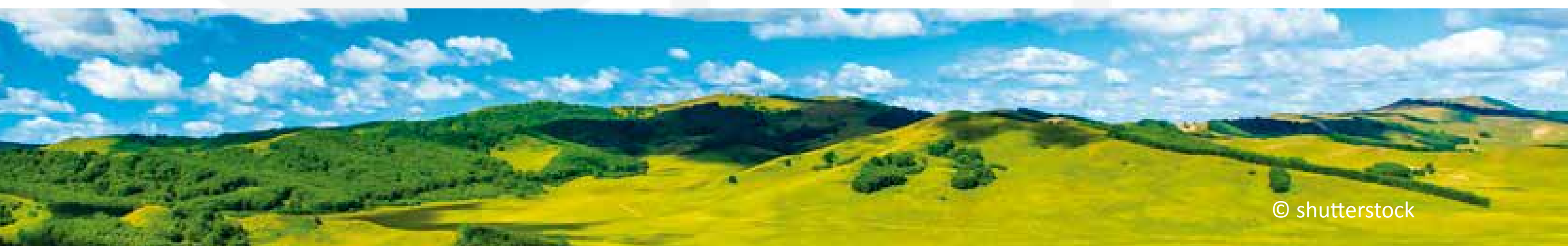
1. National REDD+ management arrangements established while ensuring improved stakeholder awareness and effective stakeholder engagement;
2. National REDD+ strategy prepared;
3. Forest reference emission levels and forest reference levels developed; and
4. National forest monitoring system and safeguards information system developed.

Mongolia is National Programme will contribute to achieving the objectives of the Roadmap. The main goal of the National Programme is to support the Government of Mongolia in the design and implementation of its national REDD+ strategy and in meeting the UNFCCC Warsaw Framework requirements for results-based payments. The National Programme also helps to implement the country's amended State policy on forests until 2030, approved by the Government of Mongolia in May 2015, with ambitious plans to increase forest cover and enhance sustainable use and protection of forest resources (MEGDT, 2015; UN-REDD Programme, 2011). The UN-REDD National Programme will:

- Support the preparation of Mongolia's National REDD+ Strategy (Outcome Two of the country's REDD+ Roadmap);
- Identify specific policies and measures to address key drivers of deforestation and forest degradation;
- Support Mongolia in establishing suitable institutional arrangements for implementing REDD+;
- Undertake institutional capacity development in order to implement the Strategy; and
- Support the establishment of REDD+ fund management and benefit distribution mechanisms together with a social and environmental safeguards policy framework and procedures.

The National Programme results framework includes outcomes, outputs and activities. Output 18 on safeguards anticipates that a full list of the potential social, environmental and other benefits and risks [of REDD+ policies and measures] will be developed, and that a number of these will be prioritized for monitoring. In addition,

[1] The UN-REDD Programme is the United Nations Collaborative Programme on Reducing Emissions from Deforestation and forest Degradation (REDD+) in Developing Countries. The Programme was launched in 2008 and builds on the convening role and technical expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). http://www.unredd.net/index.php?option=com_content&view=article&id=2082&Itemid=515



the country's 2014 Readiness Roadmap sets out priority multiple benefits of REDD+, which include improved watershed functions, forest biodiversity, forest governance and rural livelihoods (MEGD, 2014a).

1.4 This work

This current report presents the outcomes of a collaboration that took place under the auspices of the Mongolia UN-REDD Programme during 2015-2016, involving the Ministry of Environment and Tourism of Mongolia (MET), the Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE) and the UN Environment World Conservation Monitoring Centre (UNEP-WCMC), with support from the UN-REDD Programme. The partners worked together to develop in-country capacity to use spatial decision support tools to inform REDD+ planning in Mongolia (see Box 2 for more information on the capacity building component of the work).

This work had two main objectives:

I. To support Mongolia in developing spatial decision-support tools for REDD+ planning in order to help deliver multiple benefits and reduce potential risks. The resulting spatial analyses will contribute to the planning of REDD+ activities, and the harmonization of REDD+ policies with other national development policies and plans, and environmental and social priorities.

II. To build capacity together with Mongolian partners on spatial information to support REDD+ planning, including the introduction of QGIS and other free software tools to create maps relevant for REDD+ planning.

REDD+ has the potential to deliver benefits beyond carbon. Identifying areas where specific REDD+ actions might be most likely to yield high levels of these benefits can help to inform decision-making on land use and to increase the overall positive impact of REDD+ implementation. The analyses in this report were carried out at national and aimag (provincial) levels, as planning of REDD+ activities needs to take into account national-level priorities and opportunities, as well as consider how environmental, social and economic characteristics vary across the country, between aimags, districts and communities.

Two aimags were chosen for the analysis of potential benefits from REDD+ at the subnational level: Khovsgol aimag in northern Mongolia and Tov aimag in central Mongolia. They were chosen by the project for two main reasons: while Tov and particularly Khovsgol are both relatively well-forested, they represent different socio-economic circumstances. Tov is close to the more densely populated, urban area of Ulaanbaatar, and Khovsgol is less densely populated and more remote.

During 2015-2016, two working sessions took place in Ulaanbaatar, and consultations on priority benefits from forests were held in Khovsgol and Tov. During the working sessions, maps relevant to REDD+ planning were created with a focus on exploring the potential benefits of REDD+. In June 2016, preliminary results were shared with stakeholders from national and aimag levels in order to gain feedback and refine the maps.

Box 2: Capacity building in spatial analysis for REDD+ planning

The project included a substantial capacity-building component for Mongolian organisations and staff involved in spatial planning. This involved the introduction of free, open-source software tools and methods, including QGIS, and two joint working sessions. These sessions brought together a range of participants from national and aimag levels, as well as UNEP-WCMC staff, to work together on the spatial analyses and practice new techniques and tools. The tutorials and other materials developed for these sessions are available in Mongolian and English online at: http://bit.ly/mbs-redd

In addition to building capacity in the use of spatial decision support tools, key outcomes of the work include an improved understanding of the availability and applicability of spatial datasets relevant to REDD+ planning, and an initial list of potential benefits of REDD+ relevant to the country, based on the consultations with stakeholders in Khovsgol and Tov aimags.

1.5 Spatial analysis and decision-support tools

Spatial analysis can play an important role in REDD+ decision-making in Mongolia, as well as in planning specific REDD+ actions. Decisions on where and how to implement REDD+ actions can involve reconciling different demands for land, addressing trade-offs, prioritizing among different potential benefits that could be achieved through REDD+ implementation, and planning to avoid or minimize risks. Map-based approaches can be used to identify areas with a high potential for reducing emissions or sequestering carbon, based on information about current and potential carbon stocks, forest cover, future land-use decisions, and degradation and deforestation risks. Information on the latter can also help to refine understanding of the likely impact of REDD+ actions compared to a business-as-usual scenario. Evaluation of the potential benefits and risks from these actions then requires analysis of further information on factors such as environmental conditions (e.g. climate, soils and topography), biodiversity and the socio-economic context.

The maps presented in the following sections of the report are intended as spatial decision support tools for Mongolia's REDD+ planning. They can be used by land-use planners, policy-makers and their advisors when identifying areas for REDD+ implementation. They can inform decisions on the:

- Types of actions that could be supported (e.g. forest restoration, measures to reduce fire hazards, introduction of reduced-impact logging);
- Prioritization of locations where these actions could be carried out (incorporating potential multiple benefits of REDD+); and
- Setting of targets for the implementation of each type of action (e.g. size of the area to be covered, percentage of the population to be involved).

Freely available software tools were used to undertake the spatial analysis, with QGIS (http://www.qgis.org/) as the main platform. *WaterWorld* (http://www.policysupport.org/waterworld), a web-based system, was used to evaluate the importance of forests for water provisioning and limiting soil erosion by water (Van Soesbergen *et al*. 2016). During the working sessions, workflows were developed to define the steps to be undertaken to develop each map and initial analyses were undertaken. The maps were finalized threafter. Annex 1 provides an overview of a range of relevant tools and approaches that can be used to provide decision support for REDD+ planning, with a focus on spatial tools.

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1.6 Forest and environmental datasets for spatial analysis to support REDD+ planning

A range of Mongolian and international datasets are useful for the spatial analyses described in this report[2]. Data sources for national REDD+ planning can include forest inventories; reforestation maps (showing coordinates of tree planting sites); maps of areas affected by desertification, fire and other drivers of degradation and deforestation; maps of official mining and other types of concessions; maps of biodiversity and ecosystem services values; and data on grazing lands and carrying capacities. Land-use plans are developed every year at soum (district) level, and every five years at aimag, municipality and national levels. These show land suitability for agriculture, development and other uses. The Multipurpose National Forest Inventory (MNFI) (Mongolian Ministry of Environment and Tourism (MET) 2016), based on sampling of 4,322 sites, provides data on tree species, information needed for the estimation of biomass and carbon densities, and forest condition. The Forest Taxation Inventory held by the Forest Research and Development Centre (FRDC) collects data on forest type, area, volume, stand age, impacts, and timber quality, among a range of parameters[3]. There is ongoing work in Mongolia to develop estimates of carbon stocks within the country, such as through the National Greenhouse Gas Inventory (including agriculture, forestry and land use (AFOLU) sector), the MNFI, the UN-REDD Mongolia National Programme and the National Institute of Botany.

In Mongolia, a number of sources of information help to illustrate species and areas considered important for biodiversity conservation. These include: data from the global IUCN Red List of Threatened Species (www.iucnredlist.org) and the Mongolia Red Book; vegetation zones and maps; data on the country's network of Special Protected Areas[4]; maps of Mongolia's six Ramsar sites, illustrating wetlands of importance; and some data on specific species or groups of species, such as ungulates.

1.7 Structure of this report

The remainder of the report comprises three main sections:

- Section 2 presents a series of maps and additional information related to REDD+ planning elements at the national and boreal forest region. These maps explore forest cover, pressures on forests and biodiversity conservation.
- Section 3 describes an exercise to identify priority values of forests (and potential multiple benefits of REDD+) in Khovsgol and Tov aimags, and subsequent spatial analyses of these benefits in relation to forest cover and condition.
- Section 4 presents two more maps, based on multi-criteria analysis and overlays, in order to explore areas in the aimags where REDD+ could deliver multiple benefits, and to highlight areas with potential for forest restoration in Tov aimag.
- Section 5 closes the report by drawing some conclusions from the work.

[2] Many of the datasets described in this section are freely accessible through the Environment Information Center (EIC) of Mongolia, a division of IRIMHE (see www.eic.mn).
[3] This inventory is carried out at the sub-compartment level, and then data is compiled for various levels; for the purposes of this report, we refer to the National Forest Taxation Inventory for the national compilation, and Forest Taxation Inventories for Tov and Khovsgol aimags, for the aimag-level compilations. Both levels of the inventory use the same source data.
[4] Parliament approves Special Protected Areas; these can be classified as strictly protected areas, national parks, nature reserves and monuments.

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2. Mongolia's forests

2.1 Mongolia's forest resources and their protection

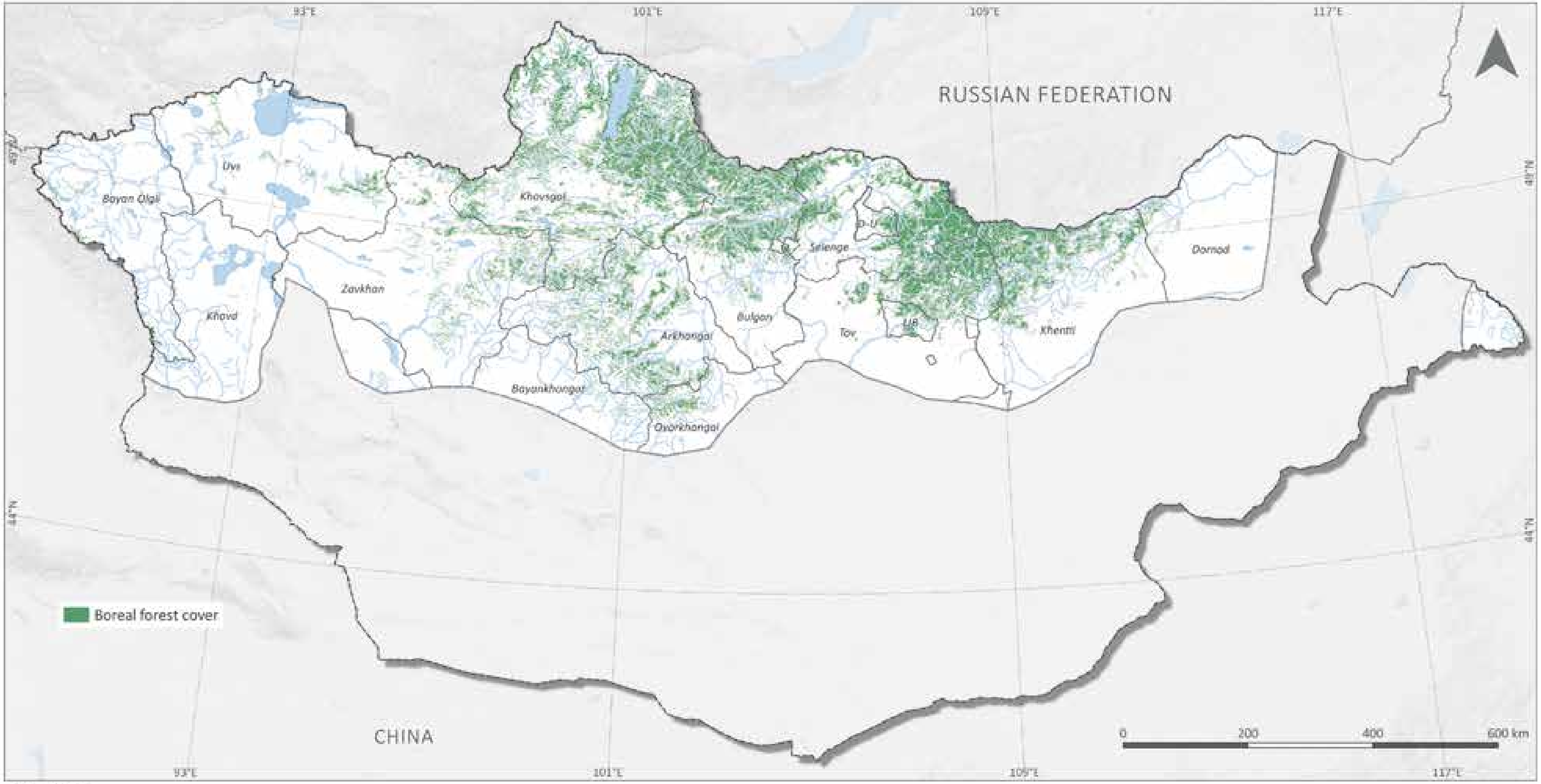
Mongolian forests can be broadly divided into two different types: the northern boreal forests and the southern saxaul forests. The northern forest type comprises deciduous and coniferous forests growing in the forest steppe, boreal forest and montane zones, which form an ecological transition between the Siberian Taiga and the Central Asian Steppes (Crisp *et al.* 2003). The highly fragmented nature of these forests is probably one of the key reasons behind the considerable uncertainty in boreal forest area, with estimates ranging from over 7 million hectares (Delamursen *et al.* 2016), to up to 10.7 million hectares (FAO 2014) (Figure 2.1). The recently published Multipurpose National Forest Inventory 2014-2016 (MET 2016) estimates the extent of boreal forest as 9.1 million hectares. These forests mostly contain coniferous species such as Siberian larch (*Larix siberica*), Scots pine (*Pinus sylvestris*), and Siberian pine or cedar (*Pinus siberica*). The broad-leafed trees found there are mainly birch (*Betula platyphylla*), aspen (*Populus tremula*) or poplar (*Populus diversifolia*) (Figure 2.2). Aimags with the highest forest cover are Khentii and Khovsgol. These deciduous trees occur mainly as pioneer species, colonizing areas affected by forest fire, pest outbreaks, windfalls or other disturbance (Mühlenberg *et al*. 2012).

The southern saxaul forests (ca. 4.5 million hectares; Crisp *et al.* 2003) grow in the southern desert and desert steppe regions. Their trees rarely attain 4 meters in height. They consist mainly of saxaul (*Haloxylon ammodendron*) and secondary species such as poplar (*Populus* spp.), tamarix (*Tamarix* spp.) and *Caragana* (Crisp *et al.* 2003). Saxaul forests are important for stabilizing active sand dunes and reducing the effects of sandstorms. They also provide fuelwood to local people.

Administratively, Mongolia's forests are divided into two categories: Conservation and Utilization Zones. The Conservation Zone (82.8% of total) includes alpine forests, special protected areas, national parks, nature reserves and cultural monuments, and forests around rivers and lakes, cities, towns, roads and railways. In these forests, only limited use of fuelwood and non-timber forest products (NTFPs) is permitted. In the Utilization Zone (17.2%), which includes all other forest, commercial logging is permitted under strict Government control.

Figure 2.1: Forest cover in Mongolia's boreal forest region

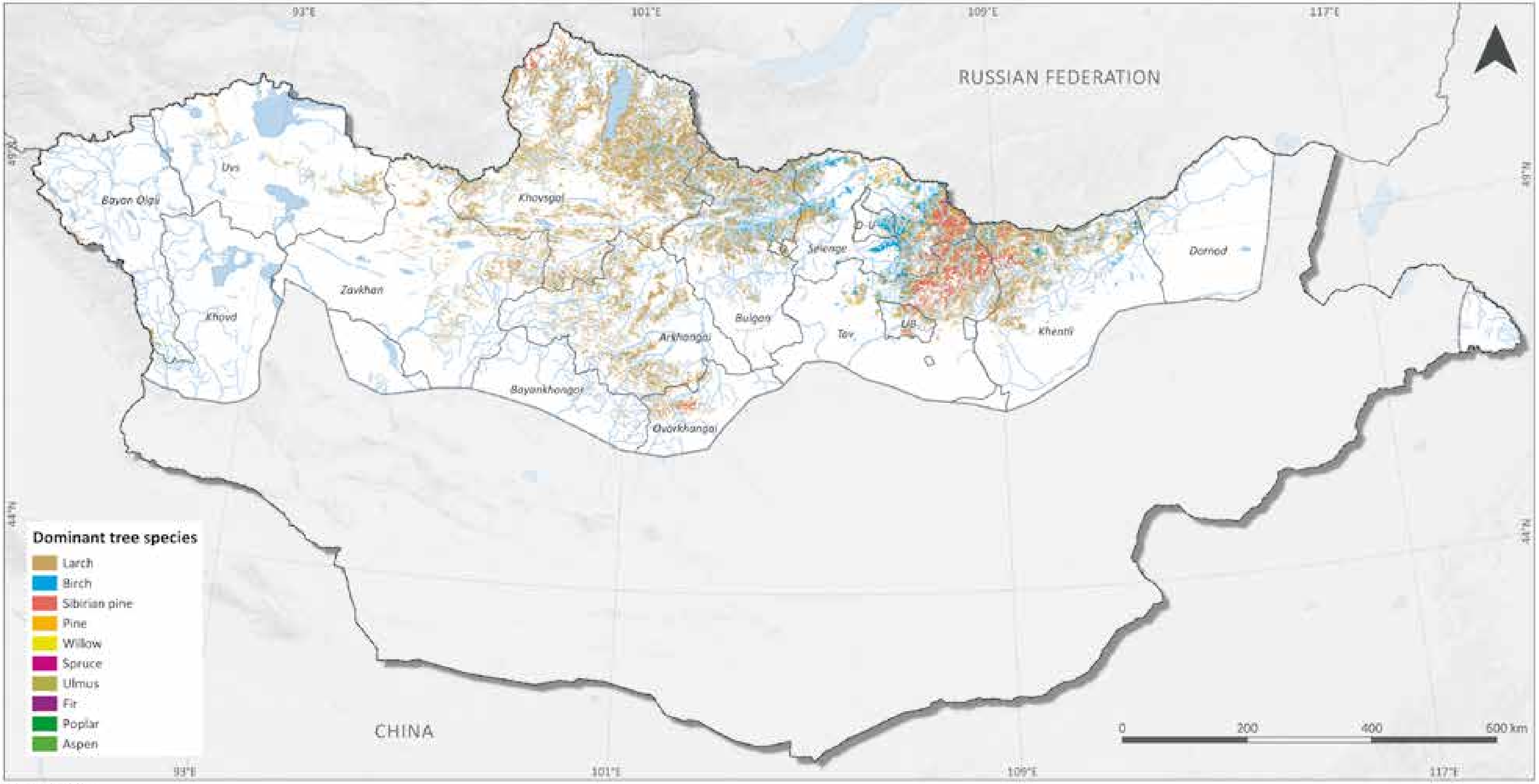
This map shows the distribution of boreal forest. Forest cover is derived from the FRDC National Forest Taxation Inventory data. This map is based on a compilation of the taxation inventories carried out at lower administrative levels, meaning that although the national data were compiled in 2014, the individual taxation inventories at the soum level were produced 2010-2014. The boreal forest region highlighted in the map is based on the ecological boundary of boreal forests, identified through the Multipurpose National Forest Inventory, covering boreal forests (MET 2016). This ecological boundary has been used for all boreal forest region maps in this study.



Data sources:
Boreal forest cover: National Forest Taxation Inventory (compilation year 2014).
Boreal forest region boundary: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).

Figure 2.2: Forest types in Mongolia's boreal forest region

This map shows the distribution of the main types of forests in Mongolia's boreal forest region, as indicated in the FRDC National Forest Taxation Inventory (compilation year 2014) for stocked forest land. These include birch, larch, pine and other forest types.



Data sources:
Boreal forest types: National Forest Taxation Inventory (compilation year 2014).
Boreal forest region boundary: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).

2.2 Biodiversity and ecosystem services

Forests provide different ecosystem services and support biodiversity (Section 1.2), but this can be compromised by fragmentation, other forms of degradation and deforestation. Key drivers associated with such forest changes in Mongolia are described below (Section 2.3). Here, we focus on forest products and resources, carbon and biodiversity as three types of ecosystem services provided at the national level, illustrated by maps prepared during the working sessions and follow-up spatial analysis (Narangarel *et al*. 2016b).

Timber, fuelwood, non-timber forest products and grazing resources

There are about 150 small- and medium-scale forest and wood production enterprises in Mongolia, employing around 4,000 people (UN-REDD Programme 2011; Ykhanbai 2010). Estimates of wood consumption range from approximately 1 million m^3 (Emerton and Enkhtsetseg 2013) to as much as 5.5 million m^3 (UN-REDD Programme 2011). The large variation in these estimates results from uncertainty over fuelwood consumption, which is estimated to account for between 33 to 79% of the total annual wood consumption. Based on official licensed harvesting volumes and projections of wood demand, Emerton and Enkhtsetseg (2013) estimate that at 2013 harvesting levels, timber and fuelwood may have an annual sale value of almost MNT 200 billion (US$ 142 million), and generate MNT 66 billion (US$ 48 million) in profits to producers (noting that more than half of this value is estimated to come from unlicensed removals).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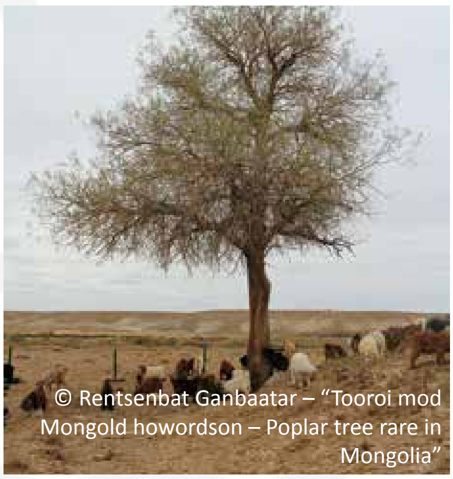
The most valuable non-timber forest products (NTFPs) include pine nuts, berries and medicinal plants. Approximately 500 forest and pastureland user groups or communities are given limited use rights under the Law on Forest to sustainably collect wood and NTFPs (UN-REDD Programme 2011). NTFP collection has an estimated total value of approximately MNT 16.5 billion (US$ 12.18 million) a year, shared among half of the rural population in soums that have boreal forest. As with timber and fuelwood, it is suggested that more than 90% of its value comes from unlicensed removals, and three quarters comprises home-consumed products (Emerton and Enkhtsetseg 2013).


© Dovjuu Gansukh – "Khush – Pine"

Forests are also widely used for grazing (sometimes seasonal), with approximately 35-40% of livestock population grazing in and near forest areas (Tsogtbaatar 2013). Emerton and Enkhtsetseg (2013) estimate that the role of forests in supporting grazing is worth more than MNT 34.5 billion (US$ 24.70 million) a year, making up 5% of the value of livestock production in soums with boreal forests. Grazing can interact with other pressures on forests that contribute to forest degradation and deforestation. For example, overgrazing results in damage to young trees and saplings, and can particularly hinder forest regeneration (Tsogtbaatar 2004; Ykhanbai 2010). The Multipurpose National Forest Inventory (2014-2016) found that 14.7% and 32% of forests experienced moderate grazing pressure in the Altai and Khangai regions, respectively, and 20.4% and 2.3% of forests suffered from intensive grazing pressure, respectively. Pressure was less intense in Khentii and Khovsgol aimags according to a draft preliminary analysis of drivers for deforestation and forest degradation (UN-REDD Mongolia Programme 2016).


© Rentsenbat Ganbaatar – "Tooroi mod Mongold howordson – Poplar tree rare in Mongolia"

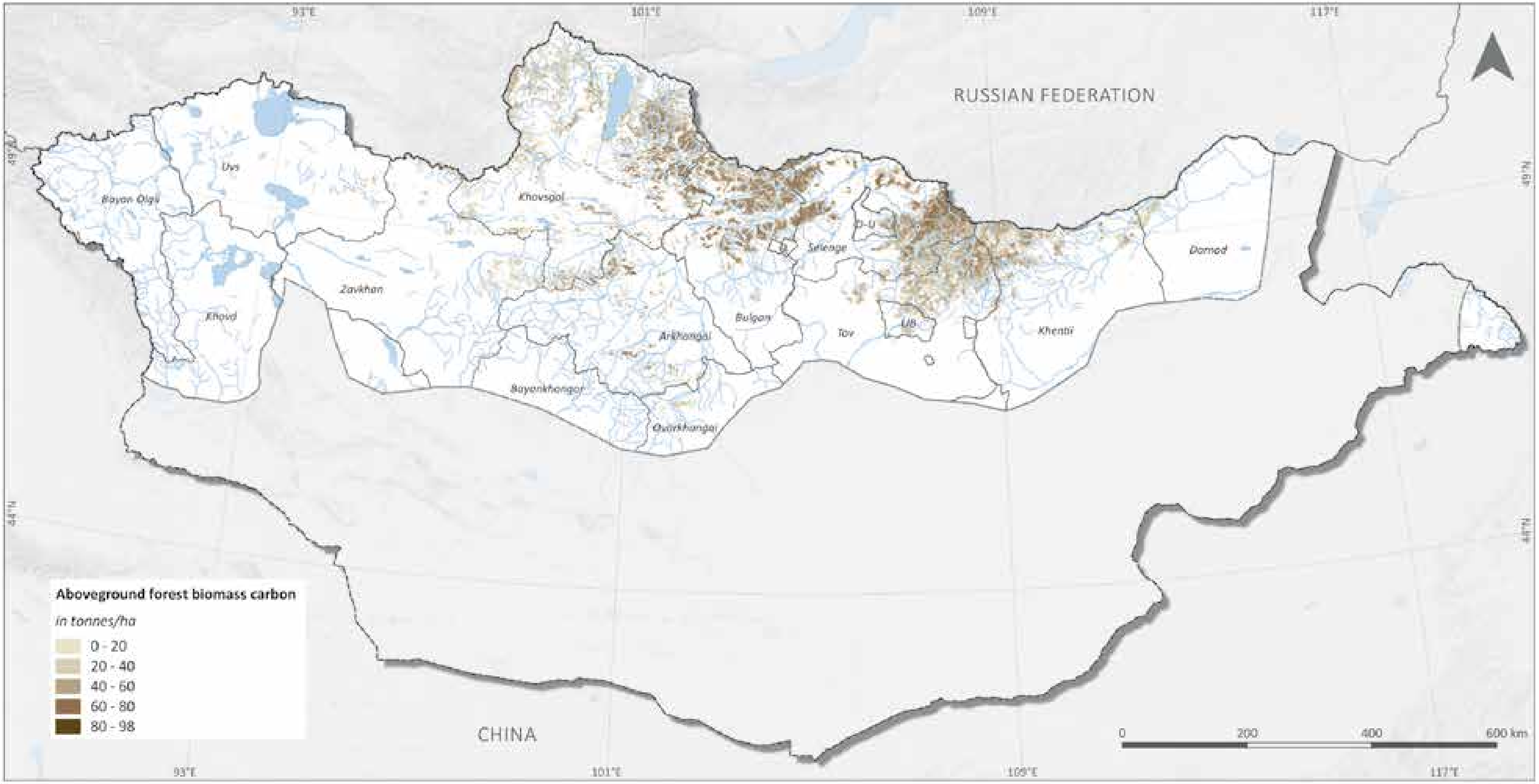
Carbon sequestration and storage

Boreal forests represent a significant carbon store, in part due to low temperatures and decomposition rates leading to large accumulation of carbon in the soil pool (Trumper *et al*. 2009). The aboveground carbon stock density in the interior of Mongolia’s boreal forests is estimated to be in the upper range of values reported from boreal forests (Dulamsuren *et al*. 2016). Boreal forest areas with the highest estimated aboveground biomass carbon densities are located in Khovsgol, Bulgan, Khentii and Tov aimags (Figure 2.3).

Belowground biomass and soil carbon can also represent a significant fraction of total forest carbon. Over thousands of years, boreal forests have accumulated a large amount of soil carbon due to the cold climate and the therefore low rates of decomposition of organic matter. Unlike the aboveground stocks, belowground carbon density is at the lower end of the reported range. More northerly boreal forests in other countries have lower soil temperatures and a thicker permafrost layer, which is thought to result in higher belowground carbon stocks (Dulamsuren *et al*. 2016).

Figure 2.3: Estimated distribution of aboveground biomass carbon in Mongolia's boreal forests (tonnes per hectare)

This map shows estimated aboveground forest biomass carbon in tons per hectare. It has been derived from a global dataset (Thurner *et al*. 2013) of a Northern-hemispheric Carbon Density Map. This is based on Growing Stock Volume (GSV) derived from Envisat ASAR data, applying the BIOMASAR algorithm (Santoro et al. 2011). Carbon density was estimated from GSV using information on wood density, biomass allometric relationships and GLC2000 land cover information (GLC2000; JRC 2003). Additionally, an uncertainty estimate was given in this study. Non-forest pixels have been masked out using GLC2000; the GLC2000 land-cover classes 1-10 were considered to be forest by Thurner *et al*. (2013).



Data sources:
Aboveground forest biomass carbon: Turner, M., Beer, C., Santoro, M., Carvalhais, M., Wutzler, T., Schepaschenko, D., Shvidenko, A., Kompter, E., Ahrens, B., Levick, S.R. & Schmullius, C. (2013) Carbon stock and density of northern boreal and temperate forests. Global Ecology and Biogeography, 23: 297-310.

© "Ankhnii alkham – The first step"

Biodiversity

Mongolia's forests provide habitat for a diversity of animals, plants and microorganisms (FAO 2014). Important areas for biodiversity conservation include the national network of Special Protected Areas and Key Biodiversity Areas (KBA) (Figure 2.4). KBAs are sites deemed to be of global significance for biodiversity conservation and are defined according to internationally agreed criteria (Langhammer *et al*. 2007; and most recently IUCN 2016). The KBAs in Mongolia are internationally identified Important Bird Areas (IBAs, Birdlife International 2016; BirdLife International and Conservation International 2016). Mongolia's most recent National Biodiversity Program notes that the area under protection has increased steadily in recent years, with 27.2 million hectares in 99 protected areas, or 17.4% of the total area, as of 2014 (MEGDT 2015). In addition, the National Biodiversity Program includes a target that by 2025 "at least 30% of each representative" of the country's main ecosystems are to be included in the National Protected Area network and their management improved (MEGDT 2015).

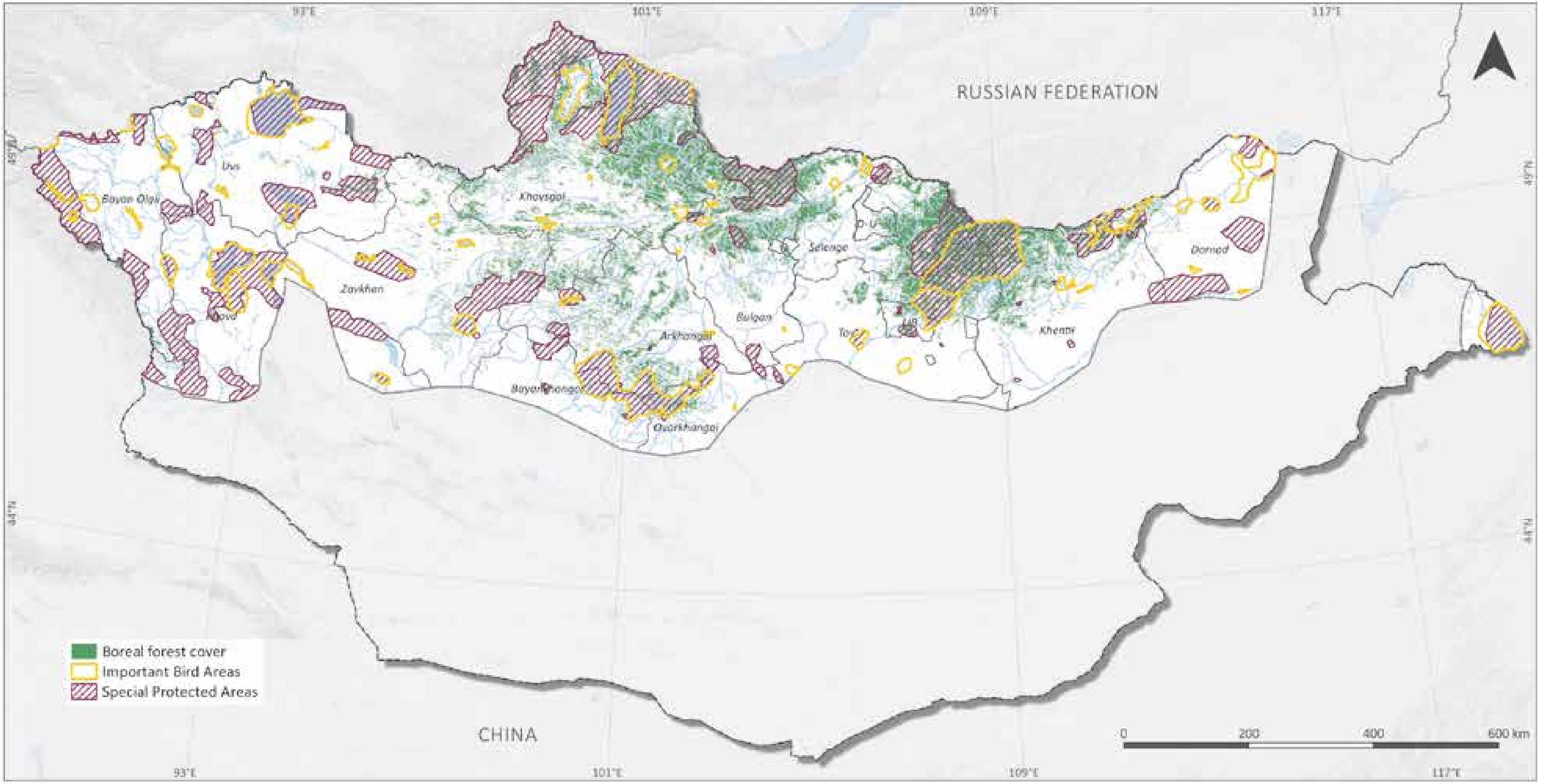
The potential richness of threatened species across the country is derived from the estimated ranges of the 181 forest-dependent mammals, birds, reptiles and amphibians that are classified as Critically Endangered (CR), Endangered (E), Vulnerable (V) and Near Threatened (NT) in the IUCN Red List of Threatened Species (2015) (Figure 2.5). Birds are the best documented taxonomic group. The regional Red List for birds (Gombobaatar *et al*. 2011) classified 10% of the 476 assessed species (forest and non-forest) as falling into one of the threatened categories. The main threats to birds correspond to the pressures on forests (Section 2.3), which are habitat loss and degradation (including in important breeding and migratory stop-over sites), human settlements and fire (Gombobaatar *et al*. 2011). Hunting for sport and game is an additional pressure on birds (Gombobaatar *et al*. 2011). The higher densities of threatened species in the north of the country reflect a general pattern of increasing species richness from the desert and desert steppe in the south through the transition zone to the mountainous boreal forests and river valleys in the north. Hotspots of threatened species richness are located in the western and eastern extremes of the north (Figure 2.5). Some areas estimated to have high numbers of threatened species fall outside the existing protected area network.

© "Great Tit (Parus major)"

© "Great Spotted Woodpecker (Dendrocopos major)"

Figure 2.4: Distribution of boreal forest cover inside and outside protected areas and Key Biodiversity Areas.

This map shows the distribution of Special Protected Areas and Key Biodiversity Areas (KBAs) in the boreal forest region of Mongolia. KBAs are places considered to be of international importance for biodiversity conservation. In the case of Mongolia, these are Important Bird Areas compiled by the international conservation organisations Birdlife International and Conservation International. This dataset was downloaded under license from the Integrated Biodiversity Assessment Tool in 2016. The Special Protected Areas network shown here is based on data from the Administrative Department for Special Protected Areas, MET (data from 2008, last updated in 2015). Mongolia's parliament approves Special Protected Areas; these can be classified as strictly protected areas, national parks, nature reserves and monuments. This map does not include aimag and soum level protected areas.



Data sources:

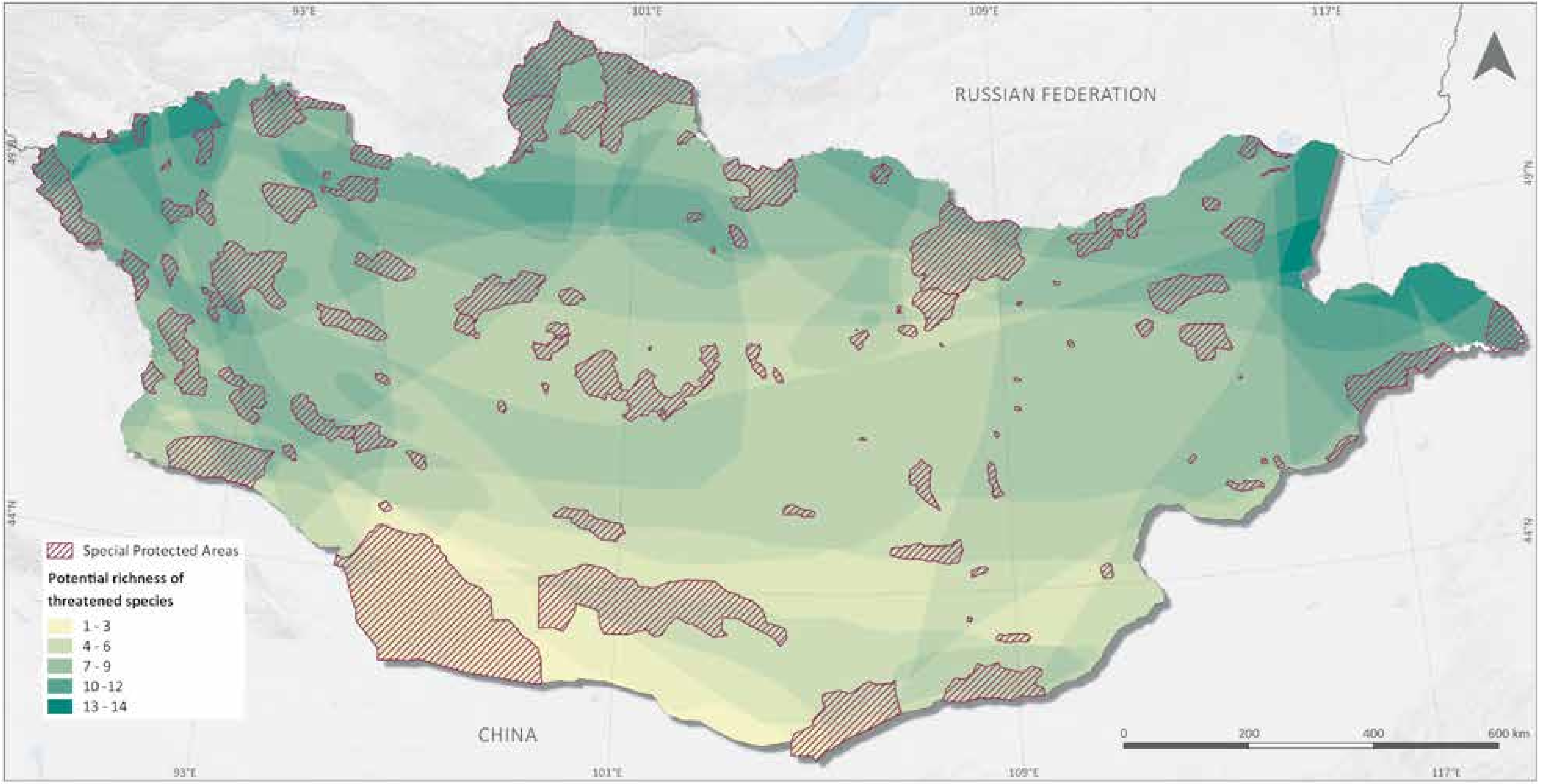
Protected areas: Special Protected Areas network data in 2008 from the Administrative Department for Special Protected Areas, MNET. Parliament approves special protected areas; these can be classified as strictly protected areas, national parks, nature reserves and monuments. Provided by Environment Information Center of Mongolia.

Key Biodiversity Areas: Including Important Bird Areas, compiled by Birdlife International and Conservation International. Downloaded under license from the Integrated Biodiversity Assessment Tool (2016). *Boreal forest cover:* FRDC National Forest Taxation Inventory (compilation year 2014).

Boreal forest region boundary: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).

Figure 2.5: Estimated distribution of threatened species richness

This map highlights areas where the distributional ranges of threatened species overlap. These ranges are based on species Extent of Occurrence (EOO). Range maps based on EOOs are usually an over-estimate of species ranges (Rocchini *et al*. 2011), however, they nonetheless remain an important source of biodiversity data especially when analyzing species richness across large areas (Hurlbert and Jetz 2007). The threatened species included here are forest-dependent mammals, birds, reptiles and amphibians classified as "Critically Endangered", "Endangered", "Vulnerable" and "Near Threatened" by the IUCN Red List of Threatened Species (IUCN 2015). The quality of the IUCN and Birdlife range maps have improved in recent years (Jenkins *et al*. 2013) and we consider their use here is justified. The distribution of Special Protected Areas has been overlaid to consider the relationship between the Protected Areas network and potential species richness.



Data sources:
Potential species richness: Derived from the ranges of forest-dependent mammals, birds, reptiles and amphibians classified as 'Critically Endangered', 'Endangered', 'Vulnerable' and 'Near Threatened' by the IUCN Red List of Threatened Species (2015). Version 2015.1. http://www.iucnredlist.org. Downloaded in May 2015.
Protected areas: Special Protected Areas network data in 2008 from the Administrative Department for Special Protected Areas, MNET. Parliament approves special protected areas; these can be classified as strictly protected areas, national parks, nature reserves and monuments. Provided by Environment Information Center of Mongolia.


© Saruul Ochir – "Khustain nuruunii khusan oi – Birch forest of Khustain nuruu"

2.3 Key trends and pressures on forest resources

2.3.1 Tree cover loss

Mongolia's forests are under pressure, although rates of forest loss have decreased in recent years. The country is believed to have lost about 1.6 million hectares of forest from the 1950s to the 1980s, and a further 660,000 hectares from 1990 to 2000 (Crisp *et al*. 2003). According to the taxation inventory data, 47,000 hectares (0.43%) of closed northern boreal forest have been lost or degraded every year since 2004 (in UN-REDD Mongolia Programme 2016). Given the extreme continental climate of the region, the forests have low growth rates and productivity, making them vulnerable to various disturbances. An indication of areas affected by tree cover loss from 2000 to 2014, based on the methodology of Hansen *et al*. (2013)[5], shows that the most affected areas are mainly in the Khentii Mountains, the northern part of Tov, and Khovsgol (Figure 2.6).

Some of the tree cover loss occurs in Mongolia's Special Protected Areas network (Figure 2.7[6]), with Khan Khentii National Park seemingly most affected. Other areas experiencing loss are Tarvagatai Nuruu and some of the protected areas of Khovsgol. Further study is needed to better understand the degree of tree cover loss in protected areas and the drivers of this change.

[5] Hansen *et al*. (2013) is an international dataset, based on global satellite data, on tree cover and its loss. Tree cover loss is defined here as the disturbance or complete removal of tree cover canopy (from any level of tree cover to zero). The dataset has been assessed as having greater than 80% accuracy in each climate domain and the globe as a whole. Although potentially less accurate than national data, an international dataset has been used for this analysis because of a lack of validated, national maps showing forest loss at the time. This information can be derived from the forest taxation inventory, though it requires significant processing time. The Mongolia National UN-REDD Programme and others are working to address this gap.
[6] Figure 2.7 does not fully reflect the current protected areas network as it omits aimag- and soum-level protected areas and only shows national designations (Special Protected Areas approved by Parliament).

2.3.2 Drivers of change in Mongolia's forests

The main drivers of forest loss and degradation in Mongolia are forest fires, pests, selective logging and clear felling, and grazing (Badarch *et al.* 2011; Tsogtbaatar 2004). Other pressures on forests, as discussed by working session participants, as well as a draft, preliminary analysis of drivers, included: poor management leading to degradation and, in the longer term, deforestation; impacts from the expansion of agriculture (though limited by land suitability) and livelihoods that are dependent on forest exploitation; and mining (Narangarel *et al*. 2016b; UN-REDD Mongolia Programme 2016). There are also concerns about climate change impacts on forests. Permafrost is important for forest vegetation and regeneration, and forests, in turn, protect permafrost. Warming temperatures, exacerbated by fire occurrence, threaten this self-regulating system, and the water provisioning services it provides to downstream communities (Dulamsuren *et al.* 2010; Kopp *et al*. 2016). The intensification of dry climatic conditions is causing an increase in forest fire frequency, and the occurrence and the intensity of forest insect and pest outbreaks (according to Mongolia's Intended Nationally Determined Contribution (INDC) of 2015). The relative importance of the different drivers of forests loss and degradation varies from place to place. For example, human migration to cities ('urban drift') has placed increased pressure on forest resources adjacent to urban areas to meet growing demands for fuelwood for heating and cooking and timber for construction (UN-REDD Programme 2011).

© Sender Chuluungerel – "Ekhlel – Start"

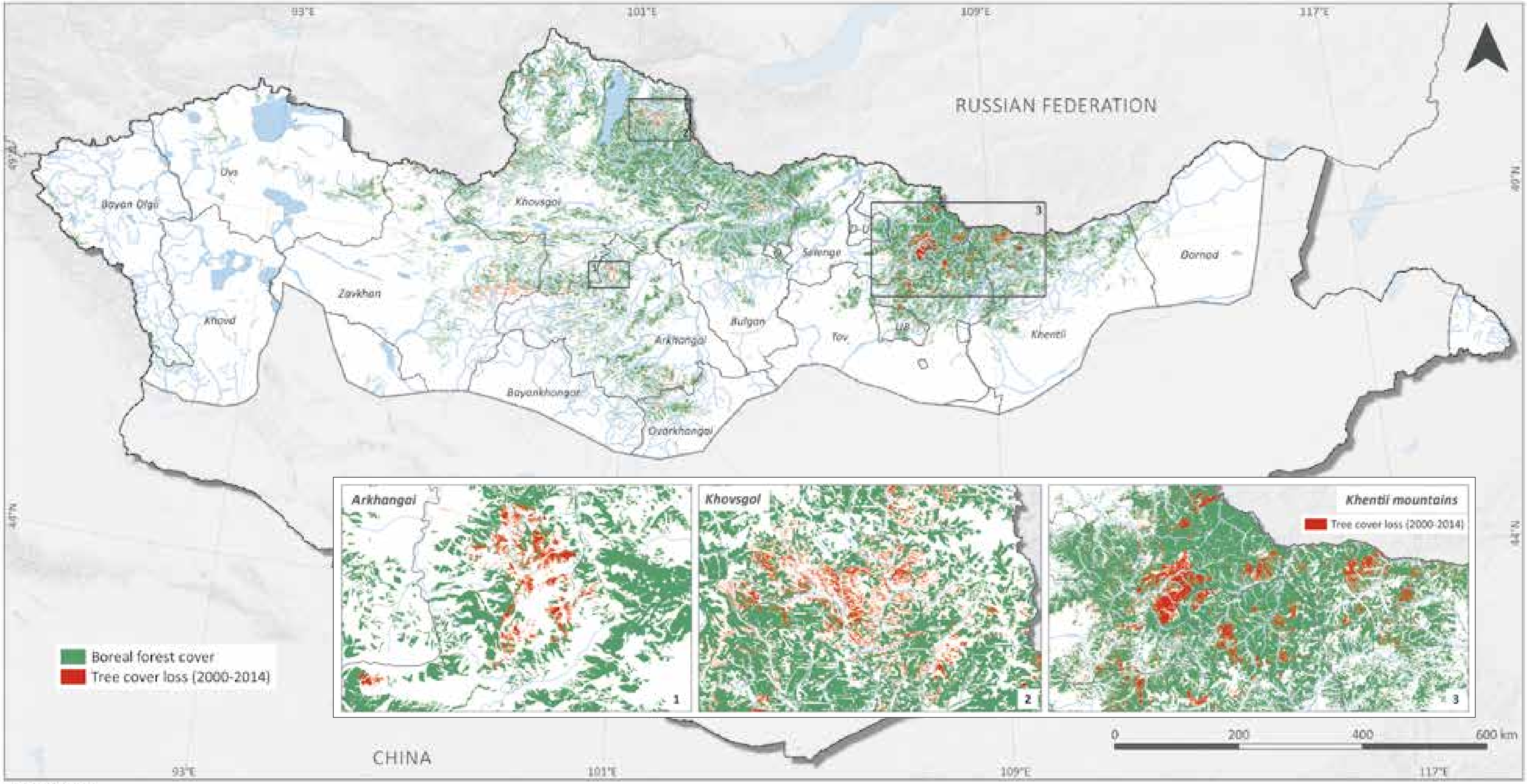
© E.Khartsaga – "Young generation"

Underlying these primary causes of forest loss and degradation is a need to improve forest governance from the national level through to aimag and soum levels (UN-REDD Programme 2011). Inherent problems identified by a draft, preliminary analysis of drivers for deforestation and forest degradation (UN-REDD Mongolia Programme 2016) include lack of long-term strategy, weak policy framework, unclear legal and regulatory framework, weak capacity and shortage of resources, corruption and lack of transparency, institutional overlaps and poor implementation of sustainable forest management.

There are ongoing efforts to replant lost and degraded forest areas, and Mongolia's Green Development Policy sets a goal of enhancing forest carbon sequestration by intensifying reforestation and expanding the country's forest areas to 9% by 2030 (UN-REDD Mongolia Programme 2016; MEGD 2014b). The Mongolia Law on Forest requires that "citizens, partnerships, economic entities and organizations shall plant 10 or more seedlings in place of every tree felled" (Article 30, Parlament, Mongolia, 2012). Specialized private forest entities carry out the planting or assist natural regeneration of disturbed forests. While tree planting during 2004-2014 amounted to some 6,000-8,000 hectares annually, very few plantations have been successful in the long term. Factors affecting success include lack of technical capacity, grazing pressures and often unfavourable climatic conditions (UN-REDD Mongolia Programme 2016; Tsogtbaatar 2007).

Figure 2.6 Boreal forest areas affected by tree cover loss

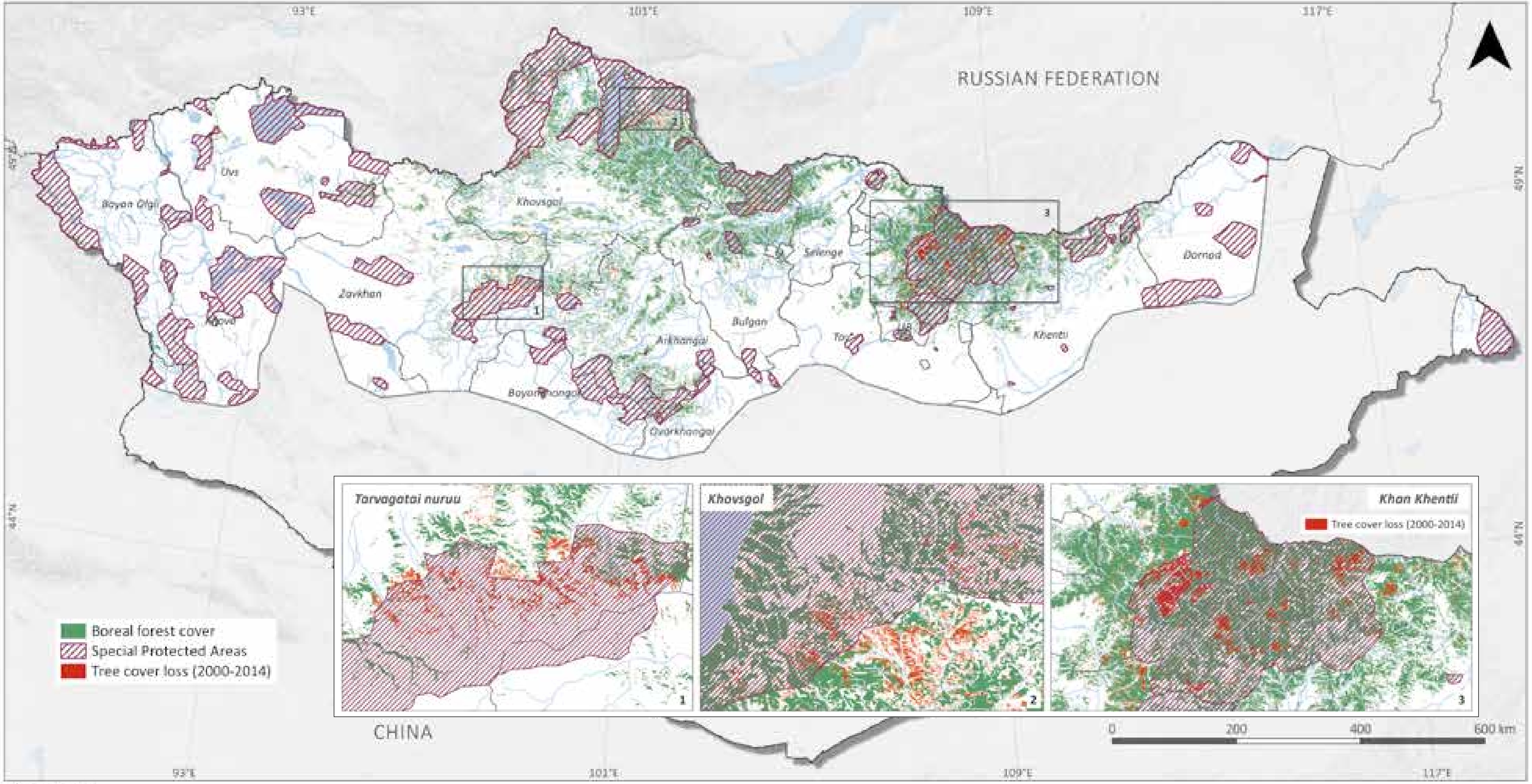
This map shows boreal forest areas that have been most affected by tree cover loss according to Hansen *et al*. (2013) from 2000-2014. Tree cover loss is defined here as the complete removal of tree cover canopy (from any level of tree cover to zero tree cover). Tree cover loss is distinct from deforestation, which is defined as the conversion of forest land into another land use. Loss pixels were resampled to 1000 metre resolution using a majority filter, in order to reflect areas of major tree loss. Boreal forest cover is derived from the FRDC National Forest Taxation Inventory (compilation year 2014).



Data sources:
Boreal forest cover: FRDC National Forest Taxation Inventory (compilation year 2014). *Tree cover loss (2000-2014)*: Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. (2013). "High-resolution global maps of 21st century forest cover change". Science 342 (15 November): 850-53. Data available online from: http://earthenginepartners.appspot.com/science-2013-global-forest. Tree cover loss during the period 2000-2014, defined as a stand replacement disturbance, or a change from a forest to a non forest state, as defined by Hansen *et al* (2013).

Figure 2.7: Distribution of areas of tree cover loss in relation to Protected Areas

This map shows the distribution of tree cover loss in Mongolia's boreal forests in relation to Protected Areas. This has been obtained by overlaying the Hansen tree cover loss data with information on the location of Special Protected Areas from the Environmental Information Center of Mongolia (provided by MET, data from 2008, last update 2015). Mongolia's Special Protected Areas network includes the national-level designations of strictly protected areas, national parks, nature reserves and monuments.



Data sources:

Boreal forest cover: FRDC National Forest Taxation Inventory (compilation year 2014).

Boreal forest region boundary: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).

Protected areas: Special Protected Areas network data in 2008 from the Administrative Department for Special Protected Areas, MNET. Parliament approves special protected areas; these can be classified as strictly protected areas, national parks, nature reserves and monuments. Provided by Environment Information Center of Mongolia.

Tree cover loss (2000-2014): Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. (2013). "High-resolution global maps of 21st century forest cover change". Science 342 (15 November): 850-53. Data available online from: http://earthenginepartners.appspot.com/science-2013-global-forest. Tree cover loss during the period 2000-2010, defined as a stand replacement disturbance, or a change from a forest to a non forest state.


© a. Dovjuu Gansukh – "After forest fire"

Fire

Forest fires can occur naturally in the northern boreal forests, but around 80% are caused by human activities (Ykhanbai 2010). An indication of fire impact on forests can be based on the density of fire-affected areas, estimated by calculating the density of MNFI plots where clear visual evidence of recent fire damage to trees and shrubs (in the last three years) had been recorded (Figure 2.8). Included in Figure 2.8 are insets showing how the fire impact data correspond to affected areas of tree cover loss according to Hansen *et al*. (2013) from 2000-2014.

Many boreal forests show lower productivity and less natural regeneration due to climate warming and the resulting increased aridity (Dulamsuren 2016). Additionally, increasing temperatures and decreasing precipitation can also increase the potential risk of fire occurrence (Otoda *et al.* 2013). Regeneration success after fire varies, depending on the species. Whereas *Betula platyphylla* and *Larix sibirica* can regenerate from seed, *Pinus obovata* and *Pinus sibirica* are not likely to establish and the dominance of late-successional conifers is likely to decrease after forest fires (Otoda *et al.* 2013).

A burned forest is also more susceptible to pests, diseases and logging. The opening of the crowns allows the growth of herbaceous vegetation, which attracts grazing animals, causing further disturbance (Tsogtbaatar 2007). Comparing the maps of tree cover loss (Figure 2.6) and fire impact (Figure 2.8) suggests that fire is the most important disturbance factor for Mongolia's forests.

Logging

Unsustainable logging and neglect of best practices in selective logging, fire and pest control also lead to degradation and the compromising of regenerative capacity, and eventually can result in forest loss. In Mongolia, illegal logging is often small-scale to meet fuelwood and other subsistence needs at the local level, but it is most damaging when carried out during large-scale operations (UN-REDD Programme 2011). Unsustainable logging and subsequent forest degradation affected on average 34,000 hectares per year from 2004-2014 according to a preliminary analysis of drivers of forest loss and degradation (UN-REDD Mongolia Programme 2016). Weak technical capacity for sustainable forest management, and increasing demand for wood products in a political environment that emphasizes forest conservation, contribute to illegal forest use.

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Grazing

Mongolia has a long tradition of raising livestock and pastoral nomadism is the prevailing form of land use. The forests are widely used for livestock grazing, and together with other factors this contributes to degradation through damage to saplings and seedlings (Ykhanbai 2010).

High impacts on boreal forests from grazing are evident in the far west of the country (Figure 2.9); these forests are relatively sparse and found at high altitudes, where livestock numbers (by soum in 2015) are usually lower than in other parts of the country (Figure 2.10). However, as grazing can affect the forest edge and sparse forest more significantly (Ykhanbai 2010), and as the forest area is smaller in this region, more plots in the west were assessed as impacted by grazing (GIZ Mongolia, pers. comm). The two maps show some alignment, for example, between impact areas and high livestock numbers in the north and north-west. The maps do not, however, consider the mobility of livestock, which may be grazing in areas beyond soum boundaries.

Pests

Recent years have seen major outbreaks of insect pests, sometimes exacerbated by drought conditions in which forests are more susceptible to attacks (Ykhanbai 2010; INDC of Mongolia 2015). Forest insect biodiversity in Mongolia comprises 315 species from 56 families, though not all are considered pests; those eating/boring leaves, needles, stems and bark are causing increasing levels of damage in Mongolia's forests (Ykhanbai 2010). Some of the most damaging are moth species such as Siberian silk moth (*Dendrolimus superans sibiricus*) and gypsy moth (*Lymantria dispar*).

The impact of pests on boreal forest can be derived from data from the Multipurpose National Forest Inventory (2014-2016), and compared with forests assessed as pest-affected from the FRDC Forest Taxation Inventory (Figure 2.11). For the Tov aimag (Figure 2.11 inset), the congruence between pest affected areas according to the MNFI and Forest Taxation Inventory can be seen. Pest control measures in such areas covered 110,000 hectares per year in the last decade (UN-REDD Mongolia Programme 2016).

Mining

Mining activities are also localized (Figure 2.12). Mongolia has significant reserves of coal, copper, molybdenum, gold, silver, zinc, uranium, nickel and other minerals. Large-scale mining operations are set to continue to expand. While many existing mining operations are located away from forested areas, there is considerable overlap of forest and mines in some areas (Figure 2.12) and mining impacts on forests are likely to amplify in the future if exploratory concessions are further developed.

© S.Bat-Erdene – "Orshikh uu, es orshikh uu"

© D.Byambaa – "Fighting with pests"

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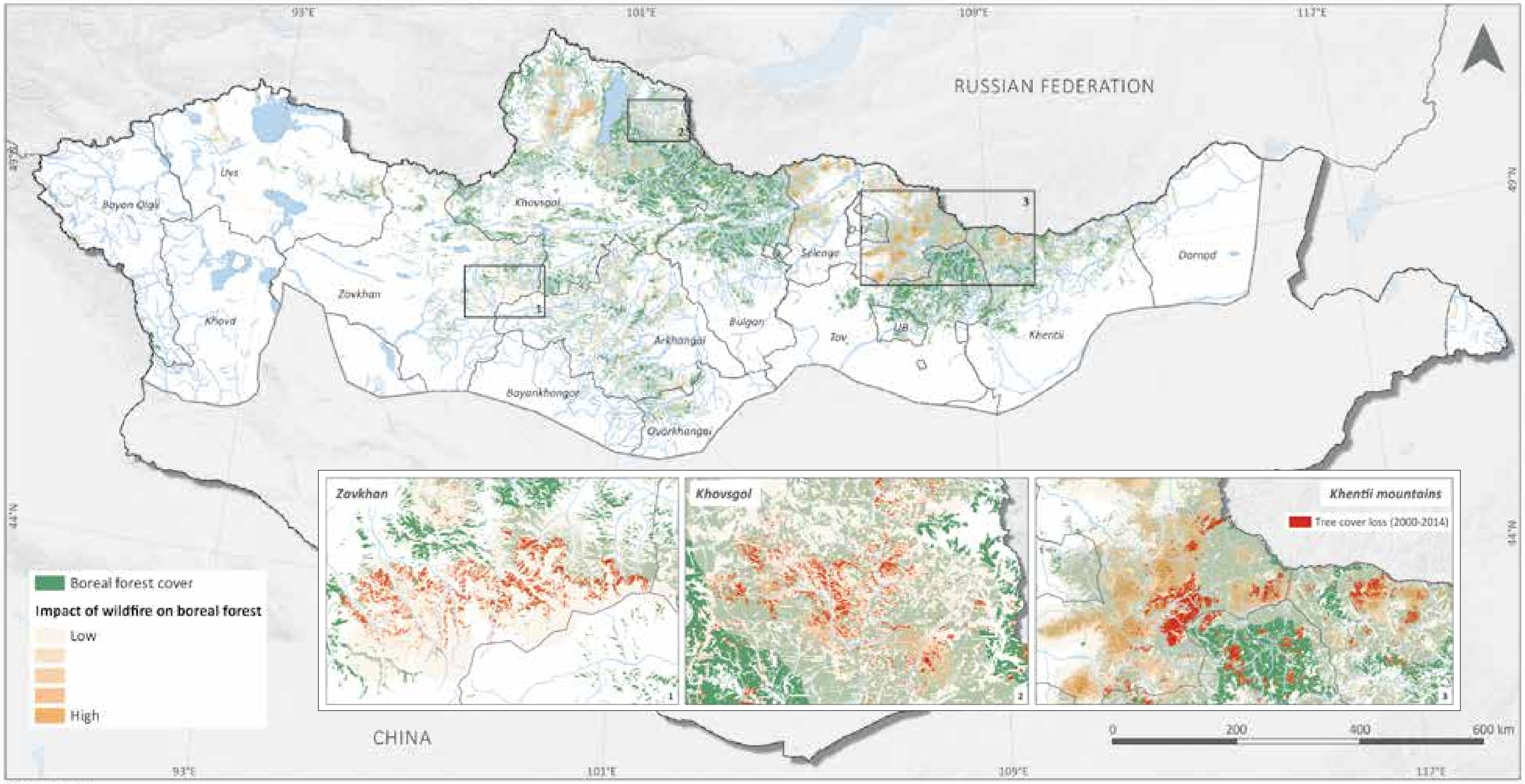
Figure 2.8: Pressure on boreal forests from fire

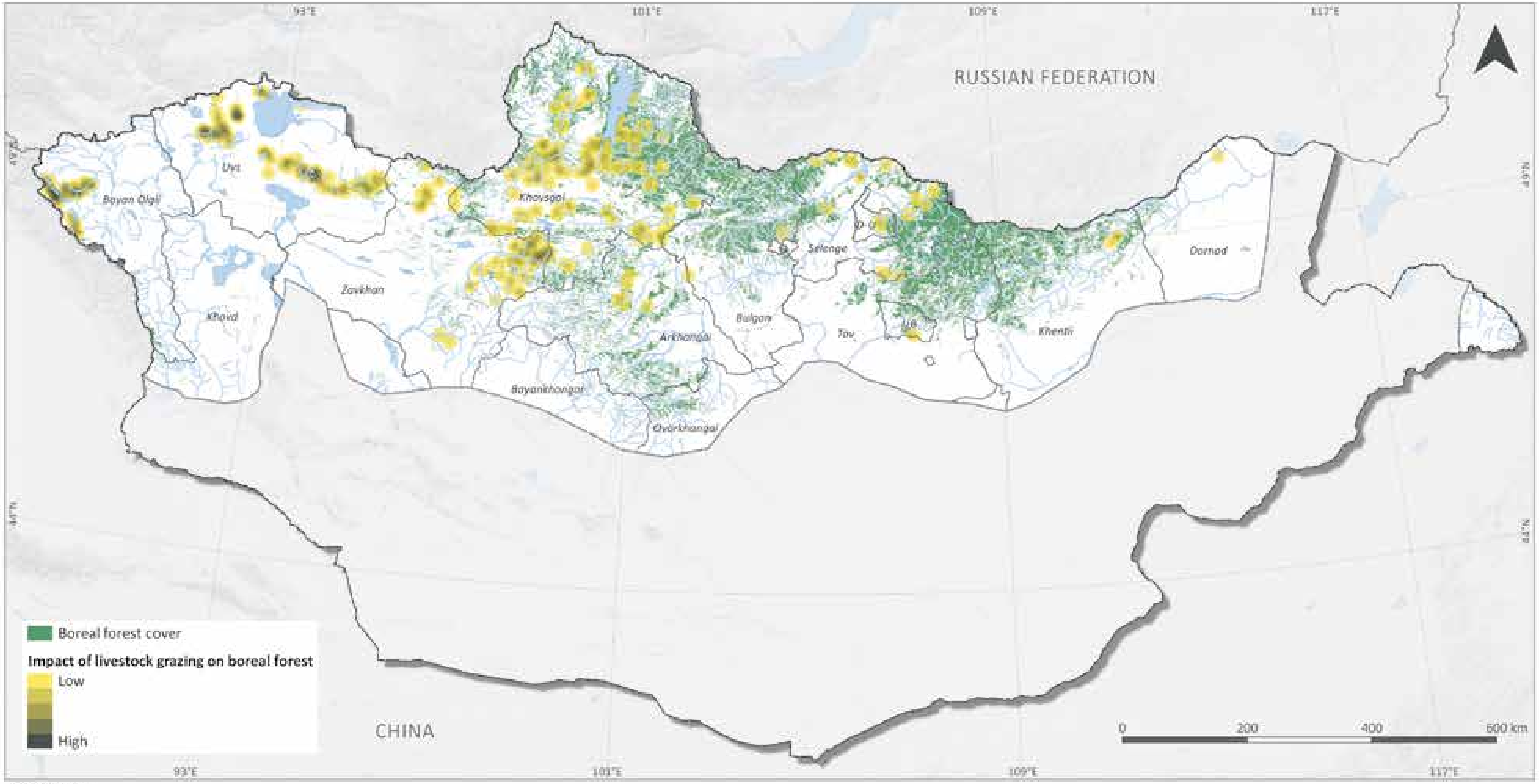
This map shows the impact on boreal forests of fires, assessed through the density of areas recently affected by fire. This was estimated by calculating the density of plots from the Multipurpose National Forest Inventory (2014-2016), where there was clear visual evidence of recent damage (in the last three years) to trees and shrubs from fire, in the three subplots that comprise each forest plot. The map shows density according to the number of plots per square kilometre, so that a larger number of clustered points of fire-affected plots, indicates a greater density of impact. In order to allow an easy identification of “hotspots” (or clusters of points) of fire impact, a point vector layer containing the spatial location of fire-affected plots from the MNFI was used to create a density raster showing number of plots per square kilometre (the SAGA Kernel Density Estimation tool within QGIS was used to create a density raster based on the number of points in a location, with larger numbers of clustered points resulting in larger values). The values were weighted according to the fire intensity values 1-3 in the plot data. Included are insets showing how the fire impact data correspond to areas of tree cover loss according to Hansen et al. (2013) from 2000 to 2014.



Data sources:
Boreal forest cover: FRDC National Forest Taxation Inventory (compilation year 2014).
Boreal forest region boundary: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).
Impact of fire: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).
Tree cover loss (2000-2014): Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. (2013). “High-resolution global maps of 21st century forest cover change”. Science 342 (15 November): 850-53. Data available online from: http://earthenginepartners.appspot.com/science-2013-global-forest. Tree cover loss during the period 2000-2014, defined as a stand replacement disturbance, or a change from a forest to a non forest state, as defined bu Hansen *et al* (2013).

Figure 2.9: Pressure on boreal forests from livestock grazing

This map shows the impact of livestock grazing on boreal forests, assessed through the density of areas that have been recorded as affected by grazing (from medium to high) in the Multipurpose National Forest Inventory (2014-2016). Medium to highly affected plots are taken as those with grazing impact rated from 12-27 (out of an index range of 0-27). A greater density of affected plots leads to a higher estimated impact. The map does not show areas where grazing has prevented the regeneration of forest loss due to fire or pests (these are, therefore, not included in the MNFI). As with other impact maps, a kernel density map was created from the point vector layer containing the location of these plots in order to create a density raster showing the number of plots per square kilometre. In areas where the forest area is small and the density of pest-affected plots is high, the yellow dots may actually cover the forest completely.

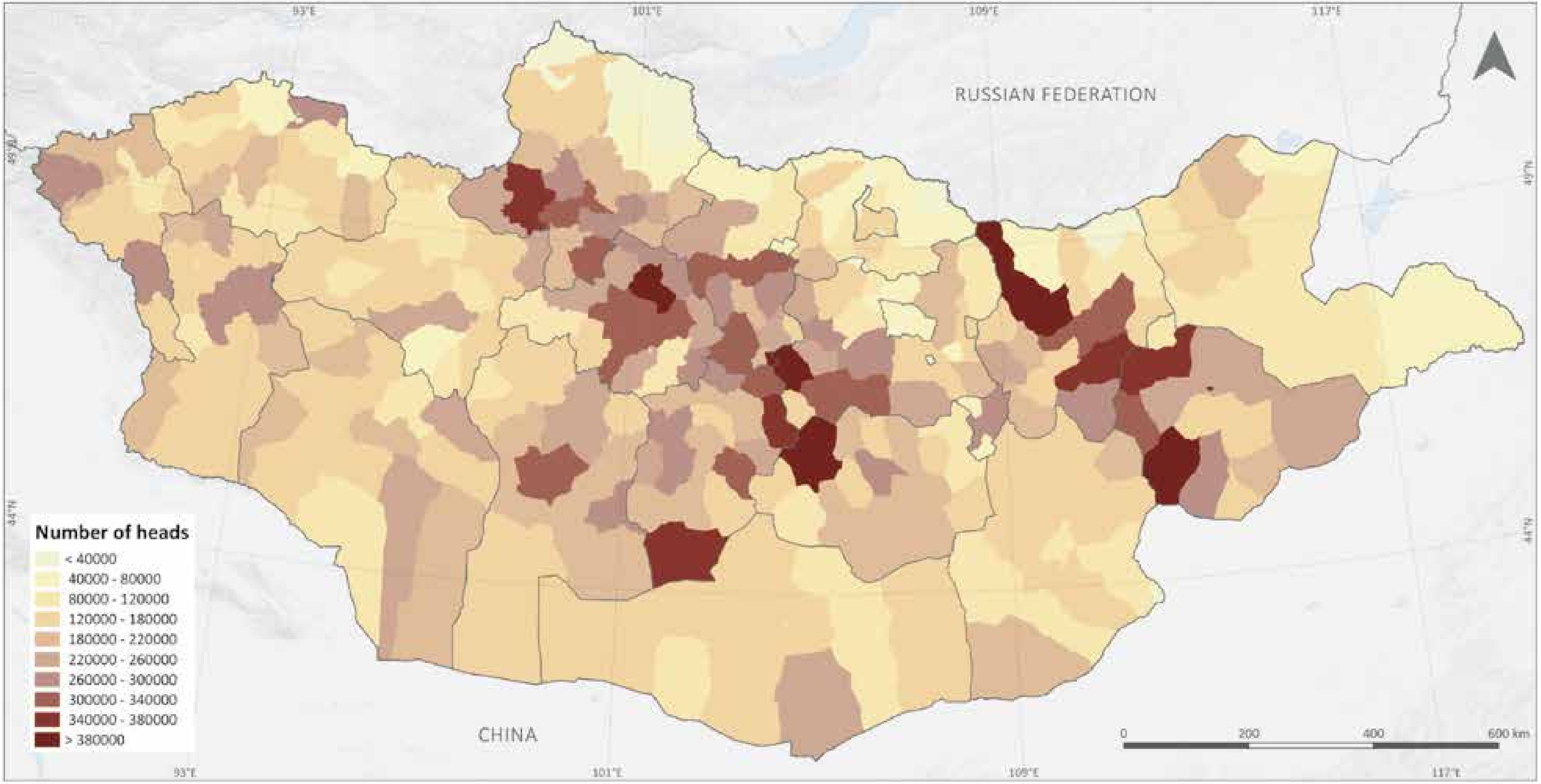


Data sources:
Boreal forest cover: FRDC National Forest Taxation Inventory (compilation year 2014).
Impact of grazing: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).
Boreal forest region boundary: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).

MINISTRY OF ENVIRONMENT AND TOURISM

Figure 2.10: Livestock numbers by soum

This map shows total recorded livestock numbers (including sheep, goats, horses, cattle, camels) by soum, provided by the Environmental Information Center (EIC) and sourced from the National Statistics Office (data from 2015). Note: the map does not provide information on the significant mobility of animals between soums under the system of nomadic pastoralism and for this reason it provides only an indication of grazing pressure.

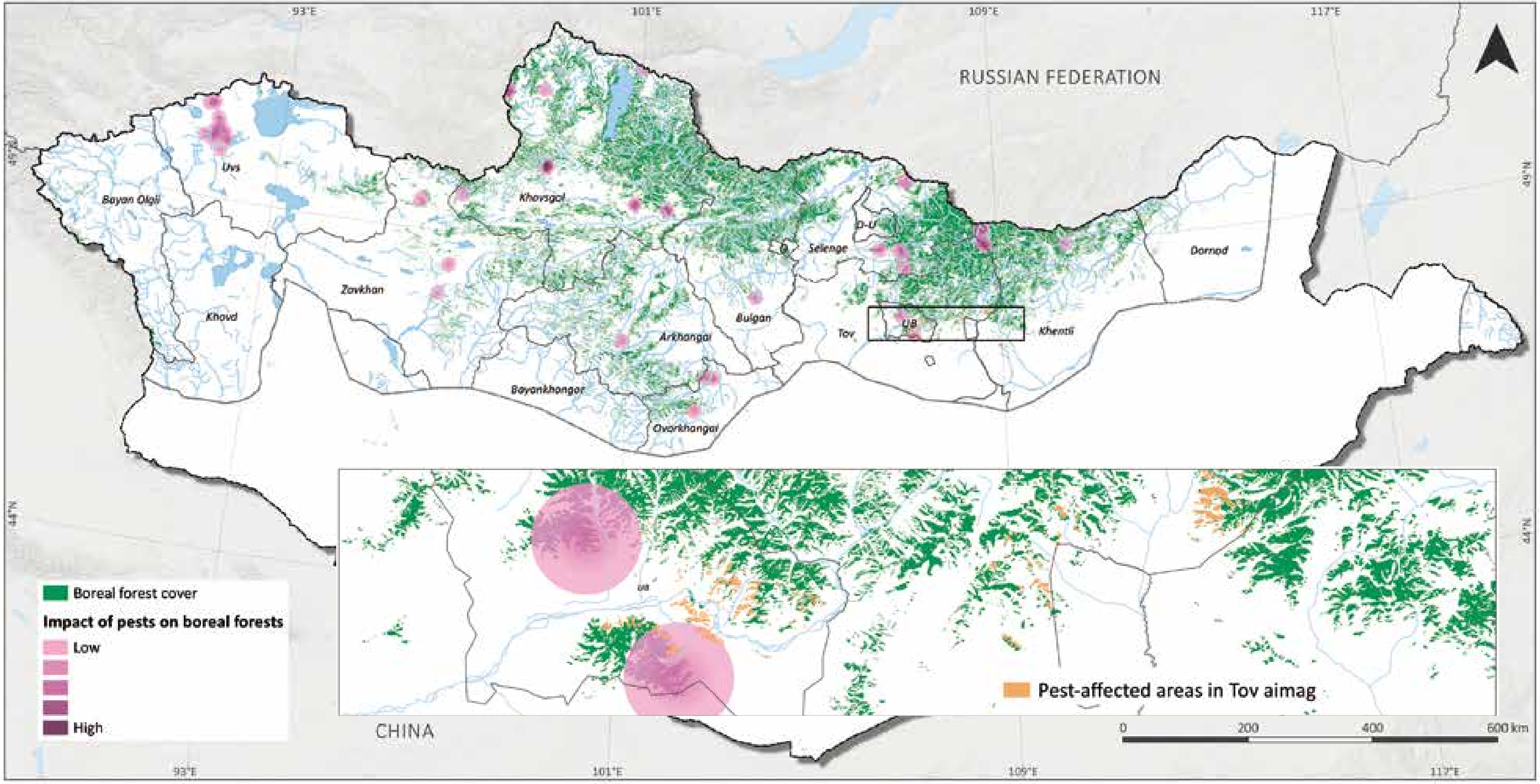


Data sources:
Number of heads: Total livestock population per soum, consisting of of horses, cattle, sheep, goats and camels, provided by National statistic office of Mongolia, 2015

REDD+ MONGOLIA

Figure 2.11: Pressure on boreal forests from pests

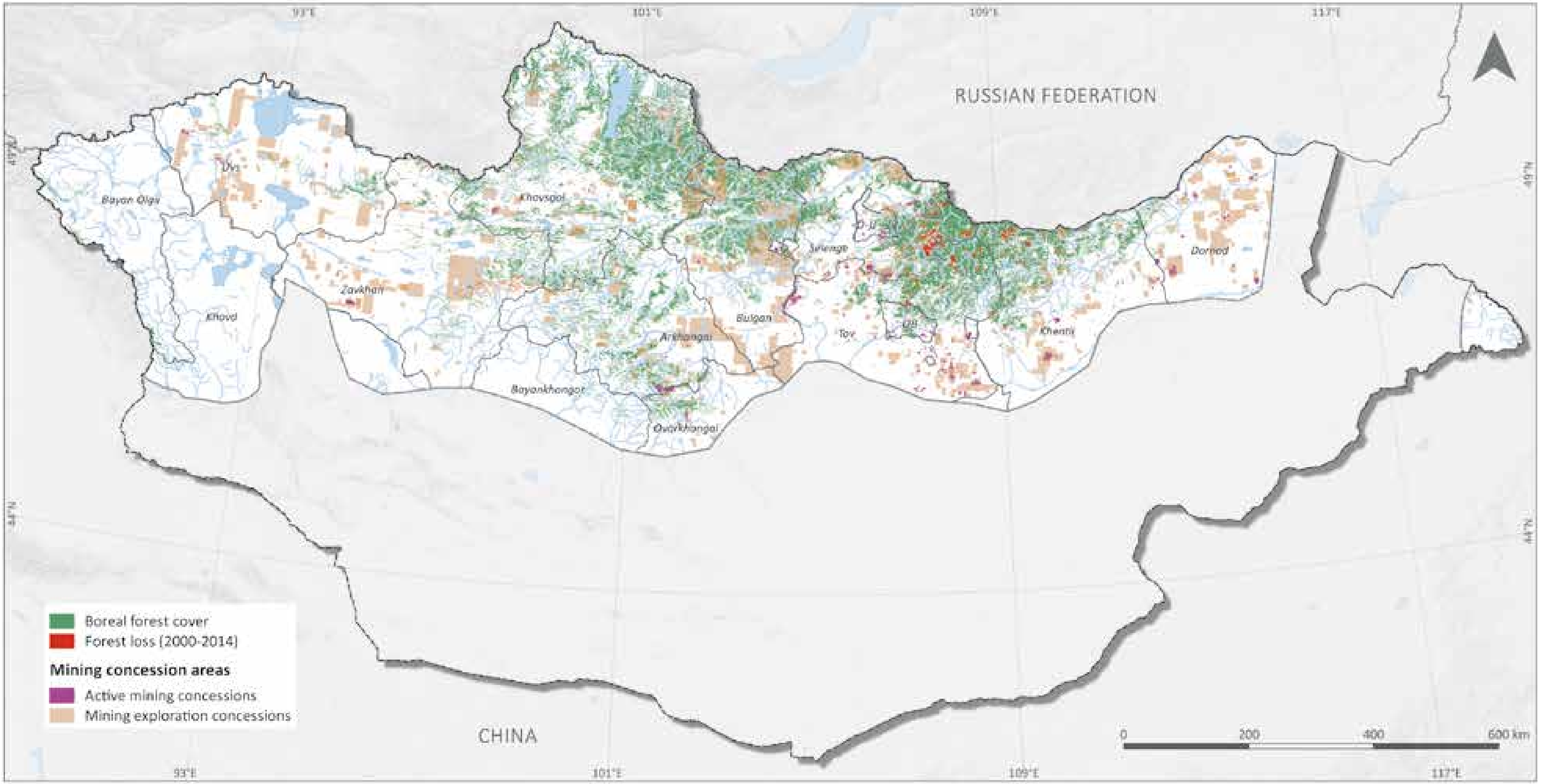
This map shows the impact of pests on boreal forests. As with other impact maps in this study, pest-affected forests are assessed here using the density of plots as recorded as affected by pests in the Multipurpose National Forest Inventory (2014–2016). Plots with 30% of their total plot basal area or higher affected by pests were recorded as such in the inventory. A greater density of affected plots leads to a higher estimated impact. In order to allow an easy identification of "hotspots" (or clusters of points) of pest impact, a point vector layer containing the spatial location of pest-affected plots from the MNFI was used to create a density raster showing number of plots per square kilometre using the SAGA Kernel Density Estimation tool within QGIS. The inset here shows an overlay of the areas affected by pests from the MNFI with forests assessed as pest-affected in Tov aimag (from the FRDC Forest Taxation Inventory for Tov, 2013). Where the forest area is small and the density of pest-affected plots is high, the pink dots may actually cover the forest completely.



Data sources:
Boreal forest cover: FRDC National Forest Taxation Inventory (compilation year 2014).
Boreal forest region boundary: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).
Impact of pests: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).
Pest-affected forest areas in Tov aimag: Forest Taxation Inventory of Tov aimag (2013).

Figure 2.12: Mining areas and boreal forest cover in Mongolia

This map shows the spatial distribution of areas of tree cover loss in Mongolia's boreal forests in relation to mining concession in 2010-2013. This has been obtained by overlaying the Hansen tree cover loss data (see Fig. 2.6) with information on the location of mining concessions, both active and exploration areas, from the Mineral Resources Authority of Mongolia.



Data sources:

Boreal forest cover: FRDC National Forest Taxation Inventory (compilation year 2014) FRDC National Forest Taxation Inventory (2014).

Mining concession areas: Mineral Resources Authority of Mongolia, 2013. This includes active mining concession areas and exploration concession areas for 2010-2013.

Boreal forest region boundary: Multipurpose National Forest Inventory of Mongolia, covering boreal forests, 2014-2016 (MET 2016).

Tree cover loss (2000-2014): Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice, and J.R.G. Townshend. (2013). "High-resolution global maps of 21st century forest cover change". Science 342 (15 November): 850-53. Data available online from: http://earthenginepartners.appspot.com/science-2013-global-forest. Forest loss during the period 2000-2010, defined as a stand replacement disturbance, or a change from a forest to a non forest state, according to Hansen's definition.

3. Supporting planning for REDD+ in Mongolia at the aimag level

3.1 Values of forests in Khovsgol and Tov

Two aimags were selected for the analysis of the different values of forests, and potential benefits from REDD+, at the subnational level: Khovsgol aimag in northern Mongolia and Tov aimag in central Mongolia. Khovsgol is the northernmost of Mongolia's 21 aimags. It covers an area of just over 100,000 km^2 and according to the National Statistics Office of Mongolia had a population of 128,159 in 2015 (http://en.nso.mn/, accessed: 13/12/2016). Lying to the east, Tov is the smaller of the two aimags in both area (74,000 km^2) and population (90,421 in 2015), and encircles the national capital of Ulaanbaatar (administered as an independent municipality) (Figure 3.1).

Figure 3.1: Location of Khovsgol and Tov aimags in northern Mongolia

During the collaboration, consultation workshops were held in Murun, capital of Khovsgol, and Zuunmod, capital of Tov aimag, on 3 and 6 of November 2015, respectively. The consultations brought together stakeholders from different sectors to discuss and prioritize forest values. The forest types and areas important for these values were initially examined through a participatory mapping approach. The key values identified in Khovsgol and

Tov are listed in the Consultations Report (Narangarel *et al*. 2016a) and their ranking by participants is shown in Table 3.1[7].

Table 3.1: Prioritization of values of forests in Khovsgol and Tov by workshop participants

Khovsgol	
Values	**Priority**
Carbon storage and oxygen supply	1
Water regulation/supply	2
Timber	3
Fuelwood	4
Natural springs/rest areas	4
Non-timber forest products (e.g. berries, nuts, mushrooms, medicinal plants)	5
Seeds and seedlings	6
Historical/archaeological sites	7
Tourism	7
Woodchips/bark	8

Tov	
Values	**Priority**
Supporting natural regeneration	1
Overall natural balance/functioning	2
Fuelwood	3
Water regulation/supply	4
Clean air	5
Wildlife habitat	5
Tourism	5
Oxygen supply	6
Seeds and cones, pine nuts	6
Soil services (e.g. desertification control, permafrost protection, soil erosion control)	7
Aesthetic value, leaves/forage/fodder	8
Timber, medicinal plants, plant diversity, disease control, springs/rest areas	9


© U.Nyamaa – "Bogd Khan mountain", REDD+ Mongolia; d. Adiyasuren Tsokhio – "Children, flowers and forest are all relatives"

The prioritization by the two aimags demonstrate some similarities as well as differences (Narangarel *et al*. 2016a). For example, both aimags rated hydrological services (such as water supply and quality), fuelwood provision and tourism or recreational aspects in their top five. However, though timber supply is considered important in Khovsgol aimag (particularly for use in construction), in Tov aimag it was rated lowest, due to the fact that there is little production forest there, either natural or plantation.

[7] Note that these rankings are based on the small sample of workshop participants, and do not reflect a wider body of opinion. They nevertheless represent an informed view to build our further analyses.

The technical working session held in Ulaanbaatar in March 2016 focused on spatial analyses of the prioritized forest values, as well as further building capacity (Narangarel *et al*. 2016b). The maps that were generated in this session and subsequent analyses are described in the following paragraphs. Further details of the methodologies used to undertake the spatial analyses can be found in Annex 1.

Forest resources and their condition in the aimags

Forest cover and type in the two aimags varies considerably (Table 3.2). The mapping, based on the FRDC Forest Taxation Inventories for Tov (2013) and Khovsgol (2012) shows a total forest cover in Khovsgol of 3,074,403 hectares (30% of the aimag) and while distributed across the aimag, it is most concentrated in the north-east. The forests are mostly dominated by larch (*Larix sibirica*), with much smaller areas of pine (mostly *Pinus sibirica*), birch (*Betula platyphylla*) and other species. Tov is much less forested with only 1,059,900 hectares (13% of the aimag). The forest is concentrated in the north-east and is minimally present or absent elsewhere. Much of the forest is dominated by larch or pine (*Pinus sibirica, P. sylvestris*), with smaller pockets of birch and other forest types.

Table 3.2: Areas and percentages of main forest types in the aimags of Khovsgol and Tov

Forest type	Khovsgol: area (hectares and percentage)	Tov: area (hectares and percentage)
Larch	2,904,134 (94.5%)	554,986 (52.4%)
Siberian pine	81,729 (2.7%)	285,240 (26.9%)
Other pine	-	85,515 (8.1%)
Birch	71,017 (2.3%)	11,480 (10.9%)
Other	17,523 (0.6%)	18,775 (1.8%)
Total	3,074,403 (100%)	1,059,996 (100%)

Source: FRDC Forest Taxation Inventories for Tov (2013) and Khovsgol (2012)

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The FRDC Forest Taxation Inventories for Tov (2013) and Khovsgol (2012) record areas of forest as being disturbed by different factors, or as undisturbed (Figure 3.2). The inventories compile soum-level data on tree and shrub species and densities, together with disturbance factors, and are used to generate national taxation inventories and statistics. Fire is the most significant of the disturbance factors recorded (Table 3.3) followed by pest outbreaks and logging.

Table 3.3: Areas of forest indicated as being in different categories of condition in Khovsgol and Tov aimags (percentage of total forest area)

Condition/state	Khovsgol	Tov
Affected by fire	353,942 ha (9.36%)	123,894 ha (9.76%)
Affected by pest outbreaks	29,464 ha (0.78%)	11,320 ha (0.89%)
Logged	9,720 ha (0.25%)	9,306 ha (0.73%)
Open forest	156,231 ha (4.13%)	40,089 ha (3.15%)
Designated for reforestation	172 ha (0.004%)	1,759 ha (0.13%)
Designated for natural regeneration	5,316 ha (0.14%)	7,663 ha (0.60%)

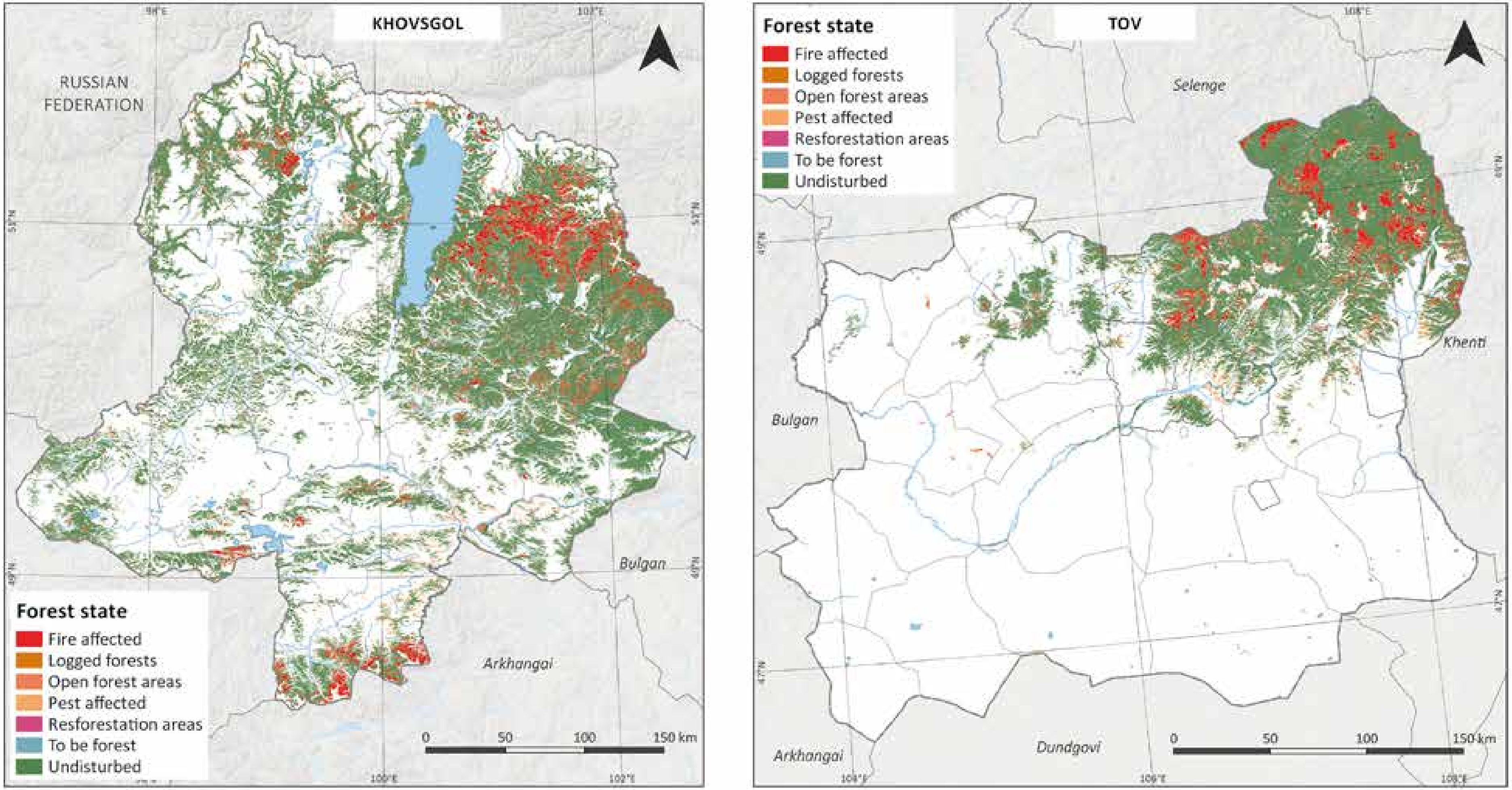
Source: FRDC Forest Taxation Inventories for Tov (2013) and Khovsgol (2012)

The disturbed areas are unevenly distributed in both aimags. Fire hotspots exist in the north-east and south in Khovsgol (in the north-east mostly due to a single fire event in 2011), while pest impact has been prevalent only along the south-east aimag boundary. In Tov, there is no clear pattern to fire disturbance, and pests have only affected the southern rim of the forest area. In the national context, forest fires annually damage a significant area. Estimations of the forest area affected by fire differ, including around 500,000 hectares per year (Ykhanbai 2010) and 139,000 hectares per year (UN-REDD Mongolia Programme 2016). Fires mainly occur as a result of human activities (about 95% according to Chuluunbaatar 2001, 2012, cited in UN-REDD Mongolia Programme, 2016) and fire prevalence is increasing due to reduced precipitation (Ykhanbai 2010).

© Rentsenbat Ganbaatar – "Ongi temple, Saikhan-Ovoo soum, Dundgobi province"

Figure 3.2. Condition of forests in Tov and Khovsgol aimags

These maps show the extent and state, or condition, of forests in Tov and Khovsgol aimags. This is derived from data recorded in the FRDC Forest Taxation Inventories for Tov (2013) and Khovsgol (2012). These inventories record numerous parameters related to forest land (stocked and unstocked) by sub-compartment, compartment, soum and aimag. The maps shows the forest cover, along with areas affected by fire, pests, and logging, as well areas designated for reforestation, and for natural regeneration (known as 'to be forest' areas). These maps suggest that fire is a key driver of forest loss and/or degradation in both aimags.



Data sources:
Forest cover and condition: FRDC Forest Taxation Inventories of Tov aimag (2013) and Khosvgol aimag (2012).

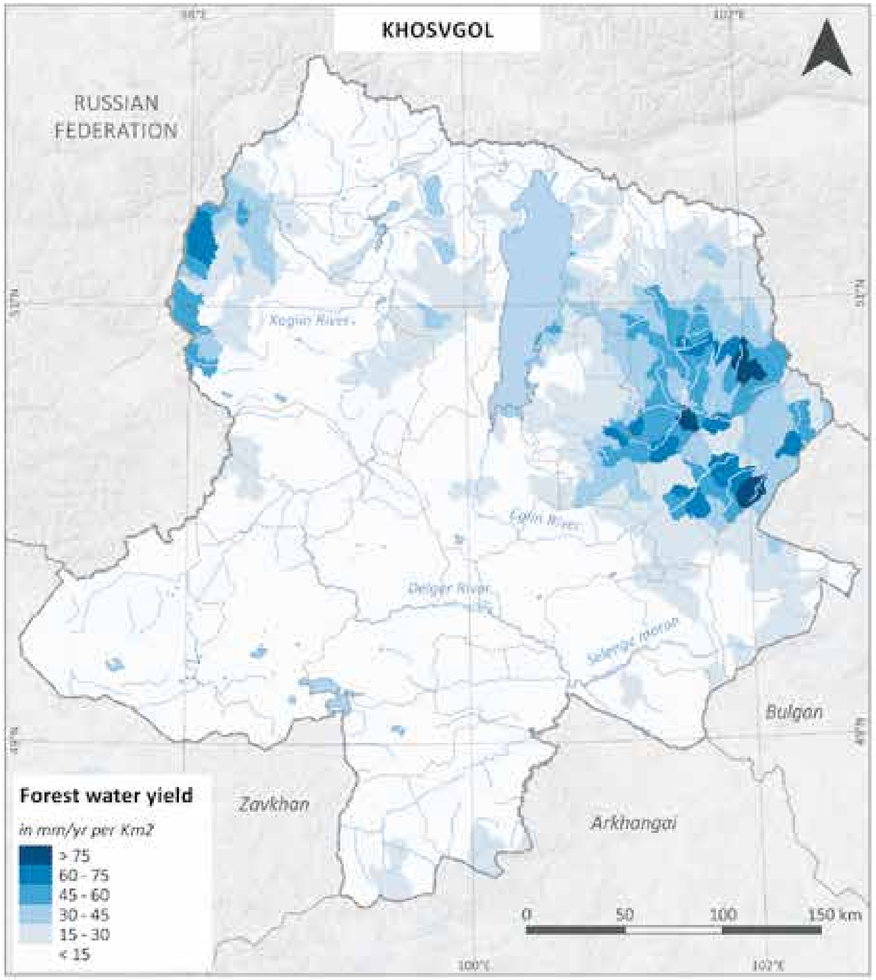
Hydrological services

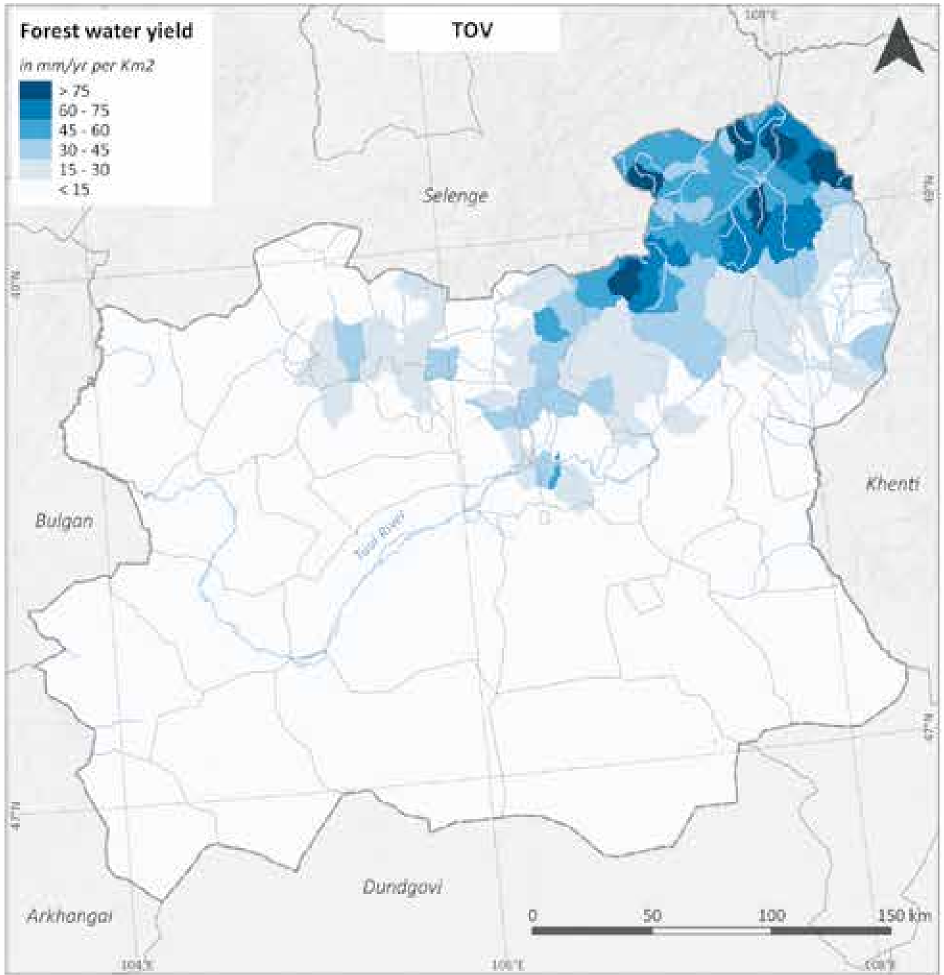
Results from the aimag consultation workshops indicate that freshwater provision is one of the most important values of forests. Forests play an important role in the local landscape in terms of controlling water balance and run-off, as well as reducing soil erosion, which can be exacerbated by the removal or degradation of forest cover.

In the working sessions, an open-access online tool called WaterWorld (www.policysupport.org/waterworld; Mulligan 2013) was used to map these hydrological ecosystem services in Khovsgol and Tov. The model draws on datasets for many meteorological variables (e.g. precipitation, relative humidity, air temperature, wind direction, cloud frequency, ice) on a monthly basis, as well as topography and land cover layers. The estimated annual forest water yield per square kilometer for the two aimags in some areas (e.g. the soums of Tsagaan Uur and Erenebulgan in Khovsgol and Erdene and Mongonmorit in Tov) reaches values of over 75 mm/km^2/year, and this is largely driven by high levels of fog capture by trees (Figure 3.3). Although there were some negative pixel values (i.e. a negative effect of forest on water yield), the number of these pixels was low; so the overall forest water yield at the river basin level was still positive. It should be noted that the advantages of freshwater provision are experienced downstream, and therefore the value to people of each forest area depends on yield, population size and the downstream uses.

Figure 3.3: Distribution of forest water yield in Tov and Khovsgol aimags

This map represents the estimated annual forest water yield per square kilometre in the two aimags. Forest water yield, or the contribution of forests to overall water yield, was calculated as the difference between the estimated annual water balance of a baseline situation of current forest cover (using land cover data from the MODIS Vegetation Continuous Field) and a scenario in which all tree cover is removed. Models were run in the WaterWorld system (Mulligan 2013), a global online modelling system, at a 1 km^2 resolution. The changes in annual water balance (in mm/year) were then used to calculate the mean value for each river basin. River basins were derived from the Hydrobasins dataset (Lehner and Grill 2013) using level 12, as this was the most appropriate basin size given the extent of the study area and the resolution of the modelling. The WaterWorld system draws on a large number of global hydrological, meteorological and landcover datasets, including precipitation, wind, snow and ice (e.g. glaciers). Although there were some negative pixel values apparent (i.e. areas in which forest actually consume more water than they produce) the number of these pixels was low, so the overall forest water yield at the river basin level was still positive.





Data sources:

Forest Water Yield: Modelled in the WaterWorld modelling system Mulligan 2013. WaterWorld: a self-parameterising, physically based model for application in data poor but problem-rich environments globally. Hydrology Research Vol. 44, No. 5) and aggregated per river basin. River basins (level 12) were derived from the Hydrobasins dataset (Lehner B., & G. Grill (2013) Global river hydrography and network routing: baseline data and new approaches to study the world's largest river systems. Hydrological Processes, Vol. 27, No. 15.

Tourism and recreation

According to the former Ministry of Roads, Transport and Tourism (MRTT), 44% of Mongolia's current tourism products are based on nature. In 2011, an estimated 90,000 international tourists travelled to Mongolia (MRTT 2013, in Emerton and Enkhtsetseg 2013); other sources note higher figures, for the total number of visitor arrivals, such as 393,000 in 2014 (World Bank 2016, based on World Tourism Organisation data) and 386,204 in 2015 (Mongolia National Statistics Office 2016). Emerton and Enkhtsetseg (2013) found no specific data on forest-related tourism; however, they were able to extrapolate rough estimates of the value of forests for recreation from total leisure tourism figures. According to their study, around five days (just under one third) during an average 16-day international tourist holiday are spent in forested landscapes.

The aimag consultation workshops both prioritized a number of tourism and recreation elements as an important value of forests; these included the springs, rest areas[8] and historically significant sites associated with forests, as well as tourism and aesthetic value. For the purpose of this study, these have been combined and referred to as 'tourism and recreation'. During the working session in Ulaanbaatar, the participants developed an approach to map the potential importance of forests for tourism and recreation.

The spatial distribution of two main nature-based tourism and recreation attractions – ger camps and natural springs – has been analyzed applying this approach (Figure 3.4). Special Protected Areas are also shown. This map shows the density of main tourist sites per square kilometer, with sites more closely clustered in forest areas in Khovsgol aimag, while more dispersed across Tov aimag. The numbers of ger camps and springs is based on data for 2007 provided by MET; as such, the map likely records only official or licensed ger camps. Discussions with workshop participants suggest that the current number of camps, particularly along streams in Tov aimag, is higher than these figures indicate.

[8] Referring to natural, mineral springs, both hot and cold, and rest areas where people can rest and access water and spend recreational time.

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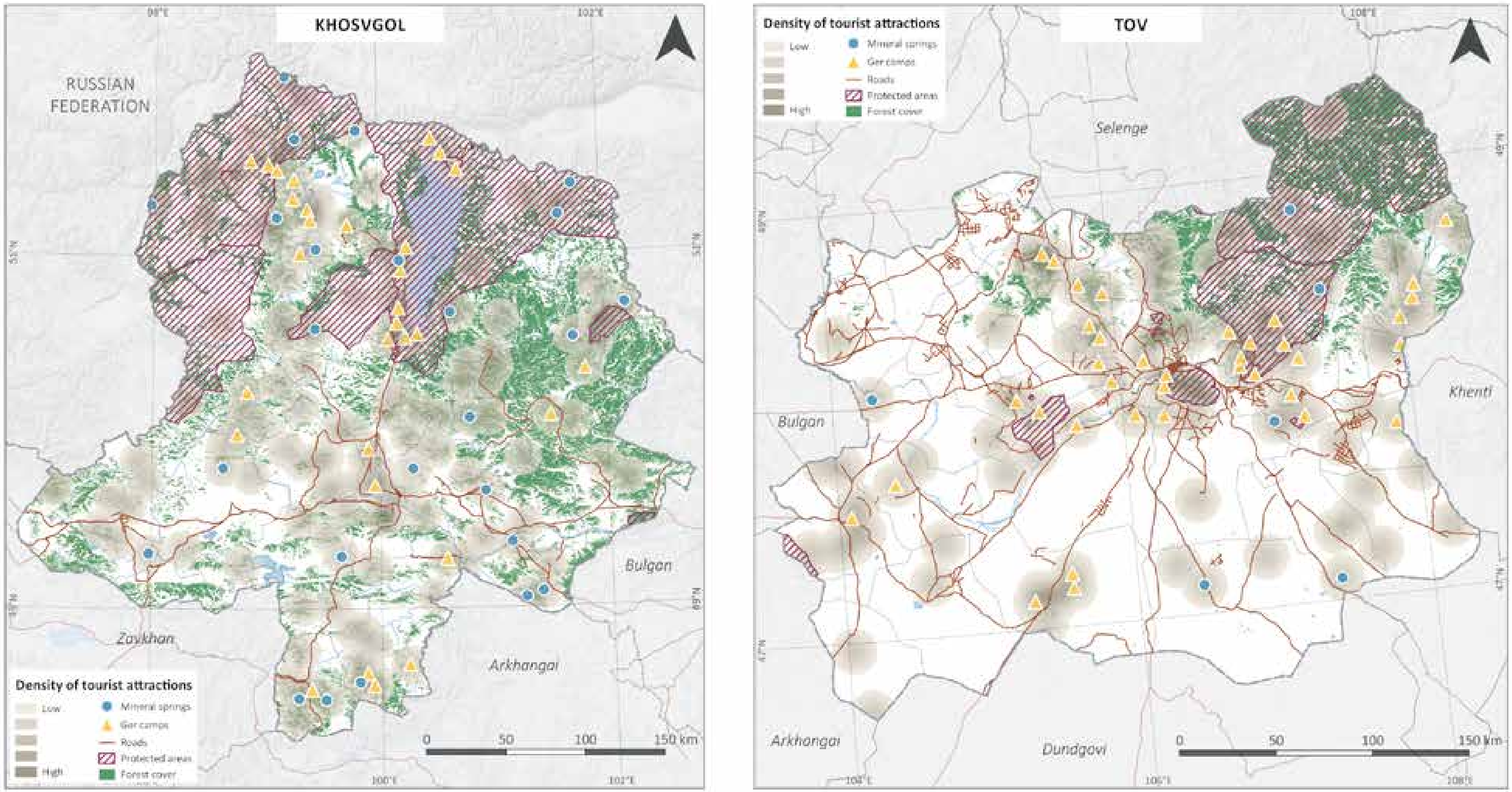
Figure 3.4: Distribution of selected nature-based tourism and recreation sites in relation to forests in Tov and Khovsgol aimags

These maps shows the spatial distribution of two main nature-based tourism and recreation attractions – ger camps and mineral springs – as prioritized through consultations in the aimags and the working sessions. Special Protected Areas are also shown. In order to allow an easy identification of the distribution of all tourist attractions in relation to forest, a point vector layer containing the spatial location of all selected important nature-based tourism sites from MET was used to create a density raster showing number of sites per square kilometre using the SAGA Kernel Density Estimation tool within QGIS. The numbers of ger camps and springs is based on data provided by the Ministry in 2007; as such, it probably records only official or licensed ger camps, and the numbers of these have likely increased in recent years.



Data sources:

Forest cover: Forest Taxation Inventories of Tov aimag (2013) and Khovsgol aimag (2012)

Roads: Ministry of Roads, Transportation, Construction and Urban Development (2007). Provided by Environment Information Center of Mongolia.

Protected areas: Special Protected Areas network data in 2008 from the Administrative Department for Special Protected Areas, MNET. Parliament approves special protected areas; these can be classified as strictly protected areas, national parks, nature reserves and monuments. Provided by Environment Information Center of Mongolia.

Ger camps and mineral springs: Ministry of Natural Environment and Tourism (MNET), 2007. Provided by Environment Information Center of Mongolia .

© Khasbaatariin Badar-Uugan – "Tinning"

Forest products

Fuelwood is very important for households in Mongolia for heating and cooking, and higher efficiency in their use, or alternatives, are needed in order to conserve forests (Narangerel *et al*. 2016a). For example, there is strong interest in Khovsgol in compressing sawdust or other types of wood waste into fuel bricks, though access to technology and funding are challenges (Narangerel *et al*. 2016a).

Modelled extraction pressure for fuelwood in Khovsgol appears highest where it is closest to the largest population centre, the aimag capital of Murun (close to the centre of the aimag, Figure 3.5). This pattern is less obvious for Tov, with very little forest classified as experiencing high extraction pressure. This may be due to the spatial data not including the administrative district of the country's capital, Ulaanbaatar. No relationship between extraction pressure and distance to nearest road was apparent in the spatial modelling.

Timber is a more important product in Khovsgol than in Tov, and was thus prioritized more highly by Khovsgol workshop participants. According to national statistical data provided by Emerton and Enkhtsetseg (2013), in 2010, Khovsgol aimag harvested 201,500 m^3 of timber, the highest amount of all aimags for that year, and well above the 33,100 m^3 harvested in Tov. The modelled timber logging intensity for Khovsgol is shown in Figure 3.6, mapped according to a similar methodology to fuelwood. The map shows the influence of the proximity to the capital Murun, and also accessibility by road, in increasing the logging intensity. It compares, for example, the relatively high level of extraction on either side of the road between Murun and Lake Khovsgol with the less accessible north-east region of the aimag. The high pressures evident outside of utilization areas suggests that either small areas of utilization forest in soums with large amounts of protection forest may be experiencing high logging intensity, or that timber may be inappropriately harvested from protection forests.

Non-Timber Forest Products (NTFPs) were also prioritized in Khovsgol. This was mapped on the basis of official data from the aimag Forest Units on licensed extractions in kilograms by soum for the period 2013-2015 (Figure 3.7). Similar to fuelwood and timber, the maps suggest that the forests providing more NTFPs are more accessible and closer to Murun. The statistical data may have some anomalies and, therefore, have to be taken with caution. For example, workshop participants stated that forests providing pine nuts often also provide berries, but this pattern is not evident from the spatial analysis.

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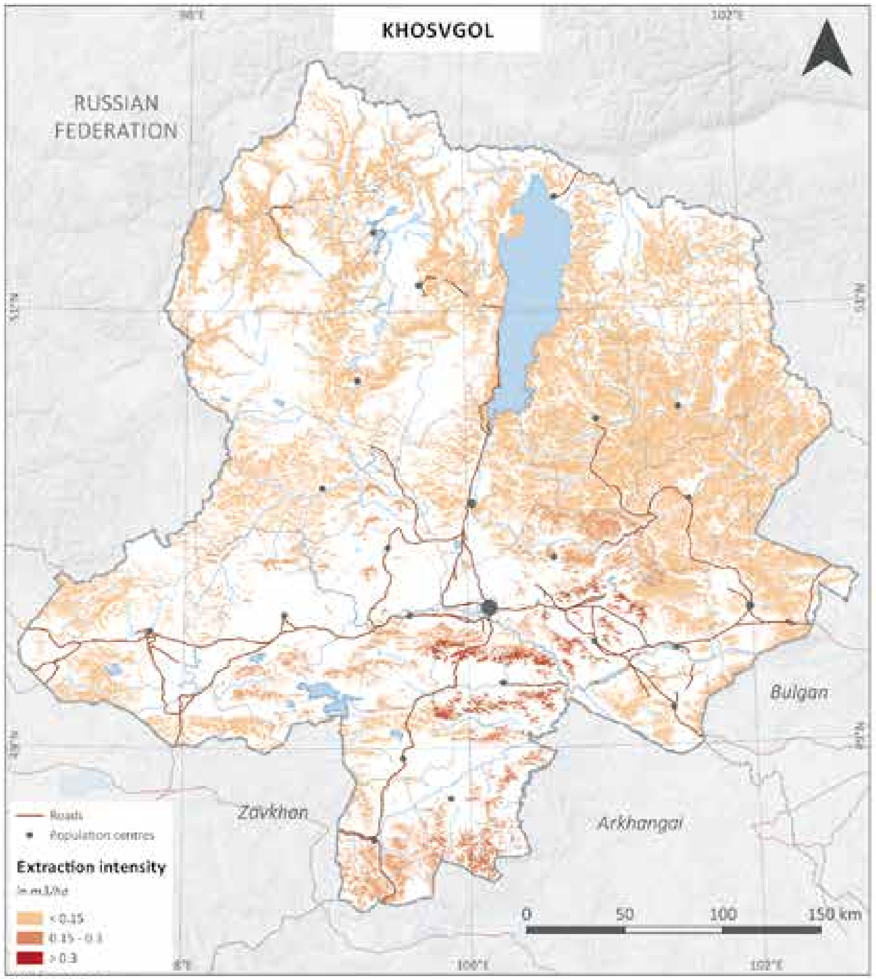
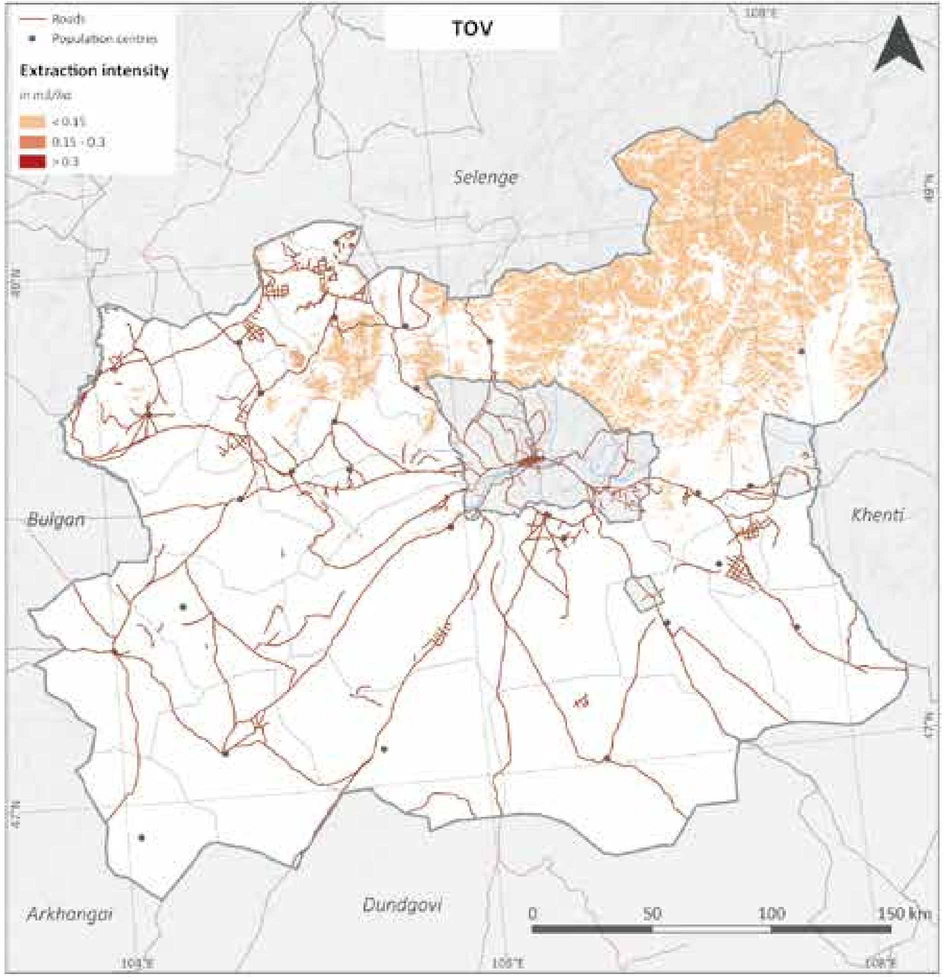
Figure 3.5: Forests providing fuelwood in Tov and Khovsgol aimag

This map shows an estimation of the relative amount of licensed fuelwood extraction in the Tov and Khovsgol aimags. Official data for the licensed or permitted fuelwood removal volumes (in m^3), from 2013-2015 per soum, were provided by each aimag. These figures were averaged over the three-year period and then divided by the forest cover per soum (in ha) in order to obtain the estimated extraction intensity (in m^3/ha), which has been classified as high, medium and low. Roads and populations centres (soum and aimag capitals) are also shown to highlight whether any spatial relationships are indicated between access and population with extraction intensity. It is legal to collect fuelwood from both forest production zones and protection zones in Mongolia. Extraction intensity is indicative of the value of the forests for fuelwood, but also of a potential impact on the forests from over-exploitation.





Data sources:

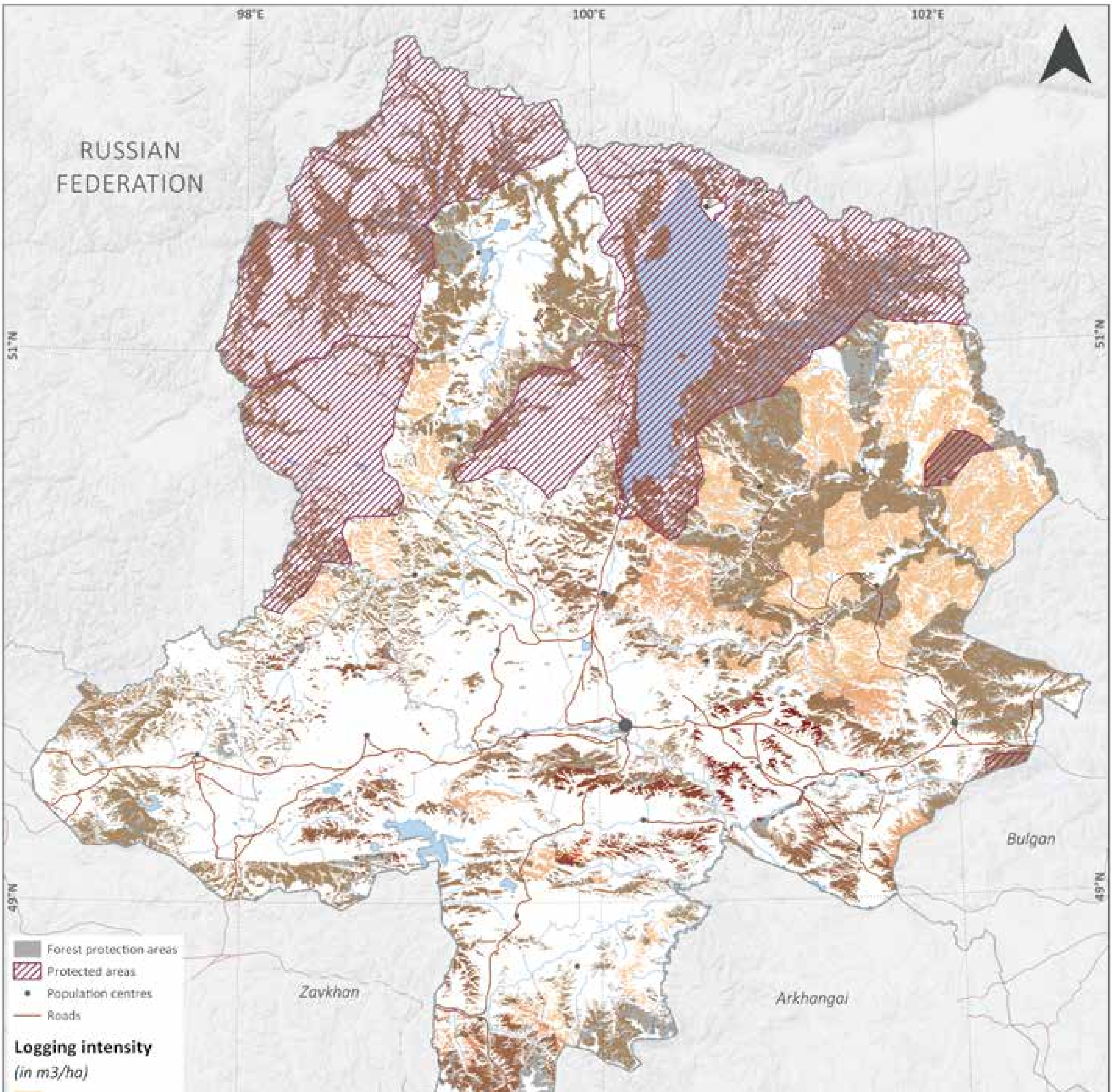
Extraction intensity: Licensed fuelwood harvesting data per soum between 2013 and 2015 (provided by Tov and Khovsgol Aimag Forest Units) was averaged and combined with forest cover areas form the FRDC Forest Taxation Inventory data for the aimag.

Population centers: Administration of Land Affairs, Geodesy, and Cartography (2009; based on administrative units update in 1999). Provided by Environment Information Center of Mongolia.

Roads: Ministry of Roads, Transportation, Construction and Urban Development (2007). Provided by Environment Information Center of Mongolia.

Figure 3.6: Forests providing timber in Khovsgol aimag

This map shows licensed timber logging intensity for the forests of Khovsgol aimag, being similar to the maps showing fuelwood and NTFPs (Figures 3.5 and 3.7). Official data on licensed timber harvested (in m^3) from 2015 per soum were divided by forest cover per soum (in ha) in order to obtain logging intensity (in m^3/ha). Protection forests and Special Protected Areas are also shown; there are only few circumstances where timber is permitted to be extracted from these forest categories. Logging intensity is indicative of the value of the forests for timber, but also of a potential impact on the forests from over-exploitation.



Methods and data sources:

Forest cover and forest protection areas: Forest Taxation Inventory of Khovsgol aimag (2012).

Logging intensity: Licensed timber harvesting data per soum in 2015 (provided by Khovsgol Aimag Forest Unit) was combined with forest cover area from the FRDC Forest Taxation Inventory data for the aimag.

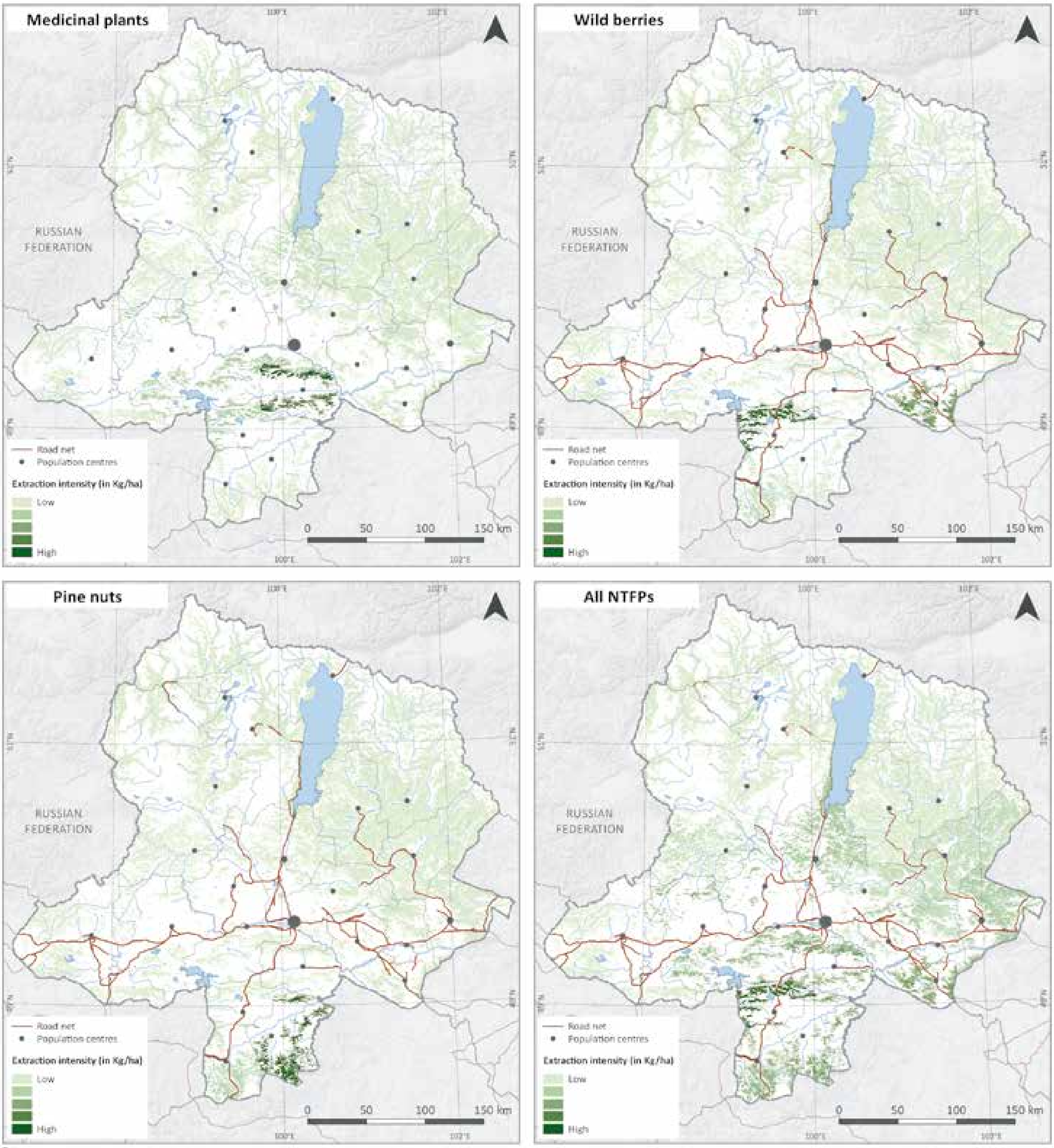
Population centers: Administration of Land Affairs, Geodesy, and Cartography (2009; based on administrative units update in 1999). Provided by Environment Information Center of Mongolia.

Roads: Ministry of Roads, Transportation, Construction and Urban Development (2007). Provided by Environment Information Center of Mongolia.

Special Protected Areas: data in 2008 from the Administrative Department for Special Protected Areas, MNET. Parliament approves special protected areas; these can be classified as strictly protected areas, national parks, nature reserves and monuments. Provided by Environment Information Center of Mongolia.

Figure 3.7: Forests providing selected non-timber forest products in Khovsgol aimag

This map shows licensed NTFPs extraction intensity for the forests of Khovsgol, which is similar to the maps showing fuelwood and timber (Figures 3.5 and 3.6). The map uses statistical data for licensed harvesting of three main types of NTFPs produced in the aimag: medicinal plants, wild berries and pine nuts. These figures are in kg, licensed for harvest in 2015 per soum. These licensed amounts were divided by forest cover per soum (in ha) in order to obtain extraction intensity (in kg/ha). The combined NTFP map was calculated by first reclassifying the individual NTFP maps into 5 classes (low to high) and then combined using a raster calculator. Extraction intensity is indicative of the value of the forests for NTFPs, but also of the potential impact on the forests from over-exploitation.



Data sources:
Forest cover: Forest Taxation Inventory of Khovsgol aimag (2012).
Extraction intensity: Licensed NTFPs harvesting data per soum in 2015 (provided by Khovsgol Aimag Forest Unit) was averaged and combined with forest cover areas from the FRDC Forest Taxation Inventory data for the aimag.
Population centers: Administration of Land Affairs, Geodesy, and Cartography (2009; based on administrative units update in 1999). Provided by Environment Information Center of Mongolia.
Roads: Ministry of Roads, Transportation, Construction and Urban Development (2007). Provided by Environment Information Center of Mongolia.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Wildlife habitat

Through the consultation exercise, wildlife and its habitat were prioritized as key values of forests in the aimag of Tov (Section 3.1; Narangarel *et al*. 2016a). However, provincial-level spatial data of important biodiversity features are lacking across the country. Proxies, such as maps of protected areas, Key Biodiversity Areas (KBAs) and Important Bird Areas (IBAs), can help consider wildlife conservation as a potential benefit of REDD+ implementation.

The mapping of such areas for Tov (Figure 3.8) comprises national-level Special Protected Areas, local-level (aimag and soum) protected areas (which include linear horse roads, i.e. trails for horse riding), and KBAs (in this case, IBAs). A comparison can be made with the map developed by participants in the consultation workshop in Tov in November 2015; this participatory map was drawn to show areas that the participants felt are important wildlife habitats. Some highlighted areas are similar to the current network of national and local protected areas, such as along the Tuul River in the central part of the aimag and the small areas of streams in the south-west of the aimag. Other areas are different; for instance, the participants highlighted the non-forested south-east corner where there are some small scattered local-level protected areas. It should be noted that non-forest areas can also be important for biodiversity and wildlife, particularly for steppe and desert species in Mongolia.


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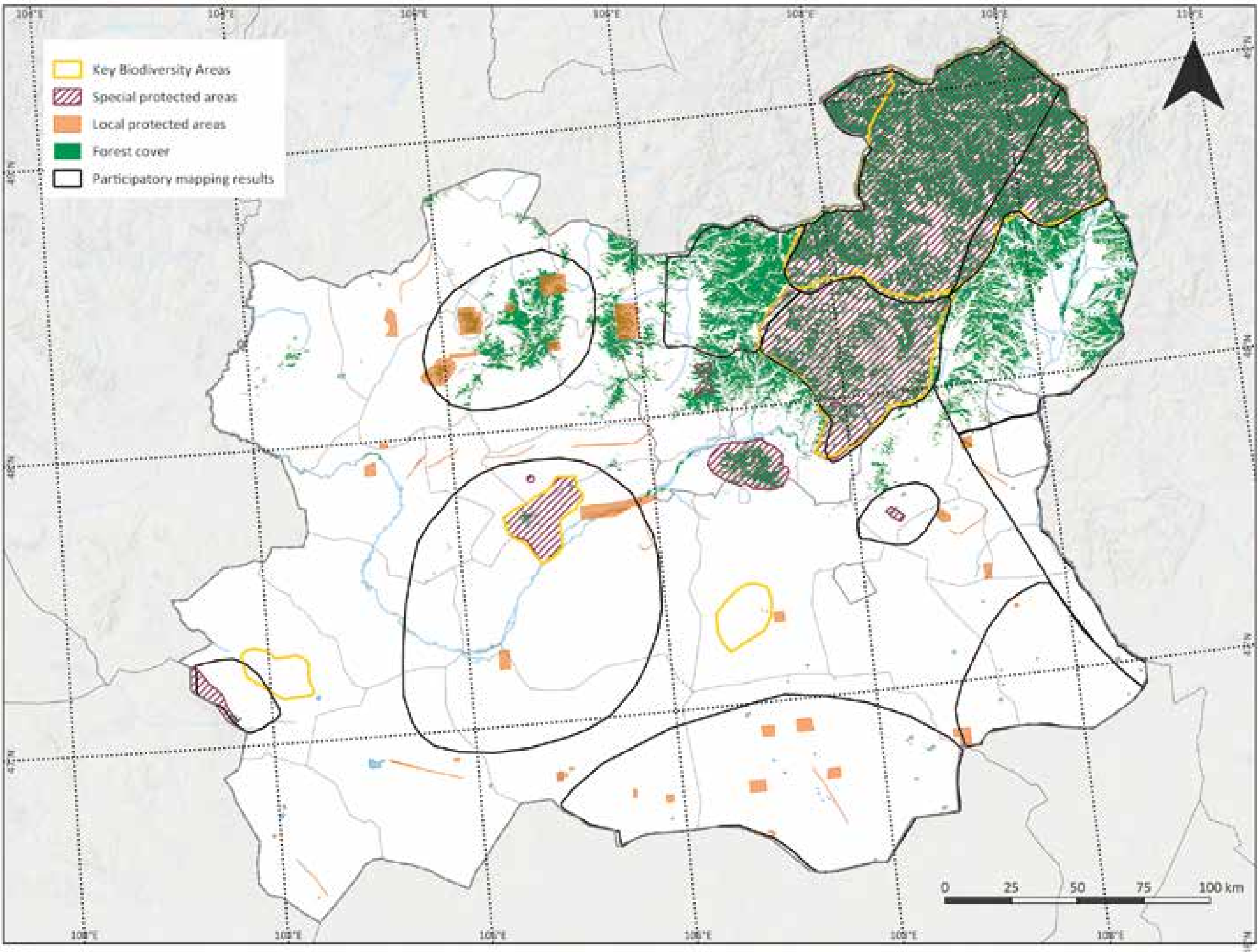
Figure 3.8: Areas considered important wildlife habitats in Tov aimag

This map shows national (Special Protected Areas) and local (aimag and soum) protected areas for Tov aimag, based on data provided by EIC (sourced from MET, dated 2015). The map also includes the participatory mapping of wildlife areas in Tov aimag (Narangerel *et al*. 2016a). These latter areas are based on a drawn map developed by a working group of participants during the Tov aimag consultation workshop, which were subsequently digitized. The participants were asked to indicate areas that they felt are important for providing habitat for wildlife.



Data sources:

Forest cover: Forest Taxation Inventory of Tov aimag (2013).

Special protected areas: Special Protected Areas network in 2008 from the Administrative Department for Special Protected Areas, MNET. Parliament approves special protected areas; these can be classified as strictly protected areas, national parks, nature reserves and monuments. Provided by Environment Information Center of Mongolia.

Local Protected Areas: Local protected areas network in Tov, provided by the National statistic office (2015).

Key Biodiversity Areas: Including Important Bird Areas, compiled by Birdlife International and Conservation International. Downloaded under license from the Integrated Biodiversity Assessment Tool (2016).

3.2 Forest areas with potential to provide REDD+ multiple benefits: Khovsgol and Tov compared

In addition to preparing individual layers exploring the spatial distribution of different forest values, we also combined the layers for different values in order to examine how and where REDD+ activities could deliver multiple benefits (Figure 3.9). The maps for Khovsgol and Tov aimags show where three selected values overlap:

- Special Protected Areas and key biodiversity areas (Figure 2.4)
- Water provision by forests (Figure 3.3)
- Aboveground forest biomass carbon (Figure 2.3)

There are areas in both aimags where up to three of these different values of forests coincide, as well as forest areas that do not hold these values (Figure 3.9). However, we should note that these forests, and indeed all forests in the aimags, may have other values of importance. In Tov aimag, the concentrations of forest values are clearly higher in the more remote and densely forested north. In contrast, in Khovsgol aimag, the forests with more of the selected values are more dispersed, located in the far east and west, as well as around Lake Khovsgol.

In the context of REDD+ planning, the implementation of REDD+ actions in these areas, depending on the types of actions chosen, may offer greater opportunities to achieve multiple benefits.

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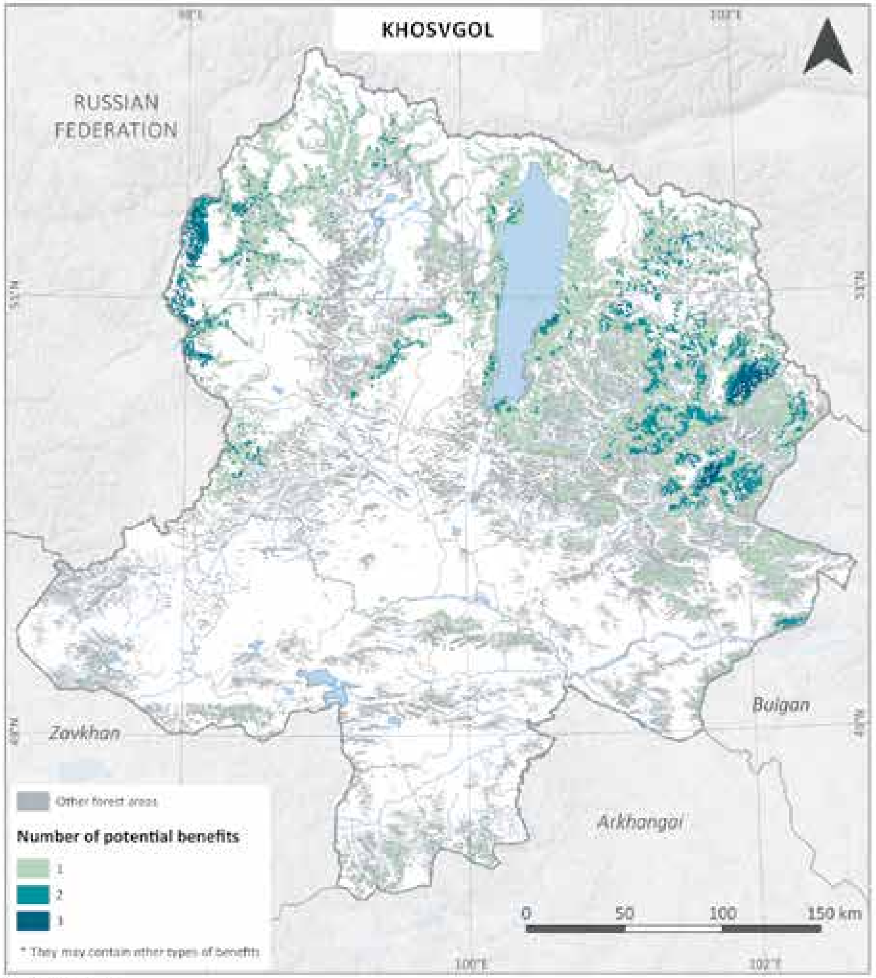
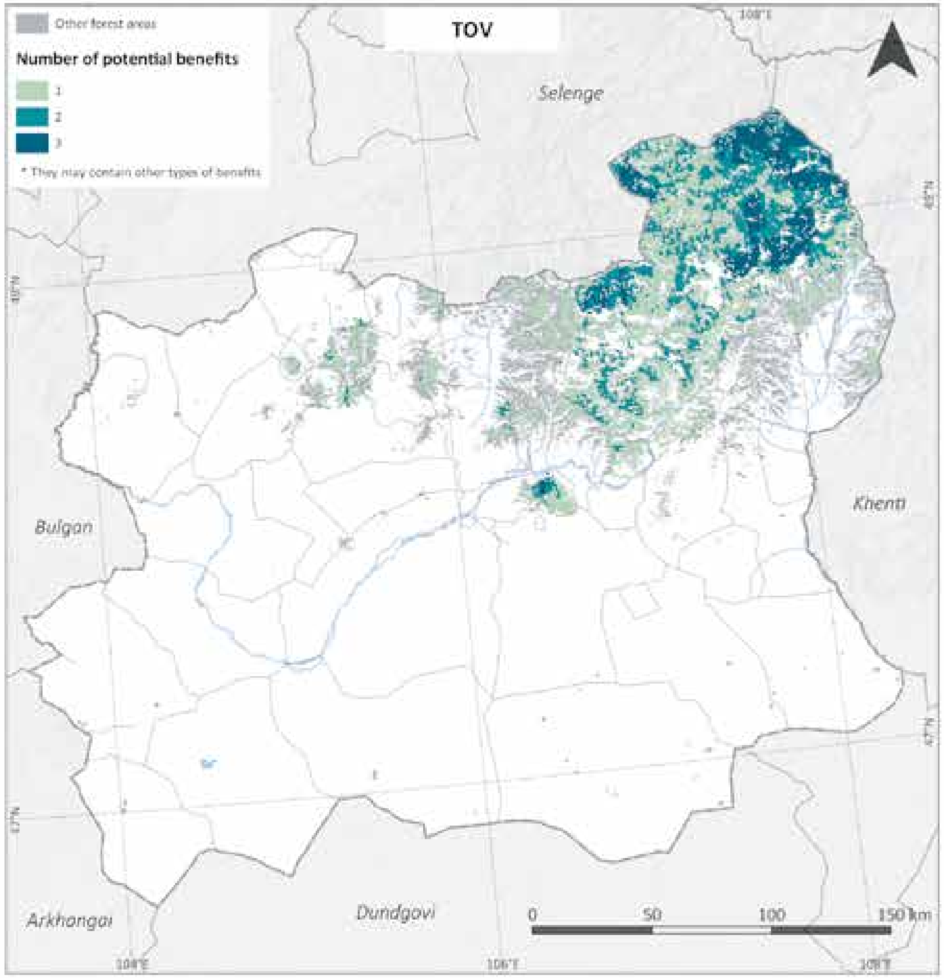
Figure 3.9: Distribution of forest values and potential REDD+ multiple benefits in relation to forests in Tov and Khovsgol aimags

These maps show areas important for one, two or three prioritized values and, therefore, where REDD+ activities could deliver multiple benefits. Forest areas that do not hold these selected values are also visible (noting that these forests may have other values of importance). Three selected layers from the previous analyses were combined: Special Protected Areas and Key Biodiversity Areas (Figure 2.4); water yield by forests (Figure 3.3); and aboveground forest biomass carbon (Figure 2.3).





Data sources:
Forest cover: FRDC Forest taxation inventory of Khövsgöl (2012) and Tov (2013) aimags.
Aboveground forest biomass carbon: Turner, *et al.* (2013) Carbon stock and density of northern boreal and temperate forests. Global Ecology and Biogeography, 23: 297-310.
Protected areas: Special protected area network. Environmental Information Center of Mongolia (2008).
KBA: Including Important Bird Areas and Alliance for Zero Extinction sites (AZEs), compiled by Birdlife International and Conservation International. Downloaded under license from the Integrated Biodiversity Assessment Tool (2016).
Forest water yield: Modelled in the WaterWorld modelling system Mulligan 2013. WaterWorld: a self-parameterising, physically based model for application in data poor but problem-rich environments globally. Hydrology Research Vol. 44, No. 5) and aggregated per river basin. River basins (level 12) were derived from the Hydrobasins dataset (Lehner B., & G. Grill (2013) Global river hydrography and network routing: baseline data and new approaches to study the world's largest river systems. Hydrological Processes, Vol. 27, No. 15).

4. Mapping potential for forest restoration through REDD+

4.1 Introduction

One activity under REDD+ is the enhancement of carbon stocks. In this section, we describe the potential for forest restoration in the Mongolian boreal forests as a means to enhance carbon stocks and realize other benefits through REDD+. We use the term *forest restoration* to encompass a range of activities to *re-establish the structure, productivity and species diversity of a forest* (Lamb and Gilmore 2003) that has been degraded or lost at a particular site. Where the tree cover has been removed, such activities involve *reforestation* through *planting, seeding and/or the human-induced promotion of natural seed sources*' (UN-REDD Programme 2016). The consultation held in Tov in late 2015 highlighted forest restoration (including reforestation) as a priority for analysis in the aimag, including the role of existing areas of natural forest in facilitating the natural regeneration of degraded forests. In prioritizing areas for forest restoration, a number of questions need to be taken into account:

- What were the original causes of forest loss? Efforts to restore forest will be in vain if the restored areas are soon degraded or deforested again.
- Are soil and vegetation conditions in the area still suitable for forest growth? Such conditions may have changed since the original forest cover was lost, for example, through soil erosion or agriculture.
- Are there any competing land uses? If so, local support for forest restoration may be prejudiced.
- What, if any, protection status does the land hold? Restoration actions will be most feasible in the long term where the areas are under protection and sustainable forest management is in place.
- How high are the existing carbon stocks? Restoration may be more cost-effective in enhancing carbon stocks where the existing stocks are much lower than the potential stocks, as long as any drivers of carbon loss are removed.

It is also important to consider how forest restoration under REDD+ can achieve multiple benefits, which has been the focus of the current work. Here, we investigate how to prioritize areas for forest restoration not only to enhance carbon stocks, but also improve ecological functionality and biodiversity (proximity to natural forests) and contribution to water (hydrological) services. Forest restoration close to natural forests provides an effective means of reversing the fragmentation of forest habitat for threatened species and biodiversity in general. Population levels of many species can be improved as forest patch sizes increase, edge effects are proportionally reduced, and connectivity is improved. Forest restoration in areas of high potential fog capture, as highlighted, can lead to improvement in freshwater provision for domestic, agricultural, industrial and ecological use. The mapping work described takes these two factors into account in the prioritization of areas for forest restoration.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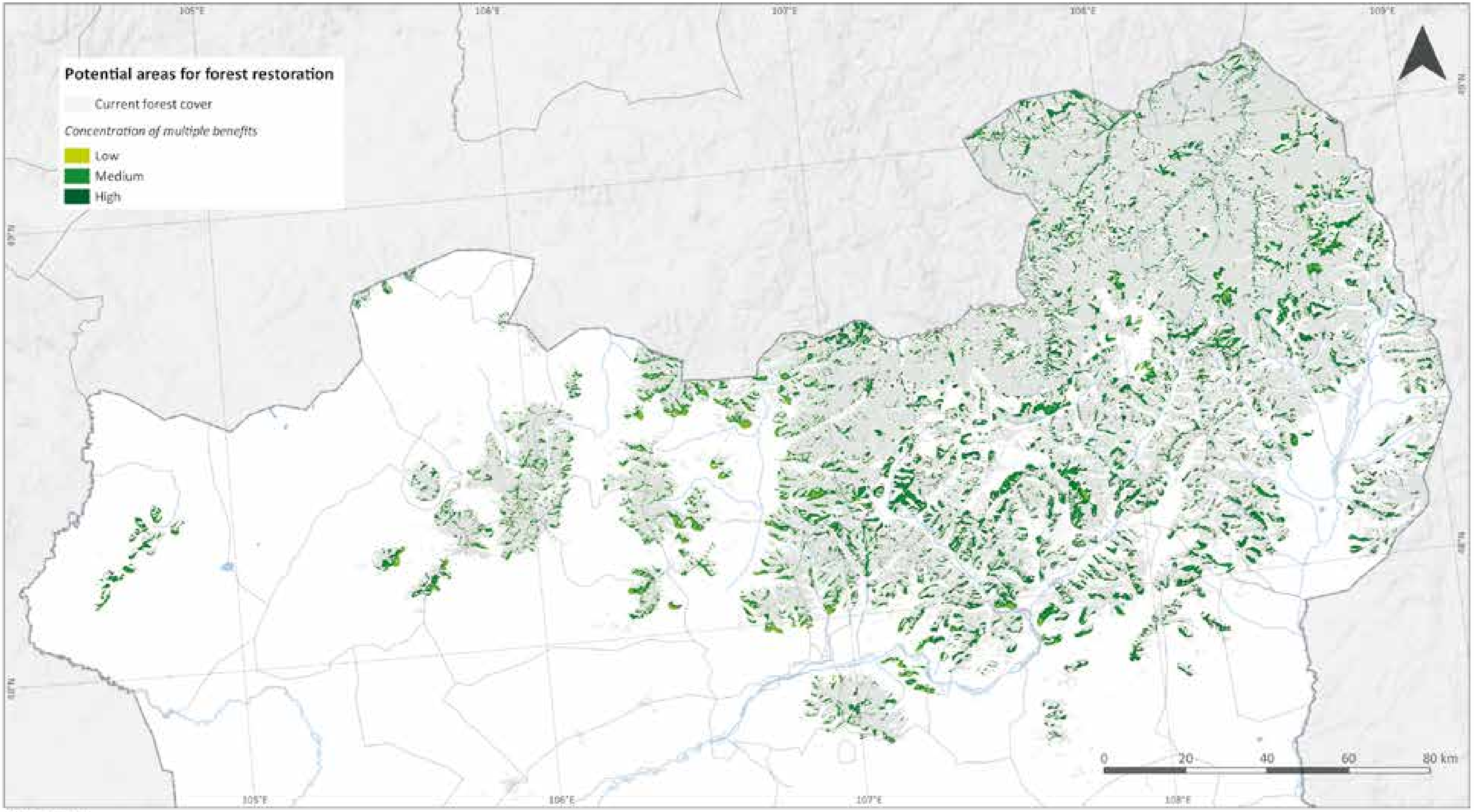
4.2 Mapping of forest restoration opportunities

Opportunity areas for forest restoration in Tov were prepared by first identifying areas of forest loss between 1981-2014, and then removing from these south-facing slopes: here, as in Central Asia generally, such aspects are drier and less favourable for tree establishment and growth (Klinge *et al*. 2015). Areas close to roads, population centres and crops were also removed using a buffer of 500 m. Such areas are considered higher risk in terms of competing land use and/or disturbance of forest restoration activities. The remaining area was then classified according to the concentration of three characteristics: proximity to natural forests; potential to store carbon (estimated total potential carbon stock that vegetation could accumulate given the biophysical conditions of the location); and potential for forest water yield increases (Figure 4.1). Grazing pressure is also relevant to identifying focal areas for forest restoration, but datasets of sufficient resolution were not available to model this factor.

The resulting map scores restoration potential as values ranging from low to high, depending on the concentration of potential multiple benefits of a REDD+ project (Figure 4.1). The total area of restoration potential is 2,673 km^2, comprising 3.7 km^2 of low potential, 733.62 km^2 of medium potential and 1,936 km^2 of high potential. The area shown in the map focuses on the north of the aimag where forest restoration potential is highest. The map also shows that many of the areas suitable for restoration that have higher concentrations of potential multiple benefits are more clustered along waterways. It should be noted that areas of high restoration potential have not been validated in the field, and will be subject to errors in the past and current forest cover maps despite the conservative approach used for their identification. More detailed validation and targeting of priority areas is a necessary step in support of restoration planning in this aimag.

Figure 4.1: Potential areas for carrying out forest restoration activities in Tov aimag, showing composite layers for analysis below

This map shows opportunity areas for forest restoration in Tov. For the purposes of this analysis, forest restoration refers to activities to restore natural forest areas that are estimated to have been deforested, with a focus on natural regeneration and enrichment planting. This map was produced by first identifying areas of forest loss between 1981-2014, estimated as the difference between the 1981 and 2014 forest cover maps, and then extracting from this south facing areas, as well as areas close to roads, population centres and crops (buffers of 500 m). These latter areas were deemed by working session participants to be unsuitable for restoration due to likely higher levels of disturbance. The areas that were selected as suitable for forest restoration were then analysed according to the potential for provision of multiple benefits. These were classified according to concentration of three multiple benefits (proximity to natural forests, potential to store carbon, potential for water provision). Proximity to natural forest was calculated by producing a raster distance map of current cover forest, and then classifying values in three classes (high, medium, low). Potential to store carbon was obtained from Smith *et al*. (2013; a global estimation of potential to store carbon) and also reclassified in three classes. Potential of non-forest areas to produce water if they were forested was estimated in a WaterWorld modelling exercise (carried out in the working session in Ulaanbaatar). The exercise consisted in: 1) estimating the annual water yield due to forest in the aimag using current forest cover (baseline scenario); and 2) setting up an alternative scenario whereby non-forest areas were afforested/reforested and estimating water yield again. The difference between these two values (per pixel) was assumed to be the potential water yield of the area if there was a forest there. These values were also reclassified in three classes and combined with the two previous ones. The result is a new raster layer with values ranging from 3 (lowest possible score) to 9 (highest possible score). This map was reclassified as 3-5= Low, 5-7=Medium, 7-9= High, covering 3.7 km^2, 733.62 km^2 and 1,936 km^2 respectively.



Data sources:

Current forest cover: National Forest Taxation Inventory (compilation year 2014).

Roads: Ministry of Roads, Transportation, Construction and Urban Development (2007). Provided by Environment Information Center of Mongolia.

Population centers: Ministry of Roads, Transportation, Construction and Urban Development (2007). Provided by Environment Information Center of Mongolia.

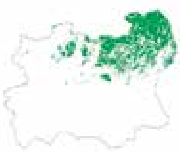
DEM: Lehner, *et al.* (2008) New global hydrography derived from spaceborne elevation data. Eos, Transactions, AGU 89 (10): 93-94. Downloaded from http://hydrosheds.cr.usgs.gov/index.php

Potential Carbon: Smith, *et al.* (2013). The climate dependence of the terrestrial carbon cycle, including parameter and structural uncertainties Biogeosciences (10) 583-606.

Potential water provision: Modelled in the WaterWorld modelling system (Mulligan 2013. WaterWorld: a self-parameterising, physically based model for application in data poor but problem-rich environments globally. Hydrology Research Vol. 44, No. 5).

Crops: IRIMHE, Remote Sensing Department (2015) Provided by Environment Information Center of Mongolia.

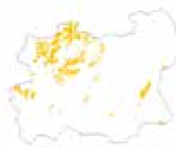

Past forest cover (1981)

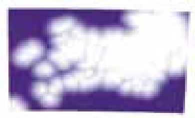

Current forest cover (2014)


Aspect (from DEM)


Roads


Population centers


Crops


Forest distance raster


Carbon potential


Water yield

5. Conclusions

Mongolia's forests are a critical resource for the country, amounting to at least an estimated nine million hectares in the northern boreal forest zone – and they are valuable to society in multiple ways. The spatial analyses described in this report quantify and map such values, including carbon storage in aboveground biomass and biodiversity, at different scales. At the subnational level, additional specific resources are valued, which we have analysed these for two aimags by first consulting stakeholders on priority values and then producing maps that describe their distribution, based on best available datasets. These include the status of forest resources, the provision of timber, fuelwood and non-timber forest products, such as pine nuts, berries and medicinal plants, recreation and tourism areas, hydrological services and areas important for wildlife.

These same values and resources are often under pressure – and this has also been the subject of the current work. Degradation and loss of forests are resulting from forest fires, often attributed to human activities, as well as unsustainable levels of exploitation, especially of timber and fuelwood. Other drivers of degradation and loss have also been investigated through the spatial analysis, including insect attacks and pressure from grazing. Fire is highlighted as probably the most important threat, and it is clear that forest within protected areas is not immune to this and other drivers, including climate change. Our spatial modelling also highlights the vulnerability of biodiversity, including areas rich in threatened bird, amphibian, reptile and mammal species falling outside of any official protection.

At the aimag level, the value of forests in providing a source of fresh water supply was prioritized in both Khovsgol and Tov. Using the GIS based WaterWorld modelling tool, we were able to quantify this provision in terms of water yield: the difference that a forest cover makes to the availability of fresh water to communities downstream. Much of this difference was shown to be due to fog capture by trees. Recreation and tourism opportunities are also highly valued in these regions, which was modelled by mapping the presence of natural springs and ger camps as particular attractions, and how these intersect with forested areas – in particular in the case of Khovsgol. Fuelwood provision is also an important forest value for both aimags, as well as timber and non-timber forest products for Khovsgol.

Based on this knowledge, we generated maps, based on official soum-level harvesting data, to identify where extraction pressures were greatest, finding this often to be the case nearer to roads and town centres (e.g. Murun in Khovsgol). Forests important for wildlife (prioritized for Tov) were more difficult to model because of a lack of local-level data. We mapped protected areas, including Key Biodiversity Areas (KBAs) and compared this approach with a consultative exercise during which participants delineated areas they knew to be important for wildlife. Such information on the distribution of forest values can be used to inform future forest management and restoration priorities, including under REDD+. From this map, as well as the others produced, simple overlays highlight areas that are significant in terms of multiple values where REDD+ activities could therefore bring about multiple benefits. We compared the distribution of such areas in Tov and Khovsgol for the three values of carbon stocks, biodiversity and water yield.

In support of the REDD+ objective to enhance carbon stocks, potential areas for forest restoration (including reforestation) were mapped for Tov aimag, where the role of existing forest in supporting natural regeneration was highlighted. They were prioritized not only on the basis of carbon storage potential, but also for water

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yield enhancement and proximity to natural forest. This corresponds to regeneration potential through natural seed supply and colonisation, but also to the biodiversity benefits of having larger, more connected patches of forest. The resulting map shows a total of over 2,500 km^2 of land with potential for forest restoration, with concentration of such areas along water courses.

The work described in this report has aimed to support REDD+ planning in Mongolia, in particular in capitalizing on the opportunity to achieve multiple benefits and progress towards a more integrated use of forest landscapes. In addition to mapping the distribution of potential multiple benefits from REDD+, we have worked to build in-country capacity in spatial analysis, including accessing relevant spatial datasets and using decision-support tools. These achievements are expected to help Mongolia pursue its National REDD+ Readiness Roadmap and National Programme. They also contribute to advancing the Government's green development pathway and harmonizing REDD+ activities within Mongolia's wider environmental and social priorities. With the current rapid economic growth, detailed land-use analysis and planning using spatial information is critical to reduce threats and negative impacts. Moreover, it can help to indicate areas where sustainable development opportunities can be realized. In the context of the REDD+ activities aiming to *conserve* and *sustainably manage* carbon stocks, the maps presented in this report show areas with strong potential to realise other benefits (Section 3). In the context of the REDD+ activities aiming to *enhance* carbon stocks, maps have been developed that show areas of high potential for the restoration of forest cover and that provide benefits in terms of biodiversity and water supply (Section 4).

Our analyses have been pursued at national and aimag levels, and this two-pronged approach is important. Planning of REDD+ activities needs to take into account national-level priorities and opportunities, considering how environmental, social and economic characteristics vary across Mongolia. At a finer resolution, the environmental conditions of different aimags are important, in particular how these are perceived, valued and prioritized by local stakeholders. The consultation workshops were designed to highlight this for two aimags, Khovsgol and Tov. Based on the aimag consultations, this study has focused on a particular set of values that forests offer to society, and which represent potential multiple benefits of future REDD+ actions. There are other values that could have been included (e.g. mitigation of soil erosion, landscape value, permafrost protection, clean air) and indeed can be in the future as the approaches advocated in this project are applied across different geographies and interests.

We encourage follow-up work to build on the analyses presented here and to capitalize on the enhanced in-country capacity for spatial analysis and use of decision support tools. This further work should include:

- wider stakeholder analysis of the priority values of forests (and, therefore, potential multiple benefits of REDD+ that could be targeted);
- field validation of the modelled priority areas for forest conservation and restoration;
- extension of the finer-scale analyses to other aimags in Mongolia; and
- translation of the spatial analysis and mapping into firm area targets for REDD+ implementation at national and aimag levels.

Such activities will further increase the overall positive impact of Mongolia's future REDD+ programme and inform decision-making on sustainable land use more widely.

REFERENCES

Badarch, O., Lee, W.-K., Kwak, D.-A., Choi, S., Kokmila, K., Byun, J.-G. and Yoo, S.-J. (2011) Mapping forest functions using GIS in Selenge Province, Mongolia. Forest Science and Technology 7 (1): 23-29.

BirdLife International (2016) Country profile: Mongolia. Available at: http://www.birdlife.org/datazone/country/mongolia. Accessed: June 2016.

BirdLife International and Conservation International (2016) Key Biodiversity Area (KBA) digital boundaries: January 2016 version. Maintained by BirdLife International on behalf of BirdLife International and Conservation International. Downloaded under licence from the Integrated Biodiversity Assessment Tool. Available at: http://www.ibatforbusiness.org.

Crisp, N., Dick, J. and Mullins, M. (2003) Mongolia forestry sector review. The World Bank, Victoria, B.C.

Dulamsuren, C., Hauck, M., Khishigjargal, M., Leuschner, H.H. and Leuschner, C. (2010) Diverging climate trends in Mongolian taiga forests influence growth and regeneration of *Larix sibirica*. Oecologia 163: 1091-1102.

Dulamsuren, C., Klinge, M., Degener, J., Khishigjargal, M., Chenlemuge, T., Bat-Enerel, B., Yeruult, Y., Saindovdon, D., Ganbaatar, K., Tsogtbaatar, J., Leuschner, C. and Hauck, M. (2016) Carbon pool densities and a first estimate of the total carbon pool in the Mongolian forest-steppe. Global Change Biology 22: 830-844.

Emerton, L. and Enkhtsetseg, B.-O. (2013) Forest sector financing flows and economic values in Mongolia. Available at: http://www.reddplus.mn/en/download/forest-sector-financing-flows-and-economic-values-in-mongolia/.

Epple, C., Williamson, A. and Thorley, J. (2012) Strengthening benefits from REDD+ for biodiversity, ecosystem services and livelihoods. A guide to tools and resources that can help to plan for multiple benefits from REDD+ in Indonesia. UNEP-WCMC, Cambridge. Available at: http://bit.ly/mbs-redd

FAO (2014) Global Forest Resources Assessment. Country report – Mongolia. Food and Agriculture Organisation, Rome.

FAO (2015) Global forest resources assessment 2015 – Desk reference. Food and Agriculture Organization of the United Nations, Rome.

Gombobaatar, S. and Monks, E.M. (compilers), Seidler, R., Sumiya, D., Tseveenmyadag, N., Bayarkhuu, S., Baillie, J.E.M., Boldbaatar, Sh., Uuganbayar, Ch. (editors) (2011) Regional Red List Series Vol. 7. Birds. Zoological Society of London, National University of Mongolia and Mongolian Ornithological Society.

Government of Mongolia (2007) Law of Mongolia on Forestry. English version available at: http://ilo.org/dyn/natlex/natlex4.detail?p_lang=enandp_isn=91035andp_country=MNGandp_count=135. Accessed: June 2016.

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turabanova, S.A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O. and Townshend, J.R.G. (2013) High-resolution global maps of 21st century forest cover change. Science 342: 850-53.

Hicks, C., Woroniecki, S., Fancourt, M., Bieri, M., Garcia Robles, H., Trumper, K. and Mant, R. (2014) The relationship between biodiversity, carbon storage and the provision of other ecosystem services: Critical review for the forestry component of the International Climate Fund. UNEP-WCMC, Cambridge.

Hurlbert, A.H. and Jetz, W. (2007) Species richness, hotspots, and the scale dependence of range maps in ecology and conservation. Proceedings of the National Academy of Sciences of the United States of America 104: 13384–-9.

Intended Nationally Determined Contribution (INDC) of Mongolia: Submission by Mongolia to the Ad-Hoc Working Group on the Durban Platform for Enhanced Action (ADP). Date of submission: 24/09/2015. Available at: http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx. Accessed: December 2016.

JRC (2003) Global Land Cover 2000 database. European Commission. Joint Research Centre. Available at: http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php

IUCN (2015) IUCN Red List of Threatened Species version 2015.1. Available at: www.iucnredlist.org. Accessed: October 2015.

IUCN (2016) A Global standard for the identification of Key Biodiversity Areas, Version 1.0. First edition. IUCN, Gland. Available at: https://portals.iucn.org/library/sites/library/files/documents/Rep-2016-005.pdf. Accessed: July 2016.

Klinge, M., Böhner, J. and Erasmi, S. (2015) Modelling forest lines and forest distribution patterns with remote-sensing data in a mountainous region of semiarid Central Asia. Biogeosciences 12: 2893-2905.

Kopp, B.J., Lange, J. and Menzel, L. (2016) Effects of wildfire on runoff generating processes in northern Mongolia. Regional Environmental Change. doi:10.1007/s10113-016-0962-y

Lamb, D. and Gilmour, D. (2003) Rehabilitation and restoration of degraded forests. IUCN, Gland and Cambridge and WWF, Gland, x +110 pp.

Langhammer, P.F., Bakarr, M.I., Bennun, L.A., Brooks, T.M., Clay, R.P., Darwall, W., De Silva, N., Edgar, G.J., Eken, G., Fishpool, L.D.C., da Fonseca, G.A.B., Foster, M.N., Knox, D.H., Matiku, P., Radford, E.A., Rodrigues, A.S.L., Salaman, P., Sechrest, W. and Tordoff, A.W. (2007) Identification and gap analysis of key biodiversity areas: targets for comprehensive protected area systems. Best Practice Protected Area Guidelines Series 15. IUCN, Gland.

Lehner, B. and Grill, C. (2013) Global river hydrology and network routing: baseline data and new approaches to study the world's large river systems. Hydrological Processes 27 (15): 2171-2186. Data available at: www.hydrosheds.org.

Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: Synthesis. Island Press, Washington, DC.

Ministry of Environment and Green Development (MEGD) (2014a) Mongolia's National REDD+ Readiness Roadmap. Version April 2014. Division of Forest Conservation and Reforestation Management, MEGD, Ulaanbaatar.

Ministry of Environment and Green Development (MEGD) (2014b) Green Development Policy of Mongolia. June 13, 2014. Unofficial translation. http://covermongolia.blogspot.co.uk/2014/06/green-development-policy-of-mongolia.html Accessed: December 2016.

Ministry of Environment, Green Development and Tourism (MEGDT) and UN-REDD Programme (2015) National Programme Document. UN-REDD Mongolia National Programme. MEGDT, Ulaanbaatar, and UN-REDD Programme. Available at: http://www.mn.undp.org/content/dam/mongolia/docs/ProjectReports/Environment/UNReddNationalProgramme_withSignatures.pdf

Ministry of Environment, Green Development and Tourism (MEGDT) (2015) National Biodiversity Program: 2015-2025. Available at: https://www.cbd.int/doc/world/mn/mn-nbsap-v2-en.pdf

Ministry of Environment and Tourism (MET) (2016*)* Mongolian multipurpose national forest inventory 2014-2016. 1st edn. Ministry of Environment and Tourism, Ulaanbaatar.

Mongolia National Statistics Office (2016) Number of inbound tourists, by country. Mongolian Statistical Information Service (MONSIS). Available at: http://www.1212.mn/statHtml/statHtml.do. Accessed: July 2016.

Mühlenberg, M., Appelfelder, J. Hoffmann, H. Ayush, E. and Wilson, K.J. (2012) Structure of the montane taiga forests of West Khentii, Northern Mongolia. Journal of Forest Science 58 (2): 45-56.

Mulligan, M. (2013) WaterWorld: a self-parameterising, physically-based model for application in data-poor but problem-rich environments globally. Hydrology Research 44 (5): 748-769.

Narangerel, Z., Hicks, C., de Lamo, X. and Guth, M. (2016a) Report of Consultations on multiple benefits from forests in Mongolia in Khovsgol and Tov Aimags, 3-6 November 2015. Prepared on behalf of the UN-REDD Programme. Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE), Ulaanbaatar, and UNEP-WCMC, Cambridge. Available at: http://bit.ly/mbs-redd.

Narangerel, Z., de Lamo, X., Hicks, C. and Guth, M. (2016b) Report: Joint working sessions on spatial analysis to support REDD+ planning in Mongolia. Working sessions convened as part of Mongolia's National UN-REDD Programme, October 2015 and March 2016, Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE), Ulaanbaatar. Prepared on behalf of the UN-REDD Programme. UNEP-WCMC, Cambridge. Available at: http://bit.ly/mbs-redd.

NASA Earth Observatory (2012) Seeing forests for the trees and the carbon: Mapping the world's forests in three dimensions. Available at: http://earthobservatory.nasa.gov/Features/ForestCarbon/. Accessed: December 2016

National Statistical Office of Mongolia (2016). Available at: http://www.en.nso.mn/home. Accessed: June 2016.

Nielsen, A. B., Olsen, S. B. and Lundhede, T. (2007) An economic valuation of the recreational benefits associated with nature-based forest management practices. Landscape and Urban Planning 80: 63-71.

Nyamjav, B., Goldammer J.G. and Uibrig, H. (2007) The forest fire situation in Mongolia. International Forest Fire News (IFFN) 36: 46-66.

Otoda, T., Doi, T., Sakamoto, K., Hirobe, M., Nachin, B. and Yoshikawa, K. (2013) Frequent fires may alter the future composition of the boreal forest in northern Mongolia. Journal of Forest Research 18: 246-255.

Rocchini, D., Hortal, J., Lengyel, S., Lobo, J.M., Jimenez-Valverde, A., Ricotta, C., Bacaro, G. and Chiarucci, A. (2011) Accounting for uncertainty when mapping species distributions: The need for maps of ignorance. Progress in Physical Geography 35: 211-226.

Santoro, M., Beer, C., Cartus, O., Schumullius, C., Shvidenko, A., McCallum, I., Wegmuller, U. and Wiesmann, A. (2011) Retrieval of growing stock volume in boreal forests using hyper-temporal series of Envisat ASAR ScanSAR backscatter measurements. Remote Sensing of Environment 115: 490-507.

Smith P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E.A., Haberl, H., Harper, R., House, J., Jafari, M., Masera, O., Mbow, C., Ravindranath, N.H, Rice, C.W., Robledo Abad, C., Romanovskaya, A., Sperling, F. and Tubiello, F. (2014) Agriculture, forestry and other land use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel T. and Minx, J.C. (eds.). Cambridge University Press, Cambridge and New York, NY.

Thurner, M., Beer, C., Santoro, M., Carvalhais, M., Wutzler, T., Schepaschenko, D., Shvidenko, A., Kompter, E., Ahrens, B., Levick, S.R. and Schmullius, C. (2013) Carbon stock and density of northern boreal and temperate forests. Global Ecology and Biogeography 23: 297-310.

Trumper, K., Bertzky, M., Dickson, B., van der Heijden, G., Jenkins, M. and Manning, P. (2009) The natural fix? The role of ecosystems in climate mitigation. A UNEP rapid response assessment. United Nations Environment Programme and UNEP-WCMC, Cambridge.

Tsogtbaatar, J. (2004) Deforestation and reforestation needs in Mongolia. Forest Ecology and Management 201: 57-63.

Tsogtbaatar, J. (2007) Forest rehabilitation in Mongolia. In: Keep Asia Green Volume II "Northeast Asia". Lee, D.K. (ed.). International Union of Forest Research Organizations (IUFRO), Vienna, pp. 91–116.

Tsogtbaatar, J. (2013) Deforestation and Reforestation of Degraded Forestland in Mongolia. In: The Mongolian Ecosystem Network: Environmental issues under climate and social changes; Yamamura, N., Fujita, N. and Maekawa, A. (eds.). Springer, Tokyo, pp. 83-98.

UN-REDD Mongolia Programme (2016) Preliminary Assessment of the Drivers of Forest Change in Mongolia: A Discussion Paper for Supporting Development of Mongolia's National REDD+ Strategy. Final draft, version August 2016. UN-REDD Mongolia Programme, Ulaanbaatar.

UN-REDD Programme (2011) UN-REDD Country-level Support to REDD+ Readiness in Mongolia. Available at: http://www.unredd.net/index.php?view=documentandalias=10016-un-redd-country-level-support-redd-mongolia-ver-4-21-april-10016andcategory_slug=workshop-reports-2385andlayout=defaultandoption=com_docmanandItemid=134

UN-REDD Programme (2016) REDD+ Glossary. Available at: http://www.unredd.net/knowledge/glossary.html. Accessed: December 2016.

Van Soesbergen, A., Ravilious, C., Mant, R., and de Lamo, X. (2016) Using modelling to help integrate biodiversity and ecosystem services into REDD+ decision making. Step-by-step tutorial: Evaluating the importance of forests for water provision and limiting soil erosion, a modelling approach using Water World. Prepared on behalf of the UN-REDD Programme. UNEP-WCMC, Cambridge. Available at: http://bit.ly/GIStools-redd.

Walcott, J., Thorley, J., Kapos, V., Miles, L., Woroniecki, S. and Blaney, R. (2015) Mapping multiple benefits of REDD+ in Paraguay: Using spatial information to support land-use planning. UNEP-WCMC, Cambridge. Available at: http://bit.ly/mbs-redd

The World Bank (2016) International tourism, number of arrivals: Mongolia, 1995-2014. Data Bank. Available at: http://data.worldbank.org/indicator/ST.INT.ARVL?locations=MN. Accessed: July 2016.

Ykhanbai, H. (2010) Mongolia Forestry Outlook Study. Asia-Pacific forestry sector outlook study II. Working Paper series. Working Paper No. APFSOS II/ WP/ 2009/ 21. FAO Regional Office for Asia and the Pacific, Bangkok.

ANNEX 1: A selection of software tools useful for analysis of potential benefits from REDD+

This table provides an overview of a range of relevant tools and approaches that can be used to support the development of decision support tools *for REDD+ planning. These tools were examined and ranked with regards to their suitability for use in the Mongolian REDD+ planning context, with the full information available in a separate document.*

Title	Web link	REDD+ relevance	Tool category			Platform
			Land use planning	Modelling	Valuation	
Artificial Intelligence for Ecosystem Services (ARIES)	http://ariesonline.org/	ARIES is a system for modelling and mapping ecosystem services and so could be a useful tool for planning for multiple benefits of REDD+.	X		X	Stand-alone. Web-based
Benefits and Risks Tool (BeRT)	http://bitly/bert-redd	The BeRT is designed to help assess the potential risks and benefits of REDD+ actions and to identify to what extent existing policies, laws and regulations tackle these.	X			MS Excel-based
CLUE (Conversion of Land Use and its Effects) model	http://www.ivm.vu.nl/en/Organisation/departments/spatial-analysis-decision-support/Clue/index.aspx (freeware) http://www.delta-alliance.org/toolboxoverview/CLUE-model	Tool for allocating future land-use change – requires projections of land area required for different uses as an input. Relevant to identifying areas under greatest threat from deforestation.		X		Stand-alone. Desktop-based
CO2FIX	http://www.cifor.org/library/1747/co2fix-v-3-1-a-model-for-quantifying-carbon-sequestration-in-forest-ecosystems/	CO2FIX V 3.1 is a simple carbon bookkeeping model.		X	X	Stand-alone. Desktop-based
Co$ting Nature	http://www.policysupport.org/costingnature	Web-based tool for natural capital accounting. Typical applications include ecosystem service assessment, prioritization of areas for conservation, analysis of co-benefits (e.g. for REDD+), and impacts of pressures and threats.			X	Stand-alone. Desktop-based

Title	Web link	REDD+ relevance	Tool category			Platform
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CRiSTAL tool – Community-based Risk Screening Tool for Adaptation and Livelihoods	http://www.iisd.org/cristal-tool/download.aspx	Tool developed by IUCN. It helps to bring together thinking about climate change adaptation at community level.	X			Stand-alone. Desktop-based
Ecosystem Management Decision Support (EDMS) system	http://www.spatial.redlands.edu/emds/	An application framework for knowledge-based decision-support for ecological assessments at any geographic scale.	X			ArcGIS
Engaging Plans	http://engagingplans.com/	Enables planners to launch and maintain interactive, place-based, public involvement websites for gathering stakeholder feedback and sharing updates to the community.	X			Stand-alone. Desktop-based
Exploring Multiple Benefits Mapping	http://bit.ly/GIStools-redd	This is a GIS toolbox, for use in ESRI's spatial analysis. The outputs can support REDD+ decision making.	X			ArcGIS
InVEST: Integrated Valuation of Ecosystem Services and Tradeoffs	http://www.naturalcapitalproject.org/InVEST.html	A family of tools to map and value the goods and services from nature.			X	Stand-alone or ArcGIS
Land Change Modeller	https://clarklabs.org/products/	Software for land use planning and decision support, developed by Clark Labs and Conservation International.	X	X		ArcGIS or IDRISI (TerrSet)
Marxan	http://www.uq.edu.au/marxan/	Marxan enables analysis of quantitative spatial data to identify sets of planning units (or areas) that meet user-defined targets.	X	X		Stand-alone. Desktop-based

Title	Web link	REDD+ relevance	Tool category			Platform
			Land use planning	Modelling	Valuation	
NatureServe Vista	http://www.natureserve.org/conservation-tools/natureserve-vista	A spatial decision-support framework that helps users bring together conservation objectives with land use and resource planning.	X		X	ArcGIS
REDD Abacus Software	http://worldagroforestry.org/regions/southeast_asia/resources/redd-abacus-sp	The REDD Abacus SP software can be used to estimate the opportunity costs of REDD+ in a landscape and to develop abatement cost curves.			X	Stand-alone. Desktop-based
SOLVES	http://solves.cr.usgs.gov/	SolVES 3.0 is a public-domain tool to help evaluate the social values of ecosystem services and to facilitate discussions among diverse stakeholders regarding the tradeoffs among ecosystem services			X	ArcGIS
SWAT (Soil and Water Assessment Tool) Model ArcSWAT and QSWAT	http://swatmodel.tamu.edu	A river basin scale model developed to quantify the impact of land management practices on water, sediment, and agricultural chemical yields in large, complex watersheds.		X		QGIS and ArcGIS
TESSA	http://tessa.tools/	Site-based toolkit, with guidance on low-cost methods for evaluating ecosystem services at particular sites.	X			Stand-alone. Web-based
WaterWorld	http://www.policysupport.org/waterworld http://www.climateplanning.org/tools/waterworld	WaterWorld is a spatial tool for testing the impacts of land- and water-related policies on water services.	X			Stand-alone. Web-based
Zonation	http://cbig.it.helsinki.fi/ http://cbig.it.helsinki.fi/software/	A framework for large-scale conservation planning.	X			Stand-alone. Desktop-based

MINISTRY OF ENVIRONMENT AND TOURISM

REDD+ MONGOLIA

REDD+ is centred on the key principle that through more sustainable forest management practices, it is possible to both reduce GHG emissions produced by deforestation, degradation and the forestry sector, and enhance the capacity of forests to act as a carbon sink. REDD+ can also provide advantages to countries, such as results-based payments for each ton of carbon emissions reduced or removed, international recognition for mitigation results, and non-carbon benefits to the environment, economy and society. The full range of benefits that may be achieved through REDD+ are known as 'multiple benefits'.

The work described in this report has aimed to support REDD+ planning in Mongolia, in particular the opportunity to promote multiple benefits, and to progress towards a more integrated use of forest landscapes. Identifying areas where specific REDD+ actions may yield significant multiple benefits can help to inform decision-making on land use and to increase the overall positive impact of the REDD+ programme.

The forests of Mongolia provide essential goods and services to people living close to forests and beyond. In addition to their role in storing and sequestering carbon and thus contributing to the mitigation of climate change, forests support people's livelihoods and well-being through the provision of forest products, contribution to hydrological services, and role in recreational and spiritual activities. Mongolia's forests are also home to biodiversity of local and international conservation importance.

The use of spatial analysis can help to highlight the distribution of these forest values across the landscape in an accessible format. Maps can thus form a valuable input to REDD+ planning, indicating areas where the potential for promoting multiple benefits from selected REDD+ actions may be higher. Spatial analysis can also indicate where forests and their values have been affected by deforestation and degradation, and where these values may be most under threat in the future.

UN-REDD PROGRAMME

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