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Original Article

National parks, protected areas and biodiversity conservation in North Korea: opportunities for international collaboration

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ABSTRACT

National parks and protected areas represent one of the best ways to safeguard nature and preserve biodiversity, especially endemic and endangered species. Currently, more than 110 countries have some form of protected areas within their borders. North Korea's comprehensive network of national parks and protected areas are rich in biodiversity and ecological value; however, contemporary research on the integrity of North Korea's protected lands is incomplete. In this paper, we utilize a remote sensing approach to explore North Korea's protected area system and investigate the current state of biodiversity conservation. We find that several key biodiversity areas have experienced severe tree loss and habitat fragmentation since 2000, indicating that the effectiveness of national park governance and management toward guarding against biodiversity loss is inadequate. To address the issue of biodiversity conservation, we recommend pathways for international cooperation aimed at enhancing conservation efforts and comment on the steps North Korea can take to achieve the United Nations Convention on Biological Diversity's Aichi Targets and Sustainable Development Goals.

Introduction

National parks and protected areas are at the core of global efforts to safeguard nature and curb biodiversity loss. As of 2020, there are more than 210,000 protected areas in 111 countries, representing 14.7% of land globally, which is nearly double the amount of land protected in 2000 (Saura et al 2018). The 1993 Convention on Biological Diversity (CBD), signed by 168 participating countries, mandated 17% of the world's terrestrial area to be protected by 2020 (CBD 2020a). Some scientists argue that current levels of biodiversity can only be sustained if 50% of all terrestrial lands are given protected status (Wilson 2016). No studies have found that biodiversity can be maintained with lower percentage coverage targets (Woodley et al 2019). While governments have committed to increasing their network of protected areas to meet the CBD's benchmark, national parks and protected areas are increasingly threatened by human pressure, and many are at risk of having their protected area status downgraded. Recent studies have documented more than 3,000 cases of protected area downgrading, downsizing, or degazettement in more than 70 countries, totaling an area of 130 million hectares (Pack et al 2016). Research has shown that the effects of climate change will drive extinction up to as high as 54%, further exasperating the problem (Urban 2015). With more than 1 million species at risk of extinction (Diaz et al 2019), countries must establish pathways for sustainable development that ensure the effective governance of their protected areas and long-term protection of their unique ecosystems and prevent the dangerous loss of biodiversity. Effectively managed protected areas not only ensure the protection of biodiversity, but the preservation of nature provides sustained economic value in the form of tourism and jobs, health care savings, water quality protection, and natural disaster mitigation (U.S. Fish and Wildlife Service 2020).

In the face of the urgent global environmental crisis, the Convention on Biological Diversity established the Aichi Targets for 2020, a multilateral agreement designed to halt the global biodiversity crisis and prioritize conservation efforts. The twenty targets fall under five overarching strategic goals, which include; (1) addressing the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society; (2) reducing the direct pressures on

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biodiversity and promote sustainable use; (3) improving the status of biodiversity by safeguarding ecosystems, species, and genetic diversity; (4) enhancing the benefits to all from biodiversity and ecosystem services; (5) enhancing implementation through participatory planning, knowledge management, and capacity building (CBD 2020a). Among the targets, there is specific action for protected area expansion and protection of biodiversity, including Aichi Target 11, which calls for Parties to increase their protected area coverage to 17%, and Aichi Target 12, the strengthening of biodiversity-inclusive environmental impact assessments. The CBD's post-2020 global biodiversity framework, the "2050 Vision for Biodiversity", aims to be a continuation of the Aichi targets, "which were not intended as endpoints but rather milestones in the long process of reducing biodiversity loss and contributing to poverty alleviation and the benefit of all life on Earth" (CBD 2020b). The United Nation's Sustainable Development Goals, 17 goals targeting sustainable development by 2030, includes SDG 15, which is devoted to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and biodiversity loss" (United Nations Sustainable Development Goals Knowledge Platform, Biodiversity and Ecosystems 2020).

The Democratic People's Republic of Korea (DPRK), also known as North Korea, has been endowed with vast natural resources, including forested mountains, rivers, long coastlines, and rich biodiversity, and wildlife. Since 1959, the country has seemingly maintained a balanced and ecologically representative protected area network, including 34 different types of designated protected areas that span a total area of more than 314,000 hectares (2.4% total land area); and comprises more than nine national parks, four national monuments, two nature reserves, three protected areas, and one scenery reserve (United Nations List of Protected Areas 2018). North Korea's national parks are officially recognized by the IUCN and UN and have met the criteria for IUCN Categories II, III, IV. Many of North Korea's national parks support rare endemic and endangered animal and plant species (CBD 2020c), and several sites, such as Mount Chilbo and Mount Kumgang, have been identified as important bird areas, with Mount Myohyang receiving the designation of World Biosphere by UNESCO in 2009 (UNESCO 2020). Comparatively, China, Japan, Mongolia, and South Korea have protected 16%, 30%, 17%, and 12% of their terrestrial areas, respectively (WDPA 2020).

In recent years, human activity and climate change have exerted increasing pressure on the environment and natural resources of DRPK. Studies of satellite imagery have revealed that more than 40% of the country's forest cover has been lost since 1985, largely due to cultivation, logging, and natural disasters (Raven 2013). During the 1990s, a period characterized by severe economic stress, deforestation accelerated, as many people turned to the forests as a source of food and firewood, which led to cascading ecological effects, including soil erosion, soil depletion, increased flood risk, and threats to biodiversity (NASA 2020). A study in 2003 reported an increasing number of animal and plant species to be critically endangered, endangered, or rare (UNEP 2003). A survey of national parks in 2013 by an international delegation of scientists reported barren landscapes, absent of wildlife (McKenna 2020). In an attempt to rectify the problem, the Government of North Korea adopted a "Ten-Year Plan for Afforestation/Reforestation" to rehabilitate two million hectares of degraded forests (Sinmun, 2015), and in 2016 had stated they produced 90 million saplings to be distributed around the country (KCNA 2016). Reforestation and environmental programs have emerged as an area for international cooperation, with North and South Korea agreeing to joint action on forest restoration. In addressing biodiversity conservation, North Korea has participated in various international environmental projects and has hosted national workshops on the conservation of wetlands and migratory birds. Several important bird species migrate through North Korea along the East-Asian-Australian Flyway, one of the eight global flyways of migratory birds, including the critically endangered bar-tailed godwit, Eastern Curlew, and Eurasian Curlew. In 2017, North Korea adopted the CBD's Aichi Targets 2020, which defines country targets, including expansion of the protected area network and protections for biodiversity.

As North Korea confronts the challenges of environmental degradation and biodiversity loss, the effective management of its protected areas is crucial for ensuring the long-term health and integrity of its environment and ecological systems. Many of North Korea's protected areas include distinct landscapes that can serve as a valuable tourism resource; however, adequate monitoring and management are required for the sustainable development of its natural resources. In this paper, we utilize remote sensing, satellite imagery, and GIS to investigate the status of North Korea's key biodiversity and protected areas. We conclude by discussing opportunities for international cooperation aimed at enhancing conservation outcomes and the sustainable management of the country's national parks and protected areas.

The environment and biodiversity of North Korea

The environment of North Korea consists of diverse alpine, forest, farmland, freshwater, and marine ecosystems that provide a range of ecosystem services. Its oceanic and continental climates provide the country with four distinct seasons, including warm summers and cold winters. Vegetation regions include subtropical, temperate, and frigid zones. More than 80% of North Korea is mountainous, with an elevation profile between -43 and 2460 meters (Figure 1). Forest coverage accounts for 70% of the terrestrial area (Figure 2), although most forest coverage occurs on slopes greater than 20 degrees (Raven 2013). As a result of deforestation; stemming from a need for firewood, energy, and food, forest cover has seen a rapid decline. Between 2000 and 2005, deforestation in North Korea proceeded at a rate of 1.9% per year, equivalent to 127,000 square kilometers, most of which was converted to low-grade agricultural systems (Kim et al 2009). Forests are also often ravaged by fires, landslides, and insect pests (UNEP 2003). Water areas, which include rivers, lakes, and wetlands, cover 6% of the country. The country has two Ramsar Sites (Wetland of International Importance), with a surface area of 7,241 hectares.

North Korea's physiographical conditions have resulted in diverse habitats for a variety of flora and fauna, and the country has a high rate of plant endemism (CBD 2016). Comparatively, North Korea exhibits a rich diversity and high density of species among northeast Asian countries (UNEP 2003). As of 2006, the number of plant and animal species recorded in the country was 10,012 and 9,795, respectively (CBD 2020c). Roughly 107 species of mammals, 420 species of birds, 866 species of fish have been recorded (CBD 2016). Twenty-one percent of vertebrate species are endangered, including large mammals such as Brown bears (Ursus aritos) and European otter (*Lutura lutura*) (CBD 2020c; CBD 2016; IUCN 2020). The main threats to biodiversity include habitat fragmentation resulting from the destruction of forest ecosystems and the harvesting and overuse of natural resources stemming from population increase (CBD 2016; IUCN 2020). North Korea has a population density even higher than China (CBD 2020c). Several plants and animal species are considered to have high economic value, including high timber value tree species, medicinal plants, wild edible fruits, greens, mushrooms, oil plants, and aromatic plants (CBD 2020c).

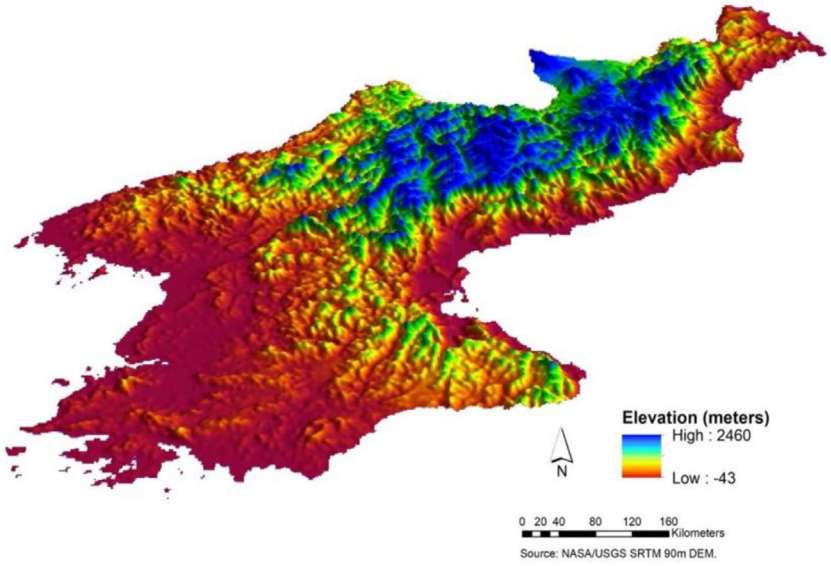

Figure 1. Elevation profile of North Korea. Source: NASA/USGS SRTM 90m DEM.

Environmental laws and international agreements

Environmental regulation in North Korea was developed in the mid-1980s to institutionalize environmental and land management following years of policy directives that fell short in addressing worsening environmental conditions (Nam 2003). While the main environmental laws, the Land Law 1977 and the Environmental Protection Law 1986, have improved environmental governance to a degree, environmental conditions in the country have continued to deteriorate, and regulation for safeguarding biodiversity in North Korea still has a long way to go to address biodiversity protection (Kim and Ali 2016). Currently, North Korea has no laws on the conservation of wild plants and threatened species or on comprehensive biodiversity conservation efforts (CBD 2020c). In addition, the efficacy of environmental protection policy in North Korea is difficult to ascertain due to a lack of available data on the subject, and the mechanisms to enforce environmental laws are unknown.

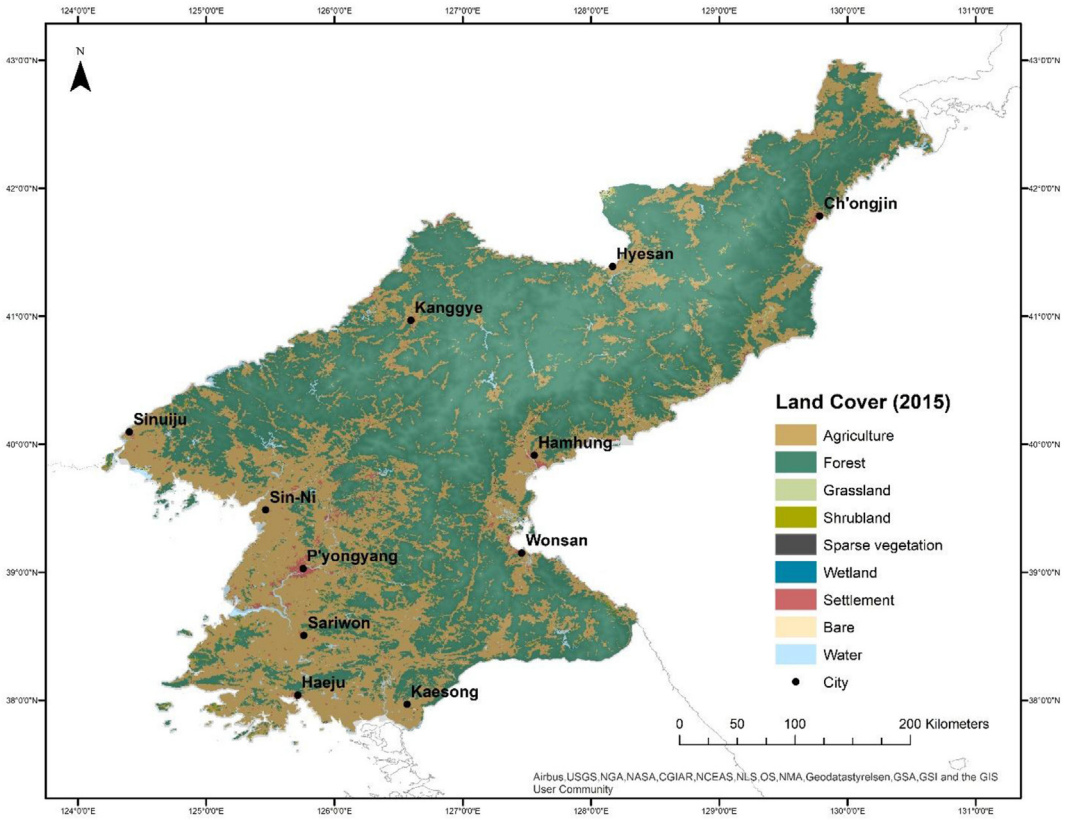

Figure 2. Land cover classification for North Korea (2015). Source: ESA Climate Change Initiative, Land Cover (2015).

Table 1. Protected areas of North Korea. Source: United Nations List of Protected Areas (2018). Woo (2002).

Name of Protected Area	Year Established	IUCN Category	Area (km^2)
UNESCO-MAB Biosphere Reserve (5)			
Mount Chilbo	2014	n/a	503.4
Mount Kumgang	2018	n/a	2625.89
Mount Kuwol	2004	n/a	527.15
Mount Myohyang	2009	n/a	96.82
Mount Paekdu	1989	n/a	1320
National Park (9)			
Lake Jangjin	1981	II	96
Lake Sohung	1981	II	53
Monggum Port	1981	II	50
Mount Chilbo	1976	II	300
Mount Jangsu	1981	II	30
Mount Kumgang	1959	II	600
Mount Kuwol	1959	II	180
Mount Myohyang	1959	II	160.53
Pakyon	1981	II	31.9
Natural Monument (12)			
Kangryong Crane Habitat	0	III	0.16
Kungangguks	1986	III	15
Monggumpho Sand Hill	1985	III	0.1
Ongjin Crane Habitat	1985	III	0.5
Outer Kumgang Geoclemys veevesii (Gray) Habitat	1986	III	0.2
Paechon Crane Habitat	1985	III	0.04
Paektu-san Korean Tiger	1980	III	50
Phanmun Crane Habitat	1985	III	10
Ryongyon Crus vipio (Phallas) Habitat	1986	III	1
Samjiyon Deer	1980	III	30
Solbong-ri Pine Tree Community	1986	III	0.1
Unmu Island Sea-Bird Breeding Site	1976	III	0.85
Natural Reserve (2)			
Mount Oga	1959	IV	60
Mount Paekdu	1959	IV	1320
Protected Area (7)			
Chail Peak	1976	IV	24.59
Chongchon River	1976	IV	8
Jangsan Cape	1976	IV	25.8
Kosong Bay	1976	IV	20
Kumya Seaside (Botanic)	1976	IV	1.2
Sonchon-rap Island (Breeding Seabird)	1976	IV	0.2
Taegam Island (Breeding Seabird)	1976	IV	0.25
Scenery Reserve (1)			
Musudan	1976	IV	90

North Korea has entered into several multilateral environmental agreements, including the Convention on Biological Diversity, United Nations Framework Convention on Climate Change, International Plant Protection Convention, Aichi Biodiversity Targets, and Sustainable Development Goals. Several of these agreements call on international cooperation, scientific exchange, and capacity development in order to support monitoring and implementing its international environmental obligations. In 2017, North Korea volunteered to join the East Asian-Australasian Flyway Partnership, an informal international group of governments, NGOs, inter-governmental agencies, and business sectors, which collectively aim to safeguard migratory birds and wetland habitats. The Mundok and Rason Migratory Bird Reserves are designated Ramsar sites, wetland areas of high conservation value that are bound by an international treaty. North Korea became the 170th contracting party to the Ramsar Convention in May 2018. Since 2018, North Korea has suggested they are willing to pursue international tourism development, with a possible focus on developing several of its national parks as tourist areas for international visitors (Ouellete 2020).

Table 2. Summary of protected areas in East Asia. Source: World Database of Protected Areas (WDPA). UNEP-WCMC (2019). Woo (2002).

UNEP-WCMC "East Asia"																		
Country	Area (km^2)	Ia/Ib		II		III		IV		V		VI		Not Reported/ Applicable		TOTAL		
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	Area (km^2)	%
China	93,61,609	7	5.74	0	0	0	0	2	1.64	0	0	18	14.75	95	77.86	122	14,61,913	15.62
China - Hong Kong	1,102	0	0	0	0	0	0	19	18.27	19	18.27	0	0	66	63.46	104	462	41.88
Japan	3,74,093	45	0.91	22	0.45	0	0	3758	76.46	932	18.96	100	2.03	58	1.18	4,915	1,09,937	29.39
Democratic People's Republic of Korea (North Korea)	1,22,186	0	0	9	26.47	12	35.29	10	29.41	0	0	0	0	3	8.82	34	2.976	7
Republic of Korea (South Korea)	99,713	31	0.89	16	0.46	2	0.06	2883	83.2	190	5.48	301	8.69	58	1.67	3,465	16,692	12
Mongolia	15,65,864	14	12.84	31	28.44	13	11.93	32	29.36	0	0	0	0	19	17.43	109	3,10,015	17
Taiwan	36,245	21	22.83	8	8.7	2	2.17	60	65.22	0	0	0	0	1	1.09	92	7,146	19.72

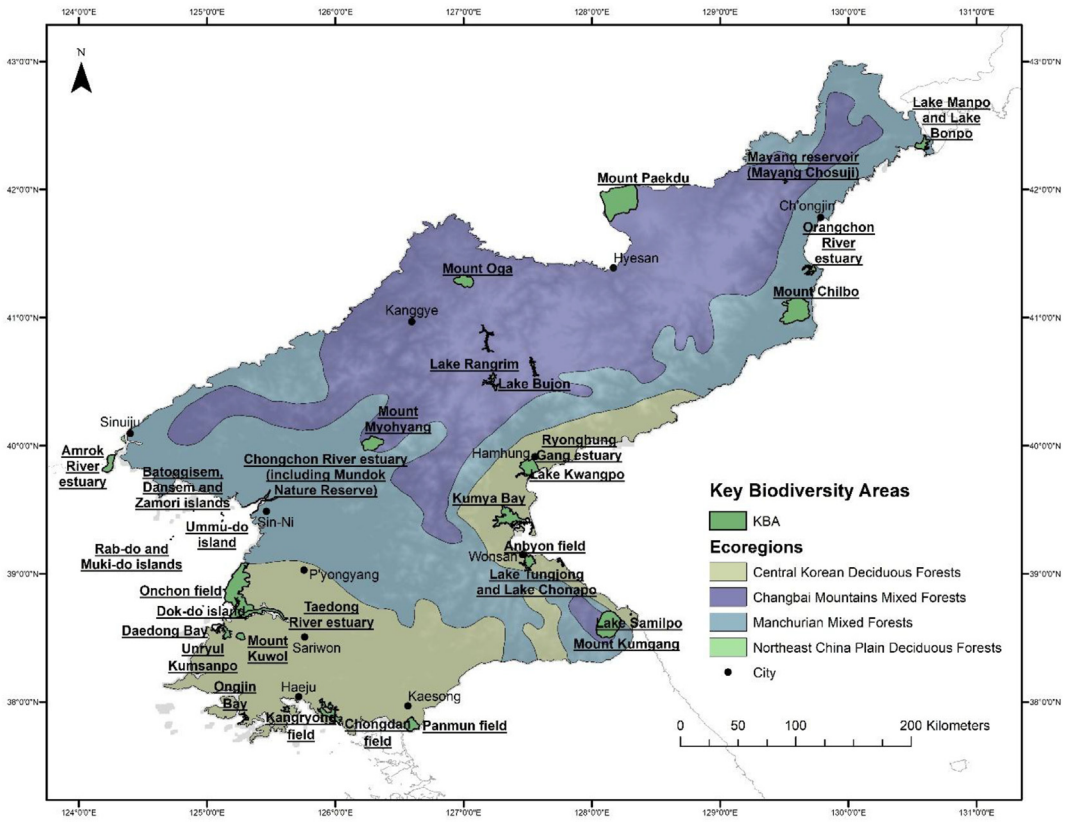

Figure 3. Key Biodiversity Areas (green) and tree cover loss (red) in North Korea. Source: BirdLife International (2020). The World Database of Key Biodiversity Areas.; The Nature Conservancy, Terrestrial Ecoregions.

Structure of North Korea's protected area network

North Korea's protected area network consists of 34 different types of international and national designated protected areas officially recognized by IUCN and UN, including UNESCO-MAB biosphere reserves (5), national parks (9), natural monuments (12), natural reserves (2), protected areas (7), and scenery reserves (1) and covers more than 3,780 square kilometers in total area (2.44% total land area) (UNEP-WCMC 2020). In terms of IUCN categories, North Korea has three types of protected areas, Category II, III, IV. Table 1 shows the protected areas of North Korea as recorded in the United Nations List of Protected Areas 2018 (UNEP-WCMC 2020; Woo 2002).

While the variety of IUCN categories represented by North Korea's protected area network reflect a balanced and ecologically representative system, questions persist on the preservation of biodiversity. The total area of protected lands in North Korea is less than half of the global average and far less than neighboring countries, Table 2 (WDPA 2020; Woo 2002). In addition, protected area connectivity, integral for effective conservation and management of biodiversity is severely lacking, with the country having less than a 4% connectivity rate (UNEP-WCMC 2020). Studies find that connectivity is essential to facilitate large-scale ecological and evolutionary processes such as gene flow, migration, and species range shifts (Saura et al 2018; Williams et al 2020; Pimm and Jenkins 2019). Buffer zones, a critical component to the sustainability of protected lands that offer efficient means of reducing biotic stress to a core area, are also lacking.

Table 3. Extent of forest loss (2001–2019) in Key Biodiversity Areas in North Korea.

Key Biodiversity Area	Forest Loss (km^2)
Mount Paekdu	292
Mount Chilbo	212
Mount Kumgang	49
Mount Oga	34
Mount Kuwol	14
Mount Myohang	7

A critical problem in assessing the efficacy of North Korea's protected area network is the dearth of information on the management and monitoring of its protected lands. Primary datasets commonly used by researchers to assess the current global conservation situation are often lacking for North Korea, and scholarly articles on important biodiversity indicators, such as where rare species live, which are critical for a timely assessment of biodiversity state and change, are scarce. Achieving the sustainable management of its protected areas will depend both on the ability to obtain data from a variety of biodiversity observation sources, including *in situ* and *ex situ* data, and the development of long-term monitoring programs to address critical data gaps (Schwartz et al 2017). If collected data are publicly available, the international research community can be better mobilized to identify biodiversity hotspots and collaborate with North Korean stakeholders to enhance conservation outcomes.

Material and methods

For this study, we utilized the Key Biodiversity Areas (KBA) spatial dataset, which includes important bird and biodiversity areas identified by the BirdLife International Partnership, Alliance for Zero Extinction Sites, and the Critical Ecosystem Partnership Fund (Birdlife International 2020). Sites qualify as a KBA if they meet one or more of 11 criteria, clustered into five categories: threatened biodiversity;

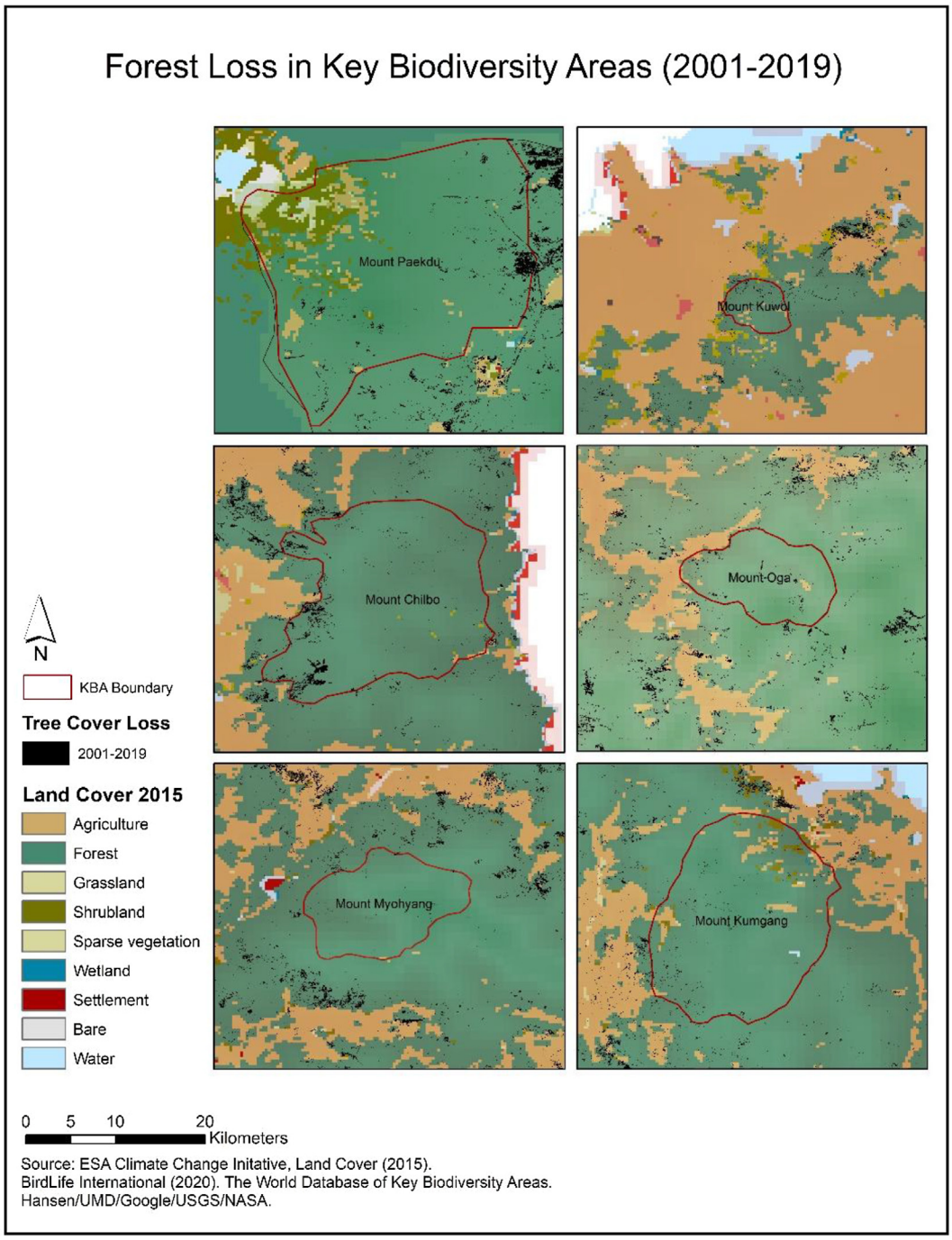

Figure 4. Forest loss in Key Biodiversity Areas (2001–2019) in North Korea. Source: ESA Climate Change Initiative, Land Cover (2015).; BirdLife International (2020). The World Database of Key Biodiversity Areas.; Hansen/UMD/Google/USGS/NASA.

geographically restricted biodiversity; ecological integrity; biological processes; and irreplaceability. Thirty-eight such sites have already been identified in North Korea, some of which are already incorporated into the protected area system (Table 1, Figure 3). The extent of KBA areas has been digitized based on the best reliable information available, and as a result, the boundaries are only estimates. The KBA dataset was selected given the lack of spatial data for existing protected areas in North Korea. We found that several of the KBA overlapped with protected areas and was the best representation available. To identify the extent of tree cover loss and habitat fragmentation, we used high-resolution forest cover change (2000–2019) produced by the University of Maryland (Hansen et al 2013). Spatial analysis and visualization were conducted using ArcMap 10.8.

Results

When KBA areas were overlaid with tree cover loss data from 2001–2019, we find that a number of these areas experienced some degree of deforestation and habitat fragmentation, particularly Mount Paekdu and Mount Chilbo, which experienced forest loss of 292 and 212 square kilometers respectively (Table 3, Figure 4). Other protected areas experienced a degree of forest loss ranging

from 1 to 50 square kilometers. While it is difficult to ascertain the precise reasons for the forest loss, these findings do suggest that enforcement and regulation of North Korea's environmental policy is uneven and inadequate, and stronger environmental safeguards are necessary if the country hopes to protect its remaining natural and wild areas and achieve its biodiversity and sustainable development goal targets. In addition, earlier surveys of local inhabitants at Mount Myohyang found that there was low awareness of nature and the value of biodiversity, and awareness campaigns and conservation information were not being disseminated (Baines 2004). Failure to provide conservation information can result in low levels of trust between local residents and park authorities, resulting in diminishing returns on conservation action (McCarthy 2018). Future studies will want to explore how recent policy changes implemented by Kim Jong-un and other socioeconomic and local factors are driving fragmentation and habitat loss. An accurate delineation of protected area boundaries would also be a highly valuable contribution to future research and assessments.

Discussion

While we found that North Korea's protected areas have experienced forest loss and habitat fragmentation, the country's commitment toward multilateral environmental agreements, such as the CBD's Aichi Targets for 2020 and the SDGs, presents an important opportunity for international collaboration to assist with the management and governance of its important biodiversity areas (McCarthy 2020). We identify three areas for international collaboration that are critical to the success of these international biodiversity targets and long-term sustainable development, and they include (1) development of long-term monitoring of biodiversity and improvement of data sources; (2) comprehensive conservation planning assessments for the expansion of the protected area network; (3) capacity development to enhance the management and enforcement of protected areas.

Long-term biodiversity monitoring and data management

Currently, long-term biodiversity data from North Korea is either unavailable, missing, or not readily accessible, as reflected by the lack of quantitative and taxonomic data in existing databases, such as IUCN Red List of Threatened Species (www.iucnredlist.org), Protected Planet (www.protectedplanet.net), and Living Planet Index (www.livingplanetindex.org), and a shortage of citied scientific articles. Only if solid, accurate, and verifiable data is collected, stored, and shared can North Korea develop a comprehensive understanding of the current state of biodiversity and make informed conservation management decisions. Fortunately, modern technology is making it possible to collect accurate data that is both timely and inexpensive. For example, satellite-based remote sensing can deliver long-term data series with a high sampling frequency and extensive geographic coverage on ecosystem function and contribute substantially to biodiversity monitoring by enabling more accurate assessments of wildlife populations, rapid detection of deforestation, illegal mining, and other changes in the landscape (Rose et al 2014). To complement satellite imagery with on the ground monitoring, camera trap technology and bioacoustic recording devices, combined with machine learning, have made it possible for automation of *in situ* data collection and processing, which can then be used alongside direct field observations, to identify and monitor biodiversity (Aide et al 2013). Modeling the dynamics of biodiversity and ecosystem services can only be established through long-term monitoring.

While the array of available monitoring tools presents an exciting opportunity for North Korea to collect biodiversity information, collected data must be stored, processed, and shared in relevant databases that will be accessible to the international community. International collaborations aimed at increasing the volume of biodiversity data collected through long-term monitoring systems and sharing it in global databases will enhance its use for analysis, conservation planning, and environmental decision-making. The widespread involvement of independent scientists in the analysis of data will ensure research is independent, autonomous, and apolitical.

Strengthening conservation planning assessments

Comprehensive conservation planning assessments are essential to guide decision-making and the governance and expansion of protected areas. Coupled with improved data collection through long-term monitoring, international collaborations aimed at strengthening system-level planning and national assessments of protected areas and biodiversity are critical to the support of conservation efforts in North Korea. Conservation planning assessments should be built around shortfalls in global targets, such as the Aichi Biodiversity Targets and Sustainable Development Goals, while also acknowledging country-level priorities. Research has shown that systematic conservation planning based solely on international recommendations fails to achieve optimal levels of conservation protection (Woodley et al 2019). Simply expanding protected area coverage by protecting the cheapest land, even if ecologically representative, only provides marginal protection for threatened species (Rodrigues et al 2004; Pimm et al 2018). Comprehensive conservation planning assessments rooted in rigorous research about North Korea's natural systems, including the extent of biodiversity and the impact of human behavior on the environment, will help identify challenges and opportunities in biodiversity conservation. Because North Korea has limited agricultural land, an understanding of agricultural opportunity cost would also be beneficial to the development of conservation decision-making systems. International collaborations aimed at sharing resources that focus on evidence-based planning tools and best practices utilized by peer conservation organizations will empower North Korean stakeholders to improve their conservation efforts.

Capacity development for effective management of protected areas

Long-term conservation benefits are more easily achieved when a wide range of stakeholders, from government agencies, businesses, and local, indigenous communities are actively engaged in the decision-making process (Sobrevila 2008). Capacity development that is inclusive of all protected area stakeholders is critical for achieving long-term success. It is our recommendation that international collaborations focus on capacity development at three distinct but related levels: individual, institutional, and societal capacities. For North Korea to meet its commitments on protected areas and biodiversity conservation, conservation efforts must be effectively coordinated between all levels of stakeholders. Particularly important is effective coordination and communication between government agencies, businesses, and local communities, which includes the general public. Full involvement of all stakeholders in the decision-making process is a time-tested mechanism for delivering the best long-term conservation outcomes.

The effective management of protected areas is increasingly recognized as playing an important role in the development of nature-based tourism and support for socioeconomic development. As North Korea attempts to attract more foreign tourists, the development of nature-based tourism centered around its protected area network may help the country achieve its goals for both nature conservation and the country's need for material

development. While inbound tourism to North Korea reached 200,000 visitors in 2018, institutional and infrastructural capacities still pose obstacles for tourism development around the country's national parks (Shim 2019). Ensuring that tourism follows a truly sustainable path, and contributes to the sustainable management of protected areas, will require cooperation and partnerships between the tourism industry, government agencies, local communities, and protected area authorities.

Conclusions

Protected areas are at the core of national and international efforts to safeguard nature and the services it provides us. While North Korea has made considerable progress in developing a balanced and ecologically representative protected area network, protected area coverage still accounts for only 2.4% of the country, far below the 17% goal defined by Aichi Target 11. In addition, we find that deforestation is common at sites identified as key biodiversity areas, highlighting the need for improved conservation action. This is of crucial importance because we know that biodiversity loss largely stems from habitat loss, fragmentation, and exploitation. North Korea's commitment to global environmental agreements, including the multilateral CBD Aichi Target 2020 and Sustainable Development Goals, presents an important opportunity for collaboration with international partners. We identify three key areas for collaboration critical to helping North Korea meet its conservation commitments: (1) improving data quality and resources through the development of long-term monitoring programs, and sharing of data with the global scientific community; (2) comprehensive conservation planning assessments for the expansion of the protected area network; (3) multilevel capacity development programs aimed at providing technical guidance on the effective management of protected areas. Properly managed, North Korea's natural parks and protected areas can contribute to the country's conservation goals, mitigate the effects of climate change, and also provide important economic value in the form of ecotourism and jobs.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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