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AN INTRODUCTION TO MID-LATITUDE ECOTONE: SUSTAINABILITY AND ENVIRONMENTAL CHALLENGES

J. Moon[1], W. K. Lee[1], C. Song[1], S. G. Lee[1], S. B. Heo[1], A. Shvidenko[2, 3], F. Kraxner[2], M. Lamchin[1], E. J. Lee[4], Y. Zhu[1], D. Kim[5], G. Cui[6]

[1] *Korea University, College of Life Sciences and Biotechnology*
East Building, 322, Anamro Seungbukgu, 145, Seoul, 02841 Republic of Korea

[2] *International Institute for Applied Systems Analysis (IIASA)*
Schlossplatz, 1, Laxenburg, 2361 Austria

[3] *Federal Research Center Krasnoyarsk Scientific Center, Russian Academy of Sciences, Siberian Branch*
V. N. Sukachev Institute of Forest, Russian Academy of Sciences, Siberian Branch
Akademgorodok, 50/28, Krasnoyarsk, 660036 Russian Federation

[4] *Korea Environment Institute*
Bldg B, Sicheong-daero, 370, Sejong-si, 30147 Republic of Korea

[5] *National Research Foundation of Korea*
Heonreung-ro, 25, Seocho-gu, Seoul, 06792 Republic of Korea

[6] *Yanbian University*
Gongyuan Road, 977, Yanji, Jilin Province, China

E-mail: jooyn.moon@gmail.com, leewk@korea.ac.kr, cholhosong@gmail.com, cristallize@naver.com, seongbongh@gmail.com, shvidenk@iiasa.ac.at, kraxner@iiasa.ac.at, naska_l@yahoo.com, leeej8912@gmail.com, zulim1118@gmail.com, daminkim14@gmail.com, cuiguishan@ybn.edu.cn

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The mid-latitude zone can be broadly defined as part of the hemisphere between 30°–60° latitude. This zone is home to over 50 % of the world population and encompasses about 36 countries throughout the principal region, which host most of the world's development and poverty related problems. In reviewing some of the past and current major environmental challenges that parts of mid-latitudes are facing, this study sets the context by limiting the scope of mid-latitude region to that of Northern hemisphere, specifically between 30°–45° latitudes which is related to the warm temperate zone comprising the Mid-Latitude ecotone – a transition belt between the forest zone and southern dry land territories. The ongoing climate change reveals a substantial increase of temperature and simultaneous decrease in the amount of precipitation across vast continental regions in the mid-latitudes. According to climatic predictions, these tendencies will continue during the 21st century, which will likely increase the frequency and severity of droughts and water stress of vegetation. Along with climate change, ongoing land degradation and deforestation are observed in many regions of the mid-latitude region. For example, the Korean peninsula, which is divided into South and North Korea, is characterized by drastically different forest conditions. Deforestation in North Korea has been exacerbating at a noticeable pace due to excessive logging and human intervention. Such problems are not confined to Korean peninsula but are witnessed across vast regions of the mid-latitude region. Within this context – acquiring better understanding in the role of terrestrial ecosystems located at different latitudes is critical – for building resilience against the negative impact of climate change and for maintaining the stability of the environment and landscapes.

Keywords: *mid-latitude ecotone, deforestation, land degradation, desertification, climate change, carbon cycle variation.*

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INTRODUCTION

While the conventional approach of «grow first, clean up later» has been a pervasive economic growth strategy that prevailed over half century, some of negative effects of the indiscriminate way of development have become evident in many parts of the world. Not only did it undermine the intrinsic value of environment, but the world has encountered a series of problems coupled with ever-increasing global economic interdependence, overpopulated urban areas, inefficient use and depletion of natural resources. Additionally, the uncertainties and negative impacts of climate change complicate these problems. It is because the reason for climate change is examined at global level while the signs of its impact are mostly witnessed on a regional scale, which makes it harder to understand human-ecosystem-climate interactions. What seems to put further constraints on this already precarious condition is a series of evidence on environmental degradation; deforestation; continued desertification and decline of carbon sink capacity, which all in all came at the expense of social and economic development (Cui et al., 2014; Kim et al., 2016; Lamchin et al., 2016).

Among five domains that are distinguished based on temperature: tropical, subtropical, temperate, boreal and polar, the mid-latitude region is generally defined as the zone of Northern latitudes between the tropics and Polar Regions. Temperate zone is covered primarily with grassland and deserts, which are found mostly in the continental interiors, and temperate forests only partly distributed throughout some regions including East Asia, Western Europe and North America, which account for about 20 % of the world's terrestrial area (State…, 2012). It is consisted of tree species that are intolerant to extreme weathers, both hot and cold (Brandt, 2009; Brandt et al., 2013). In the landscape context, the existence of temperate forests is of great importance with respect to maintenance of productivity and landscape diversity, however, it has been seriously challenged by human activities due to excessive logging, which has been putting more pressure on those various ecosystems in the zone, which are subject to unforeseen impact of climate change.

Latitudinal approach provides ecological rationale of research, and grouping by latitudes or climate regions enables better understanding on the function and interaction of ecosystems from various perspectives. This paper is structured into three components: firstly, it explores the definition and current status of mid-latitude region of the northern hemisphere. Secondly, this provides a snapshot of challenges in typical areas of mid-latitude region, specifically the case of temperate forests in Korean peninsula, Yanbian in Jilin province of China and desert and degraded area in Mongolia, which belong to the mid-latitude ecotone. By doing so, this paper reports some of the present challenging condition of the mid-latitude ecotone and sets the context for scientific investigation. This approach aims to take a far more synergistic and holistic viewpoint on mid-latitude ecotone and to provide inputs to subsequent studies of our concern; deforestation, land degradation, and changes of ecosystems' carbon budget of this dynamic region of the world.

A step toward latitudinal approach. *Definition and geography of mid-latitude region.* Mid-latitudes can be broadly defined as part of the Northern and Southern hemisphere between 30°–60° latitude. Mid-latitude area in the Southern hemisphere appears relatively small compared to that of Northern hemisphere because the Southern hemisphere has significantly more ocean and much less lands. In reviewing some of the past and current major environmental challenges that parts of mid-latitudes are facing, this study sets the context by limiting the scope of the mid-latitude region to that of Northern hemisphere, specifically between 30°–45° latitudes, which is mostly related to the warm temperate zone (Fig. 1).

From a climatic aspect, mid-latitudes refer to the area whose average temperature ranges from 10 to 20 °C throughout the year, conceptually similar when defining the heat equator as a set of locations having the highest mean annual temperature around the globe. To be more specific, we use terms of «mid-latitude zone» or «mid-latitude region» for the entire mid-latitude territory of Northern hemisphere, and «mid-latitude ecotone» – for the more narrow transition belt between the forest zone and southern dry lands. The mid-latitude ecotone occupies vast discontinuous areas depending on geographical location, elevation and landscape's specifics. Vulnerability of zonal ecosystems, particularly forests, over the ecotone is very high.

Mid-latitude of the Northern hemisphere encompasses about 36 countries of the principal regions, which can be classified by geographic group of East Asia (Korea, China, Japan and Mongolia); Central Asia (Uzbekistan, Kazakhstan, Turkmenistan, Tajikistan, Kyrgyzstan, Azerbaijan and Kyrgyz Republic); Central and Eastern Europe; Western Europe to parts of North America (United States of America).

Demographics and current status in the mid-latitude ecotone. In terms of demographics and level

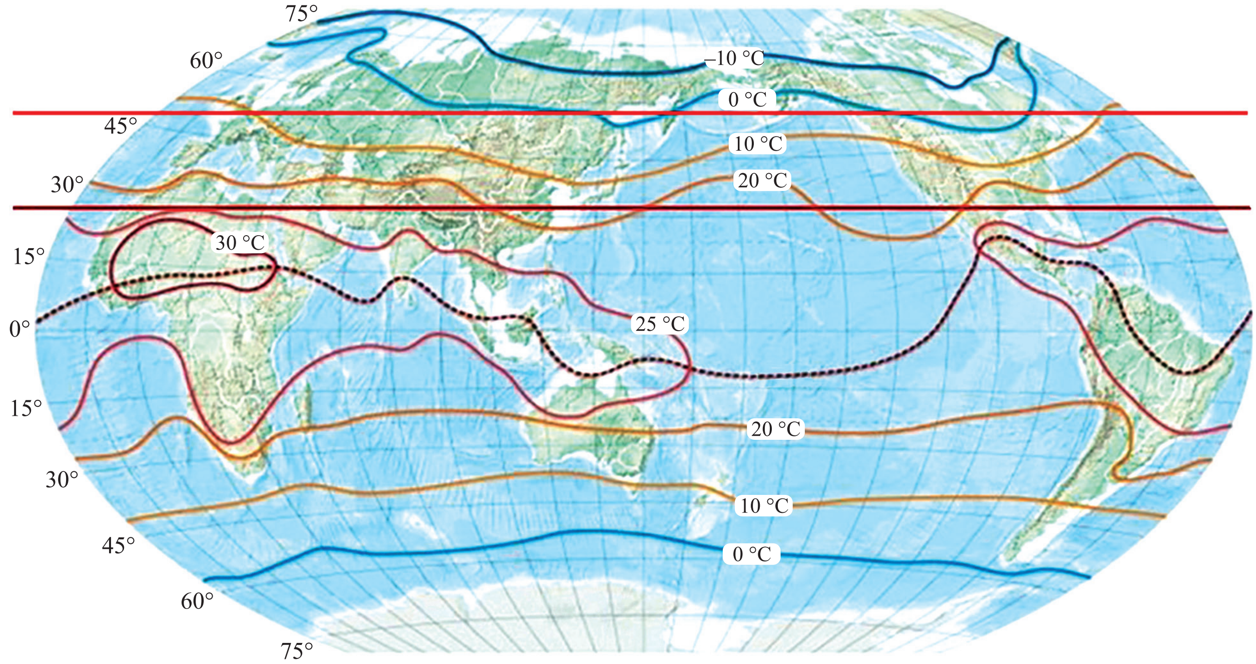

Fig. 1. Geographical zones by climate (Naver Encyclopedia, 2016).

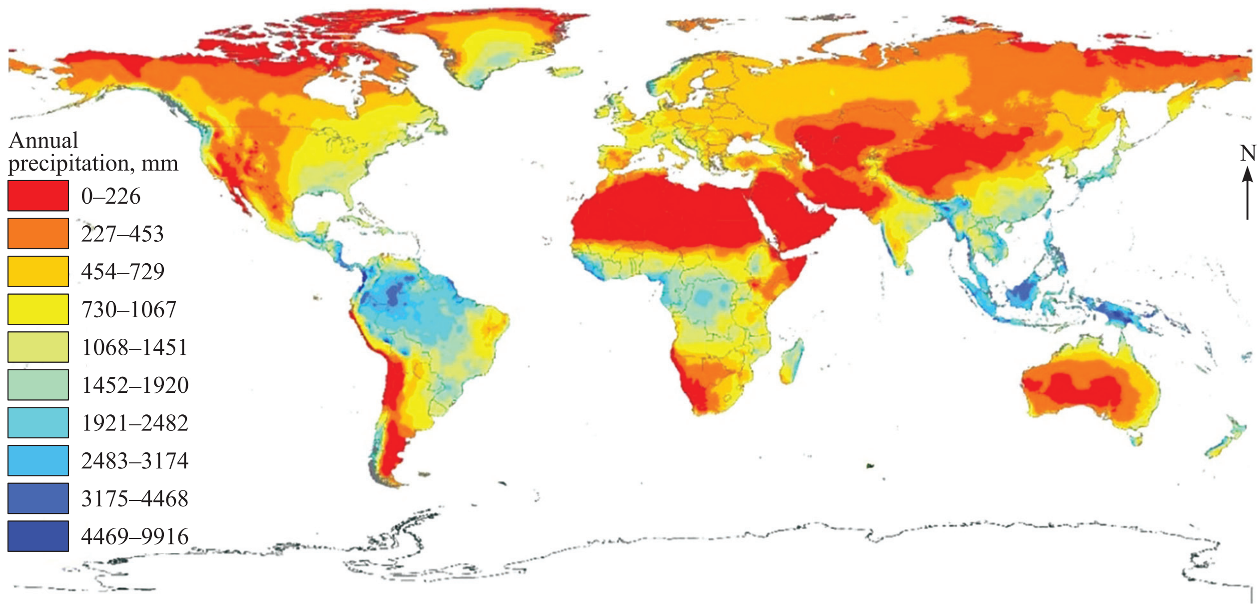

Fig. 2. Annual precipitation over 30-year period of 1961–1990 (based on WorldClim…, 2016).

of economic development in the mid-latitude region, approximately 50 % of the global population live in the area between 20° N – 40° N where most of the world development and poverty related problems are located (Kummu, Varis, 2011). Population is closely linked to the future prospects of the use of limited resources as humans are having an enormous impact on the planet's environment and ecosystems, both terrestrial and aquatic (Raven, 2002; McMichael et al., 2003; Pauly et al., 2003; Palmer et al., 2004). Land degradation and poverty are often deeply intertwined as an estimated 42 percent of the world's poorests live on land that is classified as degraded (Nachtergaele et al., 2010). About 1.3 billion people are reliant on forests, and the majority of these are extremely poor and their level of dependence is large, which are often linked to the magnitude of income obtained from agriculture (Murphy, 2011; Shepherd et al., 2013; Angelsen et al., 2014).

Table 1. Land cover types and their areas in the mid-latitude region based on remote-sensing estimates (NASA LP DAAC, 2016, MCD12Q1, NASA EOSDIS Land Processes DAAC, USGS Earth Resources Observation and Science (EROS) Center)

Vegetation type	Area, %	Vegetation type	Area, %
Evergreen needle leaf forests	6.8	Savannas	0.8
Evergreen broadleaf forests	0.0	Grasslands	23.7
Deciduous needle leaf forests	2.0	Permanent wetlands	1.3
Deciduous broadleaf forests	1.7	Croplands	15.7
Mixed forests	16.9	Urban built-up	0.9
Closed shrublands	0.1	Cropland/natural vegetation mosaic	7.3
Open shrublands	7.9	Barren or sparely vegetated	11.1
Woody savannas	3.8	Total	100

Large areas of these latitudes are subject to the interplay between population growth, resource depletion and environmental degradation, which has become of greater concern to a number of livelihoods, specifically its relation to diverse ecosystems and the service it provides. In addition, one of the major constraints of development in this most populated latitude is the shortage of water resources, and this will likely to put pressure on cropland and pasture, of which area covers over 50 % between the latitudes of 35° and 50° in the northern hemisphere (Kummu, Varis, 2011).

Climate characteristics in the mid-latitude ecotone. The climate of mid-latitude regions is characterized by relatively moderate hot or cold, but its seasonal variation of weather and differences in the amounts of precipitation are more distinctive (Chen et al., 2004). The amount and patterns of precipitation varies greatly from continental to coastal areas. As highlighted in Fig. 2, large parts of Mongolia, China and majority of Central Asia are generally classified into semi-arid zone where the annual average precipitation ranges from 0–226 mm.

The area is naturally short of precipitation, which explains various distribution of vegetation resulting from the interaction of climate, physical geography (terrain, soil nutrients), often associated with human-induced interventions.

Projections about ongoing climatic changes for most of the temperate territories, during 1990 to 2050, are increases in both summer and winter temperatures of 1–2 °C, regional changes in precipitation in summer and winter within ±20 % range and drier soils in summer (Climate…, 2007). According to climatic predictions, these tendencies will be enforced during the 21st century.

What is more at stake in this temperate zone are the uncertainties in climatic predictions, even small changes of basic climatic indicators; temperature and precipitation may provide substantial impacts on ecosystems. Furthermore, the potential area for temperate forests is projected to change the least compared to other latitudinal zones; however, the warmer and drier climate will negatively impact productivity and vitality of forest ecosystems and provoke acceleration of natural disturbances like fire and outbreaks of dangerous agricultural and forest pests (Crosson, 1989; Climate…, 2007).

Land cover characteristics in the mid-latitude ecotone. A major part of the ecotone is known as a xeric belt, the territory of a climatically driven transition from the forest to steppe zone. In the mid-latitude region, the representative types of land cover are mixed forests, croplands, grasslands, open shrublands, and woody savannas. Similar patterns are witnessed in the region of East Asia including South Korea, Japan, Eastern part of China, the Mediterranean Europe, and East coast of the North America. In contrast, grasslands are widely spread in the central part of the Eurasian Continent and the western part of the North America, which are strongly influenced by the continental climate. On the fringe of the grasslands, it appears geographic differences, which show gradual transition to open shrublands and partly woody savannas (Table 1).

Most temperate forests are located in developed countries, and this type of ceosystems is representative for the mid-latitude circumpolar belt (Molles, 2008).

Temperate forests are found in discontinuous blocks on five continents, sharing the landscape with agricultural land and urban areas (Crosson, 1989; Climate…, 2007). In Asia, the temperate mixed forest is spread throughout most parts of Japan, East China, Korea and Eastern region of Siberia (Fig. 3).

It can also be found in vast areas from Western Europe such as the southern part of Scandinavia and Northwestern Iberia to England and Eastern Europe. In North American region, temperate forests are found at East and West of different latitudes.

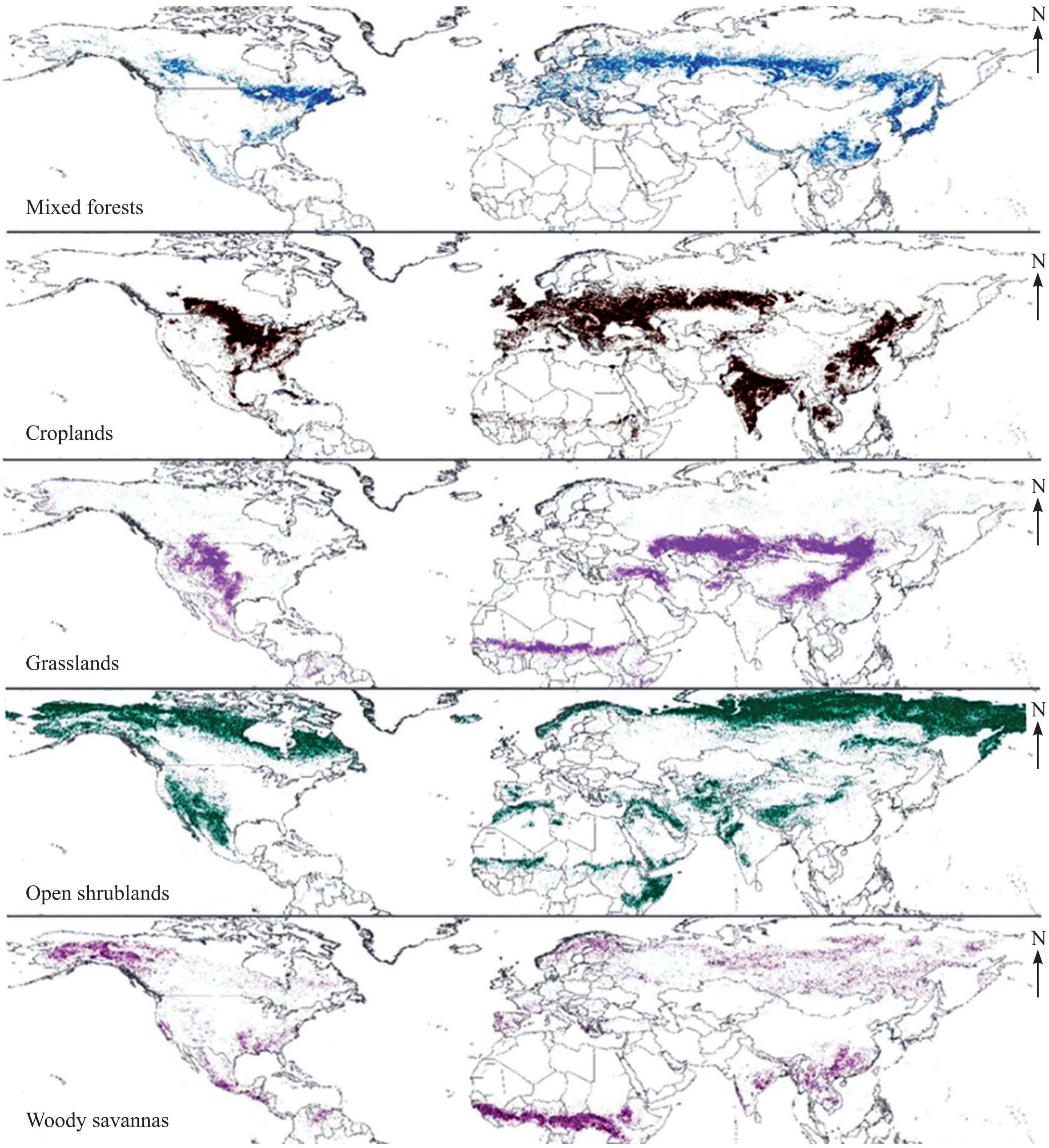

Fig. 3. Distribution of land cover types over the extra-tropical vegetation zones of Northern hemisphere.

Temperate forest is comprised of coniferous and broad-leaved tree species which are distributed in the climate of moderate temperature with annual precipitation of 350~3.000 mm (Molles, 2008).

The deserts are spread widely throughout the mid-latitude region. Unlike tropical deserts with high temperature, the deserts of mid-latitude show the characteristics of a cold desert where the amount of evaporation exceeds precipitation and water is scarce due to plant transpiration (Molles, 2008). At the Sonoran desert of North America, annual precipitation is approximately 300 mm and the average winter temperature drops to –20 °C at the Gobi desert of Central Asia.

The barrenness of the desert basically rises due to accumulated salinity from the increased amount of moisture at the surface of the desert soil. Recently, the increase of areas of degraded and desertified land from human activity is causing salinization at the regions where there used to be irrigation and turning into useless lands.

Environmental challenges and the importance of mid-latitude ecotone. *Water shortage in mid-latitude ecotones.* Building resilience and sustainable management of the mid-latitude ecotone depend both on knowledge of current state of these ecosystems and knowledge on drivers of ecosystem dynamics associated with changes caused by

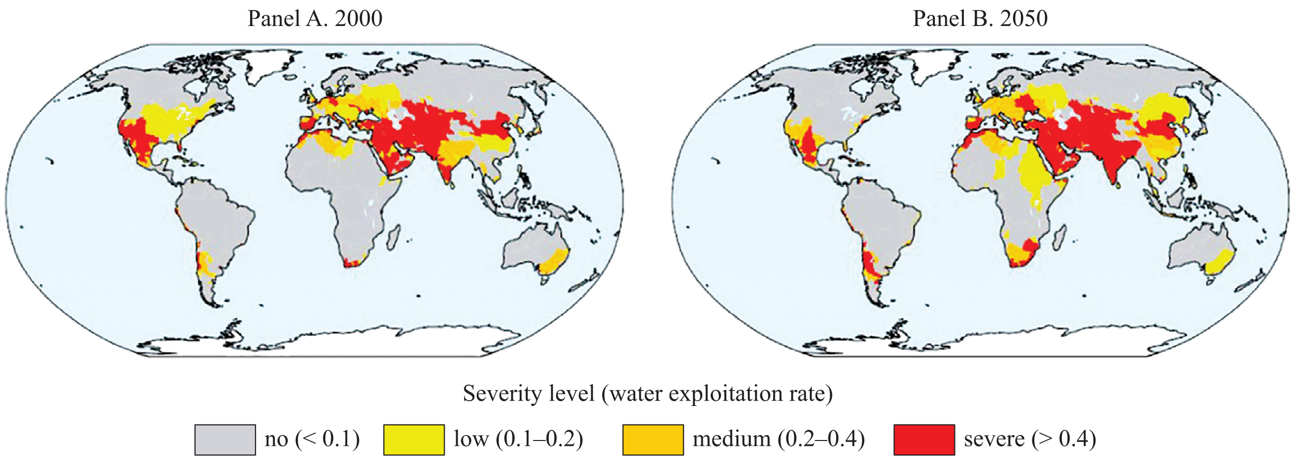

Fig. 4. Water stress by river basin: baseline, 2000 and 2050 (OECD…, 2012).

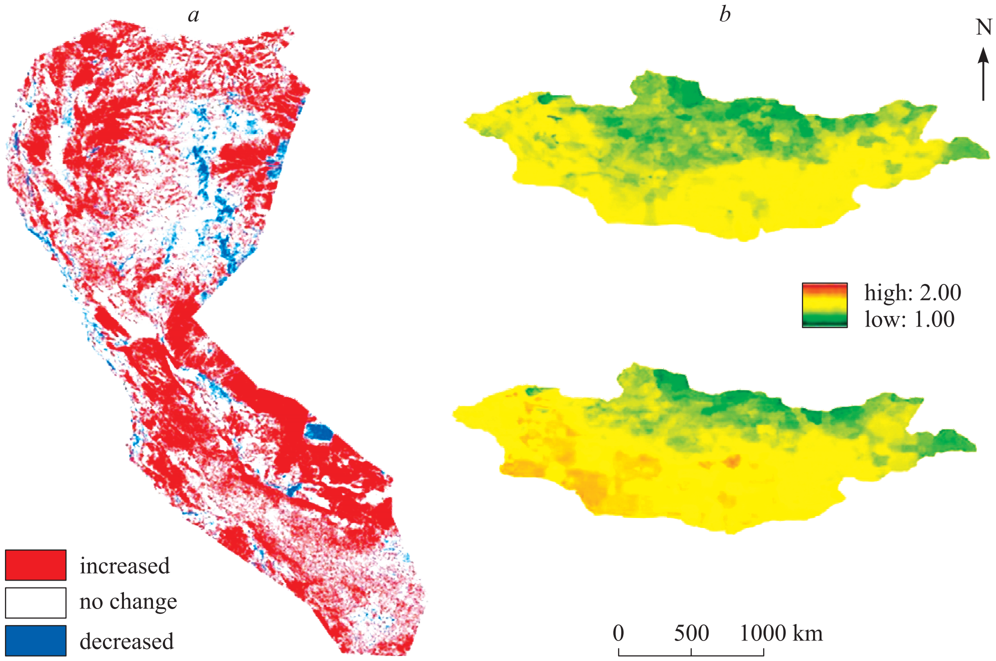

Fig. 5. Desertification change in Mongolia: *a* – the Hogno Khaan protected area between 1990 and 2011; *b* – the change of ESAI between 2003 (above) and 2008 (below).

people and human-caused climate change at different temporal and spatial scales. Highly dynamic ecosystems and their stability over the ecotone is seriously being challenged. The continued use of the resources by humans and occurrence of rapid urbanization in emerging economies have brought intensified use of land and water resources, which in turn affect the ecosystems cumulatively. According to the OECD… (2012), water stress in the mid-latitude region will substantially increase by 2050, especially in territories of the Central Asia (Fig. 4).

Such environmental challenges will be intensified by extremes of precipitation and temperature, which are often coupled with natural disturbances such as flood, hurricanes and frequent and severe drought.

Considering that both the variability of climate change and human influence is expected to be large at the mid-latitudes, the ecotone will be more strongly affected by anthropogenic and natural causes, which are often manifested in the form of deforestation, continuing desertification and alteration of the balance between carbon sinks and sources.

Deforestation: vertical differences observed in Korean peninsula. One distinct mid-latitude ecotone feature is seen in the case of North Korea's deforestation, which reflects human impacts on ecosystem. The Korean peninsula, which is divided into South and North Korea, is characterized by drastically different vegetation status of the countries. Land degradation of North Korea has been exacerbating at a noticeable pace due to excessive

Table 2. Comparison of deforested areas in North Korea (Kim et al., 2016)

References	Deforested area (decreased forest area, ha)	Period
Statistical yearbook…, 2011	1.7×10^6	1999–2008
Global Forest…, 2010	2.5×10^6	1990–2010
Lee, Bae, 2007	1.2×10^6	The late 1980s – early 2000s
Park, Yu, 2009	1.9×10^6	1989–2008
Park et al., 2014	1.7×10^6	2000–2012
Kim et al., 2016	1.8×10^6	The late 1980s (1987–1989)–2010

logging and the conversion of forested areas into agricultural land. The onset of continuous loss of forest area in North Korea started from 1980s. The forest area has been reported to be substantially decreased, approximately at 12 % by 1997 compared to its baseline year of 1945 (Statistical yearbook…, 2014; Cui et al., 2014; Kim et al., 2016). Whereas the forest cover of South Korea was restored since 1970s and acts as carbon sink till date (Cui et al., 2014; Kim et al., 2016), the change of land cover in North Korea demonstrates an opposite direction (Table 2).

North Korea has extensive forest areas followed by cropland and grassland, however, the total forest area was reduced to around 7.2×10^6 ha with a 19.9 % decrease in the 2000s, while cropland increased to approximately 3.2×10^6 ha with 70.6 % increase compared to the 1980s.

Grassland accounted for more than 9 % of the total land area (1.1×10^6 ha) (Kim et al., 2016). The lost forested area is converted to other land cover types, which will contribute to changes in the ecosystem carbon budget in the future.

Desertification: horizontal differences among the mid-latitude ecotone. Ongoing land degradation and deforestation has been observed in many regions of the mid-latitude ecotone. Land degradation seems to be concentrated in specific locations, such as in Central Asian region, whose land has been susceptible to continuous degradation due to human-induced disturbances caused by the intensive and often unregulated human activities and extreme weather conditions. The region has one of the driest climates, and has been subject to increased human pressures that have exacerbated its already harsh conditions. As the one of the case studies, Lamchin et al. (2016) composed several factors to understand the desertification processes in the Hogno Khaan protected area in Mongolia (Fig. 5, *a*).

This study used several vegetation indices with other geographic factors, and figured out the relations of the grazing effects and the vegetation cover composition of pasture areas. Lee (2016) examined desertification in Mongolia based on quantitative assessment using MEDALUS approach, a widely known technique for assessing desertification in the Mediterranean area. The method was adjusted to be applied to Mongolia. The Environmental Sensitive Area Index (ESAI) was computed using MEDALUS approach, and the findings concluded that the area in Mongolia with the highest ESAI range and the highest vulnerability to desertification was increased approximately at 5 times, from 2003 to 2008 (Fig. 5, *b*).

Carbon sequestration: the role of mid-latitude temperate forests. Since the cycling of carbon between the atmosphere and land is predominantly determined by the amount of soil moisture available to plants and local climatic conditions, some previous research demonstrated the role of forests under different global temperatures and global concentration of CO_2 (Swann et al., 2012). In terms of analyzing the role of forests located in different latitudes, the amount of carbon sequestered and released substantially varies by region.

Temperate forests account for about 20 % of the world's terrestrial area (State…, 2012) and they are partly distributed throughout the regions of East Asia, West Europe and North America. In the Asian region alone the role of forests as carbon sink has been underestimated despite their substantial contribution to global carbon cycle and climate system (Ito, 2010). One interesting case to focus on is the terrestrial ecosystems of the Korean Peninsula, which is predicted to play an important role within the region given that it contains plentiful vegetation in South Korea, and the recovery potential of the degraded vegetation in North Korea. Although several studies have addressed the contemporary carbon budget in the Korean peninsula and East Asia, few studies have explored the future response of terrestrial ecosystems particularly in North Korea.

Cui et al. (2014) studied the carbon budget change resulting from land cover change in South Korea and North Korea between 1981 and 2010. This study considered several factors related to land

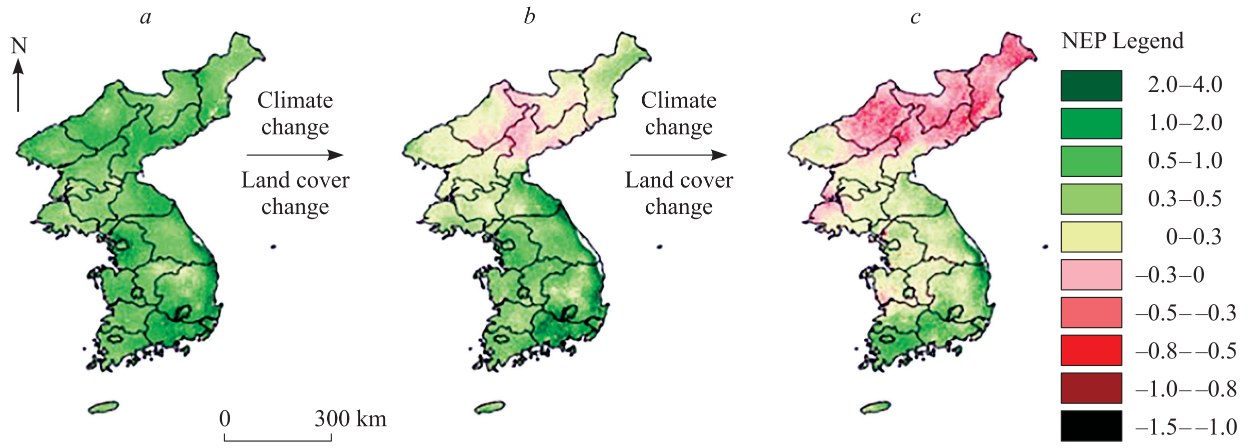

Fig. 6. Spatial distribution change of NEP of the Korean peninsula in 1980–2000 years: *a* – 1980; *b* – 1990; *c* – 2000 (Cui et al., 2014).

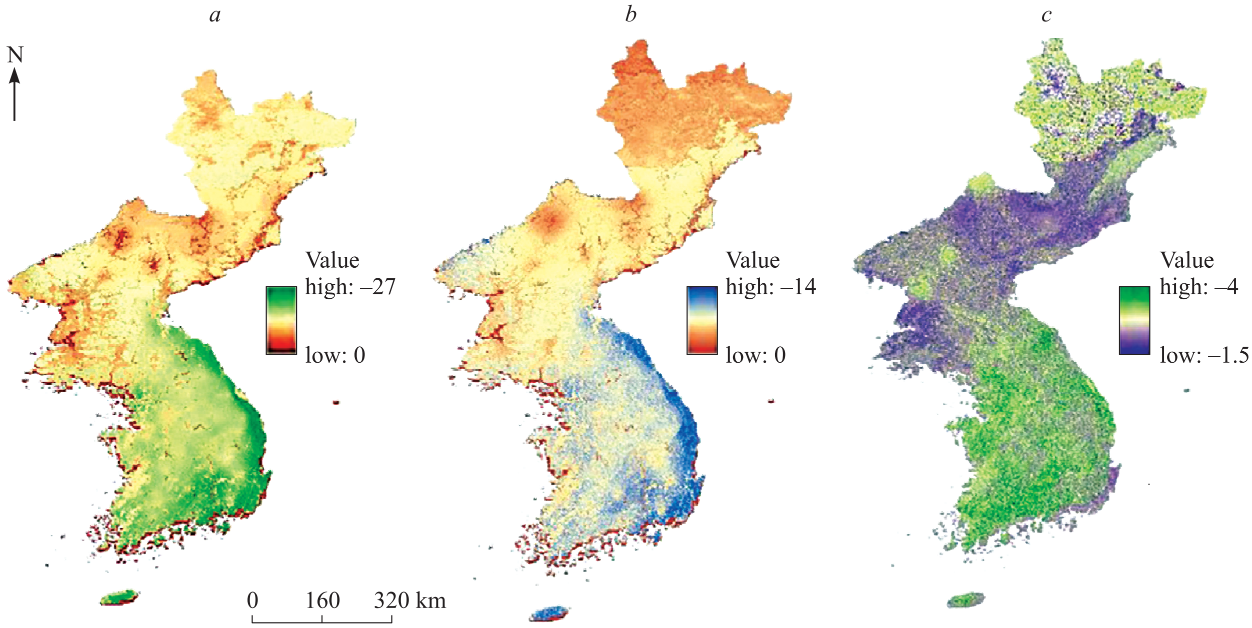

Fig. 7. Spatial distribution map of vegetation productivity in Yanbian region comparatively with the Korean peninsula: *a* – Gross Primary Production (GPP); *b* – Net Primary Production (NPP); *c* – Net Ecosystem Production (NEP).

cover change and affecting current sustainability of forests in Korean peninsula by driving the Vegetation Integrative Simulator for Trace gases (VISIT) model. They examined carbon budget trend due to land cover change, climate variations and quantification of carbon budget of the Korean peninsula, and concluded that North Korea's terrestrial ecosystems converted from carbon sinks to sources as forests were changed to croplands, whereas South Korea remained a carbon sink with cropland converting to forests and urban and built-up areas (Fig. 6).

Zhu (2015) examined and compared the carbon budget changes between Korean peninsula and Yanbian region in China from 2001 to 2010. This study used findings of Cui et al. (2014), and Zhu (2015) added a carbon budget spatial distribution map of Yanbian region to have better understanding on the carbon budget in main parts of East Asia. As a result, the terrestrial ecosystem of Yanbian acted as a carbon sink from the year 2001 to 2010. The carbon budget of Yanbian was estimated to a lower value compared to South Korea, and this is due to the spatial variation caused by differences in temperature and humidity by elevation. All in all, South Korea had a higher value in the carbon sink than North Korea and Yanbian region and such differences can be explained by distribution and state of vegetation per unit area (Fig. 7).

Following the precedent study, Kim et al. (2016) drove the Vegetation Integrative Simulator for Trace

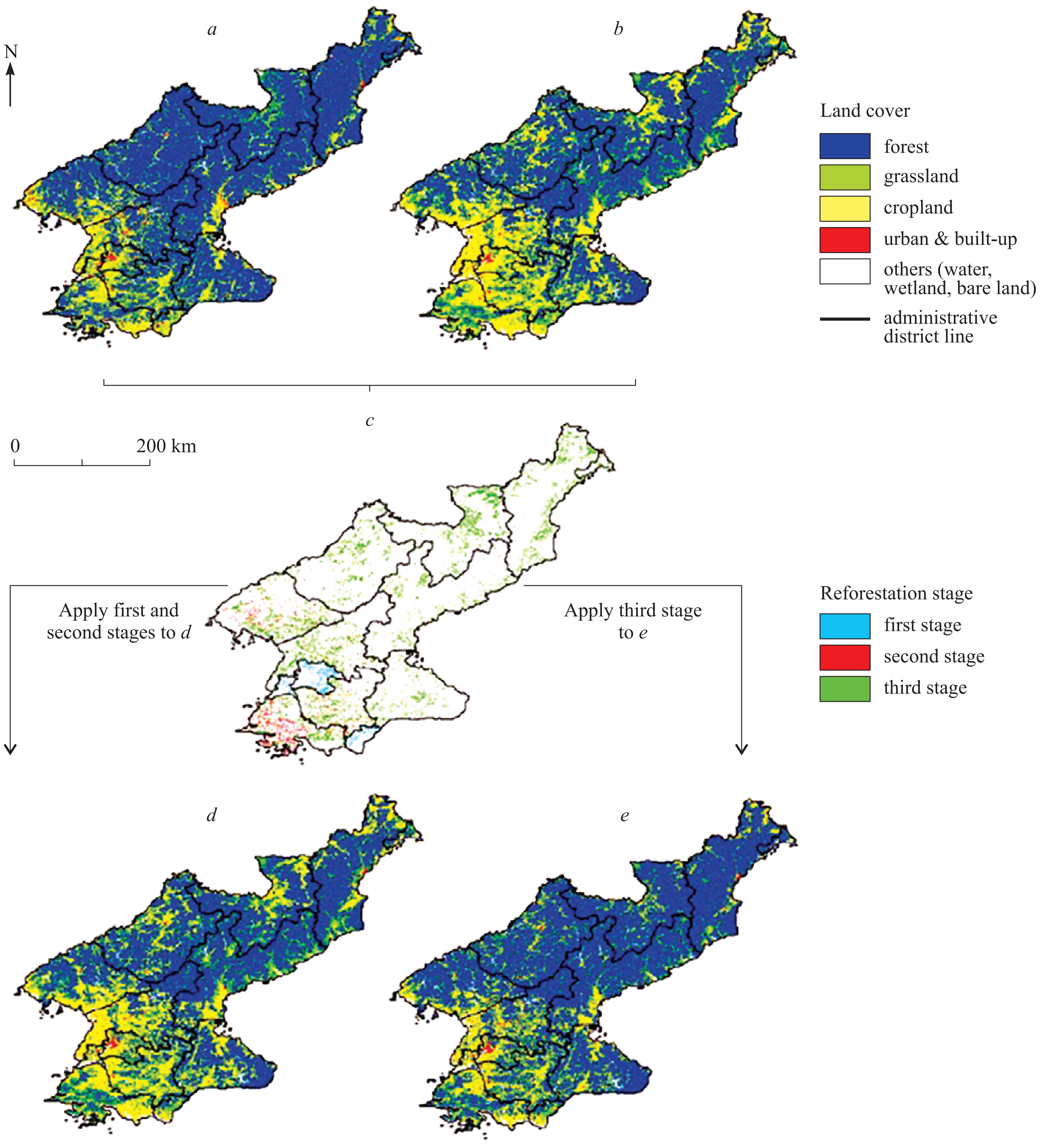

Fig. 8. Land cover change by the years of 1980–2050: *a* – 1980; *b* – 2000; *c* – area to be planted; *d* – 2020; *e* – 2050.

gases (VISIT) model to estimate the changes of the level of carbon sequestration in North Korean forests (Fig. 8).

They review the carbon budget change and land cover change by applying a reforestation scenario by taking into account the historical records of deforestation from the 1980 to 2000s. Although there are still limitations in terms of the accuracy of the input data however, it has an important implication with respect of the carbon tradeoffs from deforestation and change of carbon budget by the reforestation scenario. Such studies will provide new perspectives on the role of temperate forests and its potential as carbon sink of the region.

While the impact of mid-latitude forests on global climate variations can be minimal, however, the regional implication of that should be highlighted since the increase and decrease in forest cover is capable of driving changes in regional circulation and precipitation (Swann et al., 2012). Predicted impoverishment and death of forests over major parts of the ecotone will negatively impact the regional carbon budgets. Decrease of forest cover will have also other negative impacts on environment and stability of landscapes (Green growth…, 2012; Swann et al., 2012).

Carbon dioxide (CO_2) concentration level has grown for decades with industrialization. Despite the continuous industrial expansion, the CO_2 level fluctuation is observed, which has been driven by the terrestrial ecosystems (carbon sink). Andres et al. (2012) examined the mean sink, trend and interannual variability in CO_2 uptake by terrestrial ecosystems in middle latitude region. For the conclusion, CO_2 balance has a close relationship with both precipitation and temperature.

Barford et al. (2001) has examined the actual CO_2 uptake in 60–80 years old forest with eddy covariance. As a result, averaged 2.0 ± 0.4 Mg C per ha per year during 1993 to 2000. Furthermore, they identified the main CO_2 fluctuation driving factors, which are stand age and composition and these two factors require management for sequestration of carbon.

Swann et al. (2012) have operated NCAR Community Atmosphere and Land models with the CASA' interactive carbon cycle and an interactive slab ocean to examine the effect of afforestation in mid-latitude temperate forest in the future, by following IPCC AR5 climate change scenarios. Based on the result of the model the researchers have deduced that the afforestation success in mid-latitude region is determined by the amount of soil moisture available to plants with the greatest warming found in water-limited regions.

Global carbon circulation is simulated by climate model experiments, and the findings suggest that the terrestrial ecosystem has sequestered significant amount of atmospheric CO_2 since 1980, with major contributions from northern mid-latitude forests (Barford et al., 2001).

Further studies. A number of previous studies on the mid-latitude region tend to focus on few isolated ecosystem processes only; carbon cycle on a country level, land cover change and its implication from both social and ecological perspectives. The importance of mid-latitude region should be highlighted with respect to its evidence on continuous degradation of lands and forests. Loss of terrestrial ecosystems' areas will transform this region from carbon sink to carbon source, while ongoing climate change will likely to further constrain the enhancement of carbon sequestration capacity. In understanding the dynamics of carbon changes of the region, one should examine and monitor the transformation of terrestrial land on a longer term basis at the latitudinal scale to examine how it contributes to global carbon budget. In this context, the problems of land degradation seems to be concentrated in specific locations, such as in Central Asia and part of East Asia in mid-latitude region, whose land has been susceptible to continuous degradation with the disturbance of intensive human activities and extreme weather conditions. Continuing desertification and land degradation will likely substantially offset and undermine the potential capacity of their cumulative contribution to the global carbon budget.

Transition to the sustainable risk resilient forest management in the mid-latitude ecotone under expected rates of climate change requires solution of a complicated problem of anticipatory adaptation of forest ecosystems to expected harsh growth conditions including understanding of the impacts of forests on hydrological regime at the landscape level; development of appropriate systems of forest protection against fire, insects and pathogens; and regulation of species composition of stands at the expense of increasing share of drought resistant tree species.

Subsequent studies should make better assessment of the loss of productive terrestrial areas with the use of remote sensing techniques to detect the areas where land degradation process seems are observed. Doing so will contribute to the establishment of adaptation and land restoration plans based on environmentally sound and resilient principles in the most vulnerable parts of the world. Furthermore, the rising temperature is projected to increase the water scarcity of the region, which will adversely affect a vast region of grassland, agricultural land and forests. The negative impacts of drought on terrestrial ecosystems, however, has been clearly underestimated. In further studies the interaction between frequent and severe droughts and their impact on vitality and productivity of various terrestrial ecosystems demand in-depth analysis which will enable us to be equipped with better knowledge on one of the most disastrous natural disturbances of the unforeseen future.

CONCLUSION

This paper has examined one of the most dynamic regions of the world: the mid-latitude ecotone of the Northern hemisphere. The population living in this region have enjoyed the privilege of exploiting abundant land and natural resources. However, they had come to learn from old development paradigms that many unexpected environmental problems become apparent at large scales, which came at the cost of indiscriminate way of development. Deforestation, continuing desertification, and transformation of carbon sink to source are evidences of over-exploitation of forest resources and excessive use and transformation of land, which all in all have been justified for the enhancement of human livelihoods. Furthermore, ongoing climate change exemplifies cumulative human activities, which have been put enormous pressure to the environment and ecosystem.

There have been a great number of researches dealing with above-mentioned environmental problems, however, the scope of research has mostly been confined to the boundary of region, country or different administrative units because of the characteristics of available data used for the research. However, latitudinal approach provides more ecological rationale, which enables us to take more holistic perspective on the mid-latitude region and its ecotone. Mid-latitude ecotone encounters the most dramatic environmental problems over the mid-latitude zone, and thus, the knowledge of other regions or countries can be formed out of the areas that are facing common problems while deriving meaning in different spatial context. There are still a number of vast endangered areas within the mid-latitude ecotone, and the terrestrial ecosystems here, particularly forests, should be better understood to provide a successful adaptation to climate change and sustainable management of natural resources to ensure the sustainability of the ecotone's landscapes and ecosystems.

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ВВЕДЕНИЕ В ЭКОТОН СРЕДНИХ ШИРОТ: УСТОЙЧИВОСТЬ И ЭКОЛОГИЧЕСКИЕ ВЫЗОВЫ

Дж. Мун[1], В. К. Ли[1], С. Сонг[1], С. Дж. Ли[1], С. Б. Хео[1], А. Швиденко[2, 3], Ф. Кракснер[2], М. Ламчин[1], Й. Дж. Ли[4], Й. Джу[1], Д. Ким[5], Г. Цуй[6]

[1] *Университет Корё, Колледж наук о жизни и биотехнологии*
Республика Корея, 02841, Сеул, ул. Анамро Сеунгбукгу, 145, Ист билдинг, 322

[2] *Международный институт прикладного системного анализа (IIASA)*
Австрия, 2361, Лаксенбург, Шлосплатц, 1

[3] *Институт леса им. В. Н. Сукачева СО РАН – обособленное подразделение ФИЦ КНЦ СО РАН*
Российская Федерация, 660036, Красноярск, Академгородок, 50/28

[4] *Корейский институт окружающей среды*
Республика Корея, 30147, Седжон-си, ул. Сичьенг-даеро, 370, здание Б

[5] *Национальный исследовательский фонд Кореи*
Республика Корея, 06792, Сеул, р-н Сеочо-гу, ул. Хеонреунг-ро, 25

[6] *Яньбяньский университет*
Китайская Народная Республика, провинция Гирин, Яньцзы, ул. Гонгуян, 977

E-mail: jooyn.moon@gmail.com, leewk@korea.ac.kr, cholhosong@gmail.com, cristallize@naver.com, seongbongh@gmail.com, shvidenk@iiasa.ac.at, kraxner@iiasa.ac.at, naska_l@yahoo.com, leeej8912@gmail.com, zulim1118@gmail.com, daminkim14@gmail.com, cuiguishan@ybn.edu.cn

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Зона средних широт может быть в широком смысле определена как часть Северного полушария между 30° и 60° с. ш. На этой территории расположены 36 стран, большинство из которых сталкиваются с проблемами развития и бедности и в которых проживает около половины населения всей планеты. Анализируя главные экологические проблемы данных территорий, это исследование устанавливает рамки региона и ограничивает его 30°–45° с. ш. В большинстве своем он расположен в теплой умеренной зоне. Последствия изменения климата здесь видны уже сегодня – повышение температуры происходит одновременно со снижением количества атмосферных осадков. Прогнозы подтверждают развитие этих тенденций в XXI в.: количество и вредоносность засух, а также нехватка воды для растительности будут только увеличиваться. Наряду с изменением климата в средних широтах довольно часто наблюдаются деградация земель и вырубка лесов. Например, Корейский п-ов, который разделен на Северную и Южную Корею, характеризуется совершенно разным состоянием лесов. Обезлесение в Северной Корее очень быстро усугубляется из-за чрезмерных размеров заготовки древесины и возрастающего антропогенного давления. Подобные проблемы не ограничиваются Корейским п-овом, а распространяются на многие территории средних широт. В этом контексте важное значение приобретает понимание роли наземных экосистем, расположенных на разных широтах, в обеспечении устойчивости к негативным последствиям изменения климата и поддержании стабильности окружающей среды и ландшафтов.

Ключевые слова: *экотон средних широт, обезлесение, деградация земель, опустынивание, изменение климата, изменение углеродного цикла.*