

Practice and Research Progress on Ecosystem Conservation in Transboundary Areas

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Abstract: Many ecosystems extend across national or political boundaries. The consistent and effective protection of these ecosystems in transboundary areas (ETAs) is an important global research focus. Previous research on the protection of such areas can be categorized into seven themes: 1) ecological conservation of a single ETA; 2) investigation of the effects of a single conservation measure on a specific ETA; 3) determination of species-level effects due to ETA conservation; 4) comparison of the same protection measures between different ETAs; 5) introduction of a single conservation measure to a specific ETA; 6) understanding the relationship between conservation and sustainable development; and 7) generalization across multiple ETA conservation cases. The protection of ETAs involves various considerations, including funding support, demand and will for collaboration, community and public participation, historical and cultural factors, political backgrounds, uniqueness of biological resources, formulation of laws and regulations, founding of specialized administrative departments, non-governmental organizations, and fairness. Here, we briefly explain the research themes and considerations related to ETA conservation. The most important finding is that most major research themes do not focus on the challenges of ETA conservation. We use two nature reserves located between China and North Korea as examples to identify specific ways to improve ETA conservation on Changbai Mountains. The efficiency of ETA administration still remains low. The study of ETA conservation should focus on concrete regional information and aim to improve existing measures through the accumulation of experience.

Keywords: ecosystem in transboundary area (ETA); international cooperation; transboundary cooperation; regional sustainable development; terrestrial ecosystem

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1 Introduction

Borders between different countries or administrative regions of a single country represent political boundaries; however, they do not always represent natural ecosystem boundaries (Zbicz, 1999). Divergent policies on land use and socioeconomic development between both sides of a political boundary can increase difficulties in ecosystem protection across the border. Collaborative protection of ecosystems in transboundary areas (ETAs) is important for reducing the chance of species' extinc-

tion and maintaining natural habitats and native biodiversity. The implementation of ETA protection measures can help prevent damage to regional ecosystems due to tourism and poaching (Tamburelli, 2007; Vasiljević and Pezold, 2011; Tang *et al.*, 2011). Transboundary conservation activities can facilitate regional protection of local cultural relics, provide a platform for trade on both sides of a border, and alleviate poverty in rural areas. In order to achieve more effective ETA conservation, researchers and organizations around the world have conducted academic investigations and investigative ex-

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periments (Zbicz and Green, 1997; Tang *et al.*, 2010; Sandwith *et al.*, 2001; Vasiljević and Pezold, 2011). As the number of cases of ETA conservation increases, relevant administrative strategies need to be enhanced and conservation activities need to be intensified. At the same time, research directions and topics constantly need to be adjusted. It is important to understand the history and current status of ETA conservation. It is also important to identify research methods that correspond to the challenges of ETA conservation. The purpose of this paper is to summarize critical issues in ETA conservation and provide recommendations to aid researchers and administrators in developing better strategies and practices for ETA conservation.

2 A Brief History of ETA Protection

Various terms have been used in reference to protected ETAs, such as 'transboundary protected area' or 'park for peace' (Sandwith *et al.*, 2001). As specified by the International Union for Conservation of Nature (IUCN), a transboundary conservation area refers to a terrestrial or marine area that spans different countries or administrative areas of the same country. Compared with a general conservation area, the greatest distinction of ETA conservation is that relevant administrative authorities collaborate by legal or other means to achieve biodiversity conservation and sustainable use and protection of natural and cultural resources (Sandwith *et al.*, 2001).

Poland and former Czechoslovakia first conceived of a transboundary park in 1925 and signed a contract for its establishment through international cooperation. However, because of war, the proposed transboundary park was not built until 1945 (Thorsell and Harrison, 1990). The first transboundary conservation area that gained international recognition was the Waterton/Glacier International Peace Park, which was established by a joint effort between the US and Canada in 1932 (Sandwith *et al.*, 2001).

In the first few decades after the establishment of the concept of transboundary conservation, the number of protected ETAs grew slowly. By the 1990s, protected ETAs began emerging at a surprisingly high rate. Shi *et al.* (2012) provided statistics on the number of protected ETAs over the world from 1988 to 2007 (Fig. 1). In 1988, 59 ETAs were protected (Zbicz and Green, 1997), and by 2007, the number of protected ETAs reached 227

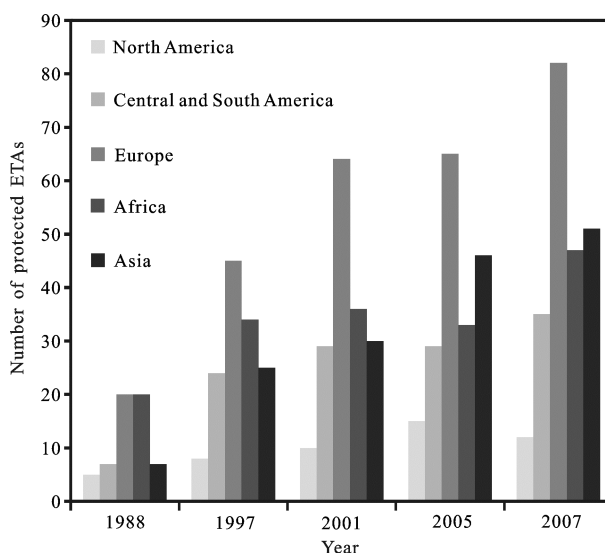


Fig. 1 Number and distribution of protected ETAs from 1988 to 2007. Data source: Shi *et al.*, 2012

(Lysenko *et al.*, 2007). The geographic distribution of protected ETAs has also changed. In 1988, protected ETAs were mainly located in Europe and Africa. After 2005, Asia surpassed Africa as the continent with the second largest number of protected ETAs, after Europe (Schoon, 2005).

3 ETA Conservation Research Themes

A large amount of information on ETA conservation practices has accumulated, and academic research on the conservation of ETAs has made substantial progress. In general, past studies have focused on seven themes, which are described below.

3.1 Conservation of a single ETA

Research dedicated to this purpose usually covers the entire history of ETA conservation. In the early phase of ETA conservation, researchers briefly summarized the status of ecological conservation. By discussing the influence of human activities on ecosystem degradation and the negative impacts brought by conflicting administrative policies on ecological systems, the significance of ETA conservation was highlighted and some feasible options were proposed. Given the limited number of ETA conservation examples in the early phases of research, researchers have suggested that successful ETA conservation measures that have gained international recognition should be studied and used for developing protection plans. Marcot *et al.* (1997) proposed a plan

for biodiversity protection in a forest on the border between China and Russia. Hu *et al.* (2010) summarized examples of transboundary collaboration between countries along the Danube River and also proposed suggestions for transboundary collaboration along rivers in China.

More diversified methods for ETA conservation have been suggested in response to the increase in the number of protected ETAs and advances in landscape ecology, ecological conservation, and resource economics. However, different outcomes may be observed when applying the same method to different ETAs. To evaluate the current status of ETAs, researchers measure the adaptability of new policies and propose options with regional specificity and operability. For example, Tang *et al.* (2011) researched the ecological landscape of the Changbai Mountains between China and North Korea and proposed measures for its protection.

3.2 Effects of a single conservation measure on a specific ETA

One feature of such studies is the evaluation of the intensity and outcome of a specific ETA conservation measure. On the basis of the comparison of the social, economic, political, and environmental backgrounds of both sides of a border, factors that influence ETA conservation execution intensity are identified. Consequently, suggestions for increasing the execution intensity of a conservation measure in an area are proposed, and the direction of policy making and relevant research is clarified. For example, Schindler *et al.* (2011) conducted an evaluation of the protection of the Eastern Rhodopes mountains located on the border between Greece and Bulgaria. Such research is based on the assumption that the research area has an intact administrative system for transboundary conservation that has been in operation for some time. Moreover, this type of research requires the study of theme 3.1 as a foundation.

3.3 Species-level outcomes of ETA conservation

The purpose of these studies is to determine whether indigenous species benefit from ETA conservation measures and appropriate population sizes are maintained. These studies focus on areas with intact transboundary conservation systems. Species behavior and biological characteristics are evaluated to measure the effectiveness of protected ETAs. For example, Lamber-

tucci *et al.* (2014) studied the reproduction and feeding behavior of Andean condors, as well as the effects of political factors and topographical boundaries, and concluded that current ETA protection measures were insufficient.

3.4 Comparison of common protection measures between ETAs

The purpose of such studies is to identify the factors that influence a specific measure's effects. For convenient comparisons, researchers must have access to data from different transboundary conservation areas that have executed the same protection measure. The effects of the specific measure are evaluated together with the social, economic, and political conditions and administrative systems of the research areas. Thus, the factors that influence the protection measure's outcomes can be identified. For example, Leibenath *et al.* (2010) identified and summarized the factors influencing ecological network construction for different ETA conservation projects in Germany.

3.5 Introducing a single conservation measure to an ETA

The purpose of this category is to examine the outcomes produced by the introduction of a new protection measure to a single ETA. In this type of research, comprehensive consideration should be given to an area's natural, economic, social, political, and historical characteristics, and possible effects from the introduction of specific protection measures are discussed. For this category of research, researchers often refer to the results of studies focused on theme 3.4. In one example, Büscher (2012) discussed the effect of ecosystem service fees on the Maloti-Drakensberg area in South Africa.

3.6 Relationships between conservation and sustainable development

This topic of research has a relatively long history. Many researchers have proposed that the extensive and long-term application of ETA protection measures is not possible or economically feasible in many cases. The key is to create a balance between protection and development. In these investigations, the applications of resources, economics, and environmental management to ETA conservation have been considered. For example, Thomson *et al.* (2013) investigated the balance be-

tween ETA conservation and the development of rural husbandry in South Africa.

3.7 Generalization of knowledge from multiple ETA conservation cases

This topic reviews the research processes and empirical manuals of relevant organizations and unions. The IUCN has published many manuals on ETA conservation that generalize knowledge from various countries (Bennett, 2004; Vasiljević and Pezold, 2011). These efforts have made great contributions to learning and disciplinary development, which are useful to future managers and scientists.

Studies addressing the problems and solutions related to ETA conservation have increased over the years, as demonstrated by the research in the seven themes described above. The most recent work in this area includes evaluations of current protection measures, and these research prospects have been broadened by the accumulation of case studies on ETA protection measures.

4 ETA Conservation Research Methods

Research on ETA conservation includes the following two steps: background investigation and subject investigation. These steps are discussed separately below.

4.1 ETA background investigation

The first step is to collect fundamental information about a target ETA, including its dimensions, geographic location, natural resources, and regional socioeconomic and political features. The administrative system and land use patterns in the research area should be understood, and the history and effects of protection should be reviewed. When conducting research on a single ETA, background data on the research area should be concrete and abundant. These data may come from surveys of administrative areas or through the combination of remote sensing data and topographic maps. Geographic information systems (GIS) can be also used for land-use analyses. Recent advances in geospatial technology, including remote sensing, GIS, and global positioning systems, can reduce the workload involved in land-use analyses. If relevant studies have been carried out in an area of interest, the literature can be reviewed for information (Marcot *et al.*, 1997; Nakul *et al.*, 2007; Tang *et al.*, 2011; Büscher, 2012; Thomson *et al.*, 2013; Wilkerson, 2013; Lambertucci *et al.*, 2014;

Selier *et al.*, 2014). When conducting research on the conservation of several ETAs conservation, connections between different ETA conservation projects should be identified. For example, several ETA projects may belong to a larger ETA conservation project if they are all located within the same region (Leibenath *et al.*, 2010), or the individual projects may be classified as one ecological landscape (Oszlányi *et al.*, 2004).

4.2 ETA subject investigation

The methods for research built upon empirical evidence are as follows: 1) reviewing existing literature, formal documents, laws, regulations, and other recorded information; 2) carrying out in-depth interviews with specialists in the area of interest; 3) designing questionnaires for personnel engaged in ETA conservation; and 4) participating in conferences and activities related to specific conservation projects, observing modes of management, and becoming involved in a project's execution process (Leibenath *et al.*, 2010; Schindler *et al.*, 2011; Büscher, 2012). For example, Leibenath *et al.* (2010) used literature reviews, interviews with specialists, and large-scale telephone interviews to obtain data on ecological network construction for different ETA conservation projects at the borders of Germany. Then, they compared the ecological network construction processes with the attributes of respective projects to identify correlations between the two.

For research based on disciplinary theories, classical theoretical models are usually employed (typically economic or biological models) and the results are analyzed in combination with geospatial techniques. For example, Tang *et al.* (2011) analyzed the reasons for the limited effects of forest ecosystem protection using a theoretical model in landscape ecology. Wilkerson (2013) used a conceptual model to simulate plant invasion and identified several potential problems with ETA conservation.

5 Challenges in ETA Conservation

Successful ETA conservation requires a large amount of labor, resources, and money. The main challenges of ETA conservation, identified from current research, are summarized in the following paragraphs.

5.1 Funding support

ETA conservation requires long-term and stable financial support because ecosystem protection measures

generally can not take effect over short time periods (Schindler *et al.*, 2011; Büscher, 2012). Moreover, maintaining effective ETA conservation requires ample communication and collaborative management and coordination across country or administrative area boundaries. The training of managerial staff, establishment of managerial departments, and formulation of administrative regulations are impossible without money, and the execution of ETA protection measures requires sufficient funding.

5.2 Demand and will for collaboration

All parties involved in ETA conservation should demand and have the will for collaboration. If one or several parties are not willing to collaborate, the executors will probably use the money for purposes other than ecological conservation, in which case, regional collaboration would have limited functionality (Lange, 2009).

5.3 Community and public participation

Community and public participation also plays a key role in the execution of ETA protection measures. Community and public participation leads to a positive public opinion on the execution of administrative rights and fulfillment of obligations by administrators (Leibenath *et al.*, 2010). Certain economic or biological incentives are necessary to encourage the community and public to contribute to ETA conservation efforts (Nakul, 2007).

5.4 Historical and cultural factors

On the two sides of a border, the residents of different communities may be isolated from or even antagonistic to one another. For example, in the ETA conservation project at Maloti-Drakensberg, the two parties had a history of antagonism and were socially unequal. These differences created a huge resistance to the execution of ETA conservation measures (Bücher, 2012). Unfriendly relations stemming from historical and cultural factors are likely to cause incompatibility between parties and result in less willingness to execute important ETA protection measures.

5.5 Political background

If one or several parties engaged in ETA conservation suffer from unstable political situations, the leaders of such parties may not have the capacity or willingness to

cooperate on conservation efforts (Bücher, 2012). Clearly, this is not beneficial to the execution of ETA conservation.

5.6 Uniqueness of biological resources on either side of an ETA

Schindler *et al.* (2011) evaluated ETA conservation on both sides of the Eastern Rhodopes Mountain between Greece and Bulgaria. These two countries differed in the protection intensity of different biological populations. Generally, the administrators tended to devote greater protection efforts to the rare plant and animal species that were native to their own administration areas. If an area has unique biological resources, stakeholders in the area may be more willing to execute relevant ETA protection measures.

5.7 Formulation of laws and regulations

The establishment of regional laws and regulations pertaining to ETA conservation can help consolidate the foundation of transboundary collaborations, enhance regional consistency with regard to administrative measures, and increase management efficiency (Leibenath *et al.*, 2010; Schindler *et al.*, 2011).

5.8 Founding of specialized administrative departments

Lack of administrative authorities or responsible persons is a major reason for the low efficiency of ETA protection measure execution (Schindler *et al.*, 2011). The establishment of specialized administrative authorities makes it possible to achieve accountability for inappropriate actions with respect to the execution of ETA protection measures. As a result, the enforcement of ETA protection measures will increase.

5.9 Non-governmental organizations

Non-governmental organizations can play a part in ETA conservation. A study on ETA conservation projects in Germany found that non-governmental organizations have a positive role in promoting the execution of ETA conservation measures (Leibenath *et al.*, 2010).

5.10 Fairness

ETA conservation collaborations should take into account the fair allocation of economic and political pressures among the administrative regions involved. The

World Bank once changed the exchange rate for one party involved in ETA conservation collaboration in South Africa, and this directly caused the collaboration's breakdown (Büscher, 2012).

6 A Case study on ETA Conservation Between China and North Korea

Temperate zones have the largest human population, but the least amount of protected areas on Earth (Potapov *et al.*, 2008; Schmitt *et al.*, 2009). Nature reserves in temperate zones play an important role in ecosystem conservation and biodiversity protection. There are two adjacent nature reserves on the Changbai Mountains, one in China and the other in North Korea, which protect the largest contiguous forest landscapes in the temperate area of the Eurasian continent (Shao *et al.*, 1996; Tang *et al.*, 2011). As they are located on either side of the national border, the two nature reserves in the Changbai Mountains do not receive mountain-wide ecosystem conservation. The two nature reserves are managed differently and suffer from different threats (Table 1).

The greatest challenge for ecosystem conservation and biodiversity protection in the Changbai Mountains is that habitat loss, fragmentation, and degradation occur on both sides of the national border (Shao and Zhao, 1998; Tang *et al.*, 2010; Piao *et al.*, 2011; Tang *et al.*, 2011). Habitat loss is caused by deforestation due to urban development in China and agriculture in North Korea. Habitat fragmentation results from logging activities within the old-growth forests around the nature reserve in China and within the nature reserve in North Korea. Habitat degradation is a result of 'invisible' damage due to human activities, such as illegal hunting and the collection of commercial and medicinal plants,

fruits, and seeds. Habitat loss, fragmentation, and degradation have direct and indirect effects on ecosystem health and biodiversity protection (Shao *et al.*, 2005; Zhou, 2008; Piao *et al.*, 2011). ETA conservation in the Changbai Mountains experiences every challenge discussed in section 5. Challenge 5.2 (demand and will for collaboration) is particularly critical in the Changbai Mountains, followed by challenge 5.8 (founding of specialized administrative departments).

Various measures of ETA cooperation are effective for solving conservation problems that exist across national borders (Sandwith *et al.*, 2001). In the case of the Changbai Mountains, economic income and food production are the major causes of habitat-protection problems. It is important for the two countries to strengthen bilateral cooperation in five areas: 1) addressing the research themes 3.1, 3.4, and 3.6 discussed above for the purpose of mountain-wide ecosystem conservation and biodiversity protection; 2) sharing experiences in nature reserve management and strengthening ETA background investigations; 3) providing technological support for promoting efficient agriculture and energy use; 4) using economic incentives for the improvement of ecosystem conservation; and 5) appealing to international organizations for assistance. There is always hope for ETA conservation in the Changbai Mountains as long as the two countries have political and economic ties. The first step is for the two governments to initiate cooperative dialogues and projects related to ETA conservation.

7 Conclusions

The increasing implementation of ETA conservation measures throughout the world has improved knowledge and experience related to ETA conservation. As discuss-

Table 1 A brief comparison of various factors affecting ecosystem conservation of two nature reserves on Changbai Mountains

	China	North Korea
Area of nature reserve	200 000 ha	132 000 ha
Dominant forest cover	Spruce-fir forest, Korean pine-broadleaf forest	Spruce-fir forest, Larch forest
Forest damage inside nature reserve	Pine seed harvesting	Strip logging
Forest damage outside nature reserve	Logging, urbanization	Deforestation for farming
International collaboration	Easy in principle	Difficult in practice
Research activities	Many but few on conservation research	Few research publications
Tourist management	Open to everyone	Controlled for selected people
Limiting factors for ecosystem conservation	Pressure from fast economic development	Lack of food and funds

Notes: Shao *et al.*, 1996; Shao and Zhao, 1998; Tang *et al.*, 2010; Piao *et al.*, 2011; Shao, 2011; Tang *et al.*, 2011

ed above, ETA conservation research has been broadened and diversified. Although the level of collaboration on ETA conservation projects is still low, the scope of collaboration has been extended. Currently, research on ETA conservation has room for improvement. This article provides an outlook for the enhancement of ETA conservation.

The need for ETA conservation has attracted increasing attention, and research on ETA conservation is expanding. However, the major research themes are not related to most of the challenges in ETA conservation. Consequently, the efficiency of transboundary administration still remains low, which can diminish the effectiveness of ETA protection measures. Responses from different administrative areas operating in collaboration need to be addressed.

Evaluating the effectiveness of ETA protection measures is a critical issue in ETA conservation research. So far, the IUCN has developed criteria for an evaluation framework. However, the sensitivity of system parameters and validity of evaluation results can vary from one area to another. Thus, establishing indicators and analysis methods to assess the performance of transboundary biological management is important for the execution of ETA protection measures.

Although similarities exist between the various modes of collaborative management, the distinctiveness of each ETA should not be neglected. Successful cases can not be blindly replicated. Thus, the study of ETA conservation should focus on concrete regional information and aim to improve existing measures through the accumulation of experience.

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