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## LARGE CARNIVORES OF THE CHERNOBYL NUCLEAR POWER PLANT EXCLUSION ZONE

M. Shkvyria<sup>1</sup>, D. Vishnevskiy<sup>2</sup>

<sup>1</sup> I. I. Schmalhausen Institute of Zoology of NAS of Ukraine,  
B. Chmielnicky str., 15, Kyiv, 01601 Ukraine

<sup>2</sup> SSSIE "Chornobyl radioecological centre" Shkilna str., 6,  
Chornobyl, Kyiv region, 07270 Ukraine

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**Large Carnivores of the Chernobyl Nuclear Power Plant Exclusion Zone. Shkvyrya M., Vishnevskiy D.** — During nine years observations on large carnivores of Exclusion Zone have been carried out. Species composition and the number of large predators in the Exclusion Zone correspond to the regional conditions. The presence of bears and permanent stay of the lynx in the Exclusion Zone was confirmed. Six wolf packs were counted. The use of an anthropogenically transformed areas, the shift of the daily regime of activity and characteristics of the diet are the most specific features of this animal group.

**Key words:** wolf, lynx, bear, exclusion zone.

**Крупные хищники Зоны отчуждения Чернобыльской АЭС. Шквыря М., Вишнеvский Д.** — Исследование крупных хищников Зоны отчуждения проводилось в течение девяти лет. Установлено, что набор видов и их численность в Зоне отчуждения в целом соответствуют региональным условиям. Подтверждено присутствие на территории зоны медведя и постоянное нахождение рыси. Учтено шесть волчьих стай. Наиболее специфическими чертами данной группы животных на исследуемой территории являются следующие — использование антропогенно изменённых территорий, сдвиг в режиме суточной активности и особенности рациона питания.

**Ключевые слова:** волк, рысь, медведь, зона отчуждения.

### Introduction

Political events associated with the disintegration of the USSR and the creation of the independent state of Ukraine led to changes in economical situation, which in their turn affected the structure of the productive forces and led to the changes in environmental conditions. Demographic trends and changes in agriculture and mining affected significantly the distribution of the human population of the country. There appeared relatively large areas with a long history of development, where production activities were phased out and hence the population reduced. Accordingly, in these areas the process of restoring the natural environment began turning them into new habitats for animals. There is a problem of environmental impact assessment and, above all, of the environmental potential. The existing in the country theory and practice of environmental measures are based on the conservation paradigm of undisturbed natural systems and do not consider the methods for their recovery. As a result, the question of value of anthropogenically modified areas remains a subject of debate. Solving of this problem is possible by exploring the indicative groups of fauna on the anthropogenically modified areas, which remain for a long time without human influence. The Exclusion Zone formed as a result of a disaster at the Chernobyl Nuclear Power Plant in 1986 can be suggested. Large carnivores are recommended as an indicative group of fauna.

### Fauna composition of the large carnivores in Ukraine

At present a group of large carnivores of Ukraine includes three species: grey wolf, brown bear and Eurasian lynx. Bear and lynx are listed as endangered species. During their long history large carnivores have been objects for extermination, hunting or number control or an object of conservation. Irrespective of their status these species have a considerable potential of conflict with man.

## Wolf

The wolf (*Canis lupus* Linnaeus, 1758) is a widespread in Ukraine predator characterized by high environmental plasticity. The number of wolves in Ukraine is between 2, 500 and 3, 000 individuals before a breeding season at the end of a hunting season. The maximum population size is reached immediately after birth and held till the autumn battue on the ungulates, when the first in the year mass elimination of wolves occurs.

The pack sizes vary. For Ukraine, an average pack size is from 5 to 7 animals, but there are groups of 3–12 wolves and the largest variability in the pack size is typical for the steppe zone.

A pack in Ukraine occupies a patch from 130 km<sup>2</sup> in the steppe zone to 390 km<sup>2</sup> in the woodland (Shkvyrya, 2008).

The wolf in Ukraine preys mainly on wild ungulates, rodents and domestic animals. Among the secondary feed are wild and cultivated plants, birds, fish, reptiles, amphibians, and insects. Preying activity of the wolf and the choice of prey depend on the season and marital status (a pack member or not, young or old). The research of this aspect in Ukraine reveals the predominance of large wild animals among the prey of packs and a large share of secondary feed and domestic animals preyed by single wolves (Shkvyrya, Kolesnikov 2008). Wolf is a game species. Hunting on wolf is not regulated in fact; moreover, poaching is actually encouraged as regulatory measure. The limitation of hunting period from October to March will not be of practical use due to the fact that it is quite difficult to hunt a wolf by legal methods in this period.

## Lynx

The lynx (*Lynx lynx* Linnaeus, 1758) inhabits the Transcarpathian, Ivano-Frankivsk, Lviv, Chernivtsi, Kyiv, Chernihiv, Rivne and Zhytomyr regions.

The most plausible estimates of the lynx number range from 400 to 500 individuals, with major number calculated in the Carpathian region. The patch of an individual female with cubs in the lowland forests rarely exceeds 100 km<sup>2</sup>, while a male can live on a territory of more than 300 km<sup>2</sup> (Zhyla, 2002). The diet of lynx in Ukraine consists of roe deer, hare and mice; birds are preyed rarely. The lynx rarely preys on domestic animals. The species is characterized by a high degree of anthropophobia.

Lynx has a status of a “rare” species in the Red Data Book of Ukraine (Shkvyrya, Shevchenko, 2009). However, poaching is currently the most important factor along with the degradation of the environment, which limits the number of lynxes in Ukraine.

## Bear

The bear (*Ursus arctos* Linnaeus, 1758) inhabits the Transcarpathian, Ivano-Frankivsk, Lviv and Chernivtsi regions. The bears' rare visits are registered in the Sumy and Kyiv regions. According to our data the number of bears does not exceed 250 individuals (Shevchenko, Shkvyrya, 2009). The individual patches of bears have a complicated structure and are presented by separate loci of certain functional load — feeding sites, den patches, and the main ways of transitions.

Females usually stay in the patch of 90 km<sup>2</sup>; males in the spring transit over a larger territory and in autumn keep to a small area, move little and spend most of the time feeding (Bears, 1993). A bear diet strategy is the most diverse among the large carnivores. It is exactly the bear's pantophagy that determines the complexity of its behavior. The diet has a clear seasonality with the plant food dominating. Anthropogenic resource makes also a certain percentage in the bear diet. The species is listed as “endangered” in the Red Data Book of Ukraine. Similarly to the case of the lynx, the conservation measures are not implemented practically. Environmental degradation, high level of disturbance factor and poaching are the causes of depopulation of bears.

## Characteristics of the area under study

The Exclusion Zone resulted from the Chernobyl disaster in 1986. It was formed in May 1986 after the evacuation of people. Its boundaries were allocated on the basis of the radiological situation that is why they coincide with neither administrative nor geographical borders. The Exclusion Zone is a control access area, accordingly secured. The law forbids permanent residence and most of land use connected with the use of natural resources. The number of personnel engaged in work in the area is about 4, 000 people. The distribution of human activity is local: the town of Chernobyl, and the industrial area of the Chernobyl Power Plant.

Geographically the Exclusion Zone is referred to the Polissya physiographic region, which is located in the river Pripyat basin, and is swampy lowland with pine forests. Before 17th and 18th centuries this whole area was completely covered with mixed forests. Its economic development, especially in the 19th century, is characterized by deforestation. At first the forests were burned for pastures that were abandoned for natural forestation after a short-term use. Besides, the forests were logged in great amounts for potash, glass and vodka production, as well as for sale. As a result, the central part of what makes the modern Exclusion Zone decreased to 11–12%. The first activities on reforestation began in the 20's, and mass reforestation was made in the 50s and 60s of the 20th century. During this period the forest area increased by four times and reached about 50%. Pine forests dominate here, which is typical for sandy soils. Deciduous forests grow on the podzolic soils of watersheds and on the loess and soddy high “islands”.

Fallow lands (30% of the territory) are the former agricultural lands, which are now on the meadow stage of succession. On some of them the process of reforestation is observed. On others due to the changes in soil

and hydrological conditions, the areas not peculiar to the forest zone with medium-steppe, freshly-steppe and meadow-steppe regime formed (Petrov, 2001).

The man-made objects — settlements, roads, industrial facilities and infrastructure — occupy about 7% of the area. The vast majority, except those that are in operation, have been gradually deteriorating turning into a natural environment as a result of secondary succession (Bidna, Petrov, Balashov, 2000).

The surface waters are presented by a large river, the Pripyat, and a number of smaller rivers: the Uzh, the Slovechna, the Sakhan and others. Besides there is a dense system of reclamation canals in a state of self-regulation. The floodplain of the Pripyat and the Uzh have numerous channels and former river beds. The floodplains of small rivers have been drained and the channels straightened. The border area includes the north-western part of the main lake of the Kyiv reservoir.

The ecological situation in the Exclusion Zone differs significantly from other areas of the region. Firstly, a new abiotic factor — ionizing radiation — appeared there. Secondly, evacuation of people, collapse of economic activity and the introduction of the control access regime have led to the restoration of natural systems (secondary environmental impacts).

Despite the fact that biota is a component of landscape most vulnerable to ionizing radiation, the changes on the group levels were recorded only in the first 2–3 months after the accident on the most contaminated lands situated very close to the Chernobyl Power Plant. Later the composition and structure of zoocenosis have gradually changed towards the reproduction of indigenous complexes inherent to this natural and geographical area.

The survey conducted from 1986 to 1996 showed a significant increase in number of hunting fauna species, an increase of rare species and returning of the species, which had disappeared from this area. This work resulted in establishing some basic characteristics of the animal world of the Zone, namely the identity of fauna species of the Polissya region, stabilization of the number and species composition in the middle 1990s, spontaneous restoration of wildlife to the steady state, which was characteristic of the area before the intensive development of the region in the 18th century.

There are not many data on the populations of large predators in the present Exclusion Zone before the accident and the first years after it. As for the wolves, their number, according to the data of hunting statistics and the surveys of the researches of the Institute of Zoology (Haychenko, Kryzhanivskyy et al., 1988), was at the same level that once again proves the stability and conservatism of the forest group. Lynx was apparently a rare species (Boyarchuk et al., 1990). In fact there are no reliable data about the reproduction in these years. The bear has not been registered since the disappearance of the Polissya population in the early 20th century.

In the Belarussian part of the Exclusion Zone — the Polissya Radiation Reserve — the researchers pointed out the rapid growth of populations of ungulates and large predators in the period from 1988 to 1990; in 1991 and 1992 40 wolf individuals were registered (Kozlo et al., 1995; Faunistic..., 2008). There is no doubt that the Belarussian part differs favorably from the Ukrainian one by the absence of key strategic facilities — the station, towns, etc., which provides a low level of disturbance from man. Accordingly, the level of conflict with man has always been higher in the more populous Ukrainian part. In particular, this is referred to preying on domestic animals (Frantsevich et al., 1991).

## Material and methods

Field research was carried out from 2002 to 2011 in the territory of a Ukrainian part of the Chernobyl Exclusion Zone. The following traditional field research methods were used: route records and tracking footsteps, mapping of den sites of wolf packs and location of lynx and bear individuals, identification of individuals by their footprint measurements, search for feces and prey remnants (analysis of a quantitative food frequency), surveys of the employees of the Exclusion Zone, creating an electronic database of the found species. The den sites of wolves were identified by the couples' routes during mating season and the birth of the pups, records on the pups' howling and visual observations in summer. The family patches of some packs were determined by a polygon method — by the extreme points of the footsteps of the adult couples. The use of anthropogenic resource was characterized quantitatively by the facts of preying on domestic animals, feeding on cultivated crops (fodder resource) and using of towns, bridges, etc. (spatial resource).

## Results

### Wolf Number and distribution

We identified 6 alpha pairs; an average pack size ranges from 5 to 7 individuals, which allows estimating the total number of 30–40 individuals. The natural fluctuations in number must also be taken into account: the newly-born pups increase the population annually, but it is offset by deaths and dispersal.

The results of 9-year study of wolves in the Polissya region and the Exclusion Zone provide an opportunity to characterize the Zone in terms of territorial structure, characteristics of carnivores' diet and relations to human resource.

Table 1. The area sizes of family packs in the Exclusion Zone and the neighbouring forest areas

Таблица 1. Размеры семейных участков территорий зоны отчуждения и прилегающих лесных районов

Pack	The patch size of a family pack (km <sup>2</sup> )	Location
Mezhrechensky	397	Forest regions of the northern part of Ukraine
Oshytkovsky	301	Forest regions of the northern part of Ukraine
Uzhsky	246	Forest regions of the northern part of Ukraine in the Exclusion Zone

Monitoring of individual packs, in particular in the Exclusion Zone, allowed establishing the patch size of family packs. The table 1 shows the winter and seasonal maximum land patch.

It should be noted that in the territory of Ukraine, in particular in Polissya there are the largest pack patches, that can be explained by specific spatial distribution and composition of food resources, landscape characteristics and the density of wolf population (fig. 1).

It is worth pointing out that in the Exclusion Zone the family pack areas are more crowded in comparison with the territorial structure of the population in the rest of the Polissya region. This fact confirms the mapping of a pack's den sites by route-tracking of the pairs during the breeding season, birth of the young and registering of the pups' howling in summer.

Such a spatial structure (fig. 2) can be explained by two reasons. The first reason is a higher density of prey species in the Exclusion Zone if compared with the Polissya region in general. The Polissya region is characterized by a depressive state of hunting economy. Therefore, the prey species fall a victim to poachers that leads to a stable decline in the number of these species. The second reason is good biotopic conditions in the Exclusion Zone; there are many habitats, which are preferred by carnivores and prey species: mixed and coniferous forests of various types, wetland floodplain and open grassland areas.

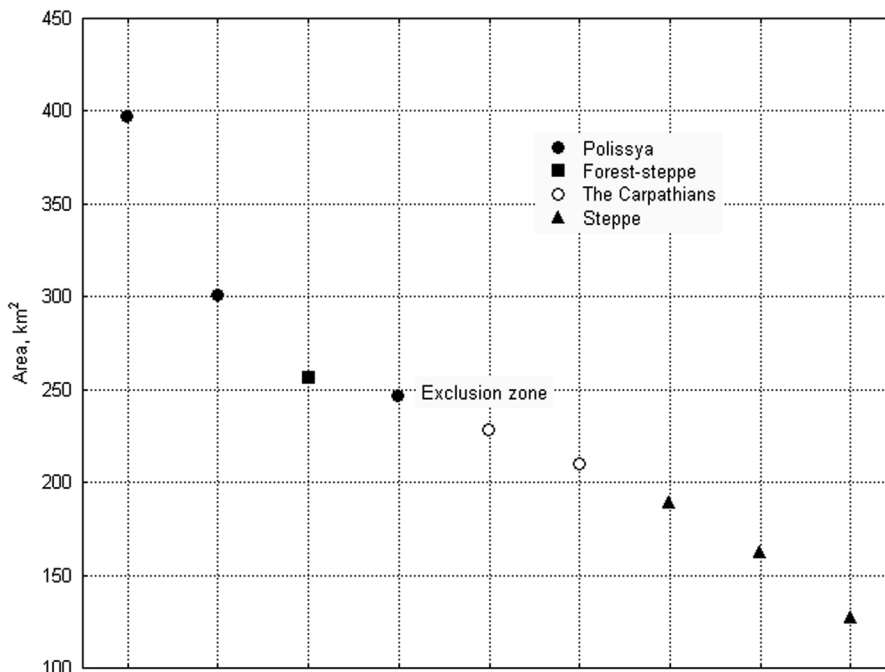


Fig. 1. The area sizes of family packs in Ukraine.

Рис. 1. Размеры семейных участков в Украине.

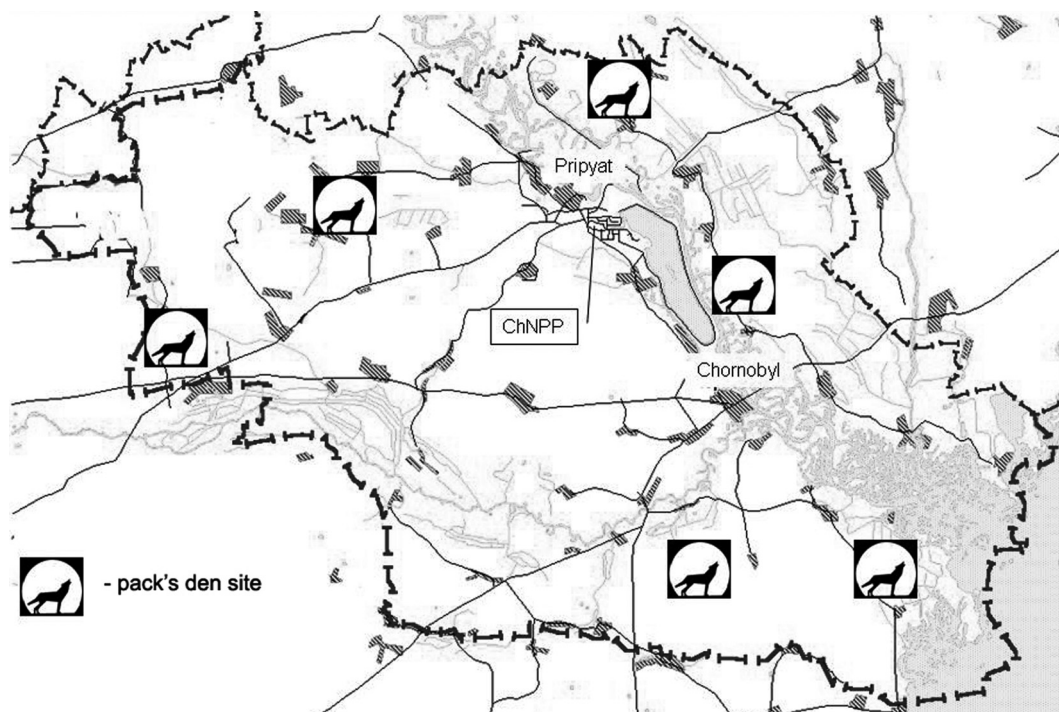


Fig 2. The spatial distribution of den sites.

Рис. 2. Пространственное распределение выводковых участков.

In addition, the vegetation of the Exclusion Zone is characterized by a high degree of mosaicism as a result of the engaging of the mechanisms of natural ecosystem dynamics. All this provides fairly high forage and protective properties of the forest in the Zone.

### Wolf diet in the Exclusion Zone

Investigation of the food showed that in general it is typical for this part of Ukraine.

Worth noting is a small share of anthropogenic food (mostly domestic animals) in the diet and minor differences in the forest region as a whole in the share of a wild boar (fig. 3).

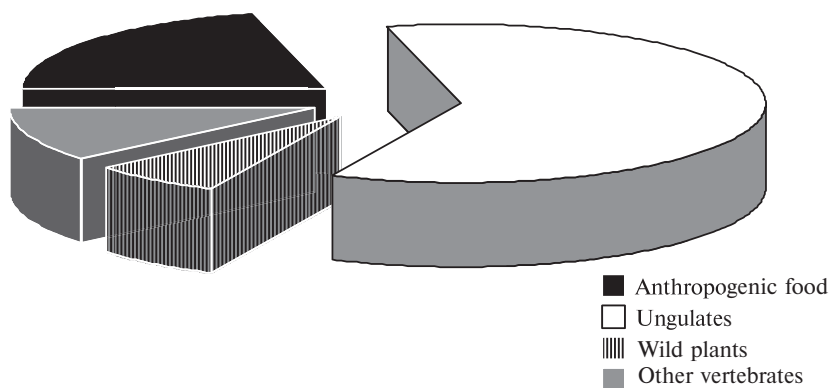


Fig 3. The wolf diet.

Рис. 3. Рацион волка.

## Lynx

### Number and distribution

Permanent stay of 4 individuals of this species in the Ukrainian Exclusion Zone area is currently confirmed by the footsteps.

### Biotopic preferences

Most of the footsteps and visual meetings occurred in forested areas with swamps or reclamation canals, often near the abandoned villages, or directly on their territories. Similar biotopic characteristics of daily routes are typical for forest regions of Ukraine — Polissya and the Carpathians (Zhyla et al., 2002; Shkvyrya, 2008; Bashta et al., 2004).

A widespread phenomenon when lynxes and wolves used the same trails and partially preferred similar habitats was also observed. This is generally typical for the Polissya area (table 2).

The table 2 shows that the main differences in biotope preferences are in the use of swamps and anthropogenically transformed areas.

For the Exclusion Zone the situation is identical except for a greater frequency of lynx registering in the anthropogenically transformed areas.

## Bear

In the 20th century this species disappeared from the fauna of Ukrainian Polissya (Tatarinov, 1956). Only rare visits to the north-eastern forest region were registered. At the moment 1 case of bear's visit to the Ukrainian Exclusion Zone has been confirmed. A tree with bear claw marks was found. In the Belarusian part of the Zone the bears have been registered since 2004 (unpublished data of G. Sysa, a Polysian radioactive reserve main expert in game keeping). The reliable findings in the nearest regions of Ukraine were registered in Sumy region (Shevchenko, Shkvyrya, 2009; pers. com. with Y. Kuzmenko, a Desna — Starogutsk Park researcher).

At the moment there are no prospects for the species to settle and form a stable breeding group because of the high levels of poaching and limited areas for resettlement.

### Use of anthropogenically altered environment

Man-made objects (roads, settlements, infrastructure, and industrial productions) occupy 7% of the Exclusion Zone area. Some of them are used permanently, such as the town of Chernobyl, Chernobyl Nuclear Power Station, forestry, check points and industrial complexes. Some of them are used occasionally and / or partially. Most of these objects are not used. Despite the small area these objects occupy, they are widespread, therefore during the counts of large predators in the Exclusion Zone we detected the peculiarities of their use by wolf and lynx.

**Table 2. The use of different biotopes of Polissya by wolf and lynx.**

**Таблица 2. Использование различных биотопов Полесья волком и рысью.**

Biotopes	Wolf, %	Lynx, %
Forest	44.02	48.24
Swamp	9.24	32.7
Open areas	9.94	6.05
Banks of water reservoirs	11.39	9.0
Biotopes with a high level of anthropogenic transformation	25.43	4.01
Lenth of route	241.5 km	122 km

For the wolf it has been a characteristic to include the settlements in the framework of permanent family pack patches. Annually from 2002 to 2010 we have recorded regular wolves' visits to the abandoned villages of the Exclusion Zone as well as the towns of Pripyat and Chernobyl. It should be noted that the wolves visit the towns only occasionally (especially Chernobyl, where people are constantly present), but their territorial behavior is very similar to the behavior in natural environment. The wolves use rural streets and rarely examine the area around the abandoned buildings and gardens. The wolves also intensely mark the area of human settlements.

Lynx is characterized by a higher degree of anthropophobia. However it also visits the villages. In particular, we have recorded their tracks in the town of Pripyat and the Martynovychy village. In late 2009 the footsteps of lynx in the central square of Pripyat were seen (pers. comm. with K. O. Burdo). While checking this message we discovered the fact of the lynx's visit to a shop building in Pripyat: the animal entered through the main entrance of the building, went ahead and left through the emergency exit, leaving clear footsteps inside and outside. In Martynovychy the lynx inspected the area around the detached houses and abandoned gardens. In 2004, footsteps of the animal on the porch of a house were recorded.

Both species actively use asphalt and earth roads in the Exclusion Zone (this is especially characteristic for the wolf). The lynx and the wolf have been repeatedly observed by the police around the Chernobyl Power Plant.

A separate element of predators' behavior is shifting of their daily activity: the animals or their fresh footsteps were often seen in the daytime.

We believe that the two factors can be the main reasons for the active use of urban landscape and shift in characteristics of daily activity: the presence of prey species in the abandoned settlements (rabbits and fallow deer eat the young growth; deer and wild boars visit orchards and gardens), and the reduction of anxiety factor. In the years after the accident the number of people living or working in the Exclusion Zone has been steadily declining.

## Conclusions

1. The species composition and the number of large predators in the Exclusion Zone correspond to the regional conditions and do not show adverse effects of radioactive contamination and anthropogenic transformation of the environment.

2. During the current study the number of wolves counted ranges from 30 to 40 individuals in 6 packs.

3. A permanent stay of the lynx in the Exclusion Zone has been confirmed. Based on the footsteps 4 individuals have been registered.

4. A bear's presence in the Exclusion Zone has been confirmed.

5. The results of the distribution and the species ecology reflect a general situation characteristic of the Polissya. The most specific moments are the following: different degree of use of anthropogenically transformed areas; the shift of the daily regime of activity towards the daylight hours; a small share of anthropogenic food in the diet.

6. In general, the state of the large predator group as an indicative fauna group, testifies to the possibility of using the previously developed areas with conservation purposes.

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