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LARGE HERBIVORES IN RESTRICTED ECOSYSTEMS: ASSESSMENT OF WATER SOURCES VALUE BY HIGH-USAGE MOVEMENT PATHWAYS AT BYRIUCHYI ISLAND SPIT

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Abstract

An animal population permanently living in a certain area not only adapts to environmental conditions, but changes the environment as a result of their activities. The constant movement of animals between valuable resources in a certain territory forms a system of permanent trails. They are valuable source of information for solving problems of directed formation of ecosystems, organisation of protection and rational use of the territory. The territory of our study — Byriuchyi Island — is an alluvial type of sand and shell rock spit. It is covered with a variety of wetlands, meadows, and steppe vegetation. There are no natural sources of fresh water. Since the 1950s, several species of large herbivores have lived here: red deer, fallow deer, onagers, and feral horses. To provide animals with fresh water, artificial ponds called "kopanki" were created in the 1970s. In order to determine the intensity of use of drinking water on the Biryuchy Island spit, we assessed them based on the analysis of the system of permanent trails. Materials used in the work consist of data collected in 2014–2018 during field research and satellite images of the area. During the study period, the total number of ungulates ranged between 2700 to 3400 individuals. To assess the intensity of water use, the number and direction of permanent paths were determined, the distance to other water and fodder sources, shelter, microrelief and climatic features, anthropogenic factors were estimated. Data were collected for 31 artificial water sources. It has been found that permanent trails can extend from the source in up to 25 directions. However, more often they are concentrated in the northern and north-eastern directions. This is due to the most weather-protected area of the island — providing cover with reeds and a variety of nutritious food — being located in the north. The nearest sources of fresh water are in 2.5–3 km from the coast of the estuary. In general, the average distance between water crates on the spit is 0.9 km. Analysis of the permanent trails system of the island showed that 45 % of water resources are intensively used by ungulates, and 22 % have no visible trails.

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LARGE HERBIVORES IN RESTRICTED ECOSYSTEMS: ASSESSMENT OF WATER SOURCES VALUE BY HIGH-USAGE MOVEMENT PATHWAYS AT BYRIUCHYI ISLAND SPIT

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Large herbivores in restricted ecosystems: assessment of water sources value by high-usage movement pathways at Byriuchyi Island spit. — M. Polzyk. — An animal population permanently living in a certain area not only adapts to environmental conditions, but changes the environment as a result of their activities. The constant movement of animals between valuable resources in a certain territory forms a system of permanent trails. They are valuable source of information for solving problems of directed formation of ecosystems, organisation of protection and rational use of the territory. The territory of our study — Byriuchyi Island — is an alluvial type of sand and shell rock spit. It is covered with a variety of wetlands, meadows, and steppe vegetation. There are no natural sources of fresh water. Since the 1950s, several species of large herbivores have lived here: red deer, fallow deer, onagers, and feral horses. To provide animals with fresh water, artificial ponds called "kopanki" were created in the 1970s. In order to determine the intensity of use of drinking water on the Biryuchy Island spit, we assessed them based on the analysis of the system of permanent trails. Materials used in the work consist of data collected in 2014–2018 during field research and satellite images of the area. During the study period, the total number of ungulates ranged between 2700 to 3400 individuals. To assess the intensity of water use, the number and direction of permanent paths were determined, the distance to other water and fodder sources, shelter, microrelief and climatic features, anthropogenic factors were estimated. Data were collected for 31 artificial water sources. It has been found that permanent trails can extend from the source in up to 25 directions. However, more often they are concentrated in the northern and north-eastern directions. This is due to the most weather-protected area of the island — providing cover with reeds and a variety of nutritious food — being located in the north. The nearest sources of fresh water are in 2.5–3 km from the coast of the estuary. In general, the average distance between water crates on the spit is 0.9 km. Analysis of the permanent trails system of the island showed that 45 % of water resources are intensively used by ungulates, and 22 % have no visible trails.

Key words: large herbivores, pathways, Byriuchyi Island spit, habitat selection.

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Introduction

Animal movement is a fundamental mechanism shaping the structure and dynamics of populations, communities, and ecosystems (Nathan *et al.* 2008). Factors that influence movement can be divided into those related to external environment (food, predation and competition) and internal state (reproductive status, navigational and movement capacity) (Singh 2014). In many regions, cumulative movements of large mammals, particularly ungulates, are recorded as networks of semi-permanent wildlife trails. These networks are created by the repeated movement of multiple animals along the same pathway, and thus define at a population-level, high-usage movement pathways between important resource patches (e.g., water, food, bedding, thermal and hiding cover) (Newmark & Rickart 2012). These trail patterns may provide information about habitat selection of animal population on specific territory (Davis *et al.* 2008).

Byriuchyi Island is a spit in the north-western part of the Azov Sea. The spit is of alluvial type, formed of sand and coquina (sandy coastal plain with occurring shell bars). Along the northern coast, there are numerous salty lakes. Several small saline lakes and a large lake Olen extend along the northern shore. There are meadows, coastal water and sand-steppe landscapes. Artificial plantations of silverberry (*Elaeagnus commutate* Bernh. ex Rydb.), with an area of 6.2 km^2, have long

been a favourite place for the deer of the island. But as a result of several severe frosts and a high trophic and mechanical load, the forest was severely degraded (Volokh 2014). Total land territory is 72.7 km^2. This territory has been part of the Ukrainian Wildlife Conservation Program since 1927. In 1993, it became a part of the Azov-Syvash National Nature Park. Wildlife management centres are situated in the village Sadki and several additional cordons over the spit (Getman 2017).

The first ungulates were brought to Byriuchyi from the Askania-Nova Sanctuary in the 1950s. Several species of large herbivores live here: red deer (*Cervus elaphus* L., 1758), fallow deer (*Dama dama* L., 1758), onager (*Equus hemionus* Pallas, 1775), and feral horses (Volokh 2014). The number of ungulates on the island during the study period based on winter counts was 1000–1200 for the red deer, 1400–1800 for the fallow deer, 200–300 for onagers, and roughly 100 for feral horses.

This amount of animals in a limited area cannot survive without a reliable water source. There are plenty of lakes and puddles all over the spit, but all of them are salty. There are no natural sources of fresh water. To provide fresh water for animals during park management in the previous century, several water crates were dug out all over the spit. The elliptical crates with a major axis up to 20 m have a the depth of 0.5 to 1.5 m. Animals also have some access to powered water holes, which were drilled near cordons (permanent residence of the reserve keepers). Prior studies have established that different water crates vary in the amount of salt, nitrogen, potassium, and zooplankton in the water (Dombrovskyi *et al.* 2014).

This work is based on assessment of the high-usage trail system. It is dedicated to the study of the use of freshwater sources on the Byriuchyi spit. We can provide data for global investigation of specific adaptations of different ungulate populations to the environment.

Materials and Methods

Field observations and satellite photos were used as the main data source. Measurements were taken using SAS/GIS Applications using Bing satellite map. To assess the value of the water source for ungulates, we identified the following criteria: location, number of trails leading to a water source, distance from other water sources, and area of the territory where it is possible to trace tracks leading to a water crate. Using this approach is possible due to the clarity of paths in the territory, both among dense vegetation and in wet lowlands (Fig. 1).

The number of tracks was counted according to a 32-wind compass rose. First, we set a circle area with a radius of 100 m centered on the water source, then draw a compass rose pattern over it and counted the number of times animal tracks cross the circumference. Directions with the number greater than zero are taken into further consideration. During the study, wild animals had access to 31 spots: 29 water crates and two powered water holes (Fig. 2).

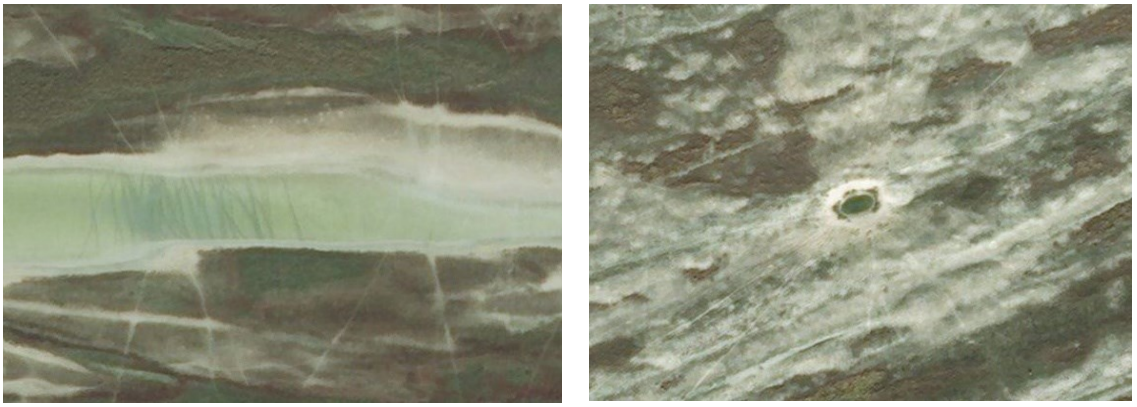

Fig. 1. Satellite images of trails of wild animals crossing flooded lowland in the northern part (left) and around watering hole # 16 (N 46°07'32.38" E 35°07'05.21") in the southern part of the island (right).

Рис. 1. Супутникові знімки стежок диких тварин, які перетинають затоплену низовину в північній частині (зліва) та навколо водопою # 16 (N 46°07'32,38" E 35°07'05,21") в південній частині острова (справа).

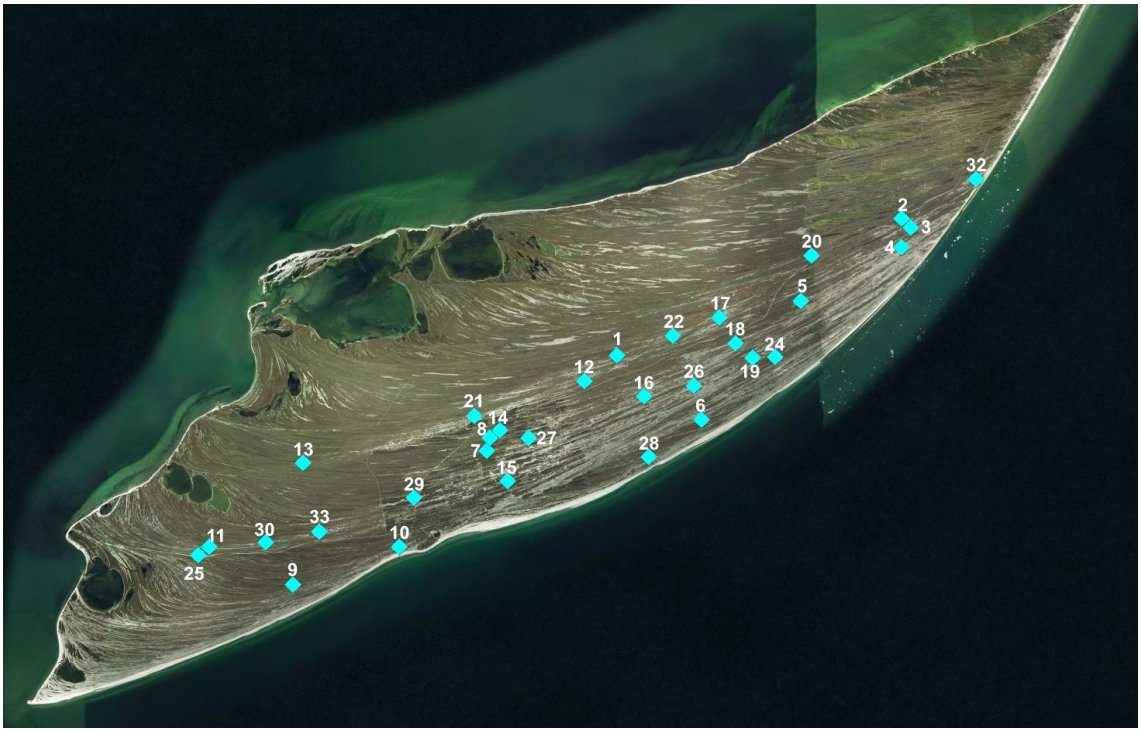

Fig. 2. Water crates of Byriuchyi Island spit.

Рис. 2. Розташування джерел води на косі Бирючий острів.

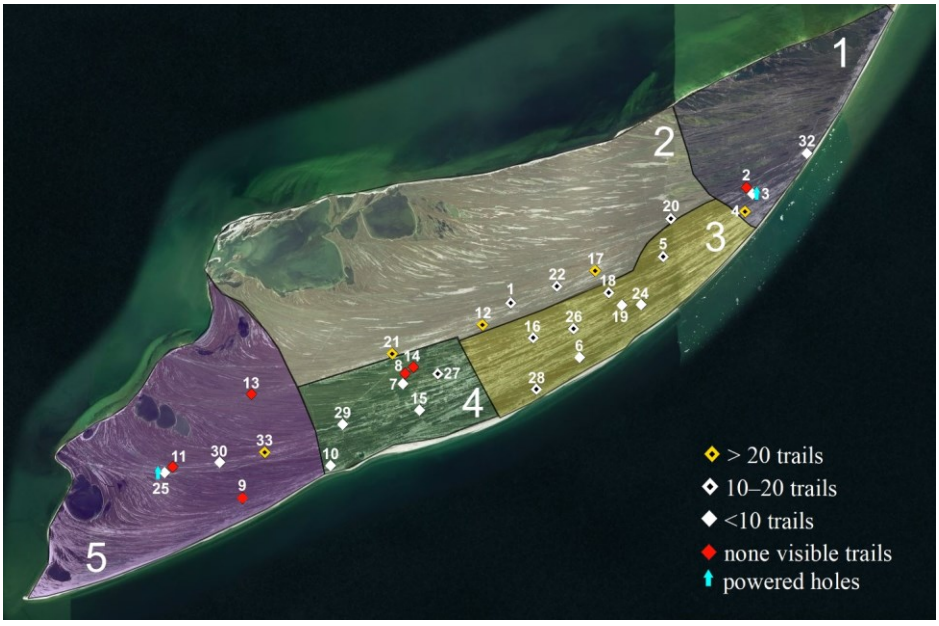

Fig. 3. Byriuchyi Island spit divided into zones (1 — from the beginning of the expansion of the spit to the cordon "Periboinia"; 2 — the central part of the spit north of the main road; 3 — south of the main road, from cordon "Periboinia" to the forest; 4 — degraded forest with the village Sadki; 5 — west of the road between the village and lake Olen) with water crate marks graded by the number of permanent trails.

Рис. 3. Бирючий острів розділений на зони (1 — Від початку розширення коси до кордону «Перебойня»; 2 — Центральна частина коси на північ від головної дороги; 3 — території на південь від головної дороги між кордоном «Перебойня» та лісом; 4 — деградований ліс та с. Садки; 5 — Території на захід від дороги з села до озера Олень) з відмітками.

Results and Discussion

For better understanding of the results, we divided the territory of the spit into five different zones Fig. 3. Each zone has different value for animals and level of human presence; they also differ by climate conditionss.

In the first zone, every lower spot is flooded; lots of small lakes here are surrounded by reed. It is nearly 9.3 km^2 in size, but less than half of its territory is land. Large groups of males can be often seen here especially when velvet antler growing. As water sources, there are three water crates and a powered water hole near cordon “Periboinia”. Due to human activity on the cordon and lots of water from the hole, tracks cannot be seen near the water hole lake. According to our data, large groups of ungulates were seen there every night. Based on animal trails, the most visited is water source #4 south of the cordon that has visible tracks in 24 directions (Fig. 4). Another two crates in this zone have no tracks that lead to them.

The second zone provides many grasslands on higher grounds as well as flooded lower spots and reed tangle too. It covers an area of 29.8 km^2. Water sources are located close to the southern border; originally, they were dug out across the main road. All of the six water crates in this zone are actively used by large herbivores. The number of tracks leading to them varies from 17 to 25. The land around them is heavily trampled. The most visited is crate #17 that has tracks in 25 directions (Fig. 5).

The third zone is about 9 km^2 of mostly dry higher land along the sea that can be described as arid steppe. It has lots of clear sand areas and less shelter from strong winds from the sea. On windy days, most of the animals hide at the northern part of the spit in the second zone, so on the day before no ungulates are seen in the third zone. There are 8 water crates, all regularly visited by ungulates. The number of trails varies between 4 and 18. Those that are closer to the sea and away from the forest are less visited, but the trails are clearly visible (Fig. 6). Water sources that are closer to the forest and are situated farther north are visited more often, such as #16 (Fig. 1). Here we clearly see that all crates are connected by trails, there are no unused crates and tracks are spread more evenly in different directions.

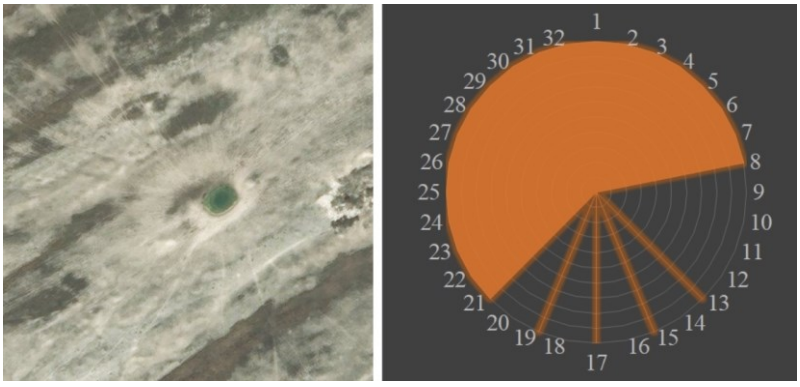

Fig. 4. Water crate #4, trails distribution by a 32-wind compass.

Рис. 4. Водопій #4, розподіл стежок за румбами.

N 46°08'55,87"
E 35°10'29,57"

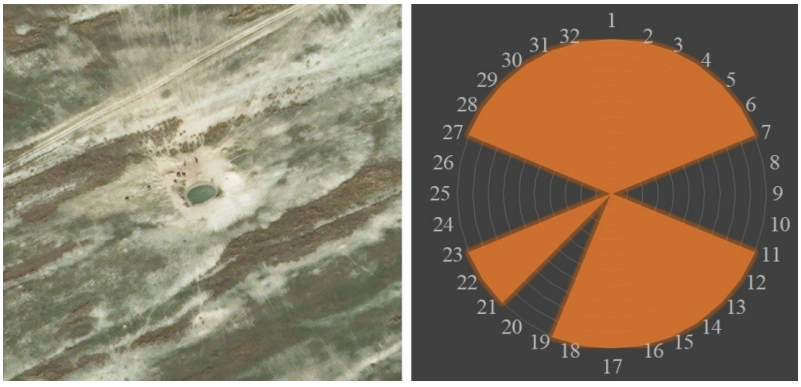

Fig. 5. Water crate #17, trails distribution by a 32-wind compass.

Рис. 5. Водопій #17, розподіл стежок за румбами.

N 46°08'16,81"
E 35°08'04,99"

The fourth zone is less than 6.2 km^2 in size and is covered with patches of degraded forest. Trees here are very depressed from rough weather conditions and high ungulate pressure. There are six relatively small water crates, two of which have no visible trails. The most visited is #27 having 17 visible trails (Fig. 7). The village Sadki also has a large artificial pond, but due to high anthropogenic influence and arrangement of the territory animal tracks are not visible and cannot be counted. We also mention that #21 in the second zone (N 46°07'20.22" E 35°04'49.18") has many trails leading directly to the forest.

The fifth zone is nearly 17 km^2 of relatively dry area without large lakes and bays. The water level in the lower lands is much higher here than in other parts of the island. Animal trails are more winding here. This territory has six crates, but only three in use. Among them is the second water hole #25 (N 46°06'02.41" E 35°01'09.90") but it has no power and form a very tiny water puddle. Therefore, it cannot be a reliable water source. The most visited water crate in this area is #33 (Fig. 8). It has 23 regular tracks that spread in all directions. The third one #30 (N 46°06'08.82" E 35°02'02.37") is within less than 1 km of the main crate and has 10 trails in the SW-SE sector.

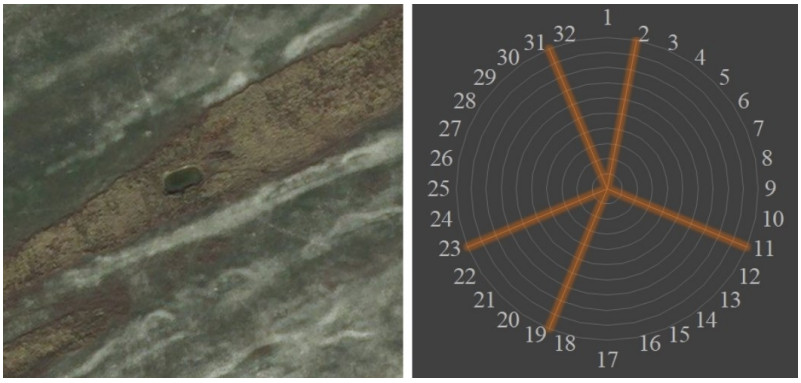

Fig. 6. Water crate #24, trails distribution by a 32-wind compass.

Рис. 6. Водопій #24, розподіл стежок за румбами.

N 46°07'53.65"
E 35°08'49.18"

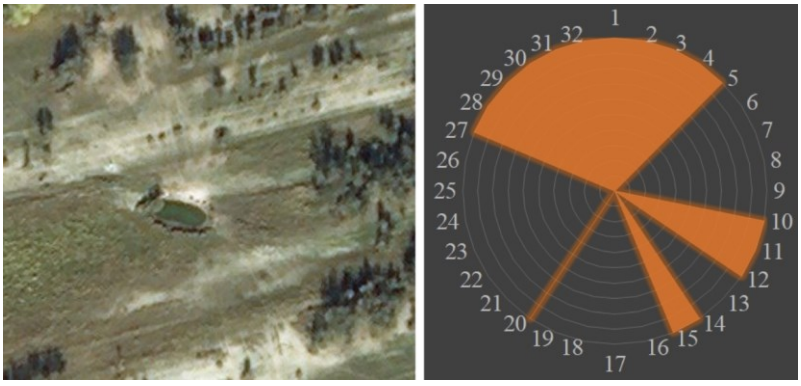

Fig. 7. Water crate #27, trails distribution by a 32-wind compass.

Рис. 7. Водопій #27, розподіл стежок за румбами.

N 46°07'08,12"
E 35°05'32,98"

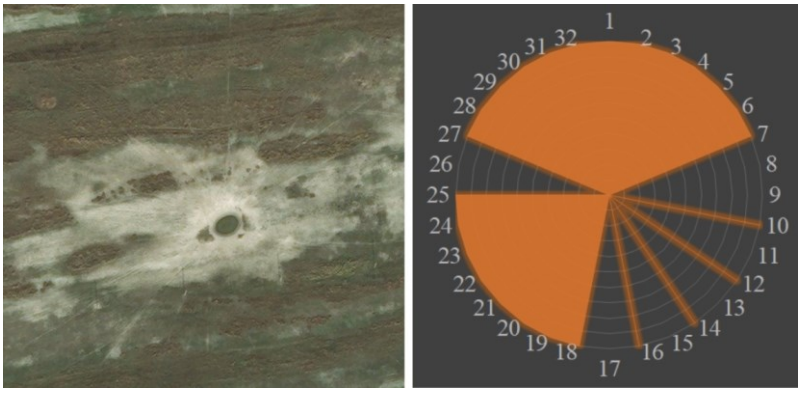

Fig. 8. Water crate #33, trails distribution by a 32-wind compass.

Рис. 8. Водопій #33, розподіл стежок за румбами.

N 46°06'14,78"
E 35°02'46,48"

Based on the permanent trail system, 14 watering places are actively visited by ungulates, 10 are less visited, and 7 have no distinguishable paths. More information about water quality and seasonal changes of these crates would help to understand this matter.

All springs that have visible paths are always directly connected to at least two nearby watering holes. The trails concentrated at the watering hole actually begin to diverge along the territory of the spit after 100 metres from it. Animal paths merge to form continuous trampled funnels. To understand their distribution, we tracked the main paths on the images. As a result, according to the river catchment principle, we were able to build polygons for the distribution of animals from each source. Some polygons are shown in Fig. 9.

Tracks are multiply intersected and the distribution boundaries overlap. However, we tend to argue that certain groups of animals can give preference to a certain source, which leads to their cyclic movement along the same routes. Since this area is replete with juicy food, the movement of animals is provoked by the need of shelter and fresh water. Therefore, animals move for 2.5–3.0 km from the northern shore to the nearest water crate. As a result, in the first zone where, in fact, only one source #4 is in active use, trails flow to it from an area of 7.5 km^2 (Table 1).

In the west of the spit (zone 5) where three sources are actively used, the coverage of trails is smaller — 3.92 km^2 for watering hole #33, as there are other sources of water. The average distance between water crates on the island is 0.9 km, but the average area of the network of paths for one watering hole is 3.4 km^2.

During the study, we noted that animals move much less from west to east than from north to south. This is related most likely to the fact that cold breeze often blow from the sea in the south, and steppe habitats supply a smaller variety of food. That is why ungulates move between watering holes in the central part of the spit and reed thickets in the north. Oddly, large herbivores do not concentrate in the forest, which is due to the high degree of plantation degradation.

Based on the analysis of the trail system, we can assume that, despite the limited amount of water, the animals have certain preferences. Since the system we observe has been formed over a long period, we cannot yet conclude what they are specifically related to.

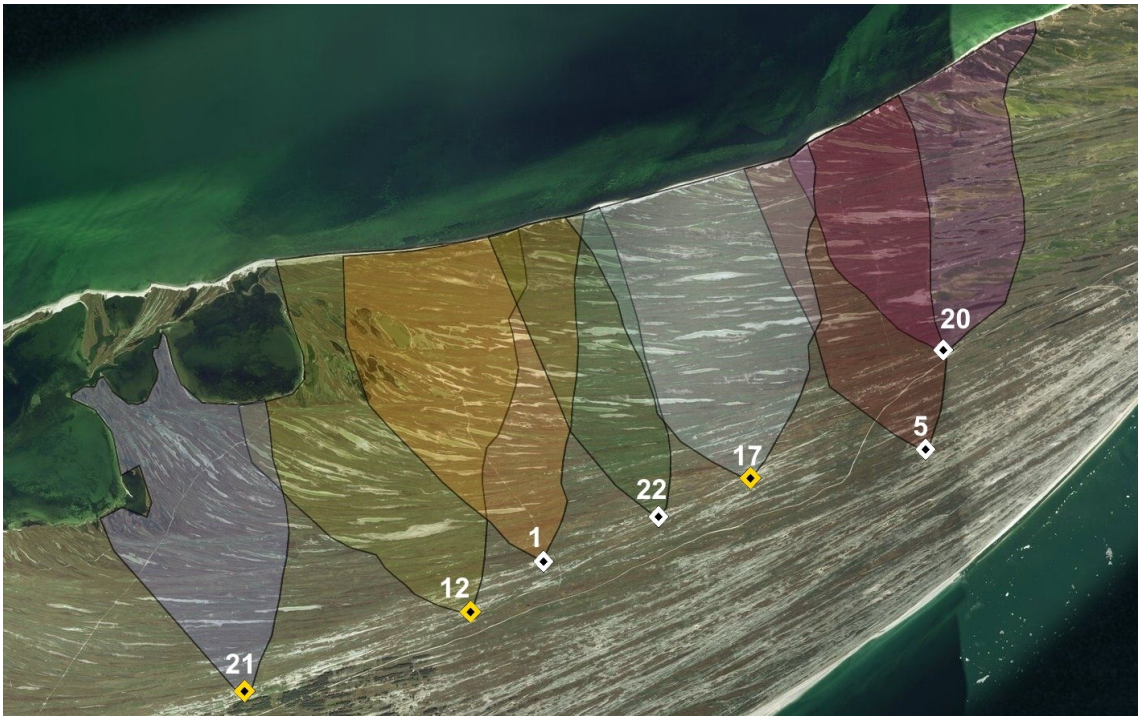

Fig. 9. Areas of distribution of trails for the most visited watering places of the central part of the spit.

Рис. 9. Зони розповсюдження стежок для найбільш відвідуваних водопоїв центральної частини коси.

Table 1. Trail system distribution areas from some water holes on Byriuchyi Island spit

Таблиця 1. Території розповсюдження системи троп для деяких водних джерел на косі Бирючий острів.

Number of directions	Water crate	Zone	Territory of distribution, km^2	Coordinates
25	17	2	3.84	N 46°08'16.81" E 35°08'04.99"
25	33	5	3.92	N 46°06'14.78" E 35°02'46.48"
24	4	1	7.5	N 46°08'55.87" E 35°10'29.57"
24	21	2	2.46	N 46°07'20.22" E 35°04'49.18"
21	12	2	4.86	N 46°07'40.95" E 35°06'16.37"
19	5	2	2.82	N 46°08'25.85" E 35°09'10.27"
17	20	2	3.17	N 46°08'50.48" E 35°09'17.78"
14	22	2	1.94	N 46°08'07.05" E 35°07'28.03"

We hypothesize that seasonal changes in both watering and population distribution may be affected. Obviously, the most valuable resource for ungulates are reed thickets in the northern part that provide shelter and food. Animals need to leave the thickets only to visit the watering hole, so most of the visited watering places are in the northern part. According to our calculations, each watering hole, in average, provides water to animals from a 3.4 km^2 area. To supply the total land territory of 72.7 km^2, it is necessary that at least 21 watering holes were actively used. The system of trails on the Byriuchyi Island spit includes 24 water holes. Therefore, it is important to ensure that they are full and accessible to animals to provide fresh water.

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