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Typologies of hunting areas using GIS technologies in specially protected natural areas of Kazakhstan

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ABSTRACT
The article focuses on the characterization of hunting grounds through the application of GIS technologies. The research involved an in-depth study of the biological diversity of mammals, assessing the typology of their habitats. Utilizing GIS technologies, the study analyzed the spatial distribution of rare animal species, such as predatory mammals, within specially protected natural areas of Kazakhstan, particularly the Andalusia State Natural (Zoological) Nature Reserve and the Ile-Alatau State Natural Park. Drawing on the findings from the project and surveys, we classified the areas into distinct types of animal habitats based on ecological conditions, topography, and soil-plant characteristics. For the first time, data on the typology of hunting grounds, including the categorization of their types and numerical indicators for each, were collected to support hunting planning. Consequently, a division map of the Andasai Nature Reserve and the Aksai branch of the Ile-Alatau National Natural Park was generated in GIS format for previously unclassified land types. Following the interpretation results, planning and cartographic resources for various types of hunting grounds were created, reflecting the actual area of the natural reserve. These resources can be utilized to enhance biotechnical and hunting operations conducted in the Andasai Nature Reserve and the Ile-Alatau State National Nature Park, contributing to improved security measures.

Keywords: Typology, GIS , Hunting grounds, Andasai Nature Ile-Alatau State National Natural Park

INTRODUCTION

The geographic information system (GIS) is a digital tool that allows for the collection, analysis, and visualization of georeferenced information. Historically, techniques for analyzing geobotanical, landscape, or forest management data played a role in the design of hunting management strategies. The exploration of aerospace data for evaluating animal habitats started in the 1980s (De By *et al*. 2001; Huggins 2002; Campbell & Shin 2011).

A digital image of the Earth's surface allows for the direct interpretation of biotopes and the identification of the specific functions of different regions. Fig. 1 demonstrates the technology for applying remote methods in various natural environments (Innes & Ward 2010; Bettinger *et al*. 2016). The elements of the geographic information system, illustrated in Fig. 1, consist of topographic maps, land management maps, forest management maps, and satellite imagery, which facilitate the assessment of wildlife populations and hunting management on farms. Through the processes of data input, modification, and integration, various types of typological stratification are identified,

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including natural zones and subzones, rivers, reservoirs, human-made landscapes, road networks, forest plantations, and landscape segments (Innes & Ward 2010; Bettinger *et al*. 2016).

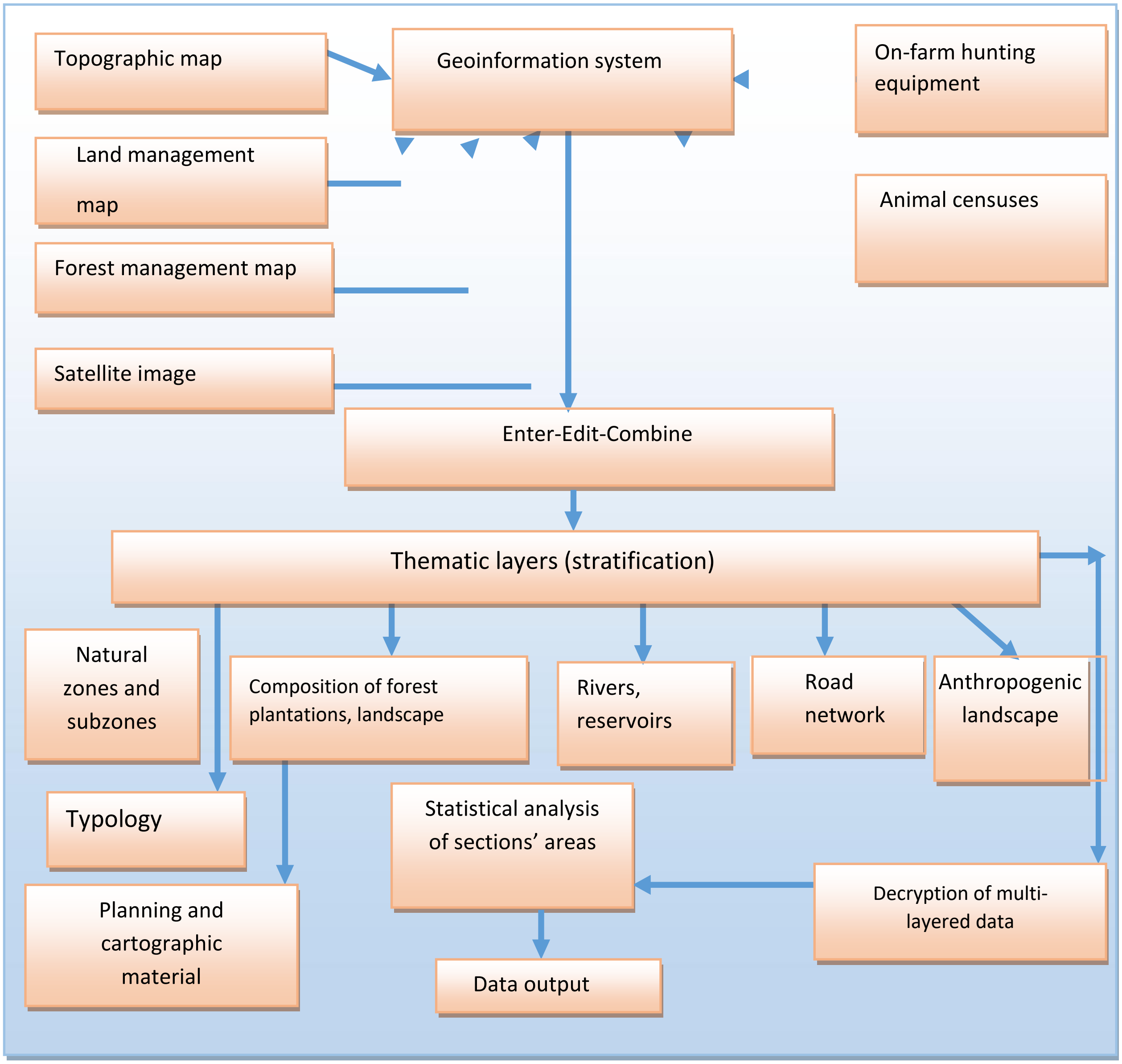

Fig. 1. Block diagram of technology for typing hunting grounds in GIS format

Currently, GIS technologies allow for an in-depth examination of forest resources and hunting areas. Various researchers, in their efforts to manage hunting, have conducted assessments and evaluations of forest hunting territories utilizing data from the compiled database (Kushwaha & Roy 2002; Varghese, Suryavanshi & Jha 2022). In a study by Osmolska (2013), GIS software was used to create thematic digital maps presenting data such as spatial positioning of state borders, forestry and hunting agencies, projected population of roe deer, environmental conditions in the region, ecological significance of birds, impact of birds on forest ecosystems, and the quantity and composition of prey using roe deer as a case study (Osmólska 2013). Dale (1995) examined the use of cartographic technology in evaluating and analyzing the ecological conditions of specially protected natural areas through geoinformation

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technologies, which offer a visual representation of the analysis outcomes on electronic maps (Lewis 1995). Kopetta *et al.* outline the utilization of geoinformation systems in forestry, having created a standard for digital forest mapping with this technology. Furthermore, by employing geoinformation systems, a plan for irrigation and enhancement of the Hungry Steppe was created to examine the effects of forest plantations on groundwater levels and the mineralization of groundwater (Korpetta *et al.* 2004).
To establish various types of hunting areas, the capabilities of thematic maps generated in the GIS FORMAP 2.1 are utilized as outlined (Lewis 1995). Therefore, analyzing the typology of hunting grounds through a GIS database offers substantial potential for categorizing different types of forest hunting areas. By contemporary hunting tools, it is feasible to evaluate and assess hunting grounds utilizing a variety of methods and classifications derived from database information. Moreover, it becomes possible to identify different types of hunting grounds based on their characteristics, vegetation habitats, types of forest plantations, species of game animals, their populations, densities, and other metrics, with these parameters being assigned to each species of game animal individually (MacDonald 2005; Rassolov & Shishikin 2023).
Although GIS technologies provide substantial benefits for managing hunting zones in protected areas, there are still challenges to address. These challenges encompass the necessity for thorough socio-economic data to improve zoning and management strategies, as well as the incorporation of historical land use data to guide restoration initiatives. Furthermore, ongoing monitoring and refreshing of GIS databases are essential for responding to evolving environmental conditions. It should be noted that the systems of interstate standards regulate geoinformation mapping, as specified in GOST R 52055-2003, GOST R 50828-95, and GOST R 51353-99 (Dölek & Avci 2016; Osmólska 2013), which are currently in effect in Kazakhstan.

MATERIALS AND METHODS

We explored the experience of analyzing the typology of hunting areas by examining examples from the Andasai State Natural (Zoological) Reserve and the Ile-Alatau National Park. The study utilized forest management documentation alongside the distribution data of different types of game animals. The information gathered can be applied for a qualitative assessment (allocation) of hunting areas in Southern and Southeastern Kazakhstan. A typological classification of hunting grounds utilizing GIS technology was carried out within the territory of protected areas in Kazakhstan, particularly the Andasai State Natural (Zoological) Reserve. This protected area was established by a decree from the Council of Ministers of the Kazakh SSR on March 29, 1966, No. 220. Per the "List of specially protected natural areas," sanctioned by the decree of the Government of the Republic of Kazakhstan on September 26, 2017, Reserve No. 593 holds a republican significance status with a permanent validity (Akiyanova *et al.* 2019). It is situated in the Moiynkum District of the Zhambyl Region, covering an area of roughly 1.0 million hectares.
The reserve has been researched fairly recently. For instance, in 2013, scientific articles were released focusing on uncommon animal species and the zoogeographic study of mammal populations. Furthermore, in 2015, articles explored issues related to the conservation of rare animal species and improving conservation strategies in this protected natural area (Loiseau *et al.* 2012). At present, the specific composition of habitat types or hunting regions within the animal kingdom of this sanctuary remains unclear. It is established that the sanctuary is situated in the Betpakdala Desert, a key component of a rubble-clay plateau. Additionally, it features haloxylon forests, shrub clusters, rocky lowlands, sandy regions, and wetland habitats. However, the classification of hunting grounds and the precise area they occupy are still not fully understood. Therefore, this study intends to fill this gap. The origins of the Ile-Alatau State National Natural Park trace back to 1931. The Ile-Alatau state sanctuary was first created, covering 15,000 hectares within the Malaya Almatinka River valley. In 1935, the area increased to 40,000 hectares, and later expanded to 856.7 thousand hectares, eventually encompassing the entire Zailiysky Alatau range.
Ile-Alatau Park holds considerable land within the Almaty region and is composed of four sectors: Aksai, Medeu, Talgar, and Turgen. These four sectors of the national park are interconnected regarding their natural, historical, cultural, and administrative significance. Through forest development and zoning regulations, the park is positioned within the fir-spruce forest province, showcasing a fruit-deciduous subregion. This area is part of the Zhongarsky forest development and forestry area, which lies within the northern spruce forests of the regional Zailiysky forestry

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production unit.The Zhetysu Alatau region is characterized by a stepped terrain, with a central massif rising to about 4,500 m above sea level from which several mountain ranges extend in a fan-like pattern to the west. The mountain-forest-meadow-steppe zone is divided into various vertical soil-vegetation subzones. The high mountain meadow subzone lies at elevations of 3,200 to 2,500 m, transitioning into the naval zone above it and the forest-meadow zone below. The mountain-forest-meadow subzone is found between 2,500 m and 1,000 m in height. This area is home to coniferous forests primarily consisting of Schrenk spruce and Siberian fir, along with deciduous trees such as aspen, birch, apple, and mountain ash. The mountain-steppe subzone is located in a sloped, low-mountain plain at altitudes of 750 to 1,000 m. It offers a variety of habitats for wildlife, with hunting species including maral, Siberian roe deer, Siberian ibex, and wild boar, as well as other carnivores, rodents, hares, and upland game. Nevertheless, the study of hunting grounds and their classification remains limited.

The typology of hunting grounds within the Andasai State Natural (Zoological) Nature Reserve and the Ile-Alatau National Park was analyzed using GIS technology via MapInfo Professional 7.5. Layers were created from a combination of a topographic map, satellite imagery from Google Earth in 2011, and some data from a forest management map. Following the interpretation, planning, and cartographic materials were produced outlining the types of hunting grounds for various animal species as well as the actual size of the natural reserve's designated areas.

RESULTS

In 2021, a GIS-based classification of hunting areas was conducted within Kazakhstan's Andasai State Natural (Zoological) Reserve. Using MapInfo Professional 7.5, researchers analyzed tax surveys and camera trap data. Topographic maps, Google Earth 2011 satellite imagery, and forest inventory maps were used to generate layers. This data informed the creation of planning and cartographic documents, detailing hunting area types for various animal species across different sections of their natural habitats (Table 1). The reserve's area was categorized into 10 habitat types—three forest and seven non-forest—based on environmental factors, topography, and soil and vegetation characteristics that favor animal survival.

Table 1. The hunting grounds' typology of the Andasai nature reserve.

Land type	Surface (ha)	Land type	Surface (ha)
Rubble-clay	694627	Rocky lowlands	91154
Plateau	39029	Salt marshes	23414
Shrubs	40043	Salt flats	2990
Haloxylon growths	4120	Wetlands	68212
Forests	32547	Other lands	6555

Analysis of Table 1 reveals that the forested area comprises 8.32% of the total area. The tree species are primarily comprised of haloxylons, mainly black haloxylon, with a minor occurrence of Persian (white) haloxylon, alongside shrub thickets that include caragana, shrubby willow, and various other species. Additionally, areas classified as open habitats feature vegetation such as saltwort, desert wormwood, and feathergrass-fescue. Wetlands in the reserve are characterized by reed and cattail, along with other wetland flora. Other land types encompass a cultural landscape that includes roads, cultivated land, estates, and settlements. Fig. 3 presents a map depicting the different biotope types (land classifications) for mammals in the Andasai Nature Reserve. The nature reserve hosts 39 species and subspecies of vertebrates that are included in both the Red Book of the Republic of Kazakhstan and the IUCN Red List. Among these, the most at-risk species include hoofed mammals like the kulan, goitered gazelle, and Tien Shan mountain sheep (argali), which face threats from illegal hunting, commonly referred to as poaching. Consequently, despite protective measures, their populations do not show significant recovery.

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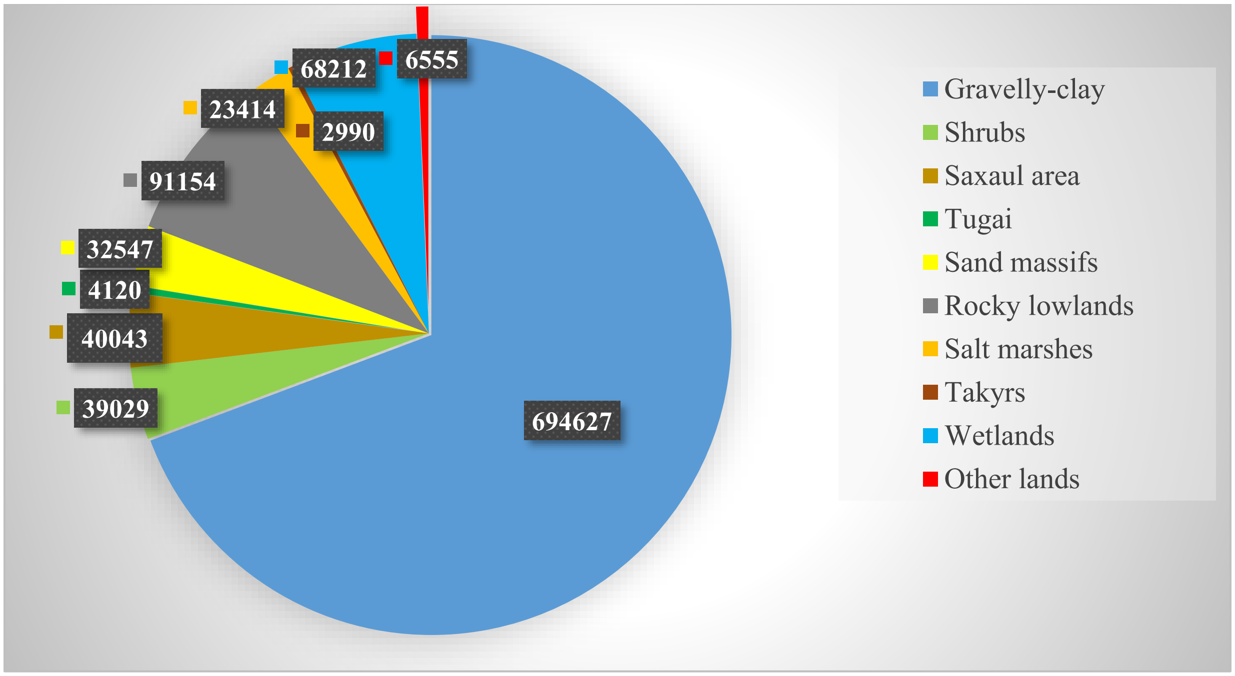

Fig. 2 . The quantitative part of hunting grounds types at the Andalusia nature reserve.

According to aerial surveys carried out in the spring of 2009, only 514 goitered gazelles were counted in the Southern Betpakdala region, covering an area of approximately 990,000 hectares near the Baigara, Kurmanshit, and Sekseuldala mountains. The kulan population raises significant concerns. From 1986 to 2011, 210 of these ungulates were introduced into the reserve, with 90 being added only in the past five years. Based on the successful reintroduction and reproduction of these ungulates in Altyn-Emel National Park, it can be concluded that their numbers soared from 32 in 1982 to 2,500 by 2012, marking a 78-fold increase. Therefore, it is believed that there should currently be approximately 7-8 thousand kulans in the Andasai Reserve. However, the current population stands at roughly 90 individuals. Poaching and insufficient protective measures are the main factors restricting population growth (Pestov *et al.* 2022; Serikbayeva *et al.* 2023).

By utilizing GIS technologies, we were able to acquire quantitative metrics regarding the areas occupied by different categories of hunting grounds or habitats of species found in desert zones. This information can aid in enhancing biotechnical and hunting operations conducted in the Andasai Nature Reserve, while also facilitating the improvement of protective measures. In protected areas, the foremost challenge is the preservation of endangered animal species, particularly ungulates.

Using GIS technologies, we examined the spatial distribution of rare animal species by assessing the types of habitats they occupy. Based on the outcomes of the project and field surveys, we categorized the territory of the Ile-Alatau National Park into various animal habitat types (lands) based on environmental conditions, topography, and the characteristics of soil and vegetation. We identified a total of 12 habitat types, which include 5 forest types: coniferous forest, deciduous forest, wild fruit forest, shrubs, and juniper forests, as well as seven non-forest types: rocky habitats, mountain meadows (hayfields), mountain steppes, glaciers, wetlands, arable land, and other areas (roads, estates, etc.). The proportions of forest and non-forest animal habitats are illustrated in Figures 4 and 5 for the four sections of the Ile-Alatau National Natural Park.

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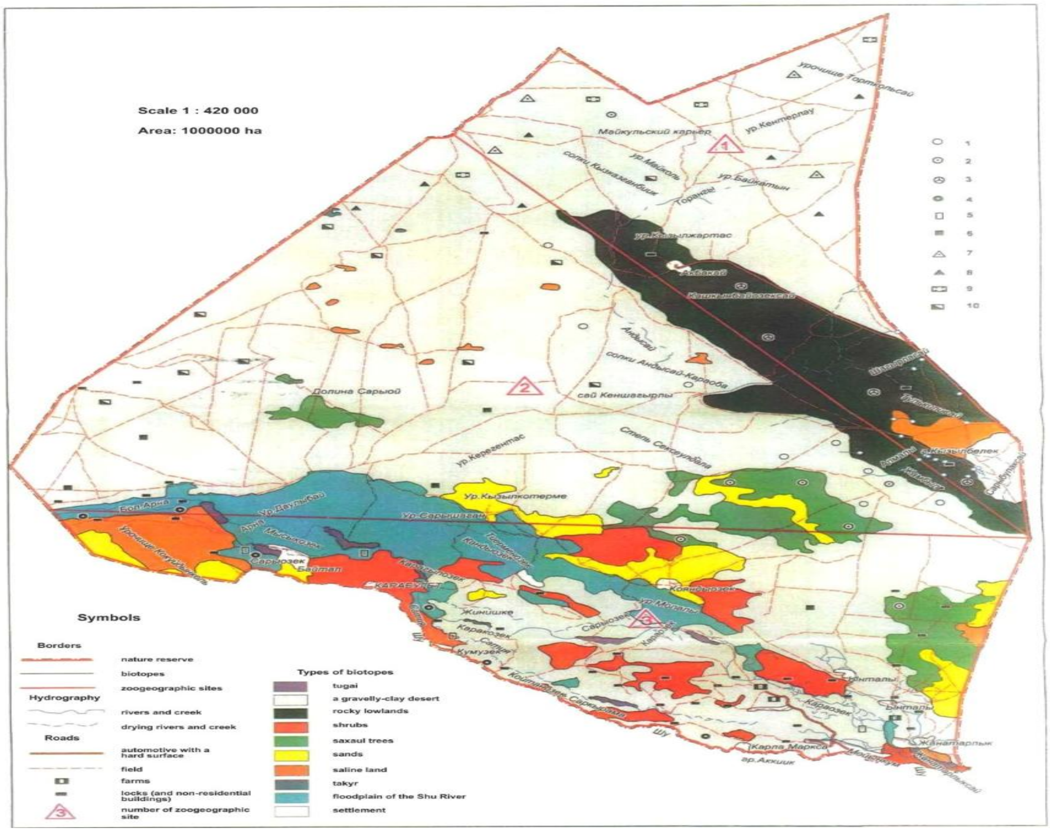

Fig. 3 . Typology of mammals' biotopes (land types).

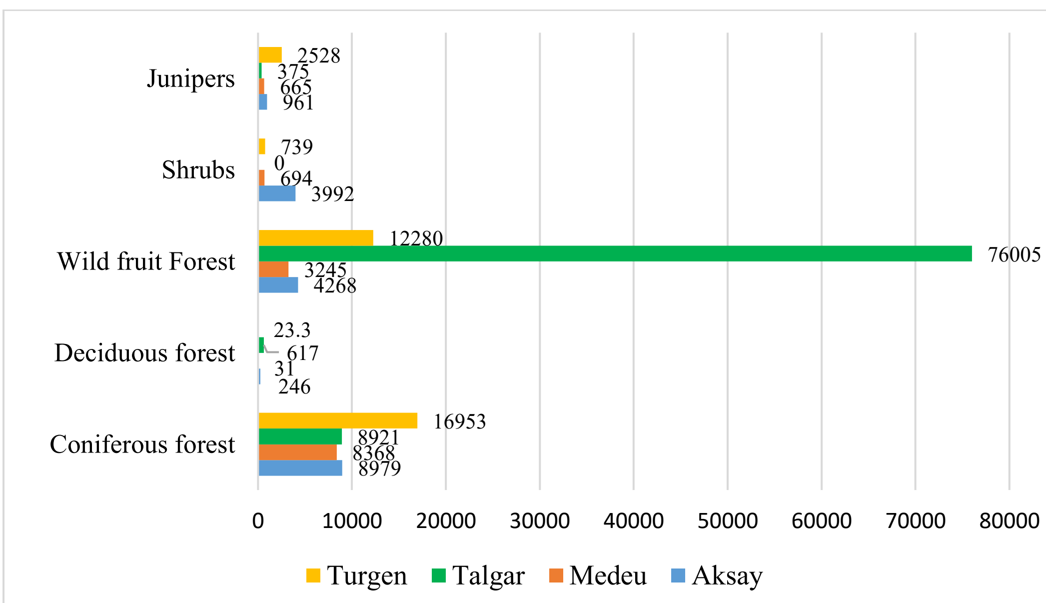

Fig. 4 . Forest types of animal habitats in the Ile-Alatau Natural Park.

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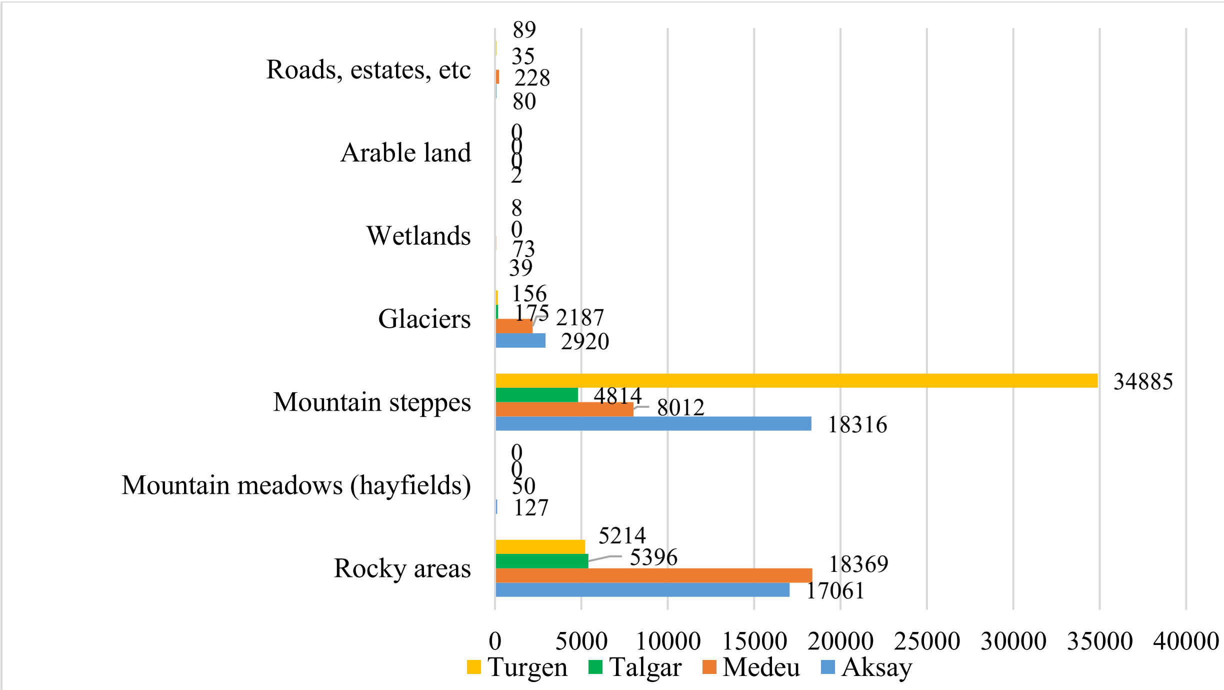

Fig. 5 . Non-forest types of animal habitats in the Ile-Alatau Natural Park.

Fig. 4 shows coniferous forests dominate the Turgen branch (16,953 ha), with other branches having similar, but less significant, coniferous forest cover. The Talgar branch has the largest wild fruit forests, at 76,005 ha, nearly six times more than other branches. Fig. 5 reveals mountain steppes are the most common non-forest land type across all branches, with Turgen having the largest area (34,885 ha). Rocky terrain is the second most common, led by Medeu (18,369 ha) and Aksai (17,061 ha). Animal habitat distribution within the national park is detailed in Table 2.

The Ile-Alatau National Park, covering 81,467 ha (40.8% of its total area), is home to the Tien Shan brown bear, which occupies five habitat types. The Turkestan lynx inhabits three habitat types across 48,644 ha (24.5%), while the stone marten is found in two habitat types spanning 89,261 ha (44.7%). The snow leopard is restricted to rocky highland environments, covering 46,040 ha (23.1%). The Central Asian river otter is present in all wetlands, but only in the middle reaches of the Shelek River within the Almaty Nature Reserve.

GIS technologies have provided the first quantitative data on animal habitat areas within the park. Schrenk spruce forests and wild fruit plantations are dominant, providing habitats for lynx and martens, particularly in the Turgen branch. Snow leopard habitats, mainly rocky massifs, are concentrated in the Medeu and Talgar branches.

Table 3 details the distribution of hunting grounds (biotopes). Deer, Siberian roe deer, and wild boar inhabit forested areas, while Siberian ibex and argali are exclusively found in rocky biotopes.

The Aksai branch of the Ile-Alatau National Park, depicted in Fig. 6, features a varied landscape. Coniferous forests cover the central region, transitioning to wild fruit orchards in the east. Deciduous forests are rare, while juniper forests are dispersed, with a significant presence in the west. The park supports around 270 animal species and subspecies, comprising 48 mammals, over 200 bird species, eight reptile, four amphibian, and eight fish types. These animals occupy diverse habitats, from foothills and woodlands to alpine zones, rocky areas, glaciers, water bodies, and human settlements. Six mammal species found in the park are rare and endangered: the Tien Shan brown bear, snow leopard, Turkestan lynx, Tien Shan mountain sheep, stone marten, and Indian porcupine (Koroleva & Dik Dikareva 2023).

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Table 2 . Typology of animal habitats in the Ile-Alatau National Park.

Type	Area (ha/%)	Among them are branches				Predator type
		Aksai	Medeu	Talgar	Turgen	
Coniferous forest	43221/21.6	8979/15.8	8368/20.0	8921/31.9	16953/23.3	Bear, marten, lynx
Deciduous forest	894/0.4	246/0.4	31/0.07	617/2.2	23.3	Bear, lynx
Wild fruit forest	27398/13.7	4268/7.5	3245/7.7	76005/27.2	12280/16.9	Bear
Shrubs	5425/2.7	3992/7.0	694/1.7	-	739/1.0	Bear
Juniper growths	4529/2.3	961/1.7	665/1.6	375/1.3	2528/3.5	Bear, lynx
Mountains	46040/23.1	17061/29.9	18369/43.8	5396/19.3	5214/7.2	Snow leopard, marten
Mountain meadows (hayfields)	177/ 0.1	127/0.2	50/0.1	-	-	-
Mountain steppes	66027/33.1	18316/32.2	8012/19.1	4814/17.2	34885/47.5	-
Glaciers	5439/2.7	2920/5.1	2187/5.2	175/0.6	156/0.6	-
Wetlands	120/0.06	39/0.07	73/0.2	-	8/0.001	Otter
Arable lands	2/0.001	2/0.003	-	-	-	-
Other lands (roads, estates,etc.)	432/0.2	80/0.4	228/0.5	35/0.1	89/0.3	-
Total	199703/ 100.0	56991/ 100.0	41922/ 100.0	27938/ 100.0	72852/ 100.0	-

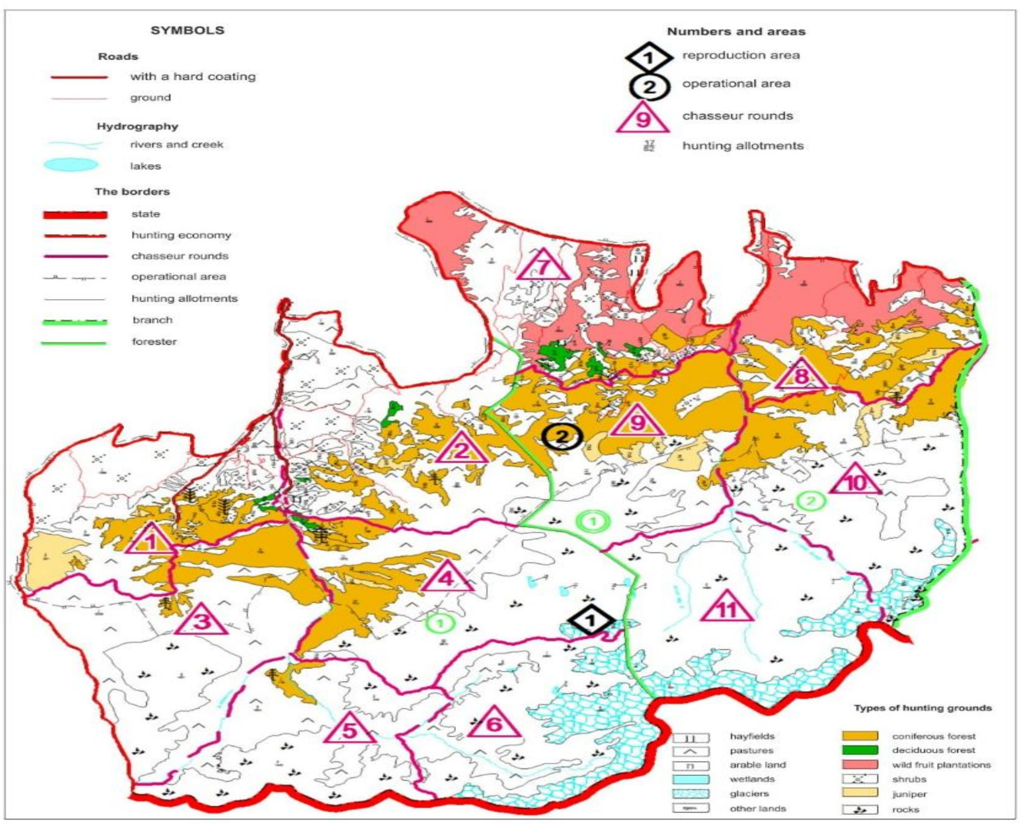

Fig. 6. Typology of the hunting grounds at the Aksai branch of the Ile-Alatau National Park.

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Table 3. Distribution of the Ile-Alatau National Park by types of hunting grounds.

Land type characteristics	Area (ha)	Among them are branches			
		Aksai	Medeu	Talgar	Turgen
Coniferous forest (1600-2600m a.s.l.) Spruce plantations of Schrenk have a variety of rare and medium densities on the slopes of northern exposures. The soils are mountain-forest dark-colored. Cover - moss, lichen, forbs, cereals; medium density. Undergrowth - wild rose, honeysuckle, barberry, mountain ash, raspberry.	43221	8979	8368	8991	16953
Deciduous forest (1200-1600m a.s.l.) Aspen forests on the southern and northern slopes. Soils - mountain forest, gray soils, forest. Cover - geranium, bluegrass, phlomis, cornflower; medium density. Undergrowth - honeysuckle, shrub willow, wild rose, currant; medium density.	894	246	31	617	-
Wild fruit plantations (750-1200 m a. s.l.) Rare stands of apple, apricot, hawthorn, Tien Shan mountain ash, etc. Soils - mountain-forest chernozems. Cover - phleum, nettle, alopecurus.	27398	4268	3245	7605	12280
Shrubs (1400-2600m a. s.l.) Thickets of wild ros and meadowsweet, shrub willow, as well as honeysuckle, currants on the southern slopes. The soil is mountain-steppe. The cover is meadow, forb.	5425	3992	694	-	739
Jumipers (2600-4200м. a.s.l.) Thickets of creeping juniper on rocky slopes in the alpine zone.	4529	961	665	375	2528
Mountains (2800-4200м. a.s.l.) Stony outcrops on steep slopes with sparse petrophytic vegetation.	46040	17061	18369	5396	5214
Hayfields (up to 750m) Cereal herbs in low mountains, along river valleys, upland. Soils - meadow chernozems	177	127	50	-	-
Arable land (up to 750 m) Agricultural crops	2	2	-	-	-
Pastures (600-1200m) Livestock grazing on the southern slopes and steppe areas with shrubs (rose hips, honeysuckle, spiraea).	66027	18316	8012	4814	34885
Wetlands Mountain rivers, lakes, swamps.	120	39	73	-	8
Glaciers (above 3400m) Alpine peaks with eternal snow and ice	5439	2920	2187	175	156
Other lands Roads, estates, settlements, cordons, settlements	432	80	228	35	89
Total:	199703	56991	41922	27938	72852

DISCUSSION

GIS integration has significantly improved conservation in Kazakhstan's protected areas by offering a spatial framework for analyzing hunting, biodiversity, and habitat dynamics, thereby balancing human activities with conservation goals. Research has classified hunting areas based on ecological, socio-economic, and managerial factors, highlighting the necessity for sustainable management that integrates traditional practices with modern conservation.

This research utilized GIS tools (e.g., QGIS) and Sentinel-2 remote sensing data to classify and map habitats within protected areas such as the Andasai State Natural Reserve and Ile-Alatau National Park. This methodology is crucial for understanding hunting ecology and guiding conservation efforts, as evidenced by the testing of a hunting ground typology. By employing forest management data and game animal distribution, the study qualitatively assessed

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hunting grounds in Southern Kazakhstan, generating habitat division maps for the Andasai Nature Reserve and the Aksai branch of Ile-Alatau National Park. These maps categorize habitats by ecological conditions, relief, and soil-plant features, which are essential for effective hunting planning. Despite challenges in data accuracy and availability, the study emphasizes the importance of innovative data collection and integration to fully leverage GIS for hunting area management and biodiversity conservation.

This research develops sustainable hunting management strategies, aligned with biodiversity conservation, using typology and ecological impact assessment. Integrating GIS into hunting area studies within protected natural areas has revolutionized conservation by providing a spatially explicit framework to analyze the interactions among hunting, biodiversity, and habitat dynamics (Martínez-Gra *et al.* 2013; Elbahi *et al.* 2023). In protected areas, GIS is invaluable for balancing human activities and conservation by enabling researchers to identify hunting area typologies, assess ecological impacts, and develop sustainable management strategies. These typologies, categorized by ecological, socio-economic, and managerial factors, highlight the interplay between traditional hunting and modern conservation (Gatiso *et al*. 2022; Rassolov & Shishikin 2023).

Hunting, particularly in protected areas, plays a vital role in habitat conservation. In regions like Extremadura, hunting has historically supported natural space preservation, emphasizing its integration into habitat management (Gallego & Martín 2016). Fenced areas, often used for conservation, exhibit richer natural habitats compared to unfenced ones, which are susceptible to overgrazing and degradation (Elbahi *et al.* 2023). Hunting tourism, as seen in Turkey, is geographically linked to game species distribution. GIS mapping helps balance tourism and conservation in these areas (Yayla *et al.* 2020). Studying hunting grounds in protected natural areas involves GIS, remote sensing (e.g., Sentinel-2 data), and field data to classify and map habitats, crucial for understanding the ecological implications of hunting (Martínez-Gra *et al.* 2013; Elbahi *et al*. 2023).

Spatial analysis methods like kernel density estimation and natural breaks classification are used in habitat network assessment and conservation planning, helping define conservation zones and manage protected areas (Tezel et al. 2020). Systematic conservation planning, exemplified by McHarg and Makhdum models, aids in zoning protected areas for strict conservation, sustainable use, and recovery based on multiple criteria (Erdi et al. 2017). GIS technologies significantly impact hunting area studies, mapping habitats, assessing conservation effectiveness (e.g., fencing impacts in North Africa), and investigating wildlife ranging behavior with tools like the dynamic Brownian Bridge Movement Model (Elbahi et al. 2023; Mukomberanwa et al. 2024). GIS also facilitates landscape analysis in protected areas, integrating physical and perceptual components to inform management decisions, as seen in Spanish natural parks (Martínez-Gra et al. 2013).

Despite the benefits of GIS in studying hunting areas, challenges remain. Accurate and available spatial data are crucial, but some regions lack socioeconomic data, requiring new collection and integration methods (Erdi *et al.* 2017). Implementing GIS also faces technical and governance hurdles; effective conservation planning demands collaboration among stakeholders, including local communities and policymakers. Integrating GIS with technologies like machine learning and UAS shows promise for conservation, yet further research and development are needed (Mukomberanwa *et al.* 2024).

GIS technology was used to create the first comprehensive typology of hunting grounds in the Andasai State Natural (Zoological) Reserve. This study identified 10 distinct habitat types: three haloxylon-dominated forest habitats and seven non-forest habitats characterized by saltwort, desert wormwood, and wetlands with reed and cattail plants (Bélisle & Asselin 2020).

The Andasai Reserve hosts 39 vertebrate species and subspecies listed in the Red Books of Kazakhstan and the IUCN. Vulnerable species like the kulan, goitered gazelle, and Tien Shan mountain sheep face significant poaching threats. Despite conservation efforts, the kulan population in the reserve remains critically low at around 90 individuals, contrasting sharply with thousands in other protected areas. The study also quantified the extent of various hunting grounds.

GIS-based typology studies of hunting areas in protected natural zones offer significant potential for conservation. These tools allow for identifying typologies, assessing ecological impacts, and developing sustainable management strategies. Overcoming data quality and governance challenges is crucial for maximizing GIS's benefits. As

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technology advances, integrating GIS with other approaches will better balance hunting and biodiversity conservation in protected areas. Ultimately, applying GIS to hunting areas in Kazakhstan's protected zones holds promise for strengthening conservation efforts.

CONCLUSION

By utilizing GIS technologies, researchers were able to acquire quantitative metrics regarding the areas occupied by different types of hunting grounds or wild animal habitats within the desert zone. These findings can enhance the efficiency of biotechnical and hunting efforts within the Andasai Nature Reserve, which includes refining protection strategies. Consequently, a typology of hunting grounds was developed for application in hunting management, categorizing their types as well as providing quantitative metrics for each category. It is significant to note that, for the first time, the typology of hunting grounds in this key region has been achieved in a GIS format. A map of the Andasai reserve and the Aksai branch of the Ile-Alatau State National Park was constructed by classifying the properties into terrain types that had not been previously defined. Additionally, the typology of habitats for rare predatory mammals within Ile-Alatau National Park was examined. This marked the first in-depth exploration of ungulate biological diversity accompanied by a typology of their habitats through the application of GIS technologies. The GIS software was employed to generate thematic digital maps that illustrated data, which included the locations of park boundaries, forestry services, and hunting departments, as well as assessments of ungulate populations, habitat conditions, fowl significance, the impact of game on forests, prey populations, and patterns of ungulate movement. GIS technology has demonstrated its value as a critical resource for aiding hunters in making well-informed decisions regarding natural resource management, facilitating both small and large-scale spatial and temporal analyses, thus contributing to more effective and sustainable bioresource management.

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