**ҚАЗАҚСТАН РЕСПУБЛИКАСЫ БІЛІМ ЖӘНЕ ҒЫЛЫМ МИНИСТРЛІГІ**

**АХМЕТ БАЙТҰРСЫНҰЛЫ АТЫНДАҒЫ ҚОСТАНАЙ ӨҢІРЛІК УНИВЕРСИТЕТІ**

**Ө. СҰЛТАНҒАЗИН АТЫНДАҒЫ ПЕДАГОГИКАЛЫҚ ИНСТИТУТЫ**

BAITURSYNULY UNIVERSITY

**Қостанай мемлекеттік педагогикалық институтының құрметті профессоры, биология ғылымдарының докторы Т.М. Брагинаның мерейтойына арналған**

# БИОЛОГИЯЛЫҚ ӘРТҮРЛІЛІКТІ САҚТАУ ЖӘНЕ ЕРЕКШЕ ҚОРҒАЛАТЫН ТАБИҒИ АУМАҚТАР ЖЕЛІСІН ДАМЫТУ атты

**ХАЛЫҚАРАЛЫҚ ҒЫЛЫМИ-ПРАКТИКАЛЫҚ КОНФЕРЕНЦИЯНЫҢ**

# МАТЕРИАЛДАРЫ


# МАТЕРИАЛЫ

**МЕЖДУНАРОДНОЙ НАУЧНО-ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ**

# СОХРАНЕНИЕ БИОЛОГИЧЕСКОГО РАЗНООБРАЗИЯ И РАЗВИТИЕ СЕТИ ОСОБО ОХРАНЯЕМЫХ ПРИРОДНЫХ ТЕРРИТОРИЙ,

**посвященной юбилею почетного профессора Костанайского государственного педагогического института, доктора биологических наук Т.М. Брагиной**





# PROCEEDINGS

**OF THE INTERNATIONAL RESEARCH AND TRAINING CONFERENCE**

# «CONSERVATION OF BIOLOGICAL DIVERSITY AND DEVELOPMENT OF THE NETWORK OF SPECIALLY PROTECTED NATURAL AREAS»,

**dedicated to the anniversary of the honorary professor of the Kostanay state pedagogical institute, doctor of biological sciences T.M. Bragina**

Қостанай 2024

**УДК 502.17**
**ББК 20.18**
**Қ 68**



**Қ 68** Қостанай мемлекеттік педагогикалық институтының құрметті профессоры, биология ғылымдарының докторы Т.М. Брагинаның мерейтойына арналған Биологиялық әртүрлілікті сақтау және ерекше қорғалатын табиғи аумақтар желісін дамыту атты халықаралық ғылыми-практикалық конференцияның материалдары (Қазақстан Республикасы, Қостанай қ., 2024 жылдың 26 акпан) / ғылыми редакторлары: С.Б. Куанышбаев, Т.М. Брагина. – Қостанай: Ахмет Байтұрсынұлы атындағы ҚӨУ, 2024. – 413 с.

Сохранение биологического разнообразия и развитие сети особо охраняемых природных территорий: Материалы междунар. научно-практ. конференции (26 февраля 2024 г., г. Костанай, Казахстан), посвященной юбилею почетного профессора КГПИ, д.б.н. Т.М. Брагиной / научн. редакторы: С.Б. Куанышбаев, Т.М. Брагина. – Костанай: КРУ имени Ахмет Байтұрсынұлы, 2024. – 413 с.

Conservation of biological diversity and development of the network of specially protected natural areas: Proceedings of the International research and training conference (February 26, 2024, Kostanay, Kazakhstan) dedicated to the anniversary of the honorary professor of the Kostanay State Pedagogical Institute, T.M. Bragina Dr. Sci. (Biol.) / science editors S.B. Kuanyshbayev, T.M. Bragina. – Kostanay: Akhmet Baitursynuly KRU, 2024 – 413 p.

**ISBN 978-601-356-339-8**

В сборнике опубликованы материалы Международной научно-практической конференции «Сохранение биологического разнообразия и развитие сети особо охраняемых природных территорий», посвященной юбилею почетного профессора Костанайского государственного педагогического института, доктора биологических наук Т.М. Брагиной. В докладах рассмотрены итоги исследований и перспективы сохранения биологического разнообразия, охраны природных территорий и популяций видов особого природоохранного значения, формирования экологической сети и вопросы интеграции природоохранной деятельности и образования. Книга предназначена для ученых и практиков, работающих в области изучения и сохранения биологического разнообразия, преподавателей вузов, аспирантов, студентов, работников природоохранных учреждений.

**УДК 502.17**
**ББК 20.18**

Утверждено и рекомендовано к изданию Ученым советом Костанайского регионального университета имени Ахмет Байтұрсынұлы» от 31.01.2024 г., протокол № 2.

ISBN 978-601-356-339-8
9 786013 563398



*За достоверность предоставленных в сборнике сведений и использованной научной терминологии ответственность несут авторы статей*
*На обложке: фото Т.М. Брагиной*

# ФАУНА МЕН ЖАНУАРЛАР ӘЛЕМІН ЗЕРТТЕУ ЖӘНЕ САҚТАУ

# ИЗУЧЕНИЕ И СОХРАНЕНИЕ ФАУНЫ И ЖИВОТНОГО МИРА

# STUDY AND CONSERVATION OF FAUNA AND WILDLIFE

# POST-RELEASE MOVEMENT BEHAVIOUR AND SURVIVAL OF KULAN REINTRODUCED TO THE CENTRAL STEPPES OF KAZAKHSTAN

## *Передвижение после выпуска и выживание кулана, восстановленного в центральных степях Казахстана*

**Petra Kaczensky[1,2,3], Albert Salemgareyev[4], John D. C. Linnell[1,3], Steffen Zuther[4,5], Chris Walzer[1,6], Nikolaus Huber[2], Thierry Petit[7]**

*[1]Norwegian Institute for Nature Research (NINA); Trondheim, Norway*
*[2]University of Veterinary Medicine Vienna, Austria*
*[3]Inland Norway University of Applied Sciences (INN), Evenstad, Norway*
*[4]Association for the Conservation of Biodiversity of Kazakhstan (ACBK), Nur Sultan, Kazakhstan*
*[5]Frankfurt Zoological Society (FZS), Frankfurt, Germany*
*[6]Wildlife Conservation Society, New York, USA*
*[7]Zoo La Palmyre, Les Mathes, France*
*e-mail: albert.salemgareev@acbk.kz*

**Аңдатпа.** Азиялық жабайы есек немесе Құлан (Equus hemionus kulan) бір кездері Еуразия даласындағы жануарлардың негізгі түрлерінің бірі болған. Қазақстанда олар 1930 жылдары мүлдем жоғалып кетті. Бұрын реинтродукцияның арқасында екі қорғалатын аумақта түрді қалпына келтіру мүмкін болды, бірақ түр өзінің бұрынғы ауқымының тек <1% – қалпына келтірді және әлі де Орталық Қазақстан даласында кездеспейді. Осы кең аймақта қалпына келтіруді бастау үшін біз құландарды ұстап алып, тасымалдадық: тоғыз құланнан тұратын бірінші топ 2017 жылы Торғай даласына шығарылғанға дейін арнайы қоршалған жайылымға орналастырылды, ал екінші тобы 2019 жылы әкелінді. Біз жаңа тіршілік ету ортасына бейімделу процесін құжаттау үшін тек қана GPS-иридий мойындығы бар төрт құланның қозғалысын қашықтықтан бақылауды жүзеге асырдық. Бастапқы популяциялардағы олардың қозғалысын салыстыру үшін біз «Алтынемел» МҰТП-дағы екі құланға және Барсакелмес МТҚ-дағы алты құланға қосымша мойындықтарды кигіздік. Әкелінген тоғыз құлан қоршалған жайылымда өте жоғары қозғалыс жиілігімен біртұтас топ құрды. Еркіне босатып жібергеннен кейін құландар тобы бастапқыда бір-бірінен алшақтаған жоқ, бірақ мамырдың ортасына қарай ыдырай бастады, ал тамыздың ортасына қарай барлық құландар жеке жүре бастады. Ауданы 48 680 – 136 953 шаршы шақырым аумағында реинтродукцияланған құландардың 95% автокорреляцияланған ядро тығыздығының диапазоны (Kernel Density Estimation) орасан зор болды және бастапқы популяцияларда шамамен 10-100 есеге көбейді. Реинтродукцияланған биелер ешқашан бір-бірімен кездескен жоқ, тиімді көбею туралы ешқандай дәлел жоқ, ал белгіленген төрт биенің екеуін браконьерлер өлтірді, ал біреуі табиғи себептердің нәтижесінен өлді. Белгіленбеген жануарлардың тағдыры белгісіз болып қалады. Біз құландар қауымдастығындағы бөліну-бірігу динамикасы мен төмен қозғалыс жаңа ортаға шығарылған жануарлардың бір-бірімен байланысын жоғалту қаупін тудырады деп болжаймыз. Бұл қауіп тік рельеф және судың шектеулі болуы сияқты қозғалысты шектейтін факторлар болмауына байланысты дала биотоптарында артуы мүмкін. Орталық Қазақстан даласында құландарды одан әрі қайта жерсіндіру аса ірі топтарды шығаруға және шектеулі санға жету үшін еркін көбейетін популяцияны тез арада құруға, құландардың тиімді көбеюі және олардың тіршілік ету мүмкіндігін арттыру үшін басқа құландармен кездесу ықтималдығын арттыруға бағытталуы тиіс.

**Түйінді сөздер:** *Equus hemionus kulan*, құлан, Қазақстан, реинтродукция, әлеуметтік бірлік, еркін босату, босатылғаннан кейінгі қозғалыс.

**Abstract.** Asiatic wild ass, or kulan, (*Equus hemionus kulan*) were once a key species of the Eurasian steppes. In Kazakhstan they went extinct by the 1930s. Early reintroductions have reestablished the species in two protected areas, but the species has reclaimed <1% of their former range and remained absent from the steppes of central Kazakhstan. To initiate restoration in this vast region, we captured and transported a first group of nine wild kulan to a large pre-release enclosure on the Torgai steppe in 2017, and two more in 2019. We used direct observations and post-release movement data of four kulan equipped with GPS-Iridium

collars to document their adaptation process in a vast novel habitat without conspecifics. For comparison with movements in the source populations, we additionally equipped two kulan in Altyn Emel National Park and six in Barsa Kelmes State Nature Reserve. The nine transported kulan formed a cohesive group with very high movement correlation in the enclosure. After release, the group initially stayed tightly together but started to break up by mid-May and with all kulan travelling independently by mid-August. With 48,680 – 136,953 km$^2$, the 95% Autocorrelated Kernel Density Estimation ranges of the reintroduced kulan were huge and about 10-100 times larger than those in the source populations. The reintroduced mares never reconnected, there was no evidence of successful reproduction, and two of the four collared mares were killed be poachers and one died of natural causes. The fate of the uncollared animals remains unclear. We speculate that the fission-fusion dynamics and low movement correlation of kulan societies harbours the risk that animals released into a novel environment lose contact with each other. This risk is likely enhanced in steppe habitats where movement constraining factors such as steep terrain and limited water availability are absent. Further kulan reintroductions to the steppes of central Kazakhstan should aim to release larger groups and built up the free-ranging population as quickly as possible to reach a critical mass, increasing the chance of kulan encountering conspecifics to successfully breed and increase their chance of survival.
**Key words:** *Equus hemionus kulan*, kulan, Kazakhstan, reintroduction, social cohesion, soft release, post-release movement.

**Аннотация.** Азиатский дикий осел, или кулан (*Equus hemionus kulan*), когда-то был одним из ключевых видов животных в евразийских степях. В Казахстане они полностью исчезли в 1930-х годах. Раннее, благодаря реинтродукции, получилось восстановить вид на двух охраняемых территориях, но вид восстановил <1% своего прежнего ареала и по-прежнему отсутствует в степях Центрального Казахстана. Чтобы начать восстановление в этом обширном регионе, нами были отловлены и перевезены куланы: первая группа из девяти куланов была помещена в специальный загон для передержки до выпуска в Торгайскую степь в 2017 году, а вторая – в 2019 году. Мы использовали дистанционное наблюдение о передвижении четырех куланов, снабженных GPS-иридиевыми ошейниками, чтобы задокументировать процесс их адаптации в новой среде обитания без собратьев. Для последующего сравнения перемещения в исходных популяциях мы дополнительно установили на двух куланов в ГНПП "Алтын-Эмель" и шесть – в Барсакельмеском ГПЗ. Девять перевезенных куланов сформировали сплоченную группу с очень высокой частотой перемещений в загоне. После выпуска на волю группа сначала держалась плотно друг к другу, но к середине мая начала распадаться, а к середине августа все куланы стали передвигаться самостоятельно. При площади 48 680 – 136 953 кв. км 95%-ный автокоррелированный диапазон плотности ядра (Kernel Density Estimation) реинтродуцированных куланов был огромным и примерно в 10 – 100 раз превышал в исходных популяциях. Реинтродуцированные кобылы так и не встретились друг с другом, не было никаких доказательств успешного размножения, а две из четырех помеченных кобыл были убиты браконьерами, а одна умерла в результате естественных причин. Судьба непомеченных животных остается неясной. Мы предполагаем, что динамика деления-слияния и низкая степень перемещения в сообществе куланов таит в себе риск того, что животные, выпущенные в новую среду, потеряют контакт друг с другом. Этот риск, вероятно, возрастает в степных биотопах, где отсутствуют факторы, ограничивающие передвижение, такие как крутой рельеф и ограниченная доступность воды. Дальнейшая реинтродукция куланов в степи Центрального Казахстана должна быть направлена на выпуск более крупных групп и скорейшее создание свободно размножающейся популяции, чтобы достичь критической массы, увеличивая вероятность встречи куланов с собратьями для успешного размножения и повышения их шансов на выживание.
**Ключевые слова:** *Equus hemionus kulan*, кулан, Казахстан, реинтродукция, социальная сплоченность, мягкий выпуск, движение после выпуска.

## Introduction

Old-growth steppe ecosystems, rich in carbon and biodiversity, face threats from land conversion, degradation, and fragmentation. Kazakhstan, with its remaining near-natural grasslands, plays a crucial role in preserving these ecosystems. The dissolution of the Soviet Union brought

about socio-economic changes in Kazakhstan, presenting both challenges and opportunities for biodiversity conservation.

Large herbivores, vital for steppe ecosystem functioning, need substantial areas for seasonal movements. The Asiatic wild ass, or kulan, once abundant across Eurasian steppes, now faces endangerment due to overhunting and habitat loss. In Kazakhstan, kulan reintroduction efforts have established populations in Barsa Kelmes State Nature Reserve and Altyn Emel National Park. Despite success, kulan remain absent from vast steppe regions, prompting ongoing reintroduction plans.

Understanding kulan movements is crucial for successful reintroduction. Limited data exists on factors influencing their movements, especially in Kazakhstan. In Mongolia, kulan exhibit nomadic behavior, covering extensive distances. However, their large-scale movements make them susceptible to habitat fragmentation, infrastructure, and human activities.

Post-release movements of reintroduced kulan are poorly documented, highlighting the need for comprehensive studies. While "soft release" methods may promote social bonds, the restoration of migratory behavior in naïve animals remains uncertain. The Altyn Dala Conservation Initiative in Kazakhstan aims to conserve flagship species like saiga and reintroduce kulan, contributing to the restoration of the original large ungulate assemblage in the steppe.

The study analyzes movement data of reintroduced kulan, comparing it with source populations, and aims to:

1. Explore fission-fusion group dynamics with low movement coordination.
2. Investigate exploratory movements followed by routine establishment.
3. Examine potential movement characteristics, such as adopting source population range sizes, using smaller ranges, establishing migratory behavior, or facing constraints from topography, rivers, and human presence.

**Material and methods**

**Study areas**

**Torgai Steppe:**

The Torgai steppe, situated in central Kazakhstan, encompasses the release site with a 55-ha pre-release enclosure near the abandoned village of Alibi. This area is strategically located within a network of protected areas (Fig.1), ecological corridors, and hunting zones, covering about 40,000 km2. The climate is continental, featuring hot summers and cold winters, with an average annual temperature of 7˚C and precipitation of 200 mm. The steppe exhibits a north-south gradient in precipitation and pasture productivity, with a variety of vegetation communities. Human population density is extremely low, and the region is core habitat for the Betpak Dala saiga population, along with other large mammals.

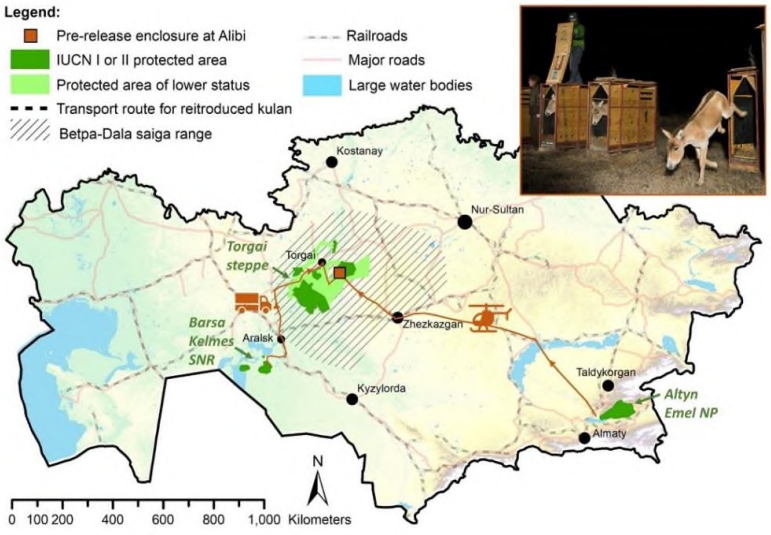


Fig.1. Study areas

**Altyn Emel National Park (NP):**

Located in southeast Kazakhstan, Altyn Emel NP covers 5,700 km2, established in 1996. The terrain ranges from 470 to 2,900m elevation, with semi-desert and desert vegetation dominating the plains. The park features a central valley with irrigation agriculture, small villages, and diverse habitats. Kulan were reintroduced to Altyn Emel NP between 1982-1994, originating from the Barsa Kelmes island population in the Aral Sea. The park hosts various ungulates, including goitered gazelle, Przewalski's horse, and a rich array of wildlife, with an estimated kulan population of around 3000.

**Barsa Kelmes State Nature Reserve (SNR):**

Situated in southwest Kazakhstan's Kyzylorda province, Barsa Kelmes SNR was initially a 133 km2 island in the Aral Sea, established in 1939. Wild kulan, saiga antelopes, and goitered gazelles were released on the island in the 1950s. Due to the Aral Sea's shrinking water levels, kulan left the island and settled in the surrounding area, leading to the SNR's expansion to 1,601 km2 in 2006. Barsa Kelmes SNR is characterized by desert shrub vegetation, limited water sources, and scarce access, with an estimated kulan population of approximately 500.

**Capture, collaring, and transport of kulan**

Kulan capture methods involved driving them into large corrals at night using jeeps and lights, following techniques from Levanov et al. (2013), or darting them with a CO2-powered rifle from a pursuing jeep as described by Walzer et al. (2007). The anesthesia process for collaring and loading into transport boxes included an early-developed protocol, detailed in Walzer (2014). Health assessments relied on visual checks, blood chemistry values, and leucocyte coping capacity measured on-site.

During anesthesia, all kulan received colored ear tags, and adult kulan were fitted with GPS collars (Vertex Lite or Vertex Plus, Vectronics Aerospace, Berlin, Germany). Those selected for transport also received long-acting neuroleptics (LANs) for stability during transport and initial release. In October 2017, nine wild kulans were airlifted from Altyn Emel NP to a pre-release enclosure in Torgai, where they stayed for five months until release in April 2018. In 2019, two additional kulan were transported from Barsa Kelmes SNR to the pre-release enclosure. Observations of body condition and behavior were conducted twice daily in the enclosure, with hay provided during winter and water in troughs when the lake was frozen (Gliga et al. 2020).

**GPS monitoring of kulan**

On the Torgai steppe we monitored the movement of four adult mares reintroduced from Altyn Emel NP in October 2017 and released from the pre-release enclosure in April 2018. We additionally monitored the movements of one adult mare reintroduced from Barsa Kelmes in 2019 in the pre-release enclosure, where she still is today. We also monitored the movements of kulan in the two source populations: two kulan in Altyn Emel NP collared in 2017 (they had to be released back into the wild due to their exited behaviour when loaded into transport boxes) and of six kulan in the source population in Barsa Kelmes SNR collared in 2019 (Table 1, Table S1; for further details see Kaczensky et al. 2018, Kaczensky et al. 2020). All collars were programmed to take 1 GPS location per hour and were equipped with pre-programmed drop-offs (CR-2A, Telonics, Mesa, AZ, USA).

After release from the pre-release enclosure, rangers attempted to locate and observe the collared kulan every two months. However, long-flight distances only made it possible to see collars whereas ear tags were largely invisible and numbers impossible to read. Once a collar became stationary, rangers checked the location for a dropped collar or a deceased kulan (for details on ground monitoring see: Kaczensky et al. 2020).

**Supplementary Table S1** – Kulan monitored in the reintroduced population in the Torgai Steppe and the source populations in Altyn Emel NP and Barsa Kelmes State Nature Reserve from October 2017 – November 2020. The 9 kulan reintroduced to the Torgai steppe from Altyn Emel NP on 23.10.2017 were released into the wild on 3.04.2018; the 2 kulan reintroduced from Barsa Kelmes SNR are still in the pre-release enclosure [as of April 2021].

| Origin | Collaring date | Name | Sex | Collar ID | Age | Collar type | Foal | Fate |
|---|---|---|---|---|---|---|---|---|
| ***Reintroduced kulan on the Torgai Steppe*** | | | | | | | | |
| Altyn Emel | 23.10.2017 | AF5 | f | 26860 | 7 | Vertex Lite-4D | yes (FM8) | Poached 20.12.2019 |
| Altyn Emel | 23.10.2017 | AF17 | f | 26176 | 7 | Vertex Plus-4D camera | yes (FF7) | Pre-programmed drop on 20.10.2018 |
| Altyn Emel | 23.10.2017 | AF4 | f | 26855 | 6 | Vertex Lite-4D | yes (FM11) | Poached 27.12.2018 |
| Altyn Emel | 23.10.2017 | AF9 | f | 26859 | 5 | Vertex Lite-4D | no | Natural mortality 08.07.2020 |
| Altyn Emel | 23.10.2017 | FF7 | f | | 0.5 | No collar | NA | unknown |
| Altyn Emel | 23.10.2017 | MF8 | m | | 0.5 | No collar | NA | unknown |
| Altyn Emel | 23.10.2017 | FF0 | f | | 0.5 | No collar | NA | unknown |
| Altyn Emel | 23.10.2017 | MF11 | m | | 0.5 | No collar | NA | unknown |
| Altyn Emel | 23.10.2017 | SM12 | m | | 3 | No collar | NA | unknown |
| Barsa Kelmes | 07.10.2019 | AF19 | f | 32671 | >10 | Vertex Plus-4 | yes | In pre-release enclosure |
| Barsa Kelmes | 10.10.2019 | SM0 | m | | 2-3 | No collar | NA | In pre-release enclosure |
| ***Kulan collared in the source populations*** | | | | | | | | |
| Altyn Emel | 23.10.2017 | AF14 | f | 26852 | 7 | Vertex Lite-4D | yes | Collar still active |
| Altyn Emel | 23.10.2017 | AF7 | f | 26850 | 10 | Vertex Lite-4D | yes | Collar still active |
| Barsa Kelmes | 25.04.2019 | AF2 | f | 26863 | ad | Vertex Lite-4D | no | Collar still active |
| Barsa Kelmes | 25.04.2019 | AF3 | f | 26861 | ad | Vertex Lite-4D | no | Collar still active |
| Barsa Kelmes | 26.04.2019 | AF18 | f | 26177 | ad | Vertex Plus-4D camera | ? | Collar stopped 25.09.2020* |
| Barsa Kelmes | 28.09.2019 | SF6 | f | 26854 | 2-3 | Vertex Lite-4D | no | Collar still active |
| Barsa Kelmes | 03.10.2019 | AM15 | m | 26857 | 3-4 | Vertex Lite-4D | NA | Collar still active |
| Barsa Kelmes | 03.10.2019 | AF1 | f | 26851 | 5-6 | Vertex Lite-4D | yes | Collar still active |

*Collar failed to drop and reached end of battery life. ** As of April 2021.

## Data analysis

To assess how synchronized kulan movements were pre- and post-release, we calculated movement correlation, deconstructed into a drift (directional), a diffusive (social), and a summarized overall component with R package *corrMove* as described in (Calabrese et al. 2018). The different models tested for were: (1) uncorrelated drift and uncorrelated diffusion (UU), (2) correlated drift and uncorrelated diffusion (CU), (3) uncorrelated drift and correlated diffusion (UC), and (4) correlated drift and correlated diffusion (CC). The algorithm further calculates the change date where movement correlation changes from one type to another.

To identify when kulan separated and whether they re-connected again, we calculated the pair-wise daily distances between all kulan pairs. To check for kulan association with the release site, we calculated the straight-line distance (net displacement – NSD) of locations to the pre-release enclosure.

To calculate range sizes, average distances travelled per day, and average range overlap among kulan, we used variograms and continuous-time movement models (ctmms) in the ctmmweb interface (Calabrese et al. 2021) of the R package *ctmm* (Calabrese et al. 2016). The ctmmweb interface allows for automated model fitting after visual inspection and calculates autocorrelated lifetime kernel density estimation (AKDE) home-range estimators and associated movements parameters with confidence intervals. For visualization of movements, we used the R package *MoveVis* (Schwalb-Willmann et al. 2020).

To allow for comparison with conventional home-range estimates, we also calculated the minimum convex polygon around all GPS locations (100% MCPs) and also used this approach to visualize how much new area was incorporated into each kulan's range as consecutive weeks of GPS locations were included in the calculation.

## Results

### Group cohesion, movement coordination, and fate of kulan

Behavioural observations over the winter 2017/18 documented that the nine kulan in the pre-release enclosure formed a cohesive group (Gliga et al. 2020) which resulted in a very high level of movement correlation (97% correlated diffusion (UC) indicative of social correlation). After release in early April, the group initially stayed tightly together (100% correlated diffusion UC) but started to split up in mid-May (mare 26860 on 21.05.2018, mare 26859 on 02.06.2018, and mare 26855 on 19.08.2018), which resulted in a drop of the UC to only 15%; the drift correlation remained 0% suggesting that there was no tendency for the kulan to move in the same direction. After the spilt-up, kulan rarely came within ≤10 km of each other again. Movement coordination among kulan in the source populations was similar in Barsa Kelmes SNR (UC = 13% with a change point on 20.05.2020) but was constantly higher among the two kulan in Altyn Emel NP (UC = 31%;).

Ground monitoring of reintroduced kulan showed that after the split-up, mare 26860 and 26855 were travelling alone, mare 26859 with a yearling, and mare 26176 with a yearling and the subadult stallion. We did not document the presence of a new foal for any of the reintroduced mares during the monitoring period. Monitoring of the four collared mares successively ended with the pre-programmed drop of the collar of mare 26176 on 20.10.2018, and the subsequent deaths of mare 26855 on 27.12.2018 (poached), mare 26860 on 20.12.2019 (poached), and mare 26859 on 08.07.2020 (natural mortality).

### Movement relative to the pre-release enclosure

The first seven days after release the group stayed within 20 km of the pre-release area, but then went on two exploration trips (10 April – 5 May 2018) towards the desert steppe ca. 140 km to the south-east of the pre-release area, both times returning to the vicinity of the pre-release enclosure. After the return from the second trip, the group immediately went to the north and east where they stayed until mare 26859 split off. After splitting up, kulan continued to range far separately, but also kept returning to the vicinity of the pre-release area.

**Movement characteristics and range sizes**

The ctmms supported a range-resident movement model for all kulan (both reintroduced and in the source populations). The best fitting model for all kulan was the general OUF model indicative of a home-range, and autocorrelated positions and velocities indicated an anisotrophic (non-circular) home range shape. The variograms for the ctmms showed an initial steep increase but reached a plateau within 1-4 months.

Modelled daily distances travelled were 36-51 km for reintroduced kulan, which is about 2-3 times larger than for kulan in the source populations. The 95% AKDEs of reintroduced kulan were huge covering 48,680 – 136,953 km$^2$, which is 10 to 100 times larger than those of kulan in the source populations (Fig. 2). The total area covered by the combined 95% AKDEs of the four kulan on the Torgai steppe was 152,875 km$^2$.

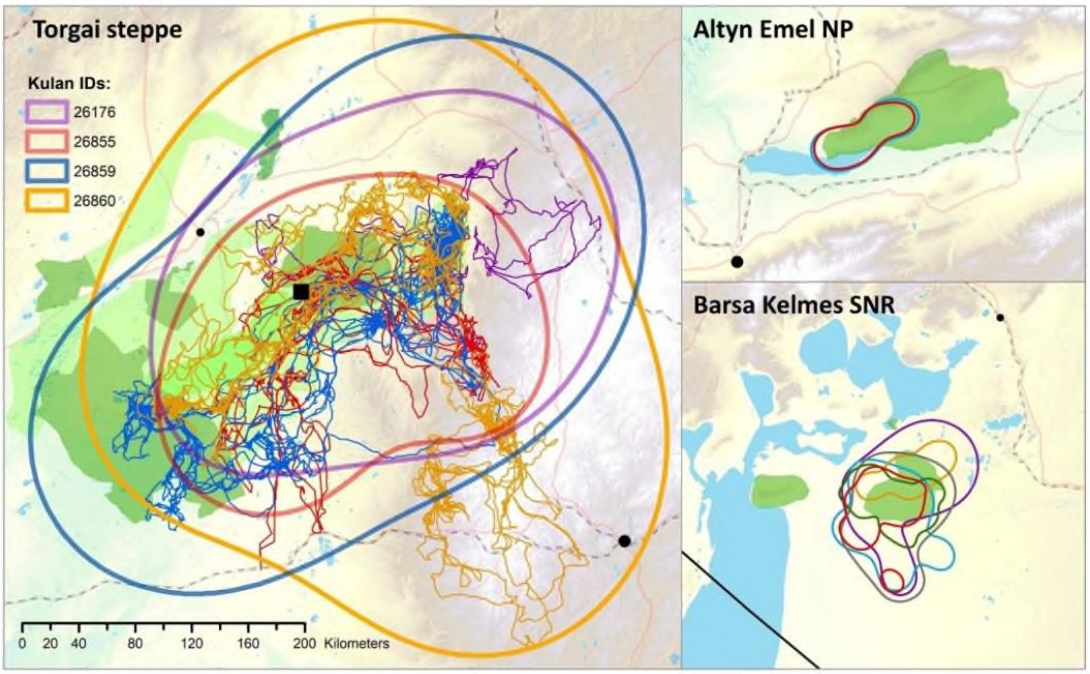


Fig.2. Kulan movements in different areas and MCP results

The 100% MCP covered over time by the reintroduced kulan showed a steep increase at the onset, a short temporary plateau after 15 weeks, followed by further increases. The two kulan monitored the longest reached a plateau in the summer of the second year, while the two kulan monitored over <1 year did not reach a plateau while being monitored.

Reintroduced kulan on the Torgai steppe did not spend the winter in the same general location and there was no evidence for a southward migration in winter. Only mare 26855 spent her first winter ca. 100 km to the south of the pre-release enclosure but was then killed by poachers. Mares 26859 and 26860 spent both winters in adjacent, non-overlapping areas ca. 100 km to the north and north-east of the pre-release enclosure, and mare 26176 was also in this general area when her collar dropped in October 2018.

**Landscape features guiding or restricting movements**

The ranges of reintroduced kulan overlapped almost entirely, and movements of individual kulan extended up to ca. 300 km away from the pre-release area to the southeast, ca. 200km to the east and west, and ca. 60 km to the north. In the east, mare 27176 crossed a railway twice (back and forth within 24 hours), and a nearby connective road four times. In the south, mare 26860 crossed the new Zhezkazgan-Saksaulskiy railway 8 times and a nearby connecting road 11 times, but mare

26855 appeared to have “bounced off” the same railway track at two locations further to the west (Fig. 2). All kulan crossed the Uly-Zhylanshyk river to the north of the pre-release enclosure, but none crossed the larger Torgai river further north and consequently no kulan came close to the connecting road between Torgai and Arkalyk (for 1-years animation of movements see Torgai steppe).

In Altyn Emel NP, the two collared kulan only used the western part of the NP and did not cross the central valley with its string of villages and irrigated agricultural land. Kulan also hardly ever went beyond the western boundary of the PA and stayed away from the steeper and higher reaches of the Sholak mountains. In the south the large Ily river and the Kapchagai reservoir were never crossed (for a 1-years animation of movements see Altyn Emel)

In Barsa Kelmes SNP, kulan never ventured onto the most recently exposed part of the former seabed and none of the collared kulan travelled to Barsa Kelmes Island. Kulan also did not venture far beyond the eastern SNR boundary into irrigated land or land used for livestock grazing (for a 1-years animation of movements see Barsa Kelmes).

## Discussion

### Movement coordination

Reintroduced kulan initially exhibited cohesive behavior in the pre-release enclosure, resembling a tightly-knit and well-coordinated group of horses (Gliga et al. 2020). Post-release, the group stayed together and moved synchronously until mid-May when it fragmented. Two mares that separated first showed signs of pregnancy, likely contributing to the separation during the normal birthing and mating period of Altyn Emel's source population (Kaczensky et al. 2020; Estep et al. 1995; Kaczensky et al. 2019). The remaining mares and subadult stallion stayed together for an additional two months before also parting ways.

The separation, potentially triggered by the subadult male's inadequacy as a mating partner, may have impacted foal survival due to the risks of being alone in an unfamiliar area. The absence of foals in 2017 and the following year may be attributed to this circumstance, further compounded by the limited ability to monitor unmarked individuals without radio collars. Kulan's fission-fusion society, effective in source populations, faced challenges in the Torgai steppe, where the reintroduced group lacked the familiarity of the Altyn Emel environment. The difficulty in regrouping underscores the significance of social learning in reintroduction projects (Brakes et al. 2021). Notably, observations showed a mare (26860) seeking company by grazing with a group of domestic horses in February 2019 (Kaczensky et al. 2020).

### Exploratory movements and soft release

The soft release approach may not have dampened post-release exploratory behaviour, but at least kulan did stay in the vicinity of the pre-release enclosure during the first week post-release and made the first exploratory movements as a group. The kulan also seemed to have bonded somewhat with the area as all animals kept coming back to the vicinity and their home ranges were centred around the pre-release enclosure.

Unfortunately, kulan did not return at the same time to allow them to re-connect. However, if kulan capture in 2018 had been successful, the presence of new kulan in the enclosure might have acted as an attraction for free ranging kulan, thus increasing the chance that free ranging kulan stay around and increasing their chance to re-connect. In the Przewalski’s horse reintroduction project in the Mongolian Gobi, the pre-release enclosure has continuously attracting free-ranging Prezewalski’s horses (mainly bachelor males), some of which even jumped the fence to join a captive group (P. Kaczensky unpubl. data).

### Movement characteristics and range sizes

Reintroduced kulan on the Torgai steppe were much more mobile than their respective peers with whom they were captured in Altyn Emel NP in 2017. Thus, the more productive pasture and the abundance of water did not result in lower mobility. Although initial exploratory movements

were to be expected, the two reintroduced kulan which we monitored over two winters showed little indication of restricting their movements, but rather kept exploring new areas to the south-east (mare 26860) and south-west (mare 26859). The range sizes of the reintroduced kulan on the Torgai steppe are in the same order of magnitude of those of kulan from Mongolia's South Gobi Region (Kaczensky et al. 2011; Payne et al. 2020), but contrary to kulan in the Gobi, which seem to be primarily nomadic (Noonan et al. 2020), the ctmm analysis indicated a clear home-range for the reintroduced kulan.

Kulan 26860 and 26859 both returned to the same area in the second winter which further suggests the animals had settled, but also points towards a possible re-emerging of migratory behaviour as documented for a zebra population in Botswana (Bartlam-Brooks et al. 2011). However, contrary to our expectation and reports from the past (Bannikov 1981) these two kulan spent the winter in the steppe and roamed both north and south during the reminder of the year. However, re-establishment of the most adaptive movement behaviour may take time (Jesmer et al. 2018). Given our very small sample and short monitoring period relative to the potential lifespan of a kulan, which is well over 20 years (Lkhagvasuren et al. 2017), these preliminary results should not be over-interpreted.

**Landscape features**

The considerable differences in daily movements and range sizes of reintroduced kulan compared to source populations raise questions. While the Torgai steppe exhibits large-scale movements, Altyn Emel NP and Barsa Kelmes SNR show small-scale movements, contrary to expectations based on the Mongolian Gobi's expansive ranges in a similar semi-desert habitat.

On the Torgai steppe, smaller rivers pose no significant barriers, but larger ones and dense vegetation bands act as obstacles. Reintroduced kulan ventured far, encountering newly constructed railways and connective roads, demonstrating their ability to cross unfenced barriers.

In Altyn Emel NP, natural features like the Sholak mountains and the Ily river/Kapchagai reservoir limit kulan movements. Discouragement from protected area staff and the presence of humans, livestock, and limited water in the eastern NP contribute to movement constraints.

Barsa Kelmes faces no natural restrictions, but the exposed Aral Sea seabed to the west and the lack of suitable habitat prevent expansion. Protection issues, including poaching and the absence of anti-poaching control, hinder movement beyond the SNP.

Both Altyn Emel and Barsa Kelmes experience a combination of natural and anthropogenic factors restricting kulan movements. In contrast, the Torgai steppe, selected for its minimal anthropogenic presence, allows high kulan mobility, though the absence of guiding features complicates monitoring. This difficulty, coupled with the vulnerability to poaching, underscores the challenges of reintroduction efforts.

**Conclusions for future reintroductions**

We speculate that the fission-fusion dynamics and low movement correlation of kulan societies harbours the risk that animals released into a novel ecosystem lose contact with each other. This risk is likely enhanced in steppe habitats where topographic features constraining movements are largely absent and where forage and water are more abundant and widely available than in desert-steppe or desert habitats. Future kulan reintroductions into the steppes of central Kazakhstan should aim to release larger groups and build up the free-ranging population as quickly as possible to reach a critical mass to increase the chance of kulan encountering conspecifics to successfully breed and increase their chance of survival.

The use of a pre-release enclosure seems to result in animals settling in the wider area and having kulan in the enclosure may also act as an attraction point for free-ranging animals, making it easier for them to re-connect with other free-ranging conspecifics. Furthermore, future releases should aim to keep kulan in the pre-enclosure until after foals are born and mating has happened in the hope that this will lower the mortality risk for foals and increase the chances of new foals in the

following year. However, such an approach needs to be carefully monitored (Gliha et al. 2020) as kulan held in captivity can show highly aggressive behavior to conspecifics and infanticide is a known phenomenon in equids (Cameron et a. 2003) both of which could easily result in losses and welfare issues in the enclosure if animals are not released before things escalate.

**Reference:**

1. Bannikov, A.G., 1981. The Asian Wild Ass. Lesnaya Promyshlennost, Moscow, Russia. [original in Russian, English translation by M. Proutkina, Zoological Society of San Diego].
2. Bartlam-Brooks, H.L.A., Bonyongo, M.C., Harris, S., 2011. Will reconnecting ecosystems allow long-distance mammal migrations to resume? A case study of a zebra Equus burchelli migration in Botswana. Oryx 45, 210–216.
3. Baumann, M., Kamp, J., Pötzschner, F., Bleyhl, B., Dara, A., Hankerson, B., Prishchepov, A.V., Schierhorn, F., Müller, D., Hölzel, N., Krämer, R., Urazaliyev, R., Kuemmerle, T., 2020. Declining human pressure and opportunities for rewilding in the steppes of Eurasia. Diversity and Distributions.
4. Bekenov, A.B., Grachevand, I.A., Milner-Gulland, E.J., 1998. The ecology and management of the Saiga antelope in Kazakhstan. Mammal Review 28, 1-52.
5. Buuveibaatar, B., Mueller, T., Strindberg, S., Leimgruber, P., Kaczensky, P., Fuller, T.K., 2016. Human activities negatively impact distribution of ungulates in the Mongolian Gobi. Biological Conservation 203, 168-175.
6. Buuveibaatar, B., Strindberg, S., Kaczensky, P., Payne, J., Chimeddorj, B., Naranbaatar, G., Amarsaikhan, S., Dashnyam, B., Munkhzul, T., Purevsuren, T., Hosack, D.A., Fuller, T.K., 2017. Mongolian Gobi supports the world's largest populations of khulan and goitered gazelles. Oryx 51, 639-647.
7. Cameron, E.Z., Linklater, W.L., Stafford, K.J., Minot, E.O., 2003. Social grouping and maternal behaviour in feral horses (Equus caballus): the influence of males on maternal protectiveness. Behav Ecol Sociobiol 53, 92-101.
8. Calabrese, J.M., Fleming, C.H., Fagan, W.F., Rimmler, M., Kaczensky, P., Bewick, S., Leimgruber, P., Mueller, T., 2018. Disentangling social interactions and environmental drivers in multi-individual wildlife tracking data. Philosophical Transactions B 373, 20170007.
9. Calabrese, J.M., Fleming, C.H., Gurarie, E., Freckleton, R., 2016. ctmm: anrpackage for analyzing animal relocation data as a continuous-time stochastic process. Methods in Ecology and Evolution.
10. Calabrese, J.M., Fleming, C.H., Noonan, M.J., Dong, X., 2021. ctmmweb: A graphical user interface for autocorrelation-informed home range estimation. Wildlife Society Bulletin, 1-8.
11. CMS, 2019. Central Asian Mammals Migration and Linear Infrastructure Atlas. CMS Technical Series Publication No. 41.
12. CMS, 2020. Central Asian Mammals Initiative. Newsletter 10/2020.
13. Edelstein, M.R., Cerny, A., Gadaev, A., 2012. Disaster by Design : Disappearance of the Aral Sea, Dry Run for the Emerging Climate Crisis. Research in Social Problems and Public Policy Volume 20, Emerald Group Publishing Limited.
14. Estep, D.Q., Crowell-Davis, S.L., Earl-Costello, S.-A., Beatey, S.A., 1995. Changes in the social behaviour of drafthorse (Equus caballus) mares coincident with foaling. Applied Animal Behaviour Science 35, 199-213.
15. Freitag, M., Kamp, J., Dara, A., Kuemmerle, T., Sidorova, T.V., Stirnemann, I.A., Velbert, F., Holzel, N., 2021. Post-Soviet shifts in grazing and fire regimes changed the functional plant community composition on the Eurasian steppe. Glob Chang Biol 27, 388-401.
16. Gerritsmann, H., Stalder, G.L., Kaczensky, P., Buuveibaatar, B., Payne, J., Boldbaatar, S., Walzer, C., 2016. Arterial pH and Blood Lactate Levels of Anesthetized Mongolian Khulan (Equus hemionus hemionus) in the Mongolian Gobi Correlate with Induction Time. J Wildl Dis 52, 642-646.
17. Giotto, N., Gerard, J.F., Ziv, A., Bouskila, A., Bar-David, S., 2015. Space-Use Patterns of the Asiatic Wild Ass (Equus hemionus): Complementary Insights from Displacement, Recursion Movement and Habitat Selection Analyses. PLoS ONE 10, e0143279.
18. Gliga, D.S., Petrova, N., Linnell, J.D.C., Salemgareyev, A.R., Zuther, S., Walzer, C., Kaczensky, P., 2020. Dynamics of Gastro-Intestinal Strongyle Parasites in a Group of Translocated, Wild-Captured Asiatic Wild Asses in Kazakhstan. Frontiers in Veterinary Science – Brief Research Report 7, 598371.

19. Huber, N., Marasco, V., Painer, J., Vetter, S.G., Göritz, F., Kaczensky, P., Walzer, C., 2019. Leukocyte Coping Capacity: An Integrative Parameter for Wildlife Welfare Within Conservation Interventions. Frontiers in Veterinary Science 6, 105.

20. Jesmer, B.R., Merkle, J.A., Goheen, J.R., Aikens, E.O., Beck, J.L., Courtemanch, A.B., Hurley, M.A., McWhirter, D.E., Miyasaki, H.M., Monteith, K.L., Kauffman, M.J., 2018. Is ungulate migration culturally transmitted? Evidence of social learning from translocated animals. Science 361, 1023-1025.

21. Joly, K., Gurarie, E., Sorum, M.S., Kaczensky, P., Cameron, M.D., Jakes, A.F., Borg, B.L., Nandintsetseg, D., Hopcraft, J.G.C., Buuveibaatar, B., Jones, P.F., Mueller, T., Walzer, C., Olson, K.A., Payne, J.C., Yadamsuren, A., Hebblewhite, M., 2019. Longest terrestrial migrations and movements around the world. Sci Rep 9, 15333.

22. Kaczensky, P., 2011. First assessment of the suitability of the Altyn Dala and Altyn Emel region of Kazakhstan for Przewalski's horse re-introduction. Report Research Institute of Wildlife Ecology, University of Veterinary Medicine, Vienna.

23. Kaczensky, P., Doldin, R., Enke, D., Linnell, J.D.C., Lukanovsky, O., Salemgareyev, A.R., Sidorova, T.V., Sklyarenko, S., Kisebaev, T., Walzer, C., Ward, S., Zuther, S., 2017. Feasibility study for kulan (Equus hemionus kulan) reintroduction into the central steppe of Kazakhstan. NINA Report 1366, 68 pp.

24. Kaczensky, P., Hrabar, H., Lukarevski, V., Zimmermann, W., Usukhjargal, D., Ganbaatar, O., Bouskila, A., 2016. Reintroduction of Wild Equids. Pages 196-214 in: Ransom, J.I., and Kaczensky, P. (Eds). Wild Equids – Ecology, Management, and Conservation. Johns Hopkins University Press, Baltimore, USA.

25. Kaczensky, P., Khaliun, S., Payne, J., Boldgiv, B., Buuveibaatar, B., Walzer, C., 2019. Through the eye of a Gobi khulan – Application of camera collars for ecological research of far-ranging species in remote and highly variable ecosystems. PLoS ONE 14, e0217772.

26. Kaczensky, P., Kovtun, E., Habibrakhmanov, R., Hemami, M.-R., Khaleghi, A., Linnell, J.D.C., Rustamov, E., Sklyarenko, S., Walzer, C., Zuther, S., Kuehn, R., 2018a. First population-level genetic analysis of free-ranging Asiatic wild ass populations in Central Asia – implications for conservation. Conservation Genetics 19, 1169–1184.

27. Kaczensky, P., Kuehn, R., Lhagvasuren, B., Pietsch, S., Yang, W., Walzer, C., 2011. Connectivity of the Asiatic wild ass population in the Mongolian Gobi. Biol Conserv 144, 920-929.

28. Kaczensky, P., Linnell, J.D.C., Zuther, S., Salemgareyev, A., Doldin, R., 2018b. Reintroduction of kulan into the central steppe of Kazakhstan: Field Report for 2017. NINA Report 1459.

29. Kaczensky, P., Lkhagvasuren, B., Pereladova, O., Hemami, M.-R., Bouskila, A., 2015. Equus hemionus. The IUCN Red List of Threatened Species 2015: e.T7951A45171204.

30. Kaczensky, P., Salemgareyev, A.R., Zuther, S., Suttibayev, M., Adilbekova, F., Linnell, J.D.C., 2020. Reintroduction of kulan into the central steppe of Kazakhstan: Field Report for 2018-2019. NINA report 1782.

31. Kamp, J., Koshkin, M.A., Bragina, T.M., Katzner, T.E., Milner-Gulland, E.J., Schreiber, D., Sheldon, R., Shmalenko, A., Smelansky, I., Terraube, J., Urazaliev, R., 2016. Persistent and novel threats to the biodiversity of Kazakhstan's steppes and semi-deserts. Biodiversity and Conservation.

32. Levanov, V.F., Sokolov, S.V., Kaczensky, P., 2013. Corral mass capture device for Asiatic wild asses Equus hemionus. Wildlife Biology 19, 325-334.

33. Linnell, J.D., Trouwborst, A., Boitani, L., Kaczensky, P., Huber, D., Reljic, S., Kusak, J., Majic, A., Skrbinsek, T., Potocnik, H., Hayward, M.W., Milner-Gulland, E.J., Buuveibaatar, B., Olson, K.A., Badamjav, L., Bischof, R., Zuther, S., Breitenmoser, U., 2016. Border Security Fencing and Wildlife: The End of the Transboundary Paradigm in Eurasia? PLoS Biol 14, e1002483.

34. Lkhagvasuren, D., Batsaikhan, N., Fagan, W.F., Ghandakly, E.C., Kaczensky, P., Müller, T., Samiya, R., Schafberg, R., Stubbe, A., Stubbe, M., Ansorge, H., 2017. First assessment of the population structure of the Asiatic wild ass in Mongolia. European Journal of Wildlife Research 64.

35. Mertes, K., Stabach, J.A., Songer, M., Wacher, T., Newby, J., Chuven, J., Al Dhaheri, S., Leimgruber, P., Monfort, S., 2019. Management Background and Release Conditions Structure Post-release Movements in Reintroduced Ungulates. Frontiers in Ecology and Evolution 7.

36. Milner-Gulland, E.J., Bukreeva, O.M., Coulson, T., Lushchekina, A.A., Kholodova, M.V., Bekenov, A.B., Grachev, I.A., 2003. Reproductive collapse in saiga antelope harems. Nature Feature 422, 135.

37. Nandintsetseg, D., Bracis, C., Leimgruber, P., Kaczensky, P., Bayarbaatar, B., Badamjav, L., Buyanaa, C., Shiilegdamba, E., Horning, N., Ito, T., Olson, K., Payne, J., Walzer, C., Shinoda, M., Stabach, J., Songer, M., Mueller, T., 2019. Variability in Nomadism: Environmental Gradients Modulate the Movement Behaviors of Dryland Ungulates. Ecosphere 10, e02924 | DOI:02910.01002/ecs02922.02924.

38. Nandintsetseg, D., Kaczensky, P., Ganbaatar, O., Leimgruber, P., Mueller, T., 2016. Spatiotemporal habitat dynamics of ungulates in unpredictable environments: The khulan (Equus hemionus) in the Mongolian Gobi desert as a case study. Biological Conservation 204, 313–321.

39. Nerlekar, A.N., Veldman, J.W., 2020. High plant diversity and slow assembly of old-growth grasslands. Proc Natl Acad Sci U S A 117, 18550-18556.

40. Olson, K.A., 2014. Saiga Crossing Options Guidelines and Recommendations to Mitigate Barrier Effects of Border Fencing and Railroad Corridors on Saiga Antelope in Kazakhstan. Report for Frankfurt Zoological Society, Association for the Conservation of Biodiversity of Kazakhstan, Fauna & Flora International, Convention on Migratory Species.

41. Payne, J.C., Buuveibaatar, B., Bowler, D.E., Olson, K.A., Walzer, C., Kaczensky, P., 2020. Hidden treasure in the Gobi: understanding how water limits range use of khulan in the Mongolian Gobi. Scientific Report, 10:2989.

42. Rashek, V.A., 1966. Kulan ecology and its acclimatisation on the island of Barsa Kelmes. PhD thesis, Moscow, UDSSR.

43. Renan, S., Speyer, E., Ben-Nun, T., Ziv, A., Greenbaum, G., Templeton, A.R., Bar-David, S., Bouskila, A., 2018. Fission-fusion social structure of a reintroduced ungulate: Implications for conservation. Biological Conservation 222, 261-267.

44. Resende, P.S., Viana-Junior, A.B., Young, R.J., Azevedo, C.S., 2021. What is better for animal conservation translocation programs: soft- or hard-release? A phylogenetic meta-analytical approach. Journal of Applied Ecology.

45. Rubenstein, D.I., Sundaresan, S., Fischhoff, I., Tantipathananandh, C., Berger-Wolf, T.Y., 2015. Similar but Different: Dynamic Social Network Analysis Highlights Fundamental Differences between the Fission-Fusion Societies of Two Equid Species, the Onager and Grevy's Zebra. PLoS ONE 10, e0138645.

46. Saltz, D., Rowen, M., Rubenstein, D.I., 2000. The effects of space-use patterns of reintroduced Asiatic wild ass on effective population size. Conservation Biology 14, 1852–1861.

47. Schwalb-Willmann, J., Remelgado, R., Safi, K., Wegmann, M., 2020. moveVis: Animating movement trajectories in synchronicity with static or temporally dynamic environmental data in R. Methods Ecol Evol. 11, 664–669.

48. Török, P., Ambarlı, D., Kamp, J., Wesche, K., Dengler, J., 2016. Step(pe) up! Raising the profile of the Palaearctic natural grasslands. Biodiversity and Conservation 25, 2187-2195.

49. Walzer, C., 2014. Non-domestic Equids. Pages 719-728 in: G. West, D. Heard, N. Caulkett (Eds), Zoo Animal and Wildlife Immobilization and Anesthesia, 2nd Edition, Wiley Blackwell, ISBN: 978-0-8138-1183-3.

50. Walzer, C., Kaczensky, P., Ganbaatar, O., Lengger, J., Enkhsaikhan, N., Lkhagvasuren, D., 2007. Capture and anaesthesia of wild Mongolian equids – the Przewalski's horse (Equus ferus przewalskii) and khulan (E. hemionus). Mongolian Journal of Biological Sciences 4, 19-30.

51. Wang, M.Y., Ruckstuhl, K.E., Xu, W.X., Blank, D., Yang, W.K., 2016. Human Activity Dampens the Benefits of Group Size on Vigilance in Khulan (Equus hemionus) in Western China. PLoS ONE 11, e0146725.

52. Wesche, K., Ambarlı, D., Kamp, J., Török, P., Treiber, J., Dengler, J., 2016. The Palaearctic steppe biome: a new synthesis. Biodiversity and Conservation 25, 2197-2231.

# МАЗМҰНЫ ❦ СОДЕРЖАНИЕ ❦ CONTENTS

## ФЛОРА МЕН ӨСІМДІКТЕР ҚАУЫМДАСТЫҒЫН САҚТАУ МӘСЕЛЕЛЕРІ

## ПРОБЛЕМЫ СОХРАНЕНИЯ ФЛОРЫ И РАСТИТЕЛЬНЫХ СООБЩЕСТВ

## PROBLEMS OF CONSERVATION OF FLORA AND PLANT COMMUNITIES

## ФАУНА МЕН ЖАНУАРЛАР ӘЛЕМІН ЗЕРТТЕУ ЖӘНЕ САҚТАУ

## ИЗУЧЕНИЕ И СОХРАНЕНИЕ ФАУНЫ И ЖИВОТНОГО МИРА

## STUDY AND CONSERVATION OF FAUNA AND WILDLIFE

## БІЛІМ БЕРУ ПӘНДЕРІНДЕГІ БИОЛОГИЯЛЫҚ ӘРТҮРЛІЛІК ЖӘНЕ ЕРЕКШЕ ҚОРҒАЛАТЫН ТАБИҒИ АУМАҚТАР ТУРАЛЫ МАТЕРИАЛДАР

## МАТЕРИАЛЫ О БИОЛОГИЧЕСКОМ РАЗНООБРАЗИИ И ОСОБО ОХРАНЯЕМЫХ ПРИРОДНЫХ ТЕРРИТОРИЯХ В ОБРАЗОВАТЕЛЬНЫХ ДИСЦИПЛИНАХ

## MATERIALS ON BIOLOGICAL DIVERSITY AND SPECIALLY PROTECTED NATURAL TERRITORIES IN EDUCATIONAL DISCIPLINES

**Қостанай мемлекеттік педагогикалық институтының құрметті профессоры, биология ғылымдарының докторы Т.М. Брагинаның мерейтойына арналған**

# БИОЛОГИЯЛЫҚ ӘРТҮРЛІЛІКТІ САҚТАУ ЖӘНЕ ЕРЕКШЕ ҚОРҒАЛАТЫН ТАБИҒИ АУМАҚТАР ЖЕЛІСІН ДАМЫТУ атты

**ХАЛЫҚАРАЛЫҚ ҒЫЛЫМИ-ПРАКТИКАЛЫҚ КОНФЕРЕНЦИЯНЫҢ**

# МАТЕРИАЛДАРЫ

# МАТЕРИАЛЫ

**МЕЖДУНАРОДНОЙ НАУЧНО-ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ**

# СОХРАНЕНИЕ БИОЛОГИЧЕСКОГО РАЗНООБРАЗИЯ И РАЗВИТИЕ СЕТИ ОСОБО ОХРАНЯЕМЫХ ПРИРОДНЫХ ТЕРРИТОРИЙ,

**посвященной юбилею почетного профессора Костанайского государственного педагогического института, доктора биологических наук Т.М. Брагиной**

# PROCEEDINGS

**OF THE INTERNATIONAL RESEARCH AND TRAINING CONFERENCE**

# «CONSERVATION OF BIOLOGICAL DIVERSITY AND DEVELOPMENT OF THE NETWORK OF SPECIALLY PROTECTED NATURAL AREAS»,

**dedicated to the anniversary of the honorary professor of the Kostanay state pedagogical institute, doctor of biological sciences T.M. Bragina**

Басуға 2024 ж. 21.02. берілді.
Пішімі 60х84/8. Көлемі 32,0 б.т. Тапсырыс № 016.

Ахмет Байтұрсынұлы атындағы
Қостанай өңірлік университетіндегі
Редакциялық-баспа бөлімінде басылған

Қазақстан Республикасы, 110000,
Қостанай қ., Байтұрсынұлы қ., 47

Подписано в печать 21.02.2024
Формат 60х84/8. Объем 32,0 п.л. Заказ № 016.

Отпечатано в редакционно-издательском отделе
Костанайского регионального университета
имени Ахмет Байтурсынулы

Республика Казахстан, 110000,
г. Костанай, ул. Байтурсынова, 47