

Annual Report

Chad Oryx Reintroduction Project

A joint initiative of the Government of Chad and the Environment Agency–Abu Dhabi,
implemented in Chad by Sahara Conservation
July 2025 – June 2026

Edited by Sahara Conservation



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Executive summary

This report provides an overview of the activities and results of the Scimitar-horned Oryx Reintroduction Project during the July 2025 – June 2026 reporting period in the Ouadi Rimé – Ouadi Achim Faunal Reserve, Chad. A joint initiative of the Environment Agency – Abu Dhabi (EAD) and the Government of Chad, the Project is implemented in-country by Sahara Conservation, with assistance from the Direction de la Faune et des Aires Protégées (DFAP). The report integrates data, information, and observations collected by the Project team, including valuable data on the behavior, social structure, calving performance, and survival of the reintroduced oryx. It draws on data from all project partners, including EAD, the DFAP, Sahara Conservation (SC), the Smithsonian's National Zoo & Conservation Biology Institute (NZCBI), and the Zoological Society of London (ZSL).

Cover photo: Group of scimitar-horned oryx in Ouadi Rimé – Ouadi Achim Faunal Reserve, Chad. © John Newby

Back cover photo: Young addax feeding on the leaves of wild colocynth, *Citrullus colocynthis*.

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Acknowledgements

This project would never have happened without the vision, the leadership, the resources, the skills and the animals of the Environment Agency – Abu Dhabi and its leaders. The partnership between EAD, the Government of Chad, and Sahara Conservation has ensured the project's success in many ways. The initiative is not only one of the most ambitious wildlife reintroductions ever undertaken but also a glowing example of what can be done to save Africa's imperiled wildlife if we all pull together.

Main abbreviations and acronyms

ASABLFB	Association de sensibilisation anti-braconnage et de lutte contre les feux de brousse (Association for Anti-Poaching Awareness and Bushfire Prevention)
DFAP	Direction de la Faune et des Aires Protégées (Directorate of Wildlife and Protected Areas)
EAD	Environment Agency – Abu Dhabi
ENCR	Ennedi Natural and Cultural Reserve
FRWC	Fossil Rim Wildlife Center
GPS	Global Positioning System
IREC	Institut de Recherche en Élevage pour le Développement (Chad Livestock Research Institute for Development)
Iridium	Iridium Satellite Communications
MEPDD	Ministère de l'Environnement, de la Pêche et du Développement Durable (Ministry of the Environment, Fisheries and Sustainable Development)
MWI	M-weight index
NZCBI	Smithsonian's National Zoo & Conservation Biology Institute
OBC	Oryx Base Camp
Oryx	Scimitar-horned oryx (<i>Oryx dammah</i>)
POROA	Ouadi Rimé – Ouadi Achim Project (project to support the development of the Réserve de Faune de Ouadi Rimé – Ouadi Achim)
Project	Chad Oryx Reintroduction Project (also “Oryx Project”)
OROAFR	Ouadi Rimé – Ouadi Achim Faunal Reserve
RZSS	Royal Zoological Society of Scotland
SC	Sahara Conservation
Vectronic	VECTRONIC Aerospace GmbH
VHF	Very High Frequency
ZSL	Zoological Society of London

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INTRODUCTION

The Ouadi Rimé – Ouadi Achim Faunal Reserve (OROAFR), located in central Chad, was established by decree No. 135/PR/EFP/PNR of May 10, 1969, to protect Sahelo-Saharan antelopes, cheetahs, and ostriches. It covers a surface area of 7,795,000 hectares.

The reserve straddles five provinces: Batha, Borkou, Bahr el Ghazal, Wadi Fira, and Ennedi-Ouest. Unfortunately, the years of conflict and drought that the country experienced during the 1970s and 1980s had severe consequences for Chad's wildlife. The scimitar-horned oryx (*Oryx dammah*) became extinct in the wild in the 1980s, but the reserve still supported populations of wild dorcas gazelles, bustards, and dama gazelles.

In September 2014, the Chadian Minister of Environment and the Environment Agency – Abu Dhabi (EAD) signed an agreement to reintroduce the scimitar-horned oryx into OROAFR. The NGO Sahara Conservation was entrusted with implementing activities on the ground in Chad. Since 2019, the initiative has expanded the reintroduction efforts to include addax (*Addax nasomaculatus*) and dama gazelles (*Nanger dama*), as well as scimitar-horned oryx.

During the reporting period, new groups of scimitar-horned oryx, addax and dama gazelles were released into the reserve, and a new reintroduction strategy for addax in the northern OROAFR was implemented. Field and remote monitoring continued to expand as the reintroduced populations grew and dispersed, with results indicating a strong recovery of the oryx population following the losses recorded during the 2024 hot season, as well as encouraging reproduction among addax released in the north. The Project also strengthened habitat management and bushfire prevention, technical capacity, and collaboration with government authorities, local communities, and conservation partners.

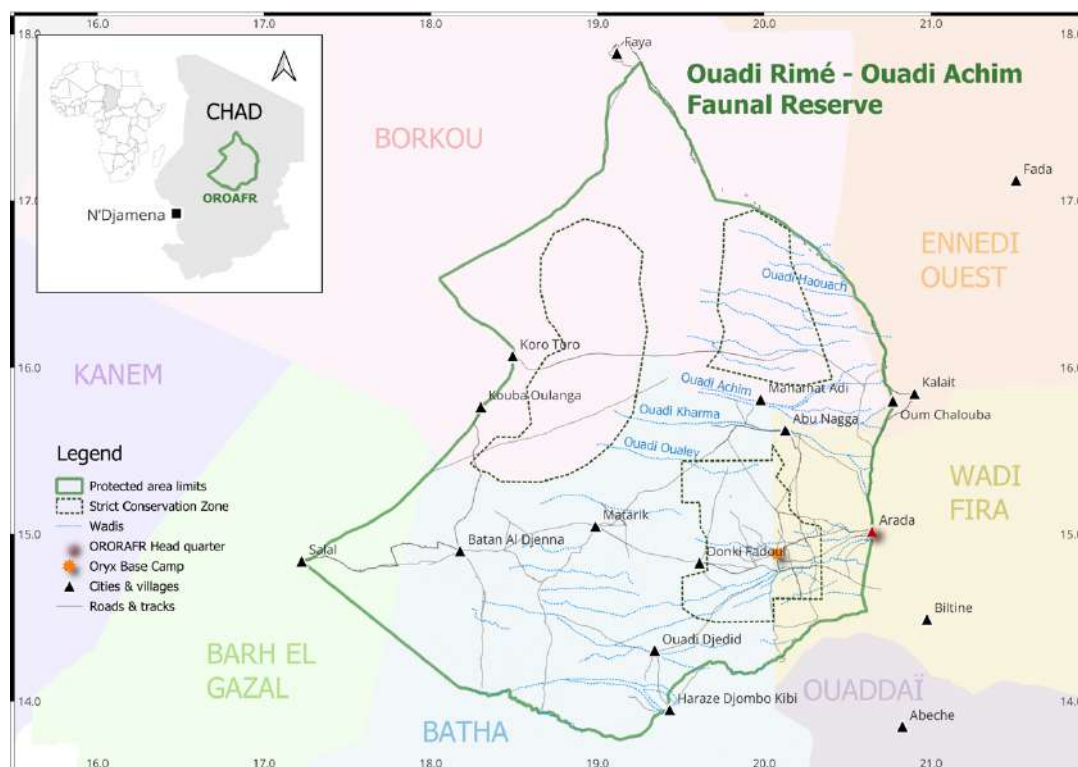


Fig.1. Ouadi Rimé – Ouadi Achim Faunal Reserve map.

Section I. *IN SITU* MANAGEMENT

Marc Dethier

Project manager – Sahara Conservation



1. Management of animals in enclosures

1.1 Scimitar-horned oryx (*Oryx dammah*)

In 2025, two groups of scimitar-horned oryx were transferred to Chad by the Environment Agency – Abu Dhabi (EAD), further strengthening the reintroduced population in the Ouadi Rimé – Ouadi Achim Faunal Reserve (OROAFR).

Ten oryx arrived on February 23, but unfortunately, one died during transport. The remaining nine were fit with GPS collars and ear tags in September before being released into the reserve on October 10. A second group of ten oryx arrived on October 25 and was released on November 15.



Fig. 1. Oryx released into the acclimatization pen on February 23, 2025.

These two transfers brought the total number of founder oryx received from Abu Dhabi since the beginning of the reintroduction program to 355. Following the November release, no oryx remained in the holding facilities at the Oryx Base Camp (OBC).

Founder oryx transferred from EAD

Arrival date in Abéché	Number of founder oryx coming from Abu Dhabi	Release date into OROAFR
March 16, 2016	25	August 14, 2016
November 14, 2016	25	January 21, 2017
January 18, 2017	25	August 3, 2017
February 11, 2018	25	August 6, 2018
February 15, 2018	25	August 6, 2018
February 18, 2018	25	August 6, 2018
February 25, 2019	25	September 17, 2019
November 11, 2019	25	December 17, 2019
March 3, 2020	25	September 22, 2020

November 8, 2021	25	December 5, 2021
March 14, 2022	20	August 17, 2022
November 7, 2023	15	January 17, 2024
November 12, 2024	25	December 11, 2024
November 17, 2024	25	December 10, 2024
February 23, 2025	10	October 10, 2025
October 25, 2025	10	November 15, 2025
TOTAL	355	

1.2 Addax (*Addax nasomaculatus*)

On February 23, 2025, 15 addax arrived in Chad from Abu Dhabi.

During the year, a new release strategy was adopted, with the addax release site moved to the northern part of the OROAFR. In September, a field mission identified a suitable location approximately 193 km from the OBC. The availability of perennial vegetation and shrubs providing shade made the site suitable for a short acclimatization period prior to release.

A temporary 0.5-hectare enclosure (boma) was constructed on October 1–2 and equipped with the required infrastructure to accommodate the animals, including water supply and feed storage facilities.



Fig. 2. Temporary enclosure constructed in October 2025 for addax reintroduction in northern OROAFR.

On October 4, the 15 addax in the acclimatization pen close to OBC were captured, placed in individual crates and transferred to the temporary enclosure in the north of the reserve. Following a short acclimatization period, they were released on October 8.



Fig. 3. Addax captured and placed in individual crates to be transported to the new release site.

A second group of ten addax arrived from Abu Dhabi on October 25 and was directly transported to the temporary enclosure in the north. After ten days of acclimatization, the animals were released into the reserve on November 4.

These releases brought the total number of founder addax received from Abu Dhabi through the reintroduction program to 140.

Founder addax transferred from EAD

Arrival date in Abéché	Number of founder addax coming from Abu Dhabi	Release date into OROAFR
November 13, 2019	15	January 18, 2020
March 6, 2020	25	September 7, 2020
November 15, 2021	25	December 12, 2021
March 7, 2022	25	August 24, 2022
November 14, 2023	25	January 16, 2024
February 23, 2025	15	October 8, 2025 (northern OROAFR)
October 25, 2025	10	November 4, 2025 (northern OROAFR)
TOTAL	140	

1.3 Dama gazelles (*Nanger dama*)

Work to improve the dama gazelle enclosure was completed in June 2025. The enclosure was divided into four five-hectare sections, with a central area designed to facilitate animal capture and manipulations.

In October, four additional dama gazelles (one male and three females) were transferred from Abu Dhabi and integrated into the existing “Manga” group.

On October 27 and 28, the gazelles were handled for veterinary procedures and population management. The operation included vaccination, the establishment of three groups representing different genetic lineages, and the selection of ten individuals for release on November 1. Four adults were also fit with GPS collars to enable post-release monitoring.



Fig. 4. Dama gazelle being blindfolded, vaccinated and collared, before release into the OROAFR.

In December, veterinarians Dr Philippe Chardonnet and Dr Mouhktar Al-Djibert of the Livestock Research Institute for Development (IREN) carried out a mission to assess the health and nutritional condition of the dama gazelles in the enclosures and provide recommendations for their ongoing management.

At the end of June 2026, the 27 dama gazelles held in the enclosures were distributed as follows:

- Manga group: 10 individuals – 8 adults and 2 juveniles (3♂ / 7♀)
- OROA/EAD group: 8 individuals – 7 adults and 1 juvenile (2♂ / 6♀)
- Manga/EAD/OROA group: 9 individuals – 6 adults and 3 juveniles (3♂ / 6♀)

ISAGRI Corporation Chad, a livestock feed manufacturer based in Moundou, supplied feed pellets for testing as a potential dietary supplement for dama gazelles held in the enclosures. Two samples were sent to N'Djamena for analysis by IREN and the Food Quality Control Centre (CECOQDA) to determine their protein, ash, moisture and fat content.

Founder dama gazelles transferred from EAD

Date of arrival in Chad	Number	Number remaining in the enclosures
March 14, 2022	5 females	3
October 25, 2025	3 females and 1 male	4
TOTAL	9	7

1.4 North African ostriches (*Struthio camelus camelus*)

The North African ostrich breeding program continued at the OBC in 2025, with 14 chicks hatching on December 27. By the end of June 2026, 28 ostriches were being managed in the enclosures:

- 4 adults (one male / three females) transferred from Zakouma National Park in 2020;
- 3 birds aged 28 months (two males / one female);
- 7 birds aged 18 months (three males / four females);
- 14 six-month-old chicks, hatched in December 2025.



Fig. 5. Top: North African ostriches of various ages in enclosures at OBC. Bottom: 14 chicks hatched on December 27, 2025.

2. Project operations and management

2.1 Team and capacity building

Team

In 2025, 14 staff members worked at the reintroduction site in the heart of the OROAFR. A further seven staff based in N'Djamena provided administrative and logistical support to the Project, alongside seven Sahara Conservation (SC) team members based in Europe.

Permanent staff at the reintroduction site (December 2025)

Name	Position
Marc Dethier	Project manager
Honoré Todjibaye Midjigue	Cook
Dieudonné Kephass Doldiguim	Cook
Evariste Djibkibeng Malbe	Mechanic
François Madjitigal	Tractor driver/Driver
Yacoub Hassaballah Hagry	Driver
Abdoulrassoul Mahamat	Tractor driver / Driver
Djiddi Aklabach Ali	Tractor driver / Animal keeper
Oumar Annadif	Head animal keeper / Ecological monitoring officer
Kher Issackha	Animal keeper / Ecological monitoring officer
Loutfallah Ali	Animal keeper
Habib Ali Hamid	Ecological monitoring officer
Ali Mahamat	Ecological monitoring officer
Hissein Abdarrahim	DFAP permanent escort guard

The permanent OBC team brings together the range of skills required to operate the site and implement field activities, including logistics, maintenance, animal husbandry and ecological monitoring.

Temporary staff can be hired as needed. In 2025, the six-member Rambo team supported firebreak construction and maintenance, bushfire response, the reconfiguration of the dama gazelle enclosure, and the construction of the temporary addax acclimatization enclosure in the northern OROAFR. Tractor operators, drivers, cooks and other temporary staff were also mobilized for specific Project operations, including the transfer, feeding and watering of addax in the north of the reserve.

The four-person Tango team, whose members belong to the local NGO *Association de sensibilisation anti-braconnage et de lutte contre les feux de brousse* (ASABLFB), continued its community outreach activities, focusing on bushfire prevention and good hygiene and water-use practices. From October onwards, these activities were implemented under contract with the *Projet de renforcement de l'élevage pastoral* (PREPAS), primarily in Batha Province, as the early southward movement of nomadic communities had reduced their presence in the Project's main intervention area.

Two interns also joined the Project during the year. Tchibinbe Bang-Djolbe worked on relationships between local communities and vultures, while Izzadine Abdelhakim provided additional support to the ecological monitoring team.

Capacity building

A number of training activities strengthened the technical skills of Project staff in 2025.

Habib Ali Hamid, a member of the ecological monitoring team, attended an ornithology training course in Zakouma National Park delivered by Tour du Valat and the French Biodiversity Agency, in collaboration with the Directorate of Wildlife and Protected Areas (DFAP). The ecological monitoring team also received practical training in bustard capture and GPS device fitting from Mattheuns Pretorius of the Endangered Wildlife Trust.

Mahamat Ali, also a member of the ecological monitoring team, completed a six-week online course in Geographic Information Systems (GIS), mapping and geospatial data analysis, delivered by Maya Digit in Burkina Faso.

Training on pastoralism and botany further strengthened the Project team's understanding of pastoral dynamics within the reserve and their ability to identify Chad's native flora.

2.2 Oryx Base Camp, logistics and security

Located in the heart of the OROAFR, the OBC is the operational center of Project activities. Operating in such a remote location requires self-sufficient infrastructure and substantial logistical capacity to maintain a permanent field presence and support activities across the reserve.



Fig. 6. Aerial view of the Oryx Base Camp.

Energy and water

The OBC relies primarily on solar power. In May 2025, a failure of the inverter controlling 57 of the solar panels temporarily reduced the system's capacity. The inverter was replaced in July, restoring the system to full operation. Total electricity consumption during the year was at least 23,836 kWh.

Water supplies for the OBC and ranger camp, as well as for animals in the enclosures and infrastructure work on site, were maintained throughout the year through the Project's water storage and supply system between Arada and the OBC.

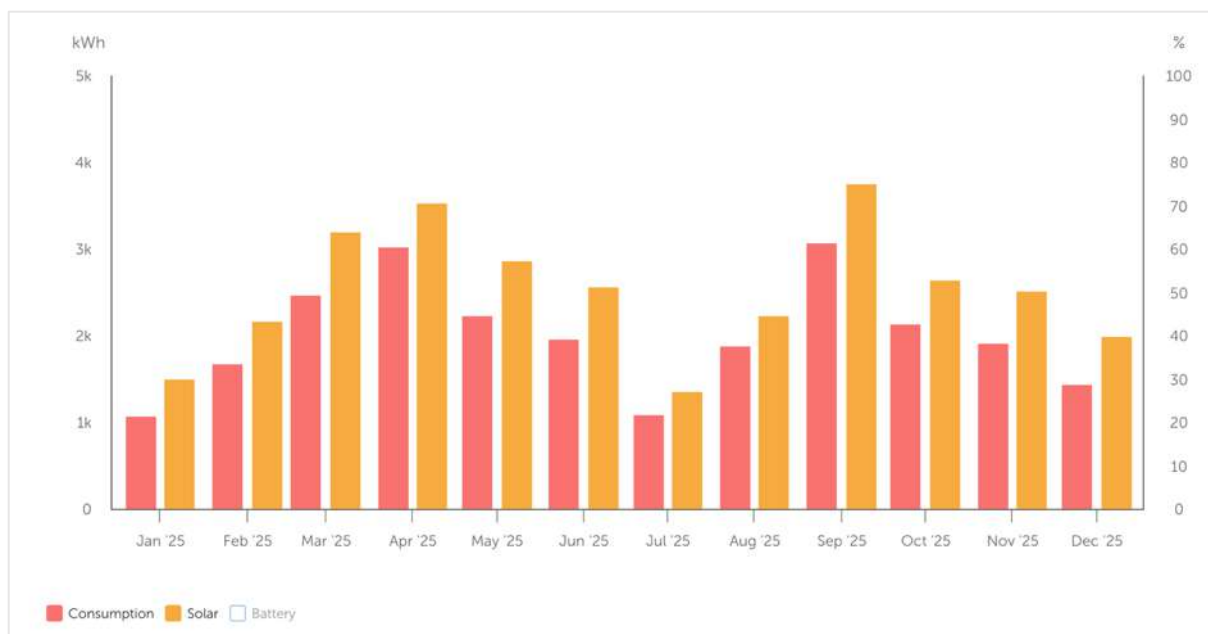


Fig.7. Electricity consumption, 2025.

Logistics

The Project operates a fleet of seven vehicles supporting activities across the reserve, including ecological monitoring of oryx, addax, and dama gazelles, enclosure management, staff and expert travel, logistical liaisons with Abéché, infrastructure maintenance and community outreach.

Given the size of the OROAFR and the remoteness of the OBC, these vehicles are essential to Project operations. Together, the light-vehicle fleet covered 144,329 km during the year.



Fig. 8. Oryx Project vehicle fleet

Five tractors are also used for firebreak construction and bushfire response:

- one John Deere 6100 acquired under the POROA project, funded by the European Union;
- one John Deere 6100 used with PREPAS, funded by the Swiss Agency for Development and Cooperation;
- one John Deere 5500 purchased through the World Bank-funded ALBIA project;
- two John Deere 5503 tractors donated by the Forest and Wildlife Guard, originally provided by the MEPDD.

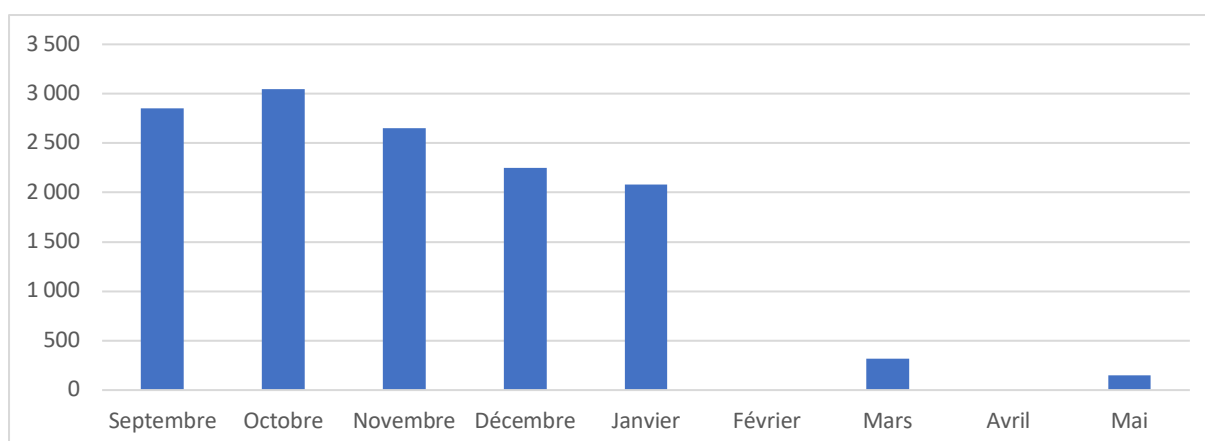


Fig. 9. Distance traveled in kilometers by tractors from September 2025 to May 2026.

Between September 2025 and May 2026, the tractor fleet covered 13,940 km. From February onwards, the tractors were also deployed in response to bushfires.

Vehicles	Main use	Purchase date	Km	Km	Mileage in km in a year
			May 31, 2025	May 31, 2026	
Land Cruiser twin-cab 18C4107TT	Ecological monitoring	August 2015	286,244	290,884	4,640
Land Cruiser single-cab 18C4213TT	Logistics enclosure	January 2016	168,243	173,426	5,183
Land Cruiser twin-cab 18C4328TT	Firebreaks logistics	August 2016	281,433	287,605	6,172
Land Cruiser V8 18C4484 TT	EAD, N'Djamena/OBC	July 2017	115,752	129,388	13,636
Land Cruiser twin-cab 18C5206TT	Long distance trips logistics	May 2021	167,700	201,992	34,292
Land Cruiser twin-cab 18C5207TT	Ecological monitoring	May 2021	134,633	165,125	30,492
Land Cruiser single-cab 18C5208TT	Logistics / infrastructures maintenance	May 2021	96,695	115,638	18,943
Land Cruiser twin-cab 18C4882TT	Logistics / monitoring/ Tango team	March 2024	159,007	189,978	30,971

Tab 1. Mileage tracking for the Project's vehicles since acquisition.

Months	Project's vehicles	Trucks	Tractors	Other light vehicles	TOTAL
June 2025	2,037	0	0	0	2,037
July 2025	1,072	0	0	310	1,382
August 2025	1,198	0	302	0	1,500
September 2025	3,105	235	3,638	0	6,978
October 2025	3,754	1,460	1,406	25	6,645
November 2025	1,977	0	474	37	2,488
December 2025	1,710	0	69	0	1,779
January 2026	1,402	1,542	866	0	3,810
February 2026	1,091	0	48	0	1,139
March 2026	1,228	0	0	0	1,228
April 2026	1,312	0	0	0	1,312
May 2026	1,321	0	50	232	1,603
TOTAL	21,207	3,237	6,853	604	31,901

Tab 2. Fuel consumption in liters by the Project's vehicles.

Security

A team of eight rangers, working on a rotational basis, provided year-round security for the OBC facilities. To ensure the safety of the Project's staff, the rangers' responsibilities include:

- escorting the Project vehicles during travel between towns and the OBC;
- escorting the ecological monitoring team on field missions;
- guarding aircraft involved in Project activities;
- monitoring the three-kilometer firebreak around the OBC to prevent domestic animals from straying into the area and unauthorized campsites from being established.

2.3 Project management

Administrative documents

The MEPDD, through the DFAP, is responsible for the following:

- providing all the permits required for animal arrivals and Project activities (CITES, aircraft overflight and landing permits, planning permissions, etc.);
- providing and helping obtain any official permits for staff and operators working on the Oryx Project (invitation letters to obtain visas, residence permits, travel permits, etc.);
- issuing export permits for samples taken from reintroduced animals;
- facilitating authorizations for documentary filming in the reserve.

Law enforcement

The government is responsible for monitoring the reserve and enforcing the law.

Patrol efforts primarily focus on areas where reintroduced animals are found. Due to limited resources, patrols are concentrated in these key areas rather than across the entire reserve. Patrols are conducted by vehicle, with teams of six to seven rangers operating in the field on ten-day rotations.

3. Habitat management and bushfire prevention

Bushfire response is vital to protecting the reserve's habitats and the natural resources on which both wildlife and domestic livestock depend. The Project combines preventive activities, including annual maintenance of a network of firebreaks and community outreach, with direct intervention when fires are detected within the area of operation.

3.1 Fire prevention and maintenance of the firebreak network

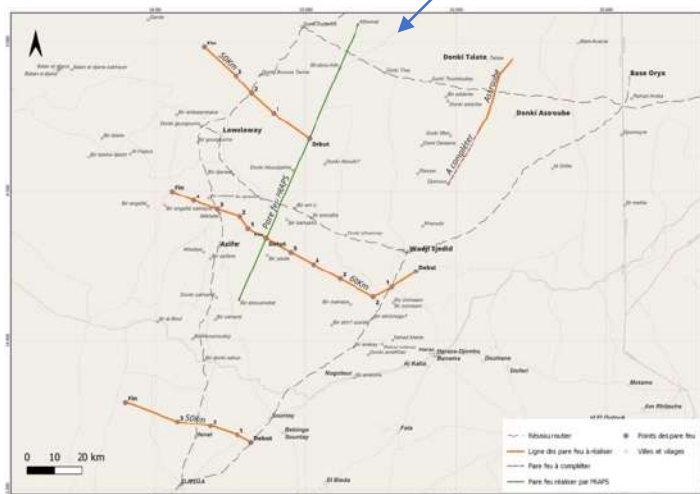
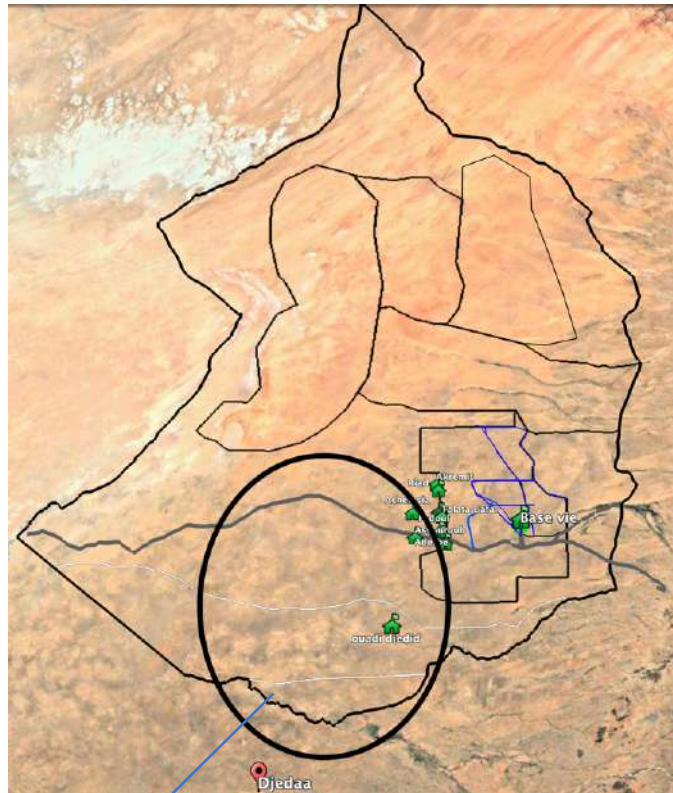


Fig. 10. 231 km of firebreaks co-funded by PREPAS and constructed by the Oryx Project

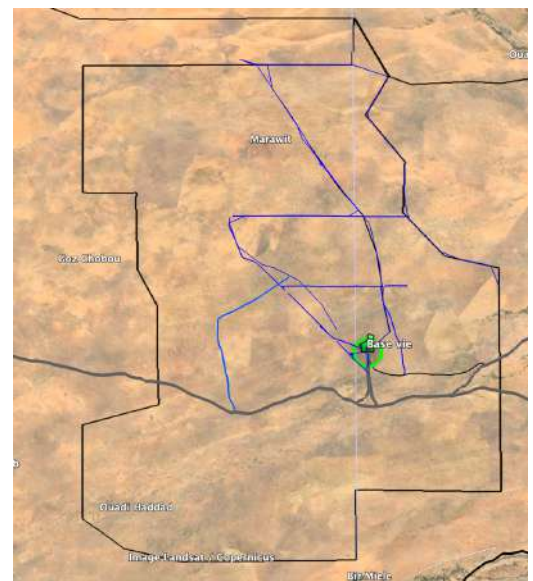


Fig. 11. 350 km network of firebreaks in the Batha-Wadi Fira Strict Conservation Area of the OROAFR

A total of 350 km of firebreaks were established during the 2025–2026 season, including 231 km supported by PREPAS.

Since 2017, the Project has renewed the firebreak network each year following the rainy season. Work begins as soon as ground conditions allow tractors to operate. Two 15 m-wide strips, separated by 50 m, are mechanically ploughed. Once the vegetation between them is sufficiently dry, it is burned, creating an 80 m-wide firebreak.

During the 2025–2026 season, the Rambo team began tractor work in September, followed by controlled burning from October onwards. Firebreaks in the oryx reintroduction area were completed in December 2025, with work elsewhere continuing until the end of January 2026.

Firebreak construction coincides with the seasonal movement of transhumant pastoralists, who gradually move south as temporary water sources dry up. Once the grass has dried, these movements can inadvertently start bushfires. Water shortages in 2025 led to a particularly early southward movement, meaning that teams working on firebreak construction were also called upon to respond to bushfires during this period.

Alongside these field operations, ASABLFB carried out community awareness activities on bushfire prevention with support from the Project and PREPAS.

3.2 Bushfire monitoring and response

Most bushfires recorded during the season were of human origin. Fires were particularly associated with movements through the reserve, with several incidents attributed to transhumant pastoralists, sedentary or semi-sedentary communities and, occasionally, other reserve users.

Bushfire monitoring relies in particular on satellite alerts from NASA’s FIRMS system, complemented by observations from field teams. Between August 2025 and May 2026, 86 alerts were recorded, with the highest level of activity occurring between September and January. Several fires had already been detected in July, despite the rainy season.

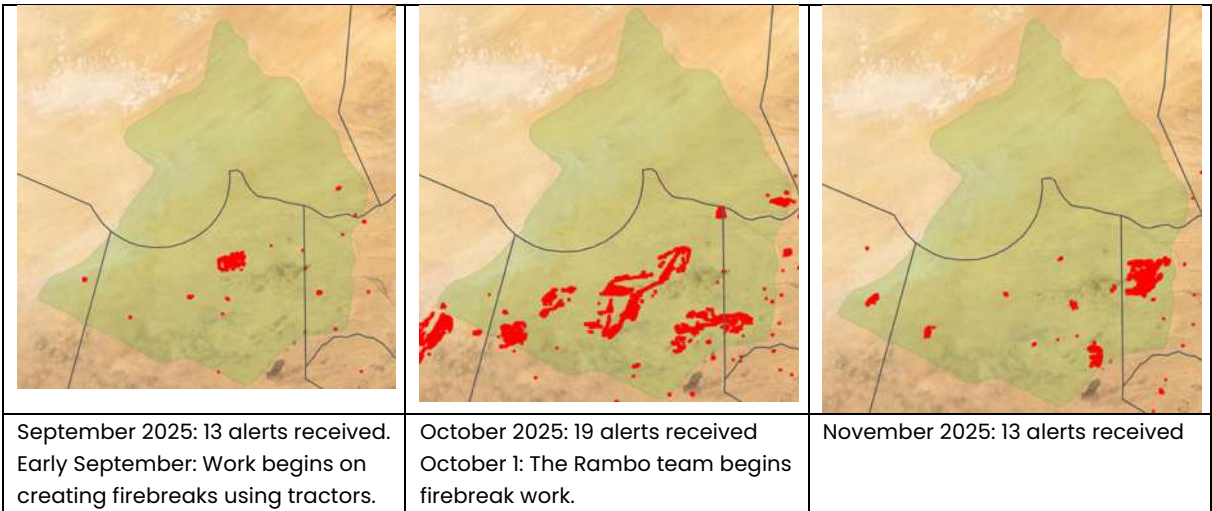


Fig. 12. NASA FIRMS alerts received during peak bushfire season.

During the same period, OBC teams carried out at least 28 direct bushfire response operations. Interventions were particularly frequent between October and January, both within and beyond the firebreak network. Some fires were too far to reach from OBC, while others had already been contained by previously burnt areas and did not require intervention.



Fig. 13. Two addax caught in a bushfire sparked by a small solar panel belonging to a herder, which was being used to charge cell phones.

Several incidents during the season demonstrated the effectiveness of the firebreak network. In November, a major fire east of the OBC was stopped by a firebreak. On the night of December 31 to January 1, another fire was contained between two firebreaks, while several fires starting within the network in January were also halted by these barriers.



Fig. 14. Firebreak construction.

4. Partnerships and coordination

Implementation of the Oryx Project relies on close collaboration with the Chadian authorities, technical and financial partners, and organizations working in and around the OROAFR. In 2025, these partnerships supported animal transfers and releases, staff capacity building, bushfire prevention and a range of activities benefiting local communities.

4.1 Institutional and technical partnerships

In 2025, EAD transferred scimitar-horned oryx, addax and dama gazelles to Chad in February and October. EAD staff accompanied these transfers and took part in animal handling and pre-release operations. In October, a team from the Zoological Society of London (ZSL) also provided technical expertise during operations involving dama gazelles, including GPS collar fitting.



Fig. 15. Dama gazelle handling by a joint SC, EAD and ZSL team.

The Project continued to work closely with the MEPDD and its technical departments, both in N'Djamena and in the field. In February, the MEPDD Provincial Delegate and the Provincial Delegate for Livestock and Animal Production attended the release of oryx and addax from the enclosures.

In June, following concerns over illegal logging and deforestation in the Ouadi Kharma and Ouadi Achim areas, the Project organized and supported an environmental assessment mission involving several Ministry departments: DFAP, the Directorate of Forests, Value Chain Development and Desertification Control, and the Directorate of Environmental Assessments and Pollution and Nuisance Control. DFAP also participated in the veterinary assessment of dama gazelles conducted in December. Administrative and traditional authorities in Al Biher Prefecture were regularly involved in

Project activities throughout the year. They participated in discussions on bushfire prevention and reintroduction activities, as well as in the debriefing following the environmental assessment mission in Ouadi Kharma and Ouadi Achim.

4.2 Partnerships for reserve management and local community support

The Project continued its collaboration with the ASABLFB NGO, which conducts community outreach on bushfire prevention as well as water, sanitation and hygiene. In January 2025, a bushfire information meeting held in Arada brought together 24 representatives of local authorities. Several members of the association also took part in training activities supported by the Project.

Collaboration with PREPAS focused primarily on bushfire prevention and the integration of pastoral issues into reserve management. PREPAS contributed equipment and resources for firebreak construction, supported ASABLFB's awareness activities in Batha and organized pastoralism training for Oryx Project staff and eight ASABLFB members. The Oryx Project also participated in the PREPAS technical monitoring committee.

The Project provided logistical support to ESAFRO (Education and Health Without Borders) for two human-health missions within the Project area, providing drivers, rangers, vehicles and field equipment.

Beyond these planned missions, Project resources are also occasionally mobilized for emergency medical evacuations of people living in remote areas of the reserve.



Fig. 16. Health mission team comprising SC and ESAFRO staff and Chadian medical personnel.

Cooperation with African Parks and the Ennedi Natural and Cultural Reserve (ENCR) also continued through information sharing, reciprocal logistical support and participation in training activities. The Oryx Project provided equipment for addax operations and lent a truck for an ostrich transfer, while Project teams were able to use African Parks facilities when travelling through Abéché.

5. Project visibility

Between July 2025 and June 2026, 84 news items and posts were published on Sahara Conservation's website and social media channels, reaching more than 745,000 people. These communications highlighted Project achievements and activities in the reserve, including animal reintroductions, field operations and conservation results.



At the international level, both SC and the Environment Agency – Abu Dhabi (EAD) participated in the IUCN World Conservation Congress in Abu Dhabi in October 2025. The Congress provided an important opportunity to showcase the scimitar-horned oryx reintroduction and highlight the international collaboration behind the Project.

In May 2026, SC organized the 25th annual meeting of the Sahelo-Saharan Interest Group (SSIG) in Cairo, in partnership with the Arab Network for Environment and Development (RAED). The meeting brought together nearly 70 participants from 15 countries to exchange knowledge and experience on conservation challenges across the Sahel and Sahara. Several Sahara Conservation team members contributed presentations highlighting the reintroduction of scimitar-horned oryx, addax, and dama gazelles in OROAFR, as well as the Project's broader conservation impacts.



Fig 17. Presentation by Habib Ali Hamid, "Reintroduction of the Scimitar-horned Oryx, the Addax, and the Dama Gazelle in the Ouadi Rimé–Ouadi Achim Faunal Reserve in Chad," at SSIG 2026.

Section II. FIELD-BASED POST- RELEASE MONITORING

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Conservation

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Introduction

Routine post-release monitoring of the reintroduced scimitar-horned oryx, addax and dama gazelle populations continued throughout the reporting period. Sahara Conservation's field monitoring team regularly records the distribution, condition, reproduction and mortality of reintroduced animals, while maintaining individual histories for tagged animals.

The Zoological Society of London (ZSL) continued to provide technical support for monitoring and data management and carried out three field missions during the reporting period.

1. Highlights in 2025

- Three line-transect surveys were carried out during the reporting period, in July and October 2025 and February 2026. Survey areas were progressively expanded and adapted to reflect the increasing distribution of reintroduced populations, including the vicinity of the northern addax release site towards the Ouadi Hawach.
 - Line-transect surveys – July 2025
 - Line-transect surveys – October 2025
 - Line-transect surveys – February 2026
- The results confirmed the strong recovery of the oryx population by the end of 2025 following the severe losses recorded during the 2024 dry season, with the population continuing to grow and estimated at between 600 and 700 individuals.
- Early results from addax released in the north of the reserve have also been very encouraging, with seven births among one of the monitored release groups in early 2026.
- A preliminary Vortex model has also been initiated to compare prospects for the dama gazelle population with and without reinforcement from the OBC captive population. Starting population size and structure were derived from photographic interpretation of Wings for Conservation datasets.



Fig. 1. Line transect team, members of SC, ZSL and DFAP, July 2025.

2. Monitoring management

As the reintroduced populations grow and expand their range, field monitoring is progressively being adapted to cover a much larger area of the OROAFR.

This has been particularly important for addax following releases in the north of the reserve, where animals are now using areas approximately 250–300 km from the Oryx Base Camp (OBC). Dedicated multi-day monitoring missions were introduced to maintain regular contact with these groups. Early results have been encouraging, including the detection of seven births among nine females in one of the monitored release groups in early 2026.

3. Data management activity

Long-term analyses of monitoring data continued during the reporting period, contributing to a better understanding of survival and population growth following reintroduction.

- ZSL has maintained detailed records of all reintroductions and post-release observation histories. Monthly CyberTracker records of field observations, birth events involving tagged individuals and mortalities have been maintained throughout the Project.
- These records consist of monthly datasets collected by the monitoring team using CyberTracker, covering field observations of scimitar-horned oryx, addax, dama gazelles and bustards, as well as dorcas gazelles, livestock, nomad camps and habitat assessments.
- For scimitar-horned oryx, addax, and dama gazelles, field observations are complemented by individual identification records and photographic archives. Individual records for each tagged animal document key events, including arrival and release dates, management history, collar and tag details, births and deaths, vaccination history, lost or damaged tags and recaptures. Photographic records provide an additional means of confirming individual identity, particularly when tags have been damaged or lost.
- Birth records document information including the date of discovery, estimated calf age and the identity and age of the dam, providing data on reproductive patterns such as calving seasonality and intervals.
- Monthly resighting histories are maintained for tagged animals of all three species. These records support estimates of survival and mortality rates and help assess factors that may influence post-release survival, including release group, season of release and pre-release management.
- Mortality records document, where possible, the identity and location of animals, evidence of the cause of death, including hunting or poaching, and findings from post-mortem examinations. These records help identify risks and provide vital-rate data for population models.

Together, these datasets allow the Project to assess survival and reproductive patterns over time and examine factors that may influence post-release survival, informing future management. They also provide an essential complement to population surveys, particularly for addax and dama gazelles, for which the number of encounters during line-transect surveys remains too low to produce reliable formal population estimates.

Detailed analysis of oryx survivorship, including comparisons with predicted population growth based on monitored vital rates, provides strong independent evidence supporting the reliability of population estimates derived from observational surveys.

4. Focused training for monitoring staff

Capacity building is an important component of the monitoring program. Training and practical guidance were provided to strengthen the team's ability to collect, manage, and report monitoring data consistently.

During the reporting period, this included support for monthly field reporting and data management, individual identification through photography, reporting from long-distance monitoring missions, detailed guidance on recording interactions with nomadic communities and the implementation of line-transect surveys. Reference materials were developed for the team and complemented by practical field training.

5. Dama gazelle *in situ* breeding program

Monitoring records maintained since the beginning of the Project provide information on the origin, identity, and history of individual animals and are used to inform decisions on both captive management and releases.

A review of the captive dama gazelle program at the OBC provided an overview of the program's development and the performance of the captive groups between 2020 and 2025, as well as the outcomes of releases recorded as of November 2025. The review analyzed the seasonality of 48 births and 32 recorded calving intervals, and examined the seasonality and causes of 28 deaths, with perinatal issues implicated in 61% of recorded mortalities. It also documented unexplained gum lesions observed during capture and analyzed their occurrence according to management group and age.

During 2025, these records supported the preparation of a new release group while helping to manage the captive population in line with genetic objectives, both for animals selected for release and those retained for breeding at the OBC. They also helped prevent the accidental separation of dams and younger calves.



Fig. 2. Collared dama gazelle released into the OROAFR.

Detailed records were maintained throughout the preparation and manipulation process, which was conducted under EAD supervision using the drop boma. These included individual identities, vaccinations administered and tagging outcomes. The operation resulted in the formation of one release group comprising animals of Manga, OROA and EAD origin, as well as three newly combined captive groups representing Manga × OROA, OROA × EAD, and OROA × EAD × Manga origins.

At the end of 2025, for the first time, there was more than one breeding-age male in some pens. Going forward, full knowledge of parentage can only be maintained if genetic monitoring (blood sampling and cold chain to a genetics lab) is included as part of the dama gazelles' management program.

Section III. ANTELOPE REMOTE MONITORING

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1. Summary

1.1 Key findings

- Based on trials with oryx, addax, and dama gazelles across Fossil Rim Wildlife Center (FRWC), Deleika Wildlife Center, and the Ouadi Rimé – Ouadi Achim Faunal Reserve (OROAFR), ear tag attachments of lightweight tracking devices are not recommended for these species. However, GSatSolar devices attached to addax and oryx horns, and custom-built collars fit to dama gazelles in October 2025 remain attached and functional. Thus, horn and collar deployments of these tags may offer a cost-effective approach for post-release monitoring activities.
- An analysis of the drivers of oryx social preferences found that gregariousness, genetic relatedness, experience difference, and reproductive homophily collectively explained nearly 75% of the variation in oryx social associations observed in early seasons during 2016–2022. Both total explanatory power and standard deviations of association indices declined over time, indicating that our selected drivers were overtaken by other, unexplored, social factors, and potential development of non-random community structure in the reintroduced oryx population.

1.2 Management applications

- In September 2025, NZCBI personnel coordinated the purchase and delivery of 13 GPS/Globalstar tracking devices to replace units ordered in 2024. All devices deployed on oryx, addax, or dama gazelle in October 2025 have maintained at least 50% battery charge, reported the expected number of GPS positions, and been fully integrated into the Project's real-time monitoring platform.
- In September and October 2025, teams comprising personnel from EAD, Sahara Conservation (SC), ZSL, Whipsnade Zoo and NZCBI fit 19 oryx, 25 addax, and 5 dama gazelle with GPS/satellite tracking devices attached as neck-mounted collars ($n = 37$), ear tags ($n = 2$), and horn tags ($n = 6$). Five separate groups across three species were released into the OROAFR between October 8 and November 15, 2025.

1.3 Products

- More than 50 tracking devices were ordered and programmed to meet Project needs in fall 2025; 45 devices fit to reintroduced oryx, addax, and dama gazelles were successfully integrated into the Project's real-time monitoring portal.
- Real-time, notification, and email-based systems to distribute and visualize recent locations of oryx, addax, and dama gazelle reintroduced into the OROAFR were continuously maintained and updated.
- NZCBI personnel collaborated with former ecological monitoring team lead Caleb Ngaba (Université de Neuchâtel, Switzerland), Julien Clark and Clara Zemp (Université de Neuchâtel), Gabriel Marcacci (Swiss Ornithological Institute, Sempach, Switzerland) and Pavla Hejčmanová (Czech University of Life Sciences, Prague, Czechia) to analyze seasonal variation in movement decisions by reintroduced oryx. The resulting manuscript was published in *Movement Ecology* on June 11, 2026.
- NZCBI and ZSL personnel collaborated to write a manuscript describing a seven-year survivorship analysis across oryx of different age classes and natal origins. This work was circulated among Project personnel for comments and is being prepared for publication.
- Material on oryx, addax, and dama movements was contributed to quarterly reports.

2. Animal tracking activities – July 2025 to June 2026

2.1 Scimitar-horned oryx

On September 17, 2025, nine scimitar-horned oryx previously translocated from Deleika Wildlife Centre (United Arab Emirates) to the Project's primary release site in the OROAFR were fit with tracking devices. A joint team from the Environment Agency – Abu Dhabi (EAD), SC, and Whipsnade Zoo fit four male and five female oryx with Vectronic Vertex Plus GPS/Iridium collars. Smithsonian's National Zoo & Conservation Biology Institute (NZCBI) personnel programmed each collar to collect a GPS location every four hours and tri-axial acceleration data eight times per second (8 Hz), transmit GPS positions once per day via the Iridium satellite communication network, broadcast on a known VHF frequency nine hours per day (07:00–12:30 and 14:00–17:30 WAT), and automatically drop off after three years. Two female and one male oryx were also fit with GSatSolar 25 g solar-powered tracking devices, which were attached as ear tags following captive trials at Deleika and FRWC (Glen Rose, Texas, USA) (Figure 1). NZCBI personnel programmed each tag to collect a GPS location every hour and transmit each location via the Globalstar satellite communication network. However, these lighter-weight, lower-cost tracking devices do not have VHF, accelerometry, or automated drop-off capabilities.

All oryx were briefly restrained in a Tamer Jr. drop-floor restraint device for device fitting and carefully monitored for elevated respiration, overheating, and other signs of stress. Each oryx was restrained for less than five minutes, and no animal exhibited undue stress during or after restraint. These nine oryx remained in the Project's acclimatization pens until October 8, when a gate was opened to allow passive release into the reserve. All individuals exited the pen by October 10, 2025, as oryx release group #13 (Figure 2).



Fig. 1. Personnel from EAD, SC, and Whipsnade Zoo attach a 25 g GSatSolar tracking device (left) to a scimitar-horned oryx as an ear tag (right).



Fig. 2. Camera trap image of oryx B04-B617F and B02-B609F exiting the acclimatization pen on October 10, 2025.

On October 17, 2025, a joint team from EAD and NZCBI fit ten oryx at Deleika with tracking devices. Three adult males, one subadult male, and four subadult females were fit with expandable oval-round Vectronic Vertex Plus Iridium/GPS collars programmed to collect GPS fixes at 4-hour intervals and tri-axial acceleration at 8 Hz, transmit GPS data once a day via the Iridium satellite network, broadcast on a known VHF frequency nine hours per day, and automatically drop off after three years. Two subadult female oryx were fit with GSatSolar tracking devices, one attached as an ear tag and one as a horn tag, programmed to collect GPS fixes every hour and transmit positions via the Globalstar satellite network. All oryx were briefly restrained in a Tamer Jr. device and carefully monitored for any signs of distress. Each restraint lasted less than ten minutes, and no animal exhibited undue stress during or after restraint. Neck circumference was also measured for each oryx; these data have been incorporated into a database of morphological measurements compiled and managed by NZCBI to support accurate collar sizing for tracking device orders, which optimizes monitoring costs.

From October 23 to 25, 2025, this cohort of 10 oryx was loaded into individual crates, transported by road to the Al Ain Airport (UAE), flown to Abéché, Chad, transported by road and track to the Project's release site in the OROAFR, and released into the acclimatization pens at the Project's primary release site. On November 15, 2025, a gate was opened to allow passive release into the reserve, and all individuals exited as oryx release group #14.

As of May 30, 2026, the Project has deployed a total of 321 tracking devices on reintroduced oryx, comprising one GSatSolar device attached as a horn tag, four GSatSolar devices attached as ear tags, four Savannah Tracking devices attached as horn tags, and 312 Vectronic GPS/Iridium collars.

2.2 Addax

On September 18, 2025, fifteen addax (*Addax nasomaculatus*) previously translocated from Deleika to OROAFR were fit with tracking devices. A joint team from EAD, SC, and Whipsnade Zoo fit six male and nine female addax with non-expandable, oval Vectronic Vertex Plus GPS/Iridium collars. NZCBI programmed each collar to collect GPS fixes every four hours and tri-axial acceleration data at 8 Hz, transmit GPS positions once a day via the Iridium satellite network, broadcast on a known VHF

frequency 9 h a day, and automatically drop off after three years. Two females and two males were also fit with GSatSolar tracking devices, attached as ear tags following captive trials at Deleika and FRWC. NZCBI personnel programmed each tag to collect hourly GPS fixes and transmit data over the Globalstar satellite network. Addax were briefly restrained in a Tamer Jr. device and carefully monitored for any signs of distress. Each animal was restrained for less than five minutes, and no individual exhibited undue stress during or after restraint.

While addax remained at the release site to return to baseline stress levels after handling, a joint team from SC, EAD, and the ZSL conducted field reconnaissance ca. 100 – 200 km to the northwest, where historical observations of addax in the OROAFR were concentrated around Ouadi Hawach and north of Ouadi Achim (Figure 3). Vegetation cover and productivity, livestock density, and signs of human activity (e.g., presence of permanent and temporary water sources) were evaluated at multiple sites where (1) addax were routinely observed during the 1970s and (2) movement data indicated previous use by addax released in the OROAFR and ENCR (Figure 4). Based on results from this mission, a secondary release site in suitable addax habitat was selected ca. 166 km north-northwest of the Project's primary infrastructure, at N16.38236°, E19.97155°. SC personnel installed a temporary boma and equipped the site with animal feed, water, and resources to support a temporary Project outpost.

On October 3, 2025, the 15 addax were captured and loaded into individual crates, then transported by road and track to the selected secondary release site 166 km northwest of the OBC. Addax were released into the boma on October 4, 2025, held for four days under the same diet and water regime as in the acclimatization pens, and released into the OROAFR on October 8, 2025, as addax release group #6.

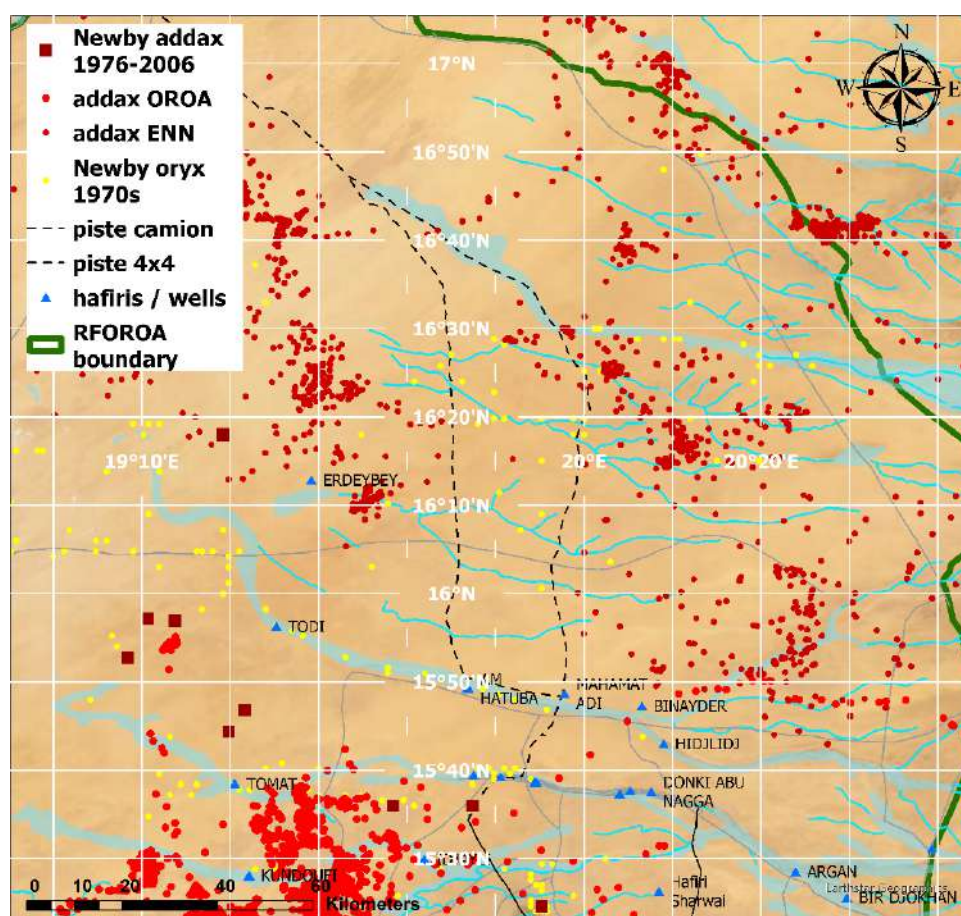


Fig. 3. Historical and recent locations of addax within the Ouadi Hawach region of the OROAFR.

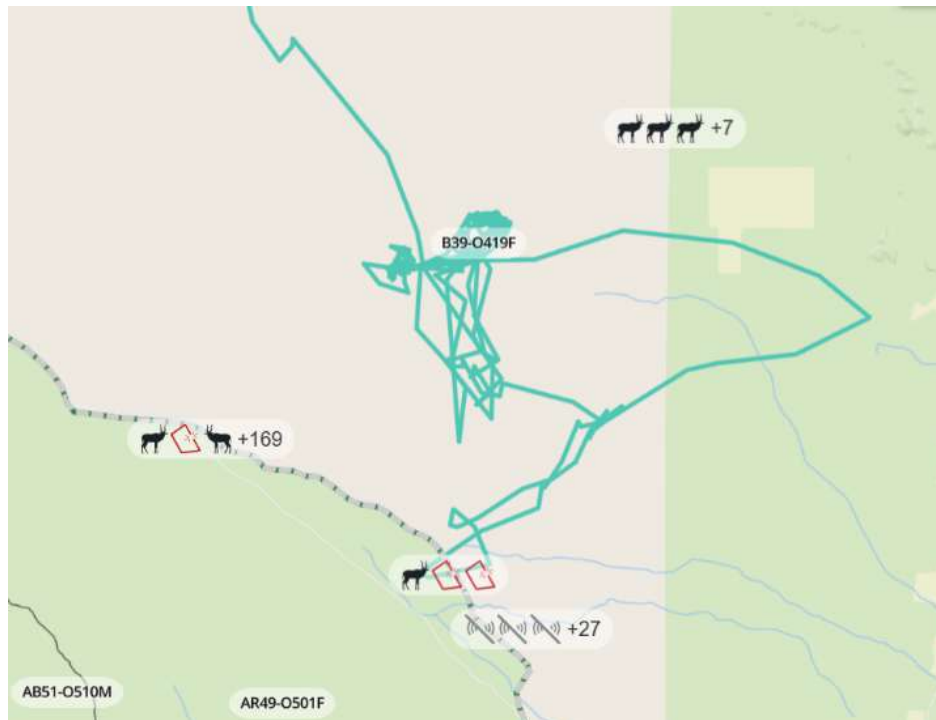


Fig. 4. Previous movements between the borders of OROAFR and ENCR by addax B39F, released into Ennedi in November 2023.

On October 16, 2025, a joint team from EAD and NZCBI fit ten addax at Deleika with tracking devices. Five adult male addax were fit with non-expandable oval Vectronic Vertex Plus Iridium/GPS collars programmed to collect GPS fixes at 4 h intervals and tri-axial acceleration data at 8 Hz, transmit GPS positions once a day via the Iridium network, broadcast on a known VHF frequency nine hours a day, and automatically drop off after three years. Five subadult female addax were fit with GSatSolar tracking devices attached as horn tags (Figure 5), programmed to collect a GPS location every hour and transmit data via the Globalstar satellite network. This cohort of addax was crated and translocated from Abu Dhabi to Chad during October 23–25, 2025.



Fig. 5. Lightweight GSatSolar GPS/Globalstar tracking devices attached to the horns of subadult female addax at Deleika Wildlife Center (Abu Dhabi, UAE) on October 17, 2025.

Upon arrival at Abéché airport, this cohort of ten addax was transported by road and track directly to the secondary release site (selected in September 2025). Animals arrived on October 24, 2025, and were immediately released into the temporary boma. After a 10-day acclimatization period, this cohort was reintroduced into the OROAFR on November 4, 2025, as addax release group #7.

2.3 Dama gazelles

In September 2025, a joint team from the Royal Zoological Society of Scotland (RZSS), EAD, ZSL, SC, and NZCBI developed genetic, reintroduction, and management priorities for the 38 dama gazelles (*Nanger dama*) under human care at the Project's primary release site in the OROAFR. The team also held virtual meetings to finalize dama capture and handling methods and select specific individuals to compose optimal breeding groups.

In June 2025, SC personnel gradually modified dama feeding and watering locations and schedules to facilitate capture. In early October 2025, NZCBI personnel constructed ultra-lightweight GPS/satellite collars (<50 g) for dama gazelles by attaching 25 g solar-powered GSatSolar tracking devices to nylon belts with a weak-link section. On October 25, 2025, the Tamer Jr. and approach alley were installed in Pen 6, with fencing panels positioned to guide dama into the Tamer, and shade cloth covering the sides and top of the alley to create a shaded tunnel (Figure 6).



Fig. 6. Layout of capture pens and alley to Tamer Jr. as of October 25, 2025. Temporary fencing panels, shade cloth, and woven natural materials were used to completely enclose sections of the capture area and Tamer alley.

On October 27 and 28, the EAD x OROA and Manga x OROA groups of dama formerly housed in Pens 3 and 6 were each readily captured by closing doors to the capture areas once adults had entered following the morning feeding. Adult and subadult dama were relatively still once in the enclosed sections of the alley, with many lying down. Each adult and subadult was briefly examined by an EAD veterinarian, given vaccines including BARVAC-10, PULMOVAC-IN, Shchelkovo Biocombinat against Foot-and-mouth disease, POXVAC, Jovac, OBP Rift Valley Fever, and anti-parasite treatments including Bayticol, and released into their destination pen and group. Individuals B17F, Y14F, Y17F, Firmin

(Y25M), and Y41F were fit with ultralight GPS/satellite collars. Six calves were not handled and were reunited with their dams as the last stage of breeding group reorganization.

Processing all 31 adult and seven juvenile dama gazelles took ca. five hours across two days and resulted in four new groups:

- an “EAD x OROA” breeding group in Pen 3 (2.7 dama),
- an “EAD x mixed” group in Pen 4 (3.5),
- a “concentrated Manga” group in Pen 6 (3.8),
- a mixed group including five collared adults staged for release into the wild (3.7).

Unfortunately, on October 31, 2025, adult female Y41F (Habiba_03) was found dead. A post-mortem examination revealed a near-term fetus in apparently normal condition, suggesting this animal was in the late stages of pregnancy at the time of handling. In response, Project protocols were revised to require any female dama of potential reproductive maturity (≥ 1 yr) that has shared an enclosure with a reproductively mature male to be manually restrained by experienced animal handlers, under close supervision by animal managers and veterinarians, instead of using mechanical restraint. No negative physiological or behavioral impacts (e.g., unexplained weight loss, increases in stereotypical behaviors) were detected in the other 1.3 collared dama.

The 10 dama gazelles remaining in this cohort were released into the OROAFR on November 1, 2025, as dama release group #2.

3. Investigating drivers of social preferences in reintroduced oryx

Since 2024, NZCBI personnel have collaborated with Dr. William Fagan of the University of Maryland (USA), who specializes in developing complex mathematical models to investigate animal movement data. One collaborative project investigates the drivers underlying oryx social preferences. This project was recently presented as a PhD thesis chapter and is being prepared for review by Project partners and subsequent submission to a scientific journal.

We used the intensive tracking data (nearly 100% of reintroduced oryx fit with tracking devices) and field observations (multiple records of each individual collected per week) from August 2016 through March 2018 as a period of near-complete coverage. We applied the framework established by Hoppitt and Farine (2018) to calculate a calibration factor from the tracking data (a dataset with fine time intervals at which most of the population is recorded, but over a shorter duration) for the field observations (a dataset that covers the population at far more irregular intervals, but for a longer duration). The M-weight index (MWI; Hoppitt and Farine 2018) proved to be the best-fitting bias-corrected social association index, with $M = 3.21$ calculated from the period of near-complete coverage ($n = 429,033$ GPS fixes of $n = 61$ distinct individuals; $n = 1,256$ observations). We then used a Multiple-Regression Quadratic Assignment Procedure (MRQAP; Dekker et al. 2007) to evaluate the extent to which hypothesized social drivers were correlated with MWI values: gregariousness, experience difference, genetic relatedness, and reproductive homophily. MRQAP models explained from 0.11 (2020 hot dry season) to 0.99 (2016 rainy season) of the observed variation in oryx social preferences, with an overall mean of 0.44 (Figure 7). In general, the proportion of variation in oryx social preferences explained by hypothesized drivers decreased as the population matured.

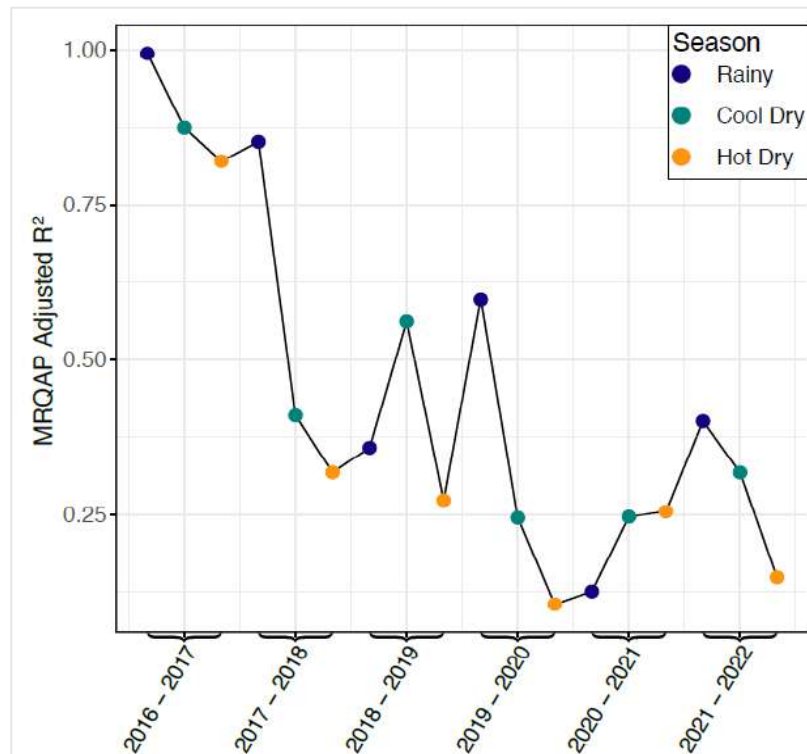


Fig. 7. Adjusted R^2 of MRQAP models fit to MWIs across all seasons, 2016–2022. Blue points indicate rainy seasons, green points indicate cool dry seasons, and yellow points indicate hot dry seasons.

The decreasing trend in R^2 is also echoed in the standard deviations of calculated M-weight indices, which indicate decreasing strength in oryx social preferences over time (Figure 8). However, average adjusted R^2 values were high compared to other animal social network studies with analogous methods (Machado et al. 2019; Mebus et al. 2024; Chen et al. 2025). Similarly, MWI standard deviations almost never fell to the levels expected under a null hypothesis of random social association. We generated null models by randomly permuting field observations within weekly blocks 20,000 times, constrained by the actual numbers of dyads and observations collected each week, and recalculating all metrics. Observed standard deviations for Generalized Affiliation Indices were significantly higher than null expectations for every season except the 2019 rainy season, and observed standard deviations for MWIs were significantly higher than null expectations for all but three seasons (2020 rainy, 2020 hot dry, and 2021 rainy; see Figure 8). Overall, both the R^2 and standard deviations of association indices over time provide strong evidence that our hypothesized social drivers initially exerted a strong influence, but were overtaken by other social preferences, indicating de novo formation of non-random social structure in a developing wild population.

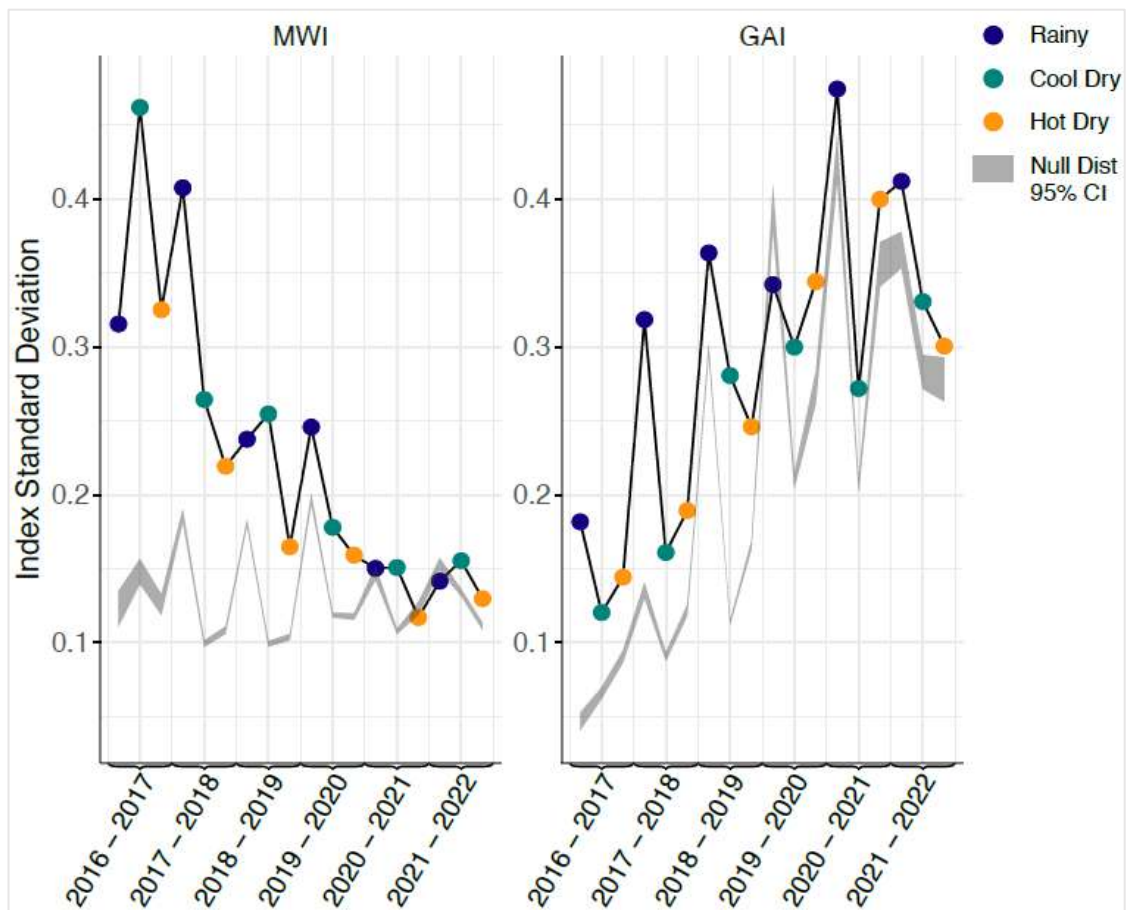


Fig. 8. Standard deviation of seasonal M-weight index (MWI; left) and Generalized Affiliation Index (GAI; right) between 2016 and 2022. Colored points denote empirical data, and gray shading indicates 95% confidence intervals for null expectations. Empirical values that fall outside 95% CIs are considered significant.

In general, our hypothesized social drivers collectively explained nearly 75% of the variation in observed oryx social associations, with roughly twice the explanatory power during rainy versus hot dry seasons. Gregariousness achieved the largest estimated effect size in almost all seasons, followed by experience difference, genetic relatedness, and reproductive homophily (Figure 9). Genetic relatedness was most influential every other year, potentially due to release timing. Reproductive homophily was consistently significant and influential during cool dry and hot dry seasons; however, its effect size was negligible compared to the other drivers. Annual patterns in effect sizes were remarkably consistent across seasons: gregariousness exhibited a characteristic U-shape, experience difference sharply dropped off, and reproductive state and genetic relatedness waned gradually over time. These results align with previous findings that seasonal factors, particularly resource availability during the hot dry season, exert strong constraints over many dynamics of the reintroduced oryx population in the OROAFR.

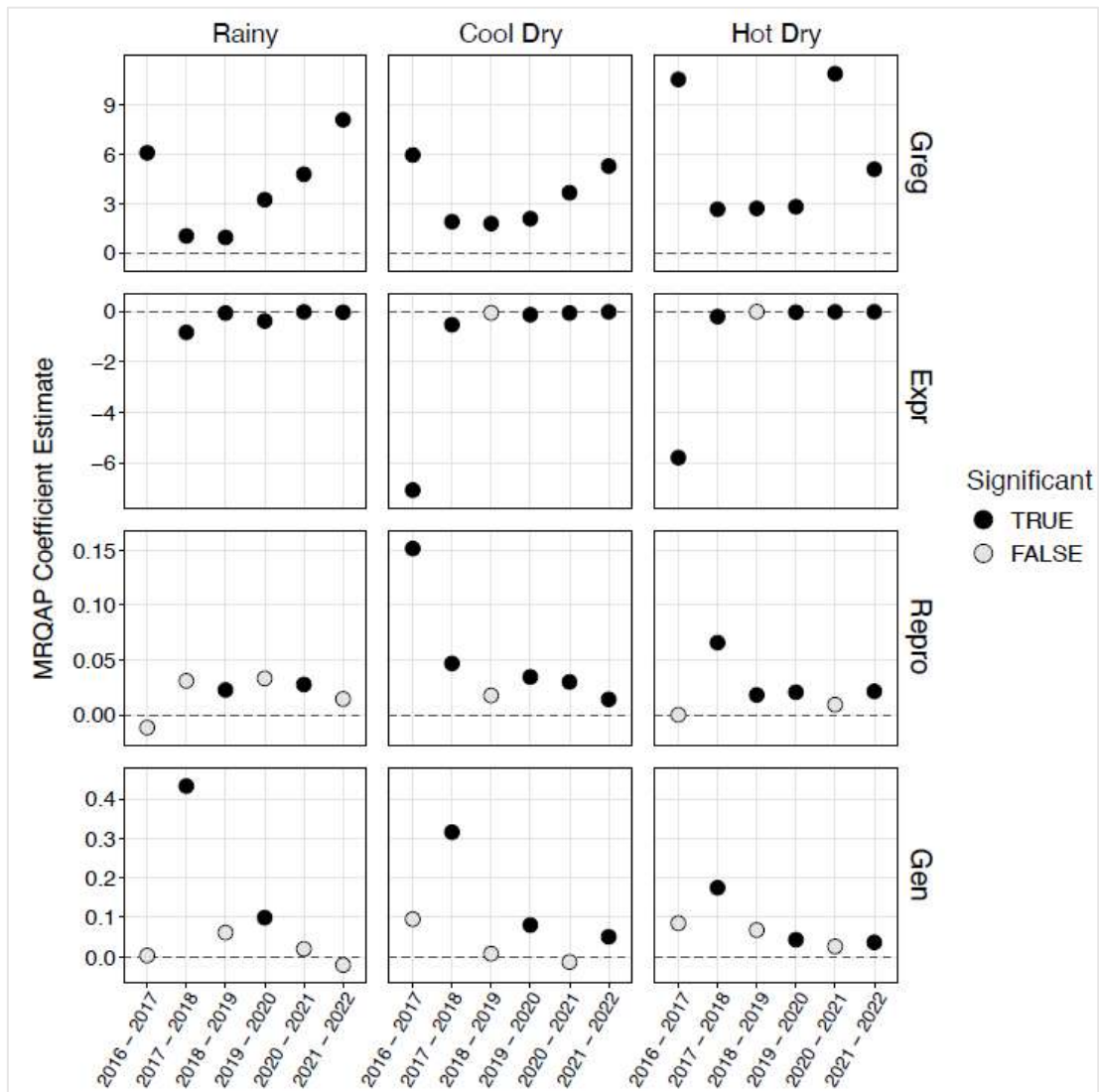


Fig. 9. MRQAP coefficient estimates for hypothesized drivers of oryx social preferences across all seasons, 2016–2022.

4. Finalizing a medium-resolution supervised land cover classification of the reserve

After persistent striping remained in multiple versions of the supervised land cover classification developed in 2019–2024 (Figure 10), we shifted from implementing our multispectral, multi-source workflow in Google Earth Engine to Google Colab, using the Earth Engine API to increase computing capacity. Once in this setting, we added a bidirectional reflectance distribution function (BRDF) to our preprocessing steps to normalize reflectance across varying sun and sensor look angles. The BRDF reduced striping artifacts that were previously prevalent in several intermediate products, including 10-day composites and final land surface phenology products.

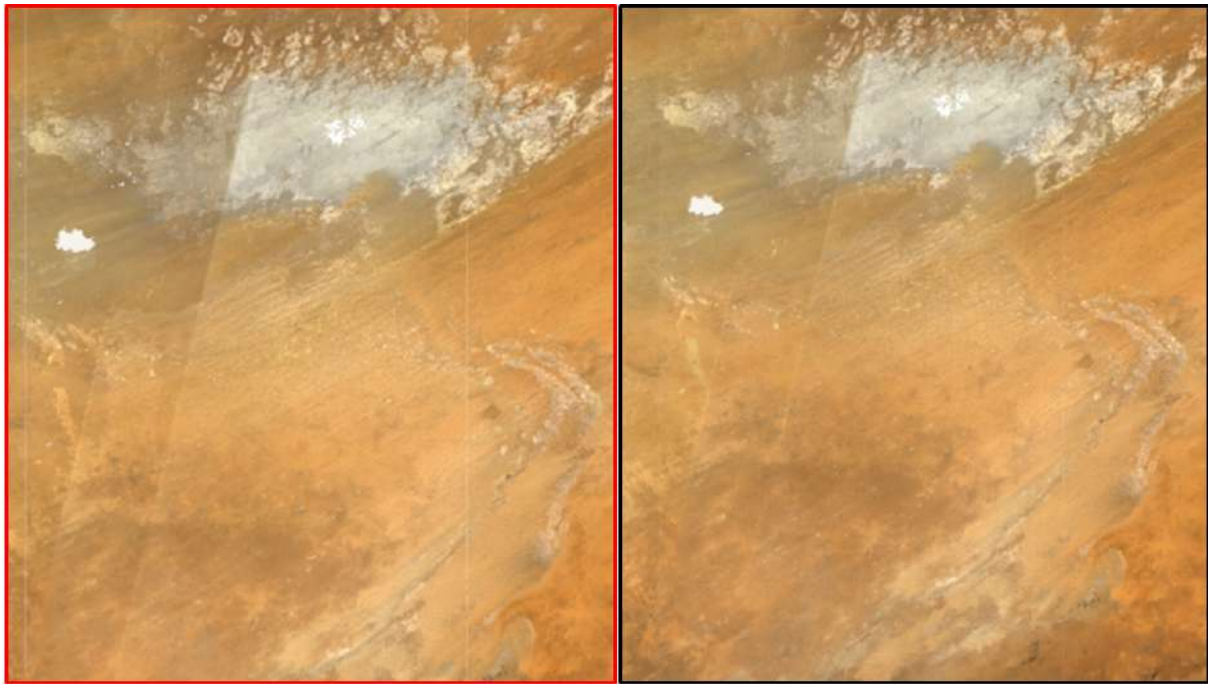


Fig. 10. RGB visualization of a 10-day median composite of Sentinel-2 data before (left) and after (right) using a bidirectional reflectance distribution function (BRDF) to correct multispectral reflectance values.

We also developed a novel layer to highlight human-made structures and maximize separation between low vegetation or bare soils and woody vegetation. Tall, rectangular objects constructed from smooth, impermeable materials cause active sensors such as Sentinel-1 C-band synthetic aperture radar (SAR) to receive a characteristic, high-energy “double bounce” return over built-up areas (Figure 11). We compiled Sentinel-1 VH SAR data across 2021 (the focal year for our land cover classification, due to when most in situ training data were collected) and calculated the 75th through 99th percentile SAR values for each pixel during this period. We then summed all percentile layers to produce a single “SAR maxes” layer that strongly accentuates surfaces with stronger returns, such as scattered or dense one- and two-story buildings, while preserving contrast with vegetated areas that return consistently lower backscatter (Figure 12). Lower thresholds (e.g., 60th percentile) captured more variation, but reduced class separability, while the 75th–99th range preserved contrast without excessive noise.

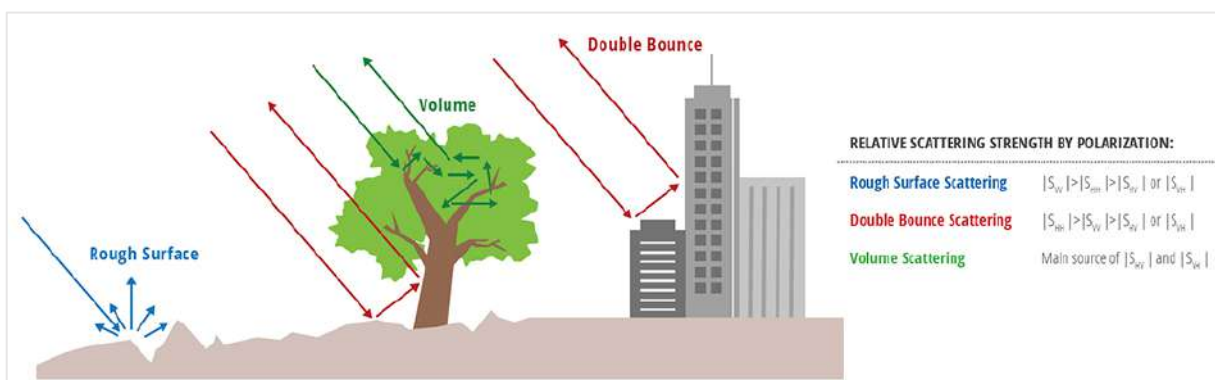


Fig. 11. Characteristic types of scattering caused by materials and structures commonly found on the Earth’s surface. Tall human-made buildings typically generate intense backscatter (i.e., “double bounce”) in co-polarized SAR channels.

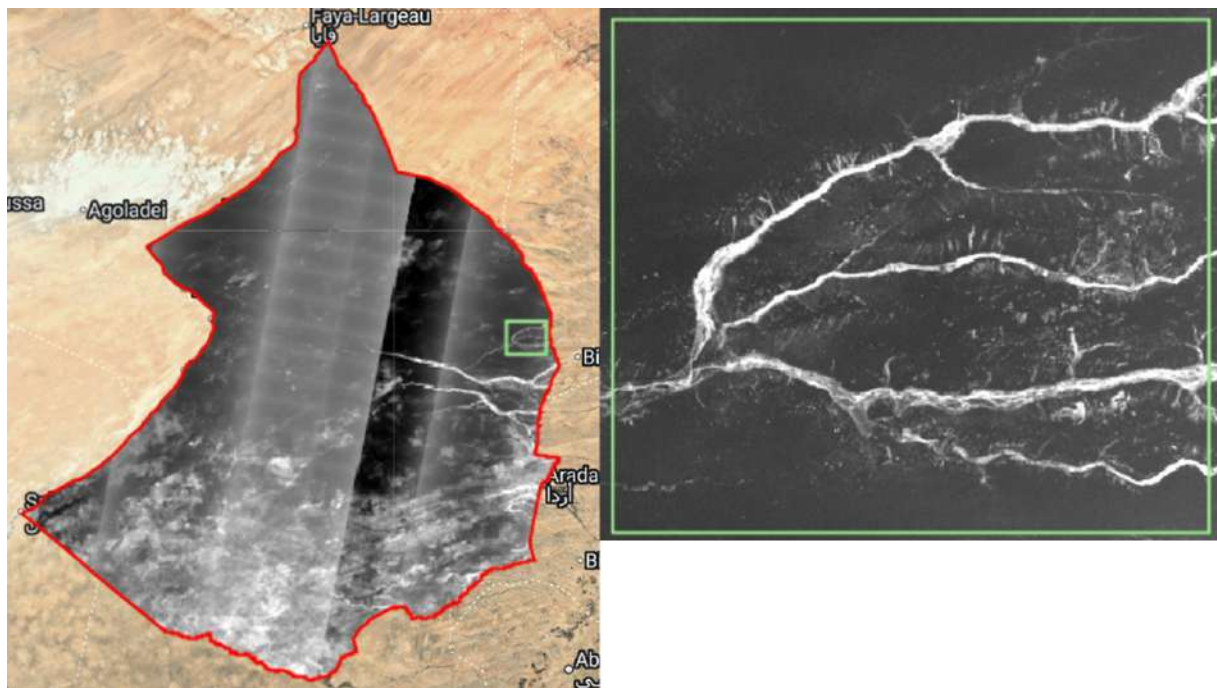


Fig. 12. “SAR maxes” layer across the OROAFR, including the test area where structured wadi vegetation is strongly distinguished (bright pixels) from adjacent grassland and bare soil vegetation (dark pixels).

We also compiled >500 sites across the OROAFR where small-scale agriculture is regularly practiced, and evaluated which layers derived from Sentinel-1 SAR data best distinguished agricultural fields from neighboring natural grasslands. We calculated 10-day median composites of Sentinel-2 multispectral imagery across our focal year of 2021, computed the Modified Soil-Adjusted Vegetation Index (MSAVI; Qi 1994) for each composite, and used harmonic regression to decompose the MSAVI time series for each pixel into a series of cosine and sine waves (Brooks et al. 2012). We then extracted the resulting harmonic coefficients as the peak timing of the growing season (“phase”) and the seasonal intensity (“amplitude”). Because agricultural fields often exhibit intermediate timing relative to natural grassland vegetation, due to delays in greenup caused by plowing and seeding activities and variable harvest timing compared to natural senescence, we developed amplitude and phase thresholds based on visual assessment of our 500 test locations. We then summed across harmonic coefficient estimates, producing a composite harmonic layer in which higher values indicate the presence of agriculture (Figure 13).

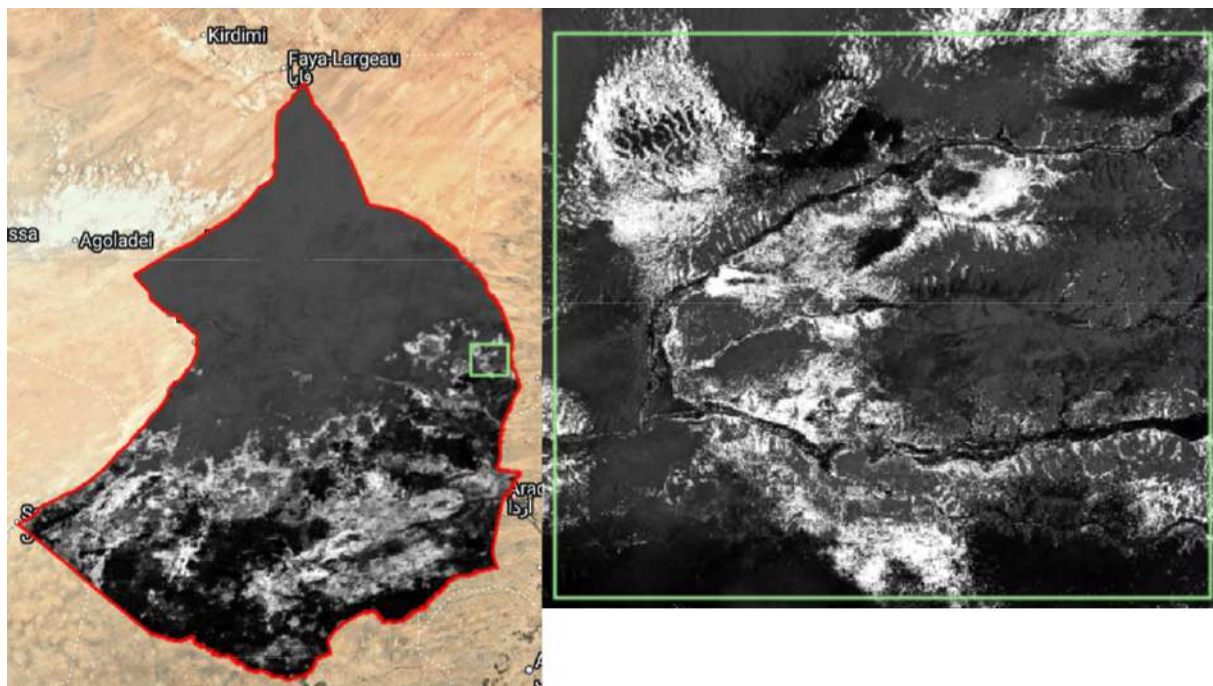


Fig. 13. Derived harmonic layer highlighting the presence of agriculture (bright pixels) relative to natural vegetation (dark pixels).

Finally, we leveraged the spectral properties of croplands in near-infrared (NIR) and shortwave-infrared (SWIR) wavelengths to develop a product based on the Normalized Burn Ratio (NBR) that highlights agricultural areas. Healthy crops typically have a high leaf area index and contain high amounts of cellular water and low ratios of cellulose and lignin, leading to high reflectance in NIR bands and low reflectance in SWIR bands. When crops are harvested, leaf loss causes NIR reflectance to fall sharply, and the presence of dry crop residues containing primarily cellulose and lignin dramatically increases SWIR reflectance. Thus, healthy, growing crops return large positive NBR values, and crop residues return deeply negative NBR values. We applied constants developed by Liu et al. (2020) to suppress the effects of water and bare soils, calculated NBR for Sentinel-2 composites that capture “peak wet” and “peak dry” conditions across 2019–2023, and subtracted seasonal NBR SWIR layers from each other (Figure 14). Intermediate values in these layers highlight agricultural fields, compared to very high (burned or high-albedo surfaces) or low values (stable water or bare soils).

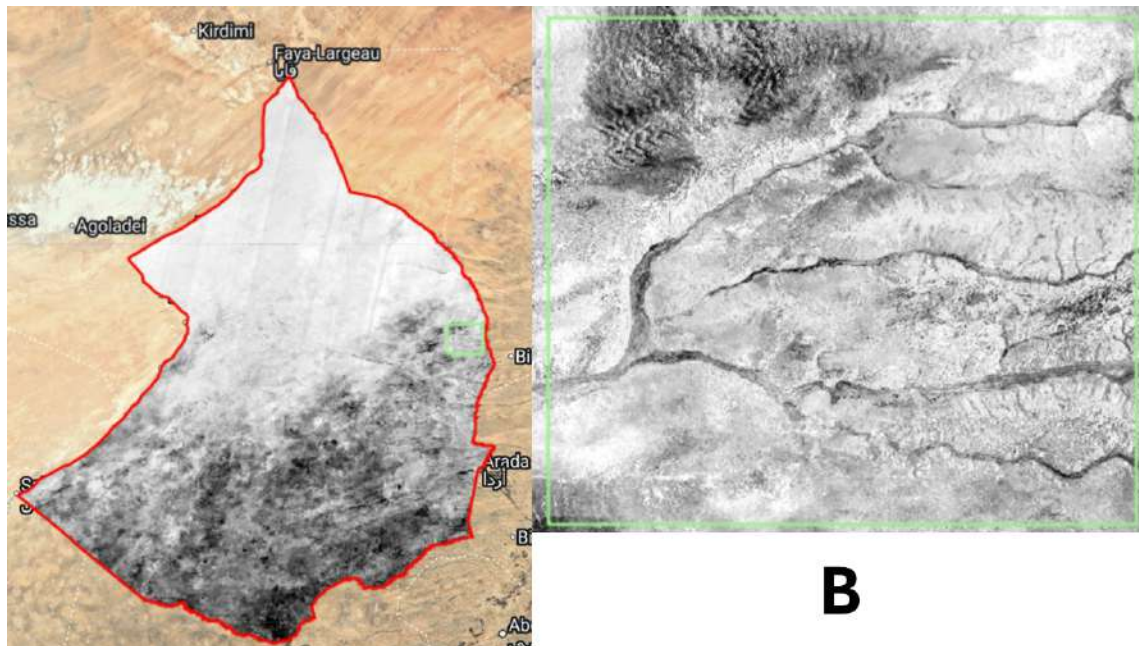
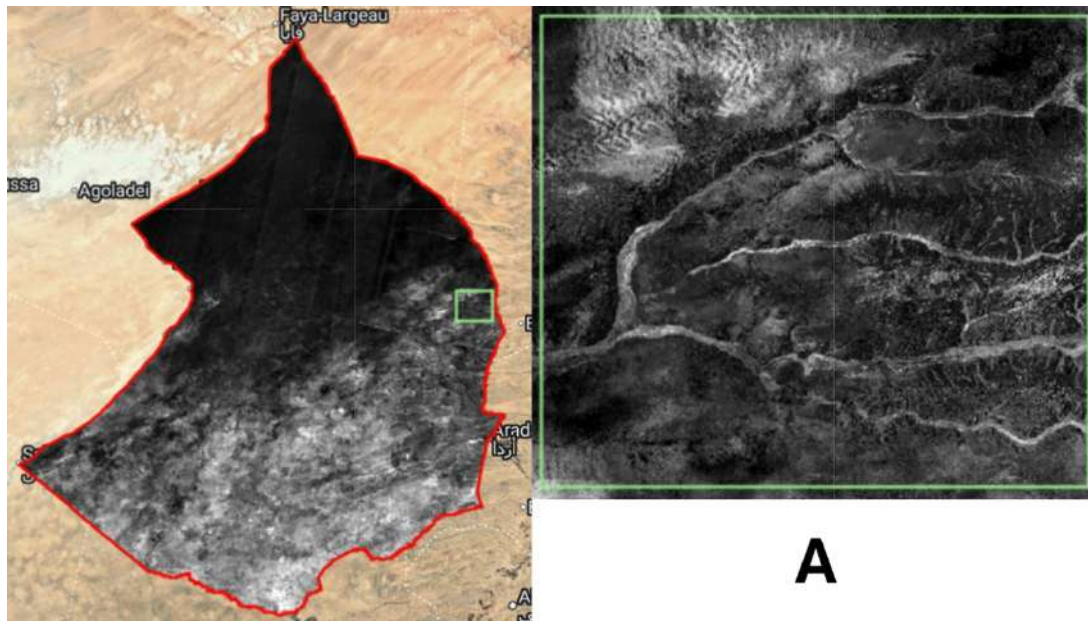


Fig. 14. Seasonal NBR products that highlight changes from peak dry to peak wet conditions (A) and vice versa (B). Intermediate values in both products highlight agricultural areas.

Integrating these revised workflow steps and additional derived products into our supervised classification workflow has greatly improved model performance, especially for agriculture and various types of human settlements in the OROAFR. We are currently generating independent testing data stratified across the study extent and thematic classes to produce an area-weighted accuracy assessment and finalize this classification.

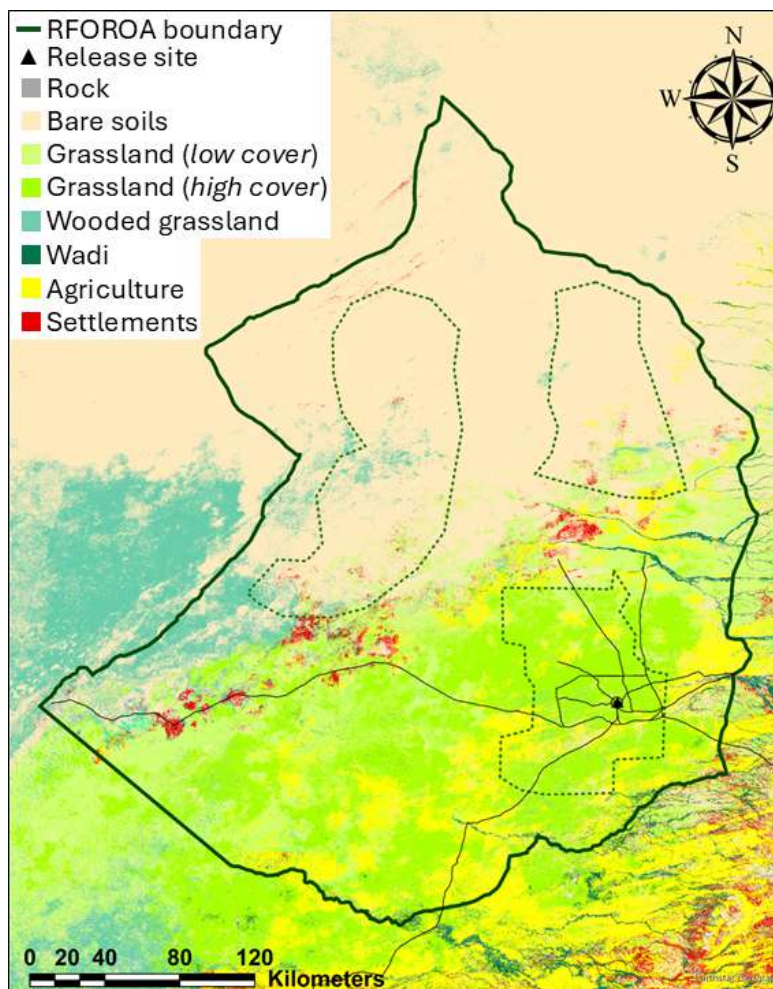


Fig. 15. Preliminary version 5.0 of the OROAFR land cover classification.

5. Section conclusions and recommendations

5.1 Mark wild-born calves and prioritize observations of marked individuals

Unmarked juvenile and subadult antelope typically cannot be individually identified over time. Thus, observations of unmarked animals cannot provide multi-temporal information about survival or other dimensions of individual health or population growth. In contrast, every observation of a marked individual adds to a time series of survival, body condition, space use, and social dynamics. Similarly, every new ear tag attached to a wild-born calf represents an opportunity to produce time series data for additional age classes and wild-born generations. Thus, focusing on (i) marking Chad-born calves and (ii) collecting observations of marked antelope represents effective strategies to produce monitoring data with maximum utility.

5.2 Collect DNA samples from Chad-born calves

While various methods such as distance sampling and aerial surveys enable estimation of total population size, other methods are required to understand the effective population size, i.e., the number of breeding adults that contribute to reproduction and recruitment. According to RZSS personnel, this quantity may be estimated via analysis of genetic samples from ca. 50 individuals in

the reintroduced oryx population. The primary opportunity to collect biological samples from wild-born oryx is soon after birth, when calves are occasionally captured and ear-tagged in the field. In March 2022, personnel from the University of Edinburgh demonstrated the use of a Helix buccal swab to collect and preserve DNA from young calves. Prioritizing field observations of late-term females will enable the marking and sampling of greater numbers of Chad-born calves, which will support both longer time series of monitoring data and insights on population genetics.

5.3 Rebuild tracked cohorts of 50 oryx and addax

Based on a revised power analysis, 50 individuals represent the minimum sample size with reasonable potential to detect massive mortality events in a free-roaming antelope population. In field missions conducted during 2020–2024, teams efficiently captured, sampled, and collared 27 oryx in the OROAFR; however, all collars fit during these missions have since dropped off. Maintaining $n = 50$ tracked individuals across founder and Chad-born groups will increase capacity to monitor population trends, estimate demographic parameters, and detect catastrophic events.

5.4 Integrate ground transects and rangeland monitoring into a seasonal schedule

Three blocks of ground transects have been developed over time: one centered on the Project's primary release site, one ca. 160 km to the north, and one near the Ouadi Ouayle. Increasing the frequency of distance sampling surveys and expanding the area covered are projected to improve the precision of population size estimates. Collecting typical rangeland measurements in dedicated plots immediately before or after conducting ground surveys will produce a valuable time series of vegetation data for estimating herbaceous biomass and related quantities, such as fuel load, and yield validation data for remote sensing analyses. Integrating these methods into a seasonal schedule of monitoring activities will also establish standardized sampling routines for the latter years of Phase III.

5.5 Integrate emerging technologies into Project monitoring

NZCBI has worked with multiple collaborators to build convolutional neural network models that have successfully detected livestock enclosures and multiple species of African ungulates in satellite and aerial imagery. Collecting UAV or aerial imagery concurrent with ground surveys will provide essential image and count data to fine-tune these models for the OROAFR, and validation data to which model predictions may be compared. Developing standard flight protocols and parameters to use Project UAVs for specific tasks, such as searching for wild-born calves and taking overhead images of large groups to enable accurate counts, may also reduce monitoring workload and costs.

5.6 Revise population viability analyses for reintroduced oryx and addax

Revising the population viability analysis for oryx (last produced in 2013) with data measured directly from the reintroduced population, and parameters derived from recent genetic analyses by RZSS, will provide a realistic assessment of whether the reintroduced population in the OROAFR is approaching long-term viability. Incorporating a range of realistic to catastrophic scenarios, such as severe dry seasons, disease outbreaks, and long-term climate change impacts projected for the region, will enable longer-term evaluations of viability under likely pressures.

