**Supplementary Material**

**Operational field trialling of Felixer™ grooming traps for the control of feral cats in the Strzelecki Desert, Australia**

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## Supplementary Information

### Additional Methods

*Additional study site context*

The Wild Deserts partnership aims to trial optimum restoration techniques for arid ecosystems, including through reintroduction of ecosystem engineering mammals to Sturt National Park. Wild Deserts is funded through a 10-year partnership between NSW National Parks and Wildlife Service (NPWS), UNSW Sydney and Ecological Horizons (Kingsford *et al.* 2021; Pedler *et al.* 2018b). To date, this partnership has eradicated feral predators from two large fenced safe havens, Thipa and Mingku totalling 4,300 ha, allowing the reintroduction of locally-extinct mammal species. An explicit Strategic Adaptive Management approach identified key objectives, supporting a vision and linked to actions (Kingsford *et al.* 2021). The control of feral cats, including innovating effective tools, is a key objective, particularly in relation to establishing populations of threatened mammal species beyond safe havens (Kingsford *et al.* 2021). Felixers were identified as a potential tool to manage cat incursions into the feral free safe havens and the 10,400 ha Wild Training Zone (WTZ), an area bounded on two sides by the dingo barrier fence (Newsome *et al.* 2001) and on two sides by 1.8m high cat and fox exclusion fencing. The WTZ does not exclude all cats or foxes but is designed to be 'leaky' to expose native reintroduced species to low levels of cat predation to accelerate natural selection for anti-predator traits (Moseby *et al.* 2016; West *et al.* 2018).

*Additional methods on cat capture for satellite collaring*

Capture of cats for satellite collaring was achieved through nocturnal spotlighting and hand netting with the aid of a trained dog to 'tree' cats or using 'Soft Catch' rubber-plated leghold traps (Victor Traps) or cage traps (Sheffield Animal Traps). Attachment of tracking collars to cats was performed under sedation with Zoletil (Tiletamine Hydrochloride 50mg/ml, Zolazepam Hydrochloride 50mg/ml) and Dormitor (Medetomidine hydrochloride 1mg/ml). A sedative reversal agent Antisedan (Antipamezole Hydrochloride) 0.25mg/kg was administered, and recovery monitored while in containment. Release occurred after dark or into shelter sites, such as animal burrows, within 12 hours following recovery.

*Measuring suppression of cats by Felixers*

To convert the cat activity from camera trapping into a density estimate, a subset of ~150,000 images, from a seven-week period 17/10/21–8/12/21 was processed using eVorta :

<u>Autonomous Vision</u> via the "Aegir" artificial intelligence model to extract images of cats. This period deliberately coincided with the presence of nine identifiable cats, that were satellite-collared within the WTZ, separating collared from uncollared cats. The Aegir algorithm isolated ~8000 images of cats over this 7-week period, manually cleaned to about 4,500 , after eliminating mis-identified photos. A four-week subset period, 10/11/21-8/12/21, was selected for manual identification of cats, based on distinguishable features such as coat colour, pattern, sex, or other distinguishing features. Sixteen individual cats were identified, including four collared individuals. Overall, these accounted for 47% of cat detections, with the remainder of detections (53%, 865 images) from an unknown number of unidentifiable cats, with indistinct tabby coat patterns. Using detections of these known and unknown individuals over the four-week period, a spatially explicit capture-mark-resight analysis was completed, with the 'secr' package in R (Efford, 2020). The first night that an individually identifiable individual was detected on camera was assigned as the capture night. A half-normal detection function was used, with a habitat mask with a 4,000 m buffer around each trap, excluding areas outside the WTZ, to which the camera trap grid was restricted. This buffer size was chosen as it represents $4\sigma HN$, a buffer size recommended to minimise truncation bias, rounded up to the nearest km (Efford 2023). All detectors (cameras on tracks and cameras on fence lines) were modelled the same way. The AIC of a null model was compared to a model with adjustments for overdispersion, due to the inclusion of unmarked sightings and the model with adjustments for overdispersion was chosen due the lower AIC (Table S3).

Two methods were used to generate activity indices from spoor counts. First, five fixed 1 km transects targeted small mammal-medium mammals, involving 'sweeping' four treatments (total 20 transects), dragged with a steel bar and chain behind an all-terrain vehicle in the afternoon creating a 1 m wide 'sweep'. This 'sweep' was then checked on foot the following morning within 1 hour of sunrise. Second, transects targeting predators and macropods involved dragging 6 tyres arranged in a triangle behind a 4WD vehicle along 30 x 200 m stretches of sand inside the WTZ and Park management treatments (Fig. 1). This created a 2.5 m wide 'sweep', checked the following morning within 1 hr of sunrise. For both methods, a crossing constituted an animals' tracks entering and then exiting the swept transect. If a track left a transect and re-entered, it was considered a new crossing, consistent with previous studies (Moseby *et al.* 2011).

**Table S1**. Details of Felixer serial numbers, model versions and dates on site in Sturt National Park.

| Felixer ID | Model, Year of manufacture | Details | Dates on site | Trial Periods |
|---|---|---|---|---|
| SP030013 | 3.0, 2017 | Wild Deserts owned | 1/3/2022 – 1/3/2023 | A, B, C |
| SP030014 | 3.0, 2017 | Wild Deserts owned | 1/3/2022 – 1/3/2023 | A, B, C |
| SP030019 | 3.0, 2017 | Wild Deserts owned | 1/3/2022 – 1/3/2023 | A, B, C |
| SP030044 | 3.0, 2017 | Short term loan | 8/3/2021 – 31/8/2021 | A |
| SP030048 | 3.0, 2017 | Wild Deserts owned | 1/3/2022 – 1/3/2023 | A, B, C |
| SP030125 | 3.1, 2020 | 3-year lease | 1/3/2022 – 1/3/2023 | B, C |
| SP030185 | 3.1, 2020 | 3-year lease | 1/3/2022 – 1/3/2023 | B, C |
| SP030279 | 3.2 (AI), 2022 | Short term lease | 8/11/2022 – 1/3/2023 | B |
| SP030280 | 3.2 (AI), 2022 | Short term lease | 8/11/2022 – 1/3/2023 | B |
| SP030281 | 3.2 (AI), 2022 | Short term lease | 8/11/2022 – 9/2/2023 | B |
| SP030306 | 3.2 (AI), 2022 | Short term lease | 13/2/2023 – 1/3/2023 | B |
| SP030217 | 3.1 R (AI) | Short term loan | 3/8/2023 – 22/5/2023 | B |
| SP030213 | 3.1 R (AI) | Short term loan | 4/8/2023– 19/7/2023 | B, C |
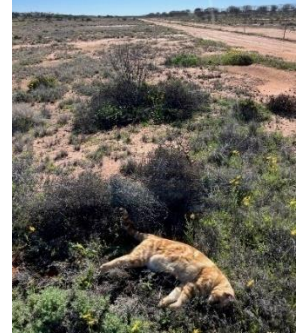
*Felixer fire event by SP030048 in the Wild Training Zone at 9:21 pm, 10 Dec 2022 and a male cat found dead near Kiwi Gate, 1.3 km from Felixer SP030048 at noon on 12 December.*

Felixer fire event by SP030013 on 5 January 2022, 12 days prior to the discovery of a carcass ~500 m away on 17 January 2022, with remnant Felixer gel on its left flank.

Felixer fire event by AI unit *SP030021*3 on 5 Aug 2023, with large ginger cat found dead within 250 m of the unit on 8 Aug 2023 with remnant Felixer gel on its right flank.

***Figure S1.*** *Details of cats found dead and attributable to Felixer firing.*

**Table S2.** Summary of Felixer fire events at satellite collared cats and their outcome.

| Fire event | Target Cat (sex) | Date/time | Felixer serial number (model) | Site (within WTZ) | Outcome | Notes | Approx time to death/motionless (hrs) | Distance moved prior to death (m) |
|---|---|---|---|---|---|---|---|---|
| 1 | Spoingus (F) | 5 May 2023 | SP030019 (3.0) | WD WTZ 04 | Non-mortality | Cause remains unclear, despite significant investigation | - | - |
| 2 | Bingus (F) | 5 May 2023 | SP030013 (3.0) | WD WTZ 07 | Mortality | No trace of Felixer gel or staining visible on fur. Lab assay confirmed 1080 | 2.62 | 230 |
| 3 | Dwight (M) | 20 May 2023 | SP030019 (3.0) | WD WTZ 04 | Mortality | Remnant Felixer gel visible on fur | - | 250 |
| 4 | Annie (F) | 29 May 2023 | SP030019 (3.0) | WD WTZ 04 | Non-mortality | Felixer oozed gel down front of unit – gel did not reach cat | - | - |
| 5 | Kiwi (M) | 29 May 2023 | SP030217 (3.2) | WD WTZ 05 | Non-mortality | AI device –60 ms second delay in firing – gel did not reach cat | - | - |
| 6 | Chonk (M) | 13 June 2023 | SP030125 (3.1) | WD WTZ 04 | Mortality | No trace of Felixer gel or staining visible on fur. Lab assay confirmed 1080 | 1.53 | 670 |
| 7 | Milkshake (M) | 20 June 2023 | SP030217 (3.2) | WD WTZ 05 | Mortality | Images show cat jumping into air upon firing. Felixer gel visible on fur upon carcass retrieval | 7.03 | 700 |
| 8 | Spoingus (F) | 27 June 2023 | SP030217 (3.2) | WD WTZ 05 | Mortality | Pink staining from Felixer gel visible. | 5.3 | 350 |
| 9 | Annie (F) | 1 July 2023 | SP030125 (3.1) | WD WTZ 04 | Mortality | Delayed mortality signal from system error prevented calculation of time of death | No data | 350 |
| | | | | | | **Mean** | **3.36** | **425** |

**Table S3.** ANOVA (Type II) for the effect of 'Treatment' (WTZ, Park) and 'Month' (August 2022 – August 2023) on the mean cat activity (per 100 trap nights). Significant terms are highlighted in bold.

|  | Sum of squares | DF | $F$ | $P$ |
|---|---|---|---|---|
| **(Intercept)** | **60.855** | **1** | **527.320** | **<0.001** |
| **Treatment** | **2.760** | **1** | **23.920** | **<0.001** |
| **Month** | **0.586** | **1** | **5.077** | **0.035** |
| Treatment:Month | 0.385 | 1 | 3.334 | 0.081 |

**Table S4.** Cat density ($km^{-2}$) estimates in the WTZ between November - December 2021. Density estimates are for the null and overdispersion adjusted spatially explicit capture-mark-resight models, including standard error (s.e.), 95% confidence intervals (LCI, UCI), detection probability at home range centre (g0), home range size index (sigma) and Akaike information criterion (Insee *et al.*).

| Model | Cats $km^{-2}$ | Density s.e. | Density LCI | Density UCI | g0 | g0 s.e. | sigma | sigma s.e. | AIC |
|---|---|---|---|---|---|---|---|---|---|
| Null | 0.26 | 0.04 | 0.19 | 0.36 | 0.40 | 0.06 | 760 | 44 | 1,555 |
| Overdispersion adjusted | 0.35 | 0.05 | 0.26 | 0.47 | 0.25 | 0.03 | 932 | 72 | 1,061 |

*Table S5. Summary of all species and objects encountered by Felixers during the 3 Trial periods*

| Order/Family | Species | A | B | C1 | C2 | Total |
|---|---|---|---|---|---|---|
| Felidae | Cat (Felis catus) | 364 | 773 | 7 | | **1,144** |
| Canidae | Dingo | 35 | 17 | | | **52** |
| | Fox (Vulpes vulpes) | 2 | 2 | | | **4** |
| Monotremes | Short-Beaked Echidna (Tachyglossus aculeatus) | 3 | 2 | | | **5** |
| Macropods | Euro | 12 | 27 | | | **39** |
| | Kangaroo species | 48 | 63 | | | **111** |
| | Red Kangaroo (Osphranter rufus) | 384 | 807 | | | **1,191** |
| | Western Grey Kangaroo (Macropus fuliginosus) | 8 | 29 | | | **37** |
| Marsupials | Bilby (Macrotis lagotis) | | 3 | 86 | 75 | **164** |
| | Crest-tailed Mulgara (Dasycercus cristicauda) | 15 | 1 | 1 | 3 | **20** |
| | Golden Bandicoot (Isoodon auratus) | | 1 | 50 | 40 | **91** |
| Bat (CHIROPTERA) | Bat (CHIROPTERA) | 2 | 17 | | | **19** |
| Rodents | Dusky hopping mouse (Notomys fuscus) | 1,455 | 475 | 34 | 58 | **2,022** |
| | Rodent (RODENTIA) | 1,584 | 1,448 | 409 | 56 | **3,497** |
| | Rabbit (Oryctolagus cuniculus) | 442 | 203 | | | **645** |
| Ungalates | Goat (Capra hircus) | 2 | | | | **2** |
| | Pig (Sus scrofa) | 6 | | | | **6** |
| Aves (birds) | Southern Whiteface (Aphelocephala leucopsis) | | | 1 | | **1** |
| | Australian Wood Duck (Chenonetta jubata) | 4 | | | | **4** |
| | Australian Magpie (Gymnorhina tibicen) | | 5 | | | **5** |
| | Black-Faced Woodswallow (Artamus cinereus) | | 3 | | | **3** |
| | Bird (AVES) | 278 | 87 | 4 | 7 | **376** |
| | Emu (Dromaius novaehollandiae) | 5 | | | | **5** |
| | Chirruping Wedgebill (Eurycnema goliath) | | 2 | | | **2** |
| | Cinnamon Quail-Thrush (Cinclosoma cinnamomeum) | 19 | 35 | 9 | | **63** |
| | Crested Pigeon (Ocyphaps lophotes) | 4 | 29 | 3 | | **36** |
| | Diamond Dove (Geopelia cuneata) | 45 | 18 | 3 | | **66** |
| | Australian Raven (Corvus coronoides) | 1 | | | | **1** |
| | Corvid sp. | 4 | 127 | 19 | | **150** |
| | Little Crow (Corvus bennetti) | 3 | | | | **3** |
| | Willie Wagtail (Rhipidura (Sauloprocta) leucophrys) | 73 | 120 | 1 | 9 | **203** |
| | Zebra Finch (Taeniopygia guttata) | 17 | 30 | 5 | | **52** |
| | Fairy Wren (MALURIDAE) | 34 | 54 | 8 | 3 | **99** |
| | Nankeen Kestrel (Falco cenchroides) | | 1 | | | **1** |
| | Kingfishers (ALCEDINIDAE) | | 1 | | | **1** |
| | Crimson Chat (Epthianura tricolor) | 22 | 2 | | | **24** |
| | Orange Chat (Epthianura aurifrons) | 1 | | | | **1** |
| | Crested Bellbird (Oreoica gutturalis) | | 1 | | 1 | **2** |
| | Bourke's Parrot (Neopsephotus bourkii) | | 1 | | | **1** |
| | Parrots (PSITTACIDAE) | 1 | | | | **1** |
| | Passerine Birds (PASSERIFORMES) | 3 | 2 | | | **5** |
| | Red-Capped Robin (Petroica goodenovii) | | 1 | | | **1** |
| | Chestnut-Crowned Babbler (Pomatostomus ruficeps) | | 2 | | | **2** |
| | Black-Tailed Native-Hen (Tribonyx ventralis) | 1 | | | | **1** |
| | Australasian Pipit (Anthus novaeseelandiae) | | 5 | | | **5** |
| | Brown Songlark (Cincloramphus cruralis) | 2 | 7 | | | **9** |
| | Rufous Songlark (Cincloramphus mathewsi) | 4 | | | | **4** |
| | Button-Quail (TURNICIFORMES) | | 1 | | | **1** |
| | Little Button-Quail (Turnix velox) | 2 | 1 | | | **3** |
| | Eastern Barn Owl (Tyto javanica) | 1 | 1 | | 1 | **3** |
| Reptiles | Central Bearded Dragon (Pogona vitticeps) | 37 | 178 | 44 | | **259** |
| | Dragon sp. (AGAMIDAE) | 1 | 1 | 1 | | **3** |
| | Gould's Goanna (Varanus gouldii) | 17 | 27 | 12 | | **56** |
| | Snake (SERPENTES) | 1 | | 1 | | **2** |
| | Woma (Aspidites ramsayi) | 1 | | | | **1** |
| Insects | Butterflies (LEPIDOPTERA) | 6 | | | | **6** |
| | Insect | 19 | 26 | 5 | 1 | **51** |
| Human | Human | 70 | 129 | 60 | 14 | **273** |
| Vehicles | Vehicle | 1,020 | 1,025 | 232 | 112 | **2,389** |
| Other | No Obvious animal | 1,620 | 1,435 | 413 | 59 | **3,527** |
| | overexposed image | | 23 | | 12 | **35** |
| | Unknown animal | 462 | 139 | 31 | 8 | **640** |
| | **Grand Total** | **8,140** | **7,387** | **1,439** | **459** | **17,425** |

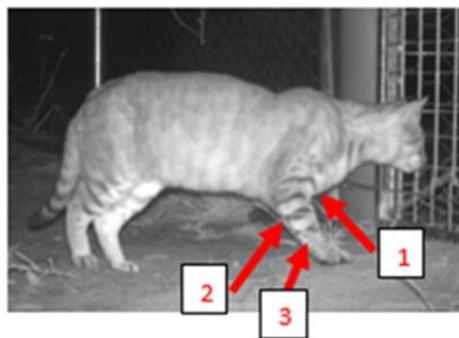"ANN TABBY DOUBLE STRIPES"

Location(s): ANN, TSRS OWGs

1. 'Flying bird' mark on upper front right leg

2. Double stripes close together on front right leg
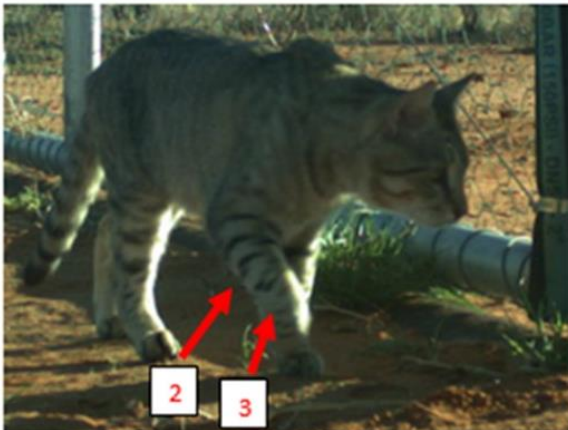
3. Broken 'splotches' below
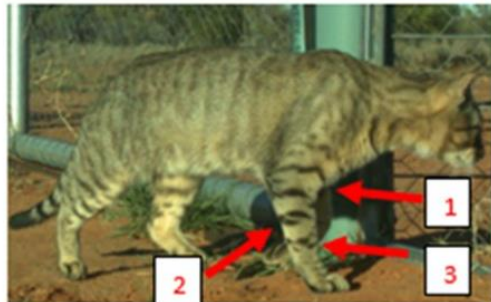
ANN_20211124 5:30:57 IMG_0076

ANN_20211125 12:26:33 IMG_0085

ANN_20211125 8:39l09 IMG_0094

ANN_20211113 7:29:04AM IMG_5774

ANN_2021116 6:15:43PM IMG_6187

TSRS_20211201 11:40:58PM IMG_0060

**Figure S2.** Example of individual Cat ID, that informed spatially explicit capture mark recapture analysis for density estimates:

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