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# CyberTracker: An integral management tool used by rangers in the Djelk Indigenous Protected Area, central Arnhem Land, Australia

**By Shaun Ansell and Jennifer Koenig**

***The Djelk Rangers have found CyberTracker to be an efficient, cost-effective, user-friendly and versatile data collection and management tool that can empower land and sea managers to engage in local, regional and national environmental decision making. This outline of its use in the Djelk Indigenous Protected Area in central Arnhem Land, Australia, shows how this ranger group have pioneered methodology to collect geo-referenced data of all its operational activities. The data capabilities and successful uptake of this technology by the Djelk Rangers demonstrate its potential as a tool for other Indigenous groups and its relevance to a broad environmental audience.***

**Key words:** *Aboriginal Land, community involvement, cultural issues and solutions, Indigenous Land Management, Reserve Management.*

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**Figure 1.** The use of CyberTracker has become an integral part of daily operations for rangers in the Djelk Indigenous Protected Area. The rangers are able to document their core duties using hand held units and build a geo-referenced database whereby all on-ground works can be mapped. Quantitative analysis of these works against existing planning goals informs decision making by the rangers, landowners and partner agencies. (Photo © J. Kitchens, NAILSMA.)

## Introduction

In northern Australia, Indigenous people living on Aboriginal-owned land face a complex range of natural resource management issues. Aboriginal lands are some of the most biodiverse and structurally intact landscapes in the country (Altman *et al.* 2007); however, they also face similar environmental challenges as the rest of northern Australia (Woinarski *et al.* 2007; Altman & Whitehead 2003). For example, fire management regimes have changed leaving large tracts of country susceptible to destructive fires (Russell-Smith *et al.* 2003), exotic plants and animals are widespread (Preece *et al.* 2010; Koenig *et al.* 2003) and many native species are in decline (Woinarski *et al.* 2010). While landowners have aspirations to preserve healthy landscapes for future generations, in many regions there are limits to the resources, community capacity and skills to deal with such issues (Brown *et al.* 2006). In response, more than 35 community-based Indigenous ranger groups have emerged in the northern half of the Northern Territory to provide a coordinated approach to tackle these environmental management challenges (Northern Land Council 2006).

Indigenous ranger groups, supported by organisations such as the Northern Land Council's 'Caring for Country Unit' (CFCU) and the North Australian Indigenous Land and Sea Management Alliance (NAILSMA) have expanded their operations and forged partnerships with research and training institutions, government bodies, corporations and philanthropic organisations. In recognition of the work and environmental services that Indigenous ranger groups provide, the Australian Government has (since 2007) been investing substantial funds to formally employ Indigenous rangers and fund their operations. The roll-out of the 'Working on Country' and 'Caring for our Country' programmes as well as funding available through the 'Indigenous Protected Areas' (IPA) programme (see http://www.environment.gov.au), have provided a measure of stability to ranger programmes by providing targeted and streamlined funding sources (May 2010). Given the complexity of many Indigenous ranger programmes, methodology is required that can document their diverse work outcomes for both their own management information as well as for their partner organisations. It is also vitally important for Traditional Landowners to be able to understand and give consent for works that are undertaken on their country (also a legal requirement under the Aboriginal Land Rights (Northern Territory) 1976 Act). As such, there is a real need for a durable, flexible and accessible data recording and analysis tool for use by field and office workers (Fig. 1). CyberTracker (see Box 1), an innovative software program coupled with rugged portable digital technology, provides such an opportunity.

## How Djelk Use CyberTracker

### Development of CyberTracker applications

The Djelk Rangers have been conducting land and sea management activities in central Arnhem Land for over 15 years (Gambold 2009). In 2007, they were introduced to CyberTracker. Other ranger groups in north Australia had previously trialled the software and had not continued its use as the hardware available at the time was not durable for the field conditions. Given recent technological advances, the Djelk Rangers researched newer 'ruggedised PDAs' on which to run CyberTracker and initially purchased three Trimble Nomad TDS800LC (Fig. 4) to trial the rangers' use of the program in harsh marine conditions. In December 2007, they developed a CyberTracker data application to record marine turtle sightings for a joint project with NAILSMA. After this successful initial trial of CyberTracker, the Djelk Ranger Manager (senior author) and senior Djelk staff developed expansions to the application to record the whole range of operational marine activities (explained in detail below). In March 2008, Djelk redeveloped this base application for NAILSMA to disseminate to other sea ranger groups and

## Box 1. The Djelk Rangers and the Djelk Indigenous Protected Area (IPA)

**The** Djelk IPA extends over 6732.2 $km^2$ (673 220 ha) of Aboriginal inalienable freehold land in central northern Arnhem Land, in the Northern Territory of Australia (Fig. 2). An IPA is an area of Indigenous-owned land or sea where Traditional Owners have entered into an agreement with the Australian Government to manage for biodiversity and cultural resource conservation in accordance with IUCN guidelines (http://www.environment.gov.au). The Djelk IPA incorporates coastal and sub-coastal land and seascapes, islands, estuaries, wetlands, rivers, monsoon rainforests, tropical savannas and sandstone escarpments (Gambold 2009). The area within the IPA has an unbroken history of Indigenous use and management, a continuous stewardship that today includes the Djelk Rangers. Djelk and landowner groups work together over an area of 14 000 $km^2$ (the area of the IPA as well as surrounding land and sea) to keep their country healthy and their culture and communities strong. Management activities undertaken by the Djelk Rangers include the protection of cultural sites, the continuity of Indigenous knowledge and skills, wildlife management, prescribed burning and wildfire mitigation (Fig. 3), feral animal and weed control, coastal surveillance, marine debris removal and the promotion of sustainable natural resource use (Harris-Pascal & Ansell 2009).

The Djelk Rangers operate out of Maningrida (Fig. 2), a remote Aboriginal community that was established as a service locality in 1957. Just under 3000 Indigenous Australians reside in the region (Altman 2008): the majority reside in the main township of Maningrida and a smaller number live at over 30 outstations (small family-based communities usually with between 10 and 50 residents) scattered throughout the Maningrida region. The Djelk Rangers are one of the largest Indigenous ranger groups in northern Australia and are a significant employer of Indigenous people in Maningrida (Djelk are the largest provider of Indigenous salaried positions within their parent organisation Bawinanga Aboriginal Corporation). Djelk employ 35 staff across three teams as land, sea and women's rangers (Harris-Pascal & Ansell 2009). A large proportion of staff salaries are funded through the Australian Government's 'Working on Country' programme. The Djelk Rangers also operate a number of fee-for-service agreements with Australian Customs, Northern Territory Fisheries, Australian Quarantine and Inspection Service (AQIS) and the West Arnhem Land Fire Abatement (WALFA) project which is funded by a large multi-national corporation (Conoco Phillips).

## Box 2. CyberTracker

**CyberTracker** is a free online software program that was initially developed in the 1990s to record data by animal trackers in Africa (see http://www.cybertracker.org). The innovation of CyberTracker lay in its graphic user interface, navigated by a touch screen, which made it possible for non-literate trackers to record the observations they made in the field using symbols and icons (Liebenberg 2003). CyberTracker can be used on a hand held personal digital assistant (PDA), laptop or tablet personal computer and data may be entered using any combination of words, pictures and sounds (Fig. 4). All the data recorded can be geo-referenced and stored in a user-friendly way that allows easy access, display and analysis. Today, CyberTracker is used extensively in many parts of the world to record information about a diverse range of activities including environmental projects, social surveys, disaster relief surveys, crime prevention, education and farming outcomes (see http://www.cybertracker.org for details). CyberTracker has also been used for ecological projects in some parts of Australia (Jackson *et al.* 2009; Brown *et al.* 2006).

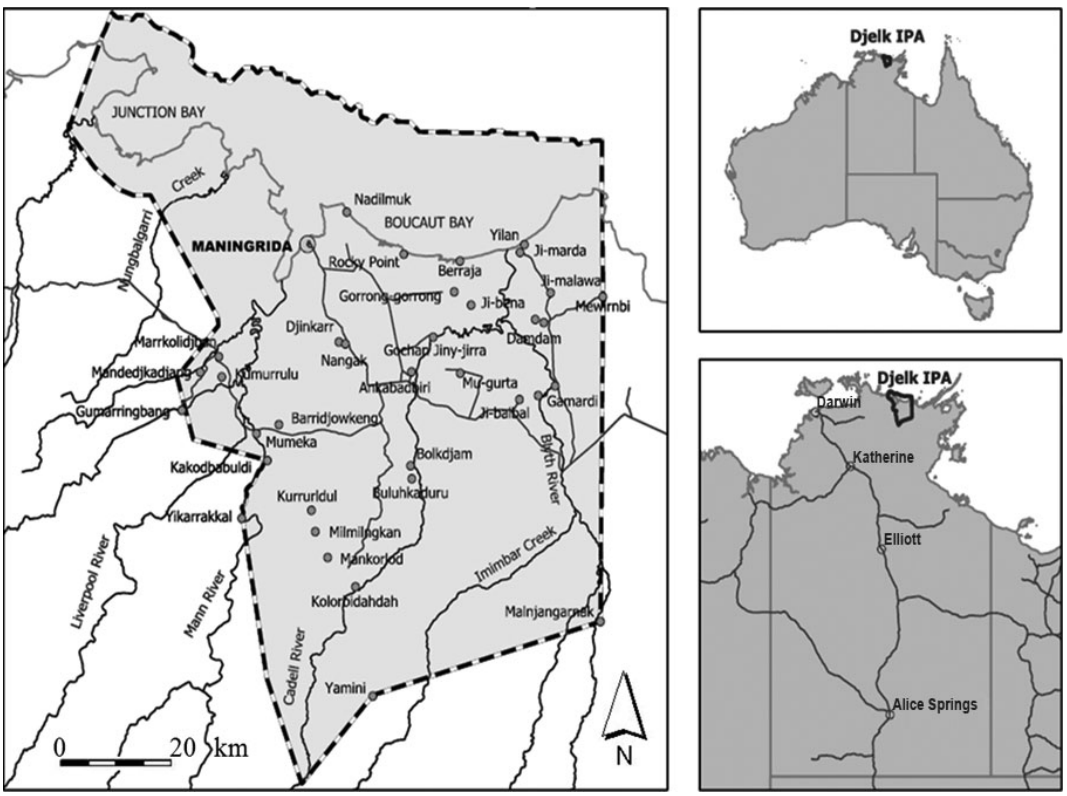


**Figure 2.** The Djelk Indigenous Protected Area as located within the broader area in which the Djelk Rangers operate. The position of Maningrida, outstation residences and major river systems are also illustrated.

this became the foundation for the 'I-Tracker' project (see Jackson *et al.* 2009). Concurrently, Djelk were partners in a project to map and treat grassy weed infestations in West Arnhem Land using a standardised paper data collection sheet and geographic positioning system (GPS). The Djelk Rangers asked to trial CyberTracker as a means of recording the weed data and the data sheet was translated into a CyberTracker data application and trialled for 1 month (March 2008). At the end of the trial, the Weeds Branch of the Northern Territory Government examined and compared the data with that collected on paper and noted that the CyberTracker data were unambiguous, compatible and of a much higher standard (B. Oliver, pers. comm.). Over the following few months, Djelk wrote data applications to cover all of their land and sea management activities.

### Hardware and set-up

The Djelk Rangers operate CyberTracker on the Trimble Nomad TDS800LC (Fig. 4). Particularly useful features of this PDA include an integrated GPS, its

**Figure 3.** An example of the Djelk Rangers involvement in a suite of land and sea management activities. Here the Rangers are conducting ground burning operations from a quad bike with CyberTracker mounted on the handlebars. (Photo © Djelk Rangers.)


**Figure 4.** The Trimble Nomad TDS800LC unit on which the Djelk Rangers run CyberTracker showing the operational screen for the Djelk Land Ranger Data Application. (Photo © J. Koenig.)

military grade durability (i.e. water and dust proofing to IP67 standard and drop, temperature and vibration proofing to MIL-810F standard), its daylight viewable touch screen, inbuilt microphone and inbuilt camera. This unit also has the capacity to use memory cards to expand and provide instant backup of all sightings in the field, a long battery life (14 hours), the capacity to run and recharge via 12 V, and simple connectivity to a desktop computer. Currently, the Djelk Rangers run 14 Nomad PDAs. To ensure that each unit is functional in the field, most boats, cars and quad bikes have installations that include hardwired 12 V chargers and Nomad Round-a-Mount (RAM) fixtures on the consoles. The rangers also have a charging station in their main office facility in Maningrida.

The Djelk Rangers run and manage their CyberTracker data on a single, non-networked computer which is connected to the internet. All Nomad PDA units are synchronised to this one computer using Microsoft Active Sync. Once data capture applications are created in CyberTracker (see below), they are installed onto the PDAs. Subsequent connection of the PDA to that computer synchronises the data from all the CyberTracker applications to the central databases. All data are stored within the central databases and can be analysed within CyberTracker or easily exported as a data spreadsheet (.xls) or shape file (.shp) for use in mapping software.

### Writing data applications

Data applications are the means by which users enter and collect data using CyberTracker. In creating data applications (also called sequences), the Djelk Rangers use a combination of text, numbers and pictures (Fig. 5). The software works like a branching tree whereby each decision links to another screen based on the user's previous answer (Fig. 5). Djelk develop data applications by two different approaches: (i) an existing methodology is turned into a sequence whereby each column on the data sheet becomes a screen in the program (e.g. the weed sequence described above) and/or (ii) the rangers collaborate to develop a list of required information pertinent to the operation with funding and work partners. This information is then sorted into elements (i.e. sorted relating to specific tasks) and given a logical progression (e.g. first identify the weed species before you enter other information about the plant). For each individual screen the creator of the data application can select the required data capture type. These include a radio list (where a list of preset choices is presented and you can only select one), check boxes (where multiple selections can be made), number and text entry screens, voice and camera recording screens and external data entry controls. During development, the track timer interval can be set and activated to record the user's movements. Once the data applications are developed, the Djelk Rangers run desktop and then field trials before putting it to operational use.

Currently, the Djelk Rangers run three data applications which cover all of their land and sea management operations: the Sea Ranger, Land Ranger and the R2 Raindance Machine data applications (see below). Each of these data applications includes an operation screen (e.g. the first screen in Fig. 5) where the user can choose the activity they are recording (i.e. weed management or feral animal


**Figure 5.** A sequence of actual screens from the Djelk Land Ranger Data Application demonstrating the graphical and user-friendly nature of the software. The sequence starts with the operational screen and then the user is navigated through a number of screens based on their previous responses (highlighted in black).

control) and where they can return to at the end of entering a particular chain of data. From this operational screen, the user is then guided through a series of screens which prompt for data related to the activity (Fig. 5). Users can also access a display map where their current position and track is located on a field map.

*Djelk Land Ranger Data Application*

This application is the most varied of all the Djelk CyberTracker sequences as it combines a number of data capture types depending on the activity being undertaken. The cultural site protection variables are mostly recorded using the voice recorder as senior landowners are interviewed about particular sites on their estates. For example, the site name, what does the name mean, what are landowner instructions for ranger work at this site and does the site need registering as a sacred site? By contrast, the weed management variables are recorded using option selection, entering text and numbers and taking photographs (Fig. 5). Other activities covered by the Djelk Land Ranger Data Application include prescribed burning (matches and drip torches), fire fighting and feral animal control.

*Djelk Sea Ranger Data Application*

This data application covers the range of operations undertaken when conducting a variety of sea patrols. Variables are entered using a combination of options. Activities recorded include: sightings of boats, live turtles and dugongs, turtle tracks or nests, checking sacred site buoys, crocodile trapping, the discovery of dead animals, observation and removal of marine debris, biosecurity surveillance, commercial crab pots and net checks, observations of fish kill events as well as the recording of unusual or 'other' events.

*Djelk R2 Raindance Machine Data Application*

The R2 Raindance machine is an aerial incendiary delivery machine developed by Aerospace Fabrication (http://www.raindancesystems.com.au) for conducting aerial prescribed burns. It feeds belts of capsules containing potassium permanganate through a carousel where they are injected with ethyl glycol, separated from the roll, fall to the ground through a chute and then ignite. The R2 Raindance machine can be fitted to a variety of aircraft and the rate of capsule delivery can be controlled either manually or by automatic settings. The R2 Raindance machine has an inherent capability to output operational status data through a serial port during operations. Djelk contracted CyberTracker's software developer, Justin Steventon, to create a data capture control to collect and georeference the operational status data outputted by the Raindance machine using CyberTracker. The information recorded with the Djelk Raindance Machine Data Application includes personnel on board the aircraft, the capsule drop rate, aircraft track and the location of every capsule dropped. Operator data arecorded for all fire activities ensuring that appropriate staff members and landowners are accountable for burning in the right places. In addition, all status codes are recorded and can be used to troubleshoot problems related to the Raindance machine.

The North Australian Fire Information (NAFI) website sources and displays fire management data such as hotspots (locations of recently burning fires as detected by satellites) and fire scars (maps of recently burnt country as detected by satellites) and displays them as maps (http://www.firenorth.org.au). Data from the Djelk R2 Raindance Machine is sorted and exported as a shape file and uploaded onto the NAFI website where it can be viewed by partner organisations in relation to the hotspots and fire scars generated.

## Djelk's Recorded Activities

Using the reporting functions within CyberTracker and statistical software (Microsoft Excel), we examined all of the records in the three Djelk databases for two consecutive financial years (1 July 2008–30 June 2010) to describe

**Table 1.** The land and sea management activities undertaken by the Djelk Rangers within the area of their IPA as recorded by CyberTracker (1 July 2008–30 June 2010)

| Activity | Ranger team | Number of days 2008–2009 | Number of days 2009–2010 |
|---|---|---|---|
| Prescribed burning (ground) | Land | 42 | 44 |
| Prescribed burning (aerial) | Land and sea | 16 | 16 |
| Feral animal control | Land | 20 | 10 |
| Weed management | Land | 38 | 93 |
| Fire fighting | Land | — | 6 |
| Customs patrol | Sea | 85 | 112 |
| Marine debris removal | Sea | 36 | 47 |
| AQIS patrol | Sea | 2 | 17 |
| Beach patrol | Sea | 7 | 3 |
| General sea patrol | Sea | 14 | 28 |
| Fisheries sea patrol | Sea | 3 | 7 |
| Cultural site protection | Land and sea | — | 19 |

IPA, Indigenous Protected Areas.

**Figure 6.** Djelk Rangers treating a noxious weed (Mimosa) infestation. CyberTracker allows the Rangers to record both treatments and newly discovered infestations, constantly feeding data into the planning and monitoring process. (Photo © Djelk Rangers.)

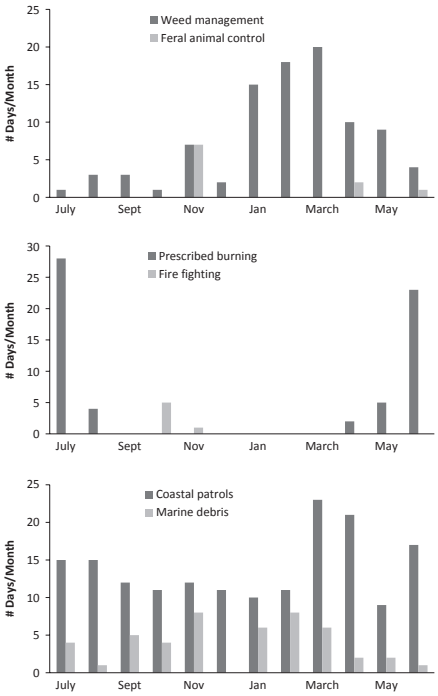


**Figure 7.** The seasonality of land and sea management activities as recorded in the Djelk CyberTracker database from 1 July 2009 to 30 June 2010.

individual land and sea management activities. Within the Djelk IPA, the number of days the rangers spend working on each activity is highly variable (Table 1). Coastal surveillance (41.8%), marine debris patrols (12.5%), weed management (19.7%) and prescribed burning (17.7%) operations accounted for the most effort within the sample time frame. The average number of activities undertaken each day increased slightly from 1.49 ± 0.05 in 2008–2009 to 1.88 ± 0.06 in 2009–2010. The CyberTracker data show the seasonality with which these activities take place on the ground (Fig. 7). For example, weed management is primarily undertaken during the wet season months (January–April; Figs 6,7) while prescribed burning activities are undertaken during the early months of the dry season (May–July; Fig. 7). By contrast, coastal surveillance and marine debris patrols are conducted relatively evenly throughout the year (Figs 7–9). Other activities (e.g. feral animal control) are more sporadic and are able to fit in around the timing of other activities (Fig. 7).

### Weed management

Weed management was undertaken at 25 outstations as well as in the township of Maningrida. For the last financial year (2009–2010) well over 1000 weed activities were recorded with CyberTracker, of which 419 were weed survey events and 650 weed control events. In 2009–2010, an average of 4.5 ± 0.43 weed species were treated at each of the outstations and 18 weed species treated within Maningrida. In total for that year, 25 individual weed species were treated (Table 2) of which grass weed species made up 55.4% of all controlled infestations, forbs 26.6%, vines 2.9%, trees and shrubs 7.4% and other weeds 2.6%. Most of these infestations were treated before large scale seeding occurred (Table 2) and many were the follow-up treatments required in any strategic weed control programme. The size of individual weed infestations is estimated into three diameter categories: 0–20; 20–50; and 50–100 individuals. Where infestations exceed 100 m in diameter, they are recorded as a combination of multiple smaller infestations. Mission Grass (*Pennisetum polystachion*) infestations account for the majority of recorded weed events of which 40.9% of surveyed infestations had a diameter of 20 m or smaller, 38.3% 20–50 m, and 20.8% were infestations up to 100 m in diameter; 100% of

**Figure 8.** Djelk has teams of both men and women rangers working throughout the Indigenous Protected Area. Here the rangers are conducting a sea patrol with CyberTracker mounted on the console. (Photo © Djelk Rangers.)

**Figure 9.** Djelk Rangers inspecting and removing marine debris (ghost net) on a remote coastal beach. CyberTracker allows the rangers to record a range of variables including the net type, its size, its state of decay, as well as the organisms found in the nets and their condition. (Photo © Djelk Rangers.)

recorded noxious Mimosa (*Mimosa pigra*) infestations were small patches under 20 m in diameter (Fig. 6).

### Prescribed burning and fire fighting

The Djelk Rangers undertook prescribed burning operations over 9518 linear km in 2008–2009 and over 17 368 linear km in 2009–2010. In 2009–2010, this took 719 person hours and involved travelling an average distance of 394.7 ± 40.4 km per day. As it began data collection with CyberTracker in 2010, the Raindance Machine spent 10 days in the helicopter travelling 4342 km and releasing 40 398 capsules at an average drop rate of 30 capsules per minute. Figure 10a displays an actual prescribed burning route undertaken through a sensitive area of the Arnhem Plateau as outputted from the Raindance Machine Data Application. Data can also be examined in relation to the fire scars that are mapped and displayed on NAFI using satellite imagery (Fig. 10b).

### Feral animal control

Feral animal culls were targeted at specific sensitive sites (Fig. 11) within the IPA such as freshwater springs and stone country billabongs which are prone to environmental damage by feral ungulates. In 2008–2009, rangers removed 669 Buffalo (*Bubalus bubalis*) and the following year 622 Buffalo were culled. The majority of these were from ground operations; however, following Civil Aviation Safety Authority (CASA) registration for aerial shooting in 2009, 110 Buffalo were shot from a helicopter. The most recent Buffalo population estimates for the region are estimated to be around 11 133 ± 1260 (for an area of 5880 km$^2$; Koenig *et al.* 2003). This suggests that up to 10% of the Buffalo population may have been removed during this time.

### Cultural site protection

Since April 2010, 21 cultural sites have been recorded using CyberTracker. All of the sound recorded data are transcribed, converted to shapefile and then added to the field maps in CyberTracker. The information can then be used during operations, to better inform consultations regarding Djelk Ranger work and to improve the accountability of all operations.

### Coastal surveillance

The Sea Rangers recorded a number of different events with CyberTracker during their sea patrols (Table 3). Many of these events relate to works contracted by Australian Customs and NT Fisheries which involve general coastal surveillance and the monitoring of commercial and recreational use of the marine environment and its resources. For example, in 2009–2010, of all recorded boat sightings, 78% were of commercial fishing boats, 8% fishing tour boats, 12% yachts and motor cruisers and 2% private fishing boats. Of the commercial boats that year, 72% were commercial Barramundi (*Lates calcarifer*) fishermen and 10% commercial Mud Crab (*Scylla serrata*) boats. The capacity of the software to automatically geo-reference the data recorded provides immediate clarity regarding suspected infringements of relevant legislation (e.g. fisherman working within river closure lines or within the sacred site boundaries). A large number of commercial nets were sighted

**Table 2.** The weed species treated by the Djelk Rangers in 2009–2010, including the percentage of infestations that had gone to seed. Species names follow Smith (2002)

| Weed species | Number of infestations treated | % Seeded |
|---|---|---|
| Buffel Grass *Cenchrus ciliaris* | 13 | 30.8 |
| Centipede Grass *Ischaemum timorense* | 1 | 0 |
| Gamba Grass *Andropogon gayanus* | 1 | 100 |
| Grader Grass *Themeda quadrivalvis* | 2 | 50 |
| Guinea Grass *Urochloa maxima* | 11 | 63.6 |
| Itch Grass *Rottboellia exaltata* | 1 | 0 |
| Johnston Grass *Sorghum halepense* | 1 | 0 |
| Mission Grass *Pennisetum polystachion* | 318 | 37.9 |
| Molasses Grass *Melinis minutiflora* | 1 | 0 |
| Mossman River Grass *Cenchrus echinatus* | 4 | 0 |
| Para Grass *Urochloa mutica* | 31 | 19.4 |
| Red Natal Grass *Melinis repens* | 2 | 50 |
| Tully Grass *Urochloa humidicola* | 1 | 100 |
| Candle Bush *Senna alata* | 3 | 0 |
| *Gmelina arborea* | 44 | 18.2 |
| Mimosa *Mimosa pigra* | 3 | 0 |
| Castor Oil Plant *Ricinus communis* | 18 | 0 |
| Coffee Bush *Leucaena leucocephala* | 2 | 50 |
| Paddys Lucerne *Sida rhombifolia* | 8 | 12.5 |
| Flannel Weed *Sida cordifolia* | 25 | 12 |
| Hyptis *Hyptis suaveolens* | 119 | 2.5 |
| Snake Weed *Stachytarpheta cayennensis* | 10 | 0 |
| Spinyhead Sida *Sida acuta* | 6 | 0 |
| Unknown Water Weed | 54 | 0 |
| Wild Passionfruit *Passiflora foetida* | 19 | 21.1 |
| Rubber Vine *Cryptostegia grandiflora* | 1 | 0 |

and checked in 2009–2010 compared with the previous year (Table 3). Of the 287 recorded crab pot events in 2009–2010, 3.8% were the discovery and removal of abandoned crab pots, 72.1% the checking of working pots (commercial or recreational crab pots in use) and the rest relates to the setting and checking of crab pots for research.

### Marine debris

The sighting and removal of marine debris accounts for a large percentage of all Sea Ranger events (Table 3). In 2009–2010, marine debris was recorded on 56 days on the water, some of which were designated marine debris patrols and some were recorded opportunistically whilst on other patrols. The average amount of marine debris recorded each day during this time was 19.3 ± 6.4 pieces. Of the 1067 pieces of debris recorded in 2009–2010, 78.4% was rubbish, 14.2% driftwood, 3.5% were buoys and 3% were ghost nets. The majority (99.6%) of the rubbish recorded was picked up and either taken to the dump or burnt on the beach; 81% of all rubbish was household rubbish with the remainder being of commercial origin. Most of the household rubbish was recorded as being of local origin (97.2%) compared with the majority of commercial rubbish which was recorded as being of foreign origin (76.3%). The number of ghost net (abandoned fishing net) sightings was higher in 2008–2009 compared with the following year (110 vs 32 respectively). Of those nets found in 2008–2009, 37.6% were of foreign origin, 36.7% local and 25.7% unknown origin (nets are identified based on the World Wildlife Fund (WWF) Net Kit distributed to ranger groups through the Carpentaria Ghost Nets Programme; Gunn *et al.* 2010). Five net samples were taken for further identification.

#### *Human and operational resources*

The Djelk CyberTracker data provides information on the human and operational resources required to undertake the above land and sea management activities. A total of 53 different staff members were recorded within the Djelk CyberTracker data over the 2-year period of this study during which time the Djelk Rangers recorded 401 working days. The number of ranger working days, the average number of teams recorded in the field, the average number of staff recorded working per day as well as the total time spent working and the distance travelled were all higher in 2009–2010 compared with those in the previous year (Table 4).

## Using the Knowledge to Improve Management

The existing management activities undertaken by the Djelk Rangers are guided by the Djelk IPA Plan of Management (Gambold 2009), a document developed following extensive consultation from over 100 different land-owning clan groups. Before CyberTracker, it was difficult to accurately prescribe the works undertaken given the massive area of Djelk operations (approx. 14 000 km$^2$). The use of CyberTracker, however, permits the Djelk Rangers, landowners and their partner agencies to progressively assess activities against land and sea management goals, entering new problems as they are identified, tracking the progress of works to ensure follow up and allowing for adjustments to be made to the work program. The Djelk Rangers conduct biannual IPA landowner meetings in which all Traditional Owners are invited to inform the planning for upcoming activities and to hear about the status of works that have occurred or are underway. CyberTracker activity maps are prepared for these meetings so that landowners and rangers can accurately discuss land and sea management activities as they relate to individual clan estates. The reporting of activities to landowners also raises their awareness of environmental problems and encourages the reporting of new or unusual sightings to the

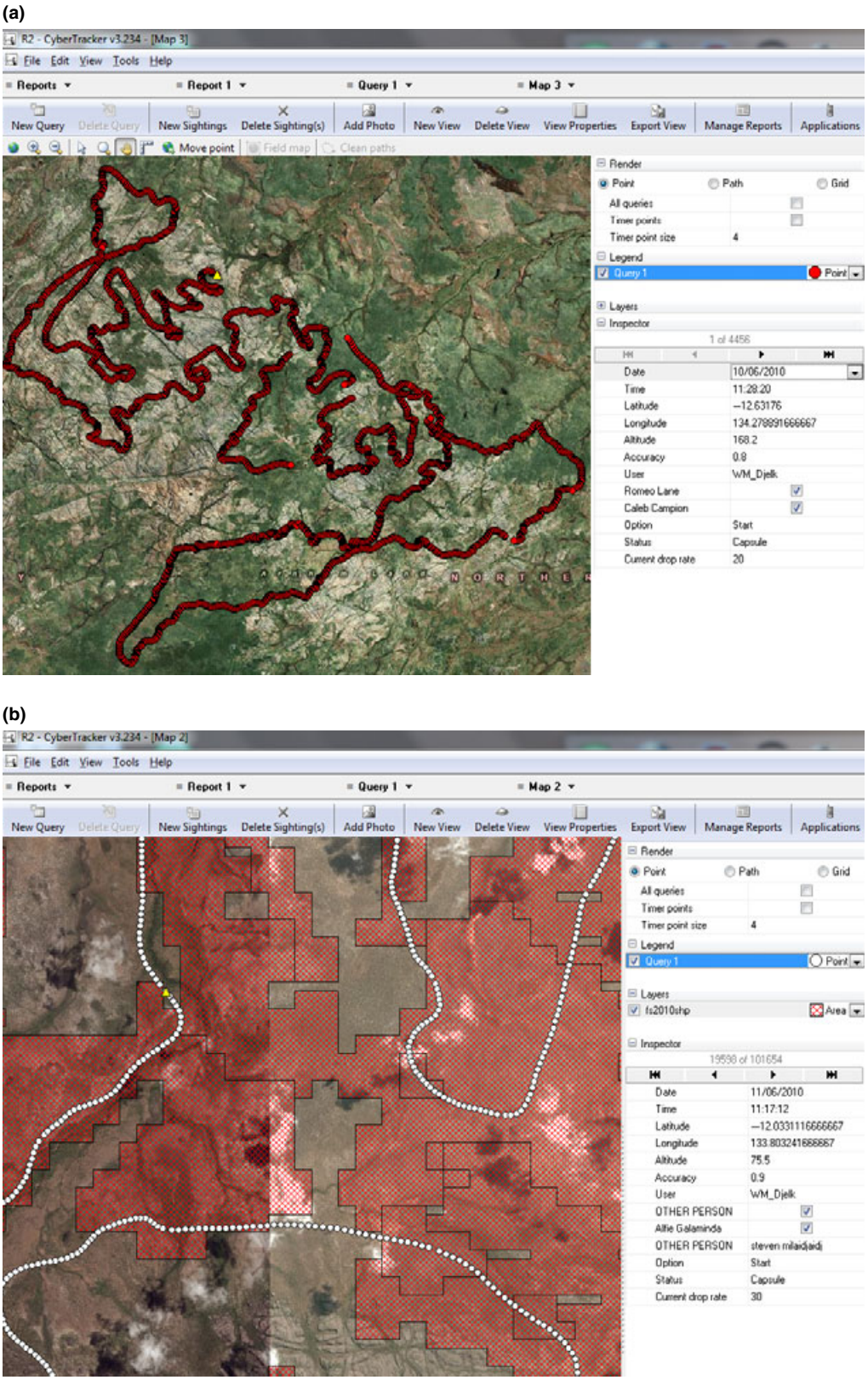


**Figure 10.** (a) CyberTracker map showing a prescribed burn line through the Arnhem Land Plateau on a single day (10 June 2010) and (b) a prescribed burn line and the resultant fire scars (red cross hatching) as mapped by NAFI. White circles denote the location of delivery of each incendiary and information related to a selected point (yellow triangle) is displayed in the right panel.

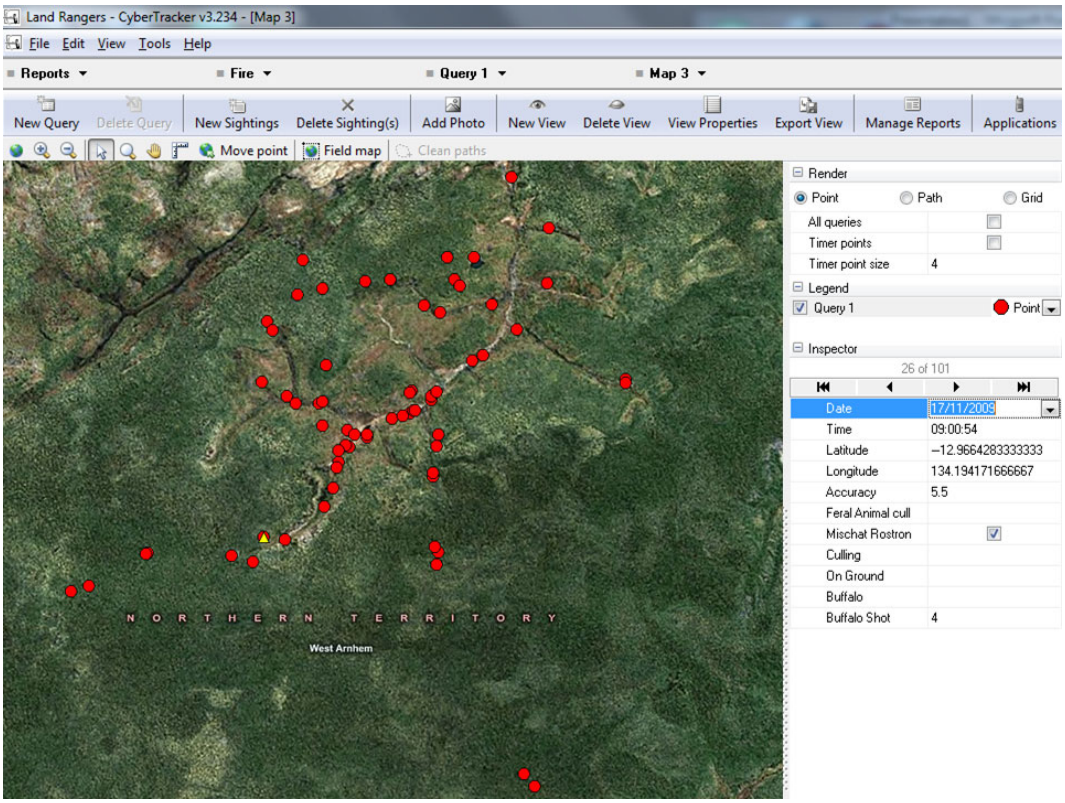


**Figure 11.** CyberTracker map showing the location of all Buffalo culled (red circles) in a sensitive spring system in the upper reaches of the Cadel River (1 July 2008–30 June 2010). Information related to a selected point (yellow triangle) is displayed in the right panel.

**Table 3.** The number of individual events recorded with CyberTracker each year by the Djelk Sea Rangers

| Events | 2008–2009 | 2009–2010 |
|---|---|---|
| Boat sightings | 66 | 107 |
| Buoy checks | — | 91 |
| Commercial nets found | 15 | 65 |
| Crab pot checks | — | 287 |
| Dead animals found | 6 | — |
| Live dugong sightings | 3 | 2 |
| Fish kills observed | 4 | 17 |
| Foreign fishing vessel | 0 | 0 |
| Insect traps set | — | 4 |
| Live sea turtle sightings | 32 | 6 |
| Marine debris found | 1577 | 1067 |
| Turtle nests found | 40 | 1 |
| Turtle tracks found | 43 | 19 |

**Table 4.** Djelk human and operational variables recorded by CyberTracker. Means are reported ± one standard error with the range of values presented in parenthesis

| Variables | 2008–2009 | 2009–2010 |
|---|---|---|
| Number of ranger working days | 183 | 218 |
| Average number of teams/day | 1.87 ± 0.08 (1–7) | 2.83 ± 0.11 (1–7) |
| Average number of staff/day | 6.23 ± 0.26 (1–19) | 7.92 ± 0.31 (0–22) |
| Total distance sea rangers (nautical miles) | 16 691 | 17 450 |
| Total distance land rangers (km) | 14 425 | 37 636 |
| Total time sea rangers (hours) | 876.4 | 1699.9 |
| Total time land rangers (hours) | 703.3 | 1947.8 |

rangers (e.g. new weed infestations for treatment).

CyberTracker also enables Djelk to be fully accountable to Traditional Landowners for the activities that occur on their country. Feral animals (in particular Buffalo and naturalised species of Cattle; *Bos* spp.) are important food resources for landowners in the Maningrida region. As such, feral animal management requires careful planning with landowners to balance culling in areas where there is significant damage while maintaining feral populations in other areas that can be accessed by customary harvesters. With the use of CyberTracker, landowners can know exactly how many animals are removed and from where they are being taken (Fig. 11). Similarly, CyberTracker enables the rangers to treat, monitor and evaluate particular weed infestations. For example, infestation sites of the noxious weed, Mimosa, are mapped and revisited on a regular basis for monitoring

and treatment. With landowner permission, these sites are also fenced to exclude feral animals spreading seed. The recording of cultural site data by the Djelk Rangers is one of the most innovative aspects of their use of CyberTracker as it provides a tangible means to incorporate the Indigenous Ecological Knowledge (IEK) of landowners to the management of country. Direct instructions recorded in the field relating to specific areas and their management needs can be accessed in CyberTracker by rangers when planning activities. Particularly important is information relating to the access and works that are allowed on or near sacred sites.

The CyberTracker database is also used for the monitoring of individual projects and reporting on outcomes to funding and work partners. All funding partners receive quarterly reports quantifying the work that was conducted during that period. The Djelk Rangers have also developed partnerships with a number of biological and social scientists who are utilising Djelk CyberTracker data in their research. One such example involves the use of data from prescribed burning and late dry season fire mitigation activities as part of the West Arnhem Land Fire Abatement (WALFA) project. WALFA is an agreement between Conoco Phillips, the Northern Land Council, the NT Government and several Indigenous ranger groups in Western Arnhem Land who are paid to reduce fire-generated carbon emissions (Whitehead *et al.* 2009). The agreement is based on a collaborative research programme (see Whitehead *et al.* 2009) which combines data on prescribed burning and fire mitigation activities with remotely sensed fire scar data and on-ground monitoring of grass fuel loads and tree densities to estimate carbon offset levels. CyberTracker allows rangers, Traditional Owners and partner agencies to fine tune prescribed burning activities against a backdrop of complex temporal, cultural and environmental factors by combining rugged data recording with basic visual interpretation and navigational functions. For example, relevant cultural site data are displayed (i.e. those places which should not be burnt) alongside fire scars from the previous year to plan burning routes in consultation with landowners at the biannual pre and post fire season WALFA planning meetings. These routes are then stored as field maps and used for navigation during actual ground and aerial fire operations.

The use of CyberTracker and the data that are generated by the Djelk Rangers is significant on a number of scales. Locally, the program empowers landowners and Indigenous rangers by allowing them to engage more comprehensively with a broader range of non-Indigenous partners, to employ their skills on a level which was previously not possible (due to low literacy levels) and to contribute important data to local, regional and national environmental decision making. The use of CyberTracker as demonstrated in this paper documents the extent of this involvement, the amount of on-ground work achieved and helps to ensure continuing participation in this industry is viable. For example, the availability of such data will influence decisions regarding funding investments by the Australian Government in natural resource management in IPAs and the Indigenous estate (now estimated at 20% of the Australian landmass; May 2010). The quantitative nature of the data paves the way for the development of more payment for environmental service agreements as investors can be confident that their investment is bringing about particular outcomes. To fulfil their Australian Customs service level agreement, Djelk compile a report at the end of each sea patrol using CyberTracker. Information reported includes: distance travelled, hours spent on the water, number of personnel and the location and description of any encountered vessels. To date, information recorded by the Djelk Sea Rangers has been used in several successful prosecutions under the following offences: entering a sacred site (Northern Territory Aboriginal Sacred Sites Act 1989), entering Aboriginal Land without a permit (Aboriginal Land Rights (Northern Territory) Act 1976) and breaches of the Northern Territory Fisheries Act 1988.

The data also contribute to a regional and national understanding of environmental issues, particularly where the same data applications are used in multiple locations. For example, the 'I-Tracker' project has seen the roll out of the sea ranger data application to Indigenous groups across northern Australia (Jackson *et al.* 2009). The use of one methodology allows data on pertinent issues such as the prevalence of ghost nets and other marine debris to be combined and analysed across a large proportion of the north Australian coastline. At an international scale, the Djelk Rangers use of CyberTracker provides an important model of the holistic nature of the software and its potential to be used as an all in one tool to record a broad spectrum of operations.

## Evaluating Djelk's Use of CyberTracker

CyberTracker software has been shown to be highly useful to the Djelk Rangers as demonstrated by its high uptake. There are several factors that have contributed to the successful uptake of CyberTracker and its continued and expanding use. These factors relate to (i) inherent properties of the software, (ii) the 'bottom up' approach of Djelk Ranger staff to the development of CyberTracker methodologies and (iii) the support received from external organisations.

CyberTracker is a powerful tool for data collection, although like any methodology, it requires well-designed and relevant questions to work most effectively. As CyberTracker is fully customisable, data applications were developed to suit the exact purposes of the Djelk program and the aspirations of staff members. With such tailored data applications, information is

easy for the rangers to record resulting in the capture of more data. A key to this has been that the rangers themselves had an important role in designing the questions and the way in which they are asked in the data applications. The whole of the ranger team dedicated themselves to trialling the program and the Djelk Ranger Manager (the senior author) provided technical support to the rangers, particularly in the early stages of development. The Djelk Ranger Manager authored the data applications, trained staff in the use of CyberTracker, coordinated the use of multiple units and their download to a central computer and gave feedback to staff at the end of each day's work. CyberTracker enables the Djelk Rangers to get instant feedback for the work they undertake on a daily basis. When back in the office each afternoon, they can review their tracks and activity points as well as see their day's work in relation to all activities taken place that year. This feedback also fosters a sense of pride and satisfaction for all members of the team.

The support received from the software's developers has played a pivotal role in the successful uptake of CyberTracker. While there are a number of GIS-based systems available that enable data collection and access using hand-held units, CyberTracker is unique in many ways. Not only is the software highly innovative, but it is available for free download on the internet and it is possible to directly converse with software development staff. The senior author contracted the software developers to customise a data control for the Raindance Machine (as described previously). Initial field trials of the Raindance Machine Data Application revealed problems with the speed of CyberTracker's saving (due to the massive amounts of data being recorded) and changes were made to the software to accommodate the operational requirements of this module. Coupled with this is the support given by members of the CyberTracker reference group, an email network of users based throughout the world, where you can ask questions, and give or receive advice. The Djelk Rangers have also received support and encouragement through their collaborations with NAILSMA on the 'I-Tracker' project. Similarly, all of Djelk's partner agencies have given positive feedback relating to the quality of the data collected and its implications for reporting on activities.

There are some limitations that require awareness and management. Although user-friendly, the program is, of course, not automated and requires individual users to take the PDA into the field, turn it on and actually use it. Use of the system can also be less than optimal, particularly during the learning phase, and we found the Djelk data likely to underestimate a number of variables. For example, total work effort is likely to be underestimated as many time-consuming activities (e.g. vehicle and equipment maintenance, administration and attendance at meetings or conferences) are not recorded in the database. Similarly, the time spent on some tasks was probably underestimated, especially if these tasks were not the main focus of the trip. An example of this is cultural site protection, which was recorded very infrequently within the database, although it could be argued that every trip undertaken by the rangers involves at least some cultural site monitoring and protection. The data also underestimate the number of staff in the field at any one time as often only the operator of the unit is recorded on the staff screen. The effect of this learning phase is reinforced by the fact that most variables were recorded as being higher in the second year of data collection, although ranger activity was probably not highly changed; suggesting an increased use of CyberTracker as staff became more confident and competent with it.

## Where to from Here?

There are many potential directions in which the use of CyberTracker can be developed. The Djelk Rangers are planning to collaborate further with CyberTracker development staff to customise more new modules that will streamline their operations. They will also develop new data applications as new projects are initiated. Currently, they are working with an ecologist employed by the NT Government to undertake biodiversity benchmarking in the region (A. Stevens, pers. comm.). Most exciting is the expanding roll out of this program to other Indigenous ranger groups as well as to environmental and research fields in Australia.

For other Indigenous ranger groups in Australia, to date, NAILSMA has disseminated marine CyberTracker data applications to a number of groups in northern Australia and offers field and office-based technical support for the software. Similarly, the Northern and Central Land Councils are supporting the use of the program. The Federal Government, recognising the potential of CyberTracker to inform their decision making, has created CyberTracker support positions through their IPA programme (Department of Sustainability, Environment, Water, Population and Communities). This has the potential to see similar CyberTracker projects operating on Indigenous lands throughout Australia. It is anticipated that the organised collection of such quantitative operational data across Australia will demonstrate the very large contribution by Indigenous Australians to the management of Australia's land and sea environments. The vision for CyberTracker is a worldwide environmental monitoring network dedicated to improving the efficiency of data collection and observer reliability (http://www.cybertracker.org). Positive, practical examples of CyberTracker in action, such as those recorded here by the Djelk Rangers, show that there is massive potential for the software to be embraced by a broader audience with the development of applicable data applications customised for use by

other practitioner groups throughout the world.

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