Summary As the operator of the Ranger uranium mine and Jabiluka lease on Aboriginal land in Australia’s Northern Territory, Energy Resources of Australia Limited (ERA) recognises that the natural and cultural values of the company’s mineral leases and the surrounding World Heritage-listed Kakadu National Park must continue to be protected. Weeds are considered to be one of the most significant threats to the natural ecosystems of Kakadu National Park and also one of the more significant impediments to successful relinquishment of the mineral leases following cessation of mining activities. In recognition of this ERA has developed and is working to a Weed Management Plan to restrict the introduction and spread of priority weeds within, into and from the Jabiluka Mineral Lease and Ranger Project Area.

This paper discusses how ERA currently manages weeds on the Ranger and Jabiluka leases through planning, control and collaboration.

Keywords Ranger, Jabiluka, mine, weed, management, mapping, Kakadu National Park.

INTRODUCTION

Energy Resources of Australia Limited (ERA) is the operator of the Ranger Uranium Mine and Jabiluka Lease in the Northern Territory of Australia. The Ranger (79 km²) and Jabiluka (73 km²) Mineral Leases are on Aboriginal Land and surrounded by the World Heritage Listed Kakadu National Park (19,804 km²). ERA is committed to maintaining the natural and cultural attributes for which Kakadu National Park (KNP) was inscribed on the World Heritage List. Weeds are considered to be one of the most significant threats to the park’s ecosystems (Kakadu National Park Plan of Management 1999–2004). Without appropriate control measures, mine activities carry a high risk of proliferating weed spread. This is due to a combination of factors including land disturbance, movement of machinery in and out of the park and vehicle transit within the lease areas.

There are currently at least 64 introduced plant species on the Ranger Project Area and Jabiluka Mineral Lease, including one weed of national significance and eight listed under the NT Weed Management Act 2001 (Addison et al. 2005). There is a minimum legal requirement to manage weeds listed under the Act. Two grass weeds receiving most attention are mission grass (Pennisetum polystachion (L.) Schult.) and annual pennisetum (Pennisetum pedicellatum Trin.).

ERA’s key regulatory instrument, The Ranger Authorisation, requires the company to rehabilitate the post mining landscape to a state that could be incorporated into Kakadu National Park. Competitive grass weeds such as mission grass and annual pennisetum pose a threat to meeting this obligation if the size of current weed infestations is not progressively reduced to a manageable level prior to mine closure.

In 2003 ERA developed and implemented a comprehensive weed management plan to structure weed management activities in order to define and then achieve weed management objectives.

WEED MANAGEMENT PLANNING METHODS AT ERA

The weed management plan The plan is for internal use by ERA and details activities to manage and control weed-infested areas on the Ranger and Jabiluka Mineral Leases during the wet season each year. The plan was developed in accordance with the guidelines provided in Section 10 of the Weed Management Act 2001 and details activities from July to June (of the following year), to ensure adequate preparation is undertaken prior to the wet season when weed control work is most active.

The plan has a number of objectives, some of which are: to manage weeds in a manner that is consistent with management practises within the surrounding Kakadu National Park; to achieve nil introduction of potential new weeds at Ranger and Jabiluka from previous years baseline data; and to control weed infestations currently present on Ranger and Jabiluka according to assigned priority.

Weed mapping and management areas Fine scale weed mapping has occurred between April and May each year on Ranger and Jabiluka leases since 2003 (Welch and Puig 2003, Welch et al. 2004). Weed mapping has been an invaluable tool in planning on-the-ground weed management and evaluating its success. This mapping forms an integral part of ERA's Weed
Management Plan and is used by ERA for several purposes:

1) To accurately record where all priority weed species occur for on-ground communication;
2) To help develop a system to prioritise areas for management; and
3) To assess the effectiveness of previous management.

The leases have been divided up into a number of weed management areas for communication and management purposes. However, the boundaries of these areas are reviewed each year, as some areas of known weed infestation may not have been included in previous year’s maps or the size of area mapped increases compared to previous year.

The timing of the weed mapping survey has been chosen (Welch and Puig 2003) to coincide with the late wet season/early dry season, a period where native grass species are ‘browning off’ (e.g. native sorghum), and to coincide with the flowering of several introduced species (e.g. Pennisetum spp.), to assist in their identification and whilst they are still green.

Figure 1. Thematic map showing weed infestations or areas 10A, 10B and 10C on the Ranger Project Area.
When an infestation of weeds is located in the field, one of three shape files (ESRI file format common to ArcPad and ArcView) format options within ArcPad is used to record their location, depending on the spatial extent of the infestation. For small patches (up to 5 × 5 m), the ‘point’ feature button is used to mark a single point. For infestations occurring along a section of track or road, the ‘polyline’ feature button is used to mark a line feature. The width of the line is recorded in the ‘width’ attribute box (for later conversion to shape file). For larger areas, the ‘polygon’ feature button is used to create a shape by walking around the weed infestation. The outer boundary of a weed infestation is automatically recorded by continual position updates by the GPS. When recording any of these points, line or polygon features, a table with the above attributes (i.e. management area, species, density) was automatically activated for manual entry (by pointer and virtual keyboard) of weed infestation details into a box for each attribute (Gardener et al. 2005). The field data is then organised to facilitate the production of a variety of thematic maps as shown by Figure 1.

**Weed risk assessment** To aid in the prioritisation of weed species ERA has adopted a risk assessment system originally developed and implemented by KNP.

**WEED CONTROL METHODS AT ERA**

The primary aim of all weed control activities at ERA is to kill existing plants so as to prevent seeding and thus ensure new individuals do not appear.

**Ground based chemical application** Ground based chemical application is the most common weed control method used. For herbaceous weeds Glyphosate (450 g L⁻¹) is used, diluted 1:100 with water. All ground-based chemical spray application is to the point of plant run-off. At least one hour is required prior to rainfall for effective use of this herbicide.

**Aerial chemical application** Aerial spraying is used sparingly because of the potential for damage to native vegetation. Only highly infested areas on the Ranger Mineral Lease are targeted. Ground-based chemical application methods are used for follow-up spraying, after aerial spraying has been conducted.

**Physical control methods** Hand pulling is occasionally used for small and isolated patches of weeds. This method is particularly important in rehabilitated areas and when small isolated patches of weeds have already gone to seed.

**Fire** Prior to machinery accessing weed areas for land disturbance activities (i.e. vegetation clearing), the area is burnt to reduce the chance of weed matter being transported outside of the area. Trials are planned to determine the effectiveness of using traditional (Aboriginal) fire management practices as an integrated part of weed management.

**Records** It is essential that good records are kept including dates of weed control activities, methods used and success of treatments. A record of weed control activities is maintained in conjunction with the weed infestation maps for Ranger and Jabiluka. At the completion of each day’s spraying, the day’s activities are recorded into a weed control log. This is an important information source for effective planning for the following year.

**Preventative control methods** ERA is committed to preventing the introduction of weeds to its operations at Ranger and Jabiluka and to preventing the spread of weeds from known infestations on its leases to other areas in KNP and the Northern Territory. In accordance with the Northern Territory Weeds Management Strategy 1996–2005, ERA aims to prevent the introduction and spread of weeds within, into and from ERA’s Jabiluka and Ranger leases through a range of methods.

**Adoption of hygiene standards** In accordance with Section 25 (r12.20) of the Environmental Protection and Biodiversity Conservation Act (1999) and Section 9 of the Weed Management Act 2001, ERA shall not allow any plants or plant material (i.e. grass, mulch, hay) to be brought onto site or into Kakadu National Park. This is in exception to those species listed on the Jabiru Approved Plants List, which employees are made aware of during their induction process.

The import of plant material is controlled largely through contract procurement procedures which specify that all earth moving equipment brought into KNP shall be washed down thoroughly and inspected by Parks Australia North (PAN) staff and equipment leaving the lease areas is to be inspected by ERA to minimise transport of weeds from Ranger to other areas in the KNP.

Gravel, sand and soil required for earthworks are sourced from weed free areas on site wherever possible. If the material is transported into KNP, a weed-free certificate from the supplier must accompany the material.

**Education and awareness** ERA employees and contractors are educated about weeds using a range
of learning tools including inductions, self-paced learning modules, notice boards, communication meetings and articles in internal publications. Weed identification and control training is also provided for ERA employees involved in conducting weed control activities.

**Quarantine measures** Areas of high weed infestation at Ranger and Jabiluka have been identified by detailed mapping work. A Weed Quarantine procedure has been developed which details areas identified as being ‘weed free’ or having a high weed infestation. These areas are sign posted and detail restrictions for entry and exit from these areas.

**Resources** ERA has a dedicated Land Management Technician whose main role is weed management. This role is also supported by the use of contract weed sprayers, use of ERA trainees, an Environmental Officer and weed science specialists from ERA’s consulting company Earth Water Life Sciences (EWLS). ERA also engages personnel from the Gundjeihmi Aboriginal Corporation (GAC) to assist in providing personnel resources for weed control activities.

In addition to human resources ERA has the equipment available for ground-based chemical application such as a 1 × 400 L Quik Spray unit (single hose reel) and 1 × 600 L Dual reel Quik Spray unit with a boomless spray and backpacks.

A herbarium has also been developed for ERA staff to help identify weed species in the field and ERA also commits financially in areas such as supporting and organising Weed Forums and Weed Workshops.

**COLLABORATION WITH STAKEHOLDERS**
Weed control is a regional issue and hence collaboration with neighbours, KNP, is essential. The responsibility for management of the land held by ERA will some day be relinquished, hence ERA has an interest in ensuring that key stakeholders are involved in setting weed management objectives and are informed of progress against these.

Most recently ERA worked with Australian Government’s Department of Environment and Heritage (DEH) hosting a two day Weed Workshop in Jabiru in October 2005 discussing weed management in the Alligator Rivers Region with all relevant stakeholders. ERA has also worked collaboratively with PAN in running a one day weed identification workshop in June 2006 which saw about 40 people from the Jabiru region attend.

**CONCLUSIONS**
Weeds are a prominent environmental issue for ERA and pose a significant threat to successful environmental management, in both the short and long term. Therefore it is important to have a structured approach to weed management. A weed management plan developed and implemented by ERA in 2003 has provided this structure and continues to be used effectively for the management of weeds on the Ranger and Jabiluka lease areas.

**REFERENCES**
NT Department of Natural Resources, Environment and the Arts (DNREA) (2001). *NT Weed Management Act.*