

Bauxite Mining and Conservation of the Jarrah Forest in South-West Australia

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Abstract

The northern jarrah forest of Western Australia is covered to a large extent by a mineral lease granted to Alcoa World Alumina Australia in 1961. During the subsequent 42 years, a series of reviews of conservation reserves (protected areas) have been undertaken to improve biodiversity protection in this region. This case study reviews the cooperative process between government and company to establish a comprehensive, representative and adequate reserve system in the northern jarrah forest. In the course of these developments, the company has relinquished about 15% of its bauxite reserves.

Beyond the protected area boundaries, mining operations take place in multiple use forests. These forests also have a significant biodiversity conservation function. Alcoa has adopted a continuous improvement process to raise standards of environmental management and mine rehabilitation to benchmark levels. The company also sponsors conservation initiatives beyond its operational boundaries. Benefits from the company's developments and from collaborations with local scientists, flow on to other industries, the community and biodiversity in general.

Introduction

Alcoa World Alumina Australia (Alcoa) commenced operations in the jarrah forest of Western Australia in 1963, with the surface mining of about 30 hectares per year and this has increased to current levels of about 550 hectares per year. Over this period community attitudes to forest conservation have changed dramatically. These changes have been reflected in international developments such as The World Commission on Development (Brundtland) report of 1987, the Global Statement of Principles on Forests at the United Nations Earth Summit in Rio de Janeiro in 1992 and the Breaking New Ground – the MMSD Final Report 2002. Changed community attitudes have also been reflected in a series of reviews of the jarrah forest conservation reserve system, increased emphasis on conservation through the mine planning process and improvements to bauxite mining practices and operations to better manage for conservation outcomes within the mining envelope.

The purpose of this paper is to briefly review the history of development of the conservation reserve system in the jarrah forest of south-west Australia in the context of bauxite mining in the region, to highlight how forest conservation issues are addressed in the mine planning process, and how bauxite mining practices and operations address desired conservation outcomes.

Forests of south-west Australia

The forests of south-western Australia are dominated by two tree species. The jarrah (*Eucalyptus marginata*) and karri (*Eucalyptus diversicolor*) forests of Western Australia are located in the south-west corner of Australia. The jarrah forest has a current extent of some 1.8 M hectares compared to its estimated pre-1750 extent of some 2.8 M hectares. Nearly 1.6 M hectares occur on land vested in the Conservation Commission of Western Australia and managed by the Department of Conservation and Land Management (DCLM). Karri forest has a current extent of 190,000 hectares compared to its estimated pre-1750 extent of 230,000 hectares, of which some 176,000 hectares occur on land managed by the DCLM (Conservation Commission 2002). Bauxite mining does not occur in karri forest.

The jarrah forest is classified as medium open forest on the basis of height and canopy density (10-30 m in height, 30-70% canopy cover). The jarrah forest is dominated by the jarrah tree and marri (*Corymbia calophylla*) also occupies a large part of this area. On more fertile and well watered sites jarrah can grow to 40 m in height, with a straight bole to 18 m and a diameter of up to 2 m, whereas at the dry end of its range it occurs as a tall shrub, often with a mallee habit. In contrast to the floristic paucity of the tree strata, the jarrah forest floor is covered by a diverse sub-shrub and shrub layer to 2 m in height. The vegetation superficially appears uniform. More realistically it forms a complex multi-dimensional continuum of overstorey and understorey species responding to a number of changing environmental variables (Bell and Heddle 1989).

The south-west of Western Australia is recognised as a global biodiversity hotspot because of the diversity of flora species (Chatterjee 1995). Areas of greatest diversity occur in the non-forest kwongan vegetation outside of the jarrah forest (Bell and Heddle 1989). In the general forest area, non-forest communities around granite outcrops, streams and swamps are recognised as being the important parts of the landscape for relictual and endemic plant species (Hopper *et al.* 1996).

The climate of the area is Mediterranean, with cool wet winters and hot dry summers. The winters are cooler in the southern part of the region and the summers are also milder and wetter in this area and consequently the southern forest is classified as moderate Mediterranean and the northern forest as dry Mediterranean. Average annual rainfall ranges from nearly 1400 mm in the west of the northern forest and south of the southern forest, to around 700 mm at the inland extent of the forest. Rainfall is strongly seasonal, most falling during the winter months of June, July and August.

The landscape is ancient and generally one of subdued topography and deeply weathered soil profiles of low to extremely low fertility.

Whilst the forest ecosystems of the south-west are largely intact, the ecosystems to the east (Wheatbelt) and the west (Swan Coastal Plain) have been heavily impacted by clearing for agriculture and urbanisation. Consequently, there have been a large number of species extinctions in the Wheatbelt (43 species) and Swan Coastal Plain (26 species) but only one associated in part with the forest ecosystems (Shea *et al.* 1997). Another 450 plant species that are endemic to the Wheatbelt and grow only in the lowlands are threatened with extinction because of rising groundwater levels and salinity (Keighery 2000). The impacts on biodiversity in the Wheatbelt and Swan Coastal Plain have elevated the importance of the management of the forests for biodiversity conservation.

Bauxite mining in the jarrah forest

Alcoa's mineral lease ML1sa was granted in 1961 under a State Agreement Act (SAA). Initially the lease covered an area of 1.26 M hectares, which included forested areas in the Darling Range, where the bauxite reserves occurred, as well as a significant area of mostly private land on the coastal plain, which encompassed the refinery sites and transport corridors. In 1994, the lease was amended to cover only the bauxite resource, reducing the area to 712,900 hectares. A second company, Worsley Alumina Pty. Ltd (Worsley) also mines bauxite in the northern jarrah forest from a mineral lease adjoining Alcoa's. Its operations commenced in 1974. Land tenure within the leases is mostly state-owned forest, with the rest freehold private properties (Figure 1). A number of reservoirs that supply water mainly to the capital city of Perth are within Alcoa's lease area.

Currently Alcoa operates two bauxite mines, Huntly and Willowdale, which supply three alumina refineries, Kwinana, Pinjarra and Wagerup. A third mine, Jarrahdale, which was the company's first in Australia, was closed in 1999 and was fully rehabilitated by mid-2001. Alcoa's mining and refining operations in Western Australia supply alumina to produce approximately 15 percent of the world's primary aluminium. With assets of over A\$8 billion in Western Australia, the company directly employs nearly 4000 people, and contributes around A\$1.1 billion each year to the State's economy. Most of the alumina is exported world-wide and generates sales revenues of nearly A\$2.2 billion a year. Worsley's mine is at Boddington and bauxite is transported by overland conveyor to an alumina refinery at Worsley, near Collie. Alumina output from the Worsley refinery comprises another 6% of world production.

Alcoa's mining operations commenced in 1963, and since then nearly 13,500 hectares have been disturbed and 11,100 hectares have been rehabilitated to forests by the company. The area disturbed so far represents about three quarters of one percent of the total jarrah forest or 1.6% of the northern jarrah forest type. Over an expected 100-year or so life of the viable bauxite reserves, Alcoa will have disturbed approximately 2.7% of all

jarrah forest or 5.6% of the northern jarrah forest type. Bauxite is usually distributed on the flanks and ridges and rarely in the valley floors and riparian areas. Mining so far has been concentrated in the parts of the mineral lease that have the densest ore. In these regions, which are generally heavily infested with dieback disease, 35-50% of land within the first-order stream catchments has been disturbed for mining. Individual mine pits range in size from 5-50 hectares, and on average, ore depth is 4-5 m in depth.

Conservation reserve system of south-west Australia

As the agricultural industry expanded through the early 20th century the desire to protect forests from clearing for agriculture was reflected in the establishment of State forests through the lower south-west. The first State forest to be established was an area in the northern jarrah forest near Collie, presumably to protect timber supplies for the local coal mining industry (Havel 1989). Some 1.1 M hectares of State forest was established during the 1920s, covering most of the northern jarrah forest. The first conservation reserve in the forest region was established in the 1890s, in the Margaret River area, to protect caves in the area. Western Australia's first large national park was established in 1913, in the Stirling Range, covering some 109,000 hectares (Moore 1993). In the northern jarrah forest, a 65,000 hectares conservation reserve near Pinjarra was established in 1894. Attempts to have the reserve dedicated as national park were unsuccessful and in 1911 the purpose of the reserve was changed from preservation of native flora and fauna to timber for government requirements. The first national park was established in 1926 from areas initially set aside for the purpose of public parks and parklands. This national park later became known as the John Forrest National Park.

Through the 1930s to the 1950s the area of State forest continued to increase, but the area of conservation reserves changed little. In 1962 a review of national parks and nature reserves in Western Australia by a sub-committee of the Australian Academy of Science, demonstrated the inadequacies of the reserve system. However, the review had little political impact (Havel 1989). From the mid 1960s to mid 1970s the Forests Department, the agency responsible for management of State forests, began informally setting aside from timber harvesting areas of forest where the primary management intent was preservation of natural values. These areas later became known as Management Priority Areas (MPA), many with a management purpose of conservation (Forests Department 1977). Under this system the areas remained as State forest and were managed for conservation or other specified purpose such as recreation.

In 1971, the Environmental Protection Authority set up a Conservation Through Reserves Committee to examine the State's conservation reserve system. The committee systematically examined the adequacy of the conservation reserve system throughout the State and in 1983 its report covering the northern jarrah forest was published (EPA 1983). The report supported the MPA concept whilst recommending legislative change to enable security of purpose for the MPAs and the preparation of management plans for these areas.

In 1986, following negotiations with the government, Alcoa amended its Agreement Act, making a commitment not to mine in the proposed conservation reserves known as Dale, Serpentine, and Monadnock, and parts of the Lane Poole reserve (Alumina Refinery Agreement Amendment Act 1986). A proviso was included in this Agreement that the commitment stood as long as the conservation values of these reserves' indigenous flora and fauna remained. A right of access for transport corridors through the conservation areas, should they be necessary, was also retained.

In 1987, three Regional Management Plans were published covering the south-west forests (CALM 1987a,b,c). Under these plans, the MPAs would become secure conservation reserves as national parks, conservation parks or nature reserves. New reserves additional to the MPAs were also proposed, adding some 500,000 hectares to the proposed conservation reserve system, mostly in the southern forest. Additions in the northern jarrah forest where bauxite resources occur included the following proposals: Julimar Conservation Park; additions to Avon Valley National Park; Wandoo Conservation Park; and Lupton Conservation Park.

In 1994, the Forest Management Plan 1994-2003 was approved (LFC 1994). The process of development of the plan included a review of the conservation reserve system with further additions of more than 120,000 hectares to the proposed conservation reserve system, mostly in the southern forest. Additions in the northern jarrah forest where bauxite resources occur included the proposed Gibbs Conservation Park and a conservation park in George block. An area proposed in the 1987 Regional Management Plan at Marradong as a Conservation Park, was to remain as State forest because of its mineral prospectivity.

In 1996 the State of Western Australia and the Commonwealth of Australia began a comprehensive regional assessment of the south-west forest region, covering environmental, heritage, social and economic values. The

information from this assessment was used to evaluate the adequacy of the conservation reserve system in relation to a recently developed set of criteria for a comprehensive, adequate and representative (CAR) forest reserve system (JANIS 1997). The forest reserves criteria included the following targets:

- 15 % of the original distribution of each forest ecosystem in reserves;
- 60 % of the current area of each vulnerable forest ecosystem in reserves;
- 100 % of the current area of each rare or endangered forest ecosystem in reserves;
- maximise the inclusion in the reserve system of areas of importance for high species richness, refugia, disjunct species, endemic species, rare species, diversity of communities, and remnants in fragmented landscapes;
- 60 % of remaining old growth forest in each forest ecosystem in reserves;
- 100 % of rare or endangered old growth forest in reserves; and
- 90 %, or more if practicable, of wilderness areas in reserves.

The outcomes from this evaluation were included in a Regional Forest Agreement (RFA) that added a further 151,000 hectares to the proposed conservation reserve system, mostly in the southern forest (Commonwealth of Australia and State of Western Australia 1999). Old growth forest in the northern jarrah forest was classified as depleted and 100 per cent reservation target applied. Most of this old growth was added to the proposed conservation reserve system. Additions to the formal reserve system in the northern jarrah forest where bauxite resources occur included four new national parks, a large addition to an existing national park and several other additions to formal conservation reserves. Consultation with the mining industry occurred throughout the RFA process, and the proposed additions to the conservation reserve system were agreed with companies covered by State Agreement Acts. The process resulted in some areas previously proposed in the FMP 1994-2003 as conservation reserves, no longer going forward as conservation reserves in the RFA and alternative areas with equivalent or higher conservation values being selected. The newly proposed conservation reserves in the northern jarrah forest focussed on capturing areas of: old growth forest; centres of endemic flora species; centres of disjunct flora species; centres of relictual flora species; declared rare flora; rare fauna; less well reserved vegetation complexes; high biophysical naturalness; remnant vegetation; and representative areas of jarrah, wandoo (*E. wandoo*) and other forest ecosystems.

In 2001, the process of developing a new forest management plan began. The plan is intended to implement the *Protecting our old growth forests* policy of the State Government elected in February 2001. The conservation reserve system committed to under that policy included, and expanded on, the reserve system proposed under the RFA. The draft forest management plan (Conservation Commission 2002) includes further additions to the conservation reserve system of more than 500,000 hectares compared to the reserve system proposed in the FMP 1994-2003, mostly in the southern forest.

The *Protecting our old growth forests* policy included the commitment to reinstate those conservation reserves proposed in the FMP 1994-2003 that were to no longer go forward under the RFA. Those outside of State Agreement Act areas are now proposed as conservation reserves; however within SAA areas a process of agreement with SAA companies was again undertaken. The objectives of the process were to maintain access for SAA companies to areas that contain significant mineral resources whilst achieving a similar overall level of protection of conservation values as would be the case if all previously proposed reserves were reinstated (Conservation Commission 2002). The process achieved its objective and some 22,000 hectares is proposed for addition to the conservation reserve system in the northern jarrah forest. These new proposed reserves focus on capturing in the reserve system: old growth forest; less well reserved vegetation complexes; and representative areas of jarrah, wandoo and other forest ecosystems (Conservation Commission 2002). Under the draft forest management plan, forest ecosystems in the northern jarrah forest would be reserved at the levels shown in Table 1 and Figure 1.

Mine planning process and jarrah forest conservation

Each year Alcoa submits for approval, rolling five year mine plans to a multi-agency committee known as the Mining and Management Program Liaison Group (MMPLG). The MMPLG includes representatives from the Department of Industry and Resources, the Department of Conservation and Land Management, the Department of Environment (representatives from environmental protection and water and rivers branches) and Water Corporation. The company also submits ten and 25 year indicative mine plans on a regular basis. Alcoa's mining is restricted to the multiple use jarrah forest and no access to conservation reserves has been made. The multiple uses of the forest include water catchment, timber production, recreation, mining and conservation. The multiple use forest is a buffer for most of the forest conservation reserves, and thus enhances greatly the value and effectiveness of the protected areas. The submission of advance mine plans allows the activities of

the other forest users to be integrated; in particular, forest silviculture, logging, and prescribed fuel-reduction burning operations.

Table 1: Level of reservation of forest ecosystems and old growth forest, for forest ecosystems that occur in the northern jarrah forest. Reservation in is proposed and existing reserves as specified in the draft forest management plan (Conservation Commission 2002). NA = not applicable.

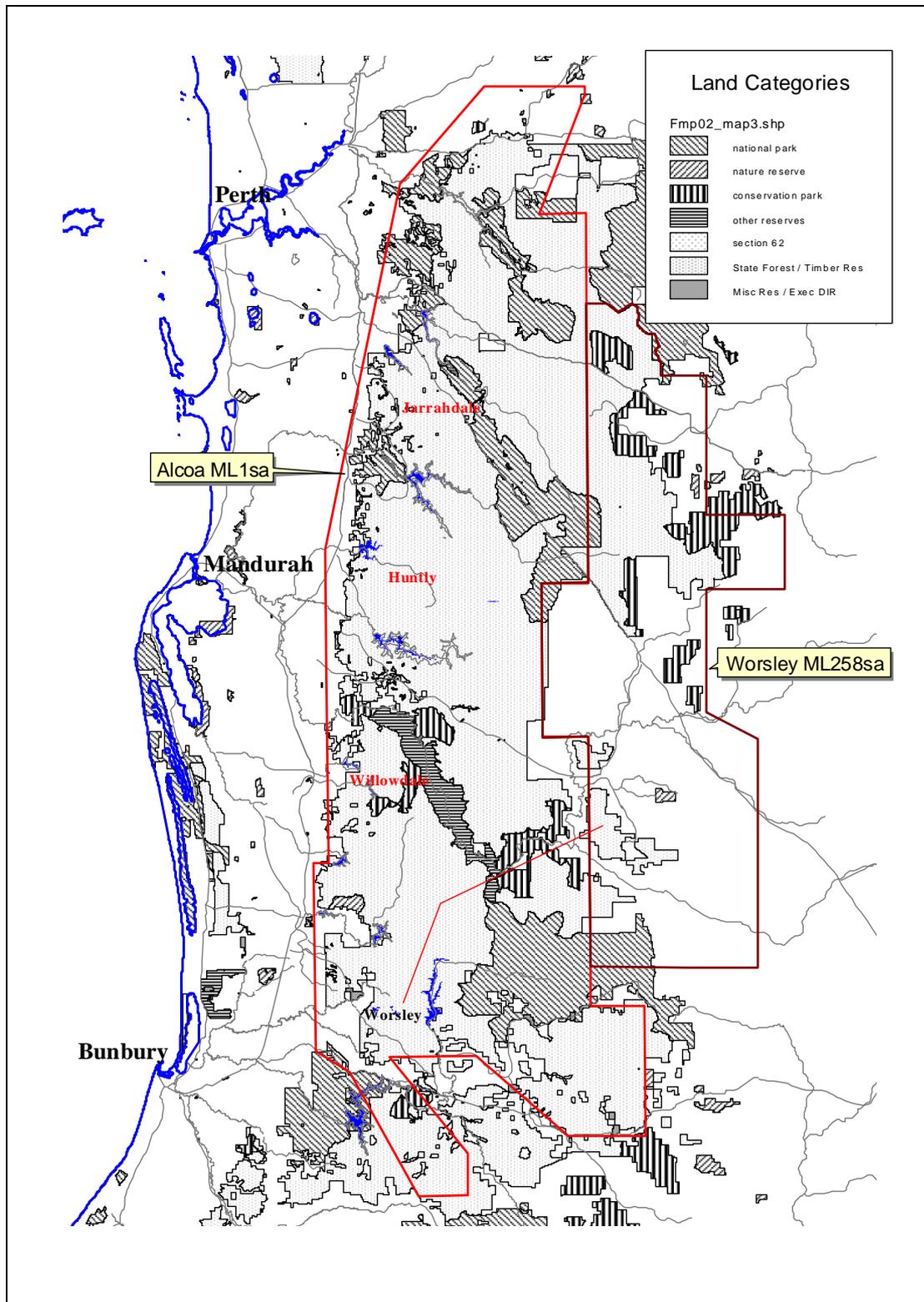
Forest ecosystem	Percent of original area forest ecosystem reserved		Percent of current area of old growth forest reserved	
	Target	Formal and CAR informal reserves	Target	All formal and informal reserves
Jarrah north east	15	17	100	99.7
Jarrah north west	15	17	100	99.9
Jarrah sandy basins	15	24	100	100.0
Jarrah woodland	15	43	100	99.6
Western wandoo forest	15	18	100	100.0
Western wandoo woodland	15	21	100	100.0
Darling Scarp	15	8	NA	NA
Rocky outcrops	15	37	NA	NA
Shrub, herbs and sedgelands	15	56	NA	NA
Swamps	15	41	NA	NA

Development of the mine plans is a complex and lengthy process, involving extensive inventory assessments of ore and environmental parameters, mining and logistics planning, and consultation with neighbours and local municipal governments. Before any drilling for exploration and ore definition commences, surveys are undertaken to map the distribution of dieback disease in the forest. Dieback is caused by the root pathogen *Phytophthora cinnamomi*. It can infect and kill jarrah trees, as well as up to 40% of the middle and understorey plant species. It can be easily transported in moist soil, such as may adhere to the wheels of vehicles. Baseline flora and fauna surveys and cultural and indigenous heritage surveys are also undertaken before mining proceeds. Vegetation is mapped using the site vegetation classifications based on Havel (1975). During these surveys, the botanical consultants also maintain a lookout for rare or threatened plant species and communities that may need to be avoided. Plant species lists are generated for defining seed mixtures for the later mine rehabilitation program. Indigenous heritage surveys involve archeological and ethnographic assessments. Representatives of the traditional landowners, the Pinjarra Nyungar community, are contracted to assist with this work.

Within the multiple use forest areas, Informal CAR Reserves were also designated as a result of the Regional Forests Agreement assessments. These are often linear reserves along streams and major travel routes, old growth forest remaining outside formal reserves, and diverse ecotype zones such as swamps and granite outcrops. Alcoa has established a policy of not disturbing forest within 50 m of granite outcrops as these are areas of high plant species richness and are also often sites of possible significance for indigenous (Aboriginal) peoples. The company is also committed to not disturbing areas of old growth forest. Bauxite doesn't usually occur low in the valleys so there is rarely any conflict over these areas for mining, however stream crossing for haul roads and conveyors are required. Through consultation with the regulatory agencies, Alcoa has established a procedure for seeking approval for disturbance of areas within informal reserves. Following baseline flora mapping and fauna assessments, and selection of the least impact route, plans are submitted to the MMPLG for approval. A sub-committee, which includes an NGO representative, inspects these areas in the field before recommending approval.

Dieback mapping, as it is known, is carried out on a number of occasions during the development, mining and rehabilitation phases, to ensure that the latest extent of the disease is known before operations are scheduled. The maps are used to segregate operations between infested and uninfested forest, to separate infested soils from uninfested soils during mine development and rehabilitation, and to identify points where equipment must be cleaned free of soil before it can leave an infested area. The distribution and extent of diseased forest is also considered during mine planning; in the placement of the mine haul roads and determination of boundaries of mine pits. These decisions can significantly change the risks for disease spread and impact.

Figure 1: Proposed land categories in the northern jarrah forest as specified in the draft forest management plan (Conservation Commission 2002) and mineral leases for bauxite mining. Most land categories are existing, as mapped, although some of the conservation reserves are yet to be established and are currently State forest or other land categories.



When mine plans have been approved and ore definition is completed (on a 15 m grid and at 0.5 m depth intervals), pit and haul road boundaries are marked in the field and a notice is submitted for clearing. A sub-committee of the MMPLG then inspects these areas, before final approval is given. Clearing is preceded by salvage logging operations managed by the Forest Products Commission. Clearing notice is usually given two years in advance of mining to allow timber products to be economically harvested.

Alcoa's mining is currently restricted to the western, high rainfall region of the lease, where soil salt storages are low and a substantial proportion of the forest is moderately to highly infested with dieback. Temporary removal of forest cover during mining therefore does not pose a threat to stream salinisation through a rise in groundwater levels. In the more eastern areas of the lease, within what is known as the intermediate rainfall zone (IRZ), soil salt storages can be high, up to 200 tonnes per hectare. In 1978, during the environmental impact assessment and approval process for Alcoa's Wagerup refinery, the company committed not to mine in the IRZ "until research showed that mining can be accomplished without significant adverse impact on the salinity of the water resources". This research program is now in about its 25th year, with a demonstration-mining project scheduled to commence late next year. Two fully instrumented treatment catchments will be mined and compared to an unmined control catchment. The research has involved all aspects of catchment hydrology and computer modeling. Mining will take place over five years. Results from this demonstration, associated research and modeling are expected to be used to seek approval for general mining in the IRZ from around 2020 onwards.

Bauxite mining practices and jarrah forest conservation

Alcoa's bauxite mines in Western Australia operate under an ISO14001 certified Environmental Management System (EMS). Many elements of biodiversity protection are recognized in the EMS's Key Aspects and Impacts Register. Environmental management and mine rehabilitation are tightly integrated into all phases of the mine development and mining operations. Operations managers clearly understand and accept their responsibilities for environmental management at the mines.

Clearing of the native forest for the bauxite mining operations is unavoidable, but every effort is made to limit the amount of non-ore clearing. In particular, wherever possible, haul roads are routed through mine pits and overburden stockpiles are placed either on ore or within mined out pits. Attention is paid to preventing "off-site impacts". Water runoff from disturbed areas is managed to avoid soil erosion, turbidity and siltation in streams, and transport of the spores or other inoculum of *P. cinnamomi*. Dieback disease management generally is a critical priority. Drainage from all haul roads is contained and channeled to sumps, which either allow infiltration of the water or discharge at points low in the landscape, usually directly into the dense riparian vegetation. These areas are almost always already infested with the disease, but the vegetation is largely resistant. Sumps at discharge points are designed to remove sediments to acceptable levels. Drainage management is designed to minimize impacts on aquatic biota and restrict the spread of dieback disease.

The surface bauxite mining activities in the jarrah forest do not expose any pyritic materials or mobile metals that may contaminate surface waters. However, by its very nature, large mining equipment carries with it many hundreds of litres of fuels and lubricants. Since the mines are within a sensitive forest environment and within water catchments, hydrocarbon spill prevention and response are carefully managed. Management strategies include: no use of underground storage tanks, secondary containment bunding around all storage tanks; employee awareness and spill reporting; and rapid response procedures for spills, which contain and recover contaminated soils. Hydrocarbon contaminated soil is transported with the ore to the refineries for processing.

Mine rehabilitation has been a particular improvement focus and a key performance indicator for the operations. Initially, rehabilitation simply attempted to establish plantations of introduced pine and eucalypt species, instead of the native jarrah. Concern that dieback would kill jarrah prevented it from being considered for widespread use. Nevertheless, since the mid-1970s Alcoa has committed a sustained effort to improving the mine rehabilitation practices. After much research and field monitoring, in 1989 the decision was made to use only the native jarrah and marri tree species in the mine rehabilitation. From this point on the focus changed to attempting to restore the jarrah forest ecosystem and the full suite of pre-mining land uses. Descriptions of the current mine rehabilitation practices have been published in a number of recent papers (Baker et al. 1995, Gardner 2001, Gardner and Grant 2002).

During the last ten years, a key objective has been to return the plant species richness of the jarrah forest to the mined areas. A number of innovative techniques for soil handling, soil cultivation, seed collection and

treatment and plant propagation have resulted in plant species richness, measured at 15-months age, increasing from an average of 65% of forest control sites in 1991 to 100% in 2001 rehabilitated areas. These improvements have been achieved through a collaborative effort between scientists within the company's environmental research group and in local universities, Kings Park and Botanic Gardens, and the Department of Conservation and Land Management (DCLM).

Alcoa and the DCLM have worked together on other projects to bring about nature conservation outcomes in the jarrah forest, beyond the boundaries of the company's operations. Alcoa is a major sponsor of Operation Foxglove, a feral animal control program to remove the threat of predation by feral foxes to small and medium sized native mammals. Operation Foxglove is part of the wider feral animal control program Western Shield, which covers an area of over 3 M hectares and is sponsored in part by other mining companies. These projects have led to the recovery of populations of a number of threatened fauna species and have also allowed reintroductions of locally extinct species like the Noisy Scrub Bird and Tamar Wallaby to commence. Alcoa has also contributed directly to threatened species recovery programs and sponsored rare plant propagation initiatives. During the CAR assessments of the forest reserve system described earlier, Alcoa contributed a significant volume of data on flora and fauna from its baseline and performance monitoring programs. Alcoa's fauna monitoring data has also contributed to the conservation status of some species being amended and additional rare species being identified. This situation is repeated a number of times over with other mining companies in Western Australia, particularly those establishing operations in remote areas where the ecosystems have been poorly studied.

Contributions to biodiversity beyond the jarrah forest

Sponsorship of landcare projects and community groups in the agricultural and coastal plain regions of Western Australia has extended Alcoa's contribution to biodiversity further still. Grants of about A\$15 million have supported mainly revegetation and education projects in these regions. Community conservation groups working to restore health to the Swan River and its catchment are also major recipients of sponsorship from Alcoa. The Swan River flows through the centre of the Perth metropolitan region, where about 2/3 of the population of the state live.

Conclusions

Alcoa's mineral lease in the northern jarrah forest pre-dates most of the conservation reserves in the region. The lease is protected by an act of parliament that provides great security. The bauxite resource is a key asset to the State of Western Australia and Alcoa's global alumina business, and in particular, to the A\$8 billion replacement value of investment in mines and refineries in Western Australia. What then has motivated the company to relinquish around 15% of its bauxite reserves for biodiversity? Changing community expectations, the need for the community's "licence to operate", and a sense of corporate citizenship are probably the main reasons.

This case demonstrates that where circumstances allow, and where there is a cooperative approach with goodwill amongst the parties, admirable biodiversity and protected area outcomes can be achieved, even where land uses have competing and possibly incompatible objectives. Stronger conservation legislation may be helpful in some circumstances, but on its own, it is unlikely that it will achieve optimum triple bottom line outcomes.

Alcoa's bauxite resources in the jarrah forest have some features that have allowed flexibility to negotiate over conservation reserves. It is a large, dispersed and highly viable deposit. In other situations, where a mineral reserve might be small, concentrated and marginally viable, the same opportunities may not arise. In such cases, the conflict between mining and biodiversity protection will be more difficult to resolve.

Alcoa's West Australian experiences of continuously improving environmental management standards when mining in the multiple use forest, outside protected areas, also provide some interesting observations. While the changing community attitudes and corporate citizenship have no doubt played a role, much of the motivation for improvement has come from within the workforce; from management to machine operator, technical staff to lay person. Another major contribution has come from collaboration between environmental staff and academics and students at local universities. The benefits have been mostly mutual, and many of the outcomes have been shared beyond the company's uses; benefiting science generally, amongst the mining, forestry and agriculture sectors, and biodiversity conservation.

Benefits from a profitable enterprise have flowed to the company and its shareholders, its employees, and suppliers, the State and Nation, and the community; directly through dividends, royalties, wages, taxes, local expenditure, etc. They have also benefited, through corporate grants and sponsorships, a wide range of biodiversity projects.

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