

Bauxite Mine Rehabilitation Programs - A Progress Report Patrick Atkins, Alcoa Inc.

Bauxite is the primary source of raw material for the production of aluminum oxide and aluminum metal. At the current primary aluminum production level, known bauxite reserves will last for hundreds of years. Two to three tonnes of bauxite are required to produce one tonne of alumina and two tonnes of alumina are required to produce one tonne of aluminum metal. Typical bauxites contain from 30%-60% aluminum hydroxides and various levels of iron, silica, and titanium impurities. Approximately 125 million tonnes of bauxite are mined each year from 45 mines located on every continent except Antarctica. The major mining areas are located in the tropics, above and below the equator, as well as in Western Australia, the Caribbean Region, and the Mediterranean. Most bauxite is surface mined, although a few small underground mines remain active. The overburden depth ranges from almost none to several 10s of meters, with the average near five meters. The total land disturbed by bauxite mining each year is estimated to be 2,000-2,500 hectares per year.

In 1992 the International Primary Aluminum Institute (IPAI), a London based organization, conducted a survey of the active bauxite mines to gather data on the rehabilitation practices that were being used throughout the world. Survey responses were received from mines that accounted for 63% of the worldwide production of bauxite. The results were published an IPAI report, Bauxite Mine Rehabilitation Survey, by Peter Martyn.

The report concluded:

1. Substantial progress has been made in the rehabilitation of bauxite mines in many different climates, topographies and ecological situations;
2. Progress has not been uniform everywhere and much remains to be done; and
3. The bauxite mining industry is broadly in harmony with the approach set out in the UNEP "Guidelines for the Environmental Management of Alumina Production."

Recently, a new questionnaire was developed and sent to all active bauxite mines. The new questionnaire was similar to the 1992 questionnaire, but the format was streamlined and several questions were consolidated to reduce the time required to complete the survey. The questionnaire was designed to provide a comprehensive data base of rehabilitation activities that can be used by the worldwide industry to gauge their performance against an industry norm and benefit from learning more about what others have accomplished.

The sections of the two questionnaires were:

- A. Bauxite Production
- B. Mine Infrastructure
- C. Topography and Climate
- D. General Rehabilitation
- E. Human Resources
- F. Wildlife Protection
- G. Drainage Practices
- H. Soil and Surface treatment
- I. Revegetation
- J. Local Community and Town Site
- K. Environmental Impacts
- L. Legislation and Regulations
- M. Mine Rehabilitation Promotional Activities
- N. Research and Development Projects

The purpose of this paper is to provide a progress report on the industry performance from 1992 until the present by comparing the responses to several selected questions from the two questionnaires. A more comprehensive review of the industry wide rehabilitation programs can be obtained from the IPAI report on the 1999 survey results, which will be available this spring.

Survey Coverage:

The 1992 survey responses came from mines that produced 72,697,500 tonnes of bauxite (63% of the world total). The 1992 survey responses were from mines that produced 89,835,844 tonnes of bauxite (72% of the world total for that year). The total area mined per year was reported to be 1,376 hectares in 1992 and 1,591 hectares in 1999. Extrapolating the reported numbers to the full worldwide production suggests that the area mined per year has increased by 1.2% over the last eight years to 2,209 hectares, while production has risen by over 39%.

Mine Infrastructure:

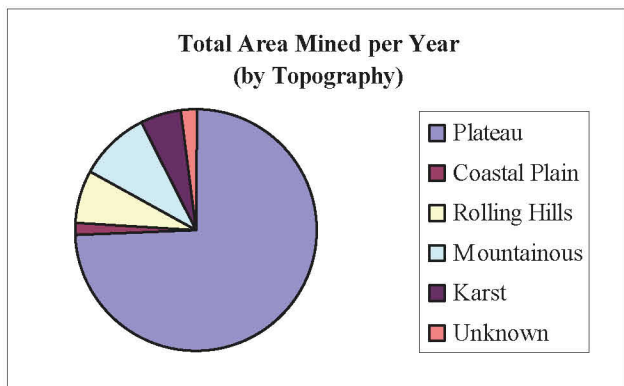
The 1992 survey reported that 1,872 hectares of additional land was disturbed to support the mining activities (roads, shops, etc.). That figure rose to 3,244 hectares from the 1999 survey. This suggests that the infrastructure requirements have risen rapidly, and these areas will represent an additional rehabilitation challenge for the industry.

Topography and Climate:

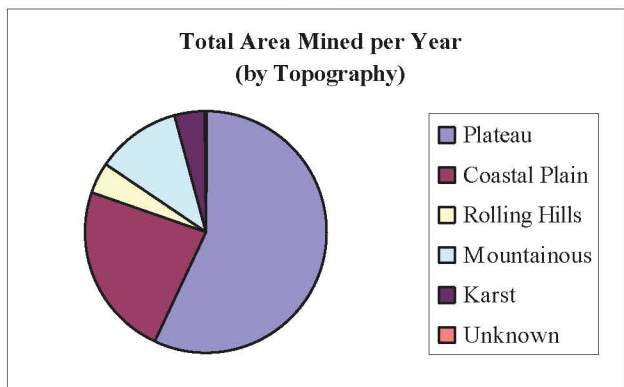
The survey results show a slight shift away from mining in plateau areas and an increase in the mining that takes place in coastal plains. Mining in rolling, mountainous, and karst (irregular

limestone regions with sinks, underground streams and caverns) remained at approximately the same level.

1992

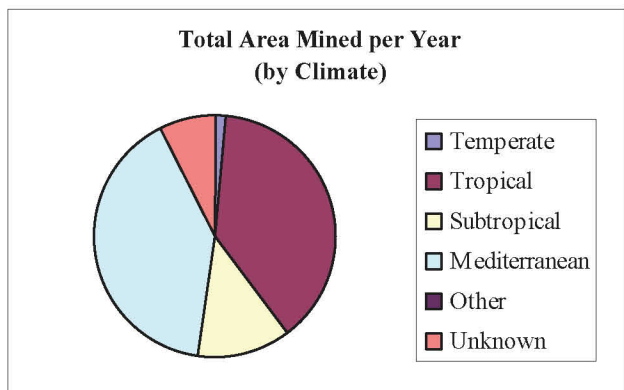


1999

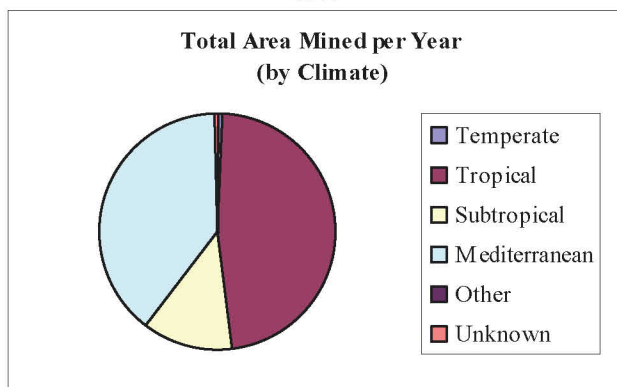


The amount of mining that is done in temperate climates has decreased, while the amount of bauxite produced in tropical climates has increased by over 25%. Production in subtropical areas also increased.

1992



1999



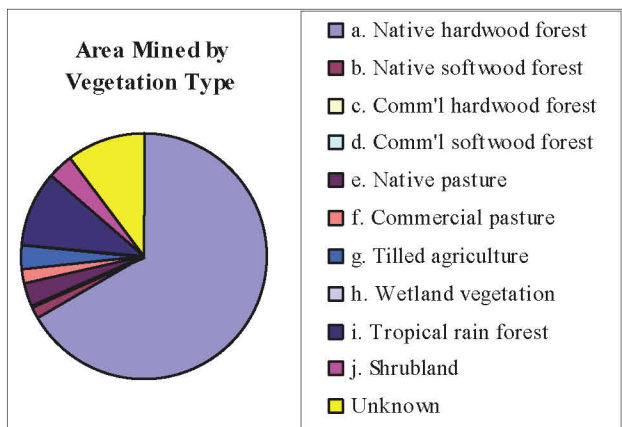
Rehabilitation:

In 1992 only 72% of the mines responding said they had a formal rehabilitation procedure in place. These mines represented less than 70% of the bauxite production covered by the survey. By 1999 over 96% of the mines responding said they have formal rehabilitation procedures, representing 92.6% of the bauxite production covered by the survey. In most cases, these written procedures are part of comprehensive land management programs. This significant increase in the development of formal programs indicates the degree of importance that the industry is placing on rehabilitation programs.

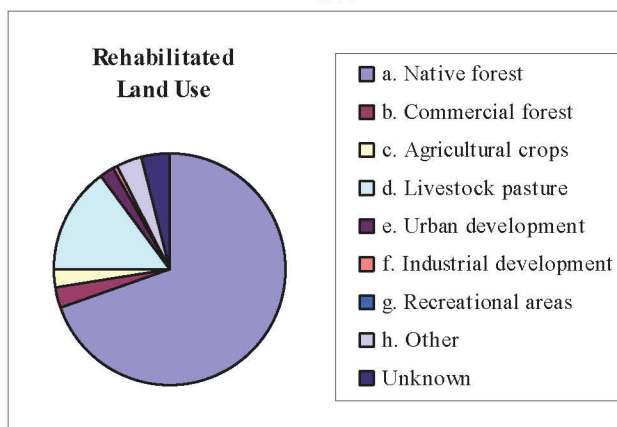
The rate of rehabilitation has increased from a reported value of 1,011 hectares per year (1,605 hectares if extrapolated to the full worldwide production) in 1992 to a reported level of 1,256 hectares (1,744 hectares if extrapolated to full worldwide production) in 1999. This 24% increase in the amount of land that is rehabilitated each year indicated that 80% of the land that is being mined each year is being rehabilitated, up from a ratio of 73% in 1992. This suggests that a number of areas remain open for several years before rehabilitation can begin. Eventually the ratio of reclaimed land to mined land should approach unity.

The rehabilitated land is returned to a variety of uses. Native hardwood forests represent the type of vegetation cover that typically exists at a majority of the mine sites (67% in 1992 and 58% in 1999). Tropical rain forest was the vegetation cover for 9.6% of the area mined in 1991 and 14.5% of the area mined in 1999. The rain forest area disturbed in 1999 was 230 hectares, an extremely small area when compared to the 10 million hectares per year of rain forest that is converted to other land uses such as agriculture and cattle grazing.

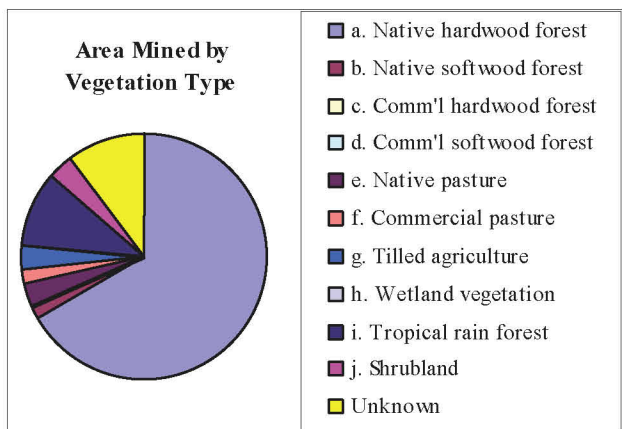
1992



1999



1999



The rehabilitated land is returned to native forests in many areas (72.65% in 1992 and 69.6% in 1999). In 1992, 9.4% of the rehabilitated land was designated for livestock and 0.6% was designated for agricultural crops. In 1999 these percentages have grown to 14.7 and 2.4% respectively. These significant increases suggest that there is increasing pressure to convert the mined land to high productivity uses.

The survey provides information on topsoil management techniques used to ensure that the soil nutrients and soil-based organisms are effectively used. Vegetation waste management practices are also described, with the trend moving away from burning on site to more mulching of the waste to preserve the organic content for soil enhancement. Significant progress has also been made on drainage design for erosion control in the newly reclaimed areas.

Costs:

The survey results indicate that the average cost to rehabilitate the mined land in 1991 was \$7,572 per hectare, and in 1998 the average cost had risen to \$7,755 per hectare. Reported R&D expenditures also increased from \$1.5 million to \$1.7 million for the industry.

Community Involvement:

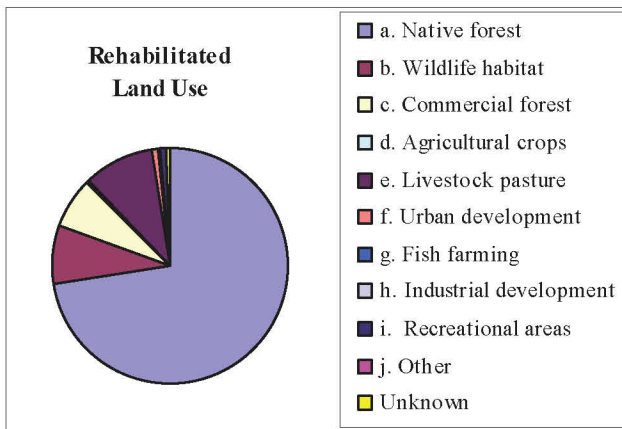
The reported distance from mining areas to the local community was seven kilometers in 1992 and nine kilometers in 1999. Although both sets of data demonstrate a significant level of community involvement from the mining operations, the responses suggest that the amount of involvement in programs such as community medical care, cultural development and the arts, and airport development have declined since 1992. Conversely, support for activities such as schools, parks and recreation and infrastructure development remain high.

A larger number of the reporting mines indicated that they have conducted formal assessments of the potential impacts of mining on the local indigenous community. The percentage rose from 40% in 1992 to 63% in 1999, driven at least in part by increased awareness and public concern.

Additional Data:

The survey also asked for information on the energy and water use as well as air emissions associated with activities such as bauxite washing and bauxite drying. This information can be used to support life cycle analysis studies of the aluminum industry.

1992



Conclusions:

It can be concluded from this brief review of these two surveys that the bauxite mining industry is progressive and responsive. The amount of land that is disturbed each year to meet the world's requirements for bauxite remains small. The amount of land mined in tropical rain forests increased from 132 hectares to 250 hectares in 1992. However, since the annual deforestation rate for tropical rain forests is on the order of 10-15 million hectares per year, mainly for agriculture and livestock activities, it is clear that the impact of the bauxite mining industry on tropical rain forests is extremely small. Never-the-less, this subject continues to be of significant concern to the public, and the industry must be diligent in managing, monitoring and reporting on the impacts of the mining activities in tropical rain forests.

The survey results show that the industry's commitment to rehabilitation of mined land is strong and increasing. The techniques used for vegetation development, topsoil management, drainage and erosion control, and eco-system monitoring are effective at most locations. Most mines have well developed rehabilitation strategies and reclamation plans that are reviewed and approved by control agencies. The land area disturbed to provide the supporting infrastructure for the mining activities appears to be growing at a relatively rapid rate. Rehabilitation plans should be designed to include proper management and the ultimate reclamation of these areas.

The costs to conduct the rehabilitation programs have remained relatively constant, and the level of investment in R&D has been maintained from 1992 through 1999. Outreach activities and community involvement have remained strong and appear to be shifting toward educational and recreational efforts.

The 1999 survey provides useful information on the progress that the bauxite mining industry has made and will give the individual mining operation the opportunity to measure themselves against the rest of the industry. The full report can be used as a tool to identify areas of excellence and areas where additional efforts are needed. IPAI will continue to conduct these surveys and make the information available to the worldwide industry.