WILDLAND RECLAMATION AND REFORESTATION OF TWO COAL STRIP MINES IN CENTRAL ALBERTA

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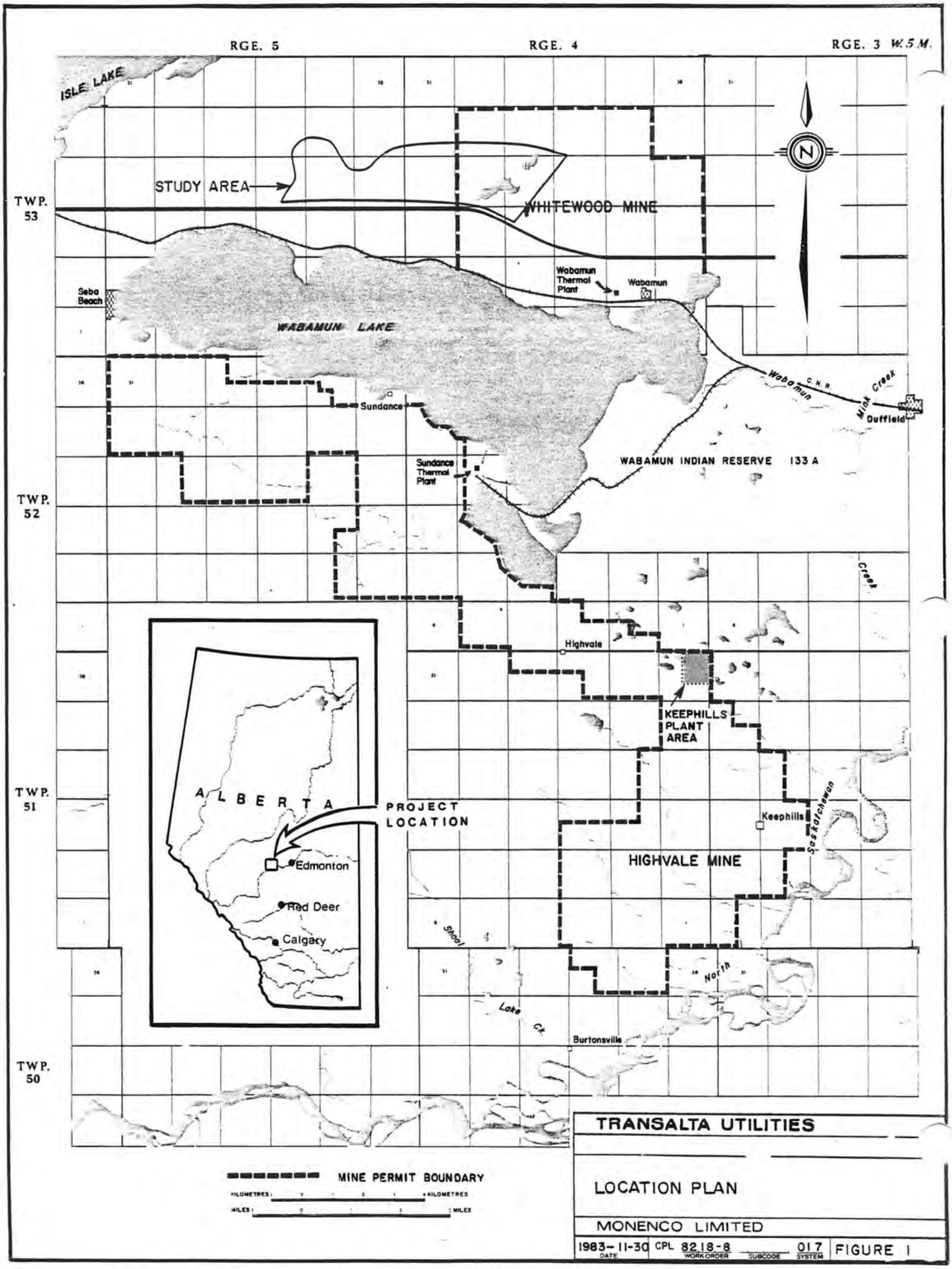
ABSTRACT

The productivity and capability of forested areas at TransAlta Utilities Corporation's Whitewood and Highvale mines have been quantified. This information has been used to evaluate the success with which mined areas supporting forest stands have been restored to their original capability. Spruce stands planted on mined land at Whitewood in 1959 have yields and densities far below that of undisturbed sites. The capability of these areas to support spruce forests is, however, comparable to undisturbed sites. The yield of naturally established deciduous stands on mined lands is similar to undisturbed sites, however the densities are far greater. This is a function of stand age and has little to do with the productive potential of the area. The capability of mined land to support deciduous stands at the Whitewood mine is equal to and even slightly greater than undisturbed areas.

INTRODUCTION

TransAlta Utilities Corporation operates two coal strip mines in Central Alberta (Figure 1). The production of the two mines totals roughly 10,500,000 tonnes of thermal grade coal. The combined mine permit areas encompass 16,962 hectares (ha) of which approximately 150 ha are mined annually. By the end of 1982, 1307 ha had been mined and 646 ha had been reclaimed. The objective of reclamation is to return mined land to capabilities equal to or better than those that existed before mining (TransAlta Utilities Corporation 1983).

Before mining proceeds, surveys and inventories of existing resources are undertaken to provide information on the land use capabilities of undisturbed land. This information is then used for the development of long-term reclamation goals and land use objectives for areas affected by mining. Present land use in the area of the Whitewood Mine north of Wabamun Lake is split roughly in half between agricultural areas and wildland areas which include peatlands, upland forest and water bodies (Monenco Limited 1983a). At the Highvale Mine south of Wabamun Lake, agricultural land uses account for two-thirds of the mine permit area and wildland land uses account for approximately one-third of the mine permit area (Monenco Limited 1983b). Land use plans for the two mines propose a variety of end land uses including agricultural, industrial and recreational land with the development of



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LOCATION PLAN

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1983-11-30 DATE | CPL 8218-8 WORKORDER | SUBCODE | 017 SYSTEM | FIGURE 1 wildland habitat as a specific goal (EPEC Consulting Western Ltd. and Earthscape Consultants 1983, Montreal Engineering Limited 1980).

This paper is a summary of the techniques used to quantify the capability of wildland and forested areas to support productive forest growth within the Highvale and Whitewood mine permit areas and the means of comparing this to areas affected by mining.

METHODS

Background

The growth of forests is the result of many complex and interacting factors which collectively control the growth of individual trees (Kozlowski 1971). The major components are soil depth, soil texture, profile characteristics, mineral composition, steepness of slope, aspect, microclimate and species. To compare the productivity of different forest sites, an index that best represents the sum total or combined effect of all these factors on individual tree growth is required. The most direct approach would be to measure the volume of wood or biomass produced per unit of time, just as agronomists measure crop yield per hectare per year. The actual yield of forests, however, is not only influenced by site factors, but also by stand age and density, genetic factors and the biotic history of the stand. The actual volume increment measured in any one year, therefore, may not necessarily reflect the true capability of a given forest site. The traditional approach to predicting the productivity or capability of a given site would be to use a regression equation or model that combines all the measurable parameters that affect tree growth into an estimate of productivity based on thousands of sample sites in and around the area of study. However, since the number of growth patterns resulting from such a complex matrix are virtually infinite (Bickerstaff et al. 1981) and because reclaimed environments rarely resemble the original environment, the estimation of whole forest productivity on reclaimed areas could not be determined accurately or economically without a model that would combine hundreds of measurable and non measurable environmental parameters.

To overcome the problems of the effect of stand condition on productivity and the complexity of predicting site capability using countless environmental parameters, the height of free-grown trees of a given species at a particular reference age (generally 50 years) is commonly used as an index of site quality (Baker 1950, Curtis et al. 1973, Spurr and Barnes 1980, Stage 1963). The height growth of a dominant tree is less affected by stand density than other measures of tree dimensions (i.e., diameter); it is also a sensitive measure of differences in site and is easily determined in relation to age (Baker 1950, Carmean 1968). By using a free-grown or dominant tree, the effects of stand density and competition on tree growth are removed. Height may thus be used as an index of site quality in stands of varying density, age and silvicultural history (Spurr and Barnes 1980).

For the Whitewood and Highvale mine permit areas, both forest stand productivity (in terms of wood volume and biomass) and the height of dominant free grown trees at a particular reference age (site index) have been used to evaluate the site capability of natural undisturbed forest stands. These have been compared to reforested areas on mined land. The sampling methodology for each method is detailed below.

Forest Productivity Assessment

Native, undisturbed forest stands in the Whitewood and Highvale mine permit areas were sampled using a traditional timber cruise approach. Vegetation types were first grouped together on the basis of species composition. A total of 176 sample sites were then distributed among five forest cover types on a random grid. Point sampling or variable plot radius techniques using wedge prisms were used to define the sample size at each site. All trees regardless of species were tallied if stem overlap was evident when the tree was viewed through the prism from a temporary sampling point that served as a plot centre. For each tree within the plot, the species, total height, age and diameter at breast height (dbh) were recorded. Heights were determined using a clinometer, dbh by a diameter tape and ages using an increment borer. Total timber yield in cubic meters per hectare for each stratum by diameter class and species were determined using volume equations developed by the Alberta Forest Service (Alberta Forest Service 1979). The biomass of each plot was calculated with biomass equations published by the Northern Forest Research Centre (Singh 1982) using total height and dbh. Stand density was calculated using the stem frequency constant for each prism used (Husch et al. 1982). The mean annual increment of each sample site was determined by dividing the total yield by the age of the stand.

Site Capability Assessment

Single dominant trees of white spruce, balsam poplar, aspen, black spruce and jack pine were felled at 61 locations throughout the Highvale and Whitewood mine permit areas. Sample sites were selected to provide a complete range from best to poorest growing conditions as evidenced by height in relation to age, soil, slope and exposure factors. The tallest dominant tree was felled and sectioned at one metre intervals at each plot location. Discs were then labelled and taken to the Wood Technology Laboratory at the University of Alberta for analysis using a Swedish tree ring measuring instrument (Addo-X).

The age associated with a given section at a known height was then determined by subtracting the number of annual rings in that section from the total age of the tree. The pattern of height growth for each tree over its entire course of development was then plotted. The results for each species at each mine were then combined to give an average growth curve. Growth curves from spruce stands planted on mined areas in 1959, and from naturally established aspen stands on abandoned mine areas were then compared to their native counterparts on undisturbed sites at the exact same stage of development.

RESULTS AND DISCUSSION

Forest Productivity

The volume and density of the forest stands sampled are summarized in Table 1. The yield data has been presented graphically with standard deviations in Figure 2. The native white spruce stands are the most productive of those sampled yielding 361 and 281 cubic metres per hectare at Highvale and Whitewood, respectively. These two stands also exhibit the lowest densities of the natural stands. The volume is therefore distributed over a fewer number of stems than in the other native stands. Spruce trees up to 23 m in height and 38 cm in diameter are not uncommon while balsam poplars as large as 46 cm dbh and 22 m in height were also found in isolated areas in these stands. Stand ages vary from 46 to 87 years with an average of 70 years. These stands typically occupy gleyed profiles where they have been protected from ground fires and have been allowed to develop to the climax stage.

The yields of the three deciduous stands on undisturbed areas (aspen and mixed deciduous stands at Highvale and mixed deciduous stands at Whitewood) are all similar producing approximately 200 m^3/ha. The naturally established deciduous stands on reclaimed areas have yields similar but slightly less than their native counterparts at 158 m^3/ha. The stocking densities, however, are much higher in the deciduous stands on reclaimed land than most stands on undisturbed sites. These

Table 1

Summary of Yields and Densities of Native and Reclaimed Forest Stands at Whitewood and Highvale

Stand Type	Average Yield* (m^3/ha ± SD)	Average Density Stems/ha
Highvale (native)		
Aspen	185 ± 125	1784 ± 1084
Mixed Deciduous	208 ± 108	1684 ± 1486
White Spruce	361 ± 42	1131 ± 213
Jack Pine	106 ± 17	2354 ± 1540
Black Spruce	204 ± 75	2802 ± 2069
Whitewood (native)		
Mixed Deciduous	171 ± 114	2135 ± 2514
White Spruce/Poplar	281 ± 281	1447 ± 725
Black Spruce	158 ± 109	2418 ± 1023
Whitewood (reclaimed)		
White Spruce (planted)	25 ± 7	1087 ± 323
Deciduous (naturally invaded)	158 ± 97	7233 ± 5736

* 0.0 cm stump height to 0.0 cm top diameter

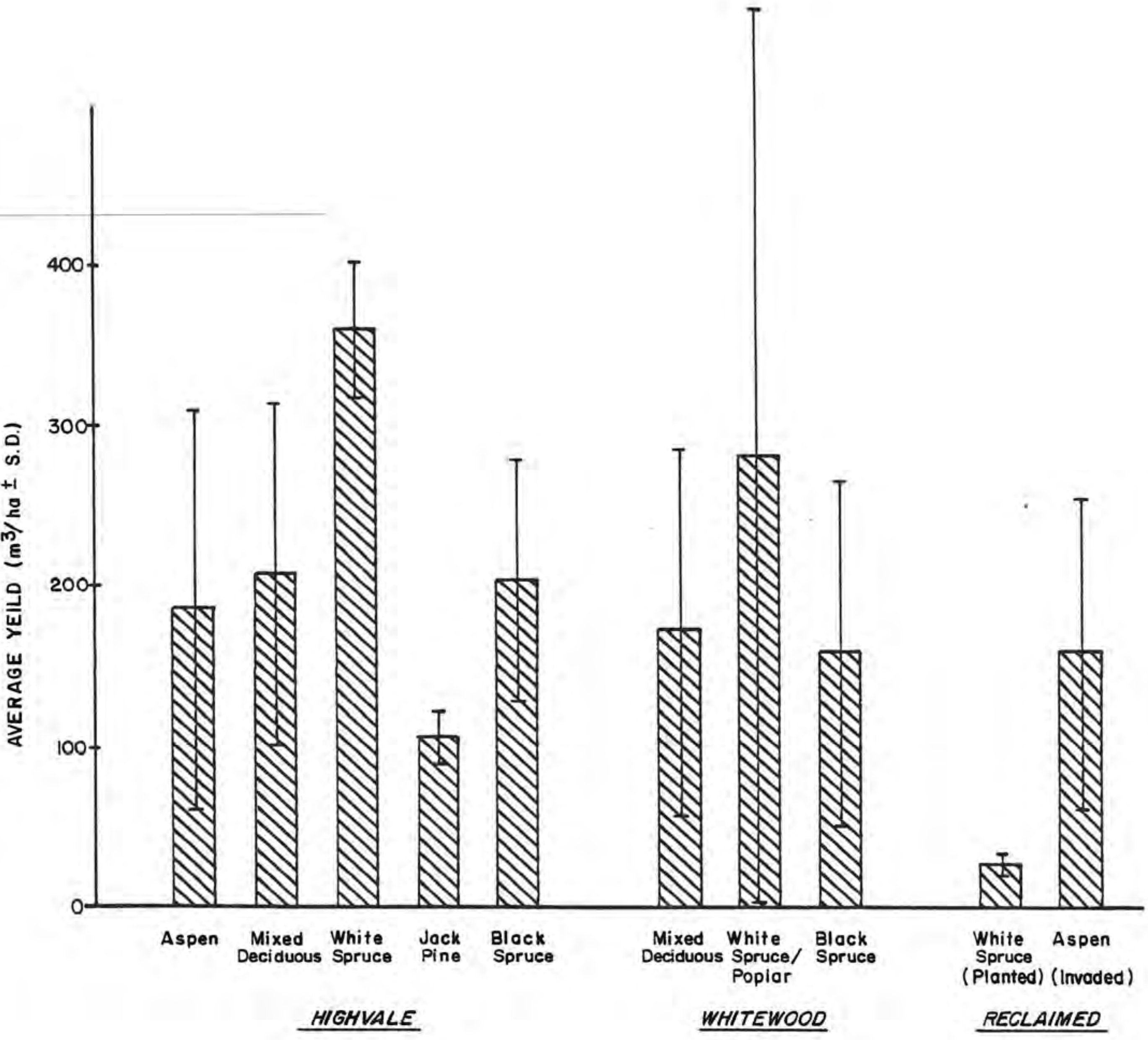

FIGURE 2
TOTAL YIELD OF NATIVE AND RECLAIMED STANDS

higher densities on disturbed sites are not unexpected and are typical of young deciduous stands in the Whitewood area and elsewhere. The older deciduous stands on undisturbed areas have lower densities due to the high sapling mortality rates that typically occur at canopy closure. High mortality rates are also expected to occur in the young deciduous stands on mined areas as they mature. Although the present yield of the deciduous stands on mined areas are comparable to the yields on undisturbed areas at a much younger age, they are not expected to increase much beyond their present yield due to the associated increase in tree mortality. Instead, the same yield is likely to be distributed over a fewer number of stems as competition increases.

The yield of the white spruce plantation on the reclaimed area is much lower than spruce stands on undisturbed sites. The average stocking density is 1087 stems/ha which is the lowest density of the stands sampled. Tree heights average 5 m and range from 2.7 m to 6.5 m and the average dbh is 7 cm with a range from 3.4 cm to 12.3 cm. The stand is properly spaced and is typical of a fully stocked stand without any competition. Mortality rates in this stand will be minimal and the total yield will continue to increase without competition until the stand matures.

Site Capability

Growth curves for all major tree species have been prepared as a baseline to compare the growth achieved on mined areas. For the purposes of this paper, however, growth curves are only presented for species of which there is data from trees growing on mined land. At present, there exists no data for the height growth of trees growing on reclaimed portions of the Highvale mine. However, as this information becomes available from planting trials, it will be compared to the baseline information.

Growth curves for aspen on undisturbed sites in the Whitewood Mine permit area and on mined lands in the same area are presented in Figure 3. These curves represent the "best fit" lines for all the data collected and are therefore an average of all the trees sampled. The curve for mined areas is only accurate to 30 years. The dotted portion of this curve over 30 years is predicted based on the regression equation. The growth rate beyond this point is, however, expected to decrease and follow the same shape as the curve for undisturbed areas.

From the curves, it is evident that the growth of aspen on mined land is equal to and even slightly greater than the growth achieved on undisturbed soils. At 25 years, undisturbed soils in the Whitewood area produce free-grown aspen 11 m in height whereas free-grown aspen on mined areas are 12 m high. It should be noted that the curve for

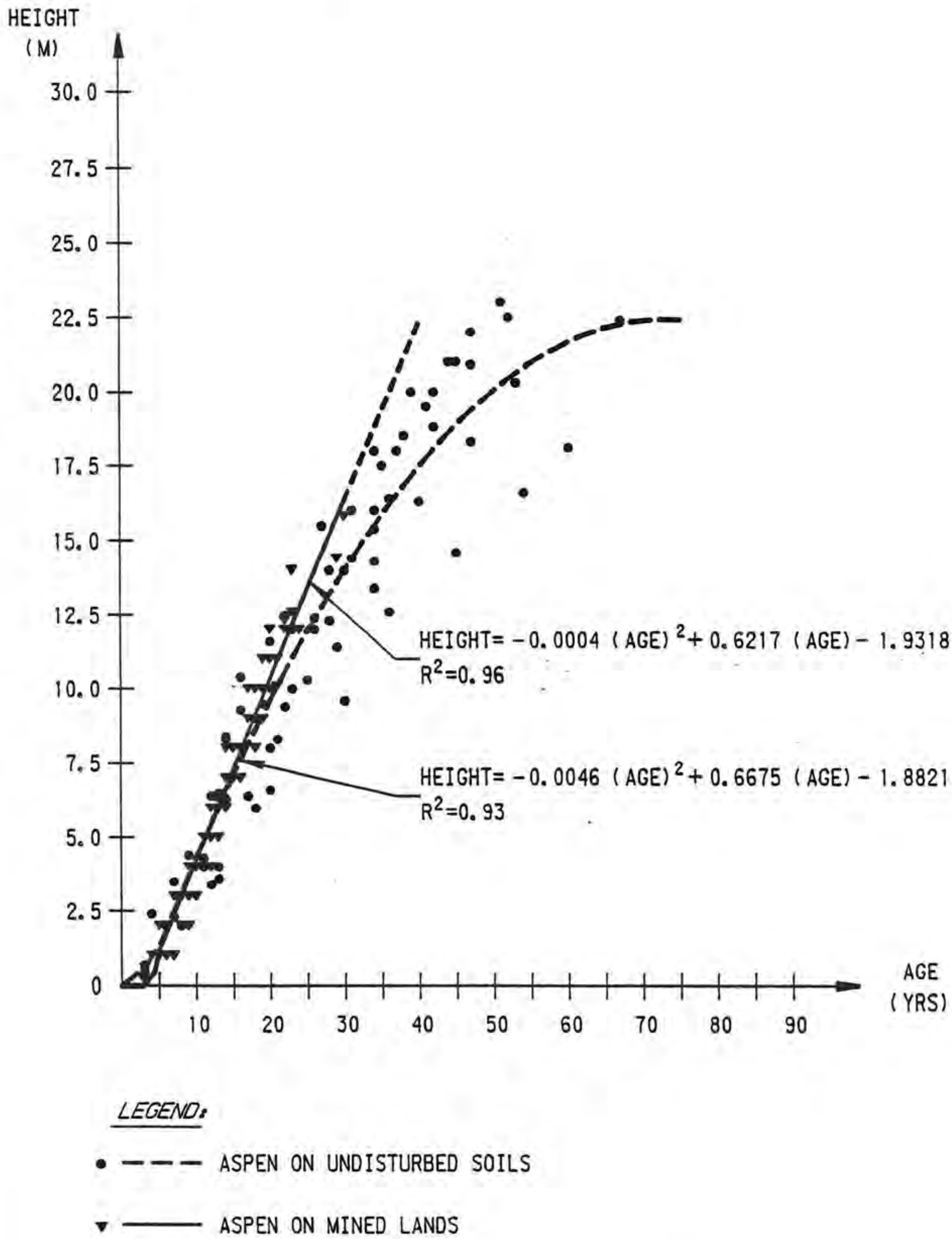

FIGURE 3
TRANSALTA UTILITIES
WHITEWOOD WILDLAND RECLAMATION
HEIGHT GROWTH OF ASPEN POPLAR

undisturbed areas is influenced strongly by five points, all coming from one tree on the underside portion of the curve. It is possible that this tree was not a dominant and suffered some degree of competition through its life. If this is true, it should not be included in the sample. The curve would then follow more closely to that of mined areas. Since there is no data to suggest that this tree is not a dominant, it was kept in the sample.

Growth curves for white spruce growing on undisturbed soils and on mined lands in the Whitewood area are presented in Figure 4. The white spruce on the mined areas were planted in raw minespoil in 1959. The growth rates of these trees was initially slower than those on undisturbed sites but once successfully established, they have released and now more closely resemble the rates of native stands. This is most likely a result of optimal spacing. The individual trees in this stand are growing at the maximum possible rate due to the lack of competition from understory species and adjacent trees. This stand will continue to produce at higher growth rates until some growth factor becomes limiting.

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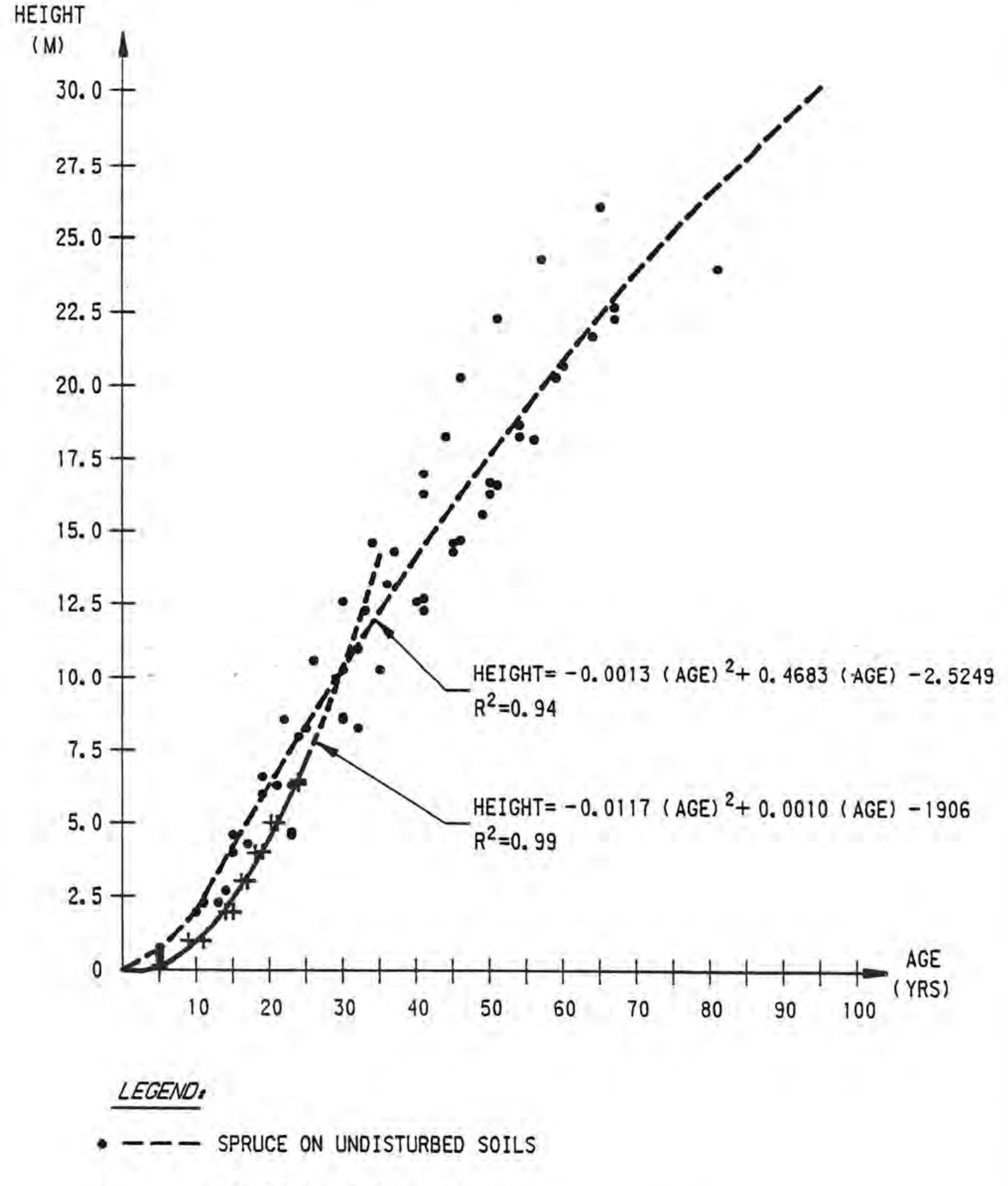

FIGURE 4
TRANSALTA UTILITIES
WHITEWOOD WILDLAND RECLAMATION
HEIGHT GROWTH OF WHITE SPRUCE

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CONCLUSION

From the previous analysis, it is evident that mined lands at Whitewood have at least the same and even slightly greater capability to support deciduous and coniferous forests.

Deciduous stands that have invaded naturally on mined areas at Whitewood have the same yields as their off-mine counterpart at a much younger age. As a result, they have a mean annual increment that is approximately three times that of native deciduous stands. This is solely a function of stocking density which is also roughly three times greater in the young stands on mined land than in the older native stands and has little to do with site capability. When site index or height growth is used as a measure of site quality, it is found that growth rates achieved on mined areas are at least equal to and even slightly greater than those on undisturbed soils.

The yield and mean annual increment of spruce stands planted in minespoil are far below that of spruce stands on undisturbed soils due to much lower stocking densities. The growth rates of spruce on minespoil are, however, similar to those on undisturbed soils.

The minespoil supporting these stands has received a minimum of management input. No selective materials handling or topsoil salvage was practised at the time and little effort was spent on re-contouring.

The fact that the capability of this area to support productive forest growth is equal to or better than that of undisturbed areas suggests that mined areas can be reclaimed to meet present regulatory requirements at minimum cost by adopting forests or wildland land uses.

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CANADIAN LAND RECLAMATION ASSOCIATION
PROCEEDINGS OF THE NINTH ANNUAL MEETING

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