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**Reclamation of aggregate mines in the Manawatu, Rangitikei and
Horowhenua Districts, New Zealand.**

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Abstract

Aggregate is the largest extractive industry in New Zealand, in terms of both volume and value of product. In central New Zealand unsustainable extraction of aggregate from rivers has encouraged development of alluvial terrace resources which are often overlain by valuable agricultural soils. Research at commercially reclaimed aggregate mines has shown long-term degradation of the soil resource with productivity of reclaimed land not being maintained at any reported site.

Field trials were designed and implemented on three soils characteristic of major landscape units containing aggregate resources which are mined in the greater Manawatu region. Rangitikei fine sandy loam represents free draining Recent soils; Ashhurst stony silt loam represents excessively draining Yellow-brown soils; and Ohakea silt loam represents imperfectly to poorly drained Yellow-grey soils. In each of the trials a "best-case" reclaimed soil was constructed by stripping and replacing soil horizons in their natural order while minimising compaction and ensuring non-limiting nutrient levels. The productivity and soil physical characteristics of other treatments, including different depths of replaced soil and mixed soil horizons, were compared with this "best-case" treatment. Compaction and drainage treatments were also investigated. Control treatments of soils which were ploughed were also used as a reference.

Soil depth and horizon mixing

- * Spreading Rangitikei sand over compacted fill material to depths of 0, 0.4, 1.0 and 1.5 m depths resulted in incremental increases in yield of cereal of 92 ± 21 , 142 ± 13 , 169 ± 14 and 184 ± 7 kg ha⁻¹ respectively.
- * The same treatments had no consistent effect on production of clover and ryegrass for most harvests, probably because pasture roots were able to exploit the fill material as a source of moisture.
- * Yields of pasture were reduced by removal of 0.5 m of the Ohakea upper B horizon, resulting from decreased aeration. This effect was mainly due to the closeness of the water table, which was exacerbated by the sunken surface of this treatment.
- * In contrast, pasture yield was unaffected by removal of a 0.2 m deep Ashhurst B horizon, reflecting the lack of impediment to root extension to depth in the Ashhurst soil.
- * Dilution of Ohakea topsoil by mixing with subsoil material resulted in an increase in soil particle density and bulk density and decrease in percentage of total soil organic carbon so that the mixed soil had properties similar to unmixed subsoil.
- * Separate stripping and replacement of topsoil significantly increased establishment of pasture in Ohakea soil but not Rangitikei soil.
- * Dilution of topsoil had no long-term detrimental effects on soil physical properties or pasture production in any of the three soils under the management practices used.

Compaction

- * A compacted layer at 0.20 m (Ohakea soil $\rho_b=1.64\pm 0.11$ on construction) either benefitted or did not effect pasture production over 13 of 14 harvests.
- * The effect of compaction varied with position in the soil profile: pasture production and root length were negatively correlated with bulk density at 0.20 m depth.
- * greater root mass was produced at 0.30 to 0.35 m depth in low compaction treatments
- * A compacted layer at 0.20 m (Ashhurst soil $\rho_b=1.40\pm 0.08$ on construction) had no significant effect on pasture production, although cumulative production over 9 harvests was 18% higher in the high compaction treatment.
- * Pasture growing in a compacted Rangitikei soil ($\rho_b= 1.61$) produced less than 40% of pasture growing in the same soil with $\rho_b= 1.21$, and comprised a higher proportion of weeds.

Drainage

- * Drainage lowered the volumetric water content of Ohakea soils at four increments to 0.60 m by a mean 3% on five measurement dates.
- * Pasture production was similar in drained and undrained treatments for 9 of 14 harvests.

The Resource Management Act 1991 requires sustainable use of non-mineral resources. Sustainable use of soil resources requires reclamation of mined land. The highly competitive nature of the aggregate industry means reclamation is unlikely to occur unless it is both required and monitored by District and Regional Councils. A survey of aggregate extraction sites in the greater Manawatu region showed that, prior to the Resource Management Act, no sites were required to be reclaimed to their prior productivity. Results from the trials were used to identify basic strategies for reclamation, to pasture, of three groups of soils most commonly disturbed by extraction of alluvial aggregate. The strategies aim to ensure mining is an interim land use.

Mining of alluvial aggregate should be promoted on soils which are resilient to disturbance; i.e. free-draining Recent and Yellow-brown soils. Where post-mining land use is agricultural or horticultural production, conditions of extraction must include maintenance of pre-mining productivity under a strategy of rolling reclamation. Conditions related to reclamation must be specific and monitored, preferably by the extraction company under supervision of the authorising Council. Linking specific, measureable reclamation criteria to significant bonds would provide a strong incentive to extraction companies to reclaim land adequately.

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