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Plants and Techniques Used for Sand Dune Reclamation in Australia

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ENVIRONMENT AND LOCATION OF DUNES

Successful selection of plants for sand dune reclamation requires a knowledge of the macro- and microenvironment of planting locations.

Reclamation of coastal dunes in Australia has mainly been undertaken in the temperate and Mediterranean winter-rainfall zones of southern Australia, with average annual rainfall of between 500 mm and 850 mm, and in the summer-rainfall, subtropic and tropic zones of eastern Australia, with average rainfall between 600 and 1,200 mm.

The main treatment of inland dunes has been in the agricultural area of the winter rainfall zone where the annual rainfall is between 250 and 350 mm and the summers are hot (average maximum daily temperatures 32°C) and dry (potential evapotranspiration 125 mm/month).

Coastal dunes are extremely low in plant nutrients and range from acid siliceous to highly calcareous sands.

Large areas of stable dunes are in a delicate state of balance and readily erode if their protective vegetative cover is weakened or removed.

Dune instability is caused by clearing, cultivation, overgrazing by stock and/or rabbits, fire, and recently by beach mining for titanium minerals and concentrated recreational trafficking by people and their vehicles.

COASTAL DUNES

RECLAMATION. In the winter-rainfall zone in southern Australia, the main stabilizer used for frontal dunes is marram grass, AMMOPHILA ARENARIA, planted vegetatively. In the summer-rainfall zone of the eastern coast, native hairy spinifex SPINIFEX HIRSUTUS, established from seed sown under brush, is used. Sea wheat AGROPYRON JUNCEUM is planted at the toe of the seaward face of the frontal dune in Victoria. Pyp grass EHRHARTA VILLOSA has also been successful as a primary stabilizer in South and Western Australia.

The most important secondary stabilizers used include Lupins LUPINUS DIGITATUS (cv. West Australian), tree lupin LUPINUS ARBOREUS, pigface CARPOBROTUS SPP., coast acacia ACACIA SOPHORAE, and A. CYANOPHYLLA. Bone seed or bitou bush CHRYSANTHEMOIDES MONILIFERA is also widely used in New South Wales.

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On hind dunes in southern Australia cereal rye SECALE CEREALE (cv. South Australian) is often sown as a primary stabilizer, and where the annual average rainfall exceeds 350 mm it is undersown with the secondary stabilizers perennial veldt grass ERHARTA CALYCINA and lucerne MEDICAGO SATIVA. On the summer-rainfall sub-tropic east coast, forage sorghum and sorghum-sudan grass hybrids are used after topsoiling. Rhodes grass CHLORIS GUAYANA is also often used as a primary stabilizer.

There is a wide range of trees and shrubs used as tertiary stabilizers. These include coast tea-tree LEPTOSPERMUM LAEVIGATUM, coast banksia BANKSIA INTEGRIFOLIA, and drooping sheoke CASUARINA STRICTA in southern Australia and horse-tail sheoke C.EQUISETIFOLIA in the sub-tropical eastern coast. The most important fertilizers are nitrogen and phosphate. Maintenance fertilization of nitrogen is applied.

Techniques used include brush-matting, mulch, topsoil, clay, gravel, or sprayed adhesives such as bitumen. Sand-drift fences are mainly used to recreate or seal a breach in a frontal dune. They are constructed of brush, slats, jute, or more recently of plastic mesh.

RESEARCH

Research is concentrated on plant introduction and selection of primary and secondary stabilizers, the refinement of fertilizer practice and the mechanized planting and application of temporary stabilizers.

PRIMARY AND SECONDARY STABILIZERS.- Current agronomic investigations into stabilization of the frontal dune are mainly concerned with selection, improvement of planting techniques, and fertilizers for the two primary stabilizers, marram grass and hairy spinifex, and with the legumes that may be grown in association with them. Related research is concerned with surface stabilization, improved dune-building techniques and high population pressure.

Comparative trials using selections of marram grass from various parts of southern Australia and Israel showed marked differences in survival rate, culm increase and seed setting (Zallar, personal communication). Selection is made of those plants with the best combination of these factors. Trials of American beach grass, AMMOPHILA BREVILIGULATA, have indicated its greater persistence and vigour in comparison to marram grass, however it appears more palatable to rabbits (Beare, personal communication).

Attempts in the field to establish marram grass by direct seeding with and without surface protection, have been generally unsuccessful on exposed sites.

Natural seeding from established plantings in certain localities has resulted in quite rapid spread - for example marram grass has been estimated to have spread from seed at least 20 miles along the coast in 40 years. This was from plantings made near the Warren river outlet in the south western corner of Western Australia (Perry, personal communication).

However, in other areas little spread from seed has been observed. This variation at different localities is considered due to the influence of different environments on seed-set and the presence of different ecotypes of marram grass.

Trials to improve planting techniques indicate that cleaning culms prior to planting does not improve survival sufficiently to warrant the labour involved. Similar survival rates and growth to those from cleaned culms can be obtained provided plant material is from young, vigorous stands and adequate fertilizer is applied (Anonymous, 1963).

Recent trials have shown that there is no significant difference in survival due to trimming of planting material (Alsop, personal communication).

Planting is restricted in southern Australia to the winter months. If this period is extended a lower percentage establishment results. However in drought years, even with this restriction total loss of plantings can occur. In dry years soaking of culms in water for two days before planting and then planting in the moist sand at depths of at least 30 cm, in comparison with normal 25 cm, is adopted to reduce losses.

The most promising legumes in Victoria are the perennial tree lupin from New Zealand and LOTUS CRETICUS obtained from Israel (Anonymous, 1965). Seed of the native coast acacia A.SOPHORAE broadcast or drilled between marram plants after establishment is often successful. However in general, legumes have been more successful when sown or planted in the year following initial establishment of the primary stabilizer.

FERTILIZERS. Fertilizer trials indicate that the main response of marram grass is to nitrogen, with lower responses to phosphate and in some instances to potassium. No significant growth response to any other element has been recorded (Anonymous, 1960). Current research is concentrated on refining the application of nitrogen in respect to rate, time and form of application.

TEMPORARY STABILIZERS. Trials with and without various temporary surface stabilizers, have shown brush matting to be necessary for survival of plants on the eastern coast both for hairy spinifex and marram grass (Atkinson, 1971). However along the southern and south-western coasts direct planting of marram grass without a stabilizer is generally successful.

Numerous temporary surface stabilizers have been used experimentally on hind dunes. After evaluation in a wind tunnel under controlled conditions, field trials are undertaken of those materials that have withstood wind speeds up to 90 km/h.

Stabilizers tested have included starch, cement, bitumen, oil, rubber and synthetic latexes, resins, plastics, oil-latex emulsions and numerous surface stabilizers or organic or inorganic origin.

Evaluation of these stabilizers has shown that while some are effective, namely bitumen, oil-latex emulsion, bitumen stabilized mulch, and disked-in straw-mulch, the cost of pre-preparation, application and the material itself discourages their wide-spread use except for very severe environments or for those situations that can withstand a high cost of treatment.

The mechanized application of straw-mulch and its fixation either by a light disking into the sand or use of bitumen emulsion as an adhesive is one of the most promising and lowest cost techniques for temporary surface stabilization.

Barr and Golenski (1969) reported a successful trial using slow breaking bitumen emulsion and mulch as a substitute for brush associated with planted marram grass as the primary stabilizer.

Trials in Victoria have demonstrated the success on hind and inland dunes of straw-mulch fixed into the sand by a disk drill. Simultaneously seed of the primary stabilizer cereal rye and secondary stabilizers are sown and fertilizer applied through the drill.

Both of these techniques can be further mechanized by the use of a "mulch-spreader" to spread the straw and, if required, to incorporate bitumen emulsion as an adhesive.

The application rate of straw used is approximately 2,500 kg/ha.

MECHANIZATION. Unless mechanized, dune stabilization work is slow, labour intensive and consequently costly. Machines can substantially reduce costs. These include the "mulch-spreader"; a machine which constructs flexible slat and wire sand drift fencing; a knife-bar plough, used to cut the roots of marram grass to facilitate lifting, and various types of marram grass planters and disk seeders adapted to travel over sand.

SAND DRIFT FENCING. Field studies of the effect of sand drift fencing have indicated that plastic mesh is a satisfactory and lower cost substitute for brush or slat fences.

INLAND DUNES

RECLAMATION. Inland sand dune reclamation is generally restricted to agricultural areas where the rainfall exceeds 250 mm. In arid and semi-arid areas, treatment of unstable dunes is generally limited to control of grazing by stock and of rabbits.

The most important primary stabilizer of eroding dunes is cereal rye, SECALE CEREALE cv. South Australian. This cultivar, which makes rapid early growth, was produced by natural selection in South Australia (Sims, 1949).

The severity of the environment, especially wind-speed and consequent sand movement, and growing conditions determine the time taken for cereal rye to become resistant to sand-blast. For example in South Australia, Beare (1951) showed that given adequate moisture, cereal rye sown in mid-March will have made adequate growth in one month to be safe from damage by sand-blast, while in that time being subjected to only two dangerous days and eight possibly dangerous days.

With later sowing the hazard increases greatly because of less favourable growing conditions and more frequent days of high wind velocities. A crop sown in June will take nearly 2.5 months to reach safety and in that time can be expected to have suffered 8 dangerous and 30 possibly dangerous hazardous days.

Hence early sowing gives at least 4 times as much chance of successful establishment.

Lucerne, MEDICAGO SATIVA, is the most frequently sown secondary stabilizer after initial stabilization with cereal rye.

Other species used as secondary stabilizers are harbinger medic, M. LITTORALIS barrel, medic M. TRIBULOIDES, and evening primrose, OENOTHERA BIENNIS and especially in Western Australia, lupin, LUPINUS DIGITARIS.

Fertilizer trials have shown that on most dunes both phosphorus and nitrogen are essential for effective development of cereal rye and nitrogen is necessary to stimulate rapid early growth.

RESEARCH

Current research is concentrated on the selection of secondary and tertiary stabilizers for dune stabilization on the non-agricultural areas and refinement of the fertilizer requirements for infertile sands.

MANAGEMENT

The management of both coastal and inland dunes to retain stability after reclamation resolves itself into the retention of sufficient surface cover to provide protection from wind erosion.

On coastal dunes this is achieved by fencing or rotational use of the area to control grazing, or the prolonged concentration of animals or humans on those parts of the dunes most vulnerable to wind erosion.

The annual application of fertilizer may be necessary on the frontal dune to maintain plant vigour.

On inland dunes in agricultural areas there is a high degree of management skill required to retain stability of sand dunes after reclamation, especially in drought years. While the sand rises are excluded from the normal rotational cropping, they need annual fertilization with superphosphate and infrequent cropping to retain the vigour of the pasture and also to utilize accumulated fertility. A minimum fallow period is used before cropping and the sand cultivated only when wet, so that a rough surface, resistant to sand movement, results.

Grazing management is necessary to avoid reduction of plant cover by over-grazing or stock trampling below that required for soil protection. Fencing is sometimes used to exclude dunes where they are of sufficient size or hazard to warrant it. However, often this is not practical because of the frequency of the sand rises, and other techniques of grazing management are practised such as the location of shade, shelter and watering points on nearby, less vulnerable areas, to avoid stock concentration on the dunes.

Vermin such as rabbits must be kept under control otherwise erosion can result from their grazing and disturbance of the sand surface.

Because of the less intense use required of the sand rises in the relatively light rainfall of the inland agricultural areas, effective management is only possible if properties are large enough to be farmed as economic units.

PRINCIPLES INVOLVED

From this brief account of sand-dune reclamation in Australia, some principles emerge which have general application.

(1) The first and most obvious one is that the cause of reduction of surface cover should be treated and not just the effect, i.e. the erosion itself. Removal of the cause is often sufficient to allow natural revegetation to occur.

(2) The whole area should be considered and not just the eroding dune - for example in dryland farming on sandy soils the cause of reduction of surface cover on sand rises may be sand-blast from drift arising from over-cultivation of inter-dunal flats and the solution may be simply the use of improved soil conservation practices on these areas to avoid soil drift.

(3) When the cause or causes have been determined and measures taken to overcome them, then the modification of the surface environment of the eroding dune can be considered.

This may require mechanical dune reshaping to remove projections which cause wind turbulence or the use of drift fences or surface protection by a temporary surface stabilizer such as brush, mulch or an adhesive spray to allow the natural processes of plant succession to commence.

(4) Where planting or sowing of seed is considered necessary, species should be selected on their ability to establish in the existing or modified environment. This necessitates a knowledge of both the macro- and micro-environment.

The more severe the environment the fewer are the species adapted to it. Hence for the harsh conditions that occur on unconsolidated sand of the seaward face of a frontal dune or for semi-arid or arid areas the choice of species is very limited. These primary, sand-stilling species modify the environment and set in motion the process of secondary and then tertiary plant succession.

(5) Planting or sowing should take place during the period most suitable for establishment and when the risk of loss by sand-blast, moisture stress or erosion is least.

Finally it is essential that reclaimed dunes are managed and maintained to ensure that sufficient vegetative cover is retained for protection of the sand surface from erosion.

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