EROSION CONTROL AND IMPACT ON HYDROLOGY

Erosion soil accelerated

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INTRODUCTION

The discussion in the next half hour will concentrate on the effects of erosion on water quality. That is most appropriate since all reference to erosion and its effects in the Forests Department General Working Plan are to be found under the Water Resource Management Section.

However I believe we should also be concerned about the effects of erosion in a more general sense. Although erosion is a natural process occurring on the earth's surface, accelerated erosion caused by mis-management, could result in loss of topsoil leading to degredation of vegetation cover; and poorer tree establishment and growth. The effects of erosion can also cause a prolonged impact on the visual forest resource by degradation of the landscape.

Today I will begin with a simple explanation of the erosion process and how it is possible to manipulate some of the factors causing erosion using a logging operation as an example.

Then I will examine the effects of erosion on hydrology, in particular the impacts of siltation and turbidity on water supplies and on stream biota.

We will look at some of the research projects currently underway to monitor the effects of logging and roading operations on water quality and finally consider some management actions which are being taken and which could be taken in the future to minimize erosion and its effects.

SURFACE EROSION

$$E = f(H, P, F)$$

For those people inclined towards mathematical formulae the above formula describes the relationship between

Surface Erosion (E) and factors of:
Inherent Soil Erosion Hazard (H)
Protection afforded to the soil (P) and
For ces applied by raindrops or overland flow (F)

Simply put, erosion is directly related to:

1. The inherent soil erosion hazard which includes such factors as soil detachability and slope.

2. The protection afforded to the soil by vegetation, litter or artificial covering.

3. Forces applied to the soil by raindrops and overland flow of water, including speed and volume.

Under a stable forest ecosystem, hazards are low and protection is maximised. Mild ecological disturbance (eg. prescribed burning) disrupts the balance decreasing P (Protection). Severe disturbance (eg. logging) increase H (Hazard), and decreases P (Protection).

Over time a new ecological balance is established on the disturbed site which leads to a new erosion "norm". This may differ from the original bacause of permanent change to site factors.

An objective in forest operations should be to minimize such permanent changes.

The opportunity for surface erosion to occur is at a maximum immediately after the disturbance and decreases with time. It is important therefore, that any control measures prescribed to minimize erosion be well planned and implemented as soon as possible following disturbance.

Manipulation of the factors H, P and F is possible at all stages of forest operations. For example in a logging operation:-

- Time since burning will greatly affect vegetation status, a factor of P. Burning can be manipulated before logging commences.

- Trafficking by logging machines may cause a loss of soil structure, a factor of H. Extraction patterns can be manipulated during logging.

- Direction and speed of overland water flow will affect F. Manipulation of flow patterns can be done following logging.

EFFECTS OF STREAM SEDIMENT AND TURBIDITY IN WATER SUPPLIES

To begin this section some definitions. SEDIMENTATION, SILTATION AND TURBIDITY are terms often used to describe the movement of fine suspended material.

TURBIDITY is an opthal property - Turbid water is water containing visible amounts of suspended material - silt clay, humus, algae etc. Coloured water is not necessarily turbid.

Turbidity is measured in N.T.U.'s (An instrument measures the amount of light diffracted by particles in the water).

Australian Water Quality Standards state that 25 N.T.U. is the maximum level appropriate for drinking water. 5 N.T.U. is drinking water of excellent quality; 10 N.T.U. is about the level of turbidity which can be detected by eye.

SEDIMENTATION refers to the deposition of all material across the full range of particle size downstream from a source of disturbance. It includes the fine fraction mentioned above in TURBIDITY.

The only true method of measurement is to sample deposits on the stream bed. The sophisticated technique for measuring sedimentation involves a sampling device which collects a sample from the entire profile of the stream (height and width) without interrupting the velocity of the stream flow.

SILTATION is often used in the same context as SEDIMENTATION but strictly refers to deposition of particles larger than clay but smaller than sand.

Moderate to high levels of sediment concentrations and turbidities in streamflow can lead to public health risks and consumer complaints in water supplies. For example, the effectiveness of chlorination is much reduced in turbid waters. Through adsorption of fine clay particles bacteria can avoid contact with the disinfectant and thereby survive high chlorination dosages. Consumers quite understandably object to drinking and washing in visually discoloured waters. The cost of filtration plants to reduce turbidity in water supplies and enable efficient chlorination are expensive both to construct and to operate. Treatment can often double the cost of water supply.

While short periods of highly turbid streamflow may not necessarily be a problem if the water supply is drawn from a large reservoir where there is sufficient time for turbidity to settle out, turbid streamflow is of major concern when water supplies are drawn from small to moderate sized reservoirs (5% to 50% of mean annual inflow). Storages likely to be developed in the Manjimup-Pemberton area are in this small to moderate sized category.

In the Woodchip Licence area stream sediment loads are low. However, isolated high concentrations have been recorded following logging and roading operations. While coupe regeneration can stabilise exposed soils relatively quickly permanent road systems can be an ongoing source of turbidity in streamflow. Minimising the persistant effect of highly turbid runoff from haul roads is, therefore, important on both current and possible future water supply catchment.

Results from monitoring in forested catchments to date show much higher sediment concentration in runoff from road subcatchments than for clearfelled subcatchments without roads.

Hopefully differences in sediment concentrations can be related to differences in road lengths, slopes and areas which may lead to guidelines for road drainage design.

EFFECTS OF SEDIMENT ON STREAM BIOTA

(Notes from Knott and Bunn, Department of Zoology, University of Western Australia).

Rivers are, ecologically, very complex structures and it is largely for this reason alone that lotic research was neglected for so long in favour of studies on lakes and impoundments. The complexity derives from the many variables changing along the course of a river: for example degree of shading, size of water course, and water temperature to mention but a few factors. From the biological prespective, perhaps the single most important factor is the current, creating a unidirectional gradient and exerting an influence both directly on the riverina biota and indirectly through its transporting and processing substantial quantities of sediment, suspended organic matter and nutrients. Animals either avoid the current, or else show a variety of morphological and behavioural adaptations (Hynes, 1970) which enable them to cope with it. Invertebrates inhabiting riffle zones typically drift with the current, a phenomenon reaching a peak of activity shortly after dusk. The current therefore plays an important role in integrating the terrestrial environment with the aquatic component into one ecosystem.

There are 3 faunal zones determined by the dominant geomorphological processes operating within each zone:-

1. An upland erosion zone which is characterised by great variations in flow, often without flow in summer, when the rivers degenerate to a series of pools exhibiting essentially lentic characteristics and increase in water salinity.

2. An intermediate zone

3. A depositional zone

The functional feeding groups in a river system include:

Shredders: species that feed by shredding coarse organic material - bark, leaves, twigs.

collectors: feed by filtering fine organic particles from the water and substrate.

scrapers: feed by removing algae and other organic material from submerged surfaces.

predators: carnivorous macroinvertebrates. Members of this functional category the second most abundant group after the collectors.

The role of sediment in riverine biology.

Most erosion occurs in high rainfall years, particularly during storms. The deposited sediments present an array of particle sizes, and the colonisation by biota depends upon the particle size and stability of the beds of sediment.

Unconsolidated silt and other unstable substrates are unfavourable microhabitats for the majority of benthic invertebrates from rivers. Silt disrupts feeding in filter feeders, impairs gill function, and is an unsuitable substrate for burrowing and sessile forms. Furthermore, a high content of suspend silt in rivers reduces light penetration and thereby reduces the composition and productive potential of the algal component of a river's biota.

Few forms are capable of colonising silted or unstable areas.

Predicition of the effects of significantly increased erosion, eg. from clear felling, opens a Pandora's box for speculation on specific results in the local context, but perhaps general trends can be predicted from experience elsewhere. Lemly (1982) cited increases in inorganic sedimentation as the greatest single cause of water quality degradation.

Deforestation has typically led to temporary increased run off into streams, with significantly altered seasonal patterns of flow, leading to higher salinity, nutrient and silt loads in streams. The effects are more significant in the smaller order 1 and 2 upland streams where permanent, clear watercourses have frequently been turned into turbid, silted, ephermeral streams with higher salinity. Just how large or rapid a change to the terrestrial environment must be before it leads to changes in the biota of streams in southwest Western Australia for example has yet to be determined. There is considerable scope for interesting and valuable research here.

RESEARCH PROJECTS TO MONITOR EFFECTS OF FOREST OPERATIONS ON WATER QUALITY IN THE WOODCHIP LICENCE AREA

In 1973 a steering committee under the chairmanship of Mr K. J. Kelsall initiated research to monitor the effects of woodchipping on water quality. Four projects were established the most significant of which were Project 2 - a long term paired-catchment study on 7 calibrated catchments; and Project 4 an early warning study of underground and stream water in four operational coupes.

The Project 4 data has shown that although salinity and sedimentation increased following clear felling, the increases were proportional to the increases in stream flow. The latest data shows that stream flow and other water quality parameters have almost returned to normal some eight years following commencement of falling operations. The Project 2 study has less data to present as logging only began in 1982 after six years of catchment calibrations, however it is possible to show that the catchment coupe with the greatest potential for erosion (March Road) through roading, winter logging and no stream reserve buffer has recorded a high average flow weighted turbidity in the year following logging, in comparison with the other catchments.

Worldwide and other Australian Research has highlighted the significance of permanent logging roads as the most important contributory cause of high sediment loads in water catchments.

The continued use of roads resulting in surface disturbance and the consequent need for grading of the road surface are contributing factors in the persisting deterioration in water quality.

Research has shown that stricter prescriptions for logging roads governing intensity, location, drainage and maintenance are essential.

The current philosophy of locating roads low in the landscape to minimise the spread of dieback disease created a high risk of increased stream turbidity. Roads higher in the landscape would minimise turbidity problems but would increase the risk of dieback spread. If roads are to remain low in the landscape careful planning, design and additional research effort is required to minimise the adverse effects of road drainage.

Reliable measurement of comparative sediment and turbidity of road runoff is extremely difficult. An approach is being developed to compare storm averaged concentrations of runoff from 8 subcatchments in Sutton 13 block (March Road Catchment) which have different proportions and lengths of roads in their catchments. Small flume devices which divert a constant proportion of flow (usually 1% or less) into a small storage container (less than $2m^3$) have been constructed. The flume is opened for the duration of a single storm (say over 24 hours) and enables one composite sample to be taken which represents the flow weighted concentration of the whole storm runoff. Comparisons of different catchment responses to the same storm event can readily be made.

ACTION REQUIRED TO MINIMISE EROSION AND THE EFFECTS OR EROSION ON WATER QUALITY

1. Assess erosion hazard and plan counter measures prior to the operation. Consider soils, slope, timing of the operation, intensity and pattern of the operation.

2. Evaluate the need for a stream buffer after consideration of the proximity of the operation to the watercourse. Width of the stream buffer required will depend on:-
   - partial or total exclusion of machinery
   - vegetation status within the buffer
   - slope and soil type
   - type and intensity of the operation
   - landscape and exposoure factors of the buffer itself.

3. Following the operation evaluate the erosion risk and prescribe control measures where necessary eg. cross drains, erosion barriers, surface stabilization.

4. Specific measures which can be prescribed prior to an operation to minimise erosion include:-
   - fuel accumulation prior to activity commencement
   - predetermined machine movements, favouring contour patterns
   - controls on soil displacement
   - controls on stream crossings and machine movements adjacent to watercourses
   - training of operators and supervisors to create awareness of problems
   - creation of exclusion zones, special care zones or strategic vegetation filter strips.

5. Following an operation, where an erosion risk is recognized the following counter measures may be prescribed:-
   - cross drains, erosion barriers to be installed
   - additional planting and seeding to hasten revegetation
   - stabilizing bare soil surfaces with bark, woodchips, scrub thatch or even bitumen spray on very sensitive surfaces.

6. In respect to construction and maintenance <u>forest roads</u> the following points should be considered to minimize erosion (in drains and banks) and discharge of sediment into water courses.

   - minimize stream crossings, and minimize distrubance at crossings
   - road location in the landscape
   - vegetation status below the road (filter capacity)
   - culvert spacing in relation to slope and sub catchment size
   - provision of suitable sumps regularly maintained
   - stabilized road surfaces batters and banks
   - stabilized culvert outlets (rocked)
   - in-drain barriers to slow water speed
   - roadside maintenance to maintain vegetation protection (slashing)