

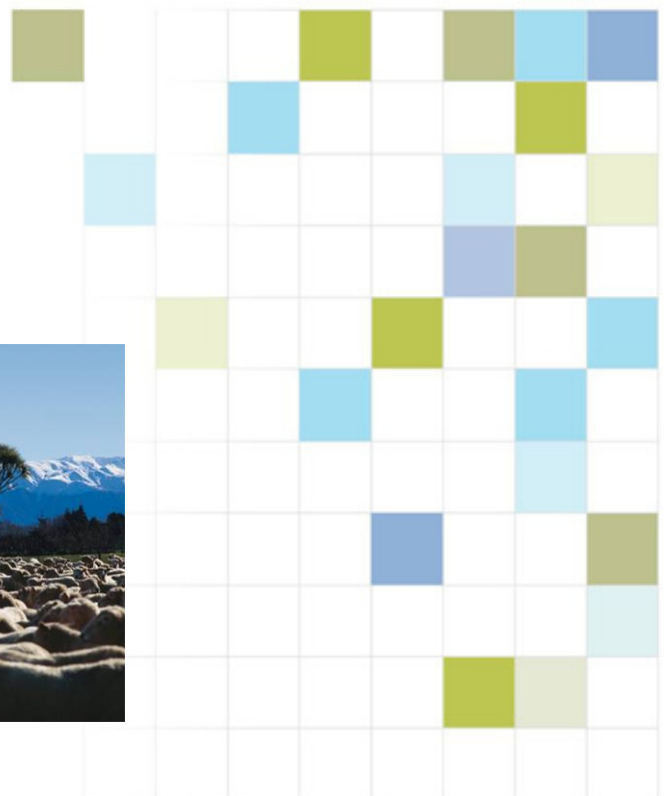
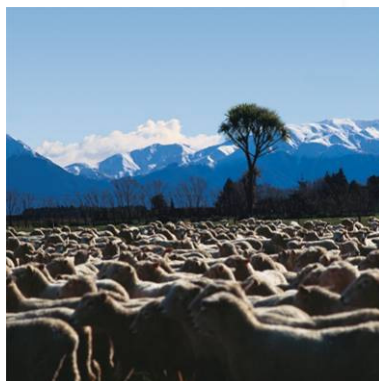


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Establishing a common framework for Regional Councils to assess, quantify and report on the effectiveness of soil conservation works on farm erosion risk and potential sediment loss.

June 2012

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Establishing a common framework for Regional Councils to assess, quantify and report on the effectiveness of soil conservation works on farm erosion risk and potential sediment loss

**Report prepared for Horizons Regional Council
Envirolink Medium Advice Grant Project
HZLC87 - Effectiveness of soil conservation works**

June 2012

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Establishing a common framework for Regional Councils to assess, quantify and report on the effectiveness of soil conservation works on farm erosion risk and potential sediment loss.

1. Introduction

Soil erosion management is a core activity for many Regional Councils. Where soil erosion is an issue within regions, Regional Councils have land management programmes that offer some type of assistance to land owners through soil conservation plans, environmental plans or in the case of Horizons Regional Council whole farm plans for encouraging land use change to reduce the risk of erosion and the loss of sediment to waterways. Since 2008 Horizons Regional Council has delivered over 350 whole farm plans covering over 250,000ha as a part of its Sustainable Land Use Initiative (SLUI).

Other agencies also offer advice on managing soil erosion. Beef & Lamb New Zealand offer, through their Land and Environment Plan (LEP) Toolkit (<http://www.beeflambnz.com/LEP>), a resource management tool for sheep and beef producers to assess the risk and severity of soil erosion on-farm and to determine the response required to reduce the risk.

Monitoring to date of the **effectiveness** of soil conservation/environmental/whole farm plans and other plan types has been largely limited to monitoring implementation of the conservation works programme - an activity based approach (Douglas et al., 2008).

Outcome based monitoring, compared with reporting on the progress of the works programme is gaining momentum, with approaches proposed for systematically assessing the effectiveness of vegetation in reducing the risk of erosion and the subsequent impact on sediment export from the farm.

This project seeks to advance a common approach to reporting on the effectiveness of soil conservation works in collaboration with the *Overseer*® nutrient budget owners (MPI, FertResearch and AgResearch). *Overseer*® is an on-farm decision support tool for assisting farmers and their advisers to examine nutrient use and movements within a farm to optimise production and environmental outcomes. *Overseer*® contains a suite of N and P mitigations, utilises readily available inputs and is already widely used in the primary sector as an on-farm decision support tool for assisting farmers and their advisers to examine nutrient use and movements within a farm to optimise production and environmental outcomes (<http://www.overseer.org.nz/OVERSEERModel/Information/Technicalnotes.aspx>)

Discussions have been held with the owners of the *Overseer*® nutrient budget on the merits of adding a soil conservation (erosion-risk mitigation) module. This would allow the user to assess, quantify and report on the effectiveness of soil conservation works in reducing the risk of erosion on-farm and the potential reductions in sediment discharge from the farm.

A major advantage of using *Overseer*® is that it is already used in nutrient budgeting and management by both the primary industries and Regional Councils. Importantly erosion-risk-mitigation adds to P mitigations, as much of the P loss in less intensive hill country is associated with sediment movement. It also brings the management of soil erosion closer to other on-farm decision making processes.

To be acceptable to Horizons Regional Council the underlying resource information and work plans from soil conservation and whole farm plans (e.g. SLUI Whole farm plans) would need to be built into the architecture of the soil conservation module.

This project will provide a wiring diagram of how the underlying biophysical resource information and proposed work plans and programmes from a whole farm plan can be built into the architecture of the soil conservation module. This module will enable the user to assess, quantify and report on the effectiveness of soil conservation works in reducing the risk of erosion on-farm and the potential reduction in sediment discharge possible from the farm, calculated from a sediment network model (SEDNet).

An additional key output will be a presentation to land managers of Regional Councils and the *Overseer*® owners once the initial wiring diagram has been completed.

2. Erosion Risk Mitigation Module for inclusion in the *Overseer*® nutrient budget model

2.1 General principles and approaches

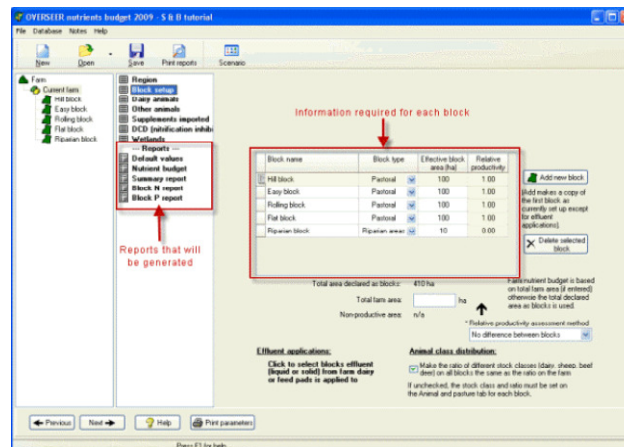
- It is important to maintain consistency with the current structure of *Overseer*® (e.g. block structure, calculation of pasture production, calculation of nutrient requirements) and the current approach taken to soil conservation by Regional Councils.
- Develop as a separate module: Erosion risk mitigation.
- It is important that the module is integrated into the *Overseer*® model because of the implication of soil conservation practices on a wide range of agro-ecosystem functions and outputs (e.g. impact on pasture growth, phosphorus losses, etc) and potential utility for other applications of the model (e.g. calculation of animal shade, carbon budget for farm, nutrient requirements).
- Input information should adhere to the underlying principles that have guided *Overseer*® development (Based on summaries of NZ and overseas research: *Overseer*® relies on sound science generated from research programmes).
- It should recognise that some producers will have access to detailed information through soil conservation plans.
- For example, Land Use Capability (LUC) mapping is at the core of soil conservation planning.
 - LUC units contain 5 broad categories
 - i Slope
 - ii Soil type
 - iii Vegetative cover
 - iv Erosion type and severity
 - v Parent material (Rock type)

Note. These are all crucial inputs for developing the erosion risk mitigation module. The LUC unit can also be utilised in the module to provide information on the recommended land use and soil conservation practices. This could be available in look up tables or by direct reference to the LUC Survey Handbook (Lynn et al., 2009).

- There will be instances where the farmer does not have the detailed resource information on their property (e.g. LUC units at the required scale). Therefore input information will be required to drive the Erosion Risk mitigation module. That information will have to adhere to the underlying principles that have guided *Overseer's* development, i.e. use input data that are reasonably easily obtainable by farmers or consultants. Default values are built into the model
- Set up on a block basis rather than on a whole farm basis. A block may be a whole farm but it is unlikely.
- In the first instance we will be dealing with pastoral blocks only.
- Within any block there may be several LUC units (much like the topography/slope of a block). At this stage each block will only be allowed to have one LUC unit allocated to it. If there are two dominant units, develop a new block.
- Determination of the area that needs protection and the stage of protection at a point in time. It was decided that at the first stage of development a single value (%) would be allocated for the area that requires protection (or is already protected) and a further value for the stage or level of protection. The stage of protection would be based on for example the % cover of the trees present.

3. Structure of the Erosion Risk Mitigation Module

The front window will request the following inputs from the user for each block. This will be in addition to the existing information required to describe a block in the *Overseer®* model.



3.1 Area

If the area requiring treatment is different from the area of the block, record this area. This leaves the option of reporting the activity at two levels (Block and Sites within a block).

3.2 Topography/Slope

Currently there are 4 slope categories available in *Overseer®*. The predominant slope within the block is selected if there are several slopes present. Categories are

- Flat
- Rolling
- Easy Hill
- Steep Hill

However, within any one block, there may be significant areas/slopes that need to be treated differently from the rest of the block and each other. In this situation another block will be created. The incorporation of Flats and Sideling's within a block was suggested as a possible way around this.

3.3 Erosion Type

There are three main categories

- Gully erosion
- Landslides
- Earth flow (slumping)

These are described in the LUC Survey handbook (Lynn et al., 2009).

3.4 Erosion severity

Extent of erosion. Categories for identifying the severity of the erosion still need to be developed and current assessment criteria vary with erosion type. Refer to the LUC Survey Handbook (Lynn et al., 2009).

3.5 Parent material

Parent material has a major impact on the risk of soil erosion and as such is a crucial datum to obtain. GNS and Landcare Research hold this information for the country but it may not be available/released in an electronic format for this purpose. Some type of licensing agreement may need to be arranged for access.

3.6 Connectivity to water

Having these data will enable the link between the risk of erosion and the progress with erosion risk mitigation to be made to the risk of sediment loss to waterways. In time it will be possible to establish, estimate and predict the potential reductions possible with on-farm soil conservation plan.

3.7 Vegetative cover

The basic vegetative cover options are;

- i Pasture
- ii Wide-spaced trees (i.e. Poplar and willow)
- iii Native forestry
- iv Exotic forestry
- v Regenerating vegetation

Options i, ii, iii and iv are already available in *Overseer*®

3.8 Additional inputs

Many of the additional inputs required are likely to be already captured within the block set up within *Overseer*® e.g. rainfall, soil type, stock classes, grazing management and other data.

The inputs topography/slope, erosion type, erosion severity, parent material, and vegetative cover are also within the LUC classification.

These estimates will be made from relatively small data sets initially. Regional look-up tables will be added in a later version that is built up from local knowledge.

Other factors which need to be modelled include the influence of spaced trees at different densities on pasture growth and stock carrying capacity for that block, future production levels, fertiliser requirements and P losses. At this stage the potential benefits of shade and shelter on animal performance will be noted but not captured in the module.

Other block variables are yet to be resolved. e.g. fodder crops rotating through a block, change in stock class, and exclusion of stock in the early years of tree establishment. The initial focus will be pastoral blocks.

4. Management options

Within the front window there will be the option (Button) that will open to another screen that will allow the operator to include information on the current situation on that block including the

- Number of trees that have been planted in the past, when in the past and over what area (retrospective data entry);
- Number of trees proposed to be planted in the coming 12 months and in the future;
- Percentage of the block requiring planting will also be recorded. This will link to the front window.

The type of management options that the tool will be able to accommodate will be driven in the first instance by the erosion type, and then by the planting option selected by the user.

The planting options available to the user will be determined by the erosion type. To demonstrate the erosion risk mitigation module to the land managers of Regional Councils

and the *Overseer*® owners, a selection of the following will be wired into the initial development of the tool to obtain feedback.

4.1 Landslide erosion

The occurrence of landslides can be reduced or prevented by:

- ensuring a dense, healthy pasture sward coupled with establishment of wide-spaced trees e.g. *Populus* spp. to provide deeper and wider root-reinforcement of the substrate, and transpiration to reduce soil pore water pressure;
- changing land use to regenerating scrub-indigenous forest;
- or establishing exotic forest for commercial timber production.

Trees should be planted at 5 m x 5 m to 15 m x 15 m depending on the severity of landsliding. A density of 5 x 5 m (400 stems per hectare) is very high on pastoral land and it is recommended that planting be extended beyond the slipped land on to relatively stable ground. Lateral roots of broadleaved trees interlock for distances of up to 12 m from the trunk, and form very dense networks within 5 m or 6 m of the trunk. Trees can be planted on slipped sites but it is recommended that they be planted on sites with potential to slip, rather than for remediation.

4.1.1 Spaced trees

Principally *Populus* and *Salix* but may be other genera e.g. *Acacia*, *Eucalyptus* on drier sites. Establish *Populus* and *Salix* spp. using 3 m long poles with plastic sleeve protection. Assume 100% survival, trees are healthy, not used for supplementary fodder, well-suited to site conditions and mature at 15 years.

Option 1. Urgency for planting as soon as possible (severe erosion or erosion potential) or unlimited resources at start and during tree life

- Plant at 200 sph (7 m x 7 m) in Y1, thin to 70 sph (12 m x 12 m) at Y10;
- If going to practise size control, then thin to 120 sph (9 m x 9 m) at Y10 and pollard retained trees every 7-10 years.

Option 2: Less urgency to plant as soon as possible (erosion or erosion potential less severe) or limited resources at start; management during tree life

- Plant at 70 sph (12 m x 12 m); no thinning
- Pollard trees every 7-10 years (no adjustment of tree density to compensate for individual trees being less effective for slope stability).

Option 3: Less urgency to plant as soon as possible (erosion or erosion potential less severe) or limited resources at start and during tree life

- Plant at 70 sph (12 m x 12 m); no thinning
- No pollarding for size control or other purposes.

Option 4: Less urgency to plant as soon as possible, or very limited resources at start and during tree life

- Plant at 70 sph (12 m x 12 m) at rate of 20% per year; no thinning
- No pollarding for size control or other purposes.

4.1.2 Retirement/Scrub-indigenous forestry

Livestock exclusion, plant and no-plant options.

Option 1: Retirement without planting, establishment of species reliant on germination of buried seed and seed introduced by birds and other means e.g. wind

- Assume on-going animal pest (primarily rodents and possums) control and 100% canopy closure of scrub by Y5. Species might be gorse, manuka, etc
- Indigenous forest development Y20+.

Option 2: Retirement with low-input planting, establishment reliant on survival of seedlings planted and germination of buried seed and seed introduced by birds and other means e.g. wind

- Plant single or assorted indigenous species at 100 sph (10 m x 10 m)
- Implement standard weed and pest control practices
- 100% canopy closure of scrub/introductions by Y5-10; indigenous forest development Y20+.

Option 3: Retirement with high-input planting, unlimited resources, establishment reliant on survival of seedlings planted and germination of buried seed and seed introduced by birds and other means e.g. wind

- Plant single or assorted indigenous species at 2,500 sph (2 m x 2 m)
- Implement standard weed and pest control practices
- 100% canopy closure of scrub/introductions by Y3-5; indigenous forest development Y20+.

4.1.3 Exotic plantation forestry

Principally *Pinus radiata*, but could be other species such as Douglas fir (*Pseudotsuga menziesii*) or various *Eucalyptus* spp.; For *Pinus radiata*, assume that the forest will achieve maximum effectiveness by Y20 and be harvested for timber at Y25.

Since timber is the end-point with soil conservation during rotation, silviculture will be required. Assume up to three prunings with last prune to 4-6 m height at Y7/8 when trees are 10-12 m tall; all thinning to be completed by last pruning.

Option 1: Good site, high survival, excellent growing conditions

- Plant at 600 sph (square or rectangular grid) and thin to 400 sph.

Option 2: Poor site, variable survival and growth requiring much thinning

- Plant at 1000 sph (square or rectangular grid) and thin to 400 sph.

4.2 Earthflows

Vegetation options to control earthflow include space-planted trees and afforestation. Tree spacings recommended vary depending on attributes such as the extent of the earthflow, its movement and stage of development, and depth to the failure plane. On intermittently moving or creeping earthflows, tree spacing of > 8 m may enable adequate erosion control and satisfactory pasture production.

For more active, continuously moving earthflows, spacings < 5 m (400+ sph) are recommended to encourage development of a denser root network. Recommendations on appropriate control techniques vary with site geomorphology e.g. erosion control forestry on crushed argillite, pole planting on other sedimentary rocks.

Successful control of shallow earthflows (< 3 m deep) has been achieved using various plantings of *Populus* and *Salix* spp. Deep earthflows (e.g. several metres deep) are much more difficult to control with vegetation and de-watering with fast-growing evergreen species is recommended.

4.2.1 Spaced trees

Principally *Populus* and *Salix*; establish trees using 3 m long poles with plastic sleeve protection. Assume 100% survival, trees are healthy, not used for supplementary fodder, well-suited to site conditions and mature at 15 years.

Option 1: Site with intermittent or creeping earthflow

- Plant at 100 sph (10 m x 10 m).
- No size control or other tree management.

Option 2: Site with active, continuously moving earthflow; urgent need to plant and unlimited resources

- Plant at 400 sph (5 m x 5 m)
- No size control or other tree management.

Option 3: Site with active, continuously moving earthflow; urgent need to plant but limited resources

- Plant at 400 sph (5 m x 5 m) at rate of 20% per year
- No size control or other tree management.

4.2.2 Exotic forestry

Principally *Pinus radiata*; due to speed of establishment and good growth on a wide range of sites: Low unit cost. Assume that the forest will achieve maximum effectiveness by Y20, and that the stand will likely not be harvested for timber – solely planted for protection.

Option 1: Deep-seated earthflow, continuously moving.

- Plant at 400 sph (5 m x 5 m)
- No management regime for size or timber.

4.3 Slump erosion

Mitigation options are similar to those used to manage earthflow erosion. Spaced-tree planting is an effective preventative technique for potentially active sites or those with limited movement, and may offer some control on more active terrain. Depth of the failure plane is an important influence on how effective spaced-tree planting will be, and at depths greater than 5 m, additional control methods such as drainage will probably be necessary. Engineering methods have been used to stabilise large, deep-seated slumps in bedrock where erosion threatens valuable infrastructure (e.g. roads, buildings) but their high cost precludes general applicability.

Severe slumping may require retirement from grazing and afforestation (close spacing) with species such as *Populus*, *Salix*, and *Pinus radiata* and other conifers. The priority should be to retain the forest long-term. Harvesting for timber may be considered but care should be taken in deciding which trees are harvested. Replanting is recommended as soon as possible after harvesting to enable a new root system to develop before the previous one decays significantly. Encouraging the development of indigenous forest may offer better long-term stability.

4.3.1 Spaced trees

Principally *Populus* and *Salix*; establish trees using 3 m long poles with plastic sleeve protection. Assume 100% survival, trees are healthy, not used for supplementary fodder, well-suited to site conditions and mature at 15 years.

Option 1: Site with potential for slumping or with limited movement (failure plane < 5 m depth)

- Plant at 150 sph (8 m x 8 m).
- No management for size or other purposes.

4.3.2 Exotic forestry

Principally *Pinus radiata*, but also *Populus* and *Salix* spp. For *Pinus radiata*, assume that the forest will achieve maximum effectiveness by Y20, and that the stand will likely not be harvested for timber – solely planted for protection. When planted at the same spacing, assume *Populus* and *Salix* spp. achieve maximum effectiveness at Y15.

Option 1: Site with severe slumping and requiring establishment of a protective forest stand.

- Plant any species at 400 sph (5 m x 5 m)
- No tree management for any purpose.

4.3.3 Retirement/scrub-indigenous forestry

Livestock exclusion, enabling regeneration of indigenous species.

Option 1: Retirement of site with actual or potential severe slumping; establishment of species reliant on germination of buried seed and seed introduced by birds and other means e.g. wind

- Assume on-going animal pest control and 100% canopy closure of scrub by Y5.
- Indigenous forest development Y20+.

4.4 Gully erosion

The severity of the gully often dictates the type of treatment.

- For shallow (< 2 m deep) gullies, spaced planting of *Populus* or *Salix* spp. in combination with engineering structures (e.g. debris dams) while the trees establish, is recommended.
- For moderate (2-5 m deep) gullies, the outcome of this type of treatment is less certain. Tree planting patterns and spacings vary depending on the severity of the erosion, with the most successful system being 'pair planting' up the watercourse at 2-10 m spacing between pairs. Each pair comprises a tree on opposite sides of the watercourse, frequently between 1 m and 2 m apart, or alternate planting in a 'zig-zag' fashion along opposite sides of the watercourse.
- Severely eroded gullies should be retired from grazing and closed-planted with trees. Considerable experience has been gained with plantings of *Pinus radiata* but other species may also be used e.g. *Populus* spp.. The land stabilisation role of the trees is paramount and therefore they should generally not be harvested for timber, although currently many gullies that have previously been afforested are being harvested (e.g. at Mangatu Forest). Succession to indigenous scrub and forest should be a long-term objective. There has been some success with retirement, planting *Salix* spp., and then selectively removing the trees to encourage establishment and growth of indigenous species. Depending on the severity and distribution of gully erosion in a catchment, treatment may range from individual gullies and their perimeters being planted, to afforestation of most or all of the catchment.

4.4.1 Spaced trees

Principally *Populus* and *Salix*; establish trees using 3 m long poles with plastic sleeve protection. Assume 100% survival, trees are healthy, not used for supplementary fodder, well-suited to site conditions and mature at 15 years.

Option 1: Site with shallow gully (< 2 m deep); assume that debris dams have been used where necessary; unlimited resources

- 'Pair plant' up watercourse at 10 m spacing between pairs and 2 m between trees within each pair – equivalent to 500 sph on treated area.
- Assume each watercourse to be planted is 500 m long – requires 200 poles
- No management for size or other purposes.

Option 2: Site with shallow gully (< 2 m deep); assume that debris dams have been used where necessary; more severe than Option 4.1.1; unlimited resources

- 'Pair plant' up watercourse at 4 m spacing between pairs and 2 m between trees within each pair – equivalent to 1,250 sph on treated area.
- Assume each watercourse to be planted is 500 m long – requires 500 poles
- No management for size or other purposes.

Option 3: Site with shallow gully (< 2 m deep); assume that debris dams have been used where necessary; limited resources

- 'Pair plant' up watercourse at 10 m spacing between pairs and 2 m between trees within each pair – equivalent to 500 sph on treated area. Plant at rate of 20% per year.
- Assume each watercourse to be planted is 500 m long – requires 200 poles (40 per year)
- No management for size or other purposes.

4.4.2 Exotic forestry

Principally *Pinus radiata*, but also *Populus* and *Salix* spp. For *Pinus radiata*, assume that the forest will achieve maximum effectiveness by Y20, and that the stand will likely not be harvested for timber – solely planted for protection. When planted at the same spacing, assume *Populus* and *Salix* spp. achieve maximum effectiveness at Y15.

Option 1: Site with severely eroded gully and requiring establishment of a protective forest stand.

- Plant any species at 400 sph (5 m x 5 m)
- No tree management for any purpose.

4.5 Retirement/Scrub-indigenous forestry

Livestock exclusion, enabling regeneration of indigenous species.

Option 1: Retirement of site with severe gully erosion; establish interim "nurse crop" and then encourage indigenous species - reliant on germination of buried seed and seed introduced by birds and other means e.g. wind

- Plant *Salix* or *Populus* spp. at 200 sph (7 m x 7 m), selectively thin up to Y15
- Assume on-going animal pest control and 100% canopy closure of exotic trees/indigenous scrub by Y10.
- Indigenous forest development Y25+.

The management information will be used to calculate future growth of previous, current and future tree plantings, to provide a prediction of the changes into the future of the level of protection at various times e.g. at 10 years? This will be adjusted by the current

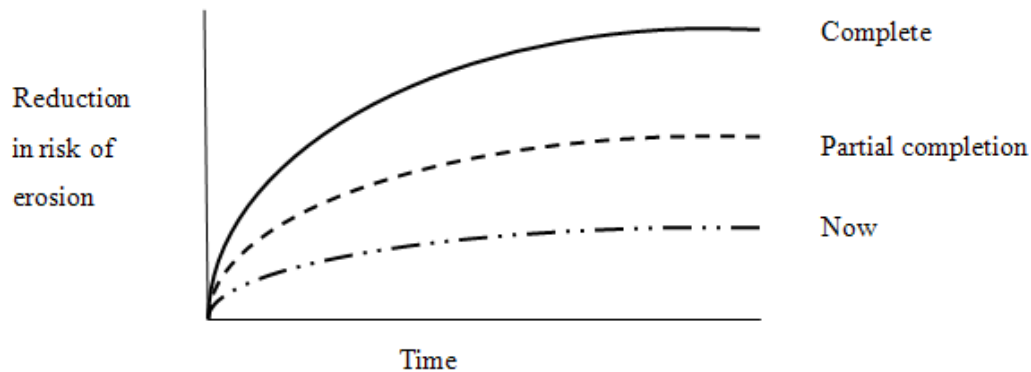
estimate of the degree protection prompted in the front window. This provides a way of adjusting the predicted level of protection with actual measurements from time to time.

5. Reporting page

What would the erosion risk report look like?

Propose to give a graphical representation showing over time three scenarios

- The erosion risk now
- The risk of erosion once mitigations have been completed and cover established (100% implementation and vegetation mature or attained maximum canopy)
- The risk of erosion if mitigation is partially complete and not finished (or mitigations have been completed but establishment has been poor or vegetation has not been maintained well).



These graphs would be reported on a block and if the interest is there could be aggregated to provide a report for the whole farm.

Additionally an estimate of the cost of these mitigations will be incorporated into the report to provide a summary of the cost over time, but also the likely future costs of the various options and practices. It is proposed to have a generic set of dollar values for each of the planting options in the first instance, but in time these could be customized by the user.

The report will give general recommendations on the mitigations used to reduce the risk of erosion plus a caveat to use an existing soil conservation plan if one exists or any other approved plan.

The proposed structure of the Erosion Risk Mitigation Module could be linked to a sediment load model because connectivity to water is included in the information collected as part of the block description. Obtaining a consensus on the structure and outputs of the module is the next step, including the links to sediment models.

There was discussion on catastrophic events and how to handle them but no guidelines were formalised.

6. Wiring of the module into the *Overseer*[®] main frame

It will be important for the module to be fully integrated into the *Overseer*® model because of the implication of soil conservation practices for a wide range of agro-ecosystem functions and outputs, such as

- impact on pasture growth
- phosphorus losses
- calculation of animal shade
- carbon budget for farm
- water balance
- nutrient requirements

In recognising the influence soil conservation practices have on a farm's other operations, it will help draw decisions on soil conservation closer to the other business decisions that have to be made on farm.

7. References

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