WORKSHOP REPORT

POPLAR AND WILLOW PLANTING ON LAND OVERLAY 3A GISBORNE, EAST COAST REGION

JOINTLY ORGANISED BY THE
MINISTRY OF AGRICULTURE AND FORESTRY
AND GISBORNE DISTRICT COUNCIL

Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

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ENQUIRIES

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DISCLAIMER

FOREWORD

The East Coast Forestry Project (ECFP) aims to achieve sustainable land management in the Gisborne District so that hill country land use makes a long-term contribution to the District's economic, social and environmental wellbeing. The Gisborne District Council is also implementing the Sustainable Hill Country Project to address soil erosion and unsustainable land use in the district.

The ECFP funds various erosion control measures including afforestation, indigenous reversion and wide-spaced poplar/willow pole plantings to achieve sustainable land management. There are well established guidelines for afforestation and indigenous reversion options. However, there has been differing opinion about the efficacy and effectiveness of various regimes of wide-spaced poplar/willow plantings. This has created doubt amongst some landowners as to the appropriate treatment.

This report contains guidelines for wide-spaced poplar/willow pole plantings for effective erosion control. The report is an outcome of a workshop attended by very experienced soil conservators from regional councils, scientists from crown research institutes and independent consultants. I would like to acknowledge their collective efforts and wisdom in reaching a consensus on this set of recommendations.

I am sure the recommendations of this report will contribute to consistent advice to landowners on wide-spaced pole planting regimes. It should also enable the ECFP to fund wide-spaced pole plantings that contribute to sustainable land management in the Gisborne hill country and to the vision of a sustainable New Zealand.

Paul Reynolds
Deputy Director-General
MAF Policy

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INTRODUCTION

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In 1992 the East Coast Forestry Project (ECFP) was established, as a continuation of projects from 1961 onwards, to tackle the severe erosion problem in Gisborne District. ECFP is funded by central government and administered by the Ministry of Agriculture and Forestry (MAF). The project administrators are responsible for ensuring that erosion control treatments funded by ECFP deliver the desired outcome at the least cost to the Crown.

The experience gained from the project confirms that the afforestation option using *Pinus radiata* is still considered a very effective, large-scale, erosion control option on severely eroding country. In some situations reversion to indigenous tree species offers superior long-term protection on suitable sites. Poplars and willows are an option where soils, soil moisture and erosion (type and severity) are conducive to establishment.

However, there has been disagreement between various parties about the efficacy and effectiveness of some regimes of wide-spaced poplar/willow planting as an erosion control approach on unstable East Coast land. The Gisborne District Council (GDC) and MAF recognise the desirability for agreed guidelines for spaced poplar/willow pole plantings for effective erosion control. As a first step towards developing a set of guidelines, GDC and MAF jointly organised a workshop on 11–12 December 2006, which brought together practising soil conservators and researchers with good collective knowledge of the performance of poplars/willows in mitigating different forms of erosion. See the list of particpants in Appendix 1, page 28 of this report.

Following the workshop, a draft version of *Poplar and Willow Planting on Land Overlay 3A, Gisborne, East Coast Region* was circulated to workshop participants for comment.

The report outlines the contextual framework behind at times differing philosophies, perspectives and approaches by soil conservators and foresters to erosion control, and documents the status of current research on erosion control practices, both of which were key considerations behind initiating this workshop. In addition, comments provided by workshop participants are discussed and a consensus is reached on planting density requirements for poplar and willow plantings to achieve successful erosion control within Land Overlay 3A.

BACKGROUND

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Until relatively recently ECFP funded afforestation as the primary erosion control treatment. In closely planted forest stands, the roles of canopy closure and root occupancy are paramount to the success of this afforestation to control soil erosion.

The processes of evapotranspiration and root reinforcement, as mechanisms through which slope stability is substantially restored to currently eroding sites and maintained on already planted sites, have been well researched (Pearce et al. 1987, Watson et al. 1995, 1999, Zhang et al. 1993, Marden et al. 2005).

The success of these processes in stabilising many existing gully, earthflow and slump erosion features, and in ameliorating against the initiation of new erosion during storm events, particularly once canopy closure has been attained (between years 6–8), has been demonstrated (O'Loughlin 1984, Phillips et al. 1990, Marden et al. 1991, 1992, 2005). In addition, there is considerable scientific evidence in support of the concept that for large erosion features the greater the proportion of the watershed treated surrounding individual erosion features, the more likely the treatment will succeed (Marden et al. 2005). This is less of an issue where erosion features are small and watersheds are large.

As afforestation generally includes planting to natural ridge lines, there is a well-founded expectation that afforestation projects on the "worst of the worst" eroding land, in most instances, will achieve a successful outcome. However, it has to be acknowledged that, when dealing with erosion features typically found within Land Overlay 3A, afforestation also has limitations. Often, local site conditions (for example, geology, groundwater, fault crushing) and size of the feature dictate whether reforestation will prove to be successful or not (Marden et al. 2005).

Since the 1998 ECFP review, other treatment options for controlling erosion on farmland have become eligible for funding through the ECFP. These include reversion of indigenous scrub and the use of poplar and willow poles and/or wands. Research data in support of the effectiveness of indigenous reversion is scant (Marden & Rowan, 1993, Bergin et al. 1993, 1995, Rowe et al. 1999) but reversion has been shown to be effective at an early age on account of the very dense nature of closed-canopy stands and the presence of a dense fine-root network with a higher root tensile strength than *Pinus radiata* (Ekanayake et al. 1997, Watson et al. 1999).

Post-storm damage assessments of poplar and willow plantings show that, where implemented appropriately, poplar and willow plantings substantially reduced physical damage to hill country grazing lands, by between 50–80 percent, even during exceptional storms such as Cyclone Bola in 1988 (Hicks 1992). They also show that damage reduction was minimal on hill slopes where plantings were absent, inadequate or not maintained (Hicks 1992). However, we must take into account that these findings are of early plantings of clones that differ from those used today, many of which were decimated by poplar rust, and these plantings were undertaken prior to a time when forest woodlots were just beginning to be accepted and used as an alternative soil conservation practice on farms. This seemingly poor performance, at times, is also symptomatic of the fact that there has never been any assistance or mandatory requirement to maintain these early plantings, combined with what was probably some poor siting of planted material, some inappropriate stocking rates and a narrow range of early species available for planting.

Experience has shown that many of the larger erosion features likely to be encountered in the Land Overlay 3A are beyond the scope of conventional pastoral-based erosion control measures and need a forest cover, often in association with gully planting, for stability. Where smaller linear gullies, slumps and earthflows are identified as controllable by pole/wand treatment, the challenge is to reach agreement on planting and management strategies that will deliver a successful erosion control outcome for land classes identified in Gisborne District as Land Overlay 3A.

This reinforces the importance of getting it right with planting specifications, that is, ensuring that trees establish on all the unstable parts of the slope. Elements in this are good siting, appropriate stocking rates, planting the right sort of tree for the type and severity of erosion in question, and targeting soil conservation works not just at controlling existing erosion but at areas of potential erosion (Hicks 1995). It is clear that unless erosion control measures are implemented in a relatively short space of time, at a scale appropriate to the problem, and then maintained, money is simply being wasted (Trotter 1989).

In addition, there is the consideration that the ECFP and the “District Plan Rule Variation” target land classes identified at property scale as the “worst of the worst” eroding land in Gisborne District.

WHY THERE WAS A NEED FOR THIS WORKSHOP

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The workshop was designed to bring current practitioners, with significant experience in soil conservation and forestry practices, together with scientists knowledgeable in the causes and solutions for erosion types typical of this region, to explore whether a consensus could be reached on the process of selecting the most effective and practical erosion control solution for different types of erosion feature.

Irrespective of tree species, close-planted stands of forest and space planted poles (poplar and willow species) are both useful erosion control options with their own strengths and weaknesses and when applied in appropriate situations, established correctly and maintained[1], each treatment can be as equally effective as the other. However, there is no clear cut process for deciding which treatment or combination of treatments is the most appropriate for all situations likely to be encountered in the field.

One of the earliest decisions to be made is whether the current land use in the immediate vicinity of each erosion feature is appropriate and viable in the long-term or if genuine land use change through conversion to forest/ retirement would be a more sustainable option.

There are a host of economic and social factors that can influence the landowner's choice of treatment and often these will override the most appropriate "one off" treatment option based on the physical evidence at sites requiring erosion control. Historically, the ultimate decision on whether, what and where to plant has rested with the landowner. Much unplanted land has remained so because the most feasible option has not been acceptable to landowners.

Furthermore, for each of the erosion types being considered there is a continuum of size of feature, degree of current activity, slope and specific site criteria that ultimately needs to be factored into deciding the most appropriate treatment. Though generally backed with experience, scientific studies and training, the selection of a treatment for a particular location is often partially subjective and tempered by successes and failures.

The unique combination of the ECFP incentive and RMA rule ensure only effective soil conservation solutions will be promoted to the landowner. There will be no scope for partial implementation, inadequate maintenance or doing nothing (unless nothing is physically the only option, for example, vertical river gorges and much of class eight mountain land identified at a property scale).

That is not to say landowners will have little input. On the contrary, it is essential that proffered solutions are able to accommodate landowner's desires where effectiveness is not unduly compromised and solutions become accepted. A regulation that does not have the vast majority of its community (in this case farming community) behind it is doomed to failure.

The aim of the workshop was to develop of a set of written guidelines outlining specifications for the treatment of eroding areas where poplar/willow pole planting could result in a successful erosion control outcome. Discussions at this workshop focused on the appropriateness of poplar and willow regimes on Land Overlay 3A.

Land Overlay 3A is classed as the worst eroding land in the Gisborne District and comprises land defined in the text descriptions of Land Use Capability Units (1st ed. NZLRI) VIIe12–16,18 and 20, VIIIe 1–6; and (2nd ed. NZLRI) VIIe18–19, VIIe21–25, and VIIIe2–9.

The key elements of the workshop were:

- a field visit where participants could view a range of erosion forms falling within Land Overlay 3A;
- a desktop exercise that required participants to prescribe treatment options for 11 gullies, 10 earthflows and 6 slip/slump complexes depicted on aerial and oblique photographs and a 3D digital elevation image of each site.

[1] It should be noted the notified rule in the District Plan and the modified ECFP include a maintenance requirement.

PRINCIPLES

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In developing a logical argument over which treatment is best suited to an individual locality, it is easy to lose sight of the purpose of the ECFP. Preceded by the Conservation Forestry Scheme (1989–1993) the ECFP is the latest of many attempts since the 1960s, to provide central government funding for erosion control. It was introduced in acknowledgement of this region's heightened erosion problems following Cyclone Bola (1988) – a 1:100 year event which has now been upgraded to 1:70 year event – and to provide a structured long-term (20 years) opportunity for this region to ultimately deal with its erosion problems. As such the ECFP was designed to traverse changes in government.

We also need to remind ourselves that in selecting the most appropriate erosion control solution we are dealing with the "worst of the worst" Category 3A land. In accordance with Variation 176 of the Sustainable Hill Country Regulation, treatment, if implemented, will have to remain effective in the event of severe storms which are likely to be more frequent.

There is optimism amongst soil conservators across the nation that, with appropriate species selection (using currently available clones), planting spacing, installation and maintenance, the erosion control performance of poplar and willow plantings can be greatly improved. To achieve an effective erosion control outcome for each site does, however, rely on the following key principles:

- Understanding the type of erosion and the processes requiring control. Each erosion type requires a different approach.
- Appreciating the severity of the erosion in question. Space planted trees will not control severely eroding soil slip faces. More severe earthflow erosion will require closer tree spacing.
- Matching the tree type to the land type. Thorough inspection of site conditions and factors such as soil moisture levels and retention, wind, frost and threats from animal pests. Failure to select the most appropriate variety will result in tree losses.
- Planting all the relevant parts of the slope and not just the actively eroding parts.
- Recognising that to achieve effective erosion control other techniques such as dewatering, drainage, gully support, dams and contouring may be required in conjunction with the various tree planting options. Treatments additional to tree planting are, however, outside the mandate of ECFP and therefore may have to be funded by the landowner.
- Continued maintenance of plantings is essential.

EROSION FORMS

APPLICABLE TO LAND OVERLAY 3A

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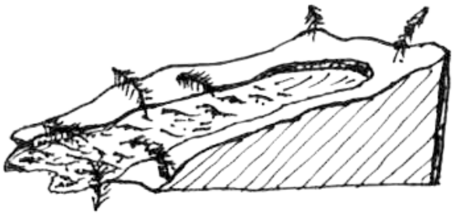
EARTHFLOWS

A slow moving, wet mass of unconsolidated earth material that exhibits viscous flow.



SLUMPS

A rapid moving mass of soil or regolith that slides over a surface of rupture that is concave upwards. Often deep seated.

GULLIES

Incised, linear to amphitheatre-like erosion features formed by running water.

DESKTOP EXERCISE

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APPROACH

The aim of the desktop exercise was to establish consensus among workshop participants on the following key areas:

a) Could effective erosion control be expected if planting regimes were restricted to Land Overlay 3A or would additional land surrounding the 3A delineation require to be treated;
b) Differentiating between erosion features requiring land use change to reforestation (blanket planting in pines, closely spaced poles/wands, reversion) versus those erosion features that could be retained in a pastoral regime by using pole/wand planting regimes to control erosion;
c) Having decided that space planted poles/wands were the most appropriate treatment, what were the best planting densities for specific erosion features.

Sixteen workshop participants were provided with aerial and oblique photographs and a 3D digital image of various sites that included 11 gullies, 10 earthflows and 6 slip/slump complexes. Other relevant information provided were mean annual rainfall, elevation, climate zone, geology, LUC unit and an outline and size (hectares) of the Land Overlay 3A area surrounding each erosion feature.

Site by site, each participant was required to select one of 20 pre-set treatment options as being the most appropriate *primary* treatment required to deliver an effective erosion control outcome. In selecting a planting treatment option, participants were asked to take into account whether or not they considered additional land area outside of the depicted 3A polygon would also require treatment, and if so indicate whether it would be greater or less than 50 percent of the watershed.

In discussions before the start of this exercise it was clear that some participants were uneasy at being restricted to choosing a single treatment option per erosion feature. It was decided by consensus that if no single treatment alone was felt to be sufficient to stabilise the feature in question, participants could chose a combination of treatments provided they denoted which option would be the *primary* treatment. The selection of a high, medium and low pole planting density of 200–500 spha, 75–200 spha and under 75 spha, respectively, was in the belief that the range was adequate and where implemented would provide effective erosion control to any erosion feature within the delineated 3A Overlay classed as the worst eroding land in the Gisborne District.

The treatment options included:

››› PLANTATION FORESTRY @ 1250 SPHA

1) All Land Overlay 3A plus treatment of over 50 percent of watershed.
2) All Land Overlay 3A plus treatment of under 50 percent of watershed.
3) All 3A area only.
4) Part of 3A area only.

››› SPACED POLE PLANTING @ 200–500 SPHA

5) All Land Overlay 3A plus treatment of over 50 percent of watershed.
6) All Land Overlay 3A plus treatment of under 50 percent of watershed.
7) All 3A area only.
8) Part of 3A area only.

››› SPACED POLE PLANTING @ 75–200 SPHA

9) All Land Overlay 3A plus treatment of over 50 percent of watershed.
10) All Land Overlay 3A plus treatment of under 50 percent of watershed.
11) All 3A area only.
12) Part of 3A area only.

SPACED POLE PLANTING @ UNDER 75 SPHA

13) All Land Overlay 3A plus treatment of over 50 percent of watershed.
14) All Land Overlay 3A plus treatment of under 50 percent of watershed.
15) All 3A area only.
13) Part of 3A area only.

PAIRED PLANTING ALONG WATERCOURSE

17) Within 3A area only.
18) Within and outside 3A.
19) Retirement (indigenous reversion).
17) No treatment.

Each participant made his/her decision independently and without discussion with other participants. Handwritten responses were entered and analysed in Microsoft Excel.

RESULTS

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Although a wealth of data was collected during the desktop exercise, the results presented here are restricted to determining consensus on:

- treating Land Overlay 3A only versus 3A plus additional land surrounding the erosion feature in question but within the same watershed (Figure 1);
- pole/wand planting versus forestry as a primary treatment (Figure 2);
- pole/wand planting densities of 200–500 or 75–200 or less than 75 spha (Figure 3).

Note: The following analyses are not claimed to be statistically defensible, given there are just 16 participants, that is, 16 observations for each parameter, but nonetheless show basic trends/patterns of participant's perception of treatment options required to provide effective erosion control of three of the most common erosion types associated with Land Overlay 3A: gullies, earthflows and slips and slumps. Where results showed a clear preference between 3A only, 3A + under 50 percent of watershed, or 3A + over 50 percent of watershed these are commented on.

LAND OVERLAY 3A AREA ONLY VERSUS 3A AREA AND ADJACENT LAND

GULLIES

For 6 of the 10 gully examples there was a definite preference for including additional land to Land Overlay 3A (Figure 1A) in their treatment and that treatment includes more than 50 percent of the watershed. Sites 1 and 3 were the exceptions where participants considered that the planting of the area defined as Land Overlay 3A alone would provide effective erosion control. For site 1 the presence of a considerable number of existing poles within the area designated as Land Overlay 3A and the presence of gentler terrain surrounding this gully likely influenced their choice. For site 3, justification for planting the Land Overlay 3A area only was possibly influenced by the presence of considerable regenerating scrub, existing pole plantings and the benign appearance of this gully as shown on the aerial and ground-based images provided to the workshop participants.

EARTHFLOWS

For about half the earthflow sites, opinions were evenly split. At sites 5, 7, and 9 it was deemed that treatment of Land Overlay 3A alone would suffice (Figure 1B) while at sites 3 and 11 it was considered that treatment would be more effective if it included land outside the designated 3A area. At site 3, visited the previous day, it was clear to participants that the entire slope had already been planted and at site 11 participants could see from the photographic imagery provided that this site was particularly wet on account of drainage from earthflows feeding into an existing gully that also required treatment.

SLIPS AND SLUMPS

For slips and slumps there was no clear domination of one option over the other (Figure 1C) but where it was deemed necessary to include additional land outside Land Overlay 3A for treatment, many chose to include greater than 50 percent of the watershed. At sites 1 and 3 the erosion feature lies within and only occupies a small proportion of the area designated as Land Overlay 3A, thereby justifying the planting of just the 3A area. Site 4 was clearly deemed to require additional planting outside the 3A area because a considerable portion of the slump lay outside the designated 3A polygon. For site 5, the presence of considerable reversion both within and upslope of the designated 3A polygon may have influenced a few participants towards the retirement option and to include poor quality land adjacent to the 3A area.

There was confusion over the location of Site 6, as shown in the oblique photograph provided to the workshop participants, relative to the Land Overlay 3A, and this may have influenced the participants' choice. It turns out that the bulk of the area portrayed in the oblique photograph lies outside the now notified Land Overlay 3A area. Realistically, for half of the six sites (sites 2, 5 and 6) participants were evenly divided over the decision on whether or not additional land outside of the 3A polygon would need to be treated to ensure effective treatment of this erosion feature.

FIGURE 1: THE PROPORTION OF PARTICIPANTS WHO CONSIDERED THAT TREATMENT WOULD BE EFFECTIVE IF CONFINED TO LAND OVERLAY 3A ONLY VERSUS LAND OVERLAY 3A AND ADDITIONAL SURROUNDING LAND IN GULLIES, EARTHFLOWS AND SLIPS AND SLUMPS

FIGURE 1A – LAND OVERLAY 3A ONLY VERSUS LAND OVERLAY 3A AND ADDITIONAL SURROUNDING LAND: GULLIES

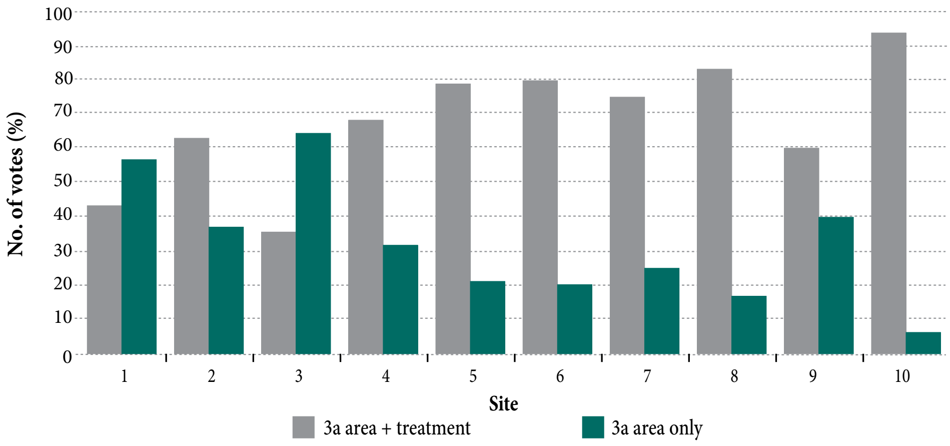
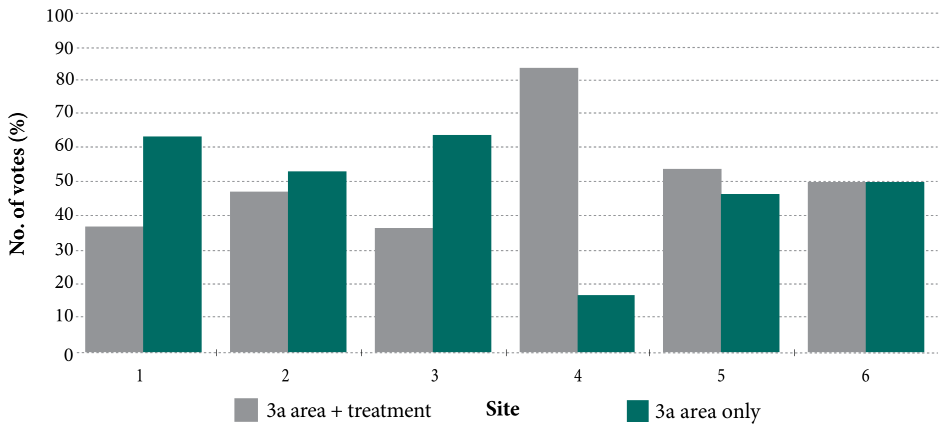


FIGURE 1B – LAND OVERLAY 3A ONLY VERSUS LAND OVERLAY 3A AND ADDITIONAL SURROUNDING LAND: EARTHFLOWS

› FIGURE 1C – LAND OVERLAY 3A ONLY VERSUS LAND OVERLAY 3A AND ADDITIONAL SURROUNDING LAND: SLIPS AND SLUMPS



››› FORESTRY TREATMENT VERSUS PLANTING OF POLES/WANDS

› GULLIES

Based on the results of the workshop there was general consensus about choosing the most appropriate treatment option for large and active gullies (8 of the 10 examples) where reforestation was considered to be the most practical option (Figure 2A). Afforestation was clearly favoured for gully systems in an "advanced" (4) and "mid" (4) stage of development. Both foresters and soil conservators appreciated that such features often require additional treatment of the channel through the use of wands or the allowance for setbacks if indigenous reversion is already present. Similarly, when deciding on an appropriate treatment option for smaller and perhaps less active gullies (examples were not well represented at the workshop except as sub-catchment elements of larger gully complexes) there is unlikely to be disagreement over treatment options as it is generally accepted that the planting of poplars and/or willows along the channel and banks of narrow, linear gullies would be sufficient to prevent further downcutting and/or lateral bank erosion at the majority of sites. Reversion, if sufficiently advanced, is also an accepted alternative option. However, although not well represented in the workshop examples, it is anticipated that gullies in the mid size range (~2–5 hectares) on pastoral land will be the most contentious when agreement is sought on their most effective treatment. Unless a set of criteria can be agreed on to define the limitations of pole/wand treatment of the different erosion types, perhaps based on type of feature, size of feature, degree of activity, aspect, slope etc, the choice of treatment will be partly subjective and open to criticism by one party or the other. These differences will need to be resolved at the time of developing a site plan or during subsequent site inspections.

FIGURE 2: THE PROPORTION OF PARTICIPANTS WHO CONSIDERED FORESTRY VERSUS POLE PLANTING MOST LIKELY TO PROVIDE THE BEST EROSION CONTROL OUTCOMES FOR GULLIES, EARTHFLOWS AND SLIPS AND SLUMPS

FIGURE 2A – FORESTRY VERSUS POLE PLANTING: GULLIES

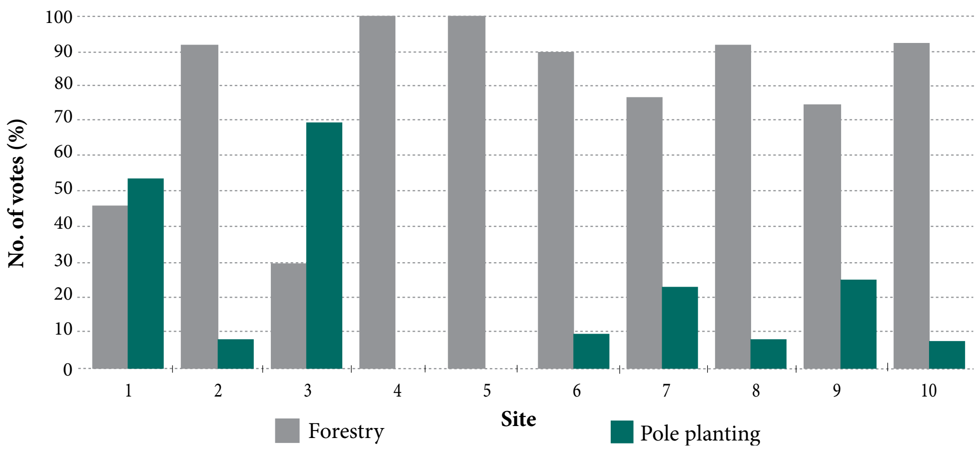
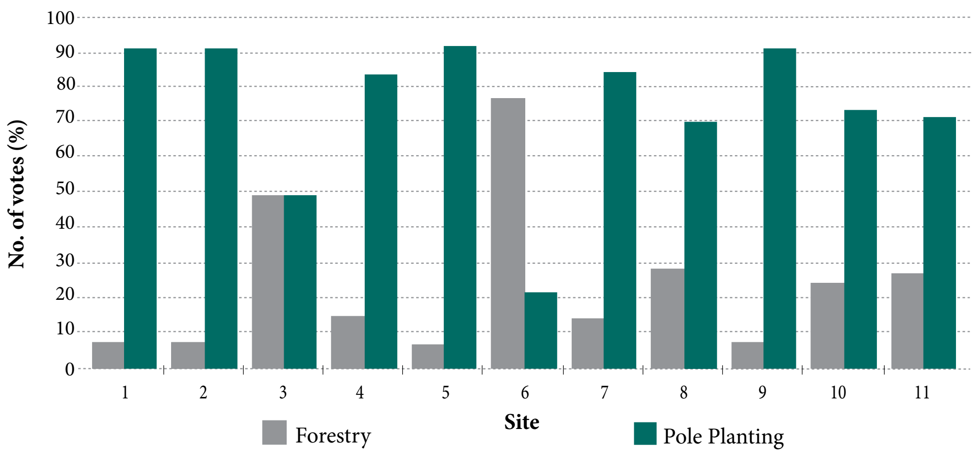


FIGURE 2B – FORESTRY VERSUS POLE PLANTING: EARTHFLOWS



› EARTHFLOWS, SLIPS AND SLUMPS

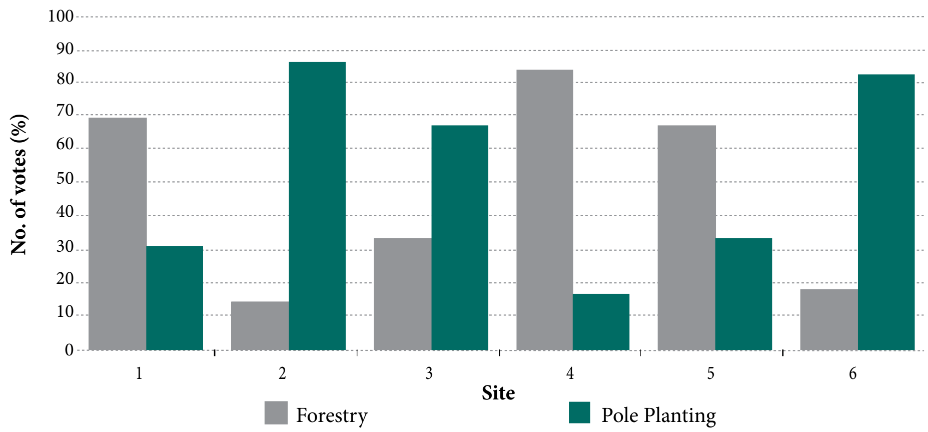
The desktop exercise results indicate a strong preference for pole/wand treatment on earthflows (9 of 11 examples, Figure 2B). There was a split decision between poles and forestry for slips and slumps (3 of 6 examples Figure 2C). For poles, the combination of site factors at each locality will often determine the success or otherwise of these plantings. There are slope treatment options often used in conjunction with plantings for example, drainage of ponded areas and/or debris dams that can significantly enhance the chance of success of planting.

››› POLE/WAND PLANTING DENSITIES FOR EARTHFLOWS AND SLIPS AND SLUMPS

› EARTHFLOWS

For all 11 earthflow sites, the density range 75–200 spha was a popular choice but at only two sites (1 and 2) was it the dominant choice (Figure 3A). For sites 7 and 8 the choice of planting density was split between 75–200 spha and the heavier stocking density of 200–500 spha and for the remainder of sites the trend was towards lighter stocking rates with <75 spha showing an even ranking with 75–200 spha.

› FIGURE 2C – FORESTRY VERSUS POLE PLANTING: SLIPS AND SLUMPS



› SLIPS AND SLUMPS

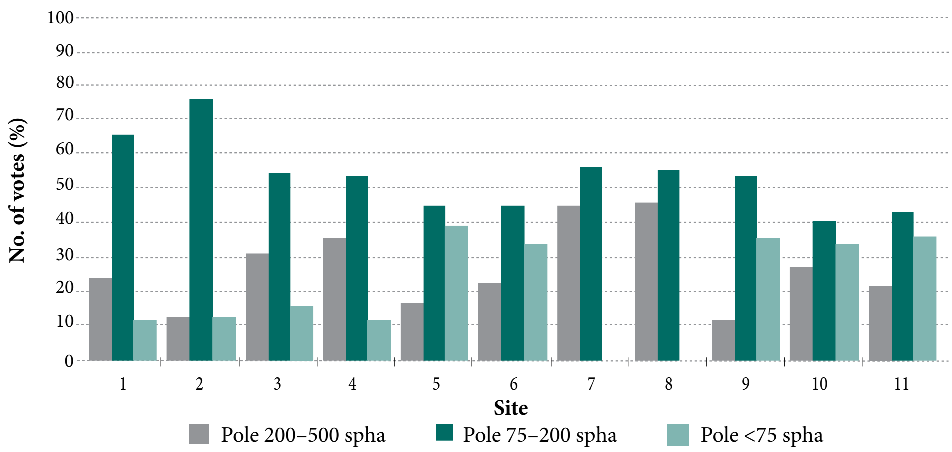
For slips and slumps, the 75–200 spha option dominated at sites 2 and 6 (Figure 3B). To achieve an effective erosion control outcome some participants recognised the need for higher densities of poles on the larger and more active slumps (sites 1 and 4) and stocking evenly split on erosion features with existing poles (site 3) and advanced reversion (site 5).

› GULLIES

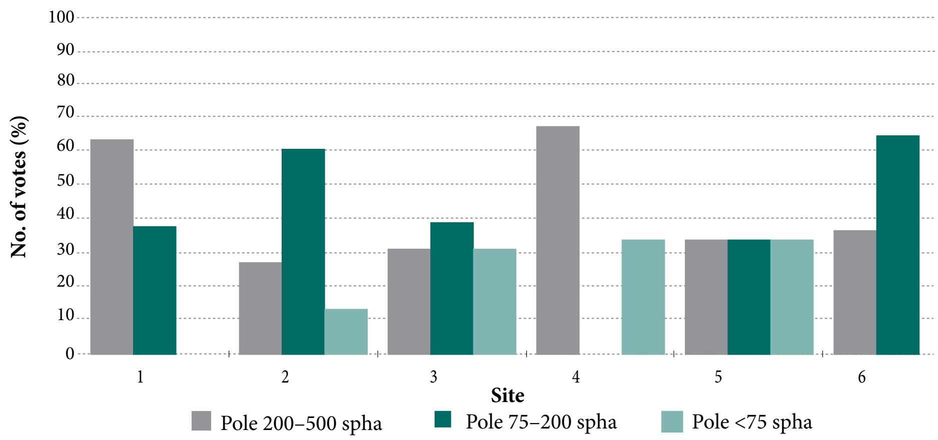
Pole planting was chosen as the primary treatment for only two of the 10 gullies presented in this exercise. For site one the preference was for 200–500 spha and for site 3 it was 75–200 spha. There was insufficient data to graph. The gully elements and sub-catchment size is expected to influence the density chosen.

››› FIGURE 3: POLE/WAND PLANTING DENSITIES SELECTED BY PARTICIPANTS AS MOST LIKELY TO PROVIDE THE BEST EROSION OUTCOME FOR EARTHFLOWS AND SLIPS AND SLUMPS

› FIGURE 3A – POLE PLANTING DENSITIES: EARTHFLOWS



› FIGURE 3B – POLE PLANTING DENSITIES: SLIPS AND SLUMPS



8

POPLAR AND WILLOW

PLANTING SPACINGS FOR EROSION CONTROL

Variations in workshop results, and in some cases a lack of a clear preference for one particular treatment, occur because combinations of treatment options were selected by most participants to give a more robust soil erosion outcome in the context of continued pastoral farming on Land Overlay 3A land.

The majority of respondents' comments to the draft workshop report focused on the issue of planting density/spacing for poplars and willows. There was strong support by respondents for the concept of devising recommended planting spacing (cf. planting densities, that is, stems per hectare) in recognition that poles should be sited in locations where they are most likely to survive and where they are most needed to effect control of the erosion feature in question. This requires acceptance that poles will inevitably be unevenly distributed across an eroding feature with a greater concentration planted on the unstable part.

A range of planting spacing criteria for poplar and willow plantings, advocated by workshop participants to achieve a successful erosion control outcome on moderate and severe earthflows, slumps and for linear gullies respectively within Land Overlay 3A is presented in Table 1. The sites at which each pole is placed would be decided at the time of work plan development. The auditing of treated areas may involve a count of surviving poles. The responsibility of replacing trees that had died in the interim rests with the landowner.

TABLE 1: INDICATIVE PLANTING SPACING RECOMMENDED FOR EARTHFLOWS, LINEAR GULLIES AND SLUMPS TO ACHIEVE A SUCCESSFUL EROSION CONTROL OUTCOME WITHIN LAND OVERLAY 3A AND FOR ADJACENT ERODED AREAS

FEATURE	SPACING (M)				PLANTING LOCATION
	POLES	THINNING	WANDS	THINNING	
Moderate earthflow	7–10m	10–12m @ 10–20 years	5–7	10–12m @ 10–20 years	unstable part of flow
	10–12m plus blanking	none			
Severe earthflow	7–10m	none	5–7	none	unstable part of flow
Moderate linear gully	6–8m	10–12m @ 10–20 years	2–4	10–12m @ 10–20 years	watercourse
	7–10		5–7		gully walls
	10–12m plus blanking	none			
Severe linear gully	6–8m	none	2–4m	none	watercourse
	7–10m		5–7m		gully walls
Moderate slump	7m	10–12m @ 10–20 years	5m	10–12m @ 10–20 years	unstable part of slump
Severe slump	5m	none	5m	none	unstable part of slump

Note
Planting spacing will vary with topography and erosion severity within a given planted area. (Table contents supplied by D. Hicks, based on published field survey data from Hawley & Dymond 1988, Thompson and Luckman 1993, Hicks 1992, Miller et al. 1995, McElwee & Knowles 2000 and modified in response to comments on the draft workshop report regarding the spacing and waste of resources if required to thin pole plantings.)

Consensus on the required spacing to achieve adequate erosion control for moderate earthflows and slumps (10–12 metres after thinning) equates approximately to the equivalent of 100–70 spha. For severe earthflows and slumps planted at 7–10 metre spacing but not thinned the final density is equivalent to ~200–100 spha for the unstable parts of these features (Table 1). This is backed up to some extent by evidence from field surveys showing the relationship between disturbed ground and poplar plantings which clearly demonstrate that to provide adequate erosion control for moderate earthflows and slumps the final stand density needs to be between 50–100 spha and that initial planting densities in excess of 100 spha helps achieve stability at severely eroding sites (Hicks 2007).

Hick's prescription for pole spacing rather than planting densities as the most appropriate means of prescribing a treatment for any given area or feature met with general acceptance from other participants. That is, in developing a work plan for an area to be treated using poles, the specification would require a given number of surviving poles within a given boundary.

With regard to the planting of wands, there was general agreement that these should be planted at the recommended higher stocking rates as indicated in Table 1 because of their availability, lower cost and general lower resistance to summer dry.

There was strong disagreement on the idea of over-planting as a means of ensuring an adequate number of trees survived. Over-planting results in the excessive and unnecessary use of poles at a time when there is a dire shortage of planting material. Instead, blanking was seen as a more cost effective and efficient means of accounting for losses and of avoiding thinning costs at a later date. Counter to this argument, and raised by only one respondent, is the viewpoint that over or heavy stocking is the best way to effect early stabilisation and could well have application to the most severely eroding earthflows and slumps particularly within Land Overlay 3A. Conversely, the risk of under-planting poles on such sites could result in inadequate protection and financial and resource wastage.

In preparing and presenting details of stocking rates, as part of property scale "work plans", it would be helpful to both practitioners and landowners to have ortho photo maps with delineated planting zones and their required stocking rates.

The recommended planting spacings or stocking rates are indicative only and should be used as a guide for sites where a prior agreement has been reached that poles and/ or wands are an appropriate treatment option. Listed below are suggested additional factors and considerations that will need to be taken into account before reaching such a decision.

Whether or not an erosion feature is classified as severe or moderate is dependent on its activity and size at the time it is assessed. This assessment will likely occur when developing each farm plan but will require reassessment at the time of planting. Cognisance should also be given to the potential erosion status of each site as shown in the *Land Use Capability Classification of the Gisborne–East Coast Region* (Jessen et al. 1999), but taking into consideration the time-dependent nature of causative factors. This is particularly important for all large-scale earthflows, gullies, slips and slumps where consideration of the potential for failure could greatly influence not only the choice of treatment option but also the area required to be treated to achieve a successful erosion control outcome.

Where applicable, that is linear gullies shallower than five metres, gully planting will require watercourse planting with willows in addition to gully wall planting with willows or poplars. The timing of watercourse planting relative to gully wall planting will require careful consideration. However, willow and poplar plantings in gullies in crushed geologies deeper than five metres, particularly those in bentonite or crushed argillite, are likely to have severe establishment constraints. Some will succeed, but many will fail. For these features, reforestation with pines or natural reversion along with poles or stakes in the watercourses is the preferred treatment option.

Pole planting on slumps will require higher concentrations on the most active parts of the slump, and lower concentrations on less active parts. Experience has shown that many of the larger and deep-seated slumps likely to be encountered in Land Overlay 3A are beyond the scope of conventional pastoral-based erosion control measures and need afforestation with pines, often in association with gully planting.

Unlike past erosion control efforts, largely funded through local authorities, there will only be one chance to secure funding through the ECFP, so all concerned with future erosion control efforts must do their utmost to get it right first time.

As the goal of the ECFP and the Sustainable Hill Country (SHC) Regulation is to achieve long-term erosion control, a number of external risks should be taken into account when considering the most appropriate erosion control option. The probability of failed erosion control efforts, particularly for a severely eroding feature, could be high in the event of increased storminess, droughts and fire risk (climate change effects) and this is of concern. In addition, there are risks associated with the very narrow genetic pool of *Pinus radiata* and willows. Thus the inclusion of a reversion option and a provision for combinations of effective erosion control options to be used are essential if this goal is to be realised.

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COMPARATIVE
EFFECTIVENESS OF WIDE-SPACED POLE PLANTING AND RADIATA PINE

The comparative effectiveness of poplars versus radiata pine for erosion control was raised at the workshop. The results of empirical studies of poplar height, diameter at breast height (dbh), root biomass and root strength were presented to benchmark the effectiveness of poplar pole plantings at various densities compared to radiata pine planting at 1250 spha. Such an approach enables a theoretical threshold root biomass to be calculated to provide effective soil reinforcement. East Coast poplar tables for dbh and stems per hectare have recently been correlated with root biomass per hectare (Knowles 2006). Allowing for variation in growth at different sites, this correlation indicates that mature poplar stands need to be about 70–100 spha to achieve the same root protection as closed-canopy pine forest and that about 160–200 spha are needed to achieve quick stabilisation by younger trees on severely eroding sites. These indications are supported by a similar correlation for a poplar stand in the Manawatu (McIvor 2007), with the proviso that McIvor inclines towards the lower end of the spha range, in view of poplars' superior fine-root mass.

The 2004 storm damage data for a random sample of 79 poplar and willow plantings in the Manawatu–Wanganui region have been converted to spha, enabling comparison with Knowles' and McIvor's tables (Hicks 2007). The converted data show little fresh erosion where spha *on unstable ground* exceeds 50 spha, but substantial erosion where spha are less than 50. Fresh erosion was measured at just one site with greater than 100 spha. The sites had been planted in response to earlier severe erosion, during wet winters from the 1950s through the 1970s. Most stands are more than 20 years old and corresponds with Knowles' and McIvor's mature category. Hicks' data supports their conclusions, that final stand density needs to be at least in the 50 to 100 spha range for adequate protection of soil; and that initial planting density in excess of 100 spha helps achieve stability at severely eroding sites (particularly if it can be maintained long-term).

However, it seems clear that more information on poplar and willow root biomass development is required to enable this approach to be used with confidence.

SUMMARY

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The results of the desktop exercise, tempered by the general expertise of the workshop participants and their subsequent comments, plus published results from post-storm surveys of soil conservation plantings, provided the basis for the planting densities now suggested in Table 1. If site factors that potentially could jeopardise a successful erosion control outcome have been taken into account in arriving at the decision to plant poles and/or wands then the recommended densities/spacing, if planted and maintained appropriately, are considered sufficient to provide effective erosion control for Land Overlay 3A and for some eroding adjacent land.

Workshop participants recognised that to achieve effective treatment a combination, rather than a single treatment option, would be required and that the combination should be decided by field inspection of the site. In particular, willow and poplar planting of gullies deeper than five metres, particularly those in bentonite or crushed argillite, are unlikely to be successful unless accompanied by afforestation or reversion of the surrounding watershed.

RECOMMENDED RESEARCH

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Several respondents appeared to have differing viewpoints on:

1) the relative contributions of evapotranspiration versus root reinforcement in studies of slope stability involving poplars and radiata pine;
2) which of the two species had the greater evapotranspiration rate over a full year's growth;
3) improved understanding of interrelationships between plantings and site factors other than the two broad research areas above;
4) how to establish equivalent effectiveness for poplars and radiata pine. The possibility of using empirical studies of poplar height, dbh, root strength to benchmark the effectiveness of poplar pole plantings at various densities compared to radiata pine (notes on this theme provided by Knowles (2007) and McIvor (2007)).

These topics are beyond the scope of this report but are nonetheless potential areas for future research.

It was also recommended that because "effectiveness" field surveys have to date largely been undertaken on Land Overlay 2 and 3 it would be worthwhile to commission a Hick's style "random" assessment of the effectiveness of later clones of poplars and willows within Gisborne District and to include elements of Land Overlay 3A land.

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APPENDIX 1
LIST OF PARTICIPANTS

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EXPERTS/PRACTITIONERS

› Colin O'Loughlin – Consultant, Christchurch
› Stan Braaksma – Greater Wellington Regional Council
› Mike Marden – Landcare Research, Gisborne
› Mike Page – GNS, Wellington
› Doug Hicks – Consultant, Auckland
› Garth Eyles – Hawkes Bay Regional Council
› Peter Manson – Hawkes Bay Regional Council, Wairoa
› Malcom Todd – Horizons
› Norm Ngapo – Consultant, Auckland
› Ian McIvor – HortResearch, Palmerston North
› Leith Knowles – SCION, Rotorua

GISBORNE DISTRICT COUNCIL

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