ECONOMIC ASSESSMENT ON THE IMPACT OF

THE GUM LEAF SKELETONISER, *URABA LUGENS* IN NEW ZEALAND

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Executive Summary

The Gum Leaf Skeletoniser (GLS), *Uraba lugens*, is a pest of *Eucalyptus* trees, and will attack a wide range of *Eucalyptus* species. A native of Australia, it has sporadic outbreaks in *Eucalyptus* forests, with the damage usually rated as “minor to moderate”. This lower level of impact is mainly due to a number of natural bio controls, which are absent in New Zealand. Hence the level of impact in New Zealand is likely to be more severe.

Little is known of the natural rate of spread of GLS; estimates are 1 km/generation or 2 km/year. At this rate if would take hundreds of years to spread throughout New Zealand. The present value of the economic impact of this would be very low due to discounting over such a time period. The probability is that it will spread much faster due to unwitting human assistance, and the assumption used in this analysis is that it would spread throughout New Zealand in 20 years.

New Zealand currently has approximately 46,000 hectares of *Eucalyptus* forest, the bulk of which is in the Bay of Plenty/Central Plateau, and to a lesser extent in Southland. Most of which is grown for pulp. Production forestry would face increased costs in terms of increased monitoring, spraying, and increased rotation length. The net present value (NPV) cost of this, at a 10% discount rate, is $69.4 million.

Eucalyptus trees are also a component of the National Amenity Tree Estate, and they would again be affected by GLS. The impact on this was assessed by two methodologies:

(i) The direct replacement cost of eucalypts into another specie.

(ii) The methodology used by Treeby in developing his “Urban Tree Estate Amenity Values and Pest Risk” matrix. This is largely based on the replacement cost of affected trees.

The NPV of the impact of GLS on the amenity estate, at a 10% discount rate, was:

(i) Replacement cost = $72.5 million

(ii) Treeby methodology = $31.5 million

The overall impact therefore is:

> Production forestry plus replacement cost amenity value = $141.9 million
> Production forestry plus (Treeby) amenity value = $100.9 million

There are health implications with GLS: contact with larval skin will cause stinging and a weal that may last some weeks. It is thought that this would be unlikely to be significant across the general population, and no costing was allowed for in this analysis. However, health concerns may be one incentive to spray for GLS within the urban amenity estate.

The impact of GLS on native flora is unknown and no costing was allowed for in this analysis. Similarly, it was thought unlikely that GLS would impact on trade and market analysis, and no costing has been allowed for in this analysis.

Background

Taxonomy

Species: ***Lugens*** (first described by Walker, 1863)

Genus: ***Uraba***

Sub Family: ***Nolinae***

Family: ***Nolidae***

Order: ***Lepidoptera***

The Gum Leaf Skeletoniser (GLS), *Uraba Lugens*, is found in all States of Australia apart from the Northern Territory, in areas where the rainfall varies from 500 mm to more than 1500 mm (Withers, 2003).

Damage

The small larvae feed gregariously and eat the upper and lower epidermis, the palisade tissue and the spongy mesophyll of the leaf, but avoid the oil cells and the veins. This feeding habit results in the leaf being “skeletonised”, hence the common name of the insect. As the larvae grow toward their final body size of 2.5 cm, they consume progressively increasing leaf quantities, meaning the latter instar larvae are the most damaging (Bain, et al, 1997, Withers, 2003).

When pupation occurs (November to December, and March to April) the larvae tends to move downwards and will commonly pupate on the bark of the tree or in the leaf litter at the base of the tree. However, they may pupate on the foliage or on animate objects such as walls of nearby houses. The larvae will incorporate its hairs, shed head capsules and some material from the substrate into the cocoon. Therefore it is often extremely well camouflaged (Withers 2003).

Adult moths emerge approximately two weeks later and will mate readily. Very little is known of their flight or dispersal ability, but they are known to fly to nearby trees, and females will locate low branches (which may be many metres above the ground) on which to oviposit. Adults are believed to live for at least a week, during which time they probably oviposit a number of separate egg batches. Females can produce up to 600 eggs, with a mean of around 400, but not all are laid at once (Farr, 2002).

GLS can have either one (univoltine) or two (bivoltine) generations per year. In general this seems to be determined to a large extent by climate but the position is not clear. In Eastern Australia “coastal” populations generally are univoltine and “inland” populations are bivoltine. The very limited amount of information available from the population in Tauranga at the time of the 1997 discovery indicates that it would be bivoltine in New Zealand, but quite possibly univoltine in the cooler parts of New Zealand.

GLS is included in a list of organisms that “appear significant in terms of their impact on conservation and/or economic values of Australian eucalypt forests” (in Bain 1997). In Australia, GLS is a typical outbreak forest pest. Between outbreaks damage may be minor, but every 5-10 years a major outbreak is recorded in Australia. Examples of this include: a 1962 outbreak covering 1,000 km^2, 45,000 ha in 1983, and 160,000 ha in 1986. Smaller localised outbreaks have occurred recently in Tasmania (Strelein 1998, Withers, 2003).

Host Range

In Australia GLS has been recorded on a very wide variety of *Eucalyptus* species. (Refer Appendix 1). It has also been recorded from *lophostemon confertus* (brush box). In New Zealand it has been found on *E.globulus. E.ficifolia, E.leucoxlyon, E.macracapa, E.Nitens, and E.saligna.* (Bain, 1997). At this stage, it is unknown whether GLS attacks any of New Zealand's native flora.

Extent of Damage

The impact of GLS on eucalypt growth in outbreaks in Australia is variable. In most of the outbreaks recorded in the 1980s, damage was generally classified as "light – moderate" with only around 1% classified as "severe" (Strelein, 1988). Re-growth of damaged crowns varied with the degree of defoliation. Those severely defoliated made little recovery until larvae pupated and then gradually refoliated from late summer, although some did not fully recover. Crowns lightly defoliated appeared to recover completely. Other studies have shown that *Eucalyptus* growth rates were generally not affected until 25% of the Crown was defoliated (Lundquist, 1987). Steinbauer (pers comm) noted that very few *Eucalyptus* feeding insects such as GLS kill trees and only levels of defoliation above 50% have resulted in significant reductions in stem volume which cannot be regained in subsequent growing seasons.

There are a number of natural parasotoids of GLS in Australia, which could very well account for the time lapse between outbreaks, and the relatively limited extent of defoliation and damage that occurs. Given that there are no natural controls existing in New Zealand, it could be assumed that the occurrence of outbreaks, and the level of damage inflicted would be much more severe.

Climatic Suitability

GLS is widely distributed through Eastern, Southern and Western Australia in a variety of climatic zones, and appears to tolerate a wide range of temperature and rainfall patterns. Comparison of temperature and rainfall data comparing Australian and New Zealand locations has been carried out by Bain, et al (1997). This showed a close compatibility for most of New Zealand with the distribution zones of GLS in Australia. New Zealand temperatures at elevated (Rotorua) and southern (Gore) localities are marginally lower than those experienced in the range of GLS in Australia, but not to the extent to limit the establishment of the species throughout most of New Zealand. Lower temperatures are likely to slow the rate of the insect's development rather than stop it. Rainfall below 500 mm is likely to be limiting in some of the drier parts of New Zealand (eg: Central Otago). Overall, GLS is likely to spread throughout New Zealand if not controlled.

Rate of Spread

Apart from a statement that the adults are poor fliers (Harris, 1974 – in Bain et al, 1997) there is virtually no information available on the rate of spread of this species. The larvae do not disperse widely. Movement of larvae from one host to another does occur but it is uncommon unless there is a shortage of food material and even then the trees must be in very close proximity, if not actually in contact. Larvae can lower themselves to the ground on silken thread and can be blown a short distance by the wind. When on the ground larvae will only move a short distance to locate another tree. (Bain et al 1997).

An estimate of their natural rate of spread is 1 km per generation (Withers, pers comm). Assuming two generations per year in most of New Zealand, this will give a natural rate of spread of 2 km per year. At this rate, it would take 100 plus years for GLS to reach the main eucalyptus plantations in the upper North Island, and hundreds of years to spread throughout New Zealand as a whole.

The economic impact of this in present value terms would be virtually zero, due to the discounting effect over such a long time period.

The more likely scenario affecting the rate of spread of GLS throughout the country, is via human intervention. The probability of infected plant material being transported, albeit unwittingly, to other areas of the country is very high. Other introduced insects which affect eucalypts have spread much more rapidly than their "natural rate of spread" would suggest (Withers, 2001). The main assumption used on the rate of spread of GLS through New Zealand is shown in table one.

Table 1: Spread Rate

	Year	
Auckland	2003	
Rest of Upper NI	2007	(5 yrs)
Lower NI	2012	(10 yrs)
Upper SI	2017	(15 yrs)
Lower SI	2022	(20 yrs)

This very closely mirrors the rate of spread of the leaf blister sawfly, another common insect pest of eucalypts in Australia (Withers, pers comm).

Geographic Regions

As shown in Tables 1 and 2, the country was split into five regions for this analysis:

Auckland:	North Shore City, Waitakere City, Auckland City, Manukau City, and Papakura District.
Upper North Island:	Northland, Waikato (including all of Franklin District) Bay of Plenty, Gisborne, and Rodney District.
Lower North Island:	Taranaki, Manwatu-Wanganui, Hawke's Bay, and Wellington.
Upper South Island:	Tasman, Marlborough, West Coast, and Canterbury.
Lower South Island:	Otago and Southland.

Economic Assessment

General/Methodology

The economic impact of GLS is based on determining the increased costs that would be incurred if it were allowed to spread throughout New Zealand. In production forestry increased costs would be incurred via the need for monitoring, spraying, and increased rotation length in order to maintain production volumes. For amenity trees costs would be incurred via the need for some spraying to protect the trees, and replacement of some trees. Potentially there would be some public health implications from GLS, which could not be readily quantified. If anything, health concerns would be one incentive to spray in urban areas.

The benefit therefore is in preventing these increased costs.

It should be noted that there was a dearth of quantifiable data on GLS in New Zealand, so a number of assumptions were required, which are detailed throughout this report. Perhaps the main assumption was that, in the absence of any natural bio-controls, the severity of impact of GLS would be much higher in New Zealand compared with Australia.

The assumption on the rate of spread was outlined in Table 1. Again in the absence of any quantifiable data, the rate of impact of GLS was modelled on a “biological” expansion, as outlined in Table 2. This was discussed with Forest Research staff (Withers, pers comm) who thought it realistic.

Table 2: Impact Rate

Yr 1 after arrival	10%
Yr 2	20%
Yr 3	40%
Yr 4	70%
Yr 5	100%

The various scenarios outlined below are predicated on these base assumptions of rate of spread and rate of impact. The scenarios were costed out through to 2030, and discounted back to give a net present value.

Discount Rate

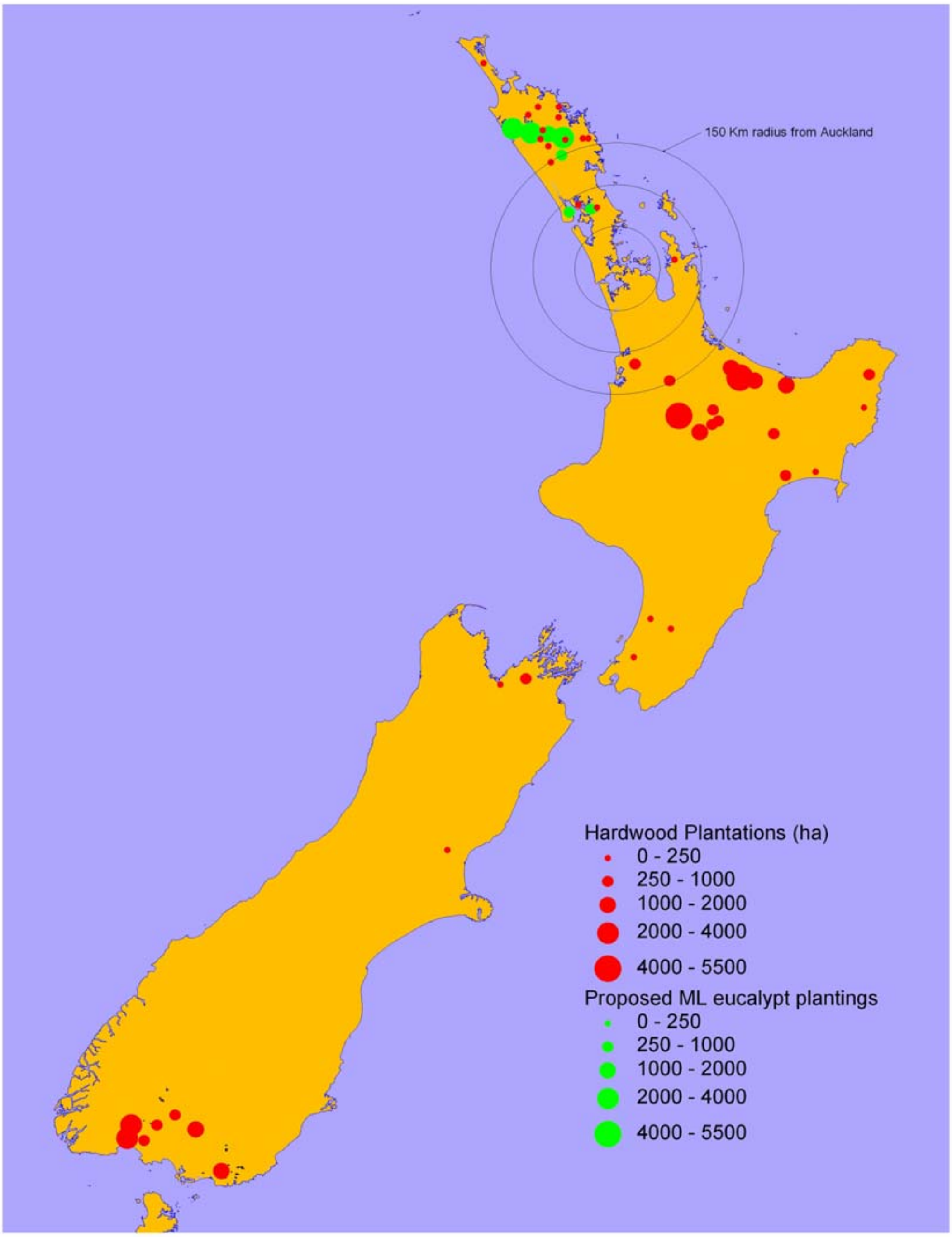
The discount rate used is the Treasury guideline rate of 10%.

Production Forestry Impact

Areas of Eucalypt

There are no exact statistics on areas planted in Eucalypt for production forestry. The National Exotic Forest Description (NEFD, MAF 2003) of Production Forest Plantations includes eucalypt species as “Hardwoods”. As at 1 April 2002, New Zealand had 54,315 ha of hardwoods in planted production forests, with the two main areas being the Central North Island and Southland. The distribution of these hardwood plantations is shown in Figure 1.

Figure 1: New Zealand Hardwood Plantations



Source: NEFD, MAF (2002)

Forestry opinion as to the proportion of eucalypts within the Hardwood estate was “80-90%”. Bain et al, 1997, used a figure of 80% in their analysis. However, there have been further plantings of eucalypts since then, particularly in the south, and the average proportion assumed in this analysis was 85%. The area of eucalypts in New Zealand is shown in Table 3.

Table 3: Areas of Eucalypts

	Hardwoods (ha)	Eucalypts (ha)
Auckland	1140	969
Rest of Upper NI	29,372	24,966
Lower NI	3,231	2,746
Upper SI	5,223	4,440
Lower SI	15,349	13,047
Total	54,315	46,168

Note: Eucalypts as a percentage of Hardwoods: 85%

Source: NEFD, 2002

The main *Eucalyptus* species planted for production forestry are as follows, all of which are susceptible to GLS:

E.nitens
E.fastigata
E.regnans
E.saligna
E.delegatensis
E.pilularis
E.muelleriana

It was very difficult to get any estimate on future intentions of expansions of the Eucalypt forestry areas. As Figure 1 indicates, there is some interest in expanding the hardwood estate in Northland. However, this is only a proposition at this point in time. Given this, no allowance has been made in this analysis for any expansion in the eucalypt forestry area.

Production systems

Much of the *Eucalyptus* resource is grown for pulpwood or chipwood, particularly the larger stands. There are a number of small woodlots scattered throughout the country as part of the farm forestry estate. Many of these smaller woodlots would be mostly for timber production. The amount of *Eucalyptus* timber being milled in New Zealand is very small, and it was not possible to determine accurate costs and returns for a timber production system. Therefore the assumption was made for this analysis that all production *Eucalyptus* forests were for pulpwood, and costed accordingly.

Within the North Island, a typical pulpwood regime is a 12-year rotation, and this was used as the basis for costing North Island *Eucalyptus* pulp production. In the South Island, growth rates tend to be somewhat slower, with typical rotation lengths being 13-15 years (Poole, Trost, pers comm). The main eucalyptus production forest in Southland is currently on a 12 year rotation, but the intent is to move to a 15 year rotation as soon as sufficient land is available (Manly, pers comm). A standard 15-year rotation was assumed for all South Island eucalypt forests. Costs and returns for these regimes were based on the “medium” costs and returns stated in Dana (2002), as shown in Appendix 2. A higher volume production and greater return per cubic metre was assumed for the South Island regime, given the longer rotation length.

Gum Leaf Skeletoniser Impact

Increased costs would be incurred in various ways relating the impact of GLS.

(1) Monitoring Costs

Given the absence of any bio-controls for GLS, it was felt that an ongoing programme would be required to monitor the build-up of GLS numbers, and the impact they were having on *Eucalyptus* trees. This would most probably involve an annual monitoring exercise (Bulman, pers comm). This monitoring would be in addition to any current forest health monitoring programme, and would require monitoring from the ground. The average monitoring cost of the current pest detection carried out by Forest Health in pine forests is 70 cents/hectare/year (Bulman, pers comm). The smaller size of the eucalyptus forests would mean less economy of scale, and hence higher costs. Poole (pers comm) indicated a cost of $1.38/hectare to monitor eucalyptus forests within a 47 km radius of Rotorua. Given the varying distances and size of forests throughout New Zealand, an average cost of $1.50/ha was used in this analysis. Also given that GLS produces two sets of eggs per year, a double survey was assumed in the year prior to any spraying, as numbers multiplied up.

(2) Spray Costs

Given the absence of natural predators, and the likely resultant severity of defoliation, it was felt that spraying of trees to control GLS was very likely. The regularity of this is uncertain, but would most probably follow a pattern of:

GLS numbers build up → defoliation becomes severe → spray → GLS numbers significantly reduced → GLS numbers start to build up → defoliation becomes severe → spray → GLS numbers relative low → and so on

For the purposes of this analysis, it was assumed that spraying for GLS would be necessary every five years.

The general consensus on the cost of spraying was $120/ha (Hammond, Towler, Foran, pers comm). Broadly, this would be broken down into $100/ha for chemical costs and $20/ha for aerial application and ground crew costs. Currently the average cost of spraying the Painted Apple Moth in Auckland is $96/ha (Towler, pers comm). It is likely that the cost of spraying smaller woodlots would be greater on a per hectare basis, but there are no statistics on the size distribution of eucalypt plantations.

It is most likely that the spray used in eucalypt plantations would be a synthetic pyrethroid, as this has a much greater efficacy compared to Bt (Hammond, pers comm). Pyrethroid-based sprays are more expensive, but given their greater knock-down, less spray runs would be required.

(3) Extension of Rotation

Australian work has shown that the growth rate of eucalypts slowed for two years after severe defoliation, and then recovered (Lowman, 1987, Withers, pers comm). Quite possibly the recovery was aided by natural bio-control taking out the GLS. In New Zealand, the severity of the defoliation is likely to be greater in the absence of bio-controls, and in the absence of spraying to kill GLS, growth rates are likely to be more affected.

As *Eucalyptus* trees mature, the properties of the fibre deposited in the trunk alter, such that any slowing of growth means that the forestry rotation is more likely to be lengthened in order to harvest a similar quality tree, as opposed to cutting the tree at the intended age (year 12) albeit at a lower volume. In order to model this within the analysis, it was assumed that the average North Island rotation length would extend to 14 years, and the South Island rotation length would extend to 18 years.

Cost Benefit Calculation

A cashflow was constructed for the standard 12-year and 15-year rotations respectively, as shown in Appendix 3. These were then adjusted for the simulated GLS impact.

For the North Island scenario, it was assumed that:

A monitoring cost of $1.00/ha was incurred every year throughout the rotation, with double surveys being carried out in years 4 and 9, prior to spraying. Sprays were carried out in years 5 and 10, and the rotation length extended to 14 years.

For the South Island scenario, monitoring costs were incurred in every year with double surveys in years 4, 9 and 14, sprays occurring in years 5, 10 and 15, and the rotation length extended to 18 years.

The difference in net present values (NPV) between the "standard" and the "GLS-impacted" was calculated (refer Appendix 3). These were then extrapolated across the whole country, relative to the rate of spread and rate of impact assumptions noted earlier, and a NPV calculated. This is shown in Appendix 4.

The overall impact of GLS on the New Zealand Eucalypt Forestry Estate was calculated at $69.4 million.

Amenity Impacts

General

The amenity value of trees comes from their contribution to improving the climatic, air and water quality of urban areas, as well as the social and psychological wellbeing of urban dwellers. Allocation of a value for this amenity service is very complex. A range of non-market valuation methodologies can be used (Rosenberger & Smith, 1997), as well as a range of specific tree-valuation methodologies as discussed by Treeby (1998). Given the limit on time and resources available, no non-market valuation type approaches were contemplated for this analysis. However, it is worth noting that currently a "willingness to pay" project is under way in Auckland.

The approach used in this analysis was two-fold:

(i) A direct replacement of eucalyptus trees for other species; and
(ii) the "Treeby" methodology.

(1) Replacement Tree Approach

This approach models the direct cost of replacing eucalyptus trees in the amenity estate over time, with non-GLS susceptible species. It does not attempt to place any value on the social and psychological effects of damaged trees.

An estimate of the number of trees in Major Urban, Secondary Urban, and Minor Urban centres is available from Treeby (1997). He also splits these trees into a number of categories: those on streets, those in parks and reserves, and those in urban schools and golf courses. A telephone and email survey was carried out on 12 cities and 15 regional golf centres, as to the percent of trees in their respective areas that may be eucalypts. The responses indicated some variation, ranging from 1-10% in the cities, with an average of around 3-5%; whereas the golf courses ranged from 1-10%, with an average of around 2-3%.

For the purposes of this analysis a medium value of 3% was used as the proportion of eucalypts within the national tree amenity estate.

In the Painted Apple Moth (PAM) Economic Impact Assessment, Branson (2002) calculated the costs involved for a combination of spraying of trees to control PAM, as well as some replacement of affected trees. Spraying to control PAM, given the wide range of trees it attacks, involves blanket spraying. Control of GLS in the amenity estate via spraying would be somewhat more problematic.

Spraying individual trees or clumps of trees in urban or semi-urban areas would be an expensive exercise. Hammond (pers comm) noted that Civil Aviation Regulations require twin-turbine helicopters over urban areas; the cost of these is in the order of $3,500-$4,000/hour. Given a somewhat “stop-start” spraying system, the best they may be able to achieve is 5-10 hectares/hour. This would give a cost in the order of $400-$700/hectare, on top of which would be the chemical cost and any ground crew cost. Currently, with the Painted Apple Moth spraying, aircraft must also remain above 150 feet, which with helicopters, gives a 200 foot lateral movement of the spray (Hammond, pers comm). Using helicopters to spray individual trees or clumps of trees would mean that a reasonable area around these trees would also end up being sprayed. Dispensation would be required from Civil Aviation if the helicopters were to fly in more closely in order to achieve a more accurate placement.

Another possibility would be ground spraying using cherry pickers (or something similar). Hireage cost of this equipment, based on discussions with Hamilton hireage firms, would be in the order of $260/day, or $200-$220/day for “five-days or more” hireage. On top of this would be the normal costs of a spraying contractor. Estimate of contract spray costs proved difficult, as local contractors talked to had never attempted to spray mature trees and were unwilling to provide estimates.

Given the relatively low percentage of *Eucalyptus* trees in the amenity estate, and the relatively high cost of aerial spraying, it is problematic whether urban authorities, schools and golf courses would spray to protect these trees. Potentially, areas of significant landscape value would be protected, and public health issues (discussed later) could provide an incentive for GLS control in the more public areas. Additionally, trees in residential sections are unlikely to be sprayed due to the expense and issues of spraying in residential areas.

Replacement of Trees

The main assumption therefore is that spraying is an unlikely control measure for GLS in the amenity tree estate, and affected trees would be replaced with non-GLS susceptible species.

For this analysis it was assumed that all eucalypts would be replaced over a 15 year period, starting five years after GLS first arrived; ie: when it was at 100% impact rate.

It was also assumed that the rate of replacement of eucalypt trees would follow a "skewed" bell shaped curve, with a longer tail. The assumption was that replacement would start out slowly, build up rapidly to a peak, and then tail off as the more difficult to get at trees (and probably more expensive) were slowly replaced. This is illustrated in Table 4.

Table 4: Rate of Replacement of Amenity Eucalypts

Year 1	GLS Arrives
Year 5	GLS at full impact
	% of Eucalypts Replaced
Year 5	2%
Year 6	3%
Year 7	5%
Year 8	7%
Year 9	12%
Year 10	13%
Year 11	12%
Year 12	10%
Year 13	9%
Year 14	7%
Year 15	6%
Year 16	5%
Year 17	4%
Year 18	3%
Year 19	2%
	100.0%

The cost of removing the eucalyptus trees and replacement with an alternative was set at $864. This is based on the 1997 NZIER cost (discussed in Branson, 2002) updated to 2003 using the CPI.

Results

The above assumptions were incorporated with the rate of spread and rate of impact assumptions discussed earlier, and cashflowed through to 2041(Appendix 6). The resulting NPV was: $72.5 million.

(2) Treeby Methodology

In 1997, Bruce Treeby produced a report entitled "Urban Tree Estate Amenity Values and Pest Risk" for the Ministry of Forestry Biosecurity team. This report used a combination of the Standard Tree Evaluation Method (STEM) – (Flook, 1996) and the "Toy/Gould Auckland City Model" in an attempt to value the urban tree estate in New Zealand. The report used the Resource Management Act interpretation and application of amenity values, and recognised that amenity values were closely related to the wealth of communities and relative values for different urban areas were based on the 1996 average house values provided by Valuation New Zealand.

The application of STEM to broad scale landscape applications has shown that the method gives large over-valuations (Treeby 1998), and within the 1997 report, Treeby adapted the STEM applications to generate more realistic values and to reflect the variation of amenity values within and between urban areas. Using this methodology, Treeby calculated that the national total value of urban trees to New Zealand was $11 billion – approximately 5% of what would have been generated by the unmodified STEM process.

Essentially the methodology used by Treeby is based on a replacement cost of trees of different types. Full details of this are explained in his paper. Using this methodology, Treeby derived a matrix, which calculated the impact on the tree amenity values, relative to the percent of trees attacked and the degree of damage. This is illustrated below in Table 5.

Table 5: Pest Value Matrix for Urban Tree Estate Amenity Value Loss

Percentage of Trees Attacked	High Impact 60% damage	Medium Impact 20% damage	Low Impact 5% Damage
15%	$993,631,259	$331,210,420	$82,802,605
10%	$662,420,839	$220,806,946	$55,201,737
5%	$331,210,420	$110,403,473	$27,600,868

Source: Treeby, 1997

In the absence of time to re-work Treeby's spreadsheets up from first principals, the above matrix was inflated through to 2003 using the CPI. This gave the results outlined in Table 6.

Table 6: Pest Value Matrix for Urban Tree Estate Amenity Value Loss, Updated to 2003 using the CPI: 1997-2002 of 7.98%

Percentage of Trees Attacked	High Impact 60% damage	Medium Impact 20% damage	Low Impact 5% Damage
15%	$1,072,884,002	$357,628,001	$89,407,000
10%	$715,256,001	$238,418,667	$59,604,667
5%	$357,628,001	$119,209,334	$29,802,333

To calculate the impact of Gum Leaf Skeletoniser, it was assumed that *Eucalyptus* trees make up 3% of the urban amenity estate. This was then applied to the percent of urban amenity trees in the regions being used for this analysis, and then multiplied up using the rate of spread and rate of impact assumptions. Assuming a medium level of impact (20% damage) as defined by Treeby, the net present value of this impact is $31.5 million.

Details of calculations are shown in Appendix 7.

Health Impacts

Each body segment of the GLS larvae has ten tubercle-carrying setae, of which there are two ventral, four lateral, and four dorsal. The four dorsal tubercles carry stiff, brown-tipped bristles, with an envenomating capacity. When these brown-tipped bristles are allowed to touch the skin (except thick palmar skin) they immediately cause a sharp stinging sensation, followed by a weal and flare (Southcott, 1978).

This stinging is caused even by the most juvenile early-hatched larvae, as well as via cast larval skins.

It is apparent that contact with any stage of the live larvae causes immediate stinging. A similar, but initially lesser reaction, occurs from contact with cast larval skins. After the spines contact the skin, there is an immediate stinging reaction attributable to the histamine content. This is followed by an erythema, then a slow wealing. These lesions can be visible for several weeks (Southcott, 1978).

Given that both the number of people affected and the probability of severe reaction are likely to be low, the total costs, such as medical expenses and labour productivity losses due to absence from work, are thought likely to be relatively small. The Ministry of Health thought it was unlikely to be significant across the range of the population (Gilbert, pers comm). While the risk to human health may be relatively low, the potential impact would provide one incentive for both households and authorities responsible for such areas as parks and reserves, schools, and golf courses, to spray to control GLS.

No costings were allowed in this analysis for any health impacts.

Conservation Estate

At this stage, the impact of GLS on native flora is unknown. Trials are underway at Forest Research to determine this. No costing was allowed for in this current analysis.

Trade

No impact on trade or market access as a result of GLS was allowed for in this report. Discussions with MAF Policy International (Allen, pers comm) and MAF Biosecurity (Self, pers comm) indicated a low probability of any constraints. There may be some risk if there was a major outbreak and cross-contamination occurred.

While the general risk was assessed as minor, there is still a degree of “unknowness”.

Results

At the 10% discount rate, the impact on production forestry is $69.4 million.

The amenity impact was:

(i) Tree Replacement = $72.5 million

(iii) Treeby methodology = $31.5 million

Overall, the impact was:

Production plus tree replacement = $141.9 million
Production plus Treeby = $100.9 million

Sensitivity Analysis

(1) At a 5.6% discount rate (Govt 10-year bond rate) the impact increases to:
Production Forestry = $161.6 million

Amenity:
(i) Tree replacement = $140.9 million

(ii) Using the Treeby methodology = $43.4 million

Combined:
Production plus tree replacement = $302.5 million
Production plus Treeby amenity = $205 million

(2) If the percent of eucalypts in the amenity estate are varied. Current scenario equals 3%.

(i) For tree replacement, a 1% increase or decrease altered the NPV by $24.1 million.
(ii) Using the Treeby methodology a 1% change altered the NPV by $10.5 million.

(3) The major cost to the production forestry system was the extension to the rotation length in order to maintain volumes. An alternative to this would be to increase the number of sprays to prevent any damage.

Current scenario of extending rotation; NPV @ 10% = $69.4 million

(i) If spraying 5-yearly were sufficient to control GLS – no extension of rotation required; NPV @ 10% = 16.4 million
(ii) Spraying 2-yearly from Year 3, but not in the final year; NPV @ 10% = $40.3 million
(iii) Spraying annually from Year 3, but not in the final year; NPV @ 10% = $70.1 million.

From this analysis, it would appear that biennial spraying is more economic than allowing the rotation to extend, while annual spraying is on a par.

(4) Change in the rate of replacement of eucalyptus within the amenity estate.

If trees were replaced at a

(i) Linear rate NPV @ 10% = $55.5 million
(ii) If trees were replaced at a curvilinear rate NPV @ 10% = $48.8 million

Table 7: Linear Rate

Year 1	GLS Arrives
Year 5	GLS at full impact
	% of Eucalypts Replaced
Year 5	0.5%
Year 6	1.0%
Year 7	2.0%
Year 8	3.0%
Year 9	4.0%
Year 10	5.0%
Year 11	6.0%
Year 12	7.0%
Year 13	8.0%
Year 14	9.0%
Year 15	9.5%
Year 16	10.0%
Year 17	11.0%
Year 18	12.0%
Year 19	12.0%
	100.0%

Table 8: Curvilinear Rate

	% of Eucalypts Replaced
Year 5	0.5%
Year 6	0.8%
Year 7	1.0%
Year 8	1.5%
Year 9	2.0%
Year 10	2.2%
Year 11	3.0%
Year 12	4.5%
Year 13	6.0%
Year 14	7.5%
Year 15	9.0%
Year 16	11.0%
Year 17	14.0%
Year 18	17.0%
Year 19	20.0%
	100.0%

(5) Rate of spread is twice that of original assumption.

Table 9: Spread Rate

	Year	
Auckland	2003	
Upper NI	2012	(10 yrs)
Lower NI	2022	(20 yrs)
Upper SI	2032	(30 yrs)
Lower SI	2042	(40 yrs)

Forestry impact: NPV @ 10% = $44.4 million
Replacement of amenity trees = $51.5 million
Treeby = $27.6 million

(6) Rate of impact of GIS is twice that of original assumption (follows a curvilinear pattern).

Table 10: Rate of Impact

Impact Rate:	
Yr 1 after arrival	3%
Yr 2	7%
Yr 3	12%
Yr 4	20%
Yr 5	30%
Yr 6	45%
Yr 7	60%
Yr 8	75%
Yr 9	90%
Yr 10	100%

Forestry impact – NPV @ 10% = $53.2 million
* Replacement amenity trees = $52.2 million
Treeby = $24.2 million
*Assumes trees start being replaced in Year 8 of impact.

(7) Assume both rate of spread and rate of impact twice original assumption.

Forestry impact. NPV @ 10% = $33.5 million
Replacement amenity trees = $38.7 million
Treeby = $21.9 million

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Appendix 1

Recordeded Hosts *Uraba Lugens* in Australia

[Extract from "Impact Assessment for the gum leaf skeletoniser, Uraba lugens, Walker (Lepidoptera: Nolidae) in New Zealand by John Bain, Heather McKenzie & Roger Crabtree, New Zealand Forest Research Institute Limited, Rotorua, 10 October 1997" publication.]

Section Rufaria
- Corymbia calophylla
- Corymbia ficifolia

Section Quadraria
- Eucalyptus (Eudesmia) erythrocorys

Section Hesparia
- Eucalyptus (Monocalyptus) patens

Section Renantheria
- Eucalyptus (Monocalyptus) delegatensis
- Eucalyptus (Monocalyptus) dives
- Eucalyptus (Monocalyptus) elata
- Eucalyptus (Monocalyptus eugenioides
- Eucalyptus (Monocalyptus) marginata
- Eucalyptus (Monocalyptus) macrorhyncha
- Eucalyptus (Monocalyptus) muelleriana
- Eucalyptus (Monocalyptus) obliqua
- Eucalyptus (Monocalyptus) pauciflora
- Eucalyptus (Monocalyptus) pilularis
- Eucalyptus (Monocalyptus) radiata
- Eucalyptus (Monocalyptus) regnans
- Eucalyptus (Monocalyptus) robertsonii
- Eucalyptus (Monocalyptus) stellulata

Section Adnataria
- Eucalyptus (Symphomyrtus) crebra
- Eucalyptus (Symphomyrtus) largiflorens
- Eucalyptus (Symphomyrtus) leucoxylon
- Eucalyptus (Symphomyrtus) moluccana
- Eucalyptus (Symphomyrtus) melanophloia
- Eucalyptus (Symphomyrtus) melliodora

Section Bisectaria
- Eucalyptus (Symphomyrtus) conferruminata
- Eucalyptus (Symphomyrtus) decipiens
- Eucalyptus (Symphomyrtus) wandoo

Section Exsertaria
- Eucalyptus (Symphomyrtus) blakelyi
- Eucalyptus (Symphomyrtus) camaldulensis
- Eucalyptus (Symphomyrtus) rudis
- Eucalyptus (Symphomyrtus) tereticornis

Section Maidenaria
- Eucalyptus (Symphomyrtus) bridgesiana
- Eucalyptus (Symphomyrtus) crenulata
- Eucalyptus (Symphomyrtus) dalrympleana
- Eucalyptus (Symphomyrtus) globulus
- Eucalyptus (Symphomyrtus) nitens
- Eucalyptus (Symphomyrtus) viminalis

Section Transversaria

Eucalyptus (Symphomyrtus) diversicolor
Eucalyptus (Symphomytus) grandis
Eucalyptus (Symphomyrtus) robusta
Eucalyptus (Symphomyrtus) saligna

There is also one reference to it feeding on Lophostemon confertus (brush box).

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Appendix 2

Costs and Returns, *Eucalyptus* Pulp Regime

2002 Growing Costs – North Island, New Zealand E. Nitens/Fastigata (NZ$/ha, M^3/ha and NZ$/M^3)

Year	Operation	Low NZ$/ha	Medium NZ$/ha	High NZ$/ha
-1	Land Purchase	1,000	2,000	3,500
-1	Access Tracking	50	100	150
-1	Site Preparation	150	270	325
0	Animal Control	20	35	40
0	Planting	500	700	800
0	Weeding	100	130	160
0	Nutrition	100	140	180
1	Weeding	100	130	160
10	Roading	2.5	4	6
10	Harvesting	10	20	30
10	Transport	8	12	17
All	Annual Costs	30	45	60
	Yield	**Low m^3/ha**	**Medium m^3/ha**	**High m^3/ha**
10	Pulp	160	250	350
	Stumpage	**Low NZ$/$m^3$**	**Medium NZ$/$m^3$**	**High NZ$/$m^3$**
10	Pulp	15	30	45

Source: The NZ Forest Products Industry Review, 2002 Edition, DANA Publishing

Appendix 3

(i) Economic Impact of GLS on North Island Eucalypt System

Standard 12 year rotation

Per Hectare — Discount rate: 10%

Year	Costs			NPV	$676.39
0	370		-370		
1	1005		-1005		
2	130		-130		
3	45		-45		
4	45		-45		
5	85		-85		
6	45		-45		
7	45		-45		
8	45		-45		
9	45		-45		
10	45		-45		
11	45		-45		
12	49	7500	7451		

Yr 12	Volume (m^3):	250
	Price $\$/m^3$	30

Impact of GLS

Per Hectare — Discount rate: 10%

Year	Costs			NPV	$179.76
0	370		-370		
1	1006		-1006		
2	131		-131		
3	47		-46.5		
4	48		-48		
5	166		-166		
6	47		-46.5	**NPV Difference:**	$496.63
7	47		-46.5		
8	47		-46.5		
9	48		-48		
10	166		-166		
11	47		-46.5		
12	47		-46.5		
13	47		-46.5		
14	49	7500	7451		

Yr 12	Volume (m^3):	250
	Price $\$/m^3$	30

(ii) Economic Impact of GLS on South Island Eucalypt System

15 Year Rotation

Per Hectare

				Discount rate:	10%
Year	Costs			NPV	$1,726.15
0	370		-370		
1	1005		-1005		
2	130		-130		
3	45		-45		
4	45		-45		
5	45		-45		
6	45		-45		
7	45		-45		
8	45		-45		
9	45		-45		
10	45		-45		
11	45		-45		
12	45		-45		
13	45		-45		
14	45		-45		
15	49	14850	14801		

Yr 15	Volume (m^3):	330
	Price $/$m^3$	45

Impact of GLS

Per Hectare

				Discount rate:	10%
Year	Costs			NPV	$751
0	370		-370		
1	1006		-1006		
2	131		-131		
3	47		-46.5		
4	48		-48		
5	166		-166		
6	47		-46.5		
7	47		-46.5	**NPV Difference:**	$975.24
8	47		-46.5		
9	48		-48		
10	166		-166		
11	47		-46.5		
12	47		-46.5		
13	47		-46.5		
14	48		-48		
15	166		-166		
16	47		-46.7		
17	47		-46.5		
18	49	14850	14801		

Yr 18	Volume (m^3):	330
	Price $/$m^3$	45

Appendix 4

Economic Impact of GLS on New Zealand *Eucalyptus* Forests

Discount rate:	10%
NPV	$69,418,130

	Hectares Affected								
		Rest of				Cummulative	Cost Per	Cost Per	
	Auckland	Upper NI	Lower NI	Upper SI	Lower SI	Hectares	Hectare NI	Hectare SI	Total cost
2003						0	$497		$0
2004	97					97			$48,124
2005	194					194			$96,247
2006	388					388			$192,494
2007	678					678			$336,865
2008	969	2497				3466			$1,721,134
2009	969	4993				5962			$2,961,032
2010	969	9986				10955			$5,440,829
2011	969	17476				18445			$9,160,525
2012	969	24966				25935			$12,880,220
2013	969	24966	275			26210			$13,016,613
2014	969	24966	549			26484			$13,153,005
2015	969	24966	1099			27034			$13,425,789
2016	969	24966	1922			27858			$13,834,966
2017	969	24966	2746			28682			$14,244,142
2018	969	24966	2746	444		29126		$975	$14,677,105
2019	969	24966	2746	888		29569			$15,110,068
2020	969	24966	2746	1776		30457			$15,975,994
2021	969	24966	2746	3108		31789			$17,274,882
2022	969	24966	2746	4440		33121			$18,573,771
2023	969	24966	2746	4440	1305	34426			$19,846,133
2024	969	24966	2746	4440	2609	35730			$21,118,494
2025	969	24966	2746	4440	5219	38340			$23,663,218
2026	969	24966	2746	4440	9133	42254			$27,480,304
2027	969	24966	2746	4440	13047	46168			$31,297,390
2028	969	24966	2746	4440	13047	46168			$31,297,390
2029	969	24966	2746	4440	13047	46168			$31,297,390
2030	969	24966	2746	4440	13047	46168			$30,816,155

Appendix 5

Urban Tree Numbers (from Treeby 1997)

	Major Urban	Secondary Urban	Minor Urban	Total
Auckland	3,714,134			3,714,134
Rest of Upper NI	1,829,093	377,133	946,992	3,153,218
Lower NI	2,821,667	670,979	457,019	3,949,665
Upper SI	1,683,307	450,191	268,744	2,402,242
Lower SI	1,415,738	142,853	138,021	1,696,612
				14,915,871

Tree Numbers (a) Streets	Major Urban	Secondary Urban	Minor Urban	Total
Auckland	139019			139,019
Rest of Upper NI	47162	8393	16537	72,092
Lower NI	77785	11181	9952	98,917
Upper SI	48998	9468	6375	64,840
Lower SI	11339	2853	3988	18,179
				393,048

(b) Parks & Reserves

Auckland	2291913			2,291,913
Rest of Upper NI	1230286	257643	507657	1,995,585
Lower NI	1830756	343231	305494	2,479,481
Upper SI	1066474	290639	195691	1,552,804
Lower SI	1152387	87567	122421	1,362,375
				9,682,158

Urban Schools & Golf Courses (ha) **(Treeby 1997)**

	Major Urban	Secondary Urban	Minor Urban	Total
Auckland	1532			1,532
Rest of Upper NI	1176	252	1596	3,024
Lower NI	1890	462	1176	3,528
Upper SI	798	504	840	2,142
Lower SI	462	252	504	1,218
				11,444

Urban Dwellings (from 2001 Census)

Auckland	353,106
Rest of Upper NI	327,420
Lower NI	332,466
Upper SI	246,978
Lower SI	107,673
Total	1,367,643

Appendix 6

Replacement of Eucalyptus Trees in the Amenity Estate

Discount rate:	10%
NPV:	$72,539,963

	Auckland	Upper NI	Lower NI	Upper SI	Lower SI	Total
2003						0
2004						0
2005						0
2006						0
2007	1925051					1925051
2008	2887576					2887576
2009	4812626					4812626
2010	6737677					6737677
2011	11550303					11550303
2012	12512828	1634326				14147154
2013	11550303	2451488				14001791
2014	9625253	4085814				13711066
2015	8662727	5720139				14382867
2016	6737677	9805953				16543630
2017	5775152	10623116	2047127			18445394
2018	4812626	9805953	3070691			17689270
2019	3850101	8171628	5117818			17139546
2020	2887576	7354465	7164945			17406986
2021	1925051	5720139	12282763			19927953
2022		4902977	13306327	1245092		19454395
2023		4085814	12282763	1867637		18236214
2024		3268651	10235636	3112729		16617016
2025		2451488	9212072	4357821		16021381
2026		1634326	7164945	7470550		16269820
2027			6141382	8093096	879361	15113838
2028			5117818	7470550	1319041	13907409
2029			4094254	6225458	2198402	12518114
2030			3070691	5602912	3077763	11751366
2031			2047127	4357821	5276165	11681113
2032				3735275	5715845	9451120
2033				3112729	5276165	8388894
2034				2490183	4396804	6886987
2035				1867637	3957124	5824761
2036				1245092	3077763	4322854
2037					2638082	2638082
2038					2198402	2198402
2039					1758722	1758722
2040					1319041	1319041
2041					879361	879361

Appendix 7

Amenity Impact of GLS Using Treeby Methodology

Discount Rate:	10%
NPV:	$31,481,018

	Auckland	Upper NI	Lower NI	Upper SI	Lower SI	Cumulative Cost
2003						0
2004	2861024					2861024
2005	2861024					2861024
2006	5722048					5722048
2007	8583072					8583072
2008	8583072	1430512				10013584
2009		1430512				1430512
2010		2861024				2861024
2011		4291536				4291536
2012		4291536				4291536
2013			1788140			1788140
2014			1788140			1788140
2015			3576280			3576280
2016			5364420			5364420
2017			5364420			5364420
2018				715256		715256
2019				715256		715256
2020				1430512		1430512
2021				2145768		2145768
2022				2145768		2145768
2023					357628	357628
2024					357628	357628
2025					715256	715256
2026					1072884	1072884
2027					1072884	1072884
2028						0
2029						0
2030						0