Forestry Insurance, Risk Pooling and Risk Minimisation Options

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1. Summary

The focus of this report is to evaluate the financial market opportunities that currently exist, and those that might feasibly come into existence, to provide relief from the physical risk associated with carbon forestry, including the options of insurance and risk pooling for post-1989 forest owners.

Under carbon forestry, and the Emissions Trading Scheme as it is currently legislated, the forest grower is subject to two types of loss from physical risk such as catastrophic wind or fire events:

- Loss of the tree crop.
- The premature surrender of carbon units that would not otherwise have been surrendered until the time of planned harvest (if indeed harvesting is intended).

Although there are a number of insurance products that cover the loss of a tree crop the majority of New Zealand plantations are not insured. A survey of New Zealand forestry companies that own or manage over 10,000 ha of plantation (1,053,000 ha of plantation in total or approximately 59% of the national plantation estate) found that while 36% of this area is insured for fire, only 19% is also insured for wind damage. While wind is a more important risk factor than fire, the cost of insurance means that fewer companies are insured for it.

The general pattern is that smaller companies have insurance while larger companies tend to have self coverage; ie, self-protection and self-insurance. The majority of the Kyoto-compliant plantations in New Zealand are not included in the survey because of the 10,000 ha limit used. Some of these "small-scale" plantations are insured particularly those that are professionally managed, in some cases only for fire.

To date there is only one product that is also offering cover on carbon units – Standsure which has been developed by FMR RiskSolutions and underwritten by QBE. Other forestry insurance providers plan to expand their cover to include carbon. Using indicative premium costs for the available product we calculate the impact of the cost of insurance on forest profitability and forest value for an example regime (assuming a carbon price of \$30/t CO_2-e). The cost of insuring for both tree crop loss and premature carbon surrender causes the LEV to reduce from \$6647/ha to \$6205/ha while the reduction in overall crop value is as high as \$627/ha.

The base (no insurance) LEV of \$6647/ha ignores risk. Analysis of historical data indicates that many parts of New Zealand have a catastrophic wind loss probability of around 0.25% per year (Somerville 1995) and a fire loss probability of 0.02 to 0.06% per year (Pearce *et al.* 2000, Watt *et al.* 2008). LEV reduces to \$6366/ha if an annual probability of 0.25% is assumed for catastrophic loss and to \$6088/ha with 0.5% loss per year. The LEV adjusted for the cost of insurance falls within the range of these risk-adjusted LEVs.

A limiting factor for wind insurance is that policies typically have an upper limit on the wind damage that can be claimed for any event. For example, the policy that we evaluated limits wind damage to $500,000 per claim for a 50 ha plantation and only applies to trees over 5 years of age. This limit means that a forest may only be partially covered, particularly when carbon unit loss is added to tree crop loss.

Consequently, an insurance mutual may be a suitable vehicle to provide coverage for the carbon component. A group of forest owners, acting as a mutual, could eliminate carbon risk. Forest owners in the mutual would put all eligible forests into the ETS and receive carbon units but not sell all units – i.e., they would leave some units in the registry account. The mutual could provide these "pooled" units to members for whom a catastrophic loss triggered the premature surrender of carbon units. In this way, at a premium of the loss of earnings on the carbon units that were not traded, the mutual would have managed to eliminate all of the risk involved if units had to be re-purchased for early surrender. A question to resolve is the percentage of units that would need to be left in the mutual pool.

An alternative to the mutual would involve the government retaining a specified percentage of carbon units and using these to "write-off" units in the registry account of forest growers following a catastrophic loss, or at least the portion of units that need to be prematurely surrendered. So long as a government organised system were to offer only partial indemnity against risks (by only insuring the carbon losses, and not the losses in the tree crop), there is likely to be sufficient scope for any subsequent problems of adverse selection and moral hazard to be mitigated. In essence, by offering only partial coverage against the total loss, the contract can be designed such that it is "incentive compatible".

In the report we also provide an analysis of most aspects of the theory of risk management in forestry, and we place that theory within the context of the general economic theory of risk management. The risks faced by forestry are often unique and interrelated, with probabilities that are notoriously difficult to estimate, making the applicability of the general theory to the specific case of forestry somewhat limited. Other difficulties for risk-sharing in forestry include the high correlation of individual risks, and the low number of both insurers and insurance customers. In order to come up with workable solutions to the problems of optimal risk mitigation, and optimal risk sharing within the forestry sector, quite some theoretical and empirical work is still required.

2. Introduction

In this section, we shall discuss the topic of risk management, with special emphasis on the particular case of insurance, in the forestry sector. Risk management in general is a subject area that has an extremely rich history. In particular, the applied micro-economics literature has taken risk management to be one of its principal areas of research. Economic theory has dealt extensively with the theory of efficient risk management, risk sharing, the effects of simultaneous risks, and a great many other topics peripheral to risk management generally. All of these topics are relevant to the case of forestry, although it is not clear exactly how, or if, the classical theories of risk management can be successfully applied to forest management.

Here, we are interested in the following concrete questions:

1. What are the particular risks facing the forestry sector, and how are they dealt with?
2. What has the academic literature on forest management said about managing risks?
3. Is the existing knowledge in the forestry literature concerning risk management aligned with the general economic theory?
4. What are the particular features of forestry as a business venture that might set it apart from other businesses as far as risk management is concerned?

Specifically, we shall go on to review the insurance options that are available under pooling and under self-coverage strategies. We shall then consider the unique features of forestry insurance, in order to consider which of the options might be better placed to provide relief from risk. We then review the literature that deals with insurance in forestry, and finally we consider what risk management strategies are currently in place in the NZ forestry sector.

2.1 Review of Insurance and Risk Management Options in Forestry

In order to successfully discuss the issue of insurance of forestry risks, it is worthwhile to firstly consider the general terminology that are used in reference to risk, and to look briefly at exactly what are the risks involved in forest management.

Risk; general definitions and terminology

Ever since the early part of last century, risk and uncertainty have been central topics for economic analysis. The seminal contribution that put risk and uncertainty into mainstream economic theory was Knight (1921). In particular, Knight gave us workable definitions of both risk and uncertainty; *risk* refers to a stochastic environment in which the probabilities of the different outcomes are commonly known (we would say that the probabilities are *objective*), while *uncertainty* refers to a stochastic environment in which the probabilities of the different outcomes must be estimated, and those estimates might well differ over decision makers (we would say that the probabilities are *subjective*). Nevertheless, the two terms, risk and uncertainty, are intertwined by the use of risk as both an adjective and a noun. As we have just seen, risk (adjective) describes a type of decision making environment (those with objectively valued probabilities), but the same word, risk, is also used as a noun to refer to a particular hazard or adverse event that might occur.[1] That is, for forestry, we can talk of the existence of the "risk of a fire", or "windthrow risk". Generally, forestry is exposed to risks for which probabilities are subjective, that is, the environment is one of uncertainty.

For the current paper, we shall use the term "risk" to refer to particular adverse events, or "hazards" that might occur. If they do occur, these hazards result in a negative impact upon the profitability of the forestry investment, and they normally imply the forest itself suffering some degree of physical damage. However, the extent of the damage, given the occurrence of the hazard, is itself uncertain or risky, and even to a certain extent the level of damage is controllable by actions taken by the forest manager *ex-ante*. These actions are an integral part of what we know as "risk management".

Risk and uncertainty are commonly accepted aspects of everyday life. Risks exist whenever decisions must be made that will have consequences into the future – the future is by nature uncertain, and so the actual consequences of any present action will depend not only upon the action itself but also upon any number of other eventualities that might occur. As such, risk is a particularly important aspect to take into account for any business project, consumption plan, or investment decision that has consequences or outcomes that take place sequentially after the actual act of formulating the decision.

Forestry, and more precisely, forest management, is a prime example of a business that is exposed to considerable risk, due to the simple fact that trees are such long-lived organisms. Indeed, according to Birot and Gollier (2001), "... the probability of occurrence of adverse factors during a rotation period (from seedling to harvest, i.e. from 40 to 200 years) can be rather high." Of course, the fact that forestry is subject to significant risks and general uncertainty has not been lost on the academic literature on optimal forest management. Indeed, in the year 2000 the journal *Forest Ecology and Management* dedicated an entire volume (number 135), containing some 35 papers, to the topic of risks in forestry. A brief glance through the principal journals on the economics of forestry, and forest management, reveals that studies relevant to risk and to risk management constitute a recurrent, and principal, feature of their contents.

However, upon closer inspection of those papers, one is lead to conclude that the goal of appropriately dealing with uncertainty in forestry is a battle that has yet to be won. Of the many papers that deal with the subject, a huge number do not purport to offer optimal, or efficient, risk management solutions, but rather they are limited to the study of risk

[1] Indeed, Gardiner and Quine (2000) use the term "risk" to refer concretely to "the probability that a hazard will occur." This, however, is not standard practice in the more general literature on risk management.

assessment (estimation of probabilities of hazards, and estimation of the set of possible damages), and of the valuation of the economic losses corresponding to particular hazards that have occurred. Risk management in the traditional sense, appears to be based upon rather ad-hoc guiding principles, rules of thumb, and even historical tradition.[2] In other cases, risk seems to be largely ignored altogether. This point of view is emphasised by von Gadow (2000), who states "Applications of risk analysis in forest scenario planning are rare and greater emphasis needs to be placed on hazard prediction."

Indeed, this also appears to be the opinion formed by Brumelle et al. (1990), at least based upon the pre-1990 literature that they review. According to them, "(The) determination of optimal forest-management regimes has been traditionally based on the assumption that the outcome of the management activity is certain. This was the case despite the almost universal recognition that forest-management outcomes are, in fact, uncertain." Traditionally, then, forest management has relied upon deterministic models, rather than stochastic ones.

Surely such a position can only be explained as a treatment simplification in order that the problem becomes tractable. In many instances, such simplifications can be justified if the result is a significant analytical cost saving when the problem is analysed. However, this is only worthwhile if the costs implied by the simplifying assumption (i.e. the imprecision that results from the use of an incorrectly specified model) are outweighed by the gains that are achieved in tractability of analysis. In particular, ignoring uncertainty as a simplification is only valid if the uncertainty that is present is small, or largely inconsequential to the process under analysis.[3] Neither of these options is even a close approximation to the real-world of forestry, for which risk and uncertainty are ever-present, and represent some of the most important and costly aspects of the business.

Another possible reason why uncertainty might have been ignored in the traditional literature on optimal forest management is that it has often been assumed that forest management is based upon purely risk-neutral preferences. In their review of the early literature, Brumelle et al. (1990) identify 20 important contributions to the literature on optimal forest management that do take into account the presence of risk or uncertainty. Of those 20 papers, 17 assume risk neutral preferences, 2 use the theory of stochastic dominance (and thus indirectly assume risk averse preferences), and only one openly uses risk averse preferences as the objective functional of the forest manager. If one assumes risk neutrality, then risk is likely to be largely inconsequential, and thus the simplification of ignoring risk, or using a very simplified risk environment, is not costly. The problem with this type of analytical position, of course, is that all it does is to disguise the assumption of a deterministic rather than stochastic environment as an assumption of risk neutrality. While not entirely equivalent, the two assumptions – non stochastic environment, and risk neutrality – are both equally implausible, at least as approximations to real world environments and preferences.

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[2] Birot and Gollier (2001) are clear in their conclusions that the goal of integrating risk into forestry deserves more attention.

[3] It would be inconsequential, for example, if risks were independent of each other, or better still, negatively correlated. In either of those cases, risks can be diversified away. However, as we shall argue below, the risks present in forestry are much more likely to be interdependent, and they are unlikely to be negatively correlated.

A forest manager displays risk-neutral preferences when he is indifferent between a guaranteed outcome, and the same outcome on average although with variability in the set of feasible outcomes. A simple example will be of use to clarify this. Say the use of a certain proven pesticide eliminates all risk of insect damage to trees, but costs \$1 million to use in a particular forest. If the forest is not damaged by insects, then say the net present harvest value is \$10 million. On the other hand, if it is damaged by insects then the net present harvest value is only \$5 million. Finally, assume that the probability that insects will damage the forest at some point if the pesticide is not used is 0.2 (and so the probability that the forest remains safe from insect damage is 0.8). The expected (or mean) outcome without the pesticide is simply the weighted average of the two possibilities; if we denote by H the net present value of the harvest, then the expected value of H (in millions of dollars) is $EH = 0.2 \times 5 + 0.8 \times 10 = 9$. On the other hand, using the pesticide guarantees an outcome of \$9 million, which is the certain undamaged harvest of \$10 million less the cost of the pesticide. A risk-neutral manager would be indifferent between the two options. On the other hand, a risk averse manager would strictly prefer the guaranteed \$9 million from the pesticide to the risky \$9 million without it, since it offers the same expected outcome but with less (indeed, with no) risk.

If we alter the assumed cost of the pesticide, our simple example serves to illustrate several aspects of choice under risk. Say, for example, the cost of the pesticide were less than \$1 million – for the sake of argument, say it only cost \$0.5 million. Then clearly, using the pesticide is a good idea for both risk averse and risk neutral managers, as it guarantees a harvest value of \$9.5 million, which is greater than the expected harvest value without using the pesticide. Such an example points toward what is perhaps the most visible cost of risk – the fact that when a risk is present, the expected outcome is lower than when the risk is not present. Thus, it may be the case (as in this modified example) that there exist some activities that are so cost effective that they cause an increase in expected value by eliminating the risk. The cost of the remedy (the pesticide) is less than the gain in expected value that we get by using the remedy. In such a case, using the pesticide is not really a risk management tool, it is a tool that contributes directly to raising the expected harvest value.[4]

However, there is a second cost of risk that we can illustrate by allowing the cost of the pesticide to be \$1.5 million. In this case, using the pesticide removes the risk (the harvest value is now a guaranteed \$8.5 million) but it also reduces the expected harvest (from \$9 million if the pesticide is not used, to \$8.5 million if it is used). A risk neutral forest manager would prefer to take his chances without the pesticide, but a risk averse manager might still prefer the pesticide. It is entirely possible that the removal of risk by using the pesticide can outweigh the cost represented by the \$0.5 million reduction in expected harvest.

It is a reasonably generally accepted hypothesis throughout all of economic theory that individuals and business units are risk averse, to a greater or lesser degree. Without risk aversion, we cannot explain the existence of insurance markets, or the fact that at the time of

[4] In such a case, rather than "risk management", using the pesticide is really just another optimal management practice.

signing, fixed rate loans generally carry a different rate of interest than variable rate loans, and risky debenture stocks carry a higher rate of interest than government guaranteed deposits. Risk itself is seen to be costly, for whatever reason – it makes it more difficult to plan ahead with any certainty, the downside to risky outcomes is seen to be worse than the upside, or perhaps the need to cover the downside of risks leads one to retain otherwise inefficient levels of low interest bearing precautionary savings deposits. It is certainly logical and reasonable that forest managers are also risk averse. Under risk averse preferences, risk itself – outside of expected value considerations – is costly, in the sense that one would pay money to remove risk.

Once we accept that risk aversion is always a feature of optimal forest management, we can then move forward to try to analyse the types of risk that are present, and the efficient management of those risks. Without risk aversion, risk is largely inconsequential, and so outside of any strategies that are so cost effective that they actually serve to increase the expected harvest value, risk management becomes irrelevant. Most risk management strategies will not fall into such a category, and so they will more typically be activities that reduce the expected value of the harvest,[5] but that also reduce the variability of the set of harvest values that can be achieved. Such strategies will only ever be contemplated by risk averse forest managers, who view risk per se as being costly, and thus who can see value in a trade-off that reduces risk at the expense of expected harvest value.

What are the risks faced in forestry?

There are a great many different risks that should be taken into account by forest managers. Of course, the most obvious group of risks refer to extreme weather events. In particular, bad weather – storms that involve wind, snow, hail and flooding are important hazards that threaten the survival of affected forests. Of those risks, perhaps windstorms are historically the most important, not because they are the most frequent, but rather because they can cause the most damage.[6] The windstorms that affected western Europe in late 1999 were the most harmful ever recorded in Europe, with more than 200 million cubic metres of timber blown down, over a huge area covering most of France, as well as significant parts of Germany, Switzerland, Spain, Denmark and Austria. Forest owners suffered heavy financial losses, and some were bankrupted.

Once trees of a certain species have been planted in a certain soil type, it may be possible to calculate the extent of damage that would occur for given windstorm intensities (as measured, perhaps, by the maximum wind speed, or the mean wind speed, and the duration of the storm). However, knowing the extent of possible damages is only half of the risk management story – we also need to know the *probabilities* of each feasible loss amount. It is much, much more difficult to estimate the probabilities of occurrence of windstorms of

[5] Insurance by specialist insurance companies, for example, must necessarily involve a reduction in expected value, that is, a premium that exceeds the expected value of claims. Otherwise, the insurer itself suffers a huge risk of bankruptcy.

[6] Of course, what is the greater risk depends largely upon the location of the forest. For example, it has been estimated for Japan that damage from snow is more probable than damage by wind (see figure 4 in Kuboyama and Oka, 2000).

sufficient intensity to cause damage, or indeed the probability of any sufficiently adverse weather event. For example, the 1999 storms in Europe were estimated to be a one in 150 year occurrence (Birot and Gollier, 2001, pg. 9-10). According to Brunette and Couture (2008), citing FAO statistics, "the risk of strong wind in European countries is estimated to be very small, between 0 and 0.3%". However, the true statistical probability of occurrence in any given year of events that historically occur with such a huge infrequency is particularly hard to estimate reliably.

Aside from storm risks, other weather events also present hazards to forests. These include the following;

1. uncharacteristically dry weather, leading to drought conditions,
2. frosts, which can damage or kill young trees

In terms of damage to the trees, another principal risk to forests comes from fires. However, the list of potential risks that can cause damage to a forest does not stop there, and we can also include the risks associated with insects and other living pests (generally known as biotic risks), damage caused by pollution of one type or another, other human damages (including aircraft accidents, and warfare), other natural hazards (volcanoes, earthquakes), and the effects of climate change.

Not all risks facing forest owners are based upon events and actions that cause physical damage to the trees. Forestry, like any other business, also faces financial risks when interest rates are variable, and the risk of future timber demand variability (which of course intertwines with the risk of a variable price for timber at harvest). Finally, more particularly for the case of forestry, there is a regulatory or political risk, in that socio-economic conditions will surely change over a rotation period, and these changes will almost certainly result in changes in the way the regulatory authorities view the business of forestry, which occupies very large spaces that could feasibly have many alternative uses socially. A good example of this is the recent introduction of carbon credit markets, and fact that they way they are regulated and organised is still under scrutiny and subject to debate.

Insurance of Forestry Risks

There are several important options for forest managers to consider when dealing with the uncertain nature of their business. The strategies can be divided into two main categories – those that involve risk sharing or pooling and those that do not – and sub-categories can be identified within each of the principal groupings.

Strategies that involve risk pooling

The first group of risk management strategies involve risk sharing, or risk pooling, of some form or another. Risk sharing options can only ever be valuable when the risks that each individual forest suffers are not perfectly positively correlated with each other. A positive correlation between risks will exist when they all suffer damages together. Indeed, as a general rule, the more positive correlation that exists between the individual risk positions, the less viable will be a risk sharing arrangement.

Risk sharing works only when risks can be disseminated, and dispersed, among the individuals in the sharing community. Risk sharing in reality is a form of risk hedging, but where more than one individual risk holder is required for the risks to hedge against each other. Risks that do not have extreme positive correlation are diversified away by sharing groups. At the extreme, consider two individuals holding one risk each, but with perfect negative correlation between the risks. Specifically, assume that two ex-ante identical forest owners are competing for a lucrative timber supply contract. The forest owner that achieves the contract will get a net profit of $100 million. If the contract is not won, then the forest's net profit is only $60 million. Say each forest considers that it has an equal (i.e. one-half) probability of winning the contract. Thus, the expected outcome of each forest owner is (in millions of dollars) $100 \times 0.5 + 60 \times 0.5 = 80$. However, each forest also has a great deal of risk. But, say the two forest owners strike a deal that says that the winner of the contract pays $20 million to the loser. In that case, each forest owner gets a net profit of $80 million for sure (the contract winner will get $100 million less the agreed $20 million payment, while the loser of the contract gets $60 million plus the $20 million payment). With the payment system, each forest owner gets the same ex-ante expected profit as without the agreement, but with absolutely no risk. Assuming that both forest owners are strictly risk averse, the agreement is strictly preferred by both.

The perfect negative correlation example is an extreme that would be unlikely to be achieved in reality. Under perfect negative correlation there always exists an agreement that keeps expected value for each participant constant and yet eliminates all variance, that is, that reduces risk to zero. Whenever there is *any* negative correlation, not necessarily perfect correlation, then risk sharing is still bound to be efficient for risk averse forest owners. However, even if the risks are independent risk sharing can also provide for a better ex-ante situation for all involved.

In the independent risk case, of course the risk-sharing benefits are not due to hedging. Again, a simple example will suffice to show the benefits. Assume, as in the previous example, that the net profits of two forest owners are $100 million with probability one-half, and $60 million with probability one-half, but where there is absolutely no correlation between the outcomes of the two forest businesses. Again, the expected profit of each forest is $80 million, but each faces considerable risk. How can we measure this risk? The normal measure of risk is the statistical variance (the square of the standard deviation). The variance of the net profits for each forest owner is 1000.[7] Now, consider the following arrangement, which is certainly feasible although not necessarily optimal. If one forest owner realises a net profit of $100 million while the other realises a profit of $60 million, then the owner who got the higher net profit pays the other owner $20 million. Under this arrangement, the expected

[7] The variance, for this particular example, is given by $0.5 \times (100 - 80)^2 + 0.5 \times (100 - 60)^2 = 0.5 \times (20^2 + 40^2) = 0.5 \times (400 + 1600) = 1000$.

profit of each forest owner (in millions of dollars) is[8] $0.25\times60 + 0.5\times80 + 0.25\times100 = 80$, that is, the expected profit of each forest is unchanged by the agreement. However, the variance after the agreement becomes:

$$0.25\times(60 - 80)^2 + 0.5\times(80 - 80)^2 + 0.25\times(100 - 80)^2$$

$$= 0.25\times20^2 + 0 + 0.25\times20^2$$

$$= 0.25\times400 + 0.25\times400$$

$$= 100 + 100$$

$$=200.$$

Thus, this simple agreement has reduced the variance fivefold, from 1000 down to only 200, while keeping the expected outcome constant. Again, this is a lucrative deal for risk averse forest owners.

The fact that the independent risk example still works to reduce risk implies that even if the two risks are positively correlated, risk sharing can still provide benefits to all participants. In fact, with perfect positive correlation it is impossible to reduce the risk at all, but with positive but not perfect correlation, the risk of each participant can always be reduced (without sacrificing any expected value of any participant) but not down to zero.

It is also illustrative that with only two participants we can achieve a significant risk saving. In fact, it is possible to show that the more identical participants we have the more risk can be eliminated at no cost to the expected value of each participant. This is purely the result of the law of large numbers, and it says that as the number of participants approaches infinity, the total risk of all participants can be diversified down to zero. Again, with some negative correlation, the risk gets diversified away with fewer participants, and with some positive correlation the risk gets diversified, but not down to zero.

The simple examples that we have used serve to show how risk sharing can be beneficial. However, risk sharing is also fraught with organisational problems. Firstly, all of our examples rely upon full and complete agreement between the parties as to the outcomes of each participant and the probabilities of each outcome. It is unlikely that in any real-world scenario each participant would know for sure the net profit outcomes that are feasible for his competitors. And it is even more unlikely that all would be in agreement as to the probabilities of the different outcomes, especially for scenarios of uncertainty where probabilities are estimated subjectively. Informational concerns of this type drive a wedge between what can be achieved theoretically and what is feasible really. Economists often call such problems "market failures", and they consider the optimal solution given such failures.

[8] After the agreement, a forest owner gets $60 million with probability 0.25 since this only occurs when both forests independently realise this profit. Likewise for the $100 million figure. When one forest owner gets $60 million and the other gets $100 million, which occurs with probability 0.5 (two chances out of the four options), then the agreement would leave each with $80 million, regardless of which of the two actually had the larger original net profit.

The resulting solution is often labelled “second best”, where the “first best” solution is given by the hypothetical scenario where there are no market failures. It may be the case that the failures are so acute that the second best outcome is actually worse than no sharing at all.

Market failures, especially those based on informational asymmetries, are not the only potential element that might interfere with the organisation of risk sharing. Another significant potential cost is the expense involved purely in the organisation of a group. There are likely to be search costs as participants in the sharing community are found, and also negotiation costs with the incorporation of new participants. In general, these types of costs are known by economists as “transactions costs”, and they are basically unavoidable in almost any economic activity. However, the more participants there are in a given activity, the greater are the transactions costs, and this of course is problematic for risk sharing in particular, since as we have seen risk diversification is likely to work much more efficiently the more participants are in the sharing arrangement.

Risk sharing is normally organised under one of two types – independent insurers, and mutuals. We now go on to consider each of these in turn.

Independent insurers

Insurance companies are some of the largest financial corporations in any developed economy. Most insurers deal with a great many types of risk, including all types of household coverage, business coverage, life insurance, automobile insurance, and of course the insurance of agricultural investments including forestry. In New Zealand, for example, FMG provide specialist forest insurance cover. Internationally, ForestRe and Lloyds of London in England and MunichRe in Germany both underwrite forestry insurance cover. As the names of some of these companies clearly implies, they also underwrite re-insurance cover for forestry – that is, they insure the risk portfolios of other (primary) insurance companies.

A specialist insurer basically underwrites risks for individual customers. Risk underwriting is nothing more than the actuarial process of valuing the insurable risk – that is, the product of the probability of damage multiplied by the corresponding claim that eventuates under the insurance contract for each level of damage. Naturally, the value of the risk that is insured plays a principal part in the determination of the premium to be paid for the cover, and of course the premium is always strictly greater than the actuarial value of expected claims, in order that the insurance company both pays its organisational costs and earns a profit.

Given the fact that any insurance premium is necessarily greater than the expected level of claims that can occur under the contract, insurance under specialist underwriters must reduce the expected value of the business in question, in our case the business of forestry. Recalling what we have already discussed above, the purchase of forestry insurance that is sold by specialist underwriters can only be consistent with strictly risk averse forest managers.

In summary, insurance companies in general are able to earn money because they act as intermediaries in the organisation of a risk sharing community. For all of the reasons set out already, so long as a diversified portfolio of clients is achieved, not all with perfectly correlated risks, then the entire group benefits from the individual insurance contracts that each has with the insurer. Of course, unless the insurer is an absolute specialist in the underwriting of forestry investments, there are likely to be a large number of totally independent risks in the company's portfolio – forestry risks, household risks, automobile risks, etc. – and this allows them to organise risk sharing not only within a particular industrial sector like forestry, but also over a wide range of economic sectors. For that reason, it is likely that a large insurance provider is an efficient supplier of all sorts of coverage, including forestry, but on the other hand it will also face higher organisational costs as the complexity of the business grows.

Insurance mutuals

Group risk sharing does not need to be organised by an independent insurer. Indeed, there are many groups of like-minded individuals that set up as risk sharing organisations without specialist underwriters. Such organisations are known as "insurance mutuals", and really they are nothing more than insurance companies that are owned by their clients (or members).

In New Zealand, for example, the Automobile Association is a mutual that provides (among other services) insurance to its members. Federated Farmers is another mutual, and while it does not directly provide insurance, it certainly does purport to protect its members from adverse market conditions, and it also offers valuable advice on all sorts of relevant business practices, including risk management.[9]

In Australia, the Australian Forest Growers Plantation Insurance Scheme is a mutual that does offer insurance to its members (see Cummine, 2000). The insurance scheme is operated on behalf of the Australian Forest Growers by endorsed brokers in Australia, and then it is underwritten by Lloyds of London.

The benefit of having a privately run mutual scheme rather than an independent insurer is largely the savings that can be made on transactions costs, and on market failures. When all of the members of the scheme are from the same business, in our case forestry, then there is likely to be a far greater consensus as to the actuarial value of the risks being insured. It is also likely that there is a reasonable rapport among the group members, since they all originate from a common background. This often leads to certain transactions costs savings.

However, on the other hand, insurance mutuals are far less able to diversify risk, especially locally, as some of the risks involved will be closely perfectly correlated. For example, it is virtually impossible that a wind storm of the size that occurred in Western Europe in 1999 could ever be insured by a local mutual, as the catastrophic nature of the storm would lead to the same or a similar scale of losses to all of the members of the mutual. Thus, locally organised insurance mutuals still need re-insuring with another group, normally a specialist insurance company, that is not local (as is the case with the Australian Forest Growers Plantation Insurance Scheme).

[9] In New Zealand there is also the case of Kiwi Bank, which is a banking mutual.

Strategies that do not involve risk pooling

Perhaps the simplest, and most basic, actions that one can take in the face of the presence of risks are those that have as a consequence either the reduction of the probability of occurrence of given hazards, or the reduction of the damages that a given hazard would cause. Both of these types of investments are common in forestry, and they are designed to mitigate the risks that impinge upon optimal forest management. They are very typical risk management strategies, and are used in almost all situations of business, investment, sport, and even warfare.

Self-insurance

Economists refer to investments and actions that have the consequence of reducing the damage that a hazard would cause as acts of *self-insurance*. This is, of course, in clear reference to market insurance (insurance offered by specialist insurance providers), which also reduce the harmful effects of hazards conditional upon them occurring.[10] The difference is that third-party insurers mitigate damages by paying out monetary indemnities, or perhaps by paying for replacement or repairs. That is, the insurer insulates the insured by accepting part or all of the consequences of the hazard, whereas self-insurance mitigates damages by directly reducing the amount of damage that may occur. A few examples will be of use to clarify what we mean by self-insurance for the case of forestry.

Perhaps the most important risk that can be self-insured in forestry is the risk of fire. Arranging a forest with appropriately cut and sized fire-breaks is a clear strategy of self-insurance. Conditional upon a fire starting in a forest, the fire-breaks will (up to a certain size of fire) contain the damage that will occur to a only a small part of the entire forest. Thus, fire-breaks do not stop fires occurring, but they do reduce the harmful effects of fires when they occur. Each tree that is removed to create fire-breaks is one less tree that will be available at harvest time, and so fire breaks are indeed costly in terms of the expected harvest value. However, by containing any fire that does break-out in the forest to within the established fire breaks, the damages that will occur to the entire forest conditional upon a fire occurring somewhere within it are reduced. In the same way, removing trees to create internal fire tracks, which aid the extinguishing of a fire should one start, are another common self-insurance strategy against the risk of fire.[11]

One particularly interesting type of self-insurance is the possibility of hedging risks. Risks can be hedged whenever there exist at least two risks that are negatively correlated. Negative correlation implies that whenever one risk turns out to imply losses, the other implies gains. Thus, two negatively correlated risks tend to cancel each other out (although not always perfectly), and thus each is implicitly insuring the other. For the case of forestry, it is difficult to think of two risks to the actual business that provide a natural hedge. Perhaps the only clear example would be the planting of drought tolerant species together with drought intolerant

[10] The seminal paper in economics that discusses the relationship between self-insurance, self-protection and market insurance is Ehrlich and Becker (1972).

[11] It is more difficult to think of self-insurance strategies against weather events like wind storms. However, perhaps the clearest are the location of the forest (in less vulnerable sites), and the choice of species to plant (more resistant to wind damage), and avoiding late thinning of tall slender trees. Forest layout is also a factor.

ones, so that if the weather is uncharacteristically dry, while the intolerant species will suffer the tolerant ones will not, while if the weather is uncharacteristically wet, the reverse will be true. However, it is hard to think of species that would thrive in windstorms and fire events, so the options for hedging by plantation species selection are clearly limited.

Although self-insurance does not imply the payment of a monetary premium per se, there are clear costs to such strategies, and those costs are generally deterministic (or at least, they are less stochastic than is the risk being addressed). The interesting point to consider about self insurance strategies is how the trade-off between the costs and benefits is viewed by different forest managers. Consider, for example, the determination of the optimal size and layout of fire breaks. The more trees are removed, the more costly is the fire break, but the more effective it is at mitigating risk. One would expect that more risk averse managers would establish larger fire breaks, as would managers with forests made up of more fire vulnerable species.

Self-protection

Contrary to self-insurance, economists use the term *self-protection* to refer to any action that has the effect of reducing the probability that a given hazard will occur. It is virtually impossible to reduce the probability of occurrence of natural weather hazards like windstorms and droughts (other than the location of the forest in a low probability zone), but in reality what is important is not the probability of occurrence of a hazard but rather the probability that a hazard will damage the forest. This clearly requires that the forest be still standing when a hazard occurs, so indeed the risk of damage can be reduced by limiting the amount of time that the forest is left standing, that is, by limiting the rotation period.

The so-called "forestry golden rule", credited to Martin Faustmann some 160 years ago (see Viitala, 2006), is that it is optimal to harvest a forest stand when the rate of change of its value with respect to time is equal to the interest rate on the value of forest capital invested in timber and land. When a risk is present, it becomes optimal to reduce the rotation period. By reducing the period of time that a forest is standing, one reduces the probability that an adverse event will occur before the harvest of the forest. This is the very clear notion that natural hazards arrive in time stochastically, so the longer you wait, the more likely it becomes that a natural hazard will occur. In that sense, reducing the rotation period is a self-protection strategy, since it reduces the probability that natural disasters will occur to the forest while it is still standing.[12]

Not only is a reduction in rotation period a self-protection strategy, it is also optimal behaviour given risk aversion by forest managers. In this case, the Faustmann rule needs to be altered to read that the optimal moment to harvest the forest occurs when the *risk adjusted* rate of growth of the value of the forest is equal to the market risk-free rate of interest.[13] When forestry returns are adjusted for risk, the rotation period implied by the Faustmann rule will be reduced, and it will be reduced by more the more risk averse is the forest manager.

[12] The optimal forest rotation literature is now very advanced – see Newman (2002).
[13] This point is not lost on Birot and Gollier (2001), who state it clearly.

Another obvious case of self-protection in forestry occurs with the risk of fire. Many fires are the result of human activity within a forest; perhaps intruders have left flammable debris, or broken glass, behind after visiting the forest, or perhaps intruders have directly been responsible (whether deliberate or not) for igniting a fire. The risk of human intrusion can be reduced (although clearly not eliminated) by appropriate fencing and other natural barriers around the edges of a forest. Also, signage warning against intrusion may well reduce the probability of entry by the general public. Finally, once again location of the forest is important for reducing fire risk, as a forest located within easy walking distance of towns and cities is much more likely to suffer intrusion by town-folk and children, who may inadvertently or deliberately be responsible for fires starting.

2.2 Unique Aspects of Forestry that Sets it Apart from Other Insurable Risks

As we have already mentioned, there is a long tradition of economic theory of risk management, and of insurance in particular. However, aside from particular case studies, the general theory is not normally written with any concrete application in mind. It simply assumes the existence of a risk, as defined by a probability density function over a given set of outcomes, and an objective function (normally expected utility), and then sets about studying the optimal behaviour of the decision maker given the risk. However, there may be significant differences between the explicit, and the implicit, assumptions that are required for the general theory and the relevant assumptions on any given case for which the theory is to be applied.

This is quite likely to be the case for forestry risks, and while it does not render the general theory useless for guiding risk management in forestry, it certainly does point to the need for a more careful analysis of the particular case of forestry. Just like market failures and transactions costs, the use of dubious assumptions for any given application of the general theory implies that the output of the model (perhaps in terms of policy guidance) is all the less reliable. However, that said, it may be the best that we can do. For example, if providing the appropriate assumptions makes the model intractable, then the benefits of having a more accurate descriptive model are unlikely to outweigh the costs.

In this section, we shall discuss some of the more salient features of forestry investments that are different to what is normally assumed in the general theory, and we shall also indicate where possible whether or not the differences that we identify should be easily remedied or not.

Interrelationships between, and simultaneous existence of, several risks

Perhaps the most perplexing issue concerning forestry risk management is the fact that there are so many different risks present. If each of the risks were independent of each other, then this would not necessarily be such a problem,[14] but this is not the case for forestry. For example, the risk of windthrow is often not independent of the risk for fire. Also, as we have already mentioned above, there is bound to be a close relationship between the variability of the final market price and the risks that are faced in the forest itself.

Difficulty in calculating probabilities

Most of the principal risks to forestry involve uncertainty of a very high degree, in the sense that there is likely to be a considerable variance in the estimates that different individuals make of the probabilities of the diverse hazards. Above all weather events of sufficient gravity to cause major damage to a forest are infrequent, and this infrequency implies that one does not have much past data upon which to base probability estimates. When there is a large divergence of opinion as to the probabilities of occurrence of hazards, it becomes difficult to organise any type of risk sharing community, either as a mutual or by specialist insurers.

If it were a mutual, then those individuals who over-estimate the probabilities of hazards will demand excessive coverage from the others, while those who under-estimate the probabilities will not be willing to contribute the amount of premium to the community that the others deem to be warranted. Under such circumstances the sharing mutual can easily break down. On the other hand, if the insurance were to be organised by an independent underwriter, then one can expect that they will always over-estimate the probabilities of occurrence of the hazard in question in order to self-insure against the very risk that they face in estimating probabilities. But if the premium is set too high, then demand for coverage is likely to be inefficiently low. Indeed, Brunette and Couture (2008) note that in Germany and France only 2% and 5% of private forest owners, respectively, are insured against windstorm losses.[15]

Extremely long time horizon

With rotation periods of anywhere between 20 and 60 years or more, forestry suffers from a particularly difficult uncertainty to deal with. Not only can a great many significant events occur over such a long time horizon, but also events that were not even contemplated at the outset can become important over a rotation period. A very good example of this is the new carbon credit markets that have recently been inaugurated, and that might not have even entered the calculations of forest managers only 20 years ago. Likewise, climate change appears to be becoming a more and more important factor to take into account in forest management, whereas not so long ago it was not even heard of. Finally, of course, one must also consider that the final demand for timber products might well change over the course of a rotation period, and so what was a market with excellent perspectives when planted might turn out to be rather poor when harvesting time comes around.

[14] The general economic theory of simultaneous, but independent, risks is well developed. It normally goes under the name of "background risk", and the focal point of this literature is to consider how the existence of one risk affects the willingness of the decision maker to insure the other risk. Under reasonable assumptions on the utility function of the decision maker, background risk makes one more willing to insure primary risks (see, for example, Gollier and Pratt, 1996).

[15] In other countries the situation is different – for example in Denmark and Sweden 68% and 90%, respectively, of private forest owners are insured against windstorms.

It is also true that when one is faced with insuring with specialist underwriters over extremely long time horizons, the very solvency of the insurers themselves becomes important. While one might consider that the risks are covered simply because one holds an insurance contract, of course any indemnity that can be received under the contract is contingent upon the insurer remaining solvent. If there is perceived to be any probability, regardless of how small, of bankruptcy of the insurer in any given period, then over a very large number of periods the probability of bankruptcy might become a significant concern.

Relationships between risk exposures and other management strategies

Not only are the risks faced by forest managers interdependent, but it is also true that otherwise good management practices can interfere with risk management. Good examples of this are the fire risks that can occur when pruning and thinning leave debris scattered around the forest. Pruning and thinning are good management strategies, designed to increase the final harvest value, but they can also turn out to aggravate the risk of fires[16]. Also, it is well known to be good planting practice in some situations to rip the area in which a tree is planted, in order that the roots grow downwards and promote good growth. However, as has been documented by Somerville (1979), this increases the risk of stem breakage in strong winds rather than uprooting. Since uprooting is a preferred damage to stem breakage, again an otherwise sound management practice has led to an increased exposure to risk.

When there exist these types of relationships between management practices, it becomes very difficult to work out the exact costs of pursuing one or the other option. Is ripping, with the benefits of better growth but the increased potential damage should a wind storm hit, better than not ripping, with worse growth but no so great a damage in a wind storm? Assuming that one follows the Faustmann rule for calculating the optimal rotation period, presumably ripping will decrease the rotation period since the trees will be of harvestable size earlier, and thus ripping implies a greater risk over a shorter period. It is not at all clear whether or not ripping is indeed a more or less risky option!

Forests are irreplaceable assets

Most normal insurance models are written for the case of repairable, or replaceable, assets. For example automobile insurance and home insurance are both cases of goods that can either be repaired or replaced. However, there are other types of insurable assets that are not really replaceable or repairable. The most obvious case is one's health; some health problems are repairable, but others are not – loss of limb, and of course death, are clear examples. Forests are also largely irreplaceable, at least once the trees are of sufficient age. Replacement can only be done if the trees that have been damaged are seedlings, or recently planted.

When insurance is of an irreplaceable asset, difficulties can arise (see Cook and Graham, 1977). By definition, if a forest cannot be replaced, any insurance indemnity cannot be arranged in the asset that was lost, but rather it can only be made in money. As soon as this happens, there is scope for disagreement as to the exact value[17] that is required as

[16] But if you don't thin you get the build up of over-stocked stands with excessive mortality and high fuel loads.
[17] It is for this reason that most NZ policies are based on an agreed value.

compensation. Indeed, different forest managers (or owners) would likely require different levels of compensation for a given lost forest, simply due to the differences in their personal situations. Imagine, for example, that a destroyed forest were owned by a corporation with many other (undamaged forests and other assets). Perhaps this owner would accept a lower compensation than would an owner for whom the destroyed asset was his principal, or perhaps only asset, upon which he was relying for retirement. Again, when insurance is contemplated for irreplaceable goods, one often finds that the efficiency of the final contracts is compromised.

Many risks to forests are catastrophic

The case of insurance of catastrophic risks is important enough to warrant special attention as a sub-discipline within the broader topic of the economics of insurance. Many of the risks facing forestry are catastrophic, at least locally, and this implies that insurance for them is much more difficult to organise.

A catastrophic risk is one that affects many people in the same way. In short, catastrophic risks imply a strong positive correlation among locals, and as we have already seen, this makes risk sharing either by mutuals or by underwriters somewhat impractical. The only way that insurance for catastrophic events can be organised is on a far larger scale, for example across international borders, or at least over geographic areas that are not all subject to the same catastrophic risk. While certainly possible for forestry, the search for insurers in far away locations is quite simply a further increase in the transactions costs associated with the insurance, which makes it somewhat less attractive.

There are few insurers, and relatively few forests to insure

Forestry insurance is a rather specialised activity, and there are not so many companies that offer insurance products for forestry. Of course, this is likely to be a logical response to the fact that in any given country there is also likely to be a reasonably reduced number of possible clients, since there are not normally too many forests (at least compared to other types of insurance – home, automobile and health insurance, for example). The low number of insurers, and the low number of insureds are both problematic for insurance markets.

When there are not many insurance companies, one might validly be worried about market power. It is well known in economics that along with market power on the supply side (which is generally taken to be evidenced by a low number of sellers) we can expect to see higher prices. So if there are not many specialist forestry insurance underwriters, then we should expect to see relatively high premiums, which will logically lead to a lower demand than would otherwise be the case. That is, individual forest owners will have to retain more risk than what they would with a more competitive insurance market, and this is costly to them.

Second, when there are relatively few forests to insure, the law of large numbers will not work quite so strongly. Recall that the law of large numbers is what implies that by bringing together many different risks, they tend to cancel each other out to a certain extent (depending on the degree of correlation between the risks in question), and this helps to eliminate variance at a low (or even null) cost in expected value. But if this is not possible because there simply are not enough insurance consumers, then the insurance market will not work as well as it otherwise would to diversify risks away.

Government intervention after disasters have struck

A reasonably common feature of forestry risks is that governments provide relief aid to affected forest owners after hazards have occurred. This was indeed the case after the 1999 storms in Western Europe[18]. However, the promise, or even the expectation, of public relief aid after storm damage will have important implications for the risk management actions of forest managers. Of course, since government aid is a substitute for insurance indemnities, and yet is given free of charge (whereas insurance indemnities are only available if a premium was paid ex-ante), and so aid of this type will have the effect of reducing the incentives to insure and to engage in other costly risk management activities (self-insurance and self-protection).[19] This is the central point of Brunette and Couture (2008).

Unless the way in which government aid is allocated is carefully thought through ex-ante, it can have detrimental risk management effects, and of course this can lead to greater exposure to risk at the aggregate level (and of course, greater costs to the government aid programmes). The type of problem that the expectation of government aid causes (i.e. the reduced incentive to engage in risk management) is known in the insurance literature as "moral hazard", and it is also well known that the way to control for moral hazard is that the aid packages only provide for partial coverage, and that the aid system be costly for forest owners to enter (like an insurance premium).

Brunette and Couture (2008) suggest that it is appropriate that government aid be allocated *only* to those forests that also did visibly use other private risk management strategies. However, this is only a partial solution to the problem – the *level* of government aid should be related with the *level* of private risk management activities, not only to the existence of such activities. That is, in order for government aid not to work in the wrong direction, it would be necessary (but not sufficient) that the aid allocated to a forest be calculated in direct relationship with the amount of private risk management that was used.

2.3 Literature Review of Insurance Models for Forestry

In our search for relevant academic literature related to risk management for forestry, and in particular for risk sharing and insurance treatments, we looked through the three principal international journals that habitually publish papers on the economics of forestry (Forest Ecology and Management, Forest Policy and Economics, and Journal of Forest Economics), as well as all of the traditional journals related to risk, uncertainty and insurance generally.

[18] This happened to a limited extent after the 2004 storms in the Manawatu where MAF paid for the cost of fencing and reestablishment.

[19] Indeed, taken to the extreme, the promise of free government aid can (theoretically) even lead to fraudulent activities, such as promoting the occurrence of disasters. This might occur, for example, if a forest owner has not taken care of the forest, and its market harvest value is actually less than what he might expect in relief should the forest be destroyed, say by fire.

None of the general journals have, as far as we can see, published any papers directly related to forestry insurance, although of course there are many papers that are still relevant, to a greater or lesser degree, to forestry insurance (for example the literature on catastrophe insurance, and the literature on insurance of low probability events). In the specialist forestry journals, we have only managed to find two papers that purport to offer models of insurance; Holecy and Hanewinkle (2006), and Brunette and Couture (2008).[20]

Of the two models that we did find, the first (Holecy and Hanewinkle 2006) is not really a behavioural model of forestry insurance at all, but rather it offers an actuarial model. That is, the principal focus of the model of Holecy and Hanewinkle is to attempt to calculate appropriate probabilities, in order that insurance premiums can be worked out. They also concentrate on a very general description of the risk involved, which in effect aggregates all possible risks together. This, of course, leads to inaccuracies when the composition of different forests is taken into account (age of stands, species, land contour, etc.), so their analysis of probabilities can be thought of as a rough approximation, applicable only on average.

The Holecy and Hanewinkle paper then goes on to consider the cash-flow implications of insurance based upon their risk calculations. This is a dubious way to analyse optimal insurance decisions, since if the objective of a forest owner is indeed cash-flow, then one is assuming that owner to be risk neural. As we have already argued above, the assumption of risk neutrality is detrimental to the ability of a model to appropriately analyse insurance markets, and the optimal decisions of individuals acting within insurance markets. Indeed, the Holecy and Hanewinkle paper does not allow forest owners to take any decision regarding their level of insurance coverage. Instead, all forest owners are assumed to simply accept the single contract that the insurer offers (which appears to be a full coverage contract). All in all, while interesting as an actuarial exercise, the Holecy and Hanewinkle paper is not really one that enlightens us as to the appropriate workings of risk sharing and insurance for the case of forestry.

The other insurance model in the forestry literature is Brunette and Couture (2008), whose primary focus is on the effect of the expectation of government financial aid after a disaster upon the risk management decisions of a forest owner (or manager). This is indeed an insurance model in the traditional sense, with risk averse preferences, and the option to choose among a variety of levels of insurance coverage.

Brunette and Couture derive within their model several interesting relationships between the demand for insurance, and for risk management activities in general, by forest managers when there are certain government aid relief programmes in place. In general, and not surprisingly, Brunette and Couture find that unless government aid programmes are linked to ex-ante acts of insurance and risk management by forest managers, then it will have a detrimental effect on the incentives to appropriately manage risk.

[20] There were a large number of other papers with titles that were very promising as offering insurance models (for example, Brumelle et al. 1990), but that upon closer inspection did not really offer a model of insurance of forestry but rather only discussed issues related to risk management in forestry more generally.

Nevertheless, the model of Brunette and Couture is really nothing more than a relatively simple general model of insurance, of a type that is very common in the general insurance literature, but here it is applied to the particular case of forestry. Perhaps the major fall-back of the model is that it assumes the demand for insurance coverage is under pure co-insurance[21], whereas in the real-world of forestry insurance it appears that deductible contracts are much more common.

2.4 What do NZ Forestry Companies Currently Do?

In order to answer this question we carried out a survey of New Zealand forestry companies that own or manage over 10,000 ha of plantation. According to the New Zealand Forest Industry Facts & Figures for 2008/2009, these companies own or manage 1,053,000 ha of plantation, approximately 59% of the national plantation estate. While 36% of this area is insured for fire, only 19% is also insured for wind damage (Table 2.1). The general pattern is that smaller companies have insurance while larger companies tend to have self coverage; ie, self protection and self insurance. A response from one forestry company was that they did not believe that fire risk was high enough to warrant fire insurance. They believed that wind was the major risk factor but they could not afford to insure for it. Consequently the company did not insure for either fire or wind.

The majority of the Kyoto-compliant plantations in New Zealand are not included in the survey. The survey includes companies who manage forests for investment syndicates that total over 10,000 ha. However it does not include the rest of the "small-scale" plantations in New Zealand. Anecdotal information confirms that some of these plantations are insured particularly those that are professionally managed, in some cases only for fire. A limiting factor for wind insurance is that policies typically have an upper limit on the wind damage that can be claimed for any event.

Table 2.1: Percentage of plantation estate of owners/managers of over 10,000 ha that is insured.

	Area (ha)	**%**
Area that is insured for fire	380,000	36
Area that is insured for both wind and fire	200,000	19
Total area	1,053,000	

[21] A co-insurance contract is one under which the indemnity is a constant proportion of the loss. For example, if the contracted indemnity is 60% of the loss, then whatever is the loss suffered, the insured only gets 60% of it back as an indemnity payment, suffering personally the other 40% of the loss. On the other hand, a deductible contract offers full insurance above a loss threshold (the deductible), and no insurance below that threshold. Other more complex contracts can be found, involving perhaps aspects of both deductibles and co-insurance. It can be proved that the deductible is in fact optimal for any risk-averse insurance consumer, although co-insurance contracts are far simpler to analyse mathematically, which is why they are often assumed in models of insurance.

3 What Are The Risks?

In this section we provide the context for the need for insurance and undertake an analysis that illustrates the impact of catastrophic loss on forest profitability and value. A catastrophic event will cause tree crop loss and a consequential reduction in carbon stocks. The latter will place the forest grower in the position of having to surrender carbon units prematurely. The question is how this, together with the tree crop loss, will affect profitability and forest value.

3.1 What are the Historical Probabilities of Fire and Wind Loss?

Although there have been major fires in New Zealand, the overall level of fire loss has not been great. Table 3.1 shows results from a study by Pearce *et al.* (2000) in which they compared fire losses in New Zealand with those of some other countries. Although the averaging period varies between the different countries, Table 3.1 nevertheless suggests that New Zealand has a relatively low loss of plantations to fire. Recent work by Watt *et al.* (2008) indicates that the annual loss over the decade to 2007 was about 0.02% of the plantation estate.

Table 3.1: Comparison of fire losses [Source: Pearce et al. (2000)]. New Zealand figures apply to plantations only.

Country	**Averaging period**	**Area burnt per year as % of forest area**
Portugal	94-97	2.989
Canada	88-98	2.230
Spain	94-97	1.364
USA	90-99	0.745
Russia	94-97	0.319
New Zealand	36-99	0.059
New Zealand	88-99	0.036
Sweden	94-96	0.007

The risk of severe damage from wind events is a more significant hazard in New Zealand. The probability of wind loss was well documented for different regions by Somerville (1995). Table 3.2 shows average annual losses from catastrophic events. It also gives estimates for on-going attritional loss from "routine" storms.

Table 3.2: Probability of wind loss in selected regions of New Zealand (% of area damaged per year). [Source: Somerville (1995)]

Region	Catastrophic loss (%)	Attritional loss (%)	Total loss (%)
Central North Island	0.26	0.15	0.41
Nelson	0.23	0.35	0.58
Canterbury	1.86	0.24	2.10
Otago	0.20	0.18	0.38
Weighted average	0.38	0.25	0.63

Clearly the risk of loss by wind and, to a lesser extent, fire needs to be considered in evaluating the profitability and risk of carbon forestry.

3.2 What is the Impact on Forest Profitability and Forest Value?

We follow the same general approach as adopted by Maclaren *et al.* (2008). For radiata pine, an average New Zealand ex-farm site of site index[22] 32.6 m and 300 Index[23] of 32.6 is assumed. The radiata pine clearwood regime involves planting 800 stems/ha, pruning to 5.5 m in two lifts, thinning at age 8 to 250 stems/ha.

Log and carbon yields are estimated using the Radiata Pine Calculator (NZTG 2003). This calculates carbon yields based on the C_Change model (Beets *et al.* 1999). Published MAF[24] 12-quarter average prices (as at January 2008) are used. Industry average costs are used. Carbon trading is based on the Emissions Trading Scheme (ETS) as it is currently legislated. A carbon price of $30/t CO_2 is used and a fixed cost ($60/ha/year) is assumed for the costs of measurement, auditing, registration associated with carbon trading. All prices and costs are in New Zealand dollars.

The impact of catastrophic events on forest profitability is modelled for a range of probabilities – 0.25%, 0.5%, 1% and 2% probability of any stand being damaged in any year. It is assumed that any damaged stand aged 15 years or older would be salvaged immediately but with:

- A reduction in the volume of all log grades of 20%.
- A 25% increase in harvesting costs.

[22] Mean top height of 100 largest stems/ha at age 20 years.
[23] 300 Index is an index of volume productivity. It is the stem volume mean annual increment at age 30 years for a defined silvicultural regime of 300 stems/ha (Kimberley *et al.* 2005).
[24] http://www.maf.govt.nz/forestry/statistics/logprices/

All damaged stands require re-establishment. An additional clean-up cost of \$500/ha is applied to reflect the increased costs of preparing land for re-establishment. Any volume not salvaged is left on site and added to the pool of residues left to decay over time.

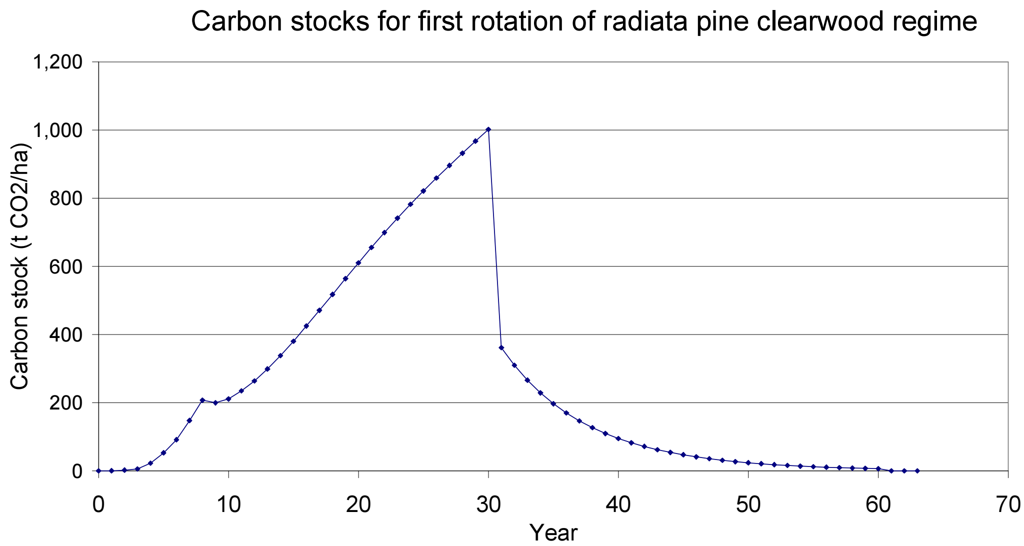
Financial criteria used are Land Expectation Value (LEV) and Net Present Value (NPV) at an 8% real discount rate. LEV is used as a measure of forest profitability. LEV is a special case of NPV calculated when land is in a bare state, about to be planted in a perpetual series of forestry rotations. It provides an estimate of how much a forest owner could afford to pay for land in order to achieve the required rate of return.

NPV is calculated for stands of different ages to provide a measure of value. The ETS creates two distinct, but related, cashflow streams – one associated with traditional forestry and one associated with carbon trading. Forest valuation in New Zealand is based on discounted cashflow analysis. Here we separately calculate the NPV of the cashflows associated with (i) the tree crop; and (ii) carbon trading.

LEV ignoring risk

When risk is ignored, the combined LEV (forestry and carbon) has a maximum value of \$6647/ha. This occurs at age 30 where the LEV of forestry is \$712/ha and the LEV of carbon is \$5934/ha. Fig 3.1 shows the carbon stocks for the first rotation. Carbon stocks increase (apart from the year following the thinning at age 8) up to 1002 t/ha at age 30. In the year after harvest carbon stocks reduce to 362 t/ha because of the removal of log volumes. Thereafter carbon stocks reduce as the residues left on site decay over time.

Fig. 3.1: Carbon stocks for the first rotation of the radiata pine clearwood regime.



Risk from catastrophic events

An analysis was carried out for a target rotation of 30 years. Fig. 3.2 shows the impact of a catastrophic event at different stand ages on the stumpage revenue of logs that are salvaged. There is a large reduction compared to the anticipated stumpage revenue at age 30 years. The reduction in stumpage revenue combined with the additional re-establishment costs translate into a marked reduction in the NPV of forestry cashflows (Fig. 3.3). The NPV of forestry cashflows is low compared to the forestry LEV of $712/ha, particularly when the event occurs when the stand is age 9 to 15 years.

Fig. 3.2: Effect of a catastrophic event at different ages on the stumpage revenue salvaged compared to the "no-loss" stumpage revenue at the target rotation age of 30.

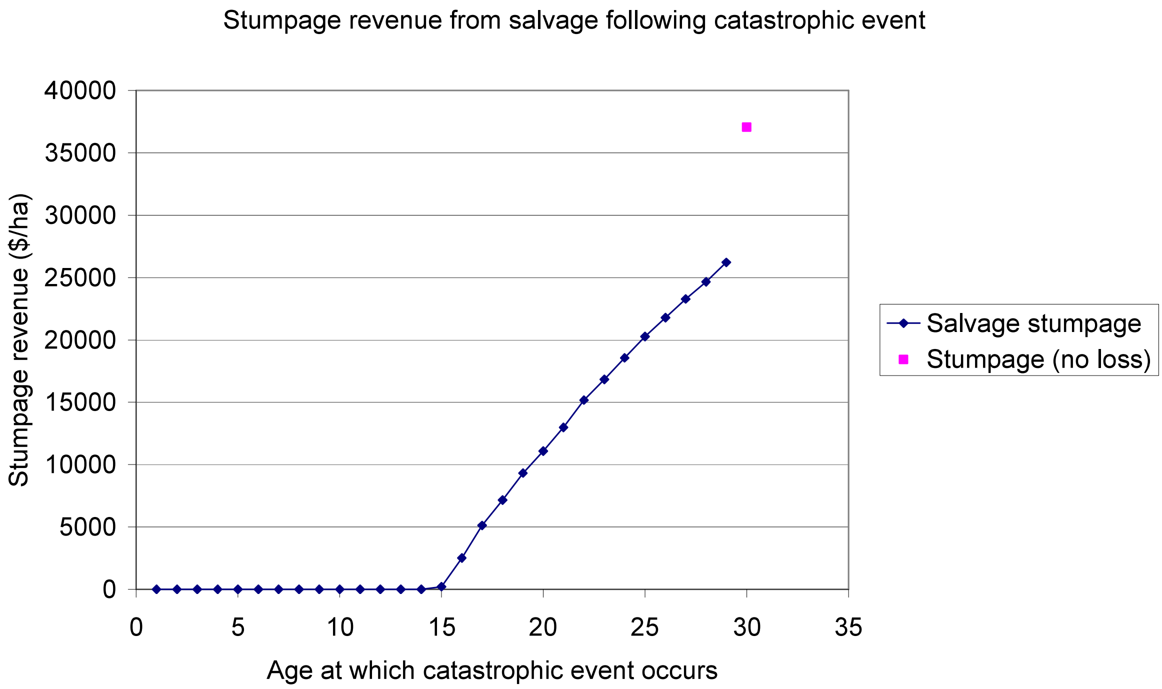
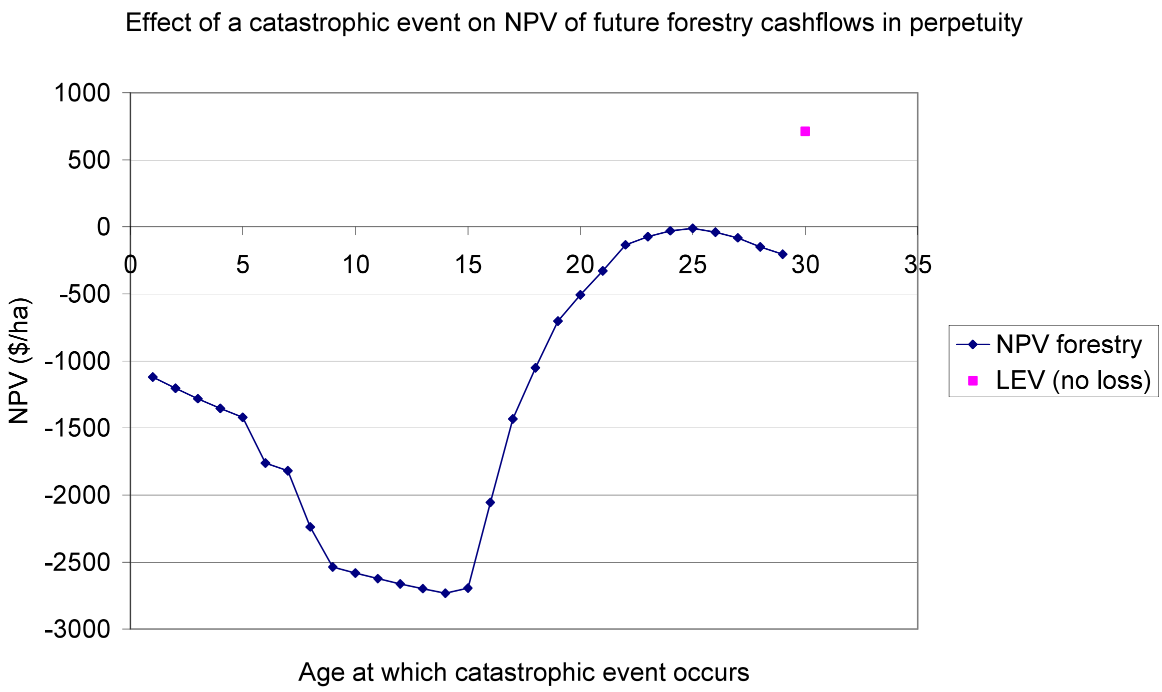
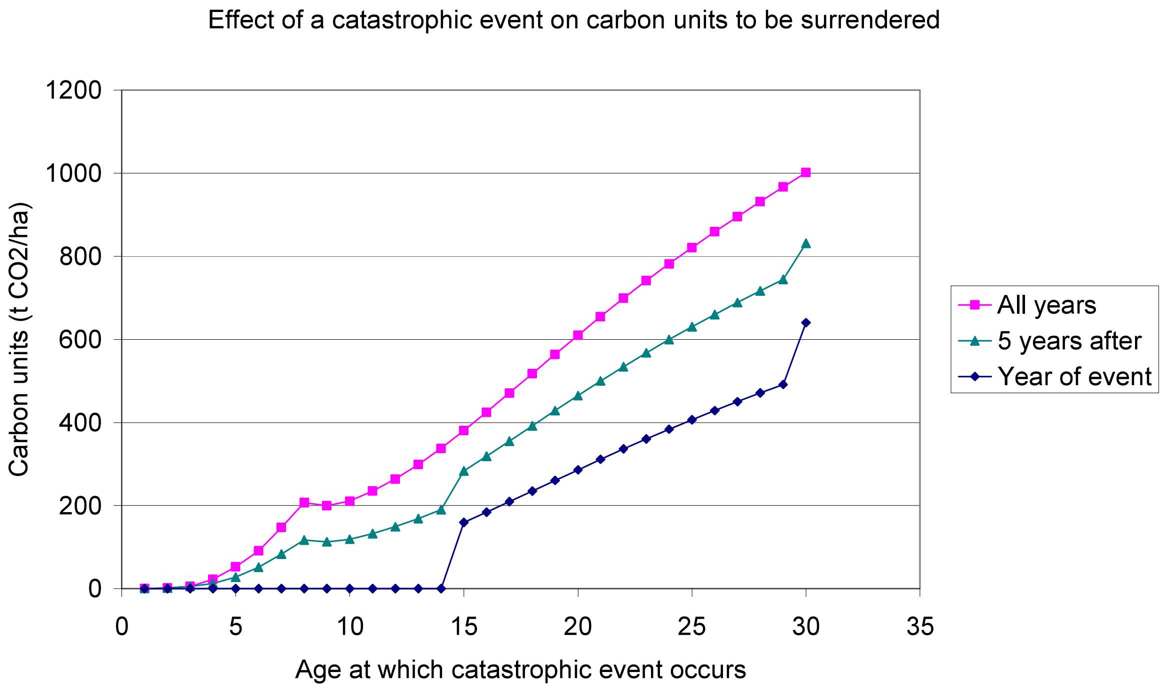


Fig. 3.3: Effect of a catastrophic event at different ages on the NPV of future forestry cashflows in perpetuity. Land is initially bare of trees. After the event occurs a perpetual series of 30 year rotations is assumed.



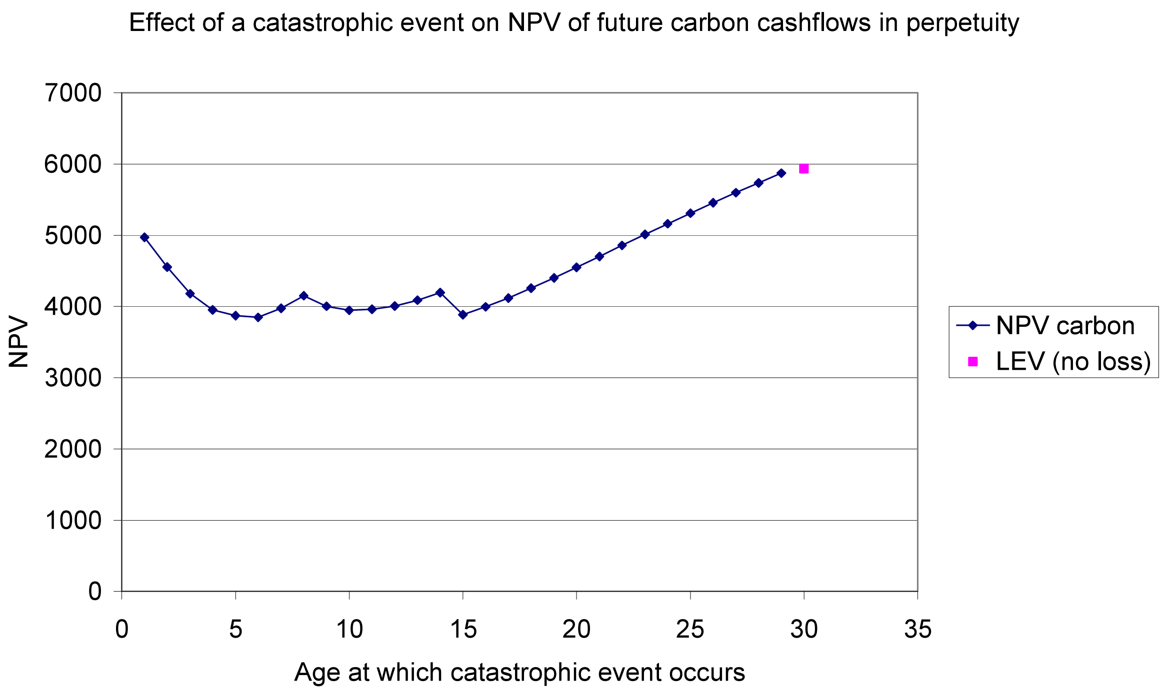
A catastrophic event requires the premature surrender of carbon units. Units have to be surrendered (a) for logs that are salvaged and removed from the site and (b) for residues as they subsequently decay. Fig. 3.4 shows the number of units that need to be surrendered (i) in the year of the event, (ii) in the first 5 years after the event and (iii) in all years following the event. The first category includes the units for carbon removed in salvage logging while the last category also includes the decay of residues following the event.

Fig. 3.4: Effect of a catastrophic event at different ages on the carbon units that have to be surrendered (i) in the year following the event; (ii) in the first 5 years following the event and (iii) in all years following the event. The age 30 values are those after planned harvest. (Values are for the first crop only. No allowance has been made for the carbon units that are earned in the next rotation.)



Although fewer carbon units have to be surrendered than would be the case following planned clearfelling, they have to be surrendered earlier than planned. The reduction in NPV (Fig. 3.5) when the catastrophic event occurs at young ages reflects the opportunity cost of using the site for the initial "rotation" and delay in re-establishing a crop. The spike at age 8 occurs because the stand is thinned at this age – some units need to be surrendered in the following year. The spike at age 14 occurs because salvage logging occurs from age 15 on – an event at age 14 means that all material stays on the site and decays gradually.

Fig. 3.5: Effect of a catastrophic event at different ages on the NPV of future carbon cashflows in perpetuity. Land is initially bare of trees. After the event occurs a perpetual series of 30 year rotations is assumed.



The risk-adjusted LEV and crop value can be calculated by assigning a probability to the catastrophic event occurring at each age. An equal probability at each age is assumed. Table 3.3 compares the risk-adjusted LEVs for different probabilities with the unadjusted LEVs. For example, the combined LEV is reduced by $1152/ha when the probability of a catastrophic event is 1% per year.

Table 3.3: Impact of the risk of catastrophic events on LEV ($/ha) with a target rotation age of 30 years. Probabilities are expressed as percentages.

	Probability of event occurring in any year				
	0	**0.25**	**0.5**	**1**	**2**
Forestry LEV ($/ha)	712	543	374	14	-802
Carbon LEV ($/ha)	5934	5823	5714	5481	4936
Forestry + C LEV ($/ha)	6647	6366	6088	5495	4134

Figs. 3.6 and 3.7 show how the forestry and carbon components of crop value at any age are reduced depending on the probability of a catastrophic event. The impact on carbon crop value is greater than the forestry crop value at least until about age 20.

Fig. 3.6: Effect of a catastrophic event at different ages on the reduction in forestry crop value for a 30 year target rotation.

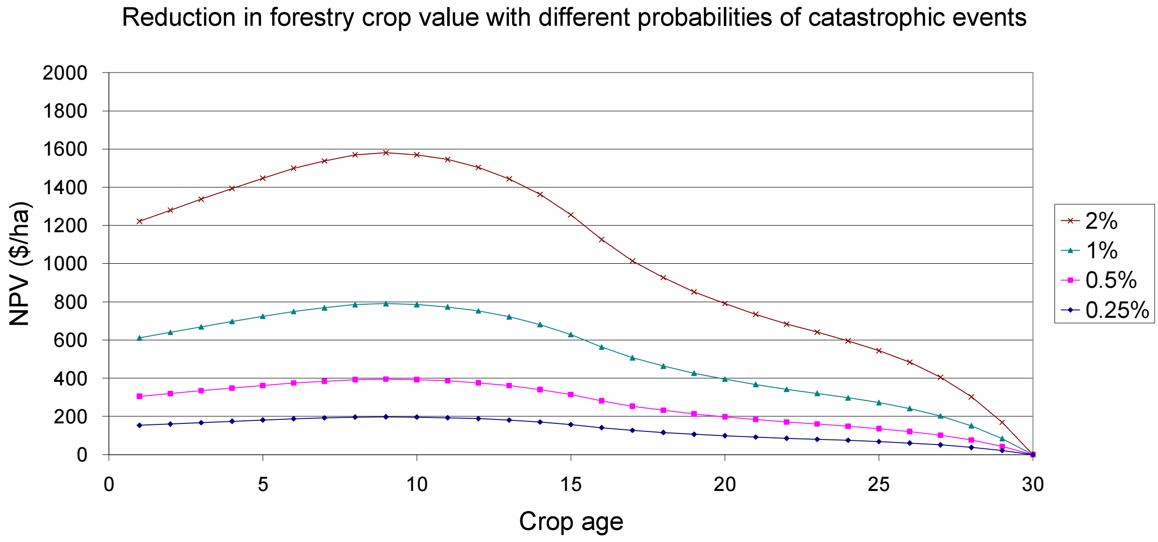
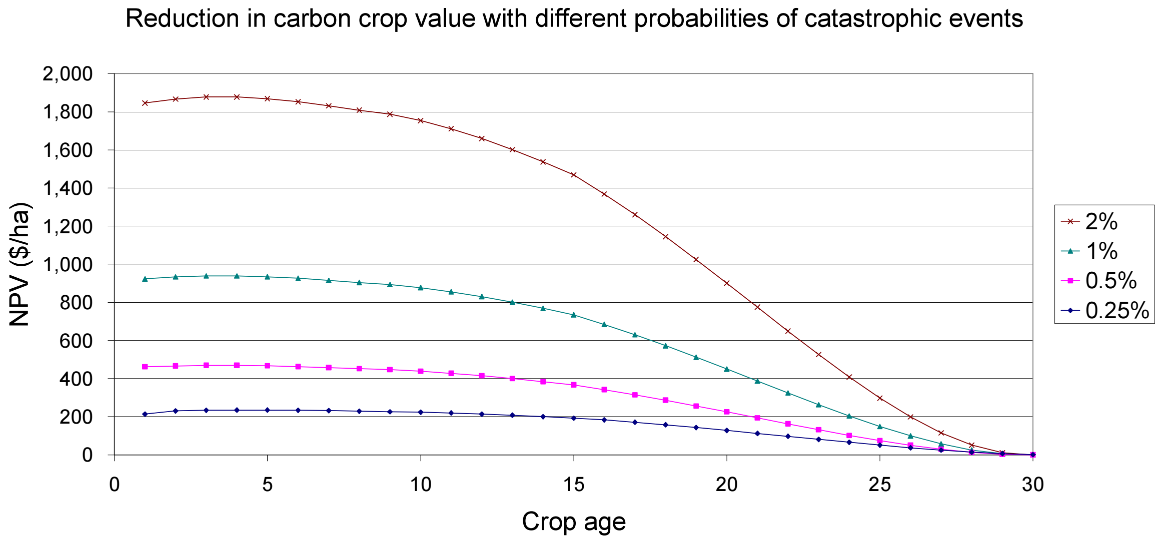


Fig. 3.7: Effect of a catastrophic event at different ages on the reduction in carbon crop value for a 30 year target rotation.



Overall we can say that the impact of catastrophic events is low when the probability is 0.25% per year but is certainly material at a probability of 1% per year. The analysis of Somerville (1995) indicates that many parts of New Zealand have a probability of around 0.25%. However even at this level forest growers are likely to be concerned about the risk. Small-scale owners in particular are concerned about worst case events, even if they are of low probability, as well as expected value. As pointed out in section 2.1, risk averse forest growers, who view risk per se as being costly, will seek to reduce this risk even if it reduces expected value.

4 Pooling Available in NZ Under Independent Insurers.

In this section, we review the insurance products that are available in New Zealand to cover forest loss. We then consider the availability of products that also include carbon. We subsequently estimate the cost of insurance to cover forest loss and also the premature surrender of carbon units that is triggered by this loss.

4.1 What Insurance Products are Offered and Who Offers Them?

Table 4.1 provides a summary of some forestry insurance products that are available. All products offer fire insurance. All but the NZI Forestcover have an option to include windthrow. Some of these products do not differentiate between different parts of New Zealand in the assessment of risk while others rate different regions separately for fire and wind risk.

Table 4.1 Insurance products available in New Zealand

Product	***Broker***	***Underwriter***	***Fire***	***Wind option***	***Other options***
Agricola Forestry Insurance	Agricola New Zealand	Lumley General (Wesfarmers General Insurance Ltd)	Fire, hail	Yes	Volcanic eruption
AgriRisk Forestry Insurance	AgriRisk	Farmers Mutual Insurance Association	Fire, hail, earthquake, volcanic eruption, landslip, malicious damage and impact	Yes	
Forestcover	NZI	NZI	Fire, explosion, lightning, thunderbolt, riots or strikes, civil commotion, aircraft, land vehicle		
QBE Forestry Insurance	QBE	QBE	Fire, lightning, aircraft damage	Yes	Earthquake, volcanic eruption, tsunami, flood or inundation
StandSure	FMR RiskSolutions	QBE	Fire, lightning, Malicious damage, other perils	Yes	Earthquake & volcanic eruption

4.2 Is Expanded Coverage Planned to Include Carbon?

The NZI insurance policy specifies a sum insured per hectare per unit of insurance which varies with tree age. All the other insurance policies listed in Table 4.1 are based on an agreed value. The general approach that is being considered for the inclusion of carbon is to increase the agreed value to cover the carbon value as well as the tree crop value.

A number of companies are planning to make products available that explicitly include carbon. However uncertainty over the final form of the Emissions Trading Scheme means that some of these proposals have been put on hold. Companies that have indicated that they will expand forestry insurance to cover carbon include:

- Agricola which is considering allowing the value of carbon to be built into the agreed value.
- AgriRisk which is considering allowing the value of carbon to be added to the sum assured.
- NZI which has developed the concept for a carbon insurance product with MunichRe.
- QBE which according the company website is “monitoring the progression of the Climate Change Bill through parliament and are confident we will be able to cover your client’s carbon exposures once they are more clearly defined”.

StandSure, developed by FMR RiskSolutions and underwritten by QBE, is now being offered with an option to insure carbon credits. Under this scheme “if carbon credits are to be insured, the value per hectare should be adjusted to give a figure that represents the total value of trees plus carbon”. An outline of the cover is provided in the Appendix.

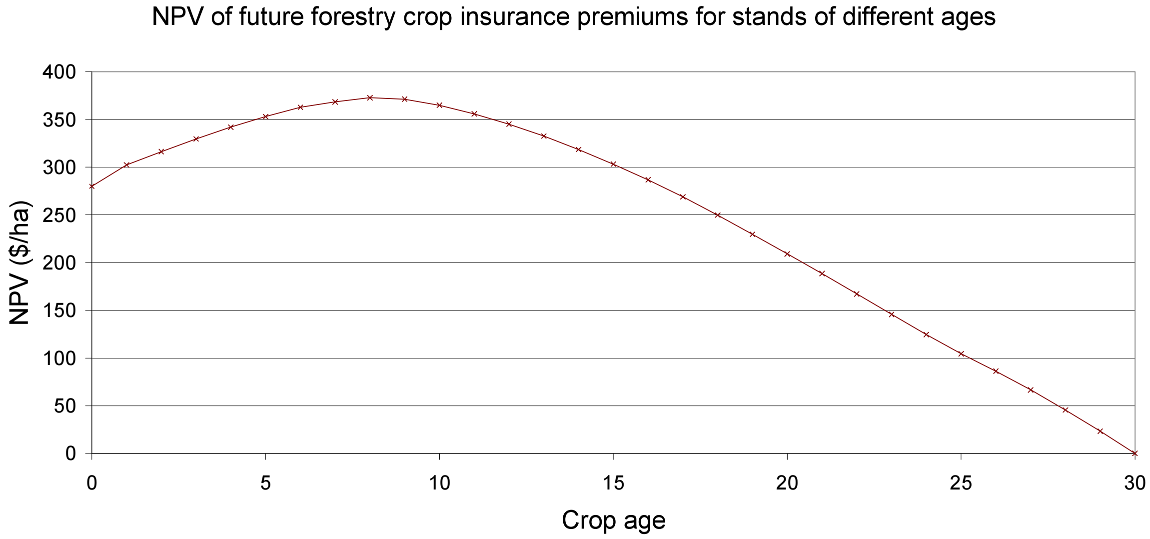
4.3 What Are the Costs?

We evaluate the cost of insurance within the context of the example presented in section 3.2. The cost is based on the premiums in Table 4.2 which are derived from information provide by FMR RiskSolutions (Tony Gouldson, pers. comm. – see the Appendix for details). These examples were obtained for a 50 ha forest. The cost of insurance for each age was found by multiplying the estimated forestry crop value by the premium for each age. From these the NPV of future insurance premiums was calculated for each age; for example, for a stand of age 10, the NPV of the insurance premiums for age 10 through to age 29 was calculated. These are shown in Fig. 4.1.

Table 4.2: Insurance premiums for different stand ages

Age	Cost ($ per $1000 of agreed value)
5	6.68
10	5.40
15	3.60
20	2.13
25	1.00
30	0.60

Fig. 4.1: NPV of future forestry crop insurance premiums for stands of different ages



A more difficult question is how much insurance to take for carbon stocks. Although a catastrophic event requires the surrender of carbon stocks, Fig. 3.4 shows that these (and more) would have had to be surrendered after planned harvest at age 30. Here we assume that insurance is taken only for carbon stocks that have to be surrendered prior to 30 years after establishment; for example, for a catastrophic event for a stand of age 25 years, we classify as premature those units that have to be surrendered in that year and the following 4 years. As a variation we also calculated the discounted sum of these units – this reflects the time profile by which units have to be purchased and surrendered if a catastrophic event occurs and insurance is received (Fig. 4.2).

The NPV of future carbon crop insurance premiums (Fig. 4.3) follows a similar pattern and has a similar order of magnitude to that of forestry crop insurance premiums (Fig. 4.1). The combined effect of the insurance cover on the tree crop and the carbon is substantial. Assuming insurance is taken based on discounted premature units, the combined reduction in overall crop value is as high as $627/ha. The combined LEV of the project is reduced from $6647/ha to $6205/ha.

Fig. 4.2: Effect of a catastrophic event at different ages on the carbon units that have to be surrendered (i) in all years following the event; (ii) in years until 30 years after establishment (ie, premature units) and (iii) the number of these premature units discounted back to the time of the event.

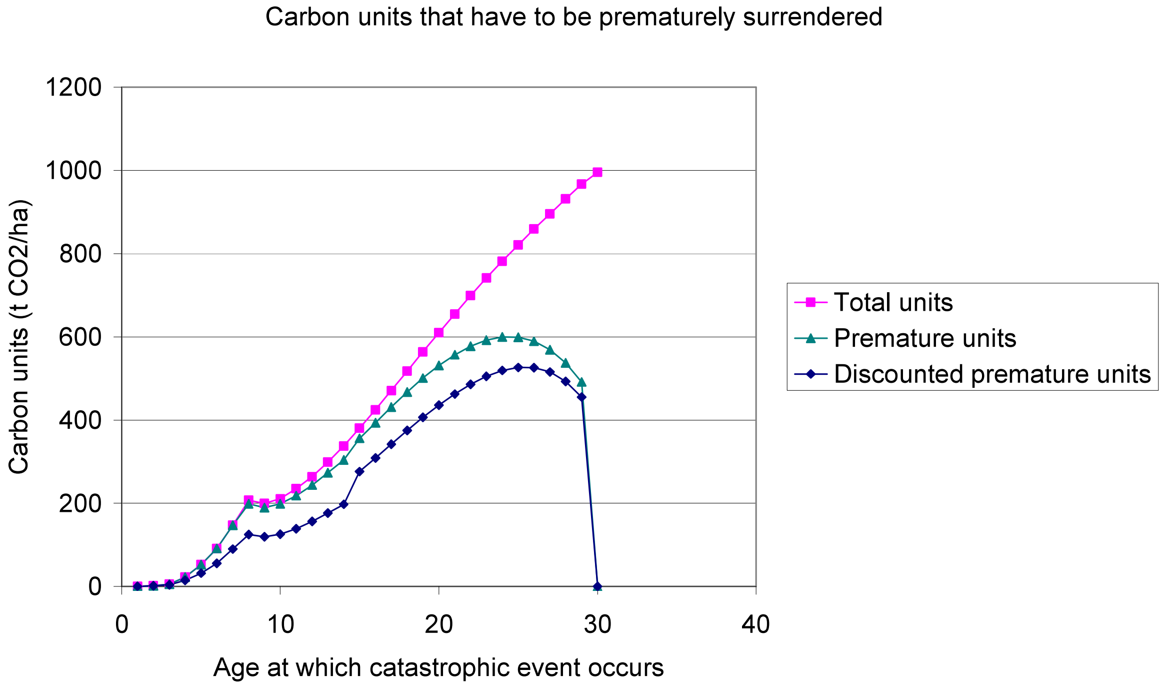
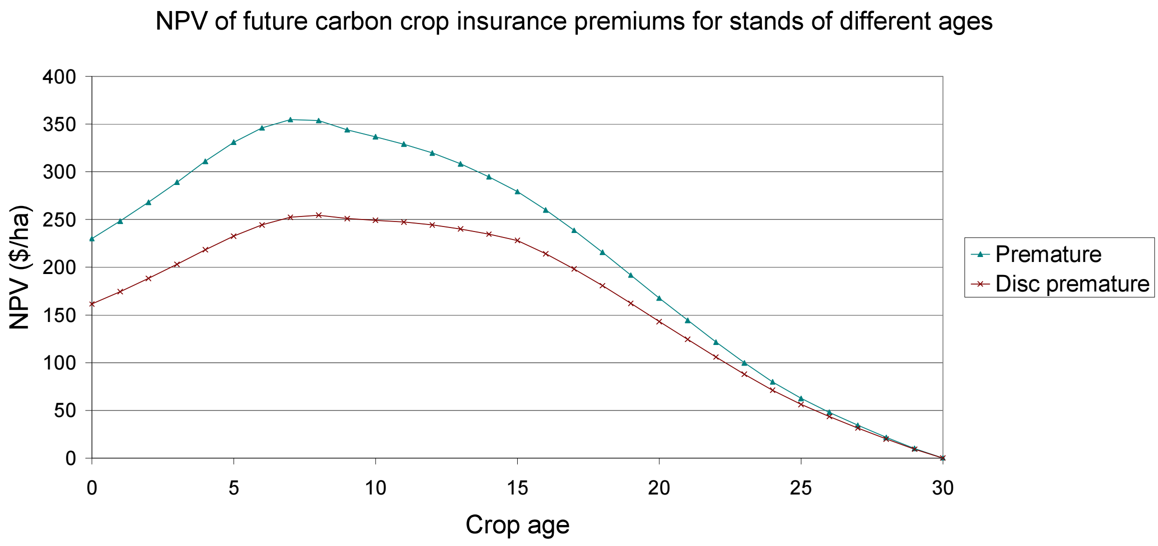
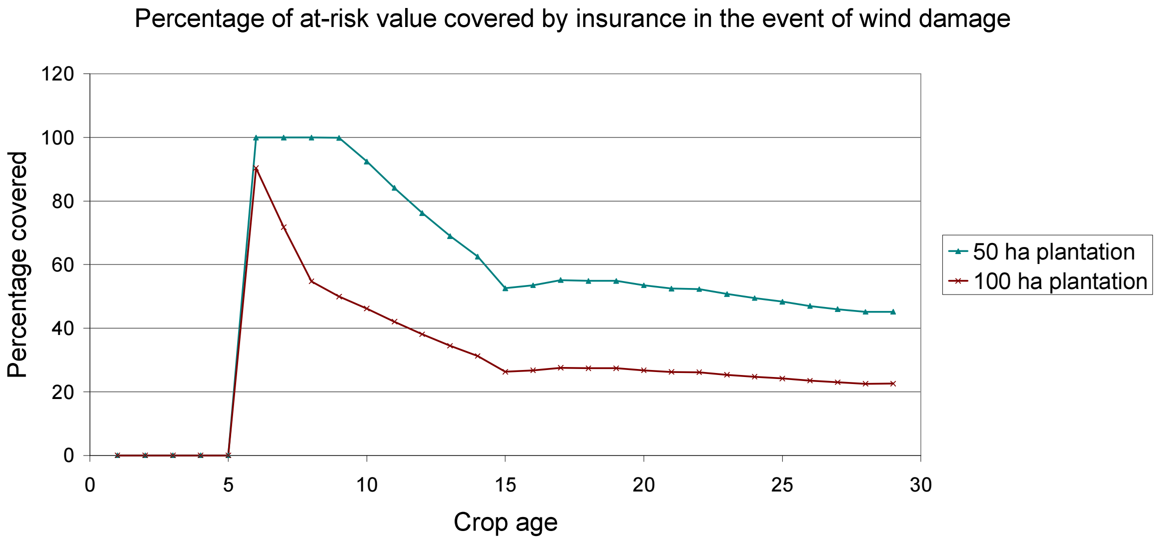


Fig. 4.3: NPV of future carbon crop insurance premiums for stands of different ages to cover (i) the value of the units that have to be surrendered prematurely and (ii) the value of these premature units discounted back to the time of the event. A carbon price of \$30/t CO_2 is used.



A limiting factor for insurance is that policies typically have an upper limit on the wind damage that can be claimed for any event. For example, the policy that we evaluated limits wind damage to \$500,000 per claim and only applies to trees over 5 years of age. This limit means that a forest may only be partially covered, particularly when carbon unit loss is added to tree crop loss. Fig 4.4 shows the percentage of "at-risk" value that is covered by insurance for the 50 ha example forest. Also shown is the percentage for a 100 ha forest assuming that the same limit of \$500,000 per claim applies. The at-risk value includes both tree crop value and the carbon stock value based on discounted premature units. The at-risk tree crop value is the net claim value; i.e., the standing tree crop value less the value of any salvage plus the additional reestablishment costs.

Fig. 4.4: Percentage of at-risk value (tree crop plus carbon) that is covered by an insurance policy which has a limit of $500,000 per claim in the event of wind damage to (a) 50 ha plantation; (b) 100 ha plantation.



5. Mutual Ownership

5.1 Are Mutuals Currently Used?

There are in New Zealand a number of firms, known as cooperatives, which are owned by either their consumers, e.g. Ravensdown, Composite Retail Group or their suppliers, e.g. Fonterra, New Zealand Honey Producers Co-operative Limited. But for some firms, such as banks or life assurance companies, the distinction between consumers and suppliers is not always very clear. If we view the firm as a set of contracts between various patrons – the purchasers of the firms output or sellers of the firm's inputs – the different sides to some of these contracts may at times be seen as representing both a 'purchasers' and a 'suppliers' relationship. For example, is the depositor at a bank a customer who is buying the bank's services or a supplier of funds to the bank? An exact answer is neither really possible nor necessary. Financial institutions, like banks and insurance companies and any number of others, play the role of intermediaries who bring together the borrower and lender, the insurer and the insured, the payee and the payer, etc. When ownership of a firm is under the control of agents who are on both sides of a financial contract that organisation is referred to as a 'mutual'.[25]

According to Evans and Meade (2006: 118) there are currently no cooperatives, and thus no mutuals, involved in forestry in New Zealand. Evans and Meade (2006: 118-9) explain the lack of cooperatives in the following way:

> Like fishing, forestry is another sector in which backward integration by processors and marketers has been the imperative instead of forward integration by producers. Large scale economies exist in wood processing, and pulp and paper production, but these do not appear to provide an incentive for cooperative organisation by forest growers. In part this has been because of significant state involvement in the forest growing and processing sector, resulting in a concentration of wood supply, as well as the adequacy of long-term contracting for securing access to supplies needed for efficient capacity utilisation of processing. This latter feature is emphasised by Boyd et al. (2000) as a suitable alternative to cooperative organisation by forest growers.

In addition there is considerable local competition for timber to go along with the foreign demand and thus few concerns about downstream market power exploitation. Also standing trees do not have to be harvested, as is the case for other agricultural products, and foresters a have considerable discretion over the exact time of harvest. This enables them to contract for sale prior to harvest. Thus many of the market drivers for cooperative organisation are missing for forest growers.

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[25] Hansmann (1996) and Ricketts (1999) give fuller explanations of the history and logic underlying mutual ownership. Much of the current discussion is drawn from these works.

Evans and Meade (2006: 119) also note that there is heterogeneity of interest among forest growers driven by the fact that growers vary in terms of scale, location, expected harvest date, extent of downstream processing involvement and/or other supply commitments. Such heterogeneity increases the costs of cooperative ownership.

There are mutuals involved in non-life assurance in New Zealand, if not specifically targeted towards the forest industry. For example, Farmers' Mutual Group covers lifestyle insurance, dairy insurance, arable crop insurance, horticulture and viticulture insurance for the farming community. PSIS offer general insurance for homes, contents, boats, caravans, trailers or vehicles as well as loan, travel and health insurance. The Southern Cross Healthcare Group consists of two separate organisations – Southern Cross Medical Care Society and Southern Cross Health Trust. Between them these organisations offers mainly health and travel insurance. The NZ Architects Co-operative Society Ltd offers, to its members, professional indemnity insurance. Such cover is provided on a "claims made and notified" basis, i.e. the policy must be in force when the claim is notified, notwithstanding that the events giving rise to the claim may have occurred some time previously. Civic Assurance is New Zealand's largest insurer of rate-payer owned assets and is owned by territorial and regional authorities in New Zealand. AMI Insurance Limited is another mutual, acting as a fire and general insurer.

5.2 How Are They Structured?

If we were to look at the purest case of a mutual, it would be one in which all the members of the organisation would provide the same services and receive the same benefits. For example, mutual savings and loan associations (MSLAs) arose in the United States as an institution in which a small group of working people would join together and pool their savings, from which they would, in turn, take loans to finance either the purchase or construction of a house. When all members had acquired a home the MSLA was dissolved. Today however the term is used in a wider sense to refer to an institution in which some members are primarily specialist savers and others are borrowers as is the case with modern building societies. Hansmann (1996: 253) discusses the development in the structure of mutuals for the US case,

> From their beginnings as time-limited pools among discrete groups of individuals seeking to finance their homes collectively, MSLAs evolved through stages. First, rather than dissolving after the members of the founding group had all financed their homes, MSLAs began to deal with successive or overlapping groups of members, with each group's finances managed as a separate pool. Later the MSLAs ceased to differentiate among different groups of members, and simply admitted individuals as members whenever they wished to join. Borrowers and depositors then came to be distinct classes of individuals: some individuals joined primarily to save; others joined primarily to borrow.

A downside to this is that a division between borrowers and lenders creates two types of 'owner' whose interests could be different and this fact would be expected to make governance more difficult.

The development of many mututal institutional structures is due, at least in part, to (a) opportunistic (or rent seeking) behaviour by the management of investor-owned companies, and (b) high levels of asymmetric information between managers and clients. It would appear that both of these aspects are also present for the case of insurance of forestry assets, and so one might expect the eventual development of mutual organisations for that activity as well. Mutuals have the advantage that a group of similar minded forest owners would be, presumably, better informed, than would an investor-owned insurer, about which of their peers would be good risks and which would be bad risks, and thus could use such information in the selection of additional members for the mutual. This mitigates the adverse selection issue. In addition a mutual insurance scheme also controls for the moral hazard problem, at least in part, since individual members who cheat know that it will be friends and neighbours (and even to a certain extent themselves) who will bear the loss.

Many of the early life assurance companies were formed as mutuals. An example being the Amicable Society for a Perpetual Assurance Office which was established in 1706.[26] The scheme allowed for a maximum of 2,000 society members to pay a set annual contribution of £6 4s each. These premiums were kept in an iron chest until they were required for the payment of claims or were made available for investment. Anyone between the ages of 12 and 45 was eligible to join and, at the end of each year, the contributions, less running costs, were to be divided between representatives of members who had died during the year.[27] In the words of Ricketts (1999: 27)

> The mechanism was crude but effective. In an era before mortality tables it provided rudimentary life assurance even if it made no allowance for age and

[26]The Amicable Society was established under a charter of Queen Anne and is thought to be the first mutual life assurance society in the world.

[27]In 1807, the society had obtained a new charter to broaden its aims and adopt the improved methods used by rival offices. Under the new charter, premiums were no longer subject to a set price but varied depending on the age and circumstances of the member. The society was allowed to grant annuities and the number of members increased to 8,000, having been raised to 4,000 in 1790. The society applied to change its charter again in 1823 to allow for 16,000 members and, in 1836, to increase that number to 32,000 members.

In 1864, the directors, feeling that progress was hampered by the proscriptions of the charters, set about searching for another company to take over its funds and liabilities. Their search came to an end when an act of parliament was obtained allowing the society to amalgamate with the Norwich Union Society for Insurances on Lives and Survivorships – it changed its name to Norwich Union Life Insurance Society in 1893 – in 1866. The Norwich Union Society for Insurances on Lives and Survivorships had been established, as a mutual, by Thomas Bignold in 1808. In 1997 Norwich Union demutualised and floated as a public limited company on the London Stock Exchange. Agencies where established in Auckland in 1870 and in Christchurch in 1872. In 1998 Norwich Union sold its New Zealand operations.

> would provide fluctuating benefits according to the number of members who died during a particular year.

More modern looking approaches developed in the late 1700s, with the introduction of the use of mortality tables and probability studies to calculate tables of fair annual premiums. The advantage of this was that the premium was fixed throughout the term of the policy and the amount paid on death was guaranteed.

Mutual governance still had its advantages. The premium calculations were highly uncertain and this meant that should the state of the world turn out to be a high mortality one, a firm could face defaulting on its promises since the agreed to premiums were set too low. On the other hand should the outcome be a low mortality one, then large profits would be made by the assurer, implying that premiums has been set too high. The advantage for the mutual was that they could set premiums prudently high, just in case the outcome was a high mortality state, but if it turned out that the state of the world was a low mortality one, then it could distribute surpluses to its members either in cash or as additions to the sum insured.

In effect the mutual had a crude state contingent premium scheme, higher for the high mortality outcome and lower for the low mortality state of the world. For the investor-owned firm both the high and low mortality outcomes carry the same premium, with the profits from the low mortality state of the world going to the investors.[28] Such benefits would also likely be available for a system of forestry insurance based upon mutual governance. Indeed, for the case of forestry, since risks are infrequent but of high value, the setting of prudently high premiums and then using a system of redistribution of unused surplus might be of great benefit in appropriately managing risks. The mutual could prudently set premiums high enough to provide for levels of reserves which are adequate for even the worst of predictions with regard to weather or fire risks to forests, and then if the outcome is better than predicted any excess reserves can be liquidated and returned to policyholders.

One obvious feature of a forestry insurance contract is the length of time the contract can be in place, these are long-term contracts. But this length of contract creates its own problems. There is a risk that the average loss, the real rate of return on investments, and the rate of inflation will be different from those assumed at the time when the policy was agreed to. The most obvious of these has to do with the rate of inflation. As Hansmann (1996: 270), in reference to life insurance, explains,

> A life insurance contract denominated in nominal dollars – as they were, and as they virtually had to be in the mid-nineteenth century, given the absence of reliable price indices – creates a pure gamble between the policyholder and the insurance

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[28]In fact, as Ricketts (1999: 27) notes,

> Some new entrants in the early part of the nineteenth century were established with outside shareholders but these allowed for a proportion of profits to be shared with policyholders.
>
>> Profit sharing became normal among these early offices founded with joint stock capital, competition with the mutuals …probably being the cause.

> company on the future rate of inflation. This gamble imposes costs on the policyholder in two forms. First, he must bear the risk that the real value of his policy will turn out to be different from its expected value. Second, he must pay a higher price for the policy to the insurance company to compensate the company for bearing its side of the same gamble – a risk that the company cannot easily reduce through diversification. In short, the purchaser must bear all of the costs, to both parties to the transaction, of a gamble that has no social value. And much the same is true, as well, of the risks that the average mortality rate and the average rate of return on investments will differ from their expected value.

The mutual form has an advantage here. The policyholder is on both sides of the transaction, he is both consumer and supplier of the insurance contract. This means there is no gamble. If it should transpire that the inflation rate, the real rate of return on investments, or the loss rate are different in actuality from that forecast, then what the member of a mutual insurance company loses on his policy he gains as an owner of the firm, and vice versa. Mutuals can adjust the dividends to policyholders so that the policyholder always maintains the appropriate amount of insurance and pays only the actual cost of providing that amount of insurance.

Both adverse selection and moral hazard mean that mutuals, in the early days of insurance, had an advantage in property and liability insurance.[29] Consider a company offering fire insurance to forestry. Different forests will differ in the risk they present. The customers of the insurance company are likely to be better informed about the risks each forest poses than is the insurance company. This informational advantage can be put to good use in a mutual insurance company. Forest managers that believe themselves to be a good risk are likely to join together in a mutual to insure themselves and these firms will be able to recognise each other as good risks in a way that an outside insurance company could not. Thus a mutual can attenuate the adverse section problem.

An investor-owned insurance company would have a much larger incentive to check customers' risk profiles better during the underwriting process, perhaps by individual visits to each potential customer's forest. However, there are a number of disincentives to undertake inspections. The company is open to hold-up in that the insured could threaten to take its business to another company unless it receives a lower premium based on the risk reducing

[29]Ricketts (1999: 29) notes,

> An early example of a mutual fire insurance company was the 'Hand-in-Hand' established in 169[6]. Insured members controlled the company and received net profits half yearly in proportion to the value of their assets insured.

It was first known as Contributors for Insuring Houses, Chambers or Rooms from Loss by Fire, by Amicable Contribution. In 1706, the company was renamed the Amicable Contributors (or Contributorship) for Insuring for Loss by Fire. It became known as the Hand-in-Hand Fire Office by 1720. In 1836 its name officially changed to the Hand-in-Hand Fire and Life Insurance Society. In 1905 the assets and business are transferred to Commercial Union and the society was dissolved.

actions that it has undertaken. Even if the insured did not leave their provider, any premium reduction would lesson the incentive for an investor-owned company to engage in inspections since it did not capture the full return from any risk reducing actions. A mutual mitigates such problems since the insured own the company. Policyholders are unlikely to hold themselves up and they capture the full return from any reduction in risk.

Another advantage, at least for smaller mutuals, is that members could exercise a degree of moral suasion on other members of the mutual to minimise any moral hazard problems.

Bearing industry wide risks is another role where mutuals can have an advantage. Insofar as the average loss level of an industry is hard to predict with any accuracy, then an insurance company writing either property or liability insurance for that particular group will face having to bear the risk that it is unable to reduce by writing a larger number of policies. It could be that such undiversifiable risk is more efficiently borne by the firms in the industry than by an investor-owned insurance company. Hansmann (1996: 280) explains the mutual's advantage as

> A mutual company has the advantage that it eliminates those risks that are idiosyncratic to individual firms within the industry, while it passes back, pro rata, to all firms in the industry the risk of variance in the overall loss experience of the industry as a whole. With a mutual company, consequently, the insured firms do not need to pay an insurance company the high premiums that would be necessary to induce the company to bear industrywide risks that would, in fact, be more easily borne by the firms themselves.

In their role as residual claimants, policyholders in the mutual must bear all the risks associated with any variance in the average industry wide loss rates. Idiosyncratic risk can be diversified and thus reduced via writing a greater number of policies while the undiversifiable risk is borne by policyholders via alternations in their share of company profits.

5.3 What are the Opportunities to Use Mutuals?

Overseas a major area for the use of mutuals in insurance is liability insurance. A common occurrence here is that firms or individuals in the same occupation or business in the same region will group together to provide cover for themselves. An advantage, as noted above, for mutuals is in dealing with industry-wide risk. When an industry faces uncertainty as to outcomes which affect the whole industry, such as was the case in the 1970s and 1980s when US courts began expanding considerably potential liability of manufacturers and service providers for injuries suffered by employees and by consumers of the firms' goods, mutuals play an increased role.

During the 1970s and 1980s the extent to which the courts would go in expanding the scope of liability and the amount of damages recoverable became highly uncertain. This led to an increase in the share of liability insurance written by mutual companies. Most of this growth occurred in industries where legal standards had become most unpredictable. This is an example where the industry faced uncertainty as to what the average loss level would be and the industry responded by forming mutual companies to provide cover. The restriction to a single industry or region is to ensure homogeneity of interest among the members of a mutual company and the effective member control which this homogeneity helps provide.

Insofar as the forestry industry in New Zealand suffers from undiversifiable, uncertain industry wide losses then a forestry specific mutual insurance company could have an advantage, for much the same reasons as mutuals have an advantage in liability insurance.

5.4 What are the Costs of Organising and Maintaining a Mutual and Managing Risks?

There are two major areas of costs associated with the mutual form of insurance companies. The first has to do with a restricted access to capital while the second concerns suboptimal diversification of risk.

As to the first of these costs there are two problems to be considered. The first is the fact that a restricted access to capital, when compared to an investor-owned firm, slows the rate at which mutuals can be founded and grow. Moreover since the capital a mutual has available for expansion comes from retained profits based on existing policies, fast growth is against the interests of existing policyholders.

Second, there is evidence that suggests that mutuals accumulate financial reserves – at the expense of policyholder – that are in excess of that needed for continued solvency. Hansmann (1996: 274) notes

> Although these reserves are evidently accumulated in part to finance future growth, in part they apparently serve simply to satisfy management's desire for a very comfortable margin within which to manoeuvre and for a large investment portfolio to oversee.

The second cost follows from the fact, as has been noted above, that mutuals often only insure firms in a single line of business. This limits the amount of diversification that the firm is able to undertake despite the fact that diversification into other areas of business has the obvious advantage of spending risk.

In addition there are problems that arise for the larger mutuals. As the company grows its advantages in being able to use local knowledge and moral suasion to help in dealing with problems of adverse selection and moral hazard is eroded. Also, as the mutual grows in size it begins, as far as policyholder control is concerned, to resemble an investor-owned firm. As the mutual grows a given policyholder is no better able to control the actions of the firm's management than is the typical shareholder in an investor-owned firm.

6 Risk-Pooling Issues

In this final section, we shall provide a short discussion of the issues related to risk-pooling as an insurance mechanism for forestry risks. Some of the points mentioned here are discussed more fully above, in section 2.2, and in section 4, and so the discussion here shall offer some summary conclusions.

6.1 Aggregation of Small-Scale Owners

Regardless of whether risk-pooling is to be organised under a specialist underwriter (an independent insurer), or under a mutual organisation, in order for risk-pooling to be of any benefit it requires the bringing together of many small, hopefully independent, risks. For the case of forestry, this implies that an appropriate insurance pool should consist of many small-scale owners, rather than only one or two very large forestry companies. That is not to say that large-scale owners should not be included, but only that in order that insurable risks be diversified, there needs to be a sufficiently large number of members of the pool.

Unfortunately it is impossible to tell exactly how many members of an insurance pool are sufficient, as this depends upon the exact risks that each supplies, and the relative amounts of risk that each supplies as a fraction of the total risk in the pool. However, if we look simply at the case of forestry insurance and, say, automobile insurance, it is clear that for the case of forestry it will always provide a more difficult prospect for risk-sharing to be as efficient. There are far, far more individual risk-holders in the automobile market, and each presents a risk that is infinitesimal relative to the aggregate. This is clearly never going to be the case for forestry, especially for locally organised insurance in a country of the size of New Zealand. This implies that any kind of risk management based upon local pooling of risks is likely to be reasonably inefficient, at least as compared to more international insurance markets.

6.2 Which Structure (Mutuals or Independent Insurers) is Most Efficient for Forestry?

Regardless of the clear possibility that forestry insurance under risk-pooling is likely to be inefficient due to a restricted ability to diversify risks, we can still consider whether or not independent insurers or mutuals are likely to be the better option. As we have noted in previous sections, risk-sharing organised by mutuals offers some benefits when compared to risk-sharing organised by independent insurers, but it also suffers certain drawbacks as well. A consideration of which is the more efficient method of organisation requires an analysis of the relative merits of each option.

For the particular case of New Zealand, it is at least instructive that forestry insurance mutuals have yet to form, and forestry insurance is largely offered by independent insurers. Such an observation is strong evidence that independently organised risk-sharing is likely to be the more efficient of the two options, at least for the case of forestry in New Zealand.

The principal drawbacks of locally organised mutual insurance in New Zealand are almost all related to the geographical features of forestry in this country. Firstly, the geographical concentration of forests implies that some of the principal risks faced (weather risks) are highly correlated over different forest owners. When this occurs, while risk-pooling does not become impossible, it is necessary to have a relatively larger number of members participating in the pool in order for the risks to be diversified sufficiently. Indeed, if the risks are too highly correlated, then the pooling of risks becomes useless, and all that is created is a system that is subject to catastrophic events.

Of course, since the number of small forest owners in New Zealand is also limited[30], then the sector clearly faces what might be severe restrictions for the formation of profitable insurance mutuals based upon local membership. To that end, it might well be the case that insurance based upon risk-pooling for New Zealand forestry is better suited to independent insurance, underwritten by large international insurance companies that insure forestry investments in many countries, and so it is not surprising to see that the majority of forestry insurance in New Zealand is carried out in this way.

That said, there is certainly one particular forestry risk that might well be better insured under a mutual organisation than under an independent insurer. The risk in question is the carbon units that have to be prematurely surrendered (when the owner has opted into the ETS) when a forest is destroyed by some hazard. When a hazard occurs, and a forest is destroyed (either totally or partially), the forest owner potentially faces two separate but related costs. First there is the cost of the actual investment in timber itself. The destruction of the forest reduces the timber that can be harvested down to the salvage level, which depending on the type of disaster that has struck, could feasibly be rather little. Second, the loss of trees triggers the early surrender of the associated carbon units, which must then be purchased back from the market.

A group of forest owners, acting as a mutual, could eliminate carbon risk. Forest owners in the mutual would put all eligible forests into the ETS and receive carbon units but not sell all units – ie, they leave some units in the registry account. The mutual could provide these "pooled" units to members for whom a catastrophic loss triggered the premature surrender of carbon units. In this way, at a premium of the loss of earnings on the carbon units that were not traded[31], the mutual would have managed to eliminate all of the risk involved if units had to be re-purchased. It would seem that this is indeed a strong point in favour of mutuals as insurance mechanisms for forestry, at least for this particular risk within forestry.

A variation of this would involve the government retaining a specified percentage of carbon units and using these to "write-off" units in the registry account of forest growers following a catastrophic loss, or at least the portion of units that need to be prematurely surrendered. Of course, we might then worry that such government insurance schemes will lead to both adverse selection and moral hazard problems (Brunette and Couture (2008)) – in general,

[30] The 2008 NEFD shows that there are 1081 forest owners with 40 to 99 ha and 721 forest owners with 100 to 499 ha. In addition there is an unknown number of owners with <40 ha.
[31] For the example from section 3, LEV would be reduced by $67/ha for every 1% of carbon units not traded.

problems of incentive compatibility. However, so long as the scheme were to offer only partial insurance of losses, then these problems can be mitigated or perhaps even overcome completely. To the extent that the government scheme would only cover for carbon losses, and not for timber investment losses, then it would certainly only provide for partial coverage of the total loss. Thus it would appear that there is at least sufficient scope to organise such a scheme in such a way that it is indeed incentive compatible.

6.3 Comparison of Structures in Terms of Costs

Insurance based upon independent underwriters, and that based upon mutual organisations, will typically differ with respect to the costs involved. The accounting cost structures of independent underwriters will be largely based upon only the estimate of the actuarial value of the risk that is being underwritten, along with the fixed costs of maintaining the company, which will be largely independent of the type of risk under consideration. Independent insurers will offer premium rates that cover the actuarial costs involved, and that are competitive with the rates of other underwriters offering similar insurance products.

It is well known that independent insurance suffers particular costs (economic, rather than accounting) related to asymmetric information. These costs represent the difference between actual profits and potential profits due to the insurer lacking full information on the insurance customers. Asymmetric information generally takes two forms: (1) *adverse selection* refers to the inability of the insurer to fully observe the identity characteristics of each insured, and (2) *moral hazard* refers to the inability of the insurer to fully observe the post-contractual activities of the insureds. It is well known that in order to successfully tackle each of these problems, the insurers should use incentive based contracts that are, generally, less profitable than what could be done in a hypothetical scenario of perfect information.

On the other hand, the cost structure of an insurance scheme that is run under a mutual organisation might be quite different. Since mutuals are united groups of individual members, and since they act (presumably) with a not-for-profit objective, the costs implied by asymmetric information and by profit seeking can be largely avoided. However, aside from the pure actuarial costs of supplying insurance, a mutual will also suffer the cost of search for members, and the costs of bargaining over members as to how the surpluses (or losses) from the mutual should be shared.

One possible significant advantage of mutuals over and above independent insurers is that the problems of adverse selection and moral hazard should be less restrictive, since mutuals by definition are groups of similar members. Thus, it is much more likely that the costs of revealing information are significantly lower for a mutual than for an independent insurer, leading to a relative efficiency gain over independently organised insurance.

Finally, any insurance contract will imply the possibility of fraud of one type or another. Thus, all insurers require systems of policing and enforcement, in order to minimise the costs that fraud imposes upon them. Policing and enforcement costs are designed to lead to incentive compatibility, in the sence that by undertaking such procedures the insurer can provide the insured with sufficient incentive not to act fraudulently. Thus, we would expect that the very existence of a policing and enforcement mechanism, that coherently checks losses for careless or fruadulent activity, and that promises a reduced (perhaps even nil, or negative) indemnity if any indication of carelessness or outright fraud is found, can be stuctured such that no insured sees any personal advantage from being careless or acting fraudlently. As such, insureds will act in the best interests of the insurer, which is exactly what we mean by the system being "incentive compatible". Again, at least theoretically, it is to be expected that fraud will be less of a problem under a mutual organisation than under independent insurance, and so the costs of policing and enforcement will also be lower. The reason for this is two-fold. First, by definition mutuals are owned by their members, and so if a member acts fraudulently he is, at least in part, only cheating himself. This must have a tempering effect upon the amount of fraud that occurs within mutuals as compared to independent insurers.

Second, fraud is a special type of asymmetrical information problem. For example, if the fraud takes the form of artificial promotion of hazards, or of claim inflation, then what is really happening is that the insured is claiming a value of loss that exceeds the true value. The only way to control for this is by a costly mechanism used by the insurer to check the validity of each claim before paying out. When the insured is very similar to all other insureds, which as we have already argued above tends to occur in a mutual, information differences are limited, including the true values of losses, or the true probabilities of losses. In short, under a mutual organisation there would appear to be less scope for insureds to act fraudulently, thus reducing the costs of controlling for fraud for the organisation.

6.4 Comparison of Structures in Terms of Risk Management

Finally, we can offer some comments regarding the comparison of independent insurers and mutuals in terms of their ability to manage risks. In short, effective risk management requires two things: (1) efficient risk minimisation, and (2) effective risk diversification. The first element basically states that any actions whose costs of carrying out are no greater than the monetary value of the resulting risk saving should be carried out. The second element says that any risks that are left need to be shared in such a way that each member of the sharing syndicate ends up with a less risky prospect, and yet all risks are catered for.

Efficient risk management is not typically something that either independent insurers or insurance mutuals will be involved with. It is much more dealing with the individual forest owners' choices of self-insurance and self-protection strategies. However, of course, insurance offered under a risk-pooling mechanism might well be made conditional upon any efficient risk minimisation strategies having been carried out. This can often be included into the insurance contracts of risk-sharing mechanisms as a premium discount conditional upon specific observable actions of the insurance consumers having been carried out.

Given that, the main purpose of either independent insurers and mutuals is risk-sharing in order to diversify risks. It is very hard to say which of the two structures is better placed to diversify risks. On the one hand, it seems likely that independent insurers might have access to a more diversified set of customers, resulting in less correlation between the risks, and thus a better ability to diversify away the risks. But on the other hand, this is likely to only be possible with less efficient contracts due to the greater informational restrictions that occur in independently organised insurance.

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Appendix

Outline of Cover Provided by Standsure and Premium Cost to Insure Carbon Credits (provided by Tony Gouldson FMR RiskSolutions, 5 June 2009)

Policy Cover

1. Fire, Lightning and Explosion provided up to the value of trees, plus the Policy extensions. Subject to a maximum of $15,000,000 per forest/per claim.

2. Wind damage is limited to $500,000 per claim, in full and applies only to trees over 5 years of age.

3. Earthquake and Volcanic Eruption risks can also be insured – few owners are interested in this – not included within premium illustrations provided.

4. Policy Extensions (given as sample amounts only)

   - Claims Preparation Costs $ 25,000
   - Site Clearing & Re-establishment Costs $ 50,000
   - Forest & Rural Fires Act cover plus Fire Protection Costs $400,000

5. Excess all claims are subject to an excess of $25,000

6. Premium Indications. The following premiums are indications of the cost of insuring the sample plantations shown in the table.

   Sample Plantation

Age	Hectare	Value per hectare	Total Value	Annual Premium excl. GST
5	50	$2,500	$125,000	$835
10	50	$5,000	$250,000	$1,350
15	50	$10,000	$500,000	$1,800
20	50	$15,000	$750,000	$1,600
25	50	$20,000	$1,000,000	$1,000
30	50	$25,000	$1,250,000	$750

7. Carbon Credits. If carbon credits are to be insured, the value per hectare should be adjusted to give a figure that represents the total value of tress plus carbon. A "Straight Line" increase or decrease in premium will give an indicated premium cost for insuring trees and carbon combined.

   Example: If the 30 year old trees have a carbon value of $5,000 per hectare

   Total value = 50 hectares x ($25,000 + $5,000)
   = 50 x $30,000
   = $1,500,000

$$\text{New Premium} = \text{old premium} \times \frac{\text{new value}}{\text{original value}}$$

$$= \$750 \times \frac{\$150,000}{\$1,250,000} = \$900$$