Perspectives on Forest Stewardship Council certification and vegetation management in New Zealand

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Abstract

The Forest Stewardship Council (FSC), a forest eco-certification body, has prohibited key herbicides used in forest vegetation management, including two of the main herbicides used in New Zealand (hexazinone and terbuthylazine). Using New Zealand as a case study we (i) review the basis of the prohibitions, and (ii) compare the financial viability of current practice (using aerial and spot control of weeds with prohibited herbicides) with alternative FSC compliant chemicals (applied aerially or using spot application), and non-chemical control methods (weed mats, mechanical, manual control).

Low values of the distribution coefficient (K_d) were found for hexazinone on a range of New Zealand forest soils. This supports the FSC ban of this herbicide based on its high mobility. Values of K_d were relatively high (average 19.7 L kg-^{1}) for terbuthylazine across a range of New Zealand soils indicating limited mobility for this herbicide. Terbuthylazine is banned because it has the potential to bioaccumulate. We contend that *in situ* breakdown in some New Zealand forest soils will reduce the risk of bioaccumulation. Assuming no losses in crop growth, analyses indicated that use of FSC compliant herbicides is likely to be a cost effective alternative. Analyses show non-chemical control methods are not cost effective in New Zealand.

Keywords: *certification, herbicides, financial viability*

Introduction

There is global consumer demand for wood products from sustainably managed forests. As a result, many forest companies comply with certification schemes that endorse the principles of sustainable forest management (Ibanez and Laye, 2008). The only global certification scheme with common principles and governance is the Forest Stewardship Council (FSC). The FSC seeks to promote "environmentally responsible, socially beneficial and economically viable management of the world's forests" (Radosevich et al., 2000). This organisation has certified 147 million ha of forests in 80 countries, of which 8% (of the total area) represents planted forests (Forest Stewardship Council, 2011). Over 50% of New Zealand's *Pinus radiata D. Don forests are currently certified by FSC.*

The FSC promotes the reduction, and ultimate elimination, of pesticides from forest pest management (Radosevich et al., 2000). Since many planted forest industries depend on herbicides for vegetation management this standard is in conflict with current management regimes. In line with their stance on pesticide use, the FSC has drafted a list of hazardous pesticides prohibited from use in FSC certified forests. Two of the key herbicides (terbuthylazine and hexazinone) used in New Zealand plantation forestry have been prohibited. These herbicides can only be used on FSC-certified land with a special approval, and there is increasing restriction on the quantities that can be used. These herbicides are prohibited because they are considered to either move rapidly in the soil (based on the K_{oc} value[1]) and/or bio-accumulate in aquatic organisms (based on a Kow value[2]) (Forest Stewardship Council, 2007). However, there is a lack of empirical research to support this position for New Zealand plantation forestry.

The ban on terbuthylazine and hexazinone has increased the pressure to find alternative vegetation management systems (both chemical and non-chemical) in New Zealand's planted forests. In an industry driven by profit, however, financial viability and efficacy remain central to the choice of certification compliant vegetation control regimes. Here we review (i) the basis of the ban on terbuthylazine and hexazinone in New Zealand forest plantations and (ii) the financial viability of

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[1] K_{oc} – *The organic carbon affinity coefficient is the soil distribution coefficient (Kd) normalised for soil organic carbon content. The most influential factor in herbicide adsorption is soil organic matter and to make the distribution coefficient more versatile it is commonly normalised to organic carbon content.*

[2] K_{ow} – *The octanol water partition coefficient is the ratio of the concentration of a chemical in octanol and in water at equilibrium, at a specified temperature. Octanol is an organic solvent that is used as a surrogate for natural organic matter. A high value for the partition coefficient is regarded as an indicator that a substance will bioaccumulate (unless other factors operate).*

using FSC compliant herbicides (in aerial or spot weed control), and non-chemical (weed mats, mechanical or manual control) methods of control, compared to current practice (aerial or spot control with prohibited herbicides). Recommendations are made on likely industry uptake of the described weed control methods in a certification compliant forest management system.

Methods

Soil sampling

Soil samples (0-100 mm), chosen to encompass the range in soil properties on which planted forests are established, were collected from around 34 sites in New Zealand. The eight major soil orders on which 96.5% of the Pinus radiata plantation estate occurs were included in the sampling strategy (Watt et al., 2010). Measurements of K_d and K_{oc} for terbuthylazine and hexazinone were determined using the batch equilibrium method fully described by Watt et al. (2010) on all 34 sites for terbuthylazine and on 8 sites for hexazinone.

Evaluation of the economic feasibility of vegetation management regimes

The influence of a range of non-compliant (current) and compliant vegetation management regimes on the stand internal rate of return (IRR) was investigated. Details of the treatments and calculation of IRR have been described previously (Rolando et al., 2011a). For all of the chemical treatments a pre-plant application of glyphosate and metsulfuron was included in cost calculations. The non-compliant practices used terbuthylazine and hexazinone in either aerial or spot release for the two years following planting. A combination of triclopyr, clopyralid and haloxyfop was used for the compliant treatments in either aerial or spot release for two years post planting. Non-chemical control methods included manual control, mechanical control and use of weed mats.

We examined the effect of the vegetation management regime on IRR across a site quality gradient. Costs were used for intensively managed, pruned 28 year *P. radiata* stands located on low (total yield of 450 m^3 ha^{-1}), medium (total yield of 580 m^3 $ha^{-1)}$, and high (total yield of 696 m^3 $ha^{-1)}$ yielding sites (Nielson, 2010). All financial calculations assumed no effect of the certification compliant vegetation management regimes on final timber yields.

Results

Determination of herbicide adsorption by the soil

For terbuthylazine, K_d averaged 19.7 L kg^{-1} and ranged from 5.1 to 50.2 L kg^{-1} across soil orders. Values of K_d were lowest on Raw and Recent soil orders (Table 1), that have low soil organic carbon. For terbuthylazine values of Koc ranged across soil orders from 268 to 576 L kg^{-1}. For hexazinone, ranges in K_d and K_{oc} across the eight sites were 1.3 to 2.8 L kg^{-1} and 19 to 37 L kg^{-1}. Values of K_{oc} were approximately an order of magnitude lower for hexazinone than for terbuthlyazine (Table 1).

Evaluation of the economic feasibility of vegetation management regimes

Compared to current operational treatments (aerial or spot control using non-compliant chemicals) use of aerially applied compliant herbicides had little effect on IRR (Table 2).

The non-chemical vegetation control regimes were several times more expensive than the current operational standard (data not shown). Consequently, IRR for the non chemical regimes was much lower than those using chemicals, with the greatest reductions in IRR occurring on low productivity sites (Table 2).

Table 1. Variation in the distribution coefficient, K_d, and soil organic carbon affinity coefficient, K_{OC}, between the eight sampled soil orders for hexazinone and terbuthlyazine. Note for hexazinone, Pallic and Raw soil orders were not sampled.

Soil order	Soil organic carbon				Hexazinone	Terbuthylazine
		K_d (L kg^{-1})	K_{OC} (L kg^{-1})		K_d (L kg^{-1})	K_{OC} (L kg^{-1})
Allophanic	10.3	2.8	30		39.3	274
Brown	5.2	1.9	37		16.9	322
Pallic	3.7	-	-		10.4	296
Podzol	7.6	1.4	19		50.2	576
Pumice	5.9	1.4	29		15.9	268
Raw	1.0	-	-		5.1	499
Recent	1.6	1.3	28		5.4	352
Ultic	3.8	2.8	30		14.6	406

Table 2. Internal rates of return for FSC compliant and non-compliant aerial and spot applications. Also shown are IRR for non-herbicide regimes. Rates are calculated for typical low, medium and high yielding P. radiata *sites in New Zealand and assume no effects of regime on final crop yield.*

Regime	Site quality		
	High	Medium	Low
Using non-compliant herbicides			
Aerial control	5.8	6.2	5.0
Spot control	5.9	6.4	5.3
Using compliant herbicides			
Aerial control	5.7	6.1	4.9
Spot control	5.9	6.4	5.2
Non-herbicide regimes			
Manual	5.3	5.5	4.2
Mechanical	5.0	5.0	3.7
Weed mats	4.8	4.7	3.3

Discussion

Results described in this study support the FSC ban on hexazinone but suggest that there is potential for terbuthylazine to be used without environmental damage. For terbuthylazine, previous field studies (Dolaptsoglou *et al.*, 2007; Dolaptsoglou et al., 2009) have shown that leaching does not occur when K_d exceeds 2.3 L kg^{-1}. Given that the lowest average value of Kd recorded in this study was 5.1 L kg^{-1} it appears unlikely that the terbuthylazine used in forest vegetation management will contaminate water bodies, before the herbicide is degraded by soil micro-organisms. Results clearly show K_d to be lowest for the Raw and Recent soils which have low organic carbon. If, conservatively, these soils are excluded, leaching is unlikely to be problematic for the vast majority (ca. 85%) of the forestry estate. In contrast, leaching of hexazinone is likely to be problematic for most soil types as K_{oc} was well below the FSC threshold (300 L kg^{-1}) for all soil orders and Kd was below 2.3 L kg^{-1} for 4 of the 6 soil orders sampled.

Assuming that use of FSC compliant herbicides does not affect final yield, analyses indicate use of these herbicides is likely to have little impact on IRR. However, as there are some weed species not well controlled by FSC compliant herbicides, the efficacy and applicability of the alternatives across a wide range of sites may be limited. Such is the case for Buddleia davidii, one of the most aggressive weeds in the Central North Island (CNI) region (Richardson et al., 1996). Preliminary trials have indicated that only herbicide mixes that include at least terbuthylazine are able to control this weed post planting, with none of the currently available alternative herbicides affecting any control (Rolando et al., 2011b). This provides a good case for a review of the risk posed by use of terbuthylazine in the forest environment.

Use of spot weed control is also a viable option, with either compliant or prohibited herbicides. Spot control with terbuthylazine and hexazinone is likely to have the advantage of reducing herbicide use, without sacrificing efficacy.

The non-chemical control methods examined here (mechanical, manual, weed mats) are not currently financially viable in New Zealand. The opportunity for these methods to be adopted by the New Zealand forest sector is limited given both the high cost and potential losses in tree growth (Rolando et al., 2011a). Although we did not examine the implications of reductions in growth on IRR here, these reductions are likely to be substantial, and the figures given here should be interpreted as being very optimistic in terms of their impact on the financial viability of the forestry sector. Given that rates of afforestation within New Zealand exhibit a strong positive correlation with the IRR (Manley and McLaren, 2009) enforced use of these costly weed control methods is likely to have substantial consequences for forestry within New Zealand.

There is wide variation in vegetation control practices within plantation forestry throughout the world. In Europe the most common alternatives to herbicides are mechanical methods to cut vegetation and achieve soil cultivation, overstorey canopy manipulation to control vegetation by light availability, and, in some instances, the use of mulches or biological control (McCarthy *et al.*, 2011). Although little research has examined why this variation exists it is very likely the context for forest vegetation control varies between Europe and New Zealand. In regions such as Scandinavia, where herbicide use is very low (McCarthy *et al.*, 2011), the shade tolerance of plantation species may result in greater growth under competition from weeds, which are slower growing than their New Zealand counterparts. Greater areas of suitable (flatter) terrain may mean mechanical and manual control can be carried out across broader scales, than in New Zealand, which may make this practice more cost effective. Further research should be undertaken to obtain greater understanding of the economic factors driving industry behaviour and response to the limitations on herbicide use imposed by certification within different countries. Such information is critical to understanding why the practices supporting the principles of certification are more easily adopted in some forest systems than others.

In conclusion, adherence to FSC criteria around herbicide use is likely to have an impact on the forestry sector. Within New Zealand the FSC criterion for banning hexazinone was well supported by measurements of K_d. However, the low mobility of terbuthylazine found for New Zealand forest soils suggest this herbicide is unlikely to bioaccumulate in aquatic organisms, before breaking down in situ. Analyses of IRR clearly show that non-chemical regimes are not cost-effective within New Zealand. However, assuming no yield reduction, using spot control of the prohibited herbicides or the use of FSC compliant herbicides, through either spot or aerial application, was found to be cost effective. As herbicides not currently banned by FSC are more phytotoxic to the crop species, than the non-compliant prohibited herbicides, further research should determine the extent of any growth reductions and their persistence over time. Spot control, using either compliant or prohibited herbicides, could be a particularly useful method to adopt as this technique combines well with oversowing and biological control.

Acknowledgements

Funding was provided by the New Zealand Foundation for Research Science and Technology programme Undermining Weeds (Contract No. C10X0811) and also the FSC Cluster Group. We thank Hailong Wang, Morkel Zaayman and Katrina Martin for undertaking analyses shown in Table 1.

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