

A critique of the Forest Stewardship Council chemicals criteria for certification of plantation forestry

I.B. Tomkins

School of Forestry, University of Melbourne, Creswick, Victoria 3363, Australia
Email: ibt@unimelb.edu.au

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Summary

This paper examines the Forest Stewardship Council (FSC) criteria for use of chemicals in plantation forestry, and an interpretation of these criteria. If fully implemented in plantation practice, these criteria could preclude plantation-based timber industries in developing countries and create serious problems for continuing plantation management in developed countries.

Keywords: certification; chemicals; pesticides; herbicides; forest plantations; reviews

Introduction

Certification has emerged as a potentially useful tool to improve the management of forests for conservation and production purposes. Various schemes have been developed, particularly over the last decade, under the auspices of governments, non-government organisations and industry. One of the earliest and initially influential certification schemes was the Forest Stewardship Council (FSC 2002), now headquartered in Bonn, Germany.

One Australian forestry corporation, Hancock Victorian Plantations, is now FSC certified (February 2004). Others, including Timbercorp Ltd, Treecorp Group and Great Southern Plantations, have either undergone initial auditing, or have applied for, or are considering FSC certification. Integrated Tree Cropping (ITC) has formally applied after final audit and is anticipating certification early in 2004. These organisations and others participated in a meeting in Canberra, ACT, early in 2003 to consider a national initiative to adopt FSC certification, but this was not pursued (Certifiedforests 2003).

Other forest certification processes that have been developed include the recently-proposed Australian Forestry Standard (2003), available through Australian Standards, and the Pan European Forest Certification (PEFC) scheme, launched in 1999 and now the world's largest (NAFI 2003); this latter scheme is really an umbrella for certification by other national or regional schemes. The National Association of Forest Industries (NAFI) has noted several certification schemes, including the North American Sustainable Forest Initiative (SFI) (NAFI 2003).

In the 'Background' to the Forest Stewardship Council's (2002) Principles & Criteria, the FSC states that it is an independent,

non-profit, non-governmental organisation, and that 'Forest certification emerged in the late 80s in response to perceived poor forestry management and calls for boycotts of certain wood products'. The FSC 'was formed to oversee a credible process of independent certification of well managed forests'.

The FSC adopted nine 'Principles' and complementary 'Criteria' for worldwide applicability at its founding meeting in 1993, and at a later date added a tenth for plantations. The FSC states that its principles and criteria require interpretation at the local level, and encourages the development of regional forest stewardship standards that are in line with the FSC's mission. The FSC claims that they are 'the key actors in the development of forest stewardship standards'. In short, the FSC claims hegemony over all other forestry certification standards. As such it might be expected to be objective and rigorous.

Whilst not monolithic in terms of the overall certification standards which may be approved in various countries or regions, a critical foundation for FSC certification arises from a commissioned report to the FSC by Radosevich *et al.* (2000), which purports to provide a scientifically defensible justification for the inclusion or exclusion of the use of specific pesticides in forestry, which the FSC rigidly applies in most instances.

As they relate to the use of chemicals in plantation forestry, the critical FSC criteria are numbers 6.6, 6.7 and 10.7:

- 6.6. Management systems shall promote the development and adoption of environmentally friendly non-chemical methods of pest management and strive to avoid the use of chemical pesticides, including the World Health Organization Type 1A and 1B and chlorinated hydrocarbon pesticides; and pesticides that are persistent, toxic or whose derivatives remain biologically active and accumulate in the food chain beyond their intended use. Moreover, any pesticide banned by international agreement shall be prohibited. Where chemicals are used, proper equipment and training shall be provided to minimise health and environmental risks.
- 6.7. Chemical containers and solid non-organic wastes including fuel and oil shall be disposed of in an environmentally appropriate manner at off-site locations.
- 10.7. Measures shall be taken to prevent and minimise outbreaks of pests, disease, fire and invasive plant introductions. Integrated pest management shall form an essential part

of the management plan, with primary reliance on prevention and biological control methods rather than chemical pesticides and fertilisers. Plantation management should make every effort to move away from chemical pesticides and fertilisers, including their use in nurseries.

Radosevich *et al.* (2000) nominated four objectives in reviewing and interpreting these criteria:

- (i) to interpret and re-write, if necessary, Criteria 6.6, 6.7 and 10.7 to provide uniformity of advice to FSC;
- (ii) to develop protocols or procedures whereby a land manager can reduce or eliminate chemical pesticide use. These procedures may include quantifiable steps that lead to chemical reduction;
- (iii) to provide clarity on the definition of a chlorinated hydrocarbon pesticide; and
- (iv) to develop lists of chemical pesticides potentially used in certified forests that are World Health Organization Type 1A and 1B and chlorinated hydrocarbon pesticides; persistent, toxic, or whose derivatives remain biologically active and accumulate in the food chain beyond their intended use; as well as any pesticide banned by international agreement.

The goals of pest and weed management in certified forests were seen by Radosevich *et al.* (2000) as controlling diseases, pests and animals, or unwanted competitive plants, only when necessary, and without the use of chemical pesticides such as fungicides, insecticides or herbicides. Moreover, they suggest that a plan of phased pesticide reduction is, in itself, insufficient for certification unless it explicitly aims at pest or weed management without chemicals.

Radosevich *et al.* (2000) saw selection harvesting and maintenance of forests in a mixed species uneven-aged condition as one of the best protections against disease and pest and weed infestations, and as a means of avoiding chemical use, and ensuring that pesticide use should not become a routine component of management. A broad comment is made regarding monitoring and documentation of pest problems to determine action thresholds, given their cyclical nature.

Use of chemicals in Australian plantation practice

The present paper challenges the justifications of the FSC criteria for chemical use provided by Radosevich *et al.* (2000), and explores the consequences as they relate to Australian plantation practice.

Plantations grown for timber production in Australia are (in all but a tiny minority of situations) monocultures of pine species or eucalypt species (notwithstanding the use in such plantations of planting stock derived from breeding programs). In pine plantations, thinning is practised at certain stages of growth in order to develop a sawlog final crop. Most eucalypt plantations in Australia are grown on a short rotation for pulpwood. The FSC can be referring only to native forest ecosystems in suggesting that forests be maintained as uneven-aged and as mixed species stands.

Australian plantations are usually grown on sites that do not permit maximum theoretical growth due to inadequate rainfall, seasonal conditions and variation, and nutritional status or imbalances that can be corrected only by the application of fertiliser. Australia is a developed country, and given these inherent growth restrictions the use of pesticides is an important management tool. For example, the use of residual herbicides in combination with appropriate site preparation techniques is essential to give long-term weed control, particularly during the summer drought period when weeds compete strongly for available soil moisture. Nevertheless, there has been significant progress towards minimising herbicide use, for example by slash retention and mulching following clearfelling of pine plantations, by the application of herbicides only along planting lines on many sites, or by spot applications to individual trees.

The FSC appears to imply that all agricultural/forestry chemicals including fertilisers are intrinsically undesirable or harmful. Applied to agricultural production, the FSC goal of pest and weed management without chemicals (including fertilisers) would lead to a collapse of the world's food supplies, and of textiles such as cotton. Use of pesticides also plays an essential role in repairing environmental damage caused by pest invasions.

Why, then, adopt such a goal for the non-food crop of timber production? The 'sustainability' argument should not override practicalities and commonsense.

How, also, is Australian plantation forestry supposed to maintain site nutrient status over long periods, given that nutrient export will occur even if only wood and bark are removed — let alone whole trees, which would be an even greater drain on site nutrient capital? Should tree growth rates be constrained by the level of natural inputs from rainfall, or nitrogen from legumes? Or should larger areas be planted to achieve mean annual increments of just a few cubic metres per hectare in order to supply wood volumes that could be grown under intensive management on much smaller areas?

Determination of 'action thresholds' is an intensive process. The wide variety and differing times of emergence of pasture and woody weeds encountered on various sites requires that best practice prevents their emergence during the first and second year after planting. Whilst appropriate site preparation techniques reduce weed emergence, plantations in Australia continue to benefit from herbicides at some stage during the establishment procedures. Similar considerations apply to insect pests, which can emerge as problems in different seasons.

The rationale for the third Radosevich *et al.* (2000) objective, so far as herbicides in use in Australia are concerned, is acceptable. For example, the two herbicides in Table 1 of the Radosevich report are not in use in Australian forestry, and one (2,4,5-T) is banned in Australia.

Chemical toxicity

The fourth Radosevich *et al.* (2000) objective considered three criteria for use of potentially persistent, toxic or bio-magnifying pesticides. Noting that laboratory determinations of toxicity —

Table 1. Half-life, RfD, Kow and other data for three triazine herbicides. Source: Tomlin (2000).

Chemical	Half-life (median) (days)	RfD ^a daily dose (mg kg ⁻¹)	log Kow ^b at 25°C	Koc ^c (median) (L kg ⁻¹)	Solubility (mg L ⁻¹) ^d
Atrazine	16–77 (41)	0.005 (rats) 0.0375 (dogs)	2.5	33–179 (NG) ^e	33
Simazine	27–102 ^f (49)	0.005 (rats) 0.008 (dogs)	2.1 ^g	103–277 (160)	6.2
Terbutylazine	30–60 (NG) ^e	0.0022 (rats) 0.004 (dogs)	3.21	162–278 (NG) ^e	8.5

^a RfD — ‘Reference Dose’ (see text for explanation); calculated as ‘No Observable Adverse Effect Level’ (NOAEL)/100 derived from the animal data listed.

^b log Kow — a measure of bio-accumulation; see text.

^c Koc — organic carbon exchange constant.

^d In water, pH = 7 at 20°C.

^e Not given.

^f Radosevich gave 60 days and no range.

^g Radosevich gave 1.96.

and comparisons based solely on toxicity of pesticides with differing persistence and degradation rates — can be misleading in the field, Radosevich *et al.* (2000) recommended combining and sequentially reviewing all relevant toxicity, persistence and ecological data for any given pesticide to determine overall acceptability.

However, I argue that the claim to have included all relevant data in the development of the acceptability lists is false, and that the data were selectively used. For example, glyphosate is considered as marginally acceptable, partly because there was a problem with the polyethoxylated tallow amine (POEA) surfactant included in some glyphosate products and which is toxic to some non-target species, particularly frogs. New non-toxic surfactants are incorporated in many products, but this was ignored.

I now examine in more detail the criteria of Radosevich *et al.* for use of toxic chemicals; viz. persistence, toxicity, bioaccumulation and bioconcentration.

Persistence

‘Persistence’ relies on a determination of the half-life of a pesticide; that is, the time, following application in a particular environment, needed to degrade, dissipate or destroy half of an applied dose of the chemical in question. Persistence was defined thus:

Non- or weakly persistent: half-life of 30 days or less,

Moderately persistent: half-life of 30–100 days, and

Strongly persistent: half-life of >100 days.

Radosevich *et al.* (2000) recommended excluding ‘strongly persistent’ pesticides, and regarding ‘moderately persistent’ pesticides as ‘marginally acceptable’, and ‘non- or weakly persistent’ pesticides as ‘acceptable’.

Although the criteria for determining acceptable pesticides were not intended to substitute for sound judgement in the field, the choice of a 30-day half-life as a limiting period for acceptability is subjective, severe and highly selective. There is no intrinsic relationship between ‘acceptability’ and soil half-life. Ninety days after application, the level of a residual herbicide with a 30-day half-life would be only 1/8th of that applied, which could encourage use of herbicides at the highest permitted rates to obtain longer-term weed control. For certain pesticides, a 15-day half-

life could be unacceptable, and for others, >60 days could be quite acceptable. A ‘one size fits all’ approach does not provide a sound basis for including or excluding a given pesticide and is not, as claimed, scientifically defensible.

Although it was acknowledged that persistence in soil is influenced by temperature, adsorption and pH, other factors such as soil moisture and UV degradation were not noted. Temperature and soil moisture are critical factors in the rate of pesticide breakdown where the principal breakdown pathway is by bacterial degradation. Despite this, the half-life data presented in the Radosevich tables in some instances are single values and not a range, for example, simazine 60 days. The half-life in soil also cannot take into account degradation from foliar knockdown of existing weeds. The half-life in water is also a critical factor, not considered by Radosevich *et al.* (2000).

Table 1 summarises data for three triazine herbicides; terbutylazine is included because the FSC has approved the use of this chemical in plantations in New Zealand.

In Australia, the National Registration Authority’s (2002) Draft Final Report: Review of Atrazine, based on a study by the Forest Herbicides Research Management Group (FHRMG), found that the half-life of atrazine varied from 12 days in Queensland to 140 days in Tasmania, with the determining factor being soil temperature. Other examples (from the Radosevich tables) include clopyralid with a half-life of 30–70 days, metolachlor, 15–70 days, and oryzalin, 20–128 days. Depending on soil type, temperature and other factors, these herbicides could fall into any one of the three arbitrary classes. Not all are used in forestry.

The sulfonyl urea (SU) herbicides provide another example. Sulfometuron methyl, used in southern Australia in plantation forestry, is a very effective chemical for the control of pasture grasses and broadleaved weeds and is classed as acceptable, yet soil pH and soil temperature strongly correlate with its persistence. As pH rises, the sulfonyl urea herbicides become more persistent. In high (>6.5–7) pH soils, SU herbicides are very persistent (Beyer *et al.* 1987). In acid soils, the principal breakdown mechanism may be acid hydrolysis. Persistence also increases with decreasing temperature (Beyer *et al.* 1987), and the use of sulfometuron methyl in cold climatic conditions can lead to problems with tree health (Tomkins unpublished).

Toxicity

Radosevich *et al.* (2000) relied on the recognition that all pesticides will be 'toxic' at some dose, and that the most relevant standard is a dosage that can be tolerated without adverse effect.

The 'Reference Dose' (RfD) used is an estimate of a 'presumably safe' level of exposure for human exposure or ingestion, and is calculated from the 'No Observable Adverse Effect Level' (NOAEL). An RfD is typically extrapolated from animals to humans using a safety factor of 100, after calculating NOAEL (see Table 1). NOAELs are based on toxicity assessments made in the most susceptible animal species and vulnerable organ systems. Thus it was claimed that an RfD should reflect a sensitive end point for ecosystem vertebrate toxicity. The EPA (USA) has calculated one, and often several, values for most pesticides. Where two or more different RfDs are known, Radosevich *et al.* (2000) suggest that the lowest value should be accepted as the most protective. No explanation was given as to how the EPA had calculated one, and often several, values for most pesticides. Is it because a range of safety factors was used? No justification was given for adopting the lowest value as the most protective in a plantation context. The lowest value may have been derived with data from an environment completely removed from, and irrelevant to, plantations.

The RfD is a measure of chronic, not acute, toxicity. The critical level set was 0.01 mg kg^{-1} of body weight day^{-1} ; an RfD >0.01 is generally permissible for chronic toxicity, and <0.01 is excluded (that is, if there are toxic effects at doses below 0.01 the toxicity is too great to be termed 'chronic'). However, at a pesticide concentration of $10 \mu\text{g L}^{-1}$ (0.01 mg L^{-1}), a 70 kg person would have to drink 70 L day^{-1} to ingest their daily dose of 0.7 mg.

Note that in Table 1, terbuthylazine has an RfD less than either atrazine or simazine and should therefore be classed as unacceptable.

The LD50 (dose in mg kg^{-1} of body weight that kills half of a test population, usually rats or rabbits) is a measure of acute toxicity and was also considered. The level set for selection of toxic pesticides was 200 mg kg^{-1} , that is, $<200 \text{ mg kg}^{-1}$ was selected as a toxic pesticide. For aquatic toxicity, the LC50 value is used. This is the median lethal concentration in an aqueous environment. The test species is usually rainbow trout, considered to be the most vulnerable species. The level set by the review is $50 \mu\text{g L}^{-1}$ (50 ppb) in aquatic environments. LD50 values in the Radosevich tables of herbicides in current use in Australia are all $\gg 200 \text{ mg kg}^{-1}$. Similarly, LC50 values all exceed 50 ppb (note that they are listed as mg L^{-1} or ppm).

Bio-accumulation of pesticides or their derivatives in individual organisms, and bio-concentration to higher trophic levels

Assessment of bio-accumulation was based on the octanol-water partition coefficient, defined as the logarithm of the amount of chemical that concentrates in octanol minus the log of the concentration in water. The resulting ratio or Kow is a measure of lipophilicity and predicts the degree of concentration of any given chemical in the fat or lipid fraction of cells or organisms. Where the logarithm of the Kow exceeds 3, the octanol/water differential gradient is about 1000. At this level and above, a chemical is very

likely to concentrate up the food chain. Hence the value of 1000 is chosen as the bio-magnification criterion.

There is a serious weakness in the use of Kow values. Many pesticides are either weak acids, for example the sulfonyl ureas (SUs), or weak bases, for example the triazines. Thus pH greatly affects their water solubility and Kow. Solubility in water increases with increasing pH (for SUs), or decreasing pH (for triazines), but the effect on Kow is the opposite, because the ionic forms are soluble in water but not in octanol (Beyer *et al.* 1987). Therefore, the value of Kow must be given at a specific pH. The most appropriate pH would relate to the *in vivo* (physiological) pH of cells, but this is not indicated.

Note that terbuthylazine has an unacceptable log Kow (Table 1).

Two other factors, BCF and BAF, were considered — the bio-concentration factor and the bio-accumulation factor. BCF is the ratio of the concentration of a pesticide in the flesh of an aquatic species and in the water it swims in. BAF is similar — the same ratio in an individual organism to the concentration in the environment.

Where human exposure to pesticides is concerned, operators who apply the chemicals are at most potential risk of suffering acute toxic effects. However, in a developed country like Australia, occupational health and safety legislation and regulation are advanced, pesticide labelling is strictly regulated and applicators must be trained and licensed. The potential for chronic toxicity arising from exposure is greater where pesticides are applied on a continuing basis.

Sources of data

Radosevich *et al.* (2000) use data and references almost exclusively from the USA. In particular, Kamrin (1997) is the only source of data which includes half-lives, RfDs, log Kows, LD50s and LC50s in the acceptability lists. The data do not necessarily agree with those from other sources; for example, *The Pesticide Manual* (see Table 1). *The Pesticide Manual* is widely regarded as the most authoritative source of pesticide data. It is not scientifically defensible to use one source of data over others without justification.

Simazine is a banned herbicide in the FSC/Radosevich lists, yet terbuthylazine is acceptable and has been approved by the FSC for use in New Zealand. There are no registered terbuthylazine products in Australia, although two companies have registered the active ingredient (the chemical), and the main use of the chemical in the US is as an algicide, microbiocide and microbiostat (US EPA 1995).

The FSC has a process whereby organisations applying for certification may apply for 'derogation' (that is, an interim exemption) for a particular chemical. Because certain plants in Western Australia generate monofluoroacetate (1080 poison) to which native animals in WA have a natural tolerance, ITC and Timbercorp will apply for derogation for 1080 in WA at least.

However, ITC is not applying for derogation for simazine, and intends to rely instead on sulfometuron methyl, despite any attendant risks — yet data from *The Pesticides Manual* in Table 1

demonstrate that terbuthylazine, which the FSC has indicated to the Australian companies would be acceptable as a substitute for simazine, ought to be even less acceptable than simazine using the Radosevich *et al.* (2000) criteria. (Note: After granting derogation for the use of simazine for three years to one plantation grower, the FSC has now extended this Australia-wide. However, seven conditions apply, including approval for use by a 'pesticides Advisory Group' to be established by the FSC.)

Other general and specific criticisms

No weighting was given by Radosevich *et al.* (2000) to the three main criteria for use of potentially toxic chemicals. A 'one size fits all' approach was adopted, regardless of other important scientific and practical considerations. Why was soil-fastness not considered, as measured by the organic carbon exchange constant (Koc), for which values are readily available? These are discussed in Shaw and Chadwick (1998), a reference used by Radosevich *et al.* (2000).

Koc values reflect adsorbed concentrations of herbicides/pesticides based on soil organic carbon (Wauchope and Myers 1985; Singh *et al.* 1990; Dousset *et al.* 1994). Ideally, Koc is a constant for a particular pesticide, providing that adsorption in soil is determined only by organic matter. However, soil materials such as clay particles and sesquioxides also absorb pesticides. In practice, there is large variation in Koc values, due probably to differences in pH and specific surface areas of adsorbent soil particles. Nevertheless, in relative and practical terms, as Koc increases a pesticide becomes more soil-fast.

Contrasting examples are oxyfluorfen and simazine; both are 'excluded' by the Radosevich criteria. Oxyfluorfen is a soil surface-active herbicide best applied to bare soil, and is extremely soil-fast, with $Koc = 100\,000\text{ L kg}^{-1}$ and very low solubility (0.1 mg L^{-1}). Its half-life of 30–40 days is 'marginal' (Radosevich *et al.* 2000). Thus it can only move off-site under extreme conditions, these being very dry with soil or surface litter being blown off site, or very wet with soil or surface litter being washed off site. Toxicity is then not an issue, given plantation buffer requirements including stream and drainage line buffers, usually of at least 10 m. These important factors are ignored by the Radosevich criteria.

Simazine is only moderately soil-fast, has low solubility and an acceptable Kow (Table 1), and is less controversial in plantation forestry in Australia than atrazine which is approved for use by the FSC. The RfD becomes the main factor, despite the low acute toxicity indicated by high LD50 and LC50 values.

Glyphosate, an essential pre-planting herbicide in plantation establishment in most situations, is classified by Radosevich *et al.* (2000) as marginal. Although its half-life is given as 47 days, it is also extremely soil-fast ($Koc = 24\,000\text{ L kg}^{-1}$) despite its very high solubility (e.g. isopropylammonium salt 1050 g L^{-1} at pH 4.3) (Tomlin 2000). The half-life given by Tomlin (2000) is 3–174 days, depending on edaphic and climatic conditions. The only factor that marginalises glyphosate is its half-life, and in practical terms that is irrelevant, because firstly the chemical is a foliar knockdown herbicide, and secondly it degrades in soil to harmless substances (carbon dioxide, phosphate, ammonia).

For the SUs, problems are ignored which can mitigate against their use. They are soluble and very mobile; and there have been

several episodes in forestry and industrial use of damaging off-site movement of sulfometuron methyl. They are also easily leached, and should not be used on acid/neutral sandy soils low in organic matter. However, the low rates of application usually result in failure to detect residues below 30 cm depth (Russell *et al.* 2002). They root prune, and are much more persistent with increasing soil pH or in cold climates. They can also sequester trace elements such as Zn and Cu in soils deficient in these essential micronutrients (Beyer *et al.* 1987).

Shaw and Chadwick (1998) discuss in their Chapter 6 several factors ignored by the Radosevich *et al.* (2000) report, including hydrolysis as a function of pH, adsorption/desorption, photolysis, degradation in natural water sediment, mobility, and differences in metabolic processes.

The critical consideration of the *total* rate of use (the amount of active ingredient per hectare over a rotation) is ignored, yet in plantation forestry in Australia, herbicides are usually applied only in the first and second season of each rotation. Later applications are usually selective, for example, basal bark treatment to kill woody weeds on some second (or later) rotation sites. Timing of herbicide application is another critical factor. In some areas it may be efficacious to clean up existing weeds with knockdown herbicides before the onset of winter rainfall, then to apply a post-planting application in late spring at minimal rates required for summer weed control. This approach minimises the risk of contaminating watercourses with residual herbicides.

The chemicals criteria would preclude any developing country from establishing industrial plantations, and it follows that the FSC approach is exclusive and protective of countries with well developed plantation industries; these may (with difficulty) be able to accommodate some of the inevitable consequent restrictions.

Conclusion

The Radosevich *et al.* (2000) report is an ideological approach to complex issues. Our knowledge of these issues is based not only on scientific data but also on a great deal of experience gained over many years by plantation managers and researchers. The criteria used in the report, however, are highly generalized, and they are supported by selected data; such an approach is pseudo-science. The review does not provide a scientifically, economically or socially acceptable basis for the inclusion or exclusion of a number of pesticides from forestry. If agriculture adopted similar criteria, world food production would be severely curtailed. For Australian conditions, the FSC criteria lack credibility.

The Australian Forestry Standard, which may be acceptable under the umbrella of the Pan European Forest Certification scheme, may be a preferred option. Whilst the FSC continues to adopt rigid and unjustifiable criteria for chemical use, its certification process will lose favour in developed countries such as Australia.

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