ASSESSING PESTICIDE RISKS TO NON-TARGET TERRESTRIAL PLANTS

SECTION ONE: KEY NON-TARGET PLANTS OF FARMLAND

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1.1. INTRODUCTION

Plants are key components of terrestrial ecosystems, providing the primary production upon which food chains are built. Different plant parts may provide a range of resources for associated fauna. Leaves may be browsed, while pollen and nectar provide resources for pollinating insects. Fruits and seeds are important for a large number of organisms. Plants have other functions apart from providing food for herbivores. They provide cover, reproduction sites and structure. From a human perspective they can provide sources of fuel, medicines, raw materials for many processes, protection, as well as aesthetic pleasure. Plants are a key part of biological diversity as well. Threats to plants from potential non-target impacts of pesticides may impact on biological diversity by eliminating populations. Those impacts may affect ecosystem function by affecting soil processes, nutrient cycling and trophic interactions via fauna, flora, microflora and fungi associated directly and indirectly with plants. That fauna can include invertebrates, reptiles, amphibia, mammals and birds.

The conservation of biological diversity is a stated aim of the UK Biodiversity Action Plan
: *To conserve and enhance biological diversity within the UK and to contribute to the conservation of global biodiversity through all appropriate mechanisms"*
(Anon, 1994).

The reasons for the conservation of biodiversity are moral and aesthetic, because we steward other organisms and because other species may be of benefit to human society and have economic value. A culture that encourages respect for wildlife is preferable to one that does not. Biodiversity can be easily lost but is difficult to regain, particularly if species are driven to extinction. Biodiversity, including genetic diversity, may provide economic benefits. Even at the level of landscape, biodiversity may influence tourism and sense of place.

In order to assess likely non-target effects of pesticides in the environment, plant species representative of the habitats and functions within agricultural systems, where most pesticides are used, need to be selected.

1.2. THREATS TO PLANT SPECIES

Non-target effects of pesticides are caused when materials reach situations beyond the target application area and species not intended to be affected growing within the target area. The direct adverse effects of pesticides can range from outright death of a plant or population, through minor effects, to enhanced growth. The spectrum of direct effects on individuals is matched by a spectrum of indirect effects on associated fauna and flora. Direct effects on plants of pesticides can appear to be insignificant, for example, reduced flowering. However, such impacts may be of major significance to species where seed production is the key element of the regenerative cycle of the plant. Effects on germination and early recruitment of plant species are believed to be of particular importance at a growth stage that is particularly susceptible to pesticides. Non-target effects may have subtle effects on plant community composition, mediated by plant competition or by effects on the water and chemical environment in the rhizosphere.

Indirect effects of pesticides on plants may be caused by effects on associated fauna, which may be necessary for plants to complete their life cycles. Pollinating insects are good examples of such fauna. Other fauna may be important for the dispersal of propagules of

plant species. Dispersal, both in time, via dormant seed, or space, is a key process for the persistence of species in patchy habitats.

Most pesticides are used in agricultural systems, though significant amounts are used in horticulture, forestry and non-crop situations, including amenity land. In all these situations, there may be non-target plant species growing within the target application area. Movement of pesticides to non-target areas may also occur. In agricultural situations, the nearest adjacent non-target, non-crop areas are typically field margins.

1.3. FIELD MARGINS

Field margins exist in the landscape as they have, or had in the past, true agricultural functions. In stock farming areas, hedges and walls were maintained to keep stock in or out. In arable land, field margins delineate the field edge and land ownership. In more recent time, a series of subsidiary roles have been identified, reflecting agricultural, environmental, conservation and cultural or historical interests:

Original roles and requirements

1.	To define the field edge
2.	To be stock- or trespasser-proof, to keep animals in or out
3.	To provide shelter for stock
4.	To provide shelter for crops, particularly as windbreaks
5.	To reduce soil erosion by wind or water
6.	Not to compete with the crop for light, moisture or nutrients
7.	Not to harbour weeds, pests and diseases
8.	To harbour beneficial plants and animals
9.	To act as a refuge or corridor for wildlife
10.	To provide a source of fruits and wood

Current and potential functions of field margins

A	Promotion of ecological stability in crops
B	Reducing pesticide use: exploiting pest predators and parasitoids
C	Enhancing crop pollinator populations
D	Reducing weed ingress and herbicide use
E	Buffering pesticide drift
F	Reducing fertiliser and other pollutant movement, especially in run-off
G	Reducing soil erosion
H	Promotion of biodiversity and farm wildlife conservation
I	Maintaining landscape diversity
J	Promotion of game species
K	Encouragement of "countryside" enterprises
L	Maintenance of historical features, heritage and “sense of place”

Table 1: Roles, requirements and potential functions of semi-natural field margins in good agricultural practice (after Marshall 1993).

Studies undertaken by the Institute of Terrestrial Ecology as part of Countryside Survey 1990 have revealed that field margins and other linear features in lowland agricultural landscapes are refugia for most botanical diversity, rather than adjacent fields (Barr *et al*.,

1993). Field margins are thus particularly important for the maintenance and enhancement of biodiversity. As linear features, field margins are also thought to act as corridors for the movement of fauna and possibly flora. Evidence for this has been shown for carabid beetles of forest and woodland in Brittany (Burel, 1989). Further, it is known that bats utilise margins to fly along as part of their feeding behaviour (Verboom & Huitema, 1997). Field margins are also known to be important over-wintering habitat for many insects that move into adjacent arable crops (Sotherton, 1984; Thomas *et al*., 1994; Wratten, 1988). However, it has also been shown that field margins can be barriers to the movement of such species between fields.

Initiatives over recent years have been taken to modify the management of arable field margins for a series of different objectives, often with the aim of enhancing wildlife while providing agronomic benefits, in terms of reduced weed ingress or enhanced populations of beneficial invertebrates. These have been widely investigated, with modifications, across Europe. The diversity of approaches can perhaps be most easily summarised in a Figure:

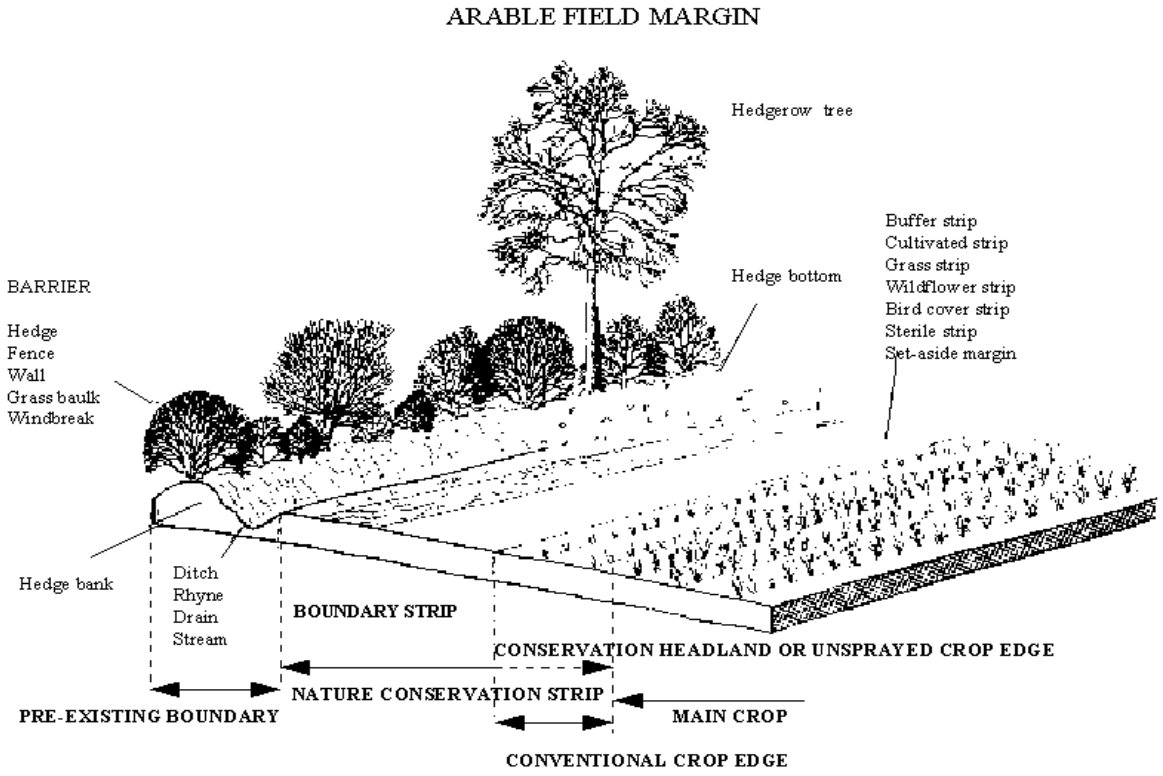

Figure 1. Arable field margin terminology, showing potential margin treatments (after Greaves & Marshall, 1987)

The terminology used here follows that of (Greaves & Marshall, 1987), in which the term field margin includes any pre-existing **boundary** structure, such as a hedge, a **boundary strip** and the **crop edge**, where conservation headlands are located.

1.4. IDENTIFICATION OF THE KEY NON-CROP PLANT SPECIES ASSOCIATED WITH AGRICULTURAL SYSTEMS

Species should be representative of a) habitat types, b) taxonomic groups, c) functional groups and d) soil types, in agricultural systems. Non-crop flora are associated with the crop as weeds, and with the range of associated non-crop habitats, which include grasslands, heathland, wetlands, tall herbaceous communities, scrub and woodland, all of which may be represented in field margins. Functional groups can be determined by life form or by strategies (*sensu* Grime, 1979).

Rare plant species are unlikely to be of great value in assessing non-target effects in the wider countryside. Rare species often require particular environmental conditions, which may not be typical of semi-natural environments in agriculture. Rarity may, for example, reflect the presence of a species at the extremes of it geographic range. Protection of rare species is best achieved by targeted management in suitable habitats.

Only higher plants have been selected in this study, leaving out the bryophytes (mosses and liverworts), the pteridophytes (clubmosses, horsetails and ferns) and gymnosperms (pines). Of these groups only the mosses and ferns are relatively common in farmed areas.

The following 40 species have been selected as important components of non-crop flora in agricultural systems. Nomenclature is according to Stace (1991), from which habitat and soil data are taken. Data for life form is from Grime *et al*. (1988).

Key: Life history - As = summer annual, Aw = winter annual, B = biennial, M = monocarpic perennial, P = polycarpic perennial.

Species	Common name	Family	Habitat	Soil type	Life history
Trees, shrubs and climbers					
Corylus avellana	Hazel	Betulaceae	Hedge, woodland		P; shrub
Crataegus monogyna	Hawthorn	Rosaceae	Wood, hedges		P; shrub
Tamus communis	Black bryony	Dioscoraceae	Hedges, scrub		P; climber
Annual weed species					
Centaurea cyanus	Cornflower	Asteraceae	Arable		A
Chenopodium album	Fathen	Chenopodiaceae	Arable, disturbed		As
Chrysanthemum segetum	Corn marigold	Asteraceae	Arable		As
Galium aparine	Cleavers	Rubiaceae	Arable, hedges		Aws
Species	Common name	Family	Habitat	Soil type	Life form
Annual weed species					
Matricaria recutita	Scented mayweed	Asteraceae	Arable		Asw
Papaver rhoeas	Common poppy	Papaveraceae	Arable, waste		Asw
Polygonum aviculare	Knotgrass	Polygonaceae	Arable, disturbed		As
Woodland/hedge ground flora					

Alliaria peteolata	Garlic mustard	Brassicaceae	Hedge		A/M
Arum maculatum	Lords-and-Ladies	Araceae	Hedge, woodland	Base-rich	P
Digitalis purpurea	Foxglove	Scrophulariaceae	Wood, heath	Acidic soils	P
Galium mollugo	Hedge-bedstraw	Rubiaceae	Hedges, grass	Base-rich	P
Hyacinthoides non-scripta	Bluebell	Liliaceae	Hedge, woodland		P
Lamiastrum galeobdolon	Yellow archangel	Lamiaceae	Woodland Hedge		P
Lamium album	White dead-nettle	Lamiaceae	Hedge, waysides		P
Primula vulgaris	Primrose	Primulaceae	Woodland, hedge	Heavy soils	P
Vicia sepium	Bush vetch	Fabaceae	Grass, hedges, wood		P
Tall herbs					
Carduus crispus	Welted thistle	Asteraceae	Hedge, ditch	Rich, basic	M
Cirsium arvense	Creeping thistle	Asteraceae	Grass, arable, waste		P
Convolvulus arvensis	Field bindweed	Convolvulaceae	Waste, cultivated		P
Dipsacus fullonum	Teasel	Dipsacaceae	Marginal, rough		B
Chamerion angustifolium	Rosebay willowherb	Onagraceae	Waste, woodland		P
Heracleum sphondylium	Hogweed	Apiaceae	Grassy, rough		P/M
Torilis japonica	Upright hedge parsley	Apiaceae	Grassy, hedgerows		A/B
Urtica dioica	Nettle	Urticaceae	Woods, rough	Rich	P
Grassland					
Centaurea nigra	Common knapweed	Asteraceae	Grass, waysides		P
Daucus carota	Wild carrot	Apiaceae	Grassy, rough	Chalky Soils	M
Leucanthemum vulgare	Ox-eye daisy	Asteraceae	Grassy areas	Rich soils	P
Species	Common name	Family	Habitat	Soil type	Life form
Grassland					
Lotus corniculatus	Eggs and bacon	Fabaceae	Grassy, waste	Well-drained	P
Lychnis flos-cuculi	Ragged robin	Carophyllaceae	Wet grass	Damp	P
Ranunculus repens	Creeping buttercup	Ranunculaceae	Grass, wood, marsh		P
Taraxacum	Dandelion	Asteraceae			P

officinale					
Trifolium repens	White clover	Fabaceae	Grass, rough		P
Vicia sativa	Common vetch	Fabaceae	Waste, field borders		Aw
Grasses					
Agrostis stolonifera	Creeping bent	Poaceae	Meadow, ditches, arable		P
Brachypodium sylvaticum	False brome	Poaceae	Woods, hedges		P
Dactylis glomerata	Cocksfoot	Poaceae	Grass, woodland, waste		P
Festuca rubra	Red fescue	Poaceae	Grass		P

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