Case Study 8.1 Inversions and herbicide drift

Inversions

Temperature inversions are layers of air where temperature increases with height (normally they decrease with height) (Figure 8.5). Inversions frequently form in the late evening and strengthen overnight (being strongest near sunrise) before being eroded by mid morning as the air near the ground heats up. Inversion layers are stable and are characterised by calm, light or variable winds, that make it difficult to predict the movement, both vertically and horizontally, of spray droplets. Do not spray when inversion conditions exist.

When thre is an inversion layer droplets may rise and be trapped before being carried away from the target area.

Herbicide drift

All foliar herbicides are capable of drift. When using a herbicide you have a legal liability for injury to persons or damage to property and a legal liability for harm to non target animals and plants. This means that you are lawfully obligated to prevent any pesticide from drifting, contaminating or damaging neighbours' crops and sensitive areas.

Particle drift

At high temperatures and low humidity the water in the spray droplets evaporates. Smaller droplets remain airborne longer and are carried by air currents away from the intended target. Avoid variable or gusty wind conditions (Table 8.2). Avoid calm conditions as small droplets may remain suspended for long periods. Spray when the wind is blowing away from sensitive areas.

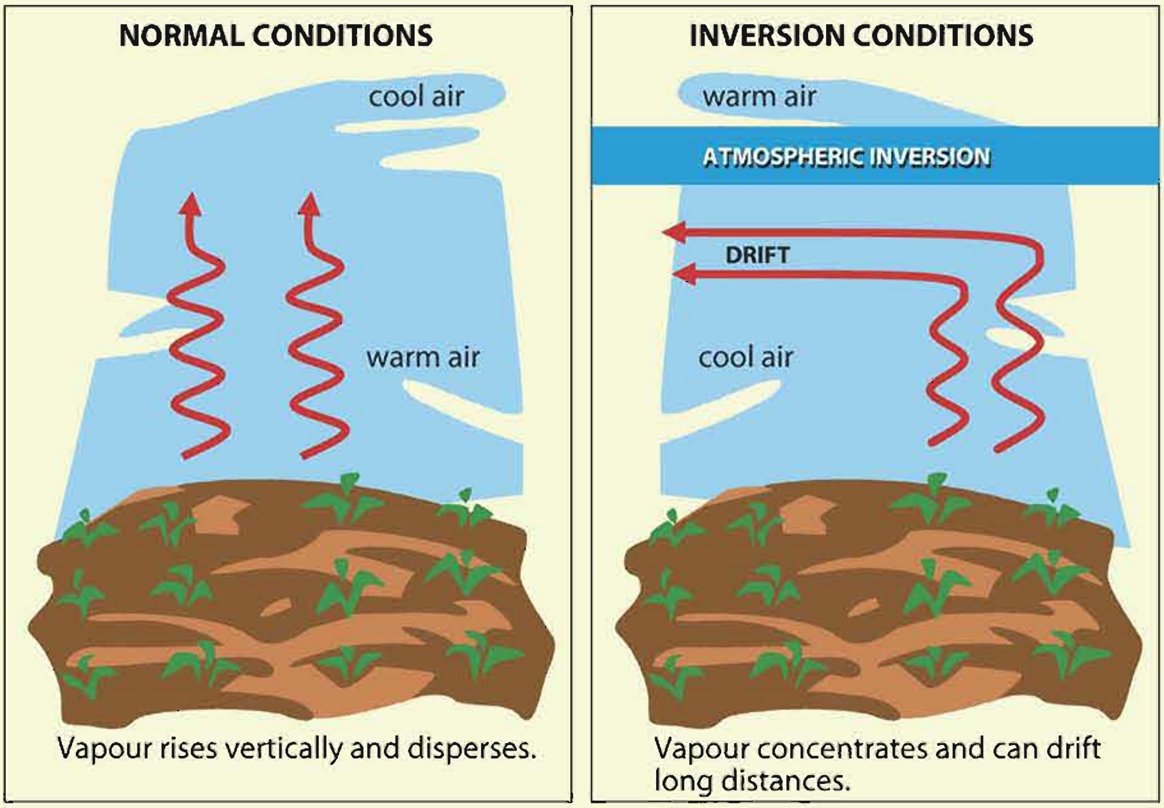
Volatility

Volatility refers to the likelihood that the active ingredient in the herbicide spray will evaporate and become a gas. High temperatures with low humidity inclines herbicides to vaporise, releasing damaging vapour. Volatilisation can occur at the time of spraying, or hours after application if temperatures heat up. Even when the observed air temperature is within acceptable limits for spraying, soil surface temperatures can be higher.

Vapour drift can be avoided by choosing low volatile active ingredients. The ester forms of 2,4-D and MCPA are highly volatile while the amine and salt forms have lower volatility. Low volatility products can still volatilise if conditions are hot and dry enough. Low volatility products are still susceptible to particle drift.

Humidity of greater than 45% is often recommended for spraying to prevent volatilisation.

Figure 8.5 Temperature inversions make it difficult to predict the movement of spray droplets.



Source: Storrie, A. 2004.

Frost

Spraying during frost will reduce herbicide uptake and movement. Spraying 24 hours before or after frost is less likely to have reduced efficacy unless there is damage to the plants. Check the product label for frost and temperature recommendations.

Soil moisture

Labels give directions for soil moisture at time of application. The effect of soil moisture varies depending on the type of herbicide, for example foliar or soil incorporated.

Dusty conditions can reduce the efficacy of glyphosate as it binds to clay particles and becomes inactive. Dust also acts as a physical barrier to the herbicide reaching the leaf surface.

Waterlogged conditions can result in crop damage when some foliar herbicides move through the soil into the crop's root zone (Figure 8.6). The free water causes the active ingredient to be separated from the crop safener and burn the roots.

Figure 8.6 Example label directions

Soil Moisture at Application:

DRY – Weed control may decline.
MOIST – Optimum performance and safety.
WATERLOGGED – May impair crop safety and reduce weed control.

NB: Always read the label of the product being applied.

Wind

Wind speed and direction affects the movement of droplets. Estimates of wind speed can be made (Table 8.2), however, is in your interest to measure wind speed as accurately as possible. Hand held devices can be purchased to measure wind speed.

Crop and weed response to herbicides

The environment influences the growth of the crop and the weeds, which in turn affects the interaction between plants and herbicides.

Plant growth is determined by light, moisture, nutrients and temperature. Plant growth can be affected by too much or too little of these and other factors such as insects and disease. Most herbicides need actively growing plants to be effective. If conditions are unsuitable for spraying and are not forecast to change, reconsider the form of weed control planned.

Temperature

Temperatures during the days before herbicide spraying can influence weed and crop growth rates. Average temperatures will result in actively growing plants, while too hot or too cold will leave stressed slow growing plants. Spraying at low (<15˚C) or high (>30˚) temperatures is not recommended as most herbicides require the plant to be actively growing for the herbicide to work.

Spray failures have occurred when high temperatures have reduced the quantity of herbicide absorbed by the stressed plants.

Post application temperatures may affect the time taken for symptoms to develop. For example low temperatures slow herbicide activity but have little effect on total weed control.

Table 8.2 Guidelines for spraying derived from the Beaufort wind scale.

Description	Approximate wind speed at 0.5–1.0 m above ground level.		Visible signs	Spraying recommendations
Calm	Less than 2 km/h	Less than 0.5 metre/sec	Smoke rises vertically.	Avoid spraying.
Light air	2 to 3 km/h	0.5–1 metre/sec	Direction shown by smoke drift.	Spraying inadvisable.
Light breeze	4 to 6 km/h	1–1.5 metre/sec	Leaves rustle, wind can be felt on face.	Ideal for boom spraying, using high pressures (>400 kPa) and low volumes (i.e. small droplets).
Gentle breeze	7 to 10 km/h	1.5–3 metre/sec	Leaves and twigs in constant motion.	Suitable for boom spraying, using low pressures (200–300 kPa) and larger droplets.
Moderate breeze	11 to 14 km/h	3–4 metre/sec	Small branches moved; raises dust or loose paper.	Suitable for spraying if using low pressure nozzles and high volume application (80–120 L/ha)
Fresh breeze	15 to 20 km/h	4–5 metre/sec	Small trees begin to sway.	Do not spray.
Strong breeze	Above 20 km/h	6 metre/sec	Large branches in motion. Telegraph and power lines whistle.	Do not spray.

Frost

Severe frosts can cause plant damage which reduces the weeds ability to uptake and transport herbicides around the plant. The effect of frost depends on the weed species and the herbicide product.

Frost can also damage tissue of crop plant tissue and increased phytotoxicity can occur resulting in yield loss.

Humidity

Humidity interacts with temperature in determining the rate of product uptake and to a certain extent movement of the herbicide around the plant. Under low humidity and high temperature conditions herbicide uptake is reduced as some plants close their stomata to prevent their leaves from drying out.

Soil moisture

Too much or too little soil moisture will cause plant stress. Water stressed plants will have reduced uptake and movement of herbicide. Grasses can be moisture stressed before wilting occurs. Spray adjuvants may be used to increase penetration into the leaf.

Plants can recover from moisture stress within 24 hours of adequate rain. However, as 'adequate' rain is difficult to predict other weed control options should be planned.

Under very wet soil conditions some post-emergent herbicides (Group A) may be root absorbed and can incur crop damage. Using a plane to spray when it is very wet may not be beneficial to the crop.

Photo: A. Johnson

Nozzle selection is important.

Further information the following book and brochure are available from NSW DPI

- **Spray drift managment – principles, strategies and supporting information.**
- **Reducing herbicide spray drift – Agnote.**

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Case study 8.2 Modifying equipment for better weed control By Tim McNee

Name	Judy, Hayden, Stuart, Michael, Nigel Wass and families.
Property	"The Plains", Nyngan (10 360 ha – 2360 ha native vegetation)
Enterprise	Continuous cropping, wheat, barley, pulses, canola.

Building machinery to suit their own system is common for the Wass brothers with two planters and a spray unit built to date. The latest project of which Stuart Wass is the "chief engineer" involves building a self propelled spray rig.

The need to build their own machinery was the result of identifying several factors that were important to their farm management style.

Precision application

Using GPS and auto steer controllers reduces overlap and gaps which results in an estimated 5% saving in chemical costs and a larger reduction in weed escapes.

Timing

To cover the large area of the property on time, the spray rigs need to be light so spraying can start soon after rain without getting stuck in the mud.

Night spraying

The combination of GPS and lighting allows night spraying which provides the opportunity to spray under the best conditions in summer. (There are no herbicide susceptible crops grown in the area.) The lights not only allow the driver to see where they are going but to light up the boom to ensure the spray is running smoothly and there are no blocked nozzles.

Efficient operation

The spray unit (36m width) has been designed to fit the property's 12m tramlines with 3m wheel spacing. The unit is set high off the ground to avoid contact with the crop when spraying.

The unit only has a 2 000 litre tank to decrease the weight. The unit is 2.7 tonne empty.

To ensure quick filling a premixing 35 000 litre 'nurse tanker' is also being built to allow rapid refills in the paddock.

Cost savings

Building the spray unit resulted in a significant cost saving when compared to purchasing a new rig. The unit cost approximately $40 000 in parts to build (labour was not costed). Fuel consumption is significantly less than trailing spray units.

Herbicide application

The fine tuning of equipment for spraying has been done at the same time as experimenting to improve herbicide application. Improving spraying has been a major part of better weed control on "The Plains". Many of the changes have resulted in less money spent on chemical and fuel, less weed escapes and better crop yields.

"We learnt more about the chemicals and the best conditions to apply them. Surfactants and wetters are important. By getting the conditions right we were able to drop the rate and still control the weeds". "If you get bad water, no matter what you do the spray won't work as well".

Weather conditions

Close attention is always paid to the weather when spraying, especially inversions. Spraying in the right conditions gives better results which means less escapes and less need to respray. Slowing down the rig, reducing the pressure and increasing droplet size has also improved coverage and reduced drift.

Photo: T. McNee

Wass's self propelled spray rig.

Appendix one
Central West weed survey

Efficient weed control in Central West NSW

Annie Johnson, Jim Dellow and Keith Pengilley (formerly NSW Agriculture).

This GRDC project investigated weeds issues affecting grain producers in the Central West of NSW. The project consisted of a survey, herbicide trials and the production of this book.

The main aim of the survey was to identify the major weed species and their affect on the cropping, pasture and fallow phases in the Central West. The results are outlined in the tables below.

Sixty nine farmers responded to a survey conducted in 2002. The farmers surveyed were from an area west of the Newell Highway extending from Narrandera and Hillston in the south, to Nyngan and Dubbo in the north. The average cropping area per farm of those surveyed was approximately 1 239 hectares. Of this wheat production was 62% of the area, barley 14%, canola 12%, oats 6% and pulses 6%.

Crop weed species		
Common name	Botanical name	Incidence on farms (%)
Annual ryegrass	*Lolium rigidum*	79.7
Wild oats	*Avena* spp.	78.3
Saffron thistle	*Carthamus lanatus*	65.2
Capeweed	*Arctotheca calendula*	49.3
Skeleton weed	*Chondrilla juncea*	47.8
Wireweed	*Polygonum aviculare*	37.7
Paterson's curse	*Echium plantagineum*	34.8
Wild radish	*Raphanus raphanistrum*	33.3
Mustard spp.	*Sisymbrium* spp.	24.6
Spiny emex	*Emex australis*	24.6
Fumitory	*Fumaria* spp.	23.2
Annual phalaris	*Phalaris* spp.	13.0
Caltrop	*Tribulus terrestris*	7.2
Corn gromwell	*Buglossoides arvense*	4.3
Silverleaf nightshade	*Solanum elaeagnifolium*	2.9
Shepherd's purse	*Capsella bursa-pastoris*	2.9
St.Barnaby's thistle	*Centaurea solstitialis*	2.9
Mexican poppy	*Argemone ochroleuca*	2.9
Camel melon	*Citrullus lanatus*	2.9
Paddy melon	*Cucumis myriocarpus*	2.9
Lucerne	*Medicago sativa*	1.4
Silvergrass	*Vulpia* spp.	1.4
Barley grass	*Hordeum* spp.	1.4
Soursob	*Oxalis pes capre*	1.4
Fleabane	*Conyza* spp.	1.4

Fallow weed species		
Common name	Botanical name	Incidence on farms (%)
Camel melon	*Citrullus lanatus*	52.2
Paddy melon	*Cucumis myriocarpus*	46.4
Skeleton weed	*Chondrilla juncea*	43.5
Saffron thistle	*Carthamus lanatus*	37.7
Common heliotrope	*Heliotropium europaeum*	34.8
Annual ryegrass	*Lolium rigidum*	26.1
Bathurst burr	*Xanthium spinosum*	18.8
Wireweed	*Polygonum aviculare*	17.4
Paterson's curse	*Echium plantagineum*	15.9
Summer grass spp.	*Echinochloa* spp.	15.9
Capeweed	*Arctotheca calendula*	13.0
Wild oats	*Avena* spp.	10.1
Barley grass	*Hordeum* spp.	8.7
Volunteer wheat	*Triticum aestivum*	7.2
Silvergrass	*Vulpia* spp.	5.8
Silverleaf nightshade	*Solanum elaeagnifolium*	4.3
Sub clover	*Trifolium subterraneum*	4.3
Annual phalaris	*Phalaris* spp.	4.3
Marshmallow	*Malva parviflora*	4.3
Quena	*Solanum esuriale*	4.3
Lucerne	*Medicago sativa*	4.3
Wild radish	*Raphanus raphanistrum*	2.9
Mustard spp.	*Sisymbrium* spp.	2.9
Field bindweed	*Convolvulus arvensis*	2.9
Spiny emex	*Emex australis*	2.9
Couch	*Cynodon dactylon*	2.9
Caltrop	*Tribulus terrestris*	2.9
Horehound	*Marrubium vulgare*	1.4
Fumitory	*Fumaria* spp.	1.4
Soursob	*Oxalis pes-capre*	1.4
Volunteer lupins	*Lupinus* spp.	1.4

Pasture weed species		
Common name	Botanical name	Incidence on farms (%)
Saffron thistle	*Carthamus lanatus*	55.1
Paterson's curse	*Echium plantagineum*	37.7
Capeweed	*Arctotheca calendula*	30.4
Barley grass	*Hordeum* spp.	29.0
Horehound	*Marrubium vulgare*	15.9
Annual ryegrass	*Lolium rigidum*	15.9
Wireweed	*Polygonum aviculare*	14.5
Silvergrass	*Vulpia* spp.	14.5
Skeleton weed	*Chondrilla juncea*	11.6
Mustard spp.	*Sisymbrium* spp.	7.2
Bathurst burr	*Xanthium spinosum*	7.2
Common heliotrope	*Heliotropium europaeum*	5.8
Wild radish	*Raphanus raphanistrum*	5.8
Galvanised burr	*Sclerolaena birchii*	5.8
Wild oats	*Avena* spp.	5.8
Silverleaf nightshade	*Solanum elaeagnifolium*	4.3
Spiny emex	*Emex australis*	4.3
Caltrop	*Tribulus terrestris*	2.9
Soursob	*Oxalis pes-capre*	2.9
Yellow burr daisy	*Calotis lappulacea*	2.9
Speargrass spp.	*Stipa* spp.	2.9
Fleabane	*Conyza* spp.	2.9
St.Barnaby's thistle	*Centaurea solstitialis*	1.4
Annual phalaris	*Phalaris* spp.	1.4
Slender thistle	*Carduus pycnocephalus*	1.4
Fumitory	*Fumaria* spp.	1.4
Wild sage	*Salvia verbenaca*	1.4
Noogoora burr	*Xanthium occidentale*	1.4
Brome grass	*Bromus* spp.	1.4
Shepherd's purse	*Capsella bursa-pastoris*	1.4
Common sowthistle	*Sonchus oleraceus*	1.4

Photo: J. Edwards

Sheep in pasture.

Appendix two
Glossary

A description of terms used in this book.

active ingredient	the biologically active part of the chemical present in a herbicide formulation primarily responsible for its phytotoxity.
annual	a plant which completes its life cycle within one year after germination.
biennial	a plant which completes its life cycle within two years after germination.
broadleaf	a dicotyledon or dicot plant usually characterised by the following: two seed leaves (cotyledons), leaves with net like veins and root systems with tap roots.
cereal or grass	a monocotyledon or monocot plant usually characterised by the following: one seed leaf (cotyledon), leaves with parallel veins and diffuse (fibrous) root systems.
dormancy	temporary suppression of growth which may be of advantage in surviving ultimately unfavourable conditions.
ecology	the science concerning the relationship between organisms and environment.
economic threshold	a level of expenditure above which it is no longer financially beneficial to continue an activity.
emergence	the event in seedling establishment when a shoot becomes visible by pushing through the soil surface.
fallow	(i) the period of time between crops, or, (ii) area of land set aside from a cropping regime – can be summer, winter or longer.
germination	the initiation of growth in seeds.
half-life (seed bank)	the time during with half the seeds left in the seed bank will either germinate or become unviable.
herbicide	a chemical or cultured biological organism that controls weeds.
herbicide drift	the drift of a herbicide off-target.
in crop	refers to (i) period of time from crop emergence to crop defoliation, or (ii) within a crop area.
Integrated Weed Management (IWM)	using a range of weed management tactics in conjunction with each other to reduce weed populations in sustainable system for whole farm management of weeds.
label	the directions for using a herbicide approved as a result of the registration process.
lateral movement	movement of a herbicide through soil, generally in a horizontal plane, from the original site of application.
ley	a brief period of time (one year) when a paddock is put under a different regime (e.g. crop under a pasture ley).
lifecycle	various stages in the life of a plant e.g. emergence, flowering, seed set.
mode of action	how a herbicide controls weeds.
non-selective herbicide	a herbicide that kills all plants treated.
noxious weed	a plant regulated or identified by law, as being undesirable, troublesome and difficult to control.
pathogen	an organism that causes a disease in another organism.
perennial	a plant which continues to grow from year to year.
phase	a period (usually 3–10 years) where a pasture or a series of crops is grown
phytotoxic	injurious or lethal to plants.
plant-back period	recommended period of time, after the use of herbicides, that will avoid damage to succeeding crops.
population	in ecology, a group of individuals of any one species.
post-emergence	after the emergence of seedlings.
pre-emergence	before the emergence of seedlings.
pre-plant application	applied before planting a crop, either as a foliar application to control existing vegetation or as a soil application.
preplant incorporated (PPI)	applied and blended into the soil before seeding.

residual herbicides	herbicides that continue to affect, injure or kill germinating weed seedlings or plant growth well after the application of the herbicide. Different herbicides have different residual effects, can remain in the soil profile for long periods of time, and can be moved around in the soil by irrigation, rainfall events or groundwater movement.
resistant populations	where the repeated use of one herbicide, or other herbicides with the same mode of action, has removed susceptible plants but has allowed the survivors to grow and multiply, producing a resistant population of plants.
rhizome	an underground stem, usually horizontal, producing leafy shoots and roots.
seed bank	the number of seeds, accumulated over time, present in the soil, which may germinate when conditions are favourable.
seed set	where mature seeds are present on the plant. Immature seeds will not germinate.
selective herbicide	a chemical that kills some plant species and not others.
soil moisture	the amount of water in the soil (wet weight minus dry weight).
species shift	the selection and increase of naturally tolerant weed species.
spot spraying	targeting of individual weeds with herbicides.
spray drift	off target movement of a pesticide.
suppression	a degree of reduction of plant growth, but not death.
surfactant	a material that improves the dispersing, spreading, wetting or other properties of a liquid by modifying its surface characteristics.
susceptibility	the sensitivity to, or degree to which, a plant is injured by a herbicide treatment.
synergism	the effect of two substances in combination which has a multiplier rather than an additive effect.
synergist	for herbicides – a non-herbicidal compound used to increase the efficacy of a herbicide by a physiological mechanism.
thresholds	a defined level beyond which action should occur.
tiller	a side shoot from the base of a grass plant near the ground, e.g. from the bottom of the stalk or stem of cereals or grasses.
tolerance	ability to continue normal growth or function when exposed to a potentially harmful agent.
toxicity	the ability of a substance to cause injury, illness, or other undesirable effects.
translocation	the process whereby a chemical is absorbed into the plant, via the leaves or roots, and is then moved to other parts of the plant.
vegetative reproduction	the reproduction of a plant via stems, leaves and rhizomes.
viable (seed)	a seed able to germinate.
weed	A plant environmentally suited to its place in the landscape, but from an agricultural productivity, ecological or aesthetic perspective is a plant out of place.
weed escapes	weeds that have survived a weed management method.
weed spectrum	the different species of weeds present within a community or given area.

NYNGAN
WARREN
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