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An Unruly Neighbour: Wimmera Ryegrass[1]

Weeds, like European settlers, arrived in the temperate regions of Australasia and the Americas as opportunistic colonisers. Weed seed hid in stock feed, lurked in clothing, or clung to the bodies of livestock. Roads and railways hastened their spread and newly cleared land promoted the distribution of wind-borne seed. Pre-adapted to flourish in disturbed soil in competition with crops, many weeds found conditions in the new lands very much to their liking. The predators and pathogens that had kept their numbers within bounds in their homeland frequently did not exist, nor did many of their natural competitors. As native plants were uprooted in favour of European crops, and capitalist markets pushed farmers towards monocultures, there was an accompanying explosion of weeds that has continued into the present.

The very subjectivity of the term "weed" offers fertile ground for the environmental historian. While weeds often share "weedy" characteristics, such as a propensity to flourish in disturbed ground and to produce vast numbers of seeds that are readily dispersed and germinate rapidly, the label we give such plants is highly dependent on time, place, and circumstance. The following parable of Wimmera ryegrass offers a case in point. Farmers routinely classify plants as weeds (useless) and crops/pasture (useful), but Wimmera ryegrass has confounded such categories. It has been the focus of vitriol when it appears in a wheat crop, but relief when it feeds hungry stock. Originally planted as a pasture grass, Wimmera ryegrass flourishes in the wheat-dominated, dryland cropping belt of southern Australia, a region of roughly twenty-five million hectares characterised by a Mediterranean-style climate. Vigorous, succulent, competitive, and vastly adaptable, Wimmera ryegrass has shaped farming practice in this region in a way equalled by few other plants. In more recent times, its agility has compelled farmers and scientists alike to pay greater attention to its biology and ecology, learning to limit its spread by "thinking like a weed" rather than by dousing it with herbicide.

1 This work was supported by an Australian Government Research Training Program Scholarship. I would like to thank Bill Twigg, Professor Katie Holmes, and Professor Andrea Gaynor for valuable comments on earlier drafts. "Unruly neighbour" is a term used by Clinton Evans in his book *The War on Weeds in the Prairie West: An Environmental History* (Calgary: University of Calgary Press, 2002), 177.

Pasture

Wimmera ryegrass is an annual grass capable of growing to almost one metre in height. Its thin green leaves have a distinctive purple-reddish tinge at the nodes and at the base of the plant. Flowers form in spring on long spikelets and the clouds of pollen they release cause hay fever sufferers to reach for their tissues. Underground it produces a network of fine roots, adept at pulling moisture and nutrients from the soil. Its presence in Australia was "discovered" in 1918 by Hubert Mullet, Chief Field Officer with the Victorian Department of Agriculture, after he noticed an unfamiliar grass growing on several farms in the Wimmera, the state's western cropping region. Despite low rainfall, the grass was thriving and Mullet's interest was immediately aroused, since the absence of reliable forage pastures had long concerned Australian agriculturalists.

Figure 1: Wimmera ryegrass plant with roots. Source: Bill Twigg

The government botanist identified the grass as *Lolium subulatum* (commonly designated *Lolium rigidum*), a native of the Mediterranean and one of eight species of ryegrass grouped under the genus *Lolium*. Mullet gave it the local name of Wimmera ryegrass. On its home territory in the Mediterranean, *Lolium rigidum* grew sedately, apparently prompting little notice. In the Wimmera, the ryegrass had originated from seed imported and distributed by a farmer, but in both South Australia and New South Wales immigrant seeds had already found a tentative foothold and naturalised.

Mullet published the results of his investigations in the Victorian *Journal of Agriculture* in 1919. Wimmera ryegrass held the potential to be "a 'paragon' among grasses," Mullet believed, since its vigorous growth promised to double the number of sheep a farm could carry; the seed and dry stems provided feed in summer; and it reproduced itself from seed, precluding the need for re-sowing. Nevertheless, he was also aware it might transform into "one of the worst of pests" since the extent to which it might compete with wheat remained untested, and he cautioned wheat growers to "watch it carefully."

Mullet's article was widely reported and prompted intense interest. Subsequent trials at government research stations proved that Wimmera ryegrass could flourish in variable soil types and climates. Individual farmers, particularly those who saw sheep as a key strand of profitable wheat farming, embraced Wimmera ryegrass. Nevertheless, it was not until the postwar years that Wimmera ryegrass emerged as a permanent inhabitant of most cropping farms. Legume pastures, such as subterranean clover and medics, began to be rotated with cereal (the ley farming system), adding much-needed nitrogen to the soil and prompting a dramatic increase in wheat yields and grain protein. Between 1945 and 1965, the area devoted to ley pastures increased threefold and Wimmera ryegrass—described as the farmer's "old friend"—was widely sown with legumes to create a healthy pasture mix. At the same time, booming prices for wool and lamb placed a high premium on nutritious stock feed, and Wimmera ryegrass was celebrated for its role in helping farmers to expand their sheep flocks. While ryegrass forced farmers to spend additional time on the tractor in order to extirpate ryegrass before sowing, the contribution it made to the farm's bank balance was seen to justify the extra effort.

Pasture and Weed

Mullet had worried about the "controllability" of Wimmera ryegrass but these fears seemed scarcely entertained in the 1950s. In the following decade, farmers reacted with shock, therefore, when ryegrass broke bounds and bolted, refusing to be confined to one particular phase of the farming cycle but flowing out in an unruly surge of green to invade wheat crops. Oral history informants testify to this abrupt transformation. In the past, farmers who were diligent in working their paddocks before sowing were almost invariably rewarded with a "clean" crop. Now suddenly it seemed they couldn't work the ground fast enough, and as soon as tractors had passed over one portion of a paddock, new ryegrass seedlings sprouted in their wake.

There was a perception that the behaviour of ryegrass had changed. It was in fact the reverse; farming techniques had altered and ryegrass had promptly responded. The introduction of legume pastures had replenished soil previously depleted by bare fallowing and overgrazing, and in the process had effectively created a new ecosystem, allowing Wimmera ryegrass (and indeed a host of other weeds) to grow and seed more abundantly. Mechanisation also played a role: the escalating numbers of tractors permitted

paddocks to be worked more easily and frequently—to the delight of ryegrass seeds that germinated rapidly in disturbed soil. The new-style headers also took longer to separate and expel harvest residues, allowing ryegrass seeds that were caught up in the chaff to hitch a ride and be distributed freely across a paddock.

Ambiguity came to define Wimmera ryegrass during this period. Designated a weed one year and a pasture the next—depending on whether a paddock was used for cropping or grazing—it sat uneasily on the border of wild and domestic. The introduction of early herbicides had little effect, since the status of Wimmera ryegrass as a grassy cousin of wheat protected it from chemicals such as 2,4-D, designed to target broad-leaved weeds but offer no threat to grasses. Indeed, by removing many of rye's competitors such as wild mustard, 2,4-D may even have assisted its spread. Eventually, the introduction of glyphosate and pre-emergent herbicides, such as trifluralin in the 1970s, gave farmers back a measure of control. Used in conjunction with cultivation, these herbicides appeared to allow the unruly nature of Wimmera ryegrass to be reined in, creating the illusion that it could be corralled into a particular phase, allowed loose only where and when it was needed.

Weed

The widespread adoption of no-till—a method of farming that allowed crops to be sown with minimum soil disturbance—meant that this situation changed in the early years of the twenty-first century. While no-till methods improved soil structure and moisture retention, the new focus on continuous cropping as well as falling prices for wool largely squeezed sheep out of Australia's southern cropping belt. Shearing sheds and sheep-proof fences fell into disrepair, and alternating crops of wheat, barley, canola, lentils, and field peas replaced fallow and pasture.

The absence of sheep meant that Wimmera ryegrass (now known more typically as "annual ryegrass" in Australia) lost a valuable ally and its status as "weed" became increasingly absolute.[2] Farmers without sheep or pasture no longer had any reason to be charitable and their "old friend" was rapidly reimagined as an outlaw. The nimbleness of Wimmera ryegrass in evading herbicides also strengthened its outlaw reputation,

2 In Australia, annual ryegrass denotes Lolium rigidum (or Wimmera ryegrass). In the United States, Canada, and the United Kingdom, however, the term annual ryegrass is more typically used to describe another species of ryegrass, Lolium multiflorum.

the sheer scale of its geographic spread, as well as the genetic diversity of its seeds, increasing the likelihood of natural resistance. The first stands of herbicide-resistant Wimmera ryegrass were encountered in southern Australia in 1982, and since then the incidence of resistant populations has multiplied. Periodic surveys in Western Australia have attempted to monitor this growth, the most recent survey finding that 95 per cent of Wimmera ryegrass stands are resistant to one or more herbicides.

The ubiquity of herbicide use across the globe has imposed an intense selection pressure on all sorts of weeds. Wimmera ryegrass, however, boasts resistance to 11 different herbicide modes of action—more than any other plant on the planet.[3] A troublesome weed in parts of Western Europe, the Middle East, and South America, Wimmera ryegrass is now considered the most significant grass weed of the Australian southern cropping belt.

Ironically perhaps, this has prompted a greater sensitivity to the ecology and biology of Wimmera ryegrass and led to a plethora of research projects and papers. While herbicides arguably encourage a "one size fits all" mindset, with each herbicide mode of action designed to kill many weed species, the need for a non-chemical response has encouraged scientists to reframe Wimmera ryegrass (and indeed other weeds) as a "plant" with particular physiologies and growth patterns that might be usefully manipulated if only they are understood.

A New Paradigm?

Roy Harrington, a Western Australian farmer, is an expert on weed seeds. Since 2005 he has been on a mission to destroy them. "I tried everything, from cooking, cremating, and catching weed seeds," he recalled before eventually deciding that smashing them presented the most effective method.[4] Modifying a cage mill previously used to crush coal into dust to make barbecue briquettes, Ray worked with the Australian Herbicide Resistance Initiative based at the University of Western Australia to develop his idea.

3 I. Heap,"Global Summary: Herbicide Resistant Weeds by Species and Site of Action," The International Survey of Herbicide Resistant Weeds, updated 17 February 2017. http://www.weedscience.com/ (Accessed 20 February 2017).

4 "Harrington Seed Destructor," *Weed Smart.* http://www.weedsmart.org.au/harrington-seed-destructor/ (Accessed 14 August 2016).

A prototype "weed destructor," towed behind a harvester to catch and macerate the seed-rich residue it expelled, was tested on Wimmera ryegrass. It proved a success—although a small proportion of the seeds remained viable—and the first commercial "Harrington Weed Destructor" was released for sale in 2014, soon followed by an integrated harvester model.

Self-consciously described as "a new paradigm for global agriculture," the Harrington Weed Destructor is part of a suite of measures aimed at intercepting weed seeds before they reach the relative safety of the soil, including collecting harvest residue in chaff carts, burning the residue in narrow windrows, or compressing it in bales for stock feed.[5] Based on an impressive body of research, these strategies aim to exploit the identified "biological weaknesses" of Wimmera ryegrass and other vigorous weeds such as wild radish; in particular their propensity to retain rather than shed their seed at maturity.

Such research rested on but also encouraged a new appreciation of the distinctive qualities of Wimmera ryegrass and especially its seeds. Wimmera ryegrass seeds are flat, straw-coloured, around 4 mm in length, and so light they are easily transported by wind, water, and animals. They seem deceptively fragile. Yet despite the spraying, squashing, burning, cutting, and zapping to which they have been exposed in recent years, they continue to persist. The reason owes a great deal not just to the seeds' genetic diversity, but to their extraordinary numbers. A dense stand of ryegrass with access to plentiful moisture can produce up to 45,000 seeds per square metre. If it is harvested for sale as pasture seed for sheep farmers, it can yield a tonne of seed per hectare.

While a growing stand of Wimmera ryegrass offers an easily visible target for control, it is the hidden seed bank that represents the plant's secret weapon. Despite efforts to extirpate the seed before it reaches the ground, its sheer quantity ensures that some always finds its way into the soil. Once there the seed has another trick up its sleeve: variable dormancy. In Mediterranean-style climates, dormancy has evolved as a protective mechanism to stop seeds from germinating after unexpected summer rains when it would be too hot for them to survive. Most ryegrass seedlings germinate after the first autumn rains, but some seedlings (those with increased dormancy) spring up across the growing season. It is an impressive evasive tactic, allowing Wimmera ryegrass to dodge

5 Michael Walsh, Peter Newman, and Stephen Powles, "Targeting Weed Seeds In-Crop: A New Weed Control Paradigm for Global Agriculture," *Weed Technology* 27, no. 3 (2013): 431–6.

pre-sowing weed control and survive to replenish the seed bank. Ryegrass's dexterity has increased even further under continuous cropping, with larger numbers of ryegrass seed inclined to lie low, even in the face of early rain, only choosing to emerge when the pre-planting regime of tillage or herbicide spraying has been completed.

While there is growing knowledge, and perhaps respect, for Wimmera ryegrass's exceptional adaptability, farmers face the daily challenge of living with this plant. "Integrated weed management" has become a buzzword, but choosing where, when, and which weed control strategy to use is complicated, and the only thing that is certain is that ryegrass will eventually kick over the traces again. The Harrington Weed Destructor might restrain it for a time, but will Wimmera ryegrass respond with earlier flowering or seed shedding plants? The consensus is, "Probably."

In the brave new world of the future, sophisticated agricultural robots—or agbots—are envisaged and indeed prototypes are already in operation. Agbots have the capacity to trawl up and down a paddock, day and night, using sensors to target weeds. Such weed control might include microwave technology, paving the way, as one researcher has suggested, for herbicides to be phased out and for the broad acre production of organic grain to become financially feasible. Will weeds such as Wimmera ryegrass cooperate in such a vision, however? Current research into microwave technology has focused on Wimmera ryegrass as its test plant. While initial tests have yielded success on moist seed, five times the level of radiation is needed to vanquish dry ryegrass seed, limiting the economical viability of the technology. Like the other forces that have been arrayed against it, Wimmera ryegrass appears set to also defy this new weed control strategy.

Conclusion

Wimmera ryegrass offers a potent illustration of evolution in action. While seemingly reliant on human behaviour for its existence, and exquisitely responsive to changes in the agricultural environment, it has also remained outside human control, its adaptations frequently forcing farmers and scientists alike to play "catch-up." When I interviewed wheat farmer Bruce Godwin, he recalled the great promise Wimmera ryegrass seemed to hold when it was first sown in his district. His final comment, however, was, "Everyone wishes now they had never brought the blessed stuff in. It's wonderful feed but knocks your wheat

around like nobody's business." Although Bruce's reflections convey something of the changing human responses to this plant—from cherished pasture to reviled weed—the story of Wimmera ryegrass defies simple binaries of good and bad, suggesting instead that in the process of seeking knowledge about such a plant we are just as likely to learn more about ourselves and the unintended consequences of our own farming practices. Rather than "friend" or "outlaw," Wimmera ryegrass might be better understood as "unruly neighbour," with control measures resting on respect for its unique adaptability.

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