Using the Seedbank Wizard to Understand and Manage Weed Seedbanks

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The Seedbank Wizard: a computational tool for predicting population dynamics of weeds (and other plants).
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Developed for cropping systems.

Why?
We know weeds can reduce crop yield and invade natural ecosystems, but…

are weeds the real problem?
WEEDS ARE NOT THE PROBLEM!

Control the disease → Control the symptom

Control the seedbank → Control the weeds

symptom

underlying disease
How do we control the seedbank?
The seedbank is hidden and its dynamics depend on the complex interactions between a mix of factors:

- the effects of various management techniques on plants and seeds
- germination and dormancy characteristics
- inter-species plant competition and seed set

Moreover, these complex hidden interactions play out over a relatively long term.
Controlling the seedbank needs long-term strategies:

- starving it of new recruits;
- exposing seeds to their natural enemies;
- burying seeds where they will eventually rot and die;
- exploiting the seeds’ own dormancy mechanisms to trigger germination in conditions where weeds can be easily killed or will have little effect.
Need to take into account how seeds of different weed species persist in the soil (or seedbank) for different periods.

- Some have no dormancy (Germinate with opening rains)
- Others require specific environmental cues (light, moisture, accumulated degree days) for dormancy to be broken and germination to commence, and can thus persist in the seedbank for years
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Seed Dormancy and Persistence

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In cropping system, need to take into account the effects of:

- different seeding/tillage systems (including No-Till and Zero-Till),
- selective and nonselective herbicides,

as well as strategic techniques, such as:

- soil inversion,
- autumn tickle to stimulate germination,
- crop competition,
- crop topping (applying a herbicide to a mature crop to sterilise weed seeds),
- spray topping,
- green/brown manuring,
- swathing (cutting crop while still green),
- seed catching at harvest,
- burning or grazing for stubble management.
Management techniques will be different in a natural system – perhaps less options – but a range of options still need to be considered.
So seedbank dynamics are

1. hidden,
2. depend on the complex interactions of a mix of factors,
3. play out over a relatively long period of time.

How can we understand and predict these complex, hidden, long-term interactions?
Computational simulation can help us understand and predict these complex, long-term interactions and give us a window into the hidden seedbank.

The wizard is the doctor who helps focus attention on the disease (the hidden seedbank) and thus move towards a longer-term view of managing the symptom (the weeds).
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The Wizard helps fight the green invaders and win the war against weeds.
A national project, with participants in Western Australia, South Australia, New South Wales and Queensland.

For the south, target weeds include:
- annual ryegrass (*Lolium rigidum* Gaud.),
- barley grass (*Hordeum leporinum* Link.),
- wild radish (*Raphanus raphanistrum* L.),
- wild oat (*Avena fatua* L.),
- brome grass (*Bromus* spp.)
- silver grass (*Vulpia* spp.)

*Raphanus raphanistrum*: courtesy John Moore and Herbiguide.
A National Project

For the north, target weeds include:
• sweet summer grass (*Brachiaria eruciformis* Sm. Griseb),
• liverseed grass (*Urochloa panicoides* P. Beauv.),
• barnyard grass (*Echinchloa colona* L. Link),
• native jute (*Corchorus trilocularis* L.),
• bladder ketmia (*Hibiscus trionum* L.),
• african turnip weed (*Rapistrum rugosum* L. All.)
• sowthistle (*Sonchus oleraceus* L.)
.. and fleabane! (*Conyza bonariensis* L. and friends)

*Conyza bonariensis*: courtesy Western Weeds.

*Sonchus oleraceus*: courtesy John Moore and Herbiguide.
Wizard is based on the vast collection of existing documented knowledge about each species.

Field trials are being carried out in each of the participating states (WA, Qld, NSW, SA) to provide further data for model validation.

This data includes
- weed counts,
- records of management applied, and
- counts of seeds in the soil.
1. A modelling framework that can be used to investigate the complex mix of factors affecting the weed seedbank, and thus contribute to our scientific understanding of seedbank dynamics.

2. A practical decision-aid / educational tool with a user-friendly interface, incorporating current scientific knowledge, that can help manage weed populations in real management contexts.

* Currently being developed together in a single computer program – may diverge in future
The Wizard is currently being built using an ‘object-oriented’ web-friendly programming language (Java).

**Input Interface:**
- Weed parameters
  - Crop parameters
  - Herbicide parameters
  - Tillage parameters
  - Weather
  - Management events
  - Initial seedbank densities

**Output Interface:**
- Graphs
- Tables
- Pictures
- Recommendations
- Events for calendar or record-keeping software

**Model Structure**

- Event Queue
- State of the Agricultural System
- Parameter Lists
Germination occurs with rainfall.

Past weather is actual observations.

Future weather is simulated or average.

- Daily time step for weather
- Summer: radish germinating but not ryegrass.
Ryegrass seedbank declines faster than radish over winter. Ryegrass seedbank conserved over summer.
The Wizard is currently being built using an ‘object-oriented’ web-friendly programming language (Java).
Different objects within the agricultural system are represented as separate ‘objects’ or modules within the program.
Representing a Natural System

No change to model’s core structure necessary
Model structure makes it:
- Easy to add new species (as far as biological knowledge is available)
- Easy to add new management events (even easier to remove)
- Competition probably the main challenge

• Seed dormancy up to 40yrs
  • Soil acidification
  • N fixation
  • Shading and shade tolerance
  • Longevity