Vulnerabilities in Weed Biology

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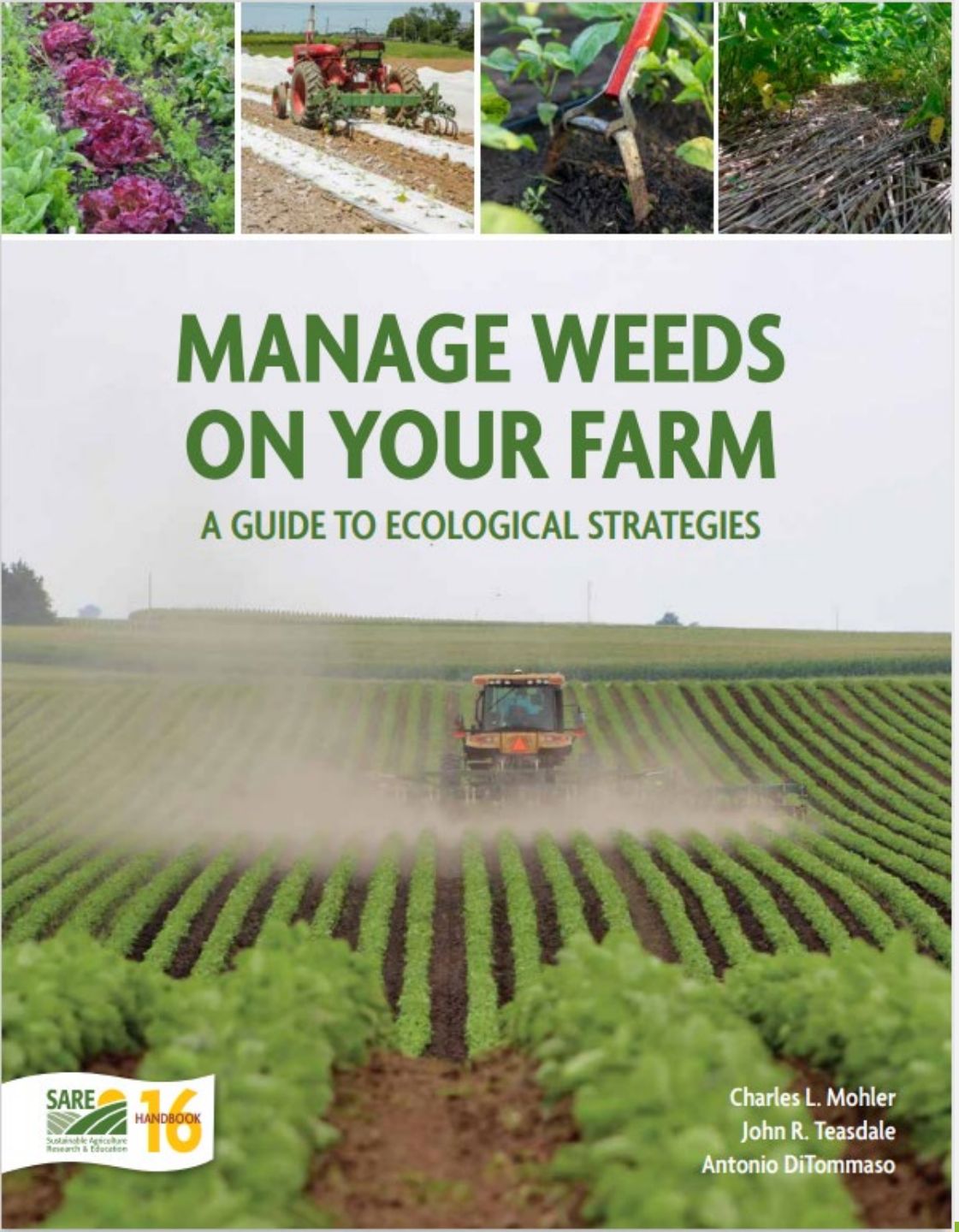
Cornell Weed Ecology and Management Lab



New book about weeds

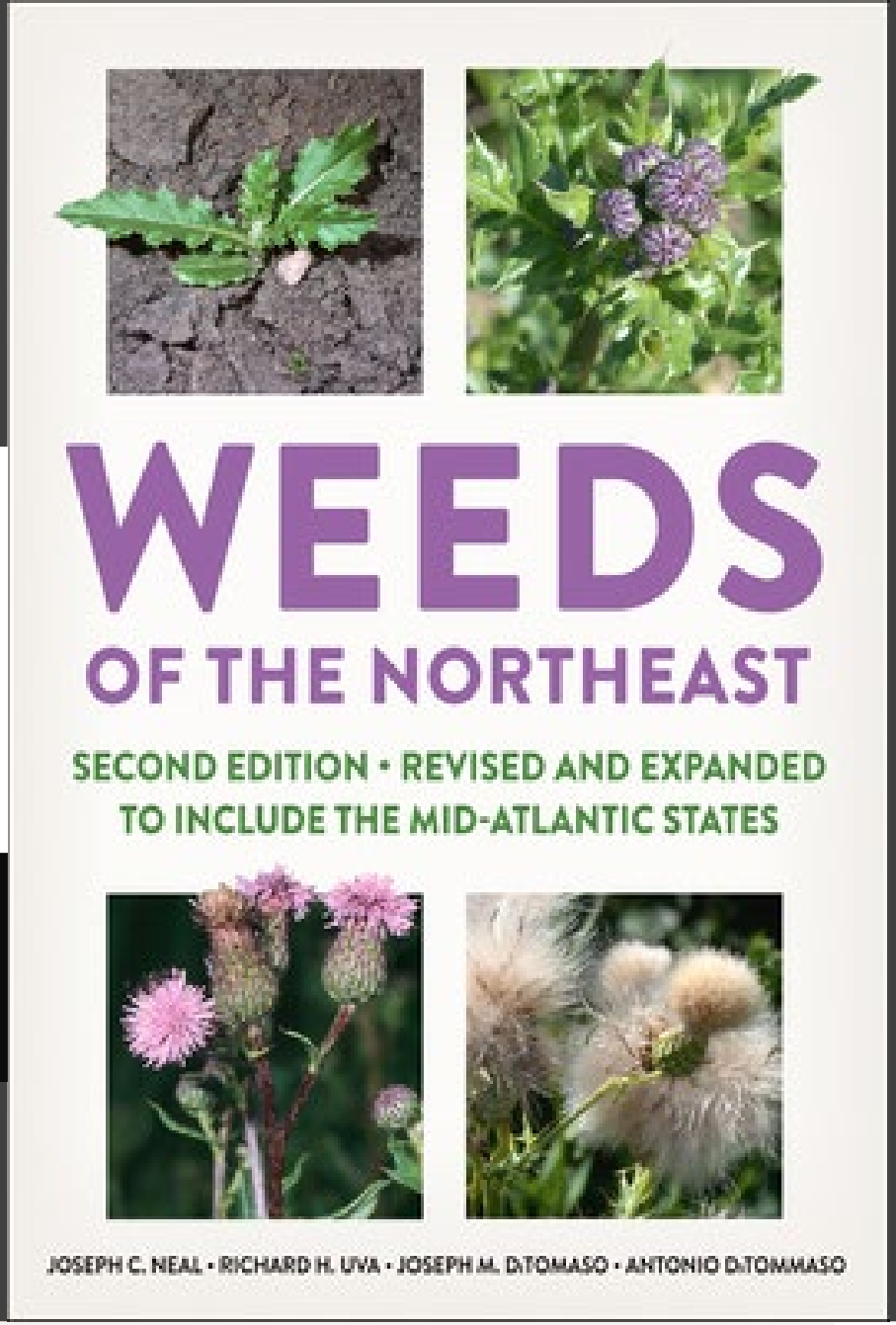
FREE ONLINE
www.sare.org/resources/manage-weeds-on-your-farm/

$24 print copy

Cornell Weed Ecology and Management Lab

Weed identification

$33 print copy from Cornell or Amazon

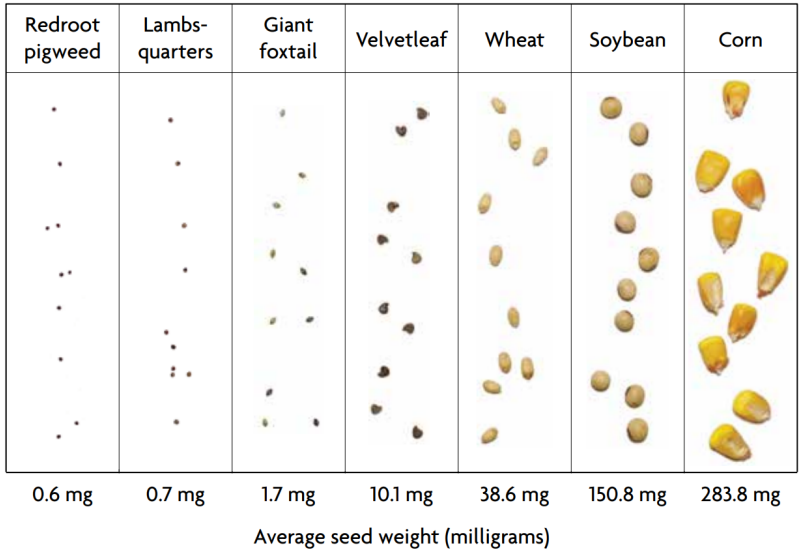


Biological factors that affect weed control

- Seed weight
- Emergence depth
- Seed germination
- Season of emergence
- Seed longevity
- Natural enemies
- Vegetative reproduction
- Growth and competition
- Allelopathy
- Nutrient use
- Drought resistance
- Frost sensitivity
- Dispersal

Seed weight

Larger seeds have more available resources



- Weed seeds are often smaller than crop seeds
- Some weed seeds are very small
- Small-seeded weeds require more signals to germinate

Source: Manage Weeds on Your Farm

Controlling small-seeded weeds

Mulching

Competition from established crop

Shallow cultivation

Images: Manage Weeds on Your Farm (top), Ashley Davenport (middle), J. Simmons (bottom)

Emergence depth

Depends on **seed size,** soil type, seed properties

Table 3. Emergence depth for weed species.

Weed species	Most seedlings emerge from	Maximum depth of emergence
common chickweed	<1"	2"
common purslane	<1"	2"
Canada thistle	<1"	3"
common lambsquarters	<1"	3"
large crabgrass	<1"	3"
eastern black nightshade	<1"	3"
redroot pigweed	<1"	3"
velvetleaf	<2"	4"
quackgrass*	<4"	8"

* Shoot emergence from rhizomes.

Source: Benvenuti et al., 2001.

Integrated Weed Management: "One Year's Seeding…"
Davis, Renner, Sprague, Dyer, Mutch (2005). Extension bulletin E-2931. Michigan State University

Perennial weeds and emergence depth

Below: sprouting yellow nutsedge tuber with roots and a new shoot

Seed germination

Tillage leads to a flush of weed emergence

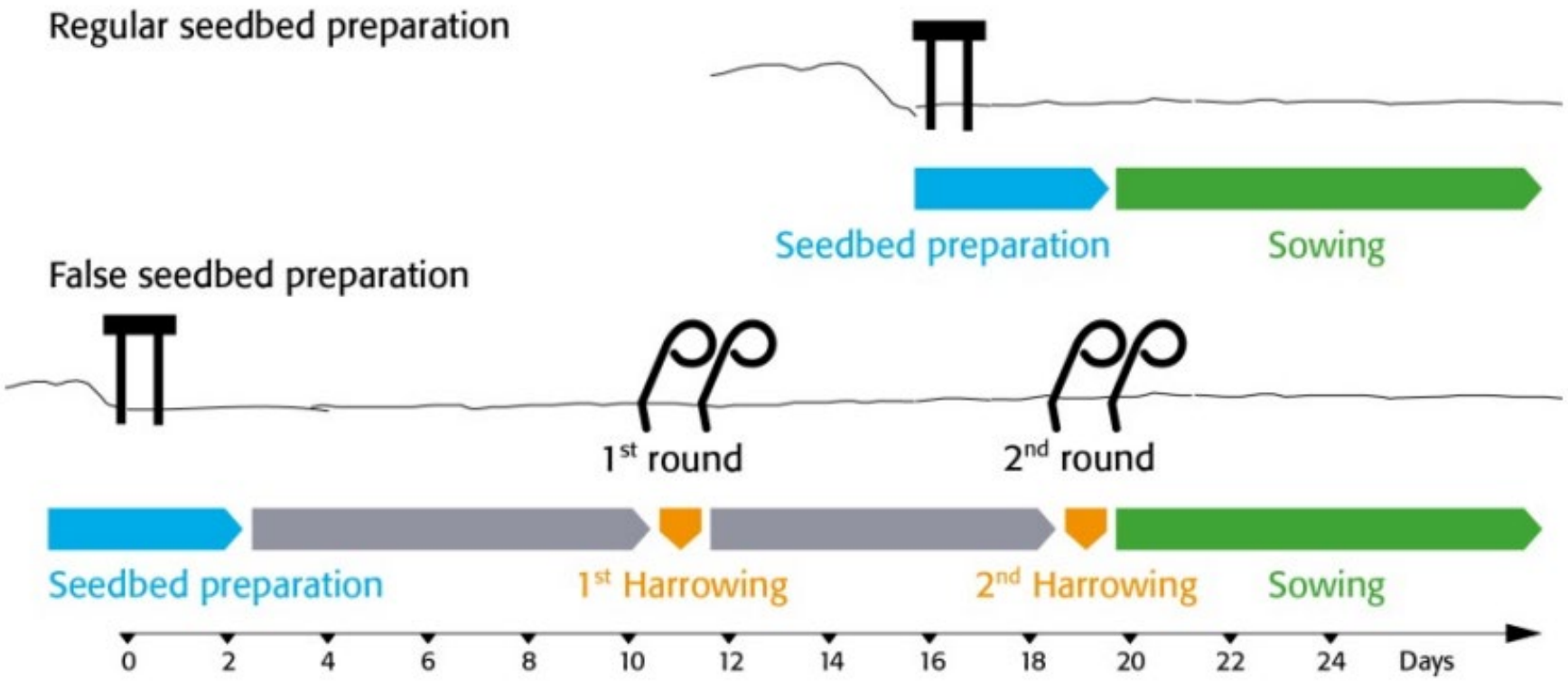
- Weeds respond to cues related to soil disturbance (i.e., few competing plants).
- Cues: light, higher temperatures, temperature fluctuation, oxygen, nitrate

Management options

- Avoid tillage
- Make use of tillage: false or stale seedbed

False seedbed technique

Great for crops with slow emergence/establishment or low competitiveness



Images: Antonio DiTommaso

Season of weed emergence

Differences between species are based on **seed dormancy** and when seeds are produced

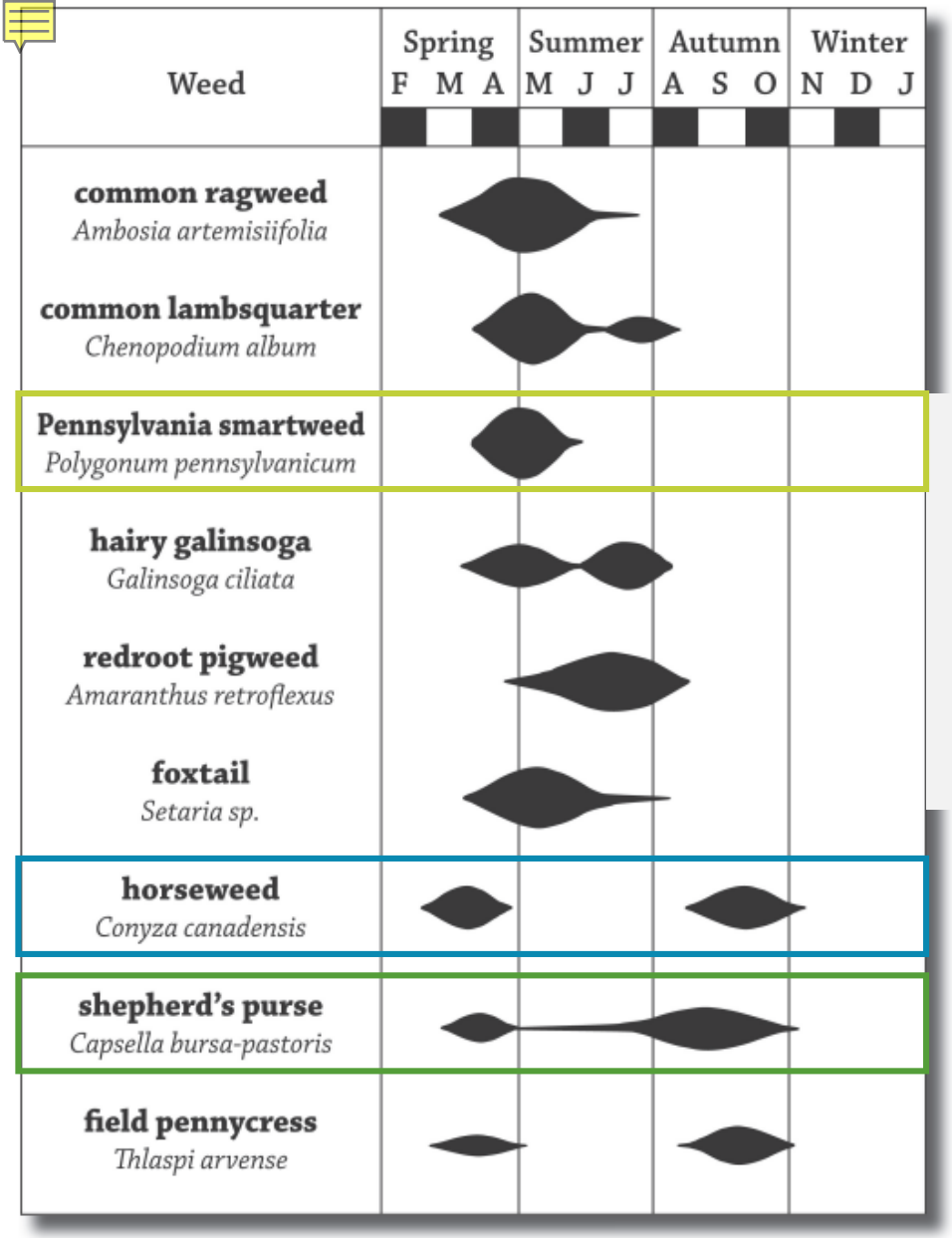
Seed dormancy

Prevents germination at the wrong time

Physiological dormancy

Physical dormancy

Images: Scott Morris (top left), Randall Prostak (bottom left), Mizzou Weed ID (right)



Proportion of weed seeds germinating throughout the season in central Pennsylvania.

Some weeds have long emergence periods

Quasi-simultaneous emergence

Periodic emergence

Continuous germination/emergence: tough to time management operations

Source: The Pennsylvania State University

Crop rotation and weed emergence season

Rotation between crops with different planting times will disrupt weed life cycles

Images: Scott Morris (giant foxtail and shepherd's purse), Antonio DiTommaso (common purslane)

Seed longevity

Some seeds persist for many years...

but most seeds don't

How seeds die

- Fatal germination, predation, or loss of viability
- Small or broadleaf seeds may survive longer than large or grass seeds (with exceptions)

Relevance to weed control

- Reducing seedbank size is very possible
- **Preventing seed production is the key to long-term management**

Reducing seedbank size to control annual weeds

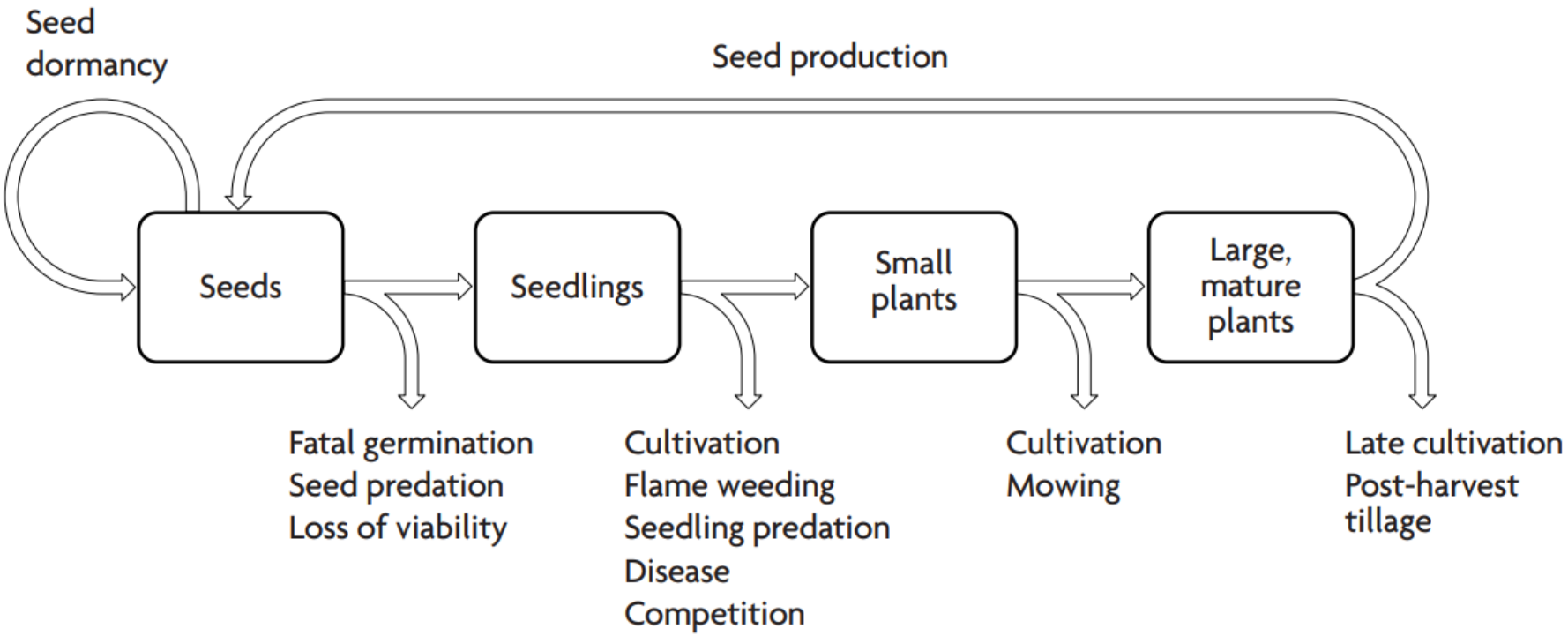


Figure 2.1. The life cycle of an annual weed species showing mortality factors that affect the population at various life stages.

Natural enemies

Top: Deer mouse by Phil Myers via animaldiversity.org. Left: M amaranthi from Shabana et al 2010 Right: field cricket by Jeffrey Reed via Wikimedia.org

Vegetative reproduction

Rhizomes, stolons, rootstocks, tubers, etc.

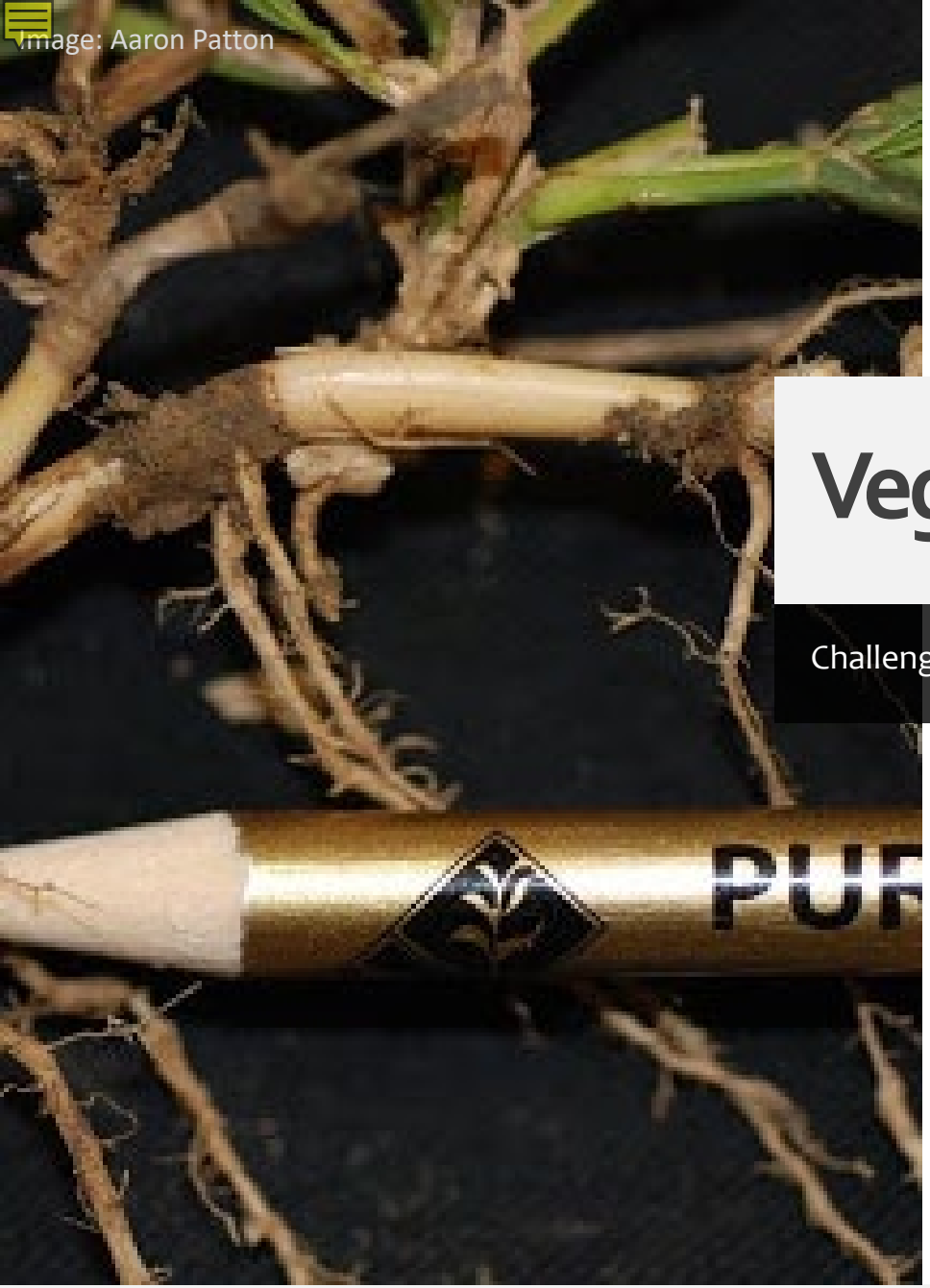


Image: Aaron Patton

Vegetative reproduction

Challenges for weed management

- Emergence **earlier** in the season**, faster**, and from **deeper**
- Regrowth and multiplication after disturbance
- Rapid colonization of new areas
- Clones of successful colonizer (same genes)

Image: Virginia Tech Weed Identification

Vegetative reproduction

Opportunities for weed management

- Less effective long-distance dispersal
- Less adaptability

Vulnerable to repeated control

- Cut storage roots/rhizomes into small pieces
- When reserves at a minimum, repeatedly remove shoots
- Expose storage organs to freezing or dry conditions, or physically remove them

Biological factors that affect weed control

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- Nutrient use
- Drought resistance
- Frost sensitivity
- Dispersal

Growth Rate & Competition for Light

Crops vs Weeds

Left: Velvetleaf, Antonio DiTommaso; Center: horseweed, Antonio DiTommaso;
Right: Corn emerging, Purdue Bob Nielsen

Growth rates and competition

Annual weeds, especially small-seeded ones, start out growing slowly because they don't have much photosynthetic area. However, they have a lot of photosynthetic area relative to their size.

Species	Seed Weight (mg)	Initial Growth Rate (mg/day)	Relative Growth Rate (mg/mg/day)
Common lambsquarters	0.41	0.14	0.35
Velvetleaf	7.8	1.9	0.24
Cocklebur	38	7.1	0.19
Sunflower	61	12	0.2
Soybean	158	24	0.16

Crops start out with a competitive advantage because they have bigger seeds.

To maximize weed suppression by crops:

1. Make sure crops stay bigger than weeds
2. Make sure crops occupy a lot of the available space

Source: Manage Weeds on Your Farm

Image: Ashley Davenport via Michigan Ag Today

Competitive crops

Minimizing resource availability to weeds

- Competitive cultivars (e.g., large leaf area, fast canopy closure)
- Crop vigor and uniformity
- High crop density (when possible)
- Narrow rows (when possible)
- Transplanting of some vegetables
- Intercropping

Allelopathy: weeds

Left: Johnsongrass, Scott Morris; Right: quackgrass, Randall Prostak

Allelopathy: Crops

Some cover crops provide additional suppression to small seeded weeds though allelopathy. If incorporating, wait two weeks before planting crops. Effects are highly variable.

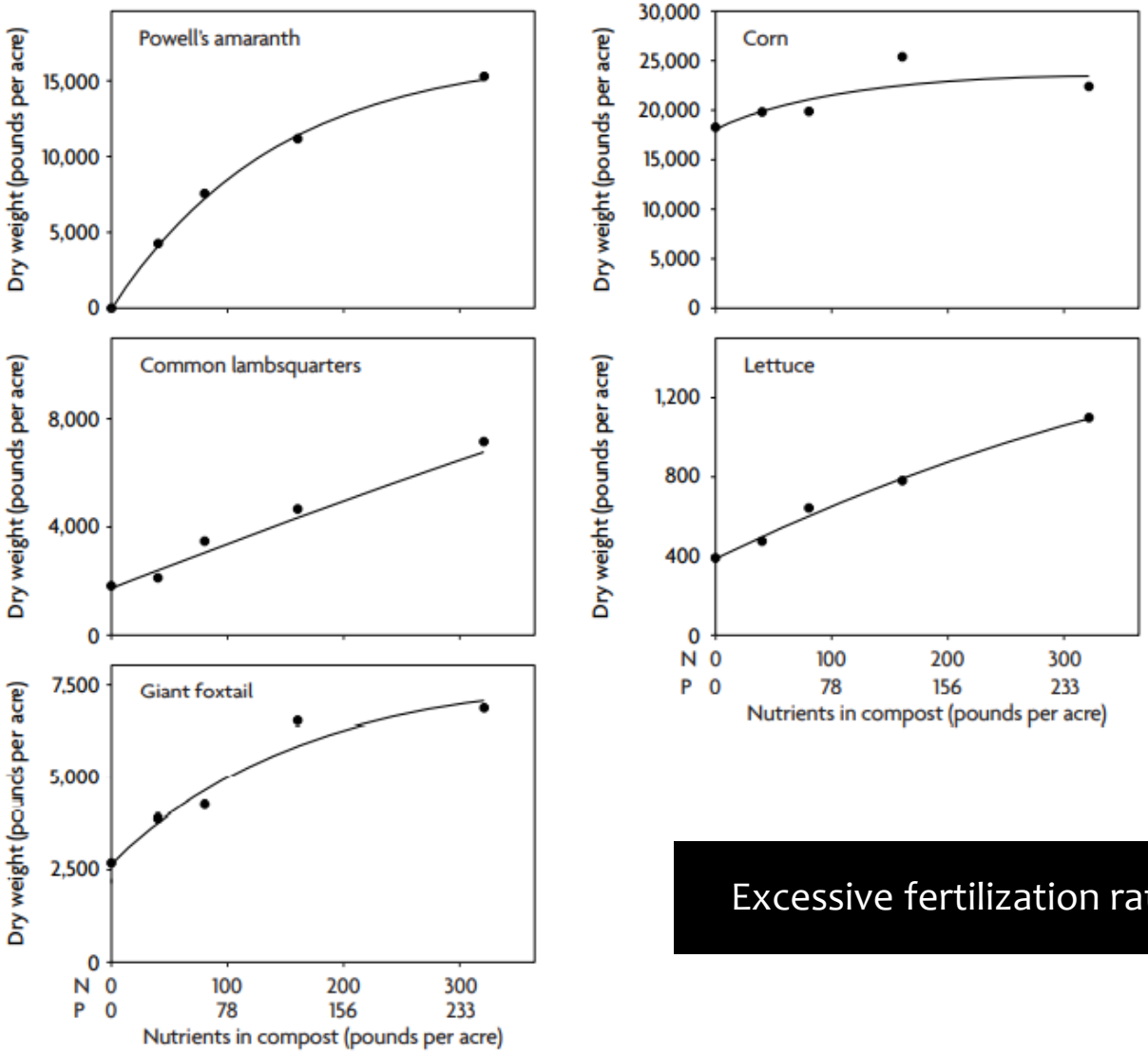
Top: Rye and vetch, UVT Vern Grubinger; Left: Barley, Bob Bugg via SAREP UC Davis; Right: buckwheat, Caroline Marschner

Image: Phil Westra

Nutrient use

Weeds are often better at nutrient uptake than crops

Many weeds are highly responsive to nutrients



Excessive fertilization rates can favor weeds

Figure 2.7. Response of common lambsquarters, Powell amaranth (a pigweed), giant foxtail, corn and lettuce to increasing rates of composted chicken manure. Rates of composted chicken manure are expressed as the amount of N and P_2O_5 contained in the compost (redrawn from Little et al. 2015).

Source: Manage Weeds on Your Farm

Drought resistance

Different weeds respond differently to drought

A few weeds are highly sensitive (common chickweed, henbit)

Most weeds, like most crops, can endure short-term droughts

Some weeds are highly resistant (Palmer amaranth, purslane)

These weeds grow best in hot, sunny conditions

Some weeds are initially sensitive (shattercane, field bindweed)

These weeds later develop deep roots to access water

Images: Scott Morris (top), Antonio DiTommaso

Image: Scott Morris

Sensitivity to frost

When will cold weather kill weeds?

- Hairy galinsoga dies with mild frost; field pennycress can survive to 7°F.
- Frost sensitivity affects whether late-emerging individuals will die before setting seed.

Dispersal Management

Seeds mature and disperse continuously

(chickweed, galinsoga)

Seeds not dispersed until well into the fall

(waterhemp, lambsquarters)

Images: Scott Morris (top), Antonio DiTommaso

Weed Dispersal:

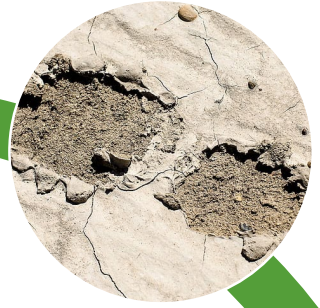
Natural

Wind

Water

Animals

Weed Dispersal: Agricultural



Boots

Tires and equipment

Seed

Amendments

Benefits of weeds

- Organic matter
- Soil cover
- Soil fertility
- Pollination
- Biological control
- Conservation
- Genetic biodiversity
- Food and medicine

Palmer Amaranth *Amaranthus palmeri*

- Multiply herbicide resistant
- Highly drought tolerant
- Emerges over a long period
- Holds seed after maturity
- Short lived seed bank
- High seed consumption at surface
- High Palmer incorporation has allelopathic properties
- Shade is NOT effective – grows too fast

Photos: Lynn Sosnoskie

Palmer Amaranth *Amaranthus palmeri*

Row Crops

- Early, timely management critical
- At 4 days intervals, blind cultivate before emergence & slow tine weed/rotary hoe after
- Rotate into perennial sod, esp. with tillage after harvest
- Rotate into perennial sod
- Seed destructor tech appropriate
- High corn density, irrigation both help

Vegetables

- Black plastic mulch, remove at holes w/in 5 weeks (peppers)
- Cover crop mulches help, especially heavy rye

Photos: Lynn Sosnoskie

Waterhemp *Amaranthus tuberculatus*

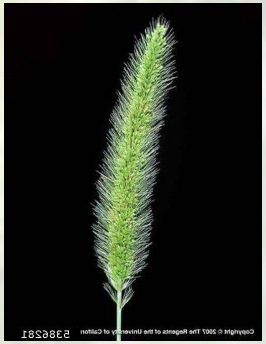
Late emerging

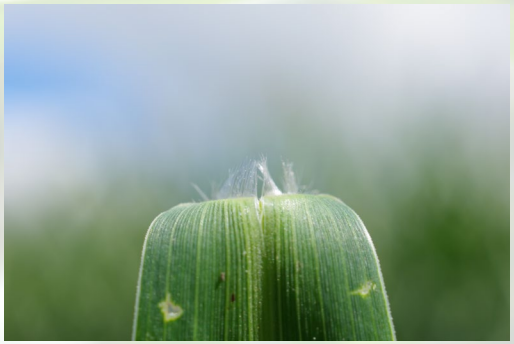
Not as drought tolerant as Palmer

- Tillage, especially moldboard
- Winter grains suppress seed production
- AVOID hay after grain – "massive seed rain" before first cutting
- Cultivation in corn and soy
- Veg: NOT early tilled fallow
- Organic mulches work well
- Future bioherbicide?

Photos: Lynn Sosnoskie

Foxtails *Setaria spp.* : Giant, Yellow, Green





Annual grasses

Giant is problem in no-till

Yellow drought tolerant, allelopathic

All love fertility, especially giant

- High seed mortality on soil surface
- Shade, esp. winter grains, oats & barley
- Post grain harvest cleanup
- Early vegetable crops with midsummer harvest

*Green foxtail = wild foxtail millet; S. Italica = foxtail millet; these hybridize

All photos: Anotnio DiTommaso and Scott Morris except yellow foxtail flower: Joseph M DiTomaso University of Utah via Bugwood.org

Jimsonweed *Datura stramonium*

Very responsive to fertility

Competition intolerant

Late emerger; variable seed life

- No till & cover crops help
- Avoid overfertilization
- High seed predation at soil surface
- Control around manure/compost storage
- Topping above crop effective but NOT mowing
- Burying seedlings better than tine/rotary weeding
- Deep shade effective

Photos: Antonio DiTommaso

Eastern Black Nightshade
Solanum ptycanthum

Problem in edible bean crops and peas

Stains product and lowers quality

- Avoid excessive nitrogen
- Relatively high seeding rates and narrow rows when possible
- No till reduces nightshade problems
- Tilled fallow periods
- Short vegetable crops with tillage
- Sod competes well with nightshades
- Avoid overgrazing pastures

Leaves and fruit: Antonio DiTommaso
Seedlings and background: Bruce Ackley via Bugwood.org

Mullein *Verbascum thapsus*

Biennial; low palatability. Usually ephemeral.

- Glyphosate spot application on rosette stage
- Reseeding with desirable species
- Hand pulling prior to seed set

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Leaves: Chris Evans via Bugwood.org Field: Alex Katovich via Bugwood.org
Background: Rebekah Wallace via Bugwood.org

Common Chickweed

Stellaria media

Problem in vegetables & winter crops

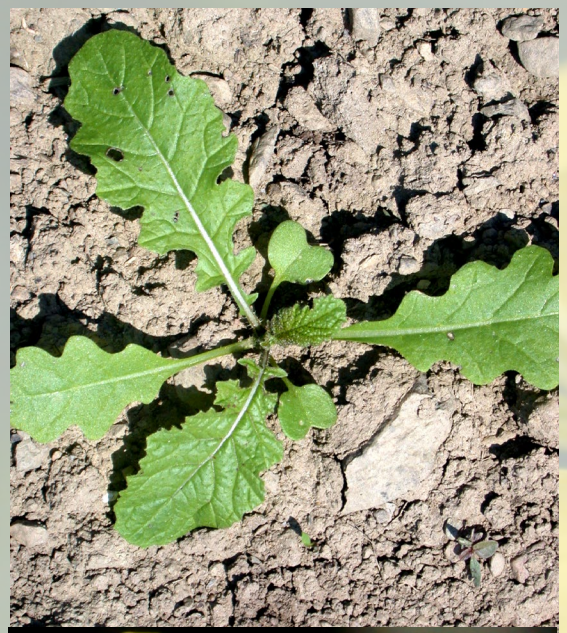
Produces seed continually

Seeds remain dormant without light

- Control through all crops
- Increase density of winter and spring grains
- Frequent, shallow weeding operations
- Small seeded vegetables – stale seedbed with flame weeding
- Organic mulches, not loose straw

Background: Scott Morris
All other photos: Antonio DiTommaso

Wild Mustard *Sinapis arvensis*



Early spring emerger; hard to control with cultivation

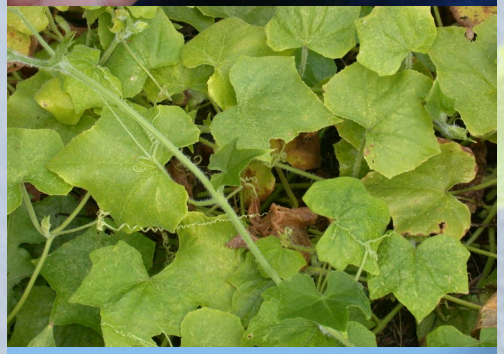
Quickly establishes large root system

Very responsive to nitrogen

- Tilled spring fallow & late planted crop
- Avoid overfertilization & side-dress later if possible
- Highly competitive crops shade dense mustard, esp. cereal grains

Photos: Antonio DiTommaso

Burcucumber *Siscyos angulatus*



Serious field crop weed; shifting north

Early spring emerger

Quickly grows large root system

Very responsive to nitrogen

- Tilled spring fallow & late planted crop
- Avoid overfertilization & side-dress later if possible
- Highly competitive crops, esp. cereal grains

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Cotyledons & Background: Ohio State Weed Lab via Bugwood.org
All other photos: Antonio DiTommaso and Scott Morris

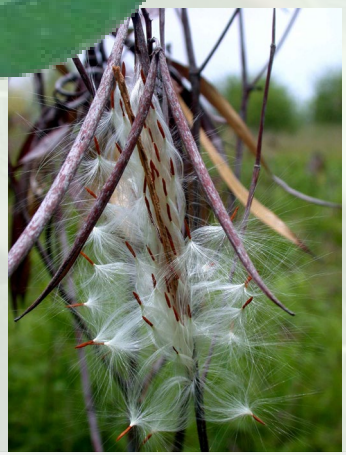
Mile-a-minute vine *Polygonum perfoliatum*

Thorny annual vine; extremely aggressive and prolific. Orchard weed.

- Manage early before seed set
- Tillage or mowing helps
- Most systemic herbicides (including triclopyr); preemergent in March for large populations
- Hand pulling prior to seed set
- Dessicate or solarize material
- Mile-a-minute weevil

Photos by Antonio DiTommaso

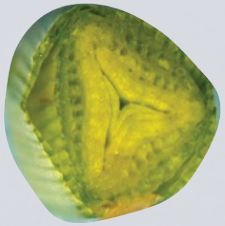
Hemp Dogbane *Apocynum cannabinum*



Perennial; can be poisonous to livestock. Problem in pasture and no-till systems

- Fall application of glyphosate or 2,4D
- Rotate to alfalfa: frequent mowing depletes storage reserves
- Early planted crops develop canopy before dogbane emerges
- Rotate to fallow or crops to disrupt life cycle

Leaves: Chris Evans via Bugwood.org Seeds: Antonio DiTommaso
Background: Forest Health Management International via Bugwood.org



Yellow Nutsedge *Cyperus esculentus*

Aggressively spreading sedge, perennial tubers.

- Rotational control for 2-3 years will eliminate most tubers
- Rotate with crops that have late spring/early summer tillage
- Overtop with dense planting
- PRE Herbicides: Groups 1/3 (i.e. Harness Xtra), 5 (atrazine, Princep), 5/15 (Bicep, CinchATZ), 5/15/27 (Acuron/Acuron Flexi, Lumax, Lexstar), 15 (Dual)
- POST Herbicides: Group 2 (Permit, Sandea, Yukon, Permit Plus)

Top, middle and background: Ohio State Weed Lab via Bugwood
Bottom: Steve Dewey Utah State University via Bugwood

Purple Nutsedge *Cyperus rotundus*

Even worse; shifting north

"Extreme measures are generally required"

- Clear plastic solarization in hot, dry weather
- Grazing: pigs (fast), geese, chickens (slow)
- Crops with full closure & deep shade
- Extensive tillage in hot, dry conditions to break up root chains and dehydrate tubers (least expensive option)

Above: Starr Environmental via Bugwood Below: Charles T Bryson ARS via Bugwood
Background: Rebekah D Wallace via Bugwood

Bindweeds *Convolvulus spp.*

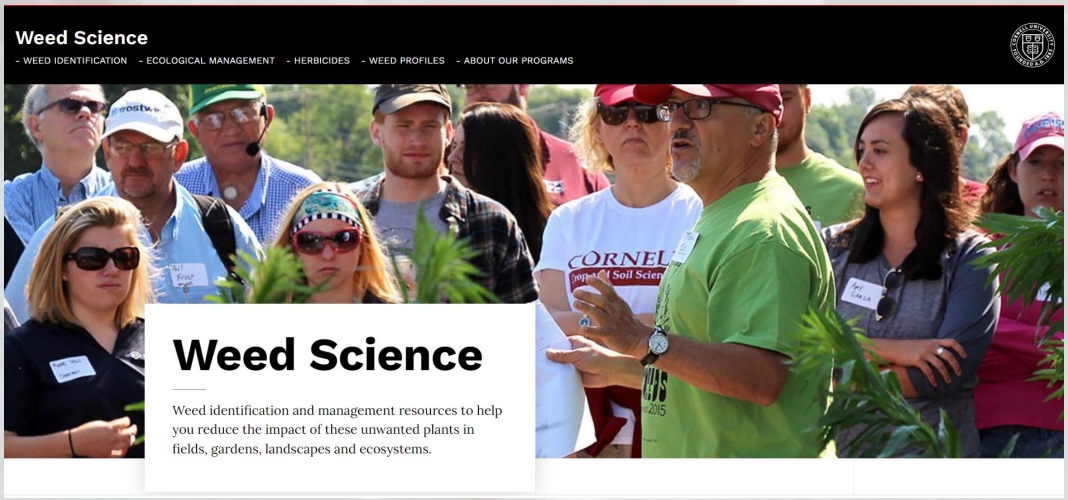
Phenomenally problematic vining perennial

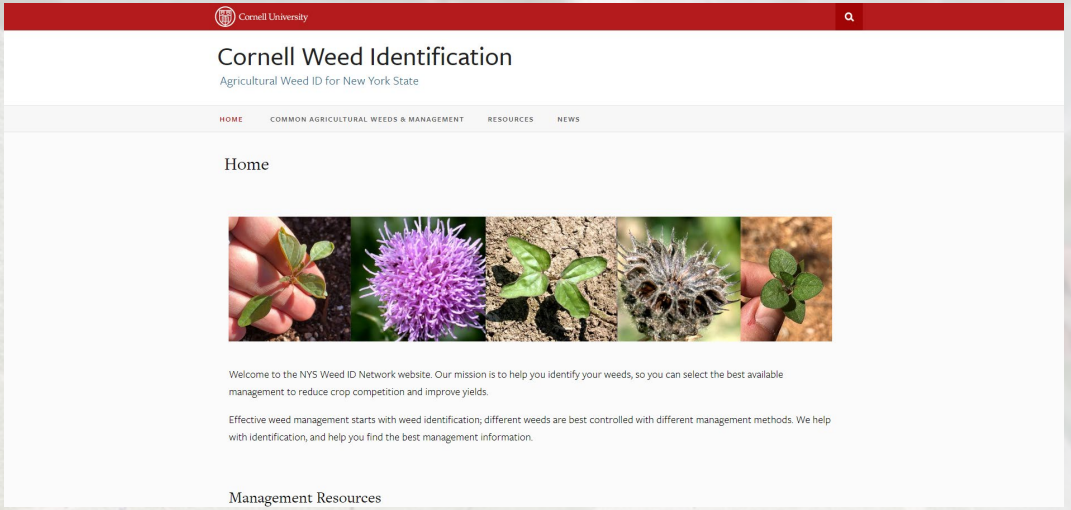
Weather after disturbance must be dry to work

- Disrupt growth at 4-6 leaves
- Repeated shallow tillage between crops
- Fallow followed by winter grains, vigorous fall planted crops
- Interseeded clover into corn can suppress
- Intense shading before it climbs: forage soybeans, rye, oats, sudangrass, German millet
- Mowed alfalfa
- In veg: overwintering rye, oats & peas, buckwheat, sudangrass
- Disk between crops
- Synthetic mulch only for field bindweed

Photos: Lynn Sosnoskie, Antonio DiTommaso, Scott Morris

Questions





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Cornell Weed Science

https://cals.cornell.edu/weed-science

Agricultural Weed ID

https://blogs.cornell.edu/weedid/

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