Much of the content of this presentation was informed by the Medusahead Management Guide for the Western States, by Guy Kyser, Joseph DiTomaso, Kirk Davies, Josh Davy, and Brenda Smith.
Overview

Medusahead background
Invasion dynamics
Control
Current research

Photo: Emilio Laca
Overview

Medusahead background

Invasion dynamics

Control

Current research

Photo: Emilio Laca
Medusahead is a member of the Triticeae, a tribe of grasses which includes the important grain crops wheat, barley, and cereal rye as well as wheatgrasses, wildryes, and goatgrasses. This grass tribe has its likely center of origin in the Middle East. There is evidence that some types were used for human food 23,000 years ago (Weiss et al. 2004); wheat, barley, and rye, of course, formed the basis for early agriculture and human settlement.
A slide to show some clear phenological differences in medusahead compared to other common annual grasses.
Medusahead was first recorded in the United States near Roseburg, Oregon, in 1887 (Howell 1903). Herbarium records indicate that the plant spread concentrically—north into Washington, south into California, and east into the Great Basin, Idaho, and other western states—but most rapidly in the direction of California (Major et al. 1960). It is not known how medusahead was introduced to the United States. It has been suggested that medusahead arrived as a contaminant in cereal grain seed, while others (George 1992; Hilken and Miller 1980) suggest it may have arrived clinging to the fur of imported livestock. Because medusahead seeds are smaller than most cereal grains, and because this plant goes to seed later than most domesticated cereals, the fur hypothesis seems most likely.

Medusahead does not appear to be weedy in its native Europe.
It is spreading rapidly in California (can increase its range at a rate of 12% PER YEAR!) Source of image: probably CalFlora
Overview

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Photo: Emilio Laca

Overview of the session. Self explanatory outline.
Medusahead can occur on sites with rainfall ranging from 10 to 40 inches per year, although it is more typically found on sites receiving 12 to 24 inches. Most common would be sites orange to light yellow, east side foothills, annual grasslands; westside annual grasslands. Because it matures late compared to other annual grasses, medusahead benefits more from spring rainfall than from earlier fall and winter rainfall. Medusahead is often found in lower density in oak dominated habitats.
Medusahead is found on many soil types. At the upper end of its precipitation range, it can survive on sites with coarse, poorly developed soils. In general, though, it is less likely to occur on sandy, well-drained substrates. Under the right conditions, medusahead can invade areas of loamy soil. In more arid areas, medusahead tends to require well-developed clay soils, which help retain soil moisture until later in the season. Soil disturbance increases the potential for medusahead Invasion on all soil types.

See more: Young and Evans 1970; Dahl and Tisdale 1975; Miller 1996; Cherr 2009
The thick silica-rich thatch which often develops in infested areas favors medusahead in dry sites, perhaps by acting as a mulch that slows water loss from the soil. Unlike most species, medusahead seeds can actually germinate in thatch, growing a root to the soil surface.
Factors for Invasion

Seed dispersal

The barbed awns on medusahead seeds make attaching to livestock, equipment, and humans very easy and the opportunity for spread greater. Seeds can attach to livestock and be moved from one grazing area to another.

See Shmida and Ellner 1983; Sorensen 1986
Medusahead seeds are less used by seed-eating birds than other grasses, even downy brome. Native seed-eating rodents also prefer seeds of other species, tending to avoid medusahead-infested areas. Consequently, the effects of a medusahead infestation are felt throughout the faunal community.

See more: Goebel and Berry 1976; Longland 1994
Thatch prevents other species from germinating by not allowing the soil temperatures to increase, and by preventing seed contact with mineral soil. Thatch slows soil warming, prevents other seedlings from reaching soil surface, blocks sunlight. There may be allelopathic effects as well that prevent other species from germinating. In one study, medusahead seedling establishment was 47 times greater under litter than on bare ground.

See more: Evans and Young 1970; Harris 1977; Young et al. 1971; Young 1992
Medusahead thatch also prepares the environment for fire. The thatch can create a fire risk in any season. Faster return fire cycle may affect native species.
Medusahead competes for water and nutrients with annual and perennial grasses, particularly while perennial grasses are establishing from seed. In comparing soils from medusahead-infested sites in Lassen County, CA, with uninfested sites, researchers found reduced nitrogen mineralization, reduced total nitrogen, and significantly increased soil pH in infested sites. However, they did not detect significant effects on soil microbiota.
Medusahead foliage has poor palatability owing to a high silica content and a rough texture. Due to the high silica content, particularly once seed is set, medusahead is of little value in livestock production. A reduction in grazing has been documented to be upwards of 75 to 80% in heavily infected rangelands.
Knowing the critical times when medusahead is susceptible to treatments can greatly improve your chance of reducing medusahead. For instance, grazing is a great management tool, but only effective at a very specific window of time. Grazing before or after that window will not reduce medusahead.

See more: (Sharp et al. 1957; Miller et al. 1999; Sweet et al. 2008)
Medusahead Growth Stages

<table>
<thead>
<tr>
<th>Stage Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>Plant germinated</td>
</tr>
<tr>
<td>V2</td>
<td>Early vegetative, before elongation of internodes</td>
</tr>
<tr>
<td>V3</td>
<td>Late vegetative, elongation of internodes and boot stage</td>
</tr>
</tbody>
</table>

This is the vegetative stage. Grazing can occur all during this stage. In most years, more desirable grasses such as soft chess will mature earlier than Mh (V3 picture, Mh is still in the vegetative stage, soft chess has developed a seed head). This is also why late rains can benefit Mh. Once in the reproductive stage, most annual grasses will not put energy into growth, but instead into seed production.
Stage Code / Description

- **R4**: From emergence of awns to full emergence of seedhead.
- **R6**: Anthesis to closure of florets. Beginning of kernel formation.

R4 starts the beginning of the reproductive stage of Medusahead. The awns are visible first, and then a seedhead emerges. In the R5 picture, you can see small Mh “flowers”. By this time, any control treatment to prevent seed development should have been completed.
Medusahead Growth Stages

**Stage code / Description**

**R7**  
Kernel elongation inside floret until it reaches full length.

**R8**  
Seeds in milk stage. Kernels occupy full length of palea.

**R9**  
Seeds in dough stage.

**M10**  
All seeds in seedhead are mature and hard. Plants are not dead yet. There is some red, brown and green in the seedheads. Glume veins are dark.

**D11**  
Tiller is dead and dry. Color is uniform, sandy yellowish but not grey. Seeds shatter.

**L12**  
Grey plant remains obviously from the previous season.

Seed development and mature plants. Plants then move into the dead and dry stage, and finally into the litter stage, or thatch.
Phenology

- Most seeds rapidly germinate in the fall
  - Practices that limit a single year of seed production can drastically reduce plant numbers
- Matures and stays green later than most annual grasses
  - Often doesn’t mature until May

- Generally 95-99% of seeds that shatter, germinate.
- Many researchers have documented several cohorts of medusahead (e.g. one cohort germinating in the fall and a second cohort germinating in mid-winter).
Overview

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Photo: Emilio Laca
How to control medusahead

- Burning
- Herbicide
- Competition (seeding)
- Grazing
- Mowing

Photos: Josh Davy

Integrated pest management
Timing is June for most of the valley sites. Generally, prescribed fires are not hot enough to induce seed mortality once the seedheads have shattered and the seeds are on the soil surface. However, when seeds are still on the plant, about 7 seconds of standard heat experienced from prescribed fire has shown to be enough to induce 90% seed kill. Burning has been shown to be more effective in low elevation, warm-winter areas, characterized by high annual grass biomass production, but it may not be successful in semiarid cool winter areas.
Good to follow burning up with herbicide of invasive seedlings or direct seeding with desired species. Burning gets the seeds on the plants that haven’t shattered. So, the hard seed already on the ground of oat, clover, and below ground seed of Filaree are not wiped out by the fire. That’s why you see almost no effect from the accidental fires in August and September, everything has already shattered. The perennial grasses have their energy in the crown, which is largely unaffected.
Partnering with UC and UCCE might help speed up permitting process to acquire and use herbicides.
Aminopyralid before germination

Mh on the left, solid ryegrass on the right. Smoked it.
Effective?

- Yes, but expensive—$2.85/ounce @ 14 oz
- 14 oz/acre is only registered as a spot treatment
- 7 oz has good, but not full control
- How long does it last
  - one site in Red Bluff still shows control after 4 years
- Forbes
  - Very little forbs on treatment year
  - Hard seeded clover and filaree returned the second season
Aminopyralid in the spring

- Still being tested
- Low rates are acceptable
  - 2-4 oz/acre possibly
- Does not kill plants, but prevents seed production

The plant in the photo shows the correct timing. If the plant is headed then the treatment won’t work.
# Grass selective herbicides

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate:</th>
<th>Cost (2013)</th>
<th>Timing:</th>
<th>Safety on established perennial grasses:</th>
<th>Grazing restriction:</th>
<th>Plantback interval:</th>
<th>Remarks:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clethodim Arrow 2EC</td>
<td>4 to 8 fluid oz product/acre (1 to 2 oz a.e./acre)</td>
<td>$120/gal (~$4 to $8/acre)</td>
<td>Early postemergence</td>
<td>May vary by species and growth stage. Older, established bunchgrasses should be safe but may show injury. Annual grasses will be severely injured or killed.</td>
<td></td>
<td>None</td>
<td>Registered for use on noncrop, fallow ground, and native prairie restoration projects. Check with your county to make sure your intended use is permitted.</td>
</tr>
</tbody>
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</tr>
</thead>
<tbody>
<tr>
<td>Fluazifop Fusilade DX</td>
<td>24 fluid oz product/acre (6 oz a.e./acre)</td>
<td>$170/gal (~$32/acre)</td>
<td>Early postemergence</td>
<td>May vary by species and growth stage. Older, established bunchgrasses should be safe but may show injury. Annual grasses will be severely injured or killed.</td>
<td></td>
<td>None</td>
<td>do not graze for 12 months after application</td>
</tr>
</tbody>
</table>

Note: these are not registered for grazed rangelands (and not registered for California), so their use has been very minimal. They are mostly reserved for cases where grass control is wanted, but desirable native broadleaves are present.
# Glyphosate

**Glyphosate**

**Rate:** 0.75 to 1 pt product (41% glyphosate)/acre (4.5 to 6 oz a.e./acre) for early-season selective control in shrubland or other perennial systems; 1 to 2 qt product/acre (0.75 to 1.5 lb a.e./acre) for late-season, non-selective control.

**Cost (2014)**: $16/gal (~$2/acre for early-season treatment, ~$4 to $8/acre for late-season treatment)

**Timing:** For selective control in shrubland, apply postemergence in spring after all seedlings are up and before heading; the tillering stage is ideal. For late-season, non-selective control, apply to rapidly growing plants before seeds are produced.

**Remarks:** Glyphosate is a non-selective herbicide with no soil activity.  

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**Note the low rates possible.**

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**From: Weed Control in Natural Areas in the Western United States**

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**Photo: Emilio Laca**

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**Photo: Josh Davy**
Dose is per acre. After herbicide use, the site became forb dominated.
Competition/seeding
Seed desired grasses

- Weeds must be controlled the year before planting (herbicide is best)
- Retreat weeds the fall of planting with grazing or burning

Photo: Josh Davy
Seed desired grasses

- The more ground prep, the better it works
- Skipping a step = total failure
- Tilling and drill seeding show best success to increase seed to soil interface

Photo: Josh Davy
Pick seeded species wisely

- Match the plant to soils
  - e.g. Don’t plant Harding grass in shallow soil, plant Berber orchardgrass

- Match the plant to climate
  - e.g. Wheatgrass does not do well in the valley, except for tall wheatgrass
Ryegrass (annual, usually the variety is ‘gulf’) is easy to grow and cheap. Soft chess ‘blando’ brome can also be added but is more expensive. These annuals nearly always work but must set seed to persist over time.
Grazing

Phenology work for proper timing

- Use the plants late maturity against it
- Defoliate late to reduce ability to make seed
- Timing is critical
- Weather, soil, etc. cause variations in maturity

Photos: Josh Davy
Use of supplements to attract cattle (molasses tubs, hay, salt, etc.) has limited use. It will draw cattle into Mh patches, but you see no impact roughly 50 yards out. It is probably the cheapest method, but time needs to be spent moving supplement to the next Mh patch when needed. It is better than doing nothing to try and control Mh.
Adding fertilizer early will increase seedling (valuable as forage) size. But it will not increase seed production. The downside is that reduction is not large enough for long term control. If lower rates are used, the best timing is spring so the added N is still present during the susceptible spring grazing months.

Grazing attraction—nitrogen

- Rates as low as 30 lbs/acre can attract cattle to graze medusahead during the spring
- Rates of 50+ lbs/acre should be done in the fall to enhance winter growth
30 lbs of N in the fall does not last long enough into spring to be different than the control during the critical boot stage. Higher rates, or later applications, will increase nitrogen (CP) content through the entire season. Note: this is only mh sampled, no other species are included.
Invitro digestibility was increased by fertilizing mh regardless of rate or timing.
Depiction after peak standing crop. Nitrogen fertilized area is grazed to very little RDM
In drought years like we have seen recently, late spring rains cannot be counted on to provide drinking water.

Grazing

It will not reduce medusahead every year.  
- Particularly on years with late spring rain  
  - Plants recover after grazing and make seed.  
  - Desirable forages are already dry and cattle need to be shipped to greener, higher quality forage.  
  - Reliable drinking water supply may be gone earlier in the season.

- It will not get worse on late spring rain years, it’s just harder to make an impact, so be patient.

On dry years, medusahead reductions can be seen.

Photo: Emilio Laca

University of California
Agriculture and Natural Resources

In drought years like we have seen recently, late spring rains cannot be counted on to provide drinking water.
Mowing

- Mowing acts similar to grazing in eliminating seed production
  - The window for mowing is longer than grazing because the awns on the seed head decrease palatability.
  - Late season fire is a concern with mowing.
  - Relatively inexpensive, but often infeasible over large scales and on rocky landscapes
Mowing

- Should be done when medusahead is in the boot stage.
- However, medusahead individuals that escape mowing will respond with an explosion of seed production, so two mowing events in a single season is ideal.

If conducted after the boot stage (during anthesis), any missed individuals will produce viable seed.
If you do nothing, and spend nothing, you will lose rangeland to medusahead. This is why even just a forage replacement cost (which is pretty low with the recent cost of hay) pencils out.
IPM approach

- IPM = Integrated pest management
- Best method of control is using different approaches within and across years.
- This results in more complete medusahead control + often comes with benefits to desired species and natives
- Single treatment applications will fail for long-term control.
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Photo: Emilio Laca
What’s new in medusahead research?

Lots of research is being conducted to investigate novel medusahead control and eradication. Much of it is occurring through the UC system and UCCE!
These are the results of a meta-analysis. Essentially, we took all published studies on medusahead control and quantified the effect of different types of control (listed on the x-axis) within the first year of treatment (top panel) and after the second year of treatment (bottom panel). The effect size (y-axis) tells you how much a particular treatment was able to reduce medusahead in a plot. So, any point (the mean) below the 0 line (dotted line) indicates that a treatment was successful in reducing the cover of medusahead. Lines attached to black points are confidence intervals. If these confidence intervals cross zero, then the treatment was ineffective. This paper is currently in press at Rangeland Ecology and Management.
Average medusahead cover before and after placement of supplement to attract cattle grazing. For more info, check this out: http://www.agalert.com/story/?id=1142
Mowing—one project

- Mowing two years in a row, while medusahead is in the boot stage.
- Medusahead reduced from 50 to 5% cover.
- Medusahead seed production reduced by almost 90%.

Mowing is effective during a longer window of opportunity than grazing—so it is a fertile area in which to investigate control approaches. This work is being done by Emilio Laca at UC Davis.

Boot stage—when medusahead is in the process of producing a spike, but the spike has not emerged yet (see R4 growth stage on previous slide).
This work is being done by E. Gornish + J. James at the UC Sierra Foothills Research and Extension Center. This work suggests that plants that escape the mowing treatment are responding with a compensatory response—that is, they are exploding in seed production after being released from competition. This suggests why single season treatments are not effective. Differences in research outcomes between this work and the previous one highlights the context specificity of medusahead control.
Best management approaches

- Burn in **YEAR 1** (to reduce seed production and get rid of thatch); till and seed with desired species in **YEAR 2**; follow up as needed in **YEAR 3** and beyond
- Spray with roundup late in the season (~$4/acre) and then seed in the fall of **YEAR 1**; follow up as needed

Control is SUPER context-dependent. However, we have found that two approaches appear to work best. Stress upkeep!
Just a reminder...

- Cooperative Extension’s role is to help you get where you want to go, not where we think you should go.
- One size does **not** fit all.
- We test the tools.
- IPM approach
Useful information

- California Invasive Plant Council (www.cal-ipc.org)
- UC Integrated Pest Management Program (www.ipm.ucdavis.edu/index.html)
- Invasive Plant News (http://techlinenews.com)
- Research Gate (www.researchgate.net)
- USDA (www.invasivespeciesinfo.gov/plants/medusahead.shtml)

Sources of free information, mostly geared towards landowners and practitioners. Research Gate is a good place to find free access to academic research papers.
More information is in this guide →

by G.B. Kyser, J.M. DiTomaso, K.W. Davies, J.S. Davy, and B.S. Smith

FREE download!
http://wric.ucdavis.edu

Questions?

Contact your local farm or livestock advisor. Alternatively, you can contact the organizers of this presentation:

- **Theresa Becchetti** (Farm Advisor, San Joaquin-Stanislaus) [tabecchetti@ucanr.edu](mailto:tabecchetti@ucanr.edu)

- **Josh Davy** (Livestock Advisor, Tehama-Glenn-Colusa) [jsdavy@ucanr.edu](mailto:jsdavy@ucanr.edu)

- **Elise Gornish** (Restoration Ecology Specialist, statewide) [egornish@ucdavis.edu](mailto:egornish@ucdavis.edu)