Loss of milkweeds in agricultural fields: Effect on the monarch population
Insect Conservation and Diversity

– Milkweed loss in agricultural fields because of herbicide use: effect on the monarch butterfly population
– JOHN M. PLEASANTS and KAREN S. OBERHAUSER
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Bt corn pollen and monarch butterflies
Things learned in Bt corn study in 2000

• 1. Milkweeds in corn and bean fields had higher egg and larval densities than milkweeds in non-agricultural habitats
• 2. We estimated that 80% or more of the monarch production in the Midwest came from agricultural fields
Change in Milkweed Numbers for all Study Plots in Fields

Number of Milkweed Stems

Year

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Growth in adoption of genetically engineered crops continues in the U.S.

Data for each crop category include varieties with both HT and Bt (stacked) traits.
Airport Rd. June 29, 2 days after glyphosate spraying
Airport Rd. July 5, 8 days after spraying
Airport Rd. July 5, 8 days after spraying
Airport Rd. July 15, 18 days after spraying
Natal origins of monarch butterflies wintering in Mexico derived from δD and δ13C data (n = 597).
• Could the loss of milkweeds in agricultural fields be responsible for the observed decline in monarch overwintering numbers?

• 1. Can we estimate the reduction in milkweeds on the Midwest landscape over the last decade?

• 2. Can we estimate Midwest monarch production over that period?
# Milkweed densities in Iowa habitats

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<tr>
<th>Land Use</th>
<th># obs</th>
<th>density (^1)</th>
<th>Land use</th>
<th>#obs</th>
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<td>Other</td>
<td>56</td>
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</tr>
</tbody>
</table>

1- m\(^2\) per hectare

1999 data from H&B 2000
2009 data from H 2010
Change in milkweed density in Iowa from 1999 to 2009

- Milkweed density in agricultural fields reduced by 78%
- Taking account of the area on the Iowa landscape occupied by each habitat (USDA) and the density of milkweeds in each (H&B 2000; H 2010, MLMP)
- 58% loss of milkweeds on the landscape from 1999 to 2010
How might this milkweed loss affect monarch production?

- Use long-term data from Monarch Larval Monitoring Project
- Weekly census of eggs and larvae per milkweed stem (non-agricultural milkweeds)
- Use peak egg density as an indicator of production
Data from Monarch Larval Monitoring Project

Average eggs per milkweed

Year

1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

Non-agricultural milkweeds
Estimating yearly monarch production

• Non-ag prod = #non-ag milkweeds X #eggs per stem
• Ag production = # ag milkweeds X #eggs/stem (ag)
• Total production = non-ag prod. + ag prod.
• Mostly based on Iowa data and extrapolated to Midwest
Estimating number of milkweeds in each year

• Number of milkweeds in each habitat = milkweed density \( \times \) habitat landscape area
• Milkweed density changes over the years
• Habitat area changes over the years
  – CRP land, acreage in corn and soybeans
  – USDA surveys
Change in milkweed density

- **non-ag**
- **Iowa ag Hartzler**
- **Iowa ag Pleasants**

Year:
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010

Percent of starting milkweed density:
- 0
- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80
- 90
- 100

Change in milkweed density
Estimating egg density in each year

• Non-ag milkweeds
  – MLMP average

• Ag milkweeds
  – MLMP average X 3.9
Monarch egg production in Midwest

![Graph showing a decline in monarch egg production from 1999 to 2010]

P = 0.004; r² = 0.58

81% decline in Midwest production from 1999 to 2010
Monarch egg production in Midwest

Overwintering population size (hectares)

P = 0.01; r² = 0.47
Conclusions

• From 1999 to 2010 there was an 81% decline in milkweeds in Midwest agricultural fields and a 58% decline in milkweeds on the landscape
• Midwest monarch production declined 81% over this period
• During that same period the size of the overwintering population declined 65%
• Yearly Midwest production values were correlated with the size of the subsequent overwintering population
  – Provides validation for our approach for estimating production
  – Midwest production is an important driver of monarch population size
Conservation implications

- Agricultural milkweeds will continue to disappear
- Increases the importance of milkweeds in non-ag habitats
- CRP land
  - Plant species used varies – encourage use of forb mixes with milkweeds
  - Number of acres declining
- Roadsides
  - Programs to plant native vegetation
  - Discourage DOT practices such as mowing and spraying
Thanks

• All the participants in the Monarch Larval Monitoring Project
• Chip Taylor, Lincoln Brower, ms reviewers
• ISU statistics consultants
<table>
<thead>
<tr>
<th>Year</th>
<th>Total non-ag milkweeds</th>
<th>Total ag milkweeds</th>
<th>Eggs/plant-non-ag</th>
<th>Eggs/plant-ag</th>
<th>Production non-ag</th>
<th>Production ag</th>
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1- m² x1000; from Table 1
2- from MLMP
3- = non-ag eggs/plant x 3.89 (ratio of ag to non-ag, see Table 2), except for 2000-2003 from Table 2
4- Total non-ag milkweeds x Eggs/plant non-ag
5- Total ag milkweeds x Eggs/plant ag
6- Production non-ag. + Production ag.
Non-ag production

• Non-ag prod = #non-ag milkweeds X #eggs per stem
  – # non-ag milkweeds = milkweed density in different non-ag habitats (based on H&B and H data and data from MLMP monitoring sites) times the area of those habitats (USDA)
  – # eggs/stem based on MLMP data
Ag production

- Ag production = # ag milkweeds X #eggs/stem (ag)
  - # ag milkweeds = milkweed density in corn and soybean fields (based on H&B and H data) times the area of those habitats (USDA)
  - #eggs/stem based on MLMP data times 3.9 (factor by which eggs/stem of ag milkweeds exceeds non-ag milkweeds)
Conclusions cont.

• Percent decline in Midwest production (81%) was larger than the decline in overwintering population (65%)
  – Mitigating effect of the eastern portion of the population which does not show a decline (Davis, 2011)
  – Eastern portion little impacted by agricultural milkweed loss
### Milkweeds in non-agricultural habitats

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<th>Year</th>
<th>CRP acres</th>
<th>CRP milkwds</th>
<th>Pasture acres</th>
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### Milkweeds in agricultural fields

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<th>Mlkwd density</th>
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1- x 1000; from USDA Conservation Programs

2- m² x 1000; CRP acres/2.47 x 212 m²/ha (milkweed density from H&B, 2000) X 0.948 (where x = 0 for 1999)

3- x 1000; from Lubowski et al., 2006

4- m² x 1000; Pasture acres/2.47 x 14 m²/ha (milkweed density from H&B, 2000) X 0.948 (where x = 0 for 1999)

5- m² x 1000; Roadside acres/2.47 x 99 m²/ha (average milkweed density from H&B, 2000 and H, 2010)

6- m² x 1000; CRP milkweeds + Pasture milkweeds + Roadside milkweeds

7- x 1000; from Iowa State Ag. Statistics

8- m²/ha; 1999 value from H&B (2000), 2009 value from H (2010); others = 1999 value X 0.858 where x = 0 for 1999

9- m² x 1000; Ag acres/2.47 (conversion to hectares) x Milkweed density

10- m²×1000
Monarchs raised on milkweeds from different habitats

Fall migrants
Study sites in Iowa

Ag-milkweed egg density is 3.9 times non-ag-milkweed egg density
Milkweed densities in Iowa habitats

<table>
<thead>
<tr>
<th>Land Use</th>
<th>1999</th>
<th># obs</th>
<th>density ¹</th>
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<tbody>
<tr>
<td>Roadside</td>
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<td>Other</td>
<td>1999</td>
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</table>

1- m² per hectare

1999 data from H&B 2000
Monarch phenology

![Graph showing Monarch phenology]

- Eggs per stem vs. Julian date
- Graph shows data from 2000 to 2003
- Peaks in egg laying in July and August