Using bioenergetics and radar-derived bird abundance to assess the impact of a blackbird roost on seasonal sunflower damage

BONNE A. CLARK – *Department of Biology, Oklahoma Biological Survey, University of Oklahoma*

PAGE E. KLUG – *USDA, Animal Plant and Health Inspection Service, Wildlife Services, National Wildlife Research Center, Department of Biological Sciences, North Dakota State University.*

PHILLIP M. STEPANIAN – *Department of Civil and Environmental Engineering and Earth Sciences, University of Notre Dame.*

JEFFREY F. KELLY – *Corix Plains Institute, Department of Biology, Oklahoma Biological Survey, University of Oklahoma.*

Photo credit: A. Schumacher

Agenda

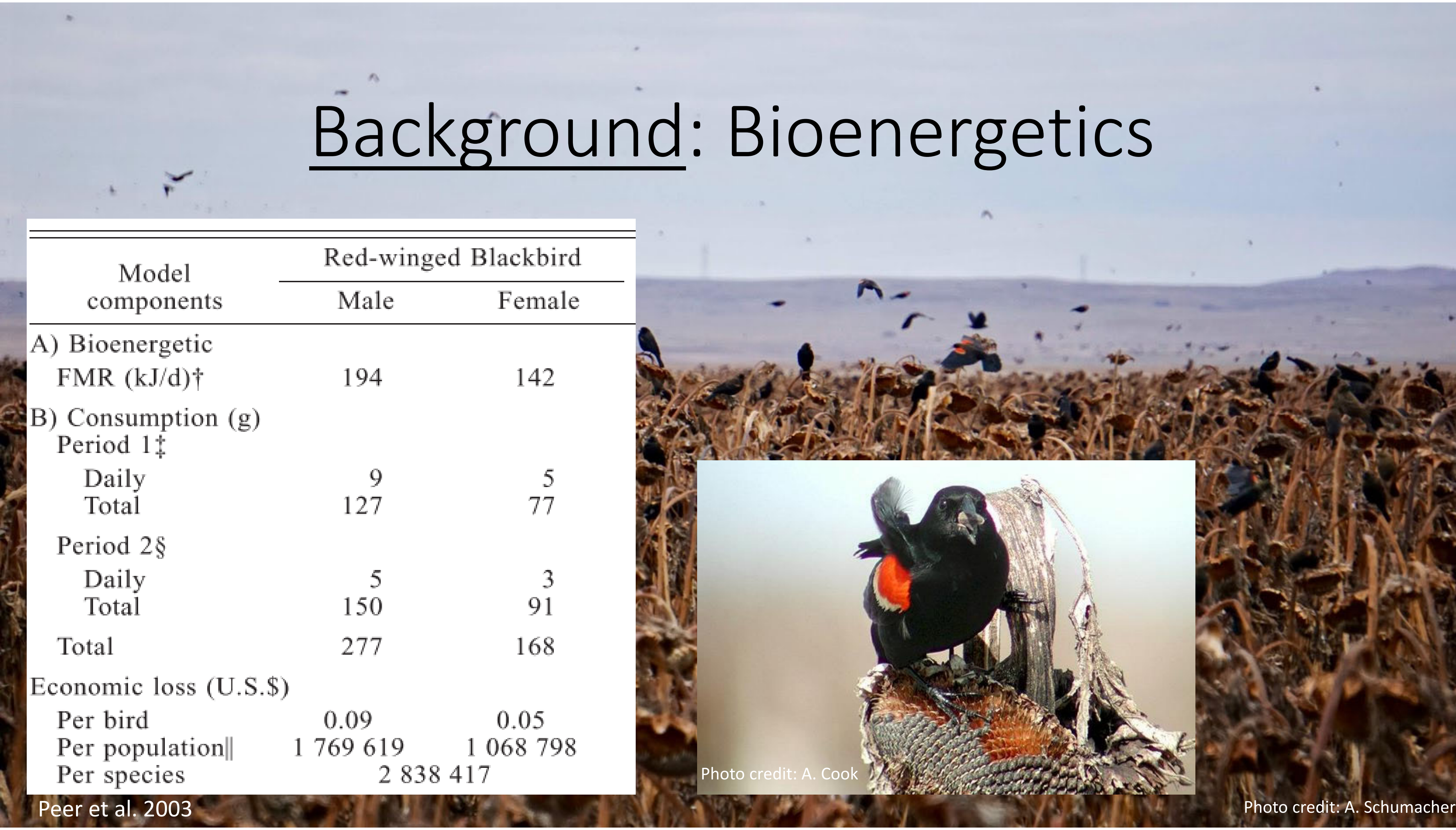
- Background
- Objective
- Methods
- Results
- Overview/Discussion
- Future directions
- Acknowledgements
- Questions

Photo credit: A. Schumacher

Background: Red-winged blackbird damage to Sunflower

- **Red-winged blackbirds** are an agricultural pest to sunflower and corn in the Prairie Pothole Region during the Fall.
- **North Dakota** is one of the leading states in national sunflower production
    - Estimated **$3.5 million** USD crop yield **loss** due to blackbirds per year (Klosterman et al. 2013)
    - Average of **$18.7 million** USD in **total economic losses** per year (Ernst et al. 2019)
- **Lack of annual sunflower damage estimates**.
    - Routine surveys are labor intensive with time constraints.
- **Significant crop damage** (>20%) within **~8-10km** of a wetland roost

Background: Bioenergetics



Model components	Red-winged Blackbird	
	Male	Female
A) Bioenergetic		
FMR (kJ/d)†	194	142
B) Consumption (g)		
Period 1‡		
Daily	9	5
Total	127	77
Period 2§		
Daily	5	3
Total	150	91
Total	277	168
Economic loss (U.S.$)		
Per bird	0.09	0.05
Per population‖	1 769 619	1 068 798
Per species	2 838 417	

Peer et al. 2003

Photo credit: A. Cook

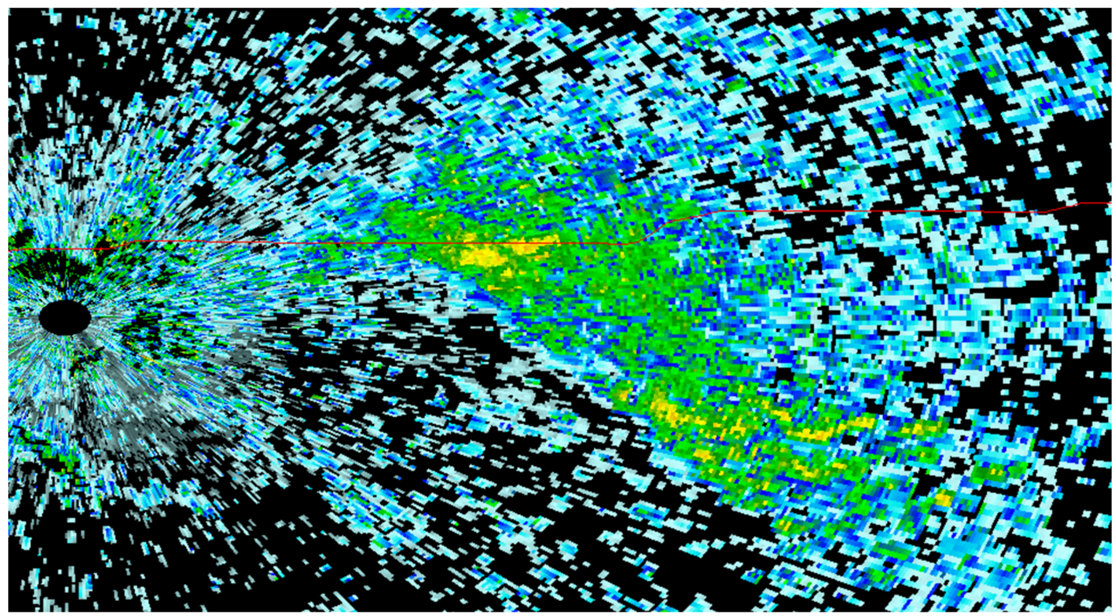
Photo credit: A. Schumacher

Background: Estimating bird populations with weather surveillance radar (WSR)

- WSR is increasingly used to monitor biological phenomena (birds, bats, insects)
- 148 radars across the U.S.
- Publicly available
- ~25 years of archived data
- Can easily distinguish weather from biological reflectivity using radar data but need ground observations to know the identity of biological masses.

RADAR AEROECOLOGY


Bismarck Tribune 2018



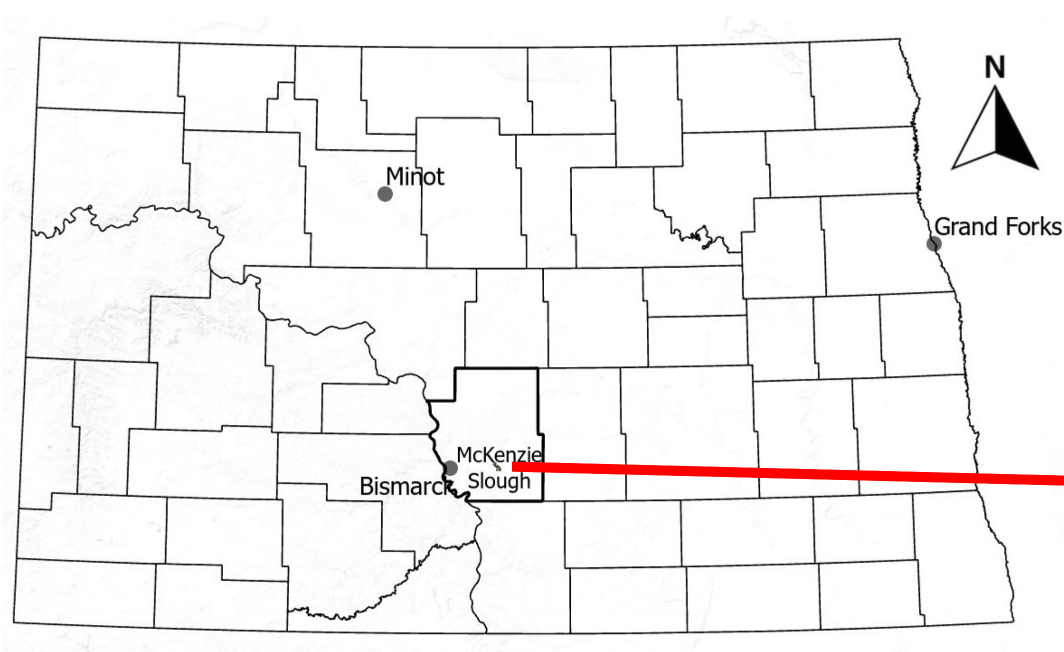
Objective

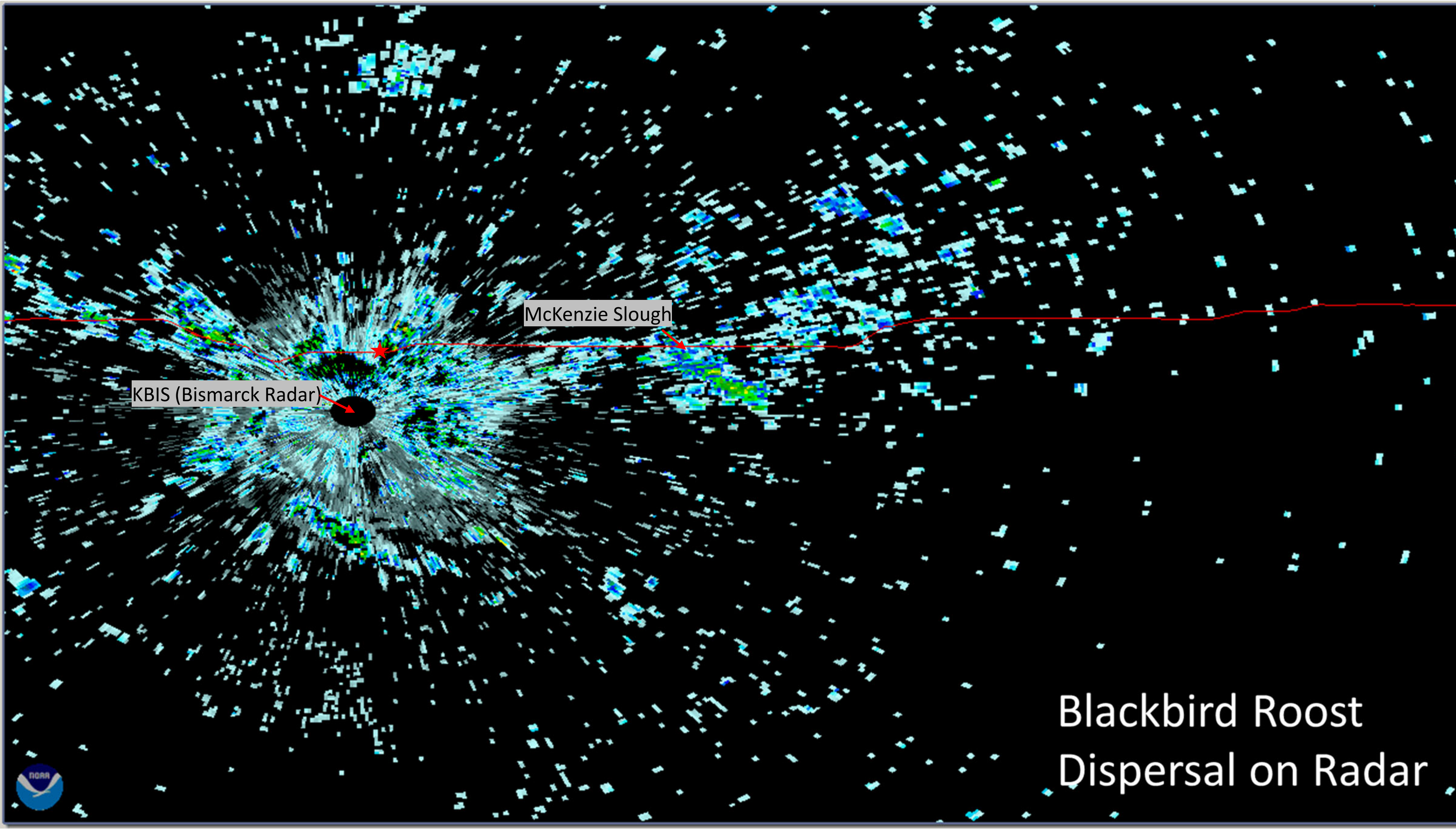
Estimate **economic damage** to sunflower from blackbirds **using radar-derived bird abundances** for one roost and previously developed **bioenergetics** models

- Damage calculations for ~10km area surrounding one roost


Photo credit: A. Schumacher

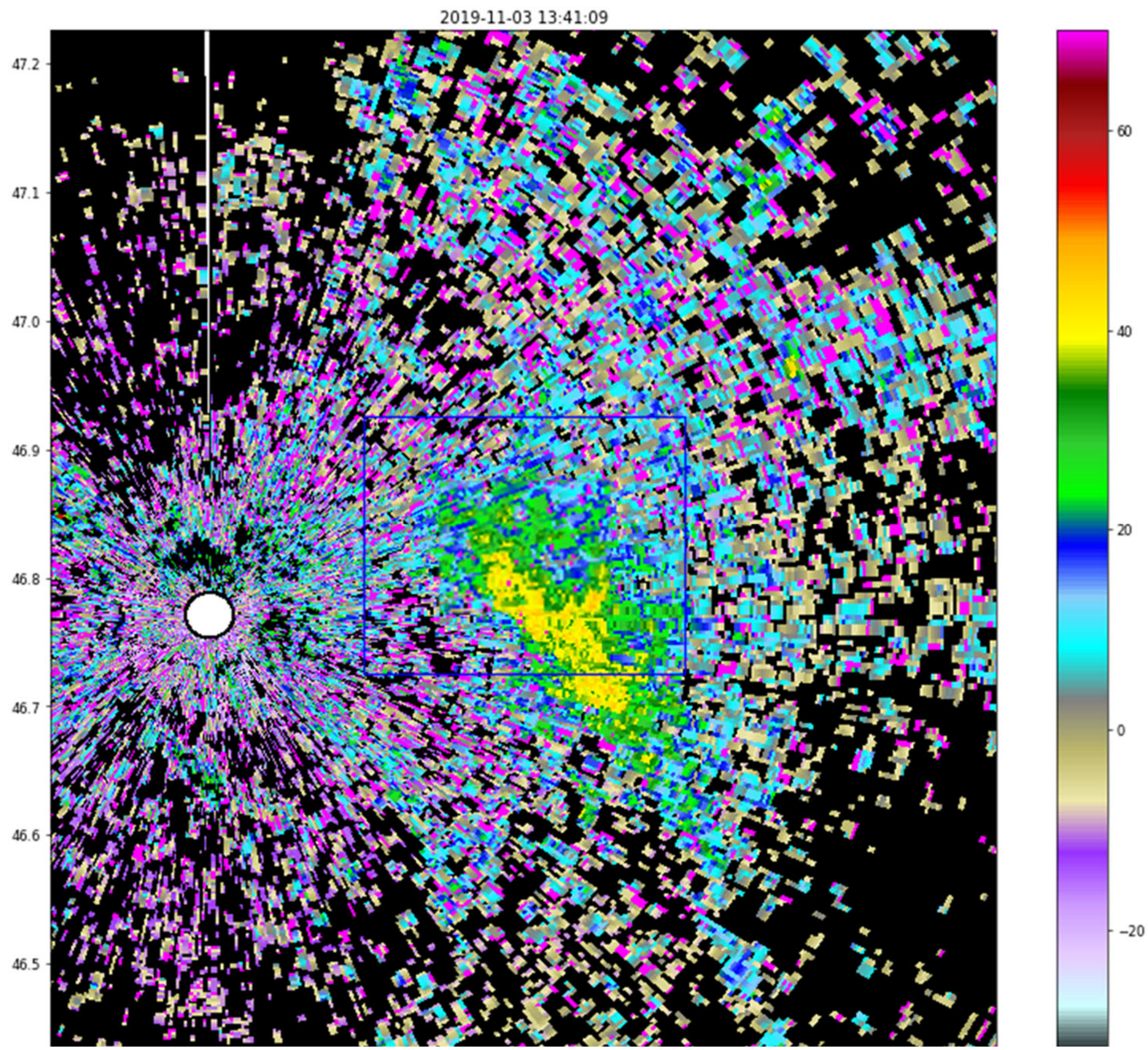
Methods: Study area




McKenzie Slough
KBIS (Bismarck Radar)
Blackbird Roost
Dispersal on Radar

Methods: Radar

- Download radar data from Amazon Web Services
  - Blue box = **encompasses the roost activity**. Reflectivity data here used for total blackbird abundance counts.
- **2012 – 2019** (8 years) When the roost is known to be active from visually screening radar.
- **01 August – 30 November**
- **1 hour before sunrise – 2 hours after sunrise**. (~1200 – 1500 UTC)
- **Sensor out** weather using dual-polarization (weather pixels represented in pink) (Kilambi et al. 2018)
- We **counted the number of blackbirds** using the approximate **radar cross section (RCS)** – derived from the **average mass** of a red-winged blackbird (60g)



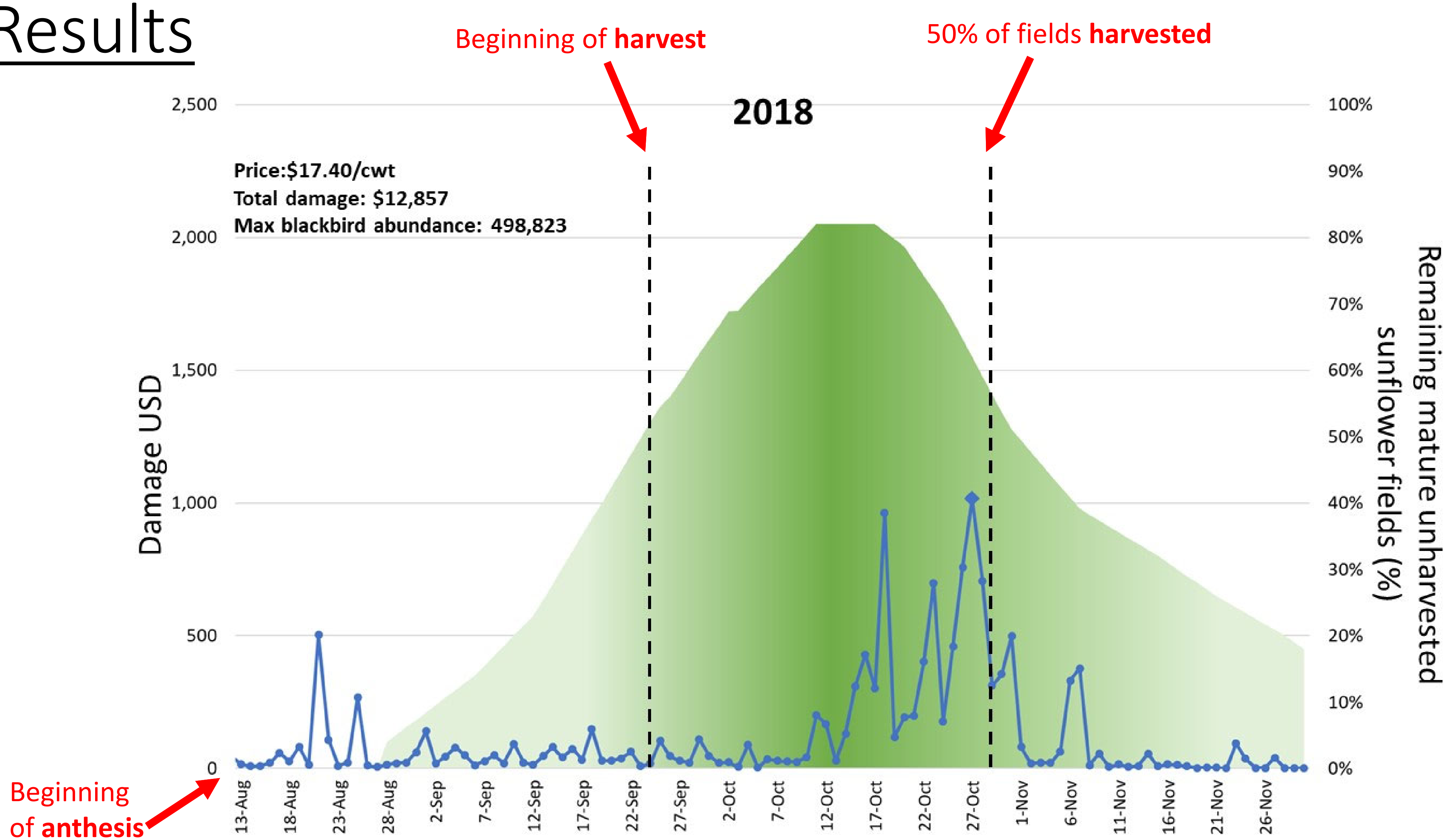
Component		Value	Source
Metabolic energy content of achenes (MBE)		15.28 kJ/g (anthesis)	Connor and Hall 1997
		30.56 kJ/g (maturity)	Park et al. 1997
Compensation → Based on mature stage of sunflower		0.85	Baltezore et al. 1994
Constants	Field metabolic rate (FMR)	168	Peer et al. 2003
% diet with sunflower ←	Diet	0.63	Linz et al. 1984
Wet mass of sunflower achene ←	Moisture	1.225	Peer et al. 2003
Hull price producer is paid ←	Hull	1.25	Peer et al. 2003

Clark et al. 2020

Methods:
Damage calculation from bioenergetics

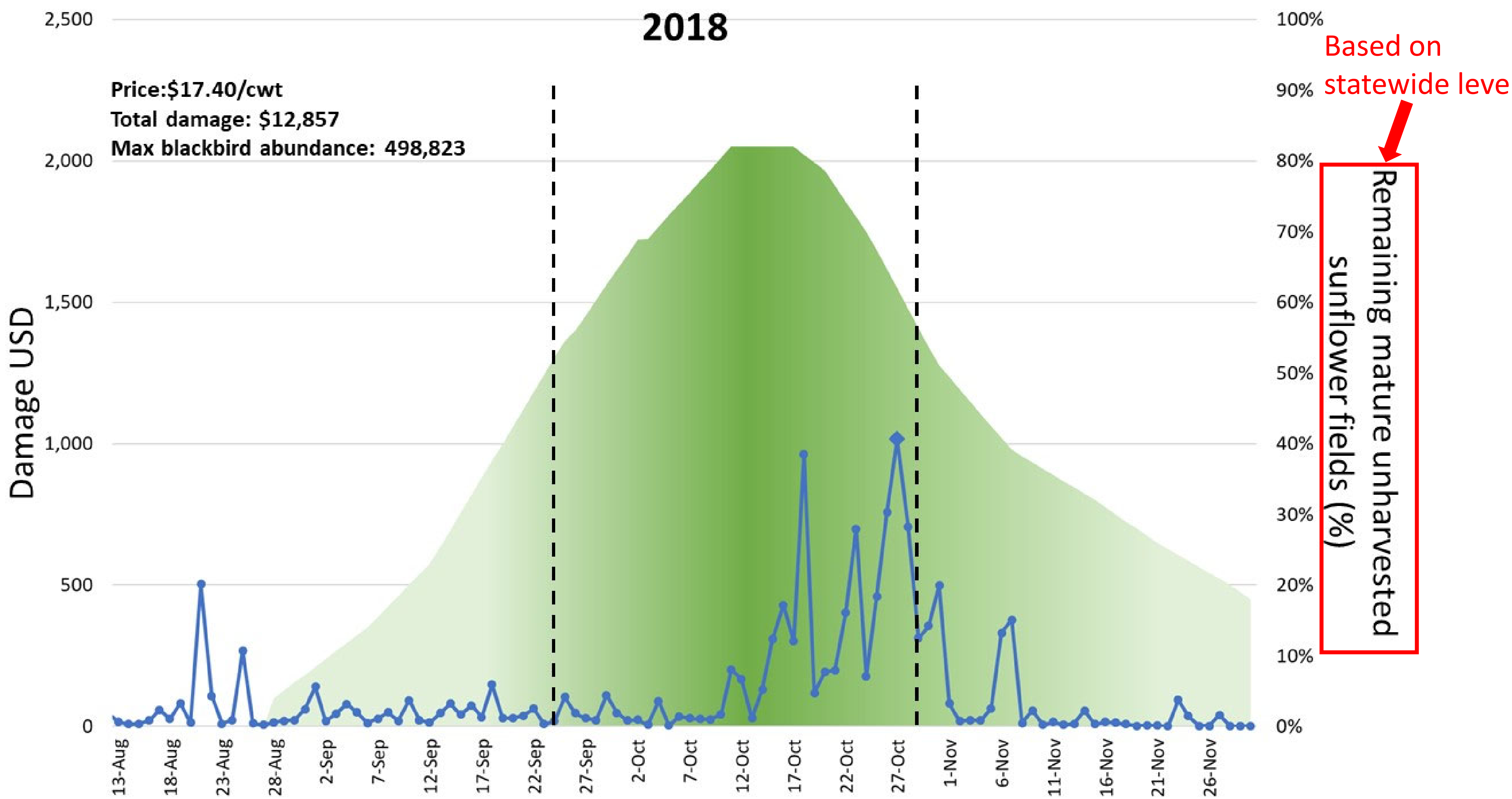
Damage calculated from Peer et al. 2003: [(FMR/MBE) * diet * moisture * compensation * hull * price] *** number of blackbirds**

Results



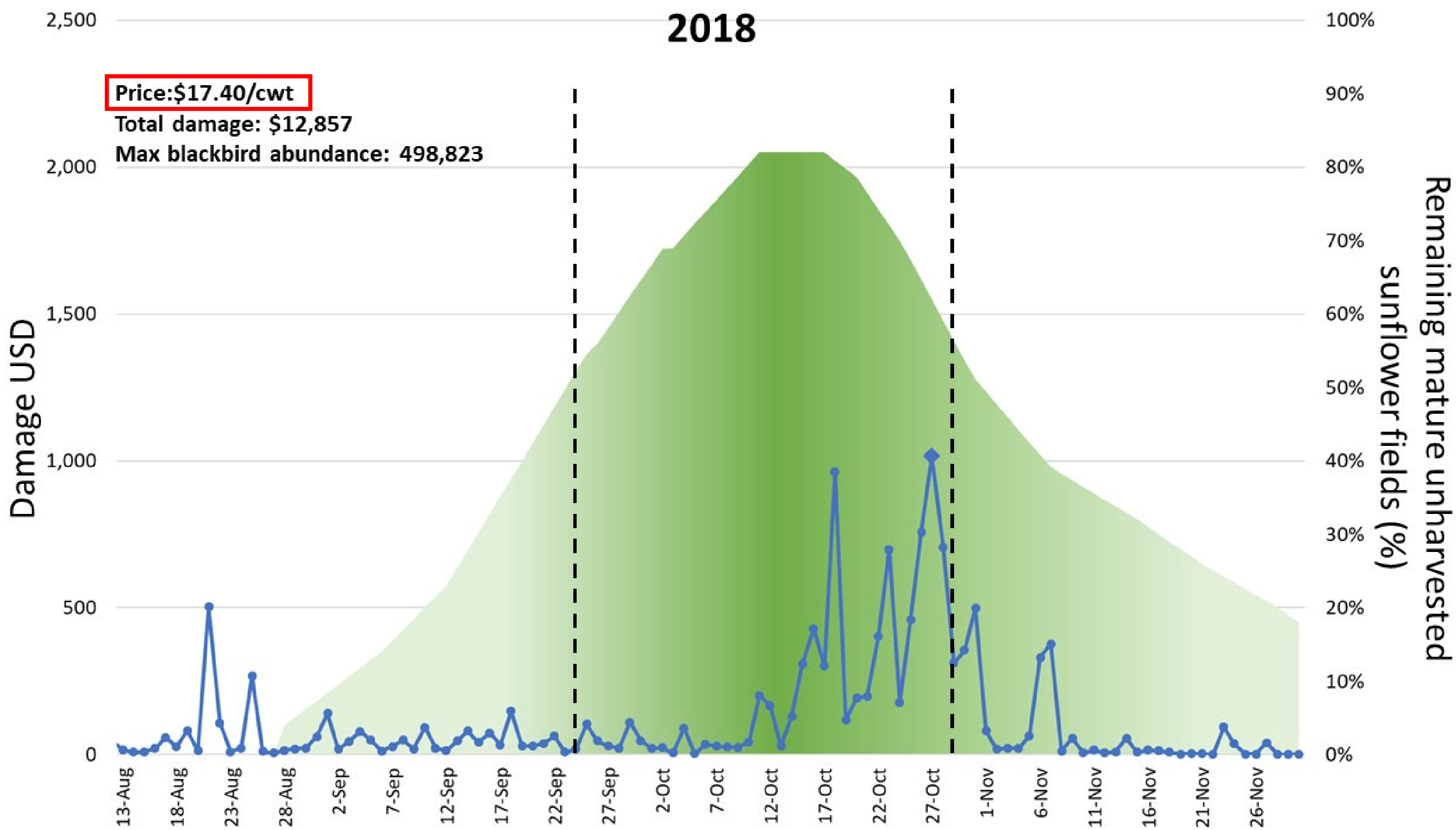
Beginning of harvest
50% of fields harvested
2018
Price:$17.40/cwt
Total damage: $12,857
Max blackbird abundance: 498,823
Damage USD
2,500
2,000
1,500
1,000
500
0
Remaining mature unharvested sunflower fields (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13-Aug
18-Aug
23-Aug
28-Aug
2-Sep
7-Sep
12-Sep
17-Sep
22-Sep
27-Sep
2-Oct
7-Oct
12-Oct
17-Oct
22-Oct
27-Oct
1-Nov
6-Nov
11-Nov
16-Nov
21-Nov
26-Nov
Beginning of anthesis

Results

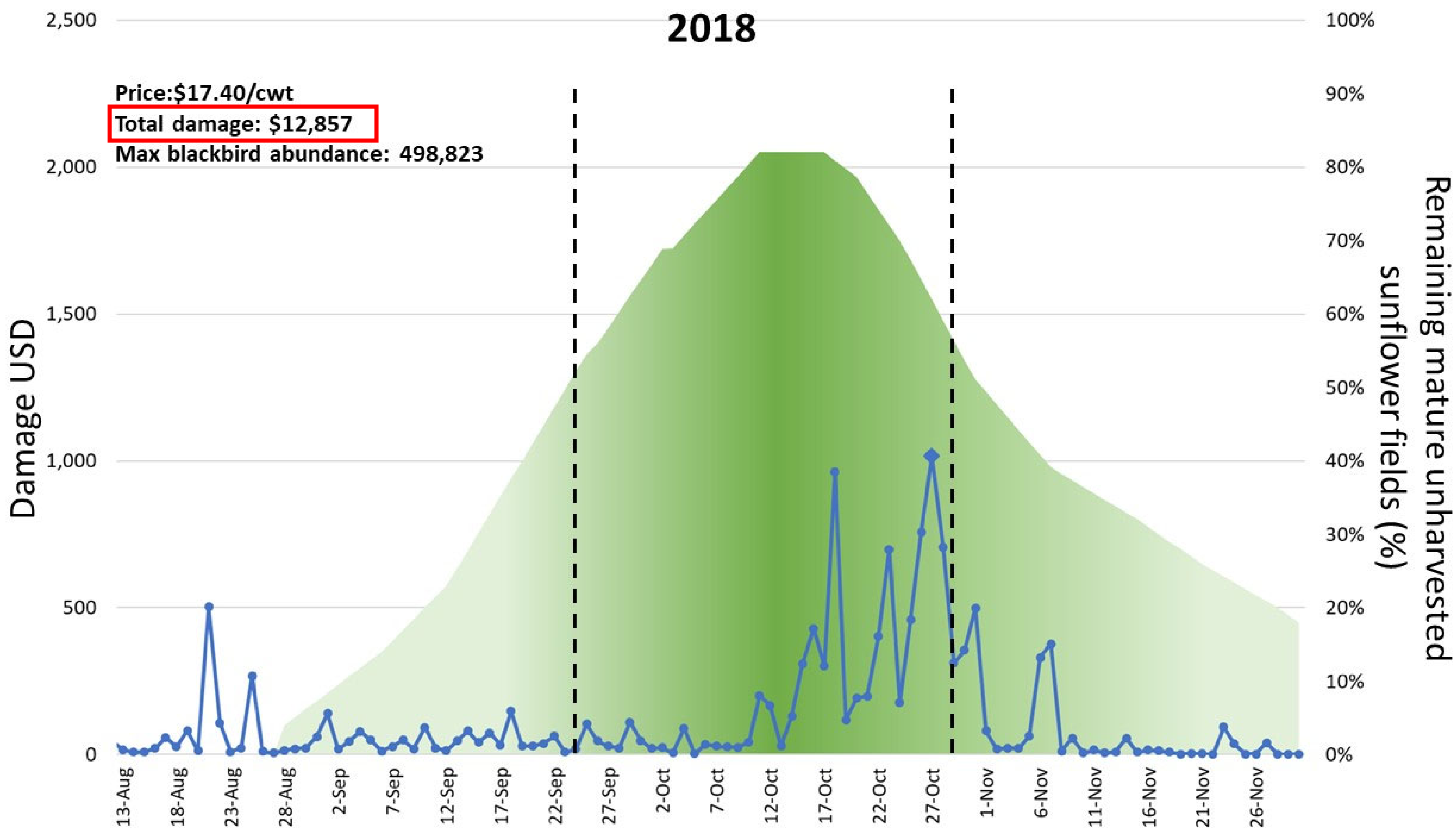


2018
Price:$17.40/cwt
Total damage: $12,857
Max blackbird abundance: 498,823
Damage USD
2,500
2,000
1,500
1,000
500
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Based on statewide level
Remaining mature unharvested sunflower fields (%)
13-Aug
18-Aug
23-Aug
28-Aug
2-Sep
7-Sep
12-Sep
17-Sep
22-Sep
27-Sep
2-Oct
7-Oct
12-Oct
17-Oct
22-Oct
27-Oct
1-Nov
6-Nov
11-Nov
16-Nov
21-Nov
26-Nov

Results

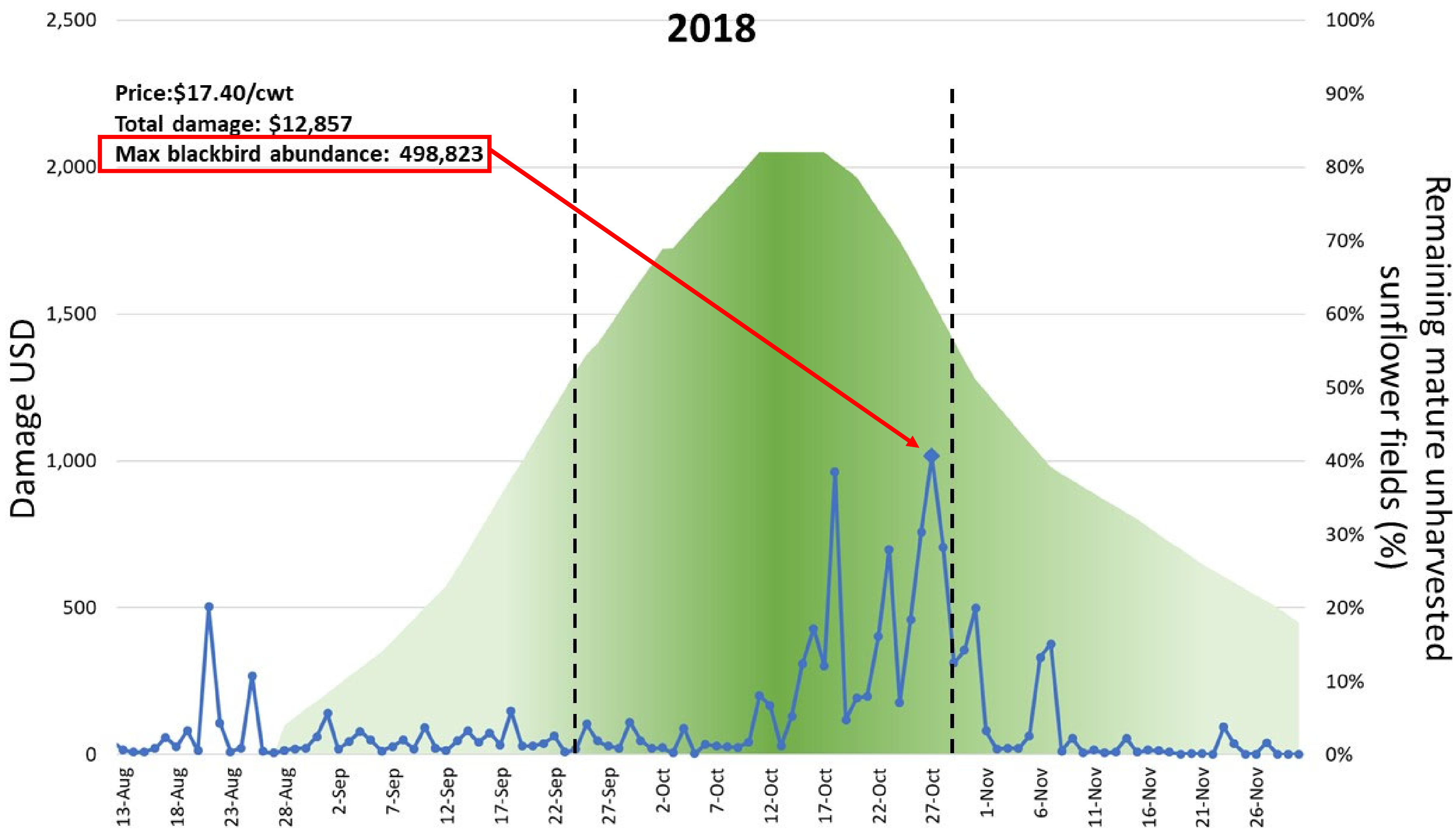

2018
Price:$17.40/cwt
Total damage: $12,857
Max blackbird abundance: 498,823
Damage USD
Remaining mature unharvested sunflower fields (%)
2,500
2,000
1,500
1,000
500
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13-Aug
18-Aug
23-Aug
28-Aug
2-Sep
7-Sep
12-Sep
17-Sep
22-Sep
27-Sep
2-Oct
7-Oct
12-Oct
17-Oct
22-Oct
27-Oct
1-Nov
6-Nov
11-Nov
16-Nov
21-Nov
26-Nov

Results

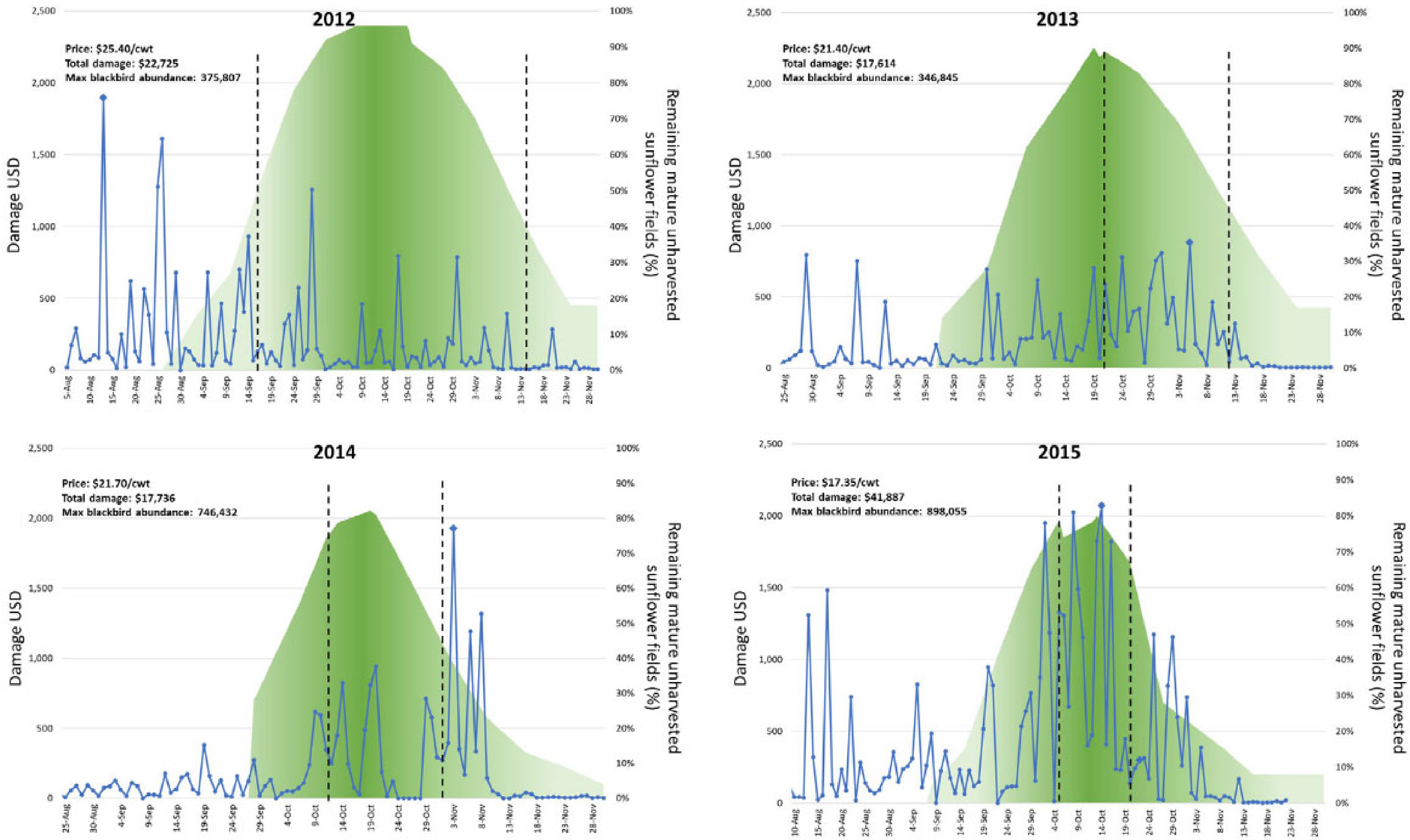


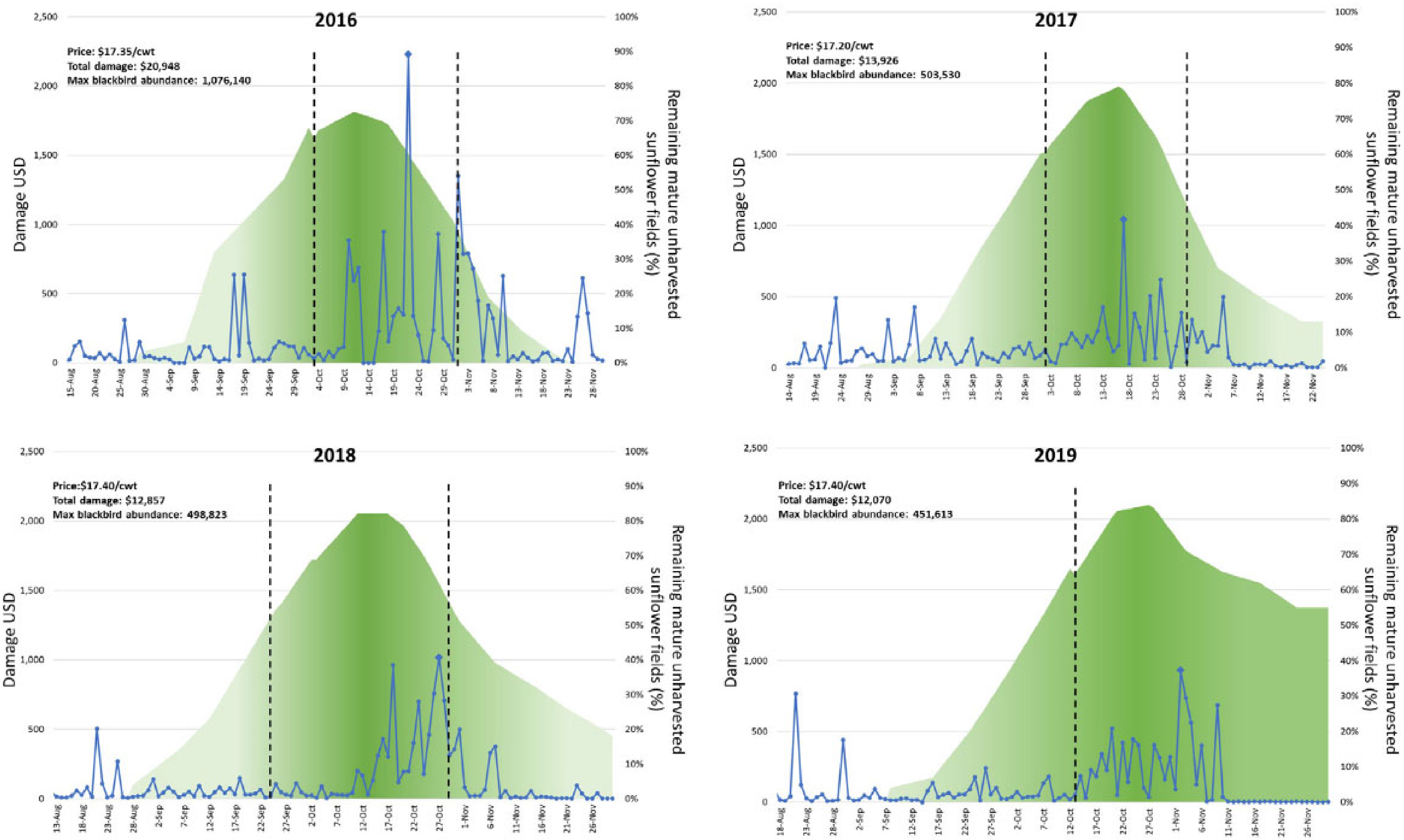
2018
Price:$17.40/cwt
Total damage: $12,857
Max blackbird abundance: 498,823
Damage USD
Remaining mature unharvested sunflower fields (%)
2,500
2,000
1,500
1,000
500
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13-Aug
18-Aug
23-Aug
28-Aug
2-Sep
7-Sep
12-Sep
17-Sep
22-Sep
27-Sep
2-Oct
7-Oct
12-Oct
17-Oct
22-Oct
27-Oct
1-Nov
6-Nov
11-Nov
16-Nov
21-Nov
26-Nov

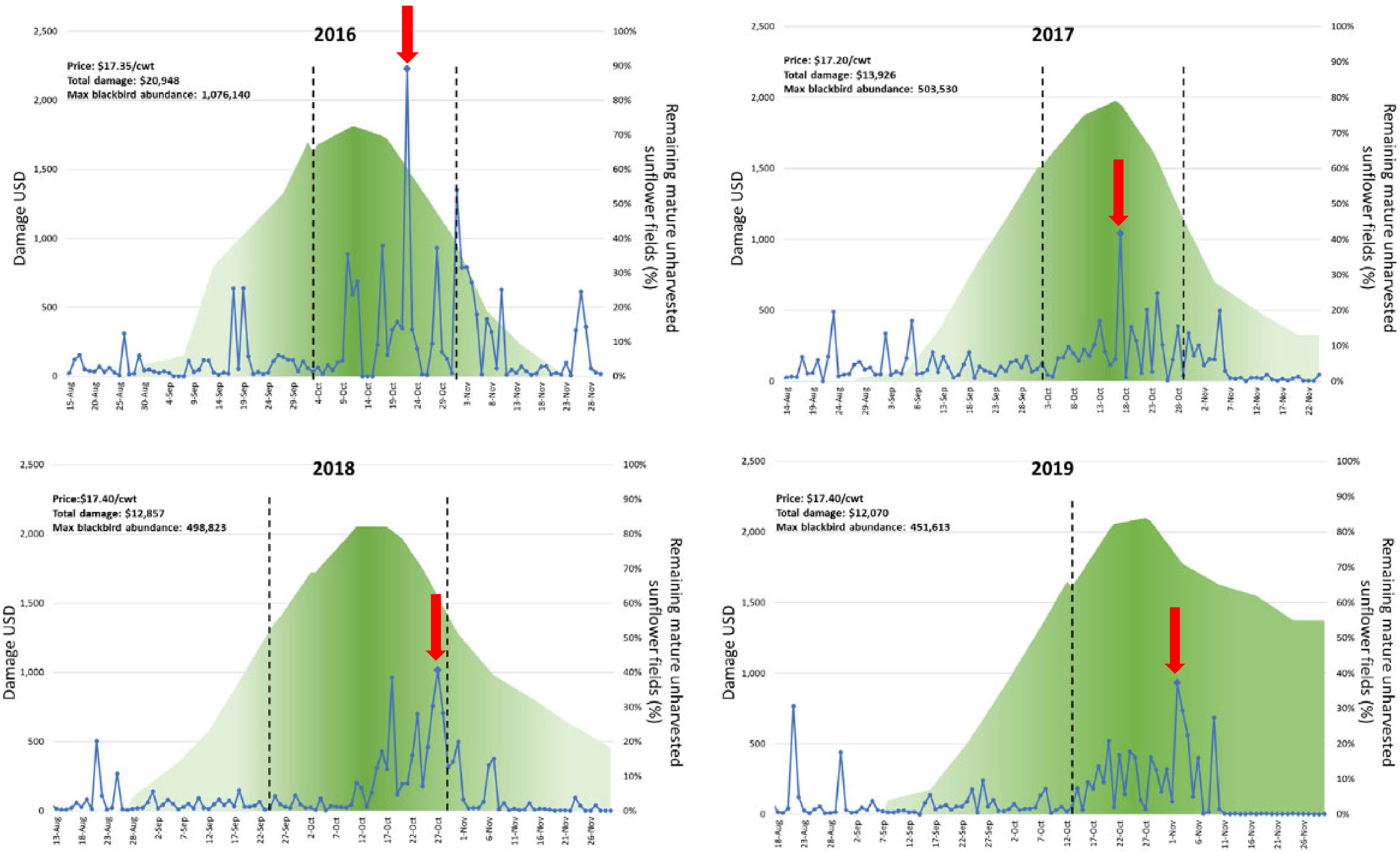
Results

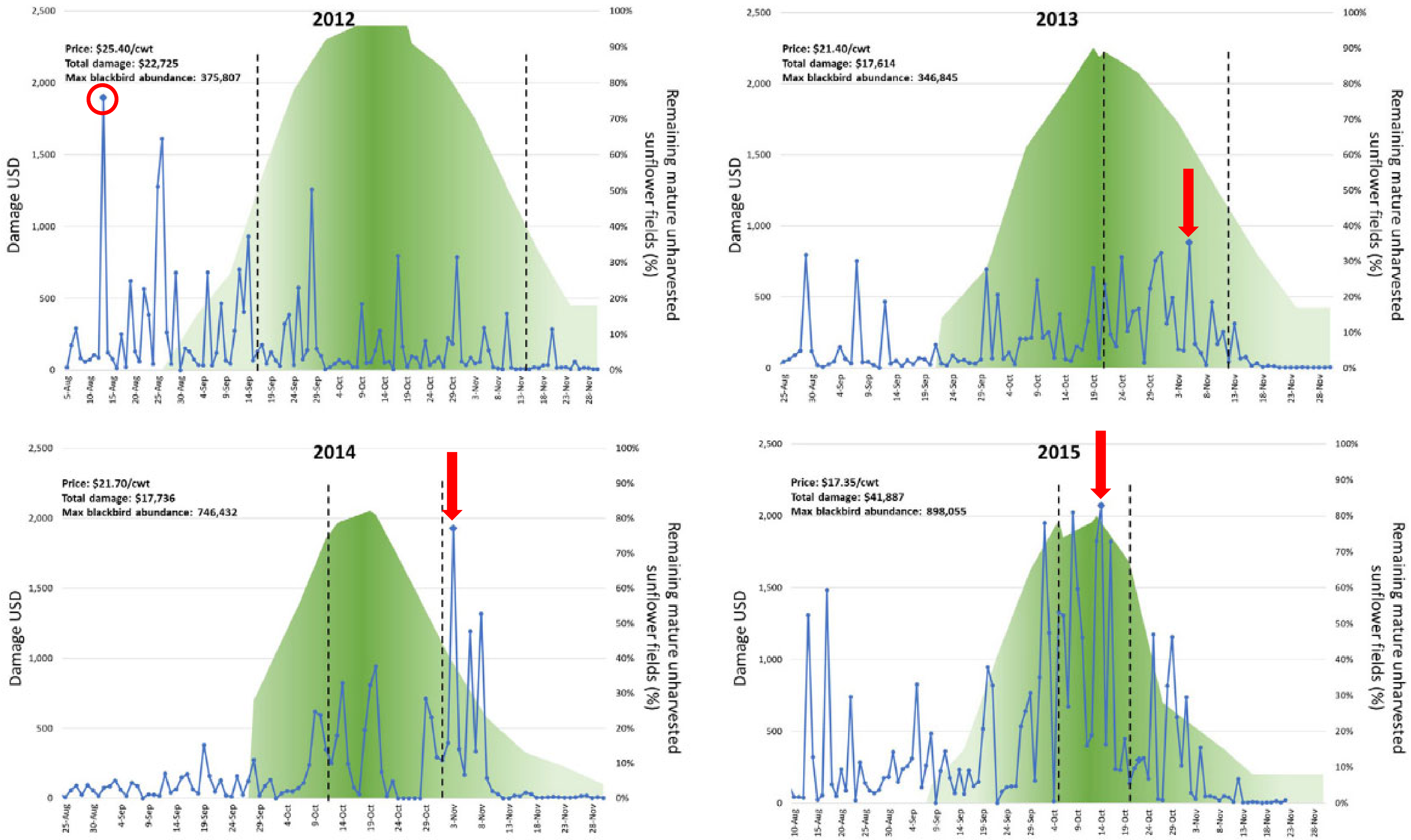


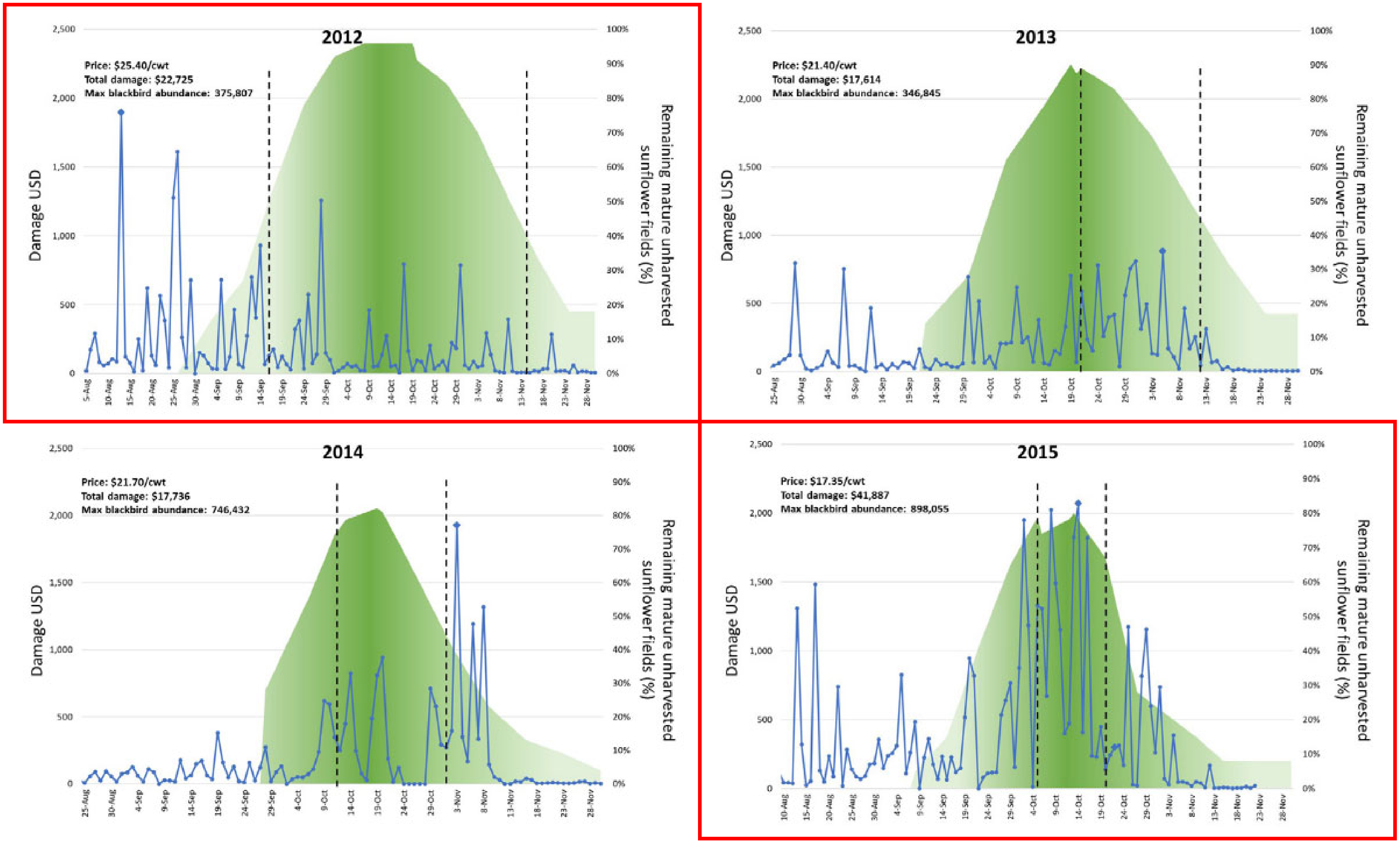
2018
Price:$17.40/cwt
Total damage: $12,857
Max blackbird abundance: 498,823
Damage USD
Remaining mature unharvested sunflower fields (%)
2,500
2,000
1,500
1,000
500
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13-Aug
18-Aug
23-Aug
28-Aug
2-Sep
7-Sep
12-Sep
17-Sep
22-Sep
27-Sep
2-Oct
7-Oct
12-Oct
17-Oct
22-Oct
27-Oct
1-Nov
6-Nov
11-Nov
16-Nov
21-Nov
26-Nov

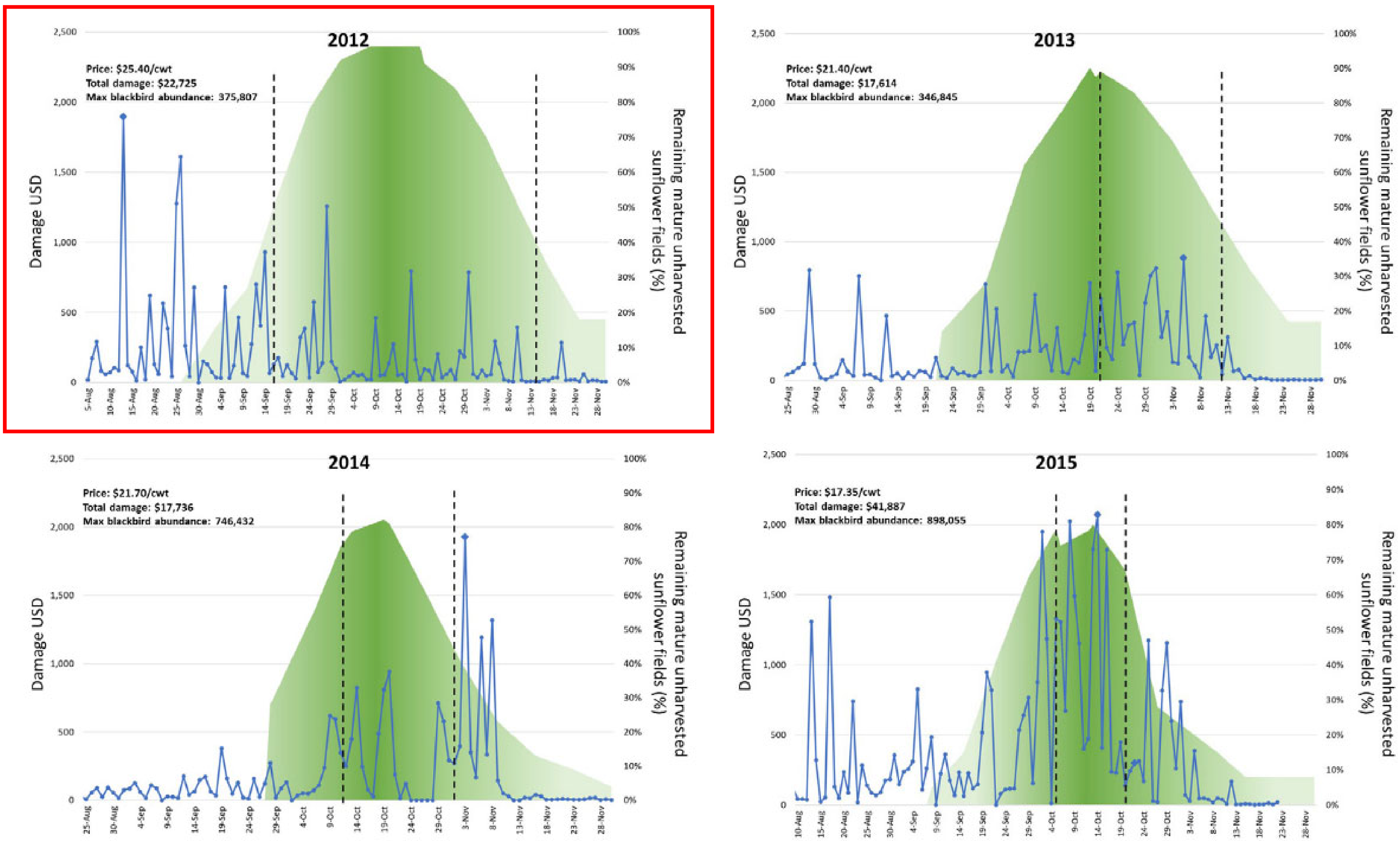

2012
Price: $25.40/cwt
Total damage: $22,725
Max blackbird abundance: 375,807
2013
Price: $21.40/cwt
Total damage: $17,614
Max blackbird abundance: 346,845
2014
Price: $21.70/cwt
Total damage: $17,736
Max blackbird abundance: 746,432
2015
Price: $17.35/cwt
Total damage: $41,887
Max blackbird abundance: 898,055
Damage USD
Remaining mature unharvested sunflower fields (%)

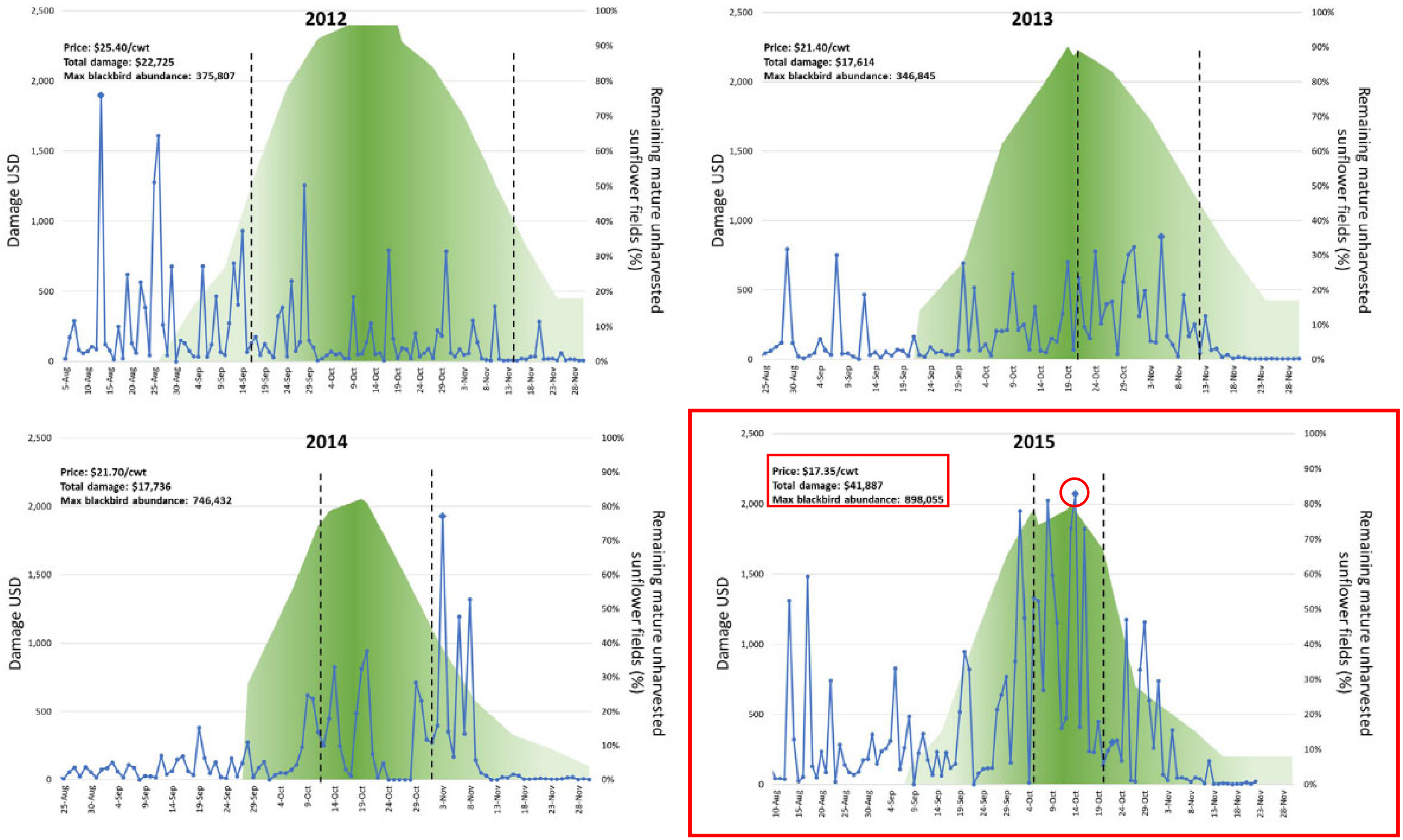

2016
Price: $17.35/cwt
Total damage: $20,948
Max blackbird abundance: 1,076,140
2017
Price: $17.20/cwt
Total damage: $13,926
Max blackbird abundance: 503,530
2018
Price:$17.40/cwt
Total damage: $12,857
Max blackbird abundance: 498,823
2019
Price: $17.40/cwt
Total damage: $12,070
Max blackbird abundance: 451,613
Damage USD
Remaining mature unharvested sunflower fields (%)


2016
Price: $17.35/cwt
Total damage: $20,948
Max blackbird abundance: 1,076,140
2017
Price: $17.20/cwt
Total damage: $13,926
Max blackbird abundance: 503,530
2018
Price:$17.40/cwt
Total damage: $12,857
Max blackbird abundance: 498,823
2019
Price: $17.40/cwt
Total damage: $12,070
Max blackbird abundance: 451,613
Damage USD
Remaining mature unharvested sunflower fields (%)


2012
Price: $25.40/cwt
Total damage: $22,725
Max blackbird abundance: 375,807
2013
Price: $21.40/cwt
Total damage: $17,614
Max blackbird abundance: 346,845
2014
Price: $21.70/cwt
Total damage: $17,736
Max blackbird abundance: 746,432
2015
Price: $17.35/cwt
Total damage: $41,887
Max blackbird abundance: 898,055
Damage USD
Remaining mature unharvested sunflower fields (%)


2012
Price: $25.40/cwt
Total damage: $22,725
Max blackbird abundance: 375,807
2013
Price: $21.40/cwt
Total damage: $17,614
Max blackbird abundance: 346,845
2014
Price: $21.70/cwt
Total damage: $17,736
Max blackbird abundance: 746,432
2015
Price: $17.35/cwt
Total damage: $41,887
Max blackbird abundance: 898,055
Damage USD
Remaining mature unharvested sunflower fields (%)


2012
Price: $25.40/cwt
Total damage: $22,725
Max blackbird abundance: 375,807
2013
Price: $21.40/cwt
Total damage: $17,614
Max blackbird abundance: 346,845
2014
Price: $21.70/cwt
Total damage: $17,736
Max blackbird abundance: 746,432
2015
Price: $17.35/cwt
Total damage: $41,887
Max blackbird abundance: 898,055
Damage USD
Remaining mature unharvested sunflower fields (%)


2012
Price: $25.40/cwt
Total damage: $22,725
Max blackbird abundance: 375,807
Damage USD
Remaining mature unharvested sunflower fields (%)
2013
Price: $21.40/cwt
Total damage: $17,614
Max blackbird abundance: 346,845
Damage USD
Remaining mature unharvested sunflower fields (%)
2014
Price: $21.70/cwt
Total damage: $17,736
Max blackbird abundance: 746,432
Damage USD
Remaining mature unharvested sunflower fields (%)
2015
Price: $17.35/cwt
Total damage: $41,887
Max blackbird abundance: 898,055
Damage USD
Remaining mature unharvested sunflower fields (%)

Results: Summary

- Damage estimates
  - Range: $12,070 - $20,948; except 2015 at $41,887
  - Maximum daily damages: $900/day - $2,000/day
  - Average: $189/day; except 2015 at $402/day
  - 50:50 sex ratio for the main calculations
  - Changing the sex ratio (60:40 or 40:60) changed damage estimate ± $800
    - Males and females have larger and smaller radar cross sections, respectively. More males = less blackbirds. More females = more blackbirds.
- Blackbird abundance
  - Range: 346,845 – 1,076,140
  - Average: 612,156
  - Average date of peak blackbird abundance and peak damage: October 27th
- Sunflower growth stage
  - Average date of beginning of anthesis: August 15th
  - Average date of beginning of maturity: September 7th
  - Average date of peak numbers mature fields yet to be harvested: October 15th

Results: Summary

- Damage estimates
  - Range: $12,070 - $20,948; except 2015 at $41,887
  - Maximum daily damages: $900/day - $2,000/day
  - Average: $189/day; except 2015 at $402/day
  - 50:50 sex ratio for the main calculations
  - Changing the sex ratio (60:40 or 40:60) changed damage estimate ± $800
    - Males and females have larger and smaller radar cross sections, respectively. More males = less blackbirds. More females = more blackbirds.
- Blackbird abundance
  - Range: 346,845 – 1,076,140
  - Average: 612,156
  - Average date of peak blackbird abundance and peak damage: **October 27th**
- Sunflower growth stage
  - Average date of beginning of anthesis: August 15th
  - Average date of beginning of maturity: September 7th
  - Average date of peak numbers mature fields yet to be harvested: **October 15th**

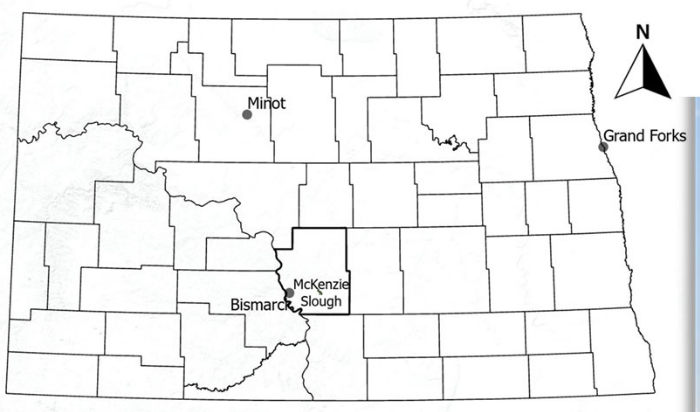
> ➢ Peak **sunflower maturity** occurred in mid-October **coinciding with maximum blackbird abundance** at the roost.
>
> ➢ **Advancing harvest time avoided** greatest **losses** in yield (up to **$1,800 in savings** near one roost)

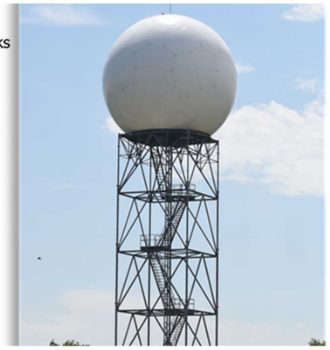
Overview/Discussion

- Integrated **radar-derived blackbird** abundance estimates with previously-developed **bioenergetics** calculations.
  - **Damages estimated** for an approximate **10km radius** area around **one roost**.
  - Largest numbers of detected blackbirds overlapped peak percentage of mature sunflower fields.
    - At time of maximum blackbird abundance, most sunflower fields statewide remained unharvested. Economic damage from blackbirds was likely severe at this time.

Future Directions

- This study can be expanded to other known blackbird roosts across the country
  - Currently only 3 NEXRAD radars in ND. (Bismarck, Minot, Grand Forks).
- Mobile Radars
  - Localized monitoring of blackbird roost numbers
  - Gather daily estimates of crop damages
  - Evaluate efficacy of local management techniques
  - Identify optimal timing of management tools (e.g. drones) when radar identifies flocks entering in.
- Landscape and weather correlates of blackbird abundance trends
- Improved species composition of flocks can strengthen damage estimates





Literature Cited

Baltezore, J. F., J. A. Leitch, and G. M. Linz. 1994. The economics of cattail management: assessing the trade-offs. Agricultural Economics Report Number 320, North Dakota State University, Fargo, North Dakota, USA.

Connor, D. J., and A. J. Hall. 1997. Sunflower physiology. Pages 113–182 in A. A. Schneiter, editor. Sunflower technology and production.

Ernst, K., J. Elser, G. M. Linz, H. Kandel, J. Holderieath, S. DeGroot, S. Shwiff, and S. Shwiff. 2019. The economic impacts of blackbird (Icteridae) damage to sunflower in the United States. Pest Management Science 75:2910– 2915.

Kilambi, A., F. Fabry, and V. Meunier. 2018. A simple and effective method for separating meteorological from nonmeteorological targets using dual-polarization data. Journal of Atmospheric and Oceanic Technology 35:1415–1424.

Klosterman, M. E., G. M. Linz, A. A. Slowik, and H. J. Homan. 2013. Comparisons between blackbird damage to corn and sunflower in North Dakota. Crop Protection 53:1–5.

Linz, G. M., D. L. Vakoch, J. F. Cassel, and R. B. Carlson. 1984. Food of red-winged blackbirds, Agelaius phoeniceus, in sunflower fields and corn fields. Canadian Field Naturalist 98:38–44.

Park, C. S., G. D. Marx, Y. S. Moon, Y. Wiesenborn, K. C. Chang, and V. L. Hofman. 1997. Alternative uses of sunflower. Pages 765–807 in A. A. Schneiter, editor. Sunflower technology and production. Agronomy Monograph 35. American Society of Agronomy, Madison, Wisconsin, USA.

Peer, B. D., H. J. Homan, G. M. Linz, and W. J. Bleier. 2003. Impact of blackbird damage to sunflower: bioenergetic and economic models. Ecological Applications 13:248–256.

Acknowledgments

We thank M. White and A. Schumacher for field data collection, photos, and observations.

Research funded by:

- USDA-APHIS-WS NWRC
- NSF, Division of Emerging Frontiers
- University of Oklahoma Biology Department

This research has recently been published in the Human-Wildlife Interactions Journal Volume 14, Issue 3 (Winter 2020).

Questions?

Photo credit: A. Schumacher