Cost-benefit analysis for reducing bovine brucellosis prevalence in southern GYA elk

Mandy Kauffman[1], Kari Boroff[1], Dannele Peck[1], Brandon Scurlock[2], Walt Cook[1], Jim Logan[3], Tim Robinson[1], **Brant Schumaker**[1*]
[1]University of Wyoming, USA, [2]Wyoming Game and Fish Department, USA,
[3]Wyoming Livestock Board, USA

Background: Management

- Despite ongoing management:
  - Recent cases in cattle/bison traced back to elk
  - Affected area expanding
- Limited $$ available for management
  - No clear scientifically sound method
  - Need for economic evaluation of available management strategies
    - Evaluation of elk prevalence reduction strategies still needed
      - Focus of this study

Background – Bovine brucellosis

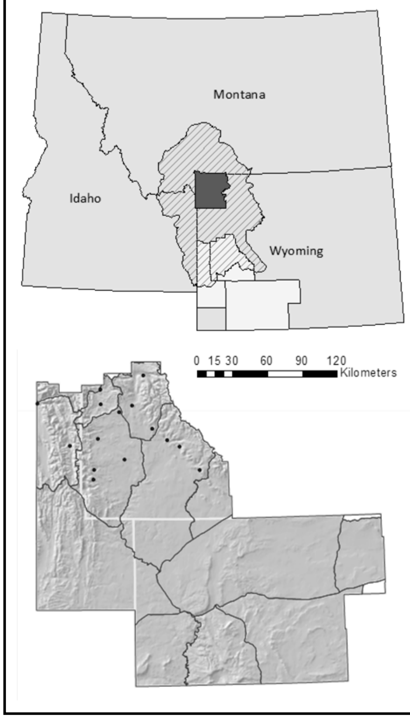
- Recent cases in cattle/domestic bison traced back to area elk
- Management strategies
  1. Maintain cattle/elk separation
     - -hazing elk -fencing haystacks
     - -elk feedgrounds
  2. ↓ likelihood of exposed cattle experiencing abortions (RB51)
  3. ↓ disease prevalence in elk
     - -T&S -low density feeding
     - -elk vaccination (S19)

Background – Previous RAs

- Limited elk data
- Relevant findings (elk → cattle):
  - High risk:
    - Abortion risk period → low elevation private ranchlands
    - Parturition risk period → public and private grazing allotments

Overall Project

- Complete cost/benefit analysis for management strategies aimed at reducing brucellosis prevalence in southern GYA elk
  1. Understand how current elk <u>sero</u>prevalence translates to risk to cattle **at coarse scale**
  2. Model how various management strategies might decrease this risk
  3. Identify costs associated with these strategies
  4. Combine 1, 2 & 3 to understand cost-effectiveness of each strategy



Study Area

- Three counties:
  - Lincoln, Sublette, Sweetwater
  - ~121,000 cattle, ~500 producers
- Site of previous brucellosis cases in cattle
- Portions of 17 EHUs
- 15/23 elk feedgrounds

Methods - Data Collection

- Limited elk collar data → mail survey
- Collect information on:
  - Cattle numbers/locations
  - Elk numbers/locations relative to cattle
- Distributed via National Agricultural Statistics Service (NASS)
  - Early February 2012
  - 486 surveys:
- 2 options for participation
- Privacy → scale of modeling

Methods - Survey Data

- 89 responses (50 usable)
- Assign cattle to locations on landscape
  - Winter/spring (Jan-early May)
- Use elk presence/pseudo-absence to estimate resource selection functions (RSFs) for elk relative to cattle
  - Land cover (NLCD)
  - Elevation
    - Slope
    - Aspect
  - Winter precipitation
  - Proximity to:
    - Wolf/human predation pressure
    - Roads
    - Feedgrounds
    - Forest cover

Risk Model

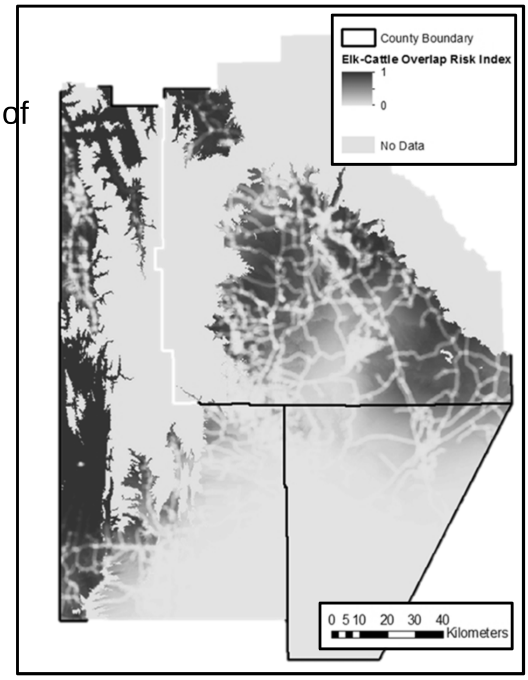
Take home message: risk of elk-cattle overlap higher if:

- **↓road density**
- **↑ cost-distance to feedground**
- **near feedgrounds**
- **↓ elevation**

Final Model Results.

Variable	Estimate	SE
Intercept	23.97**	9.82
roaddens	-2.17**	0.93
feedcostdist	1.39e-04**	5.69e-05
feeddist	-1.78e-04**	8.07e-05
elev	-1.06e-02**	4.27e-03

** indicates significance at α=0.05



- RSF "risk surface" →where elk-cattle overlap likely
- More elk → bigger problem
- So how many elk?
  - Use seasonal range, EHU populations, and expert opinion to determine

- Current Risk:
  - # years until cattle cases expected
    - # elk overlapping with cattle
    - % female
    - % pregnant
    - seroprevalence
    - probability of abortion (~~live birth~~)
  - Compare to reported cases
- Model management strategies
  - Then recalculate risk
    - Benefit
  - Compare to costs
  - Focus on Pinedale EHU

Management Strategies

(2010 dollars)

Strategy	Assumptions	Annual Cost
Test and Slaughter	All 3 feedgrounds ↓ females ↓ population ↓seroprevalence	$409,111
S19 Vaccination	All 3 feedgrounds ↓seroprevalence	$6,807
Low-Density Feeding	Fall and Muddy Creek ↓seroprevalence	$4,156

- Model potential ranges of effectiveness:
  - ↓ by 1% → 17%
  - ↓ by 5% → 13%
  - ↓ by 10% → 8%
  - ↓ to 5%

Cost of an Outbreak

- Estimated at $146,299 (Wilson, 2011)
- All costs in 2010 dollars
- Index herd: 400 bred cattle (368 successfully calve), 80 replacement heifers, 280 yearlings, and 23 bulls
- Castrating/spaying non-replacement yearlings
- Twelve-month quarantine
- Three whole-herd tests
- Does not consider changes to markets

Cost-Benefit Analysis

- Combine risk output with cost information
  - Cost of outbreak estimated at $146,299
  - Expected benefit (EB) = $\frac{\$146{,}299}{median\ years\ to\ cattle\ case\ (current)}$ - $\frac{\$146{,}299}{median\ years\ to\ cattle\ case\ (strategy)}$
  - Net benefit = EB – expected annual cost of given strategy
- Compare net benefits across strategies/implementation levels

Cost-Benefit Results

Strategy	Reduce by 1%	Reduce by 5%	Reduce by 10%	Reduce to 5%
Test and Slaughter	-$408,552	-$407,496	-$406,296	**-$406,110**
S19 Vaccination	-$6,682	-$6,248	-$5,630	-$5,462
Low-Density Feeding	-$4,031	-$3,681	-$3,074	-$2,913

Cost-Benefit Results

Strategy	Reduce by 1%	Reduce by 5%	Reduce by 10%	Reduce to 5%
Test and Slaughter	-$408,552	-$407,496	-$406,296	**-$406,110**
S19 Vaccination	-$6,682	-$6,248	-$5,630	-$5,462
Low-Density Feeding	-$4,031	-$3,681	-$3,074	-$2,913

Costs of an outbreak necessary to break even

Strategy	Reduce by 1%	Reduce by 5%	Reduce by 10%	Reduce to 5%
Test and Slaughter	$107.1M	$37.1M	$21.3M	**$19.9M**
S19 Vaccination	$8.0M	$1.8M	$846K	$740K
Low-Density Feeding	$4.9M	$1.3M	$562K	$489K

Conclusions

- At coarse scale, cattle-elk overlap risk highest in winter/spring in areas of:
  - Low elevation
  - Near feedgrounds
  - High feedground cost distance
  - Low road density
- Currently, in Pinedale EHU: expect ~1 cattle case/16 years
- Can increase time between expected cattle cases via management activities, but costs high relative to benefits
- Survey method affordable (time/$$) alternative to collecting/analyzing collar data
  - For coarse scale model
  - Possible extension to other areas

Challenges

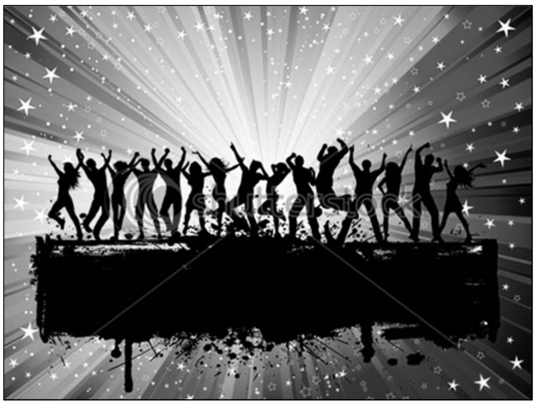
- Small sample size (18%, 10% usable)
- Poor representation of small producers
  - Impossibility of follow-up
  - Improvement via alternative sampling strategies
  - Weighting of responses
- Lack of adequate ground-truthing data
  - Other research groups working on fine-scale RSFs to identify overlap
    - Individual producer level

University of Wyoming Cattle producers
Stephen Bieber
Benjamin Rashford
Todd Cornish

Wyoming Livestock Board
Jim Logan

Wyoming Game and Fish Department
Brandon Scurlock
Hank Edwards

USDA-APHIS-VS



Questions?

Years Until Expected Cattle Case			
Elk Herd Unit	True Cases Since 1989[1]	Minimum # Years to True Case[1]	Modeled Median # Years to Expected Case
Afton	0	0	9.0
Fall Creek	0	0	17.14
Hoback	0	0	4.7
Pinedale	1	23	6.96
Piney	1	23	4.09
South Rock Springs	0	0	554,011.0
South Wind River	0	0	95.0
Steamboat	0	0	719
Upper Green River	0	0	16.09
West Green River	0	0	32.5


Test and Slaughter

- Basic premise:
  - Capture elk on all 3 feedgrounds, test adult females, remove if positive
- Assumptions for modeling:
  - All 3 feedgrounds receive management
  - Management "applied" via:
    - ↓ female proportion
    - ↓ population
    - ↓ seroprevalence

Vaccination of Elk with S19

- Basic premise:
  - Vaccinate calf elk on feedgrounds with S19
- Assumptions for modeling:
  - All three feedgrounds receive management
  - Management "applied" via:
    - ↓ seroprevalence

Low-Density Feeding

- Basic premise:
  - Alter spacing of feed to avoid mass congregation of elk
- Assumptions for modeling:
  - Two feedgrounds receive management (not feasible on Scab Creek)
  - Management "applied" via:
    - ↓ seroprevalence

Costs of Management Strategies: Assumptions

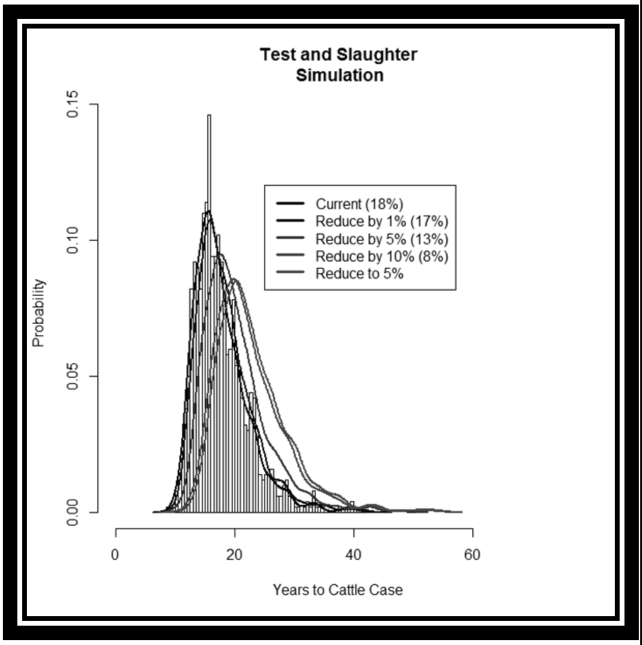
- Test-and slaughter - $346,147
  - On all 3 feedgrounds, annually
  - Assume constant variable costs
- Vaccination - $7,674
  - On all three feedgrounds, annually
- Low-Density Feeding - $1,358
  - Assume applied:
    - On 2 feedgrounds (not Scab Creek)
    - As additional time spent by feeder

Example…

- Test and slaughter → reduce seroprevalence to 5%
- Expected benefit (EB) = $\frac{\$194,627}{16.8}$ - $\frac{\$194,627}{21.9}$ = ~$2,698
- Expected annual cost = $346,147
- Net benefit = $2,698 - $345,147 = **-$342,449**

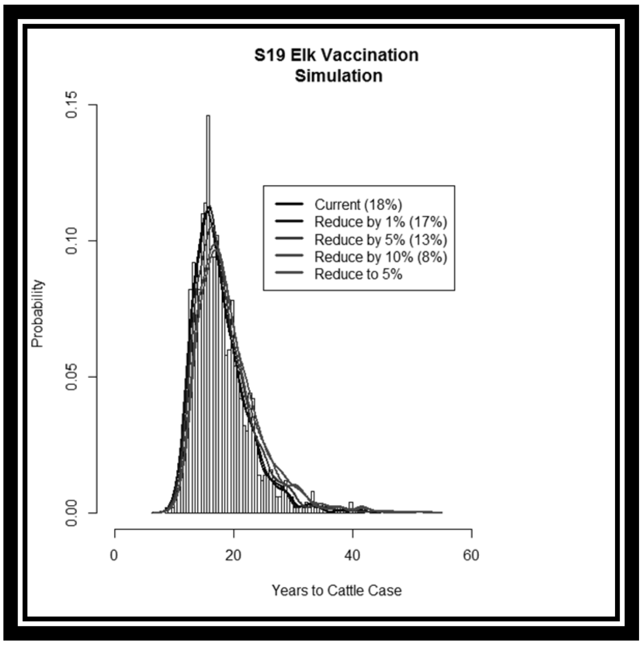
Test and Slaughter

Seroprev. Reduction	Years to Cattle Case
None (current)	16.8 (11.7, 30.0)
By 1%	19.0 (12.1, 29.7)
By 5%	19.0 (13.2, 33.2)
By 10%	21.2 (14.6, 37.2)
To 5%	21.9 (15.2, 37.7)



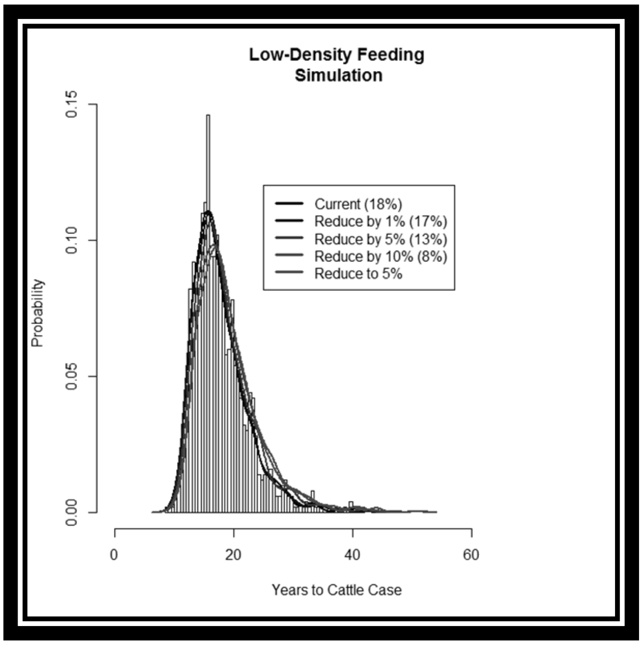
S19 Vaccination

Seroprev. Reduction	Years to Cattle Case
None (current)	16.8 (11.7, 29.0)
By 1%	16.4 (11.8, 28.9)
By 5%	17.4 (12.1, 29.9)
By 10%	17.9 (12.4, 31.9)
To 5%	18.3 (12.5, 32.6)



Low-Density Feeding

Seroprev. Reduction	Years to Cattle Case
None (current)	16.8 (11.7, 29.0)
By 1%	16.9 (11.8, 29.1)
By 5%	17.3 (12.0, 30.1)
By 10%	17.9 (12.3, 31.7)
To 5%	18.1 (12.5, 32.8)



Pinedale EHU

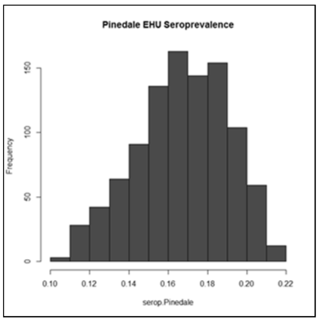
- For elk-cattle brucellosis transmission to occur:
  1. Elk must occur in close proximity to cattle

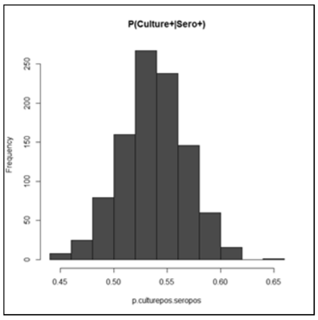
X

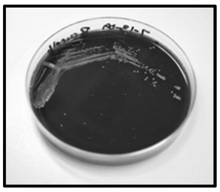
Σ(RSFxEE) = 1.92 elk overlapping with cattle

2. Elk must be infected

- Elk may test positive:
  - Seroprevalence:
    - Weighted average across the three feedgrounds = 18%
- And may or may not actually harbor *Brucella*
  - P(Culture+|Sero+)
    - Mean = 53.6%



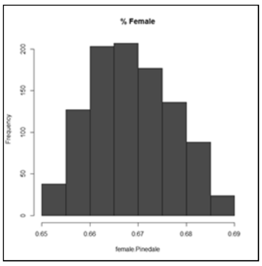


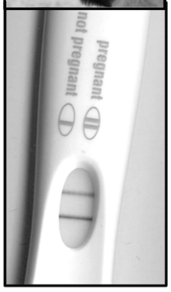


3. Elk must experience an infectious event

a) Elk must be female

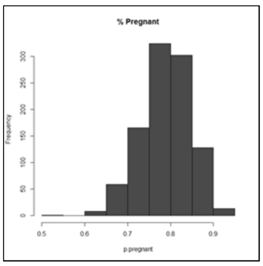
- WGFD classifies % female annually
  - Mean = 66.8%





b) Elk must be pregnant

- WGFD data suggests ~78.8% on average



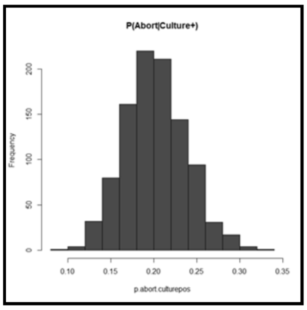
3. Elk must experience an infectious event

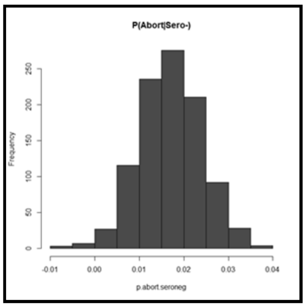
c) Elk must abort

– Given WGFD VIT data:

- P(Abort|Culture+) = 20% on average
- If Sero- → not necessarily uninfected:

  P(Abort|Sero-) ~1.7% will abort on average





Current Risk* = # infectious events expected in proximity to cattle per year

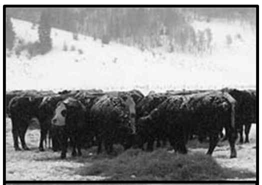
= [(#ELK) * (%FEM) * (%PREG) * (SEROPREV) * (P(CULTURE+|SEROPOS)) * (P(ABORT|CULTURE+)] — Seropositive females

+

[(#ELK) * (%FEM) * (%PREG) * (1-SEROPREV) * (P(ABORT|SERONEG)] — Seronegative females

* Note that this includes feedground and non-feedground elk

Modeling



- Small size of cattle winter feeding areas → contact with infectious materials inevitable
- Management implications same if 1 or more cattle test positive
- 1/(Current Risk) = # of years until cattle case expected
  - Pinedale EHU

    ~31 years until cattle case
    (Compare to 1 case since 1987)

Simulate Management Strategies

1. Test and slaughter
2. Elk vaccination with S19
3. Low-density feeding

- Model potential ranges of effectiveness:

  ↓ by 1% → 17%
  ↓ by 5% → 13%
  ↓ by 10% → 8%
  ↓ to 5%
- Then recalculate risk


Test and Slaughter

- Basic premise:
  - Capture elk on all 3 feedgrounds, test adult females, remove if positive
- Assumptions for modeling:
  - All 3 feedgrounds receive management
  - Management "applied" via:
    - ↓ female proportion
    - ↓ population
    - ↓ seroprevalence

Vaccination of Elk with S19

- Basic premise:
  - Vaccinate calf elk on feedgrounds with S19
- Assumptions for modeling:
  - All three feedgrounds receive management
  - Management "applied" via:
    - ↓ seroprevalence

Low-Density Feeding

- Basic premise:
  - Alter spacing of feed to avoid mass congregation of elk
- Assumptions for modeling:
  - Two feedgrounds receive management (not feasible on Scab Creek)
  - Management "applied" via:
    - ↓ seroprevalence

Example…

- Test and slaughter → reduce seroprevalence to 5%
- Expected benefit (EB) = $\frac{\$194{,}627}{31.08}$ - $\frac{\$194{,}627}{37.84}$ = ~\$1,118
- Expected annual cost = \$346,147
- Net benefit = \$1,118 - \$345,147 = **-\$345,029**

Costs of Management Strategies: Assumptions

- Test-and slaughter - $346,147
    - On all 3 feedgrounds, annually
    - Assume constant variable costs
- Vaccination - $7,674
    - On all three feedgrounds, annually
- Low-Density Feeding - $1,358
    - Assume applied:
        - On 2 feedgrounds (not Scab Creek)
        - As additional time spent by feeder

Further Steps…

- Model additional management strategies
    - Habitat improvements
    - Elk contraception
    - Fencing elk "out"
- Consider summer risk as well
    - Late elk abortion/infectious live birth
    - Cattle exposure on summer grazing allotments
    - Smaller role than winter risk
- Ground-truth models
    - Collars?
    - Intensive producer surveys?