Modeling CWD on Elk Feedgrounds
Introductions

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Overview -

- **Reminder:** CWD

- What is a model?

- **Overview:** Three models of CWD in elk populations utilizing feedgrounds

- **Overview:** Implications to elk populations & management
CWD reminders:
CWD reminder - Overview:

- Chronic Wasting Disease (CWD) is a **fatal** nervous system disease of white-tailed deer, mule deer, **elk**, moose, and reindeer/caribou
- Causative agent: Prion (infectious protein)
- Similar diseases: Animal: BSE (“mad cow”), scrapie in sheep, etc..
  Human: Creutzfeldt-Jakob disease, Kuru, etc...
CWD reminders - Clinical signs:

- Incubation period: 18 to 48 months
- No clinical signs during incubation period
- Vast majority of all harvested CWD positive animals appear normal

- Clinical signs during last 4-8 weeks of the disease:
  - Weight loss
  - Drooling
  - Behavioral changes
  - Hair/coat changes
  - Droopy ears
  - Lack of general awareness
CWD reminders -
Transmission:

• Animal to animal (Increases with density)
  
• Environment to animal
  Ingestion of contaminated feed/soil (saliva, feces, urine)
  Contact with contaminated surfaces
  Mineral licks
  Carcasses

• Long-term persistence of prions in the environment
  e.g., Scrapie = 16+ years
CWD reminders - Environmental Shedding:

CWD prions can be shed in feces, urine, and saliva for months to years during the incubation period.
What is a model?
Tools of Science: Modelling -

https://youtu.be/RK9m4OmFAbY

Advantages of using Models - CWD, elk & feedgrounds:

• Longterm
• Extrapolate to different areas, habitats, situations
• Extrapolate to different species, include other species?

• Try out management tools without real-world implications
Disadvantages of using Models - CWD, elk & feedgrounds:

• Is not exactly like the really world (there is always something)

• You are including the variables (choices are up to you)

• Don’t always know the exact variables ("most valuable rooted in real-world data")
  • Transmission types, how it works, how other diseases work...

• Based on math (highly skilled, technical expertise)
Models of CWD on feedground:
Three Models of CWD in Elk Populations Utilizing Feedgrounds

- **Supporting adaptive management with ecological forecasting:** chronic wasting disease in the Jackson elk herd (Galloway et al., 2021)
  - Model forecasting the impacts of chronic wasting disease on the Jackson elk herd (Galloway et al., 2017)
- Chronic wasting disease undermines efforts to control the spread of brucellosis in the Greater Yellowstone Ecosystem (Maloney et al., 2020)
- Chronic wasting disease model of genetic selection favoring prolonged survival in Rock Mountain Elk (*Cervus elaphus*) (Williams et al., 2014)
Modeling CWD in the Jackson Elk Herd – Galloway et al., 2017, 2021

- Five-Year model based on elk in Rocky Mountain National Park, CWD, and 20 years of data from the Jackson elk herd
- CWD prevalence most likely to reach 12% 5 years after detection
- 7% CWD prevalence most likely to have population impacts
- Once CWD is present, this herd will have little possibility for population growth
Modeling CWD in the Jackson Elk Herd - Limitations

• Model is based on CWD in elk of Rocky Mountain National Park which has a ~10X lower animal density than the National Elk Refuge

• Model does not account for differing transmission rates based on density, nor does it consider environmental transmission

• Model is limited to five years
CWD Undermines Efforts to Control The Spread of Brucellosis In The GYE – Maloney et al., 2020

- 20 year model evaluating the effects of feeding/not feeding elk in the Pinedale area
  - Economic costs of brucellosis to livestock producers
  - Economic and social value of elk harvest with and without CWD
  - Elk population models with and without CWD
  - Prediction of elk migratory behavior and population densities using GPS data
- Environmental transmission incorporated into model
CWD Undermines Efforts to Control The Spread of Brucellosis In The GYE – Maloney et al., 2020

• At current population, CWD prevalence is likely to exceed 75% - 20 years after introduction in fed populations; ~17% in unfed populations
• Predicted $19 million in losses once CWD is introduced into study area, under the current elk management strategy
• Optimal population of 950 if feeding continues, and 2,150 if feedgrounds are closed (CWD prevalence of 4.1% and 2.7% respectively)

• Recommend discontinuing feeding and develop methods to mitigate the financial impact of brucellosis on livestock producers
  • Increased depredation costs and brucellosis risks to livestock producers early on, but those costs decrease over time as brucellosis declines
CWD Undermines Efforts to Control The Spread of Brucellosis In The GYE - Limitations

• Incorrect assumption of decreasing brucellosis prevalence in elk once feedgrounds are closed?
  • Possible decrease in brucellosis, but brucellosis prevalence in some non-feedground herds exceeds 25%

• Model includes environmental transmission, but parameters in nature remain unknown
Model of Genetic Selection Favoring Prolonged Elk Survival - Williams et al., 2014

- 100 year model based on survival times and genotypes of captive elk with CWD (100% mortality)
  - MM – ~49 months (~74% of population)
  - ML – ~85 months (~24% of population)
  - LL - ~115 months (~2% of population)

- Herd data (calf ratios, harvest, etc...) based on the Pinedale elk herd

Genotype proportions in free-ranging elk from Monello et al., 2017
A: CWD in population, no harvest
B: CWD in population with harvest
C: CWD in population, genetic selection in elk, no harvest
D: CWD in population, genetic selection in elk, with harvest
E: CWD in population, genetic selection in elk, antlered harvest only
Model of Genetic Selection Favoring Prolonged Elk Survival - Limitations

• New research identifying CWD prion strain types (Moore et al., 2020)
  • Three strains documented in elk
  • CWD “resistance” is dependent on prion strain type
  • New strains more likely to originate in LL genotypes

• Modeling captive elk may overestimate rate of genetic change; not all free-ranging elk would be exposed to CWD at the same time, therefore the genetic shift may take much longer than modeled

• Authors failed to consider long-term environmental contamination at feedgrounds and subsequent transmission to other cervids (e.g. mule deer, moose) (Almberg et al., 2011)
Modeling CWD in Feedgrounds - Summary

- CWD prevalence likely to reach 12% in 5 years in the Jackson herd (Galloway), and >75% in 20 years in the Pinedale herd (Maloney)

- Jackson herd will be impacted when prevalence reaches 7% (Galloway)

- As CWD prevalence increases and populations decline, hunting opportunity will be limited or eliminated (all)

- The Pinedale elk herd may develop genetic resistance to CWD in 50 – 100 years without harvest (Williams), but will likely be susceptible to new prion strains (Moore)
Implications to elk populations & management:
Elk population dynamics

- Dictated by adult female survival* and calf recruitment** (males are not really important - sorry!)

- Adult female survival and calf recruitment interact to determine population trajectory
  - High adult female survival, high calf recruitment = vigorous growth
  - High adult female survival, poor calf recruitment = stable to slow growing population
  - Poor adult female survival, high calf recruitment = stable to declining population
  - Poor adult female survival, poor calf recruitment = declining population

- Bottom line - The growth rate of a population determines how many elk can be removed each year through hunting

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* Female annual survival - % of cows live through each year (varies with age, with older cows experiencing lower survival rates)
**Calf recruitment - calves:100 cows (incorporates calf production/birth and survival), through their 1st year of life
Elk population dynamics

- Annual adult female survival (without hunting)
  - 95%-98% in most herds without significant predation, winter loss, etc.
  - < 90% in herds with these factors operating

- Calf recruitment*
  - Considered good at 30-50 calves:100 cows
  - Considered poor at <20 calves:100 cows

- CWD does not affect calf recruitment, but does affect adult female survival

- To use the Galloway et al. (2021) example of 7% prevalence
  - estimate that 7% of females have CWD
  - CWD positive elk live 4 years on average
  - If prevalence remains constant at 7%, then 7% of females die each year (and new cows become infected)
  - This 7% is another source of mortality (and potentially an additive one) along with predation, etc.

*Calf recruitment affected by:
- cow pregnancy rates (affected by spring-summer forage/animal condition)
- brucellosis (reduces # calves born through abortions)
- other diseases (pneumonia, hoofrot, etc)
- winter malnutrition/starvation
- predation, accidents, etc.
CWD effects in different elk herds

- Elk population dynamics (adult cow survival, calf recruitment) differ among elk herds across Wyoming

Example: Jackson and Laramie Peak

<table>
<thead>
<tr>
<th>Jackson</th>
<th>Laramie Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 calves:100 cows</td>
<td>39 calves:100 cows</td>
</tr>
<tr>
<td>Adult female survival? - Lower</td>
<td>Adult female survival? - Higher</td>
</tr>
</tbody>
</table>

★ Productivity of the Laramie Peak herd is almost 2X that of Jackson
★ Higher calf recruitment may “make up” for decreased adult female survival (due to CWD)
★ Same CWD prevalence may have greater impact on Jackson elk than Laramie Peak elk
Conclusions & Summary:
Summary - CWD & Elk Feedgrounds:

• Impossible to eradicate once established & always fatal
• Elk feedgrounds become “hot spot” of CWD transmission from prion contamination
• No treatments & no vaccines at this time
• Likely to decrease populations over the long-term
• Zoonotic disease?

• Transmission to deer, elk, and moose
• Prion source likely to sustain elevated prevalence
Summary - Modeling CWD in Feedgrounds:

- CWD prevalence likely to reach:
  - 12% in 5 years in the Jackson herd (Galloway)
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- As CWD prevalence increases and populations decline, hunting opportunity will be limited or eliminated (all)

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Summary - CWD and elk population dynamics:

- Population growth is determined by the interplay of adult female survival and calf recruitment
- CWD affects adult female survival
- CWD will have larger impacts in herds where either adult female survival or calf recruitment, or both, is already lower
Conclusions - Elk & Feedground:

- Elk feedgrounds are a major wildlife disease challenge
- Concentrating animals and/or altering environmental factors

- Providing a larger number of susceptible hosts (animals) in an area, over a certain period of time
  - lots of contact between susceptible animals means infectious pathogens can be transmitted quickly
Questions?