Jackson Elk Herd Unit (E102)
Brucellosis Management Action Plan Update
June 2016

A. Introduction and herd unit overview

This update to the Jackson elk herd (JEH) Brucellosis Management Action Plan (BMAP) was prepared to evaluate brucellosis management recommendations developed and implemented during this plan's original development in 2007. Meetings among Wyoming Game and Fish Department (WGFD) personnel, interested livestock producers, federal land managers, and state and federal livestock health and regulatory officials were held to discuss progress on the plan's recommendations, review the various brucellosis management action options, and develop new brucellosis management recommendations based upon updated information. The WGFD has made much progress in the JEH to better understand characteristics of elk to elk brucellosis transmission, refine elk parturition delineations, and to reduce the risk of both intra- and inter-specific brucellosis transmission. This update should be considered complementary to the original JEH BMAP and the 2011 update.

The JEH is located in the upper Snake River drainage and includes all drainages of the Snake River downstream to and including the Gros Ventre River drainage and Flat Creek north of the town of Jackson. The JEH includes elk hunt areas (HA) 70-72 and 74-83 (Figure 1). Total area of the JEH is approximately 1,748 mi^2 (~1.1 million acres) of which 1,746 mi^2 (99%) have been delineated by the Wyoming Game and Fish Department (WGFD) as occupied elk habitat. Approximately 1,515 mi^2 (87%) are delineated as Spring/Summer/Fall range, 2 mi^2 (0.1%) as Crucial Winter Yearlong range, 138 mi^2 (7.9%) as Crucial Winter range, 51 mi^2 (2.9%) as Winter range, and 39 mi^2 (2.2%) as Winter Yearlong range (Figure 2). There are 131 mi^2 designated as parturition range (*see* Figure 2).

The U. S. Forest Service (USFS) manages 1,065 mi^2 (60.9%) of the area. The National Park Service (NPS) manages 683 mi^2 (39.0%) of land within the area, comprised of Grand Teton National Park (GTNP), Rockefeller Memorial Parkway, and Yellowstone National Park (YNP). GTNP and the National Elk Refuge (NER; 38.7 mi^2; 2.2%) comprise most of the valley floor north of the town of Jackson. Private lands account for 114 mi^2 (6.5%) of the area. State lands make up the remaining 5 mi^2 (0.3%). There are three state-operated elk feedgrounds within the JEH (Alkali, Patrol Cabin, and Fish Creek); each of these are located in the Gros Ventre River drainage east of GTNP. Elk also receive supplemental winter feed on the NER, operated by the U.S. Fish and Wildlife Service (USFWS).

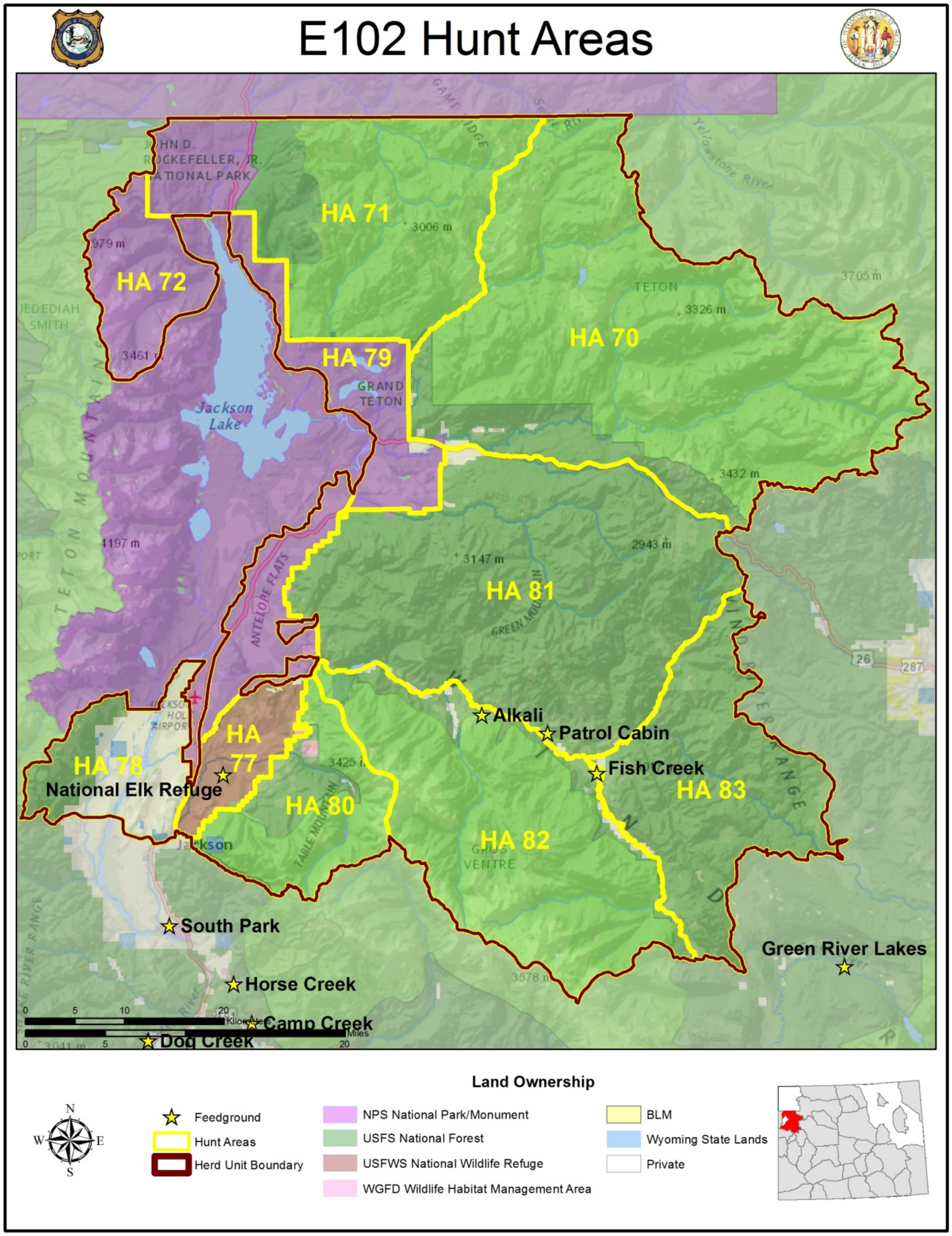

Figure 1. Land ownership, feedground locations, and hunt areas within the JEH.

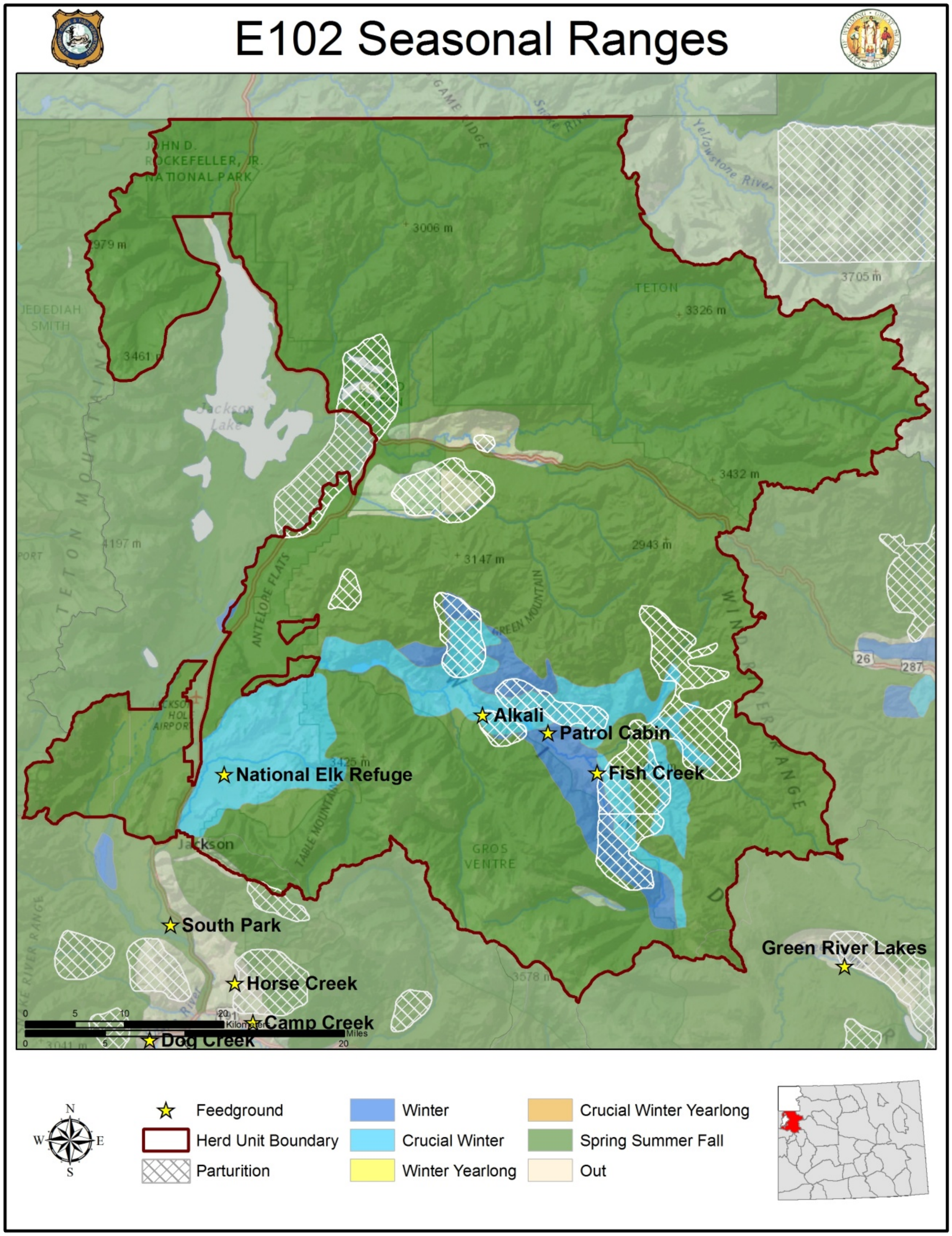

Figure 2. Currently delineated seasonal elk ranges and feedgrounds within the JEH.

B. Brucellosis Management Options

Listed below are potential options for managing brucellosis on the Alkali, Patrol Cabin and Fish Creek feedgrounds in the JEH. Short-term objectives of these options are to reduce co-mingling of elk and cattle and the prevalence of brucellosis in elk. Long term objectives include eliminating the reservoir of brucellosis in wildlife in the Greater Yellowstone Ecosystem (GYE) if determined to be technically feasible, maintain livestock producer viability, reduce/eliminate dependence of elk on supplemental feed, maintain established elk herd unit objectives, improve range health, and maximize benefits to all wildlife. Implementation of several options together will likely be more effective than instituting any option alone. The pros and cons listed after each option are based upon the best current available data and professional opinion. The Wyoming Game and Fish Commission (WGFC) will require support from various constituencies (agriculture, land management agencies, sportspersons, etc.) prior to pursuing these options, and several options will require decisions from entities other than the WGFC.

1. Feedground phase-out.
2. Reduced feeding season length.
3. Re-locating a feedground to a lower elevation site with increased area for elk to disperse and increased distance from winter cattle operations.
4. Reducing numbers of elk on a feedgrounds through increased harvest.
5. Elk-proof fencing to prevent elk from moving onto private land to reduce commingling/damage, or to facilitate elk migration.
6. Elimination of seropositive elk on a feedground through test and slaughter.
7. Conducting habitat enhancements in suitable winter ranges near feedgrounds where the potential of commingling with livestock is minimal.
8. Acquisition of native or potential winter ranges through fee-title purchase, conservation easements, or other methods.
9. Continue to investigate options for elk vaccination.
10. Utilize elk GPS location and vaginal implant transmitter (VIT) data to delineate areas of brucellosis risk.

C. Discussion of Options

1. Feedground phase-out

Phasing out a feedground would require much planning, effort and coordination. If conducted successfully, the dense aggregations of elk associated with feeding during the brucellosis transmission period would cease, reducing brucellosis transmission and seroprevalence. However, serology from winter-free ranging elk in Northwest Wyoming and other portions of the GYE suggest that the disease can persist without feedgrounds, so phasing out a feedground would not eliminate brucellosis in the GYE. However, if current conditions and herd objectives change, through implementation of one or more of options 2, 4, 5, 6, 7 and 8, this option may become more practical. The WGFC has the authority to make this decision.

Pros:

- Reduced elk-elk brucellosis transmission
- Indirectly reduces risk for elk-cattle brucellosis transmission

- Facilitates efforts to reduce elk populations where desired
- Reduced feedground and brucellosis management expenses

Cons:

- Increases the risk of elk damage and elk-cattle brucellosis transmission and associated damage control costs
- Increased elk winter mortality
- Reduced elk populations and hunter opportunity
- Increases potential for vehicle-elk collisions

In January of 2005, the Greater Yellowstone Coalition, Wyoming Outdoor council, and Jackson Hole Conservation Alliance sent a proposal to Wyoming's Governor calling for a phase-out of elk feeding in 4 different areas in Wyoming, including the 3 feedgrounds in the Gros Ventre drainage (Dorsey et al. 2005). That same year, the Greater Yellowstone Coalition released an estimate of forage production and availability for the roughly 100,000 acres of winter range in the Gros Ventre valley, suggesting that between 4,419 – 6,628 elk could winter on native ranges there (Dorsey 2005). The WGFD completed an evaluation of feeding phase-out in the Gros Ventre in response, and reported that the only way a trial phase-out of feeding could be attempted is if the current population of elk wintering in the Gros Ventre is reduced by 1,000 -1,500 animals, mitigation measures to prevent livestock and elk commingling are implemented in areas of highest potential for damage and commingling, and the NER agrees to accommodate any additional elk that could move from the Gros Ventre winter range to the NER (WGFD 2006).

Over the last decade, some conditions have changed to facilitate feeding phase out in the Gros Ventre; elk numbers wintering on the feedgrounds in the valley have decreased substantially in recent years (avg. 2002-2006, 2,887 elk; avg. 2010-2016, 1,916 elk), and some of the private lands have erected fencing to protect stored crops and livestock from elk. However, GPS collar data indicate that the reason for at least some of the reduced elk numbers wintering in the Gros Ventre is movement to the NER, despite attempts to begin feeding earlier than typical on the State feedgrounds. Additional elk wintering on the NER is problematic, as the 2007 Bison and Elk Management Plan calls for only 5,000 elk and the average number of animals counted on the NER the last 5 years has been over 7,500 (2010-2016; range 6,285-8,390). Concerns also remain over the potential for damage to stored crops and elk-cattle commingling without feeding in the area. Thus, the WGFD will not purse feedground phase-out in the Gros Ventre at this time, and will reevaluate feeding phase-out as conditions continue to change.

2. Shortened feeding seasons

Most of the variation in brucellosis seroprevalence among elk attending a particular feedground is correlated to the length of the feeding season; the longer a feedground operates into spring, the higher brucellosis prevalence is among the elk at that feedground, most likely because the peak of brucellosis-induced abortions occurs from March-May (Cross et al., 2007; Cross et al., 2015). The correlation indicates that truncating the feeding season by an average of 3 weeks could lead to a 66% reduction in brucellosis seroprevalence.

Pros:

- Reduced elk-elk brucellosis transmission and the transmission of other density-dependent diseases
- Indirectly reduces risk for elk-cattle brucellosis transmission
- Maintains elk populations at or near current levels
- Reduces feedground and brucellosis management expenses

Cons:

- Increases the risk of elk damage and elk-cattle brucellosis transmission and associated damage control costs
- Increased elk winter mortality, especially of juveniles
- Increased potential for vehicle-elk collisions
- Success or failure is highly dependent upon weather

Elk feeding on the Gros Ventre feedgrounds is conducted primarily to help reduce elk movements from the Gros Ventre River corridor down to the NER and to control elk distribution to reduce elk damage to stored crops and elk-cattle comingling and inter-specific disease transmission to domestic livestock on private lands in the area. The Gros Ventre watershed typically receives less snow than surrounding areas in the Jackson region and much of the watershed has been set aside as crucial wildlife winter range, which provides managers an opportunity to end feeding earlier than typical most winters. However, due to concerns of negatively impacting desired elk numbers on the NER and the potential for brucellosis transmission from elk to cattle, efforts to shorten the feeding season in the Gros Ventre have been difficult. The average end feeding date from 1998-2007, prior to Target feedground management efforts, was March 28th, but the average end date of the feedgrounds in the Gros Ventre since 2008 has actually increased by several days to March 31st. The WGFD will continue to investigate ways to reduce feeding season length while still providing ample protection for the remaining private lands and livestock in the Gros Ventre

3. Feedground Relocation

This option would initially require a suitable area ideally in a lower elevation and precipitation location with no winter cattle operations in the vicinity and an expansive area for distributing feed. Current habitat conditions should be evaluated to determine vegetation production, health, and approximate potential of the area. Most federal lands in the area are leased for grazing, so it is likely one or more permittees would need to be involved in the selection of a particular area. If purchase of grazing rights is acceptable to a permittee, this could reserve forage for elk, other wildlife and livestock. Decision authority would lie with the private landowner, permittee, federal land managers, and the WGFC.

Pros:

- Lowered brucellosis prevalence
- Larger feeding area for lowered elk densities while feeding
- Elk numbers could be maintained at or near current levels

- Decreased damage and co-mingling
- Moving from federal lands to private would reduce chances of litigation under NEPA

Cons:

- Brucellosis will persist
- Requires funds for erection of new structures, fences, roads, etc.
- Logistically challenging to relocate and habituate elk to the new site
- Reduced vegetation diversity around the new site
- Requires permitting process and NEPA review if relocated on federal lands

Feedgrounds in the JEH where this option would be applicable are the three state-operated feedgrounds in the Gros Ventre drainage, mostly due to the benefits of having an increased feeding area. Since wolves recolonized the Gros Ventre drainage in 1998, elk movement among the feedgrounds in the Gros Ventre has become unpredictable, frequently with the consequence of all Gros Ventre elk on feed being concentrated on just one of the feedgrounds (WGFD 2015, 2016). This is despite the WGFD attempting to separate elk among all three feedgrounds by allocating less feed (or not feeding at all), proportionally, at the feedground of highest elk density. Commission quotas for Alkali, Patrol Cabin and Fish Creek are 800, 650, and 1,000, respectively. The feeding area on Fish Creek feedground is sufficient for the times when there are >1,000 elk present (feeding area of about 71 acres), but on Patrol Cabin the feeding area is only about 40 acres creating a situation with an undesirably high density of elk. Options the WGFD could take for expanding the Patrol Cabin feeding site are on USFS or private lands. The WGFD has approached the USFS about expanding the feeding area at Patrol Cabin to adjacent USFS lands with no success thus far. Surrounding landowners have discussed the possibility of feeding elk on their private land but to date no actions have been taken.

The WGFD will not pursue relocating the feedgrounds in the Gros Ventre at this time, as the feedgrounds are currently in as optimal locations as possible for the purposes they serve. Additionally, a decreasing trend in the number of elk wintering in the Gros Ventre has been observed over the last several years, resulting in less emphasis on increasing feeding areas. However, opportunities to implement this option for feedgrounds in the JEH will be considered as opportunities arise, and would be facilitated by combining with options 4 through 8.

4. Elk Population Reduction

Reducing elk numbers on feedgrounds through liberalized hunting seasons could allow more flexibility to pursue options 1, 2, 3 and 6, and could lead to more favorable conditions for options 7 and 8. The WGFC has the authority to make this decision.

Pros:

- Decreased elk densities and lower brucellosis prevalence
- Increase hunting opportunities and license revenues in the short term
- Reduced conflicts on private lands
- Reduced costs of supplemental feeding

Cons:

- Brucellosis will persist

- General public currently unwilling to accept large reductions in elk numbers
- Success is limited to hunter effort
- Loss of some hunting opportunity in the long term

Population reductions beyond the current, Commission-established, elk herd unit population objectives would require a public input process to discuss the issue and determine the level of support. Thus, authority over this option ultimately lies with the WGFC. The postseason population objective for the JEH is 11,000 elk and the current population trend counts indicate the herd is at or near population objective. The WGFD will continue to design and implement harvest strategies to ensure elk populations are maintained at established herd unit objectives.

After several decades of managing for population reduction in the JEH, the WGFD management strategy is now transitioning to one of population maintenance. Preseason classifications indicate that herd segments in the southern portion of the herd unit reproduce at twice the rate of migratory elk from YNP, and post-season surveys indicate that resident elk on USFS lands exhibit low calf:cow ratios. There has also been an ongoing shift within the composition of the elk herd from predominantly long distance migrants to short distance migrants as noted by Cole et.al. (2015).

WGFD is recommending that future harvest target specific segments of the elk population to prevent further population decline while maintaining hunting pressure on the more robust southern herd segments. Proposed harvest strategies along with lower calf production in some herd segments will continue to move southern resident elk numbers towards the desired percentage of the population while allowing northern and Gros Ventre elk, which are below desired percentage of the population, to increase. Hunting season structure in the Teton Wilderness and GTNP will continue to reduce hunting pressure on elk that migrate from YNP. Thus, hunt season modifications enacted since 2011 focus hunting pressure on segments of the population that are difficult to harvest from subdivisions along the Snake River.

<u>5. Fencing</u>

Elk proof fencing of feedgrounds may contain most elk within a given area, and fencing of winter cattle feedlines can prevent elk from co-mingling with cattle. Fencing roadways would facilitate migration to winter ranges which would reduce dependency on supplemental feeding. This would require favorable decisions by the landowner (private, state or federal).

<u>Pros:</u>

- Reduced risk of elk-cattle brucellosis transmission
- Reduced elk damage
- Reduced elk and other wildlife vehicle collisions
- Controls elk distribution

<u>Cons</u>:

- Expensive
- Congregating all or most of the elk or cattle within a fence may be unfeasible
- Extensive fencing could impede migrations of non-target wildlife
- Does not address elk-elk brucellosis transmission

- Requires landowner cooperation and potential NEPA review for federal lands

This is an option that would facilitate implementing most other options. Fencing of winter cattle feedlines could prevent elk from commingling with cattle. Elk-proof fencing around private stackyards reduces “attractiveness” to and likelihood for damage by elk. New fencing would require favorable decisions by the landowner. Where fencing stackyards is considered beneficial at reducing damage/commingling, the WGFD provides fencing materials to landowners.

Large-scale, elk-proof fencing around feedgrounds can contain most elk within a given area, as evidenced by fences in Jackson Hole (along west boundary of NER), Star Valley (along west boundary of Greys River feedground), and Pinedale (border of USFS land from New Fork canyon to Fremont Ridge). Smaller-scale fences (e.g., adjacent west of Muddy Creek feedground) may prevent elk from drifting onto localized areas, but likely do not contain most elk in the area.

The Department has resisted large-scale fencing of private lands due to the possibility of impacts to migrations of other ungulates. However, the WGFD could support projects targeting specific problem areas (e.g., fencing fall and spring pastures with chronic elk commingling problems), but currently has no funding available for such projects. If a specific proposal were developed, with an interested and supportive landowner, Natural Resources Conservation Service (NRCS) or Animal and Plant Health Inspection Service (APHIS) could potentially provide funding for implementation. The WGFD can assist in securing other funding sources for landowners that have the desire to implement large-scale fencing projects.

<u>6. Elk Test and Slaughter</u>

This option was conducted on the Muddy, Fall and Scab Creek feedgrounds from 2006-2010. Following removal of 196 seropositive elk, brucellosis prevalence was reduced at all three feedgrounds. Capture operations occurred every year at Muddy Creek feedground, where brucellosis prevalence was reduced most significantly from 37% to 5% in the five years, yet prevalence rebounded to 32% in 2016. Test and slaughter could also reduce elk numbers to more efficiently pursue options 1, 2, 3, 7, and 8. The WGFC has the authority to make this decision.

<u>Pros:</u>

- Reduces brucellosis prevalence in elk
- Increased tolerance of elk if brucellosis prevalence is decreased
- Increases other State’s acceptance of cattle from within the GYA
- Capture infrastructure currently established in some areas

<u>Cons:</u>

- High cost and complex logistics
- Does not eliminate brucellosis transmission
- Must be implemented perpetually to maintain brucellosis prevalence reductions
- Could result in reduced hunting opportunity

Brucellosis seroprevalence would decrease on all feedgrounds within the JEH given implementation of this option for as long as test and slaughter would be conducted, but prevalence would rebound if the method were not continued in perpetuity or some other additional measure were not taken (e.g., options 1-4). Also, expenditures are not allocated for such a project at this time. The WGFC has the authority to make this decision.

7. Habitat Enhancement

Habitat enhancement projects might reduce the time elk spend on feedgrounds. If habitat improvements are completed near feedgrounds or between summer range and feedgrounds, the enhanced forage produced will decrease the dependence of elk on artificial feed, snow conditions permitting. Reduced feeding durations and lower elk concentrations on feedgrounds, especially during the high transmission risk period, may decrease the probability of intraspecific brucellosis transmission events. Habitat enhancement projects also create vegetative diversity and improve range conditions for other floral and faunal species (including livestock). Increased forage quantity/quality in autumn may entice elk onto the feedgrounds and away from damage situations, without an earlier initiation of feeding. Affected permittee or landowner consultation and cooperation is necessary.

Pros:

- Reduced feeding duration and brucellosis prevalence
- Provides long-term benefits to many species of wildlife and cattle
- Funding is available through government and non-government agencies

Cons:

- Use of treated areas is highly dependent upon weather
- Complex pre- and post logistics (sensitive species considerations, rest period)
- Increased likelihood of invasive species establishment

The Jackson Interagency Habitat Initiative (JIHI) has spearheaded much of the progress on enhancement of elk winter range and transitional range in the last decade in the JEH. JIHI was formed in the fall of 2001 by several wildlife biologists from the BTNF, NER, WGFD, and GTNP, and the group reports its progress and takes recommendations at the annual advisory group meeting of the Jackson Hole Cooperative Elk Studies Group (JHCESG). WGFD involvement with those groups, and habitat enhancement projects, is ongoing. The Lower Gros Ventre habitat enhancement included 17,000 acres of burn units between Ditch Creek and Slate Creek conducted over several years, and appears to have been successful in enhancing forage and setting back succession. Planning is currently ongoing for Upper Gros Ventre habitat enhancements. This option may be best used in conjunction with options 1, 2, 3 and 8 to achieve maximum success.

8. Acquisition/Conservation Easements

Risk of intraspecific brucellosis transmission on all feedgrounds in the JEH might be decreased by managing lands adjacent to, or connected with, areas used by wintering elk.

With adequate intact, healthy, and accessible elk winter habitat available, elk feeding may be reduced in the JEH. This option also could be used to facilitate purchase of a forage reserve, securing habitat for wildlife species in addition to elk. The buying or long-term leasing of land to be managed commensurate with wildlife benefits is an option that can be used to maintain stability and health of all floral and faunal populations. Decision authority is with the private landowner. Land transactions involving the WGFD (e.g., conservation easements) would have to proceed ultimately through the WGFC. This option could also facilitate options 1, 2, 3, 4, 5 and 7. Decision authority is with the private landowner and purchaser.

Pros:

- Could lead to reduced brucellosis prevalence in elk
- Secures habitat for all wildlife
- Long-term solution
- Helps secure future revenues for the WGFD

Cons:

- High cost and complex logistics
- Decreasing availability of undeveloped suitable properties
- Dependent upon willing seller and buyer

9. Investigate Options for Vaccination

The WGFD initiated the *Brucella abortus* strain 19 ballistic elk vaccination program in 1985 on Grey's River feedground and vaccinated approximately 85,000 elk through 2015 on 22 state-operated feedgrounds and the NER. Controlled studies with captive elk indicated strain 19 was mildly protective (Roffe et al. 2004). However, by periodically sampling brucellosis seroprevalence over time and using vaginal implant transmitters that are expelled upon birth or abortion, the WGFD found that brucellosis seroprevalence among vaccinated elk has not been reduced since the vaccination program began, and the number of abortions has not been different between vaccinated and unvaccinated elk (Maichak et al., *in press*). Furthermore, the company that produced biobullets® has not sold the rights to produce biobullets, thus they are no longer available. Other options for brucellosis vaccination on elk feedgrounds are being developed and may become available in the future, especially upon the recent consideration by APHIS to delist *B. abortus* from the select agent list, enabling vaccine research and challenge studies outside of BSL3 facilities. Another approach is the immune-contraceptive vaccine Gonacon™ which can prevent conception, thereby preventing brucellosis transmission. An effective vaccine would increase opportunity to implement options 1, 2, 4. The decision authority to implement a new vaccination program lies with the WGFC.

Pros:

- Reduces infected elk fetuses aborted on and off feedgrounds
- Indirectly reduces risk for elk-cattle brucellosis transmission
- Oral vaccines can be delivered to winter free-ranging populations
- Has been used in successful disease eradication campaigns

Cons:
- Vaccine development and approval is expensive
- Unknown effectiveness in a field setting
- Immuno-contraceptives could limit hunting opportunity

10. Map Areas of Brucellosis Risk

Since 2006, as part of the Wyoming Governor's Brucellosis Coordination Team's recommendation for elk brucellosis research, the WGFD has collected elk distribution data from 475 GPS collared elk, and reproductive data using VITs from 562 elk captured on or near feedgrounds in 7 elk herd units. Areas where elk are located during the brucellosis transmission period of February 5 - June 15 can be considered brucellosis risk areas within the elk herd unit, and maps can be developed identifying these areas. These risk areas can be refined by selecting elk locations during March-May, when data from VITs indicate that most brucellosis-induced abortions occur (Cross et al., 2015). Utilizing the risk maps, producers, land managers and livestock regulatory officials can focus efforts and make informed decisions to implement strategies that minimize brucellosis risk to cattle herds.

Pros:
- Data required to identify brucellosis risk areas are available
- Illustrates areas where disease management actions should be focused
- Repeatable to determine if elk management strategies were effective

Cons:
- Reduced vigilance in areas of lower brucellosis risk
- Risk areas dependent upon sample size
- Confidentiality concerns

This technique could be used when working with private landowners and federal land grazing permittees to further inform and assist in allotment management planning to help reduce risk of inter-specific disease transmission.

D. Coordination Meetings

1. Producer Meeting

A meeting was held December 17th, 2015 in Jackson to discuss the ten options among livestock producers and associated land and resource management agencies within the JEH. A presentation was given by the WGFD summarizing brucellosis management and research strategies and their relation to the ten options. Nine producers, six WGFD personnel, two USFS personnel and the WSLB Assistant State Veterinarian attended the presentation. Several questions and comments were proposed by attending producers regarding fencing, feedground phase-out, habitat treatments and reduced feeding seasons. There was a comment of support from producers in favor of mapping of risk areas and thanks from several produces on the efforts that the WGFD has made handling elk-cattle comingling situations. A lengthy discussion occurred over the efficacy of *B. abortus* strain 19 and RB51 vaccine in cattle and the need for a better vaccine for both cattle and elk. No substantial changes or actions were recommended for the BMAP or management of the JEH feedgrounds following this meeting.

2. Interagency Meetings

A meeting of the JHCESG was held May 3rd, 2016 and was attended by personnel representing the WGFD, USFS, GTNP and NER. WGFD personnel presented the ten brucellosis management action options for the JEH BMAP update, and members discussed the pros and cons. Cooperating agencies gave their general support for WGFD in research endeavors, habitat enhancement projects, and elk management strategies.

3. Public Meeting

A meeting was held March 23rd, 2016 to discuss the ten options as they pertain to the Afton, Fall Creek and Jackson elk herd units. Two interested publics, two producers, two non-government organization (NGO) representatives, and six WGFD personnel attended the presentation which summarized current brucellosis management and research and the ten additional management options. Most options were discussed following the presentation, with the feedground phase-out option sparking the most dialogue.

Feedground phase-out as it pertains to the Gros Ventre was discussed at length with much debate over carrying capacity of native ranges in the valley. Issues discussed included wolves, elk damage to crops and elk-cattle commingling, redistribution of elk to the NER, lower populations if not fed, lack of consequences for proponents of phase-out, policy dysfunction of not allowing elk to winter out, and the want of language spelling out potential mitigation of these issues in the plan. For reduced feeding season length, one producer asked to be notified prior to ending feeding, and the WGFD clarified they will notify the producer in the future and early end-dates are only implemented on targeted, low-risk feedgrounds. Population trend counts for each elk herd were presented for 2005-2015, and while herd counts are currently within the population objective, there was debate on the stability of the JEH in the presence of predators. For the option of fencing, it was noted that fencing haystacks and some winter livestock feeding areas have reduced elk damage/commingling. However, producers pointed out that fencing livestock feeding areas is logistically challenging (herd management and watering issues), and could present other disease issues resulting from excessive excrement accumulation.

WGFD personnel answered questions on the pilot test and slaughter project conducted in the Pinedale elk herd from 2006-2010, including the total cost ($1.2 million US dollars), if there is current support for the option (highest around the Pinedale area), with discussion on the topic ending with a comment supporting use of the method to reduce prevalence only if it were followed by feedground phase-out for a long-term solution. For vaccination, it was noted that timing of vaccination prior to peak abortion season is critical and the WGFD confirmed that delivery of vaccine during the elk vaccination program occurred from February-March. Discussion on habitat enhancement, conservation easements and mapping areas of risk included a comment suggesting the effectiveness (in affecting elk distribution) of habitat treatments over time decreases, a suggestion to investigate purchasing easements for producer change of operation, and a suggestion to map brucellosis risk in winter free-ranging areas.

Several other questions, comments and discussion arose throughout the meeting outside of the 10 brucellosis management options presented. The WGFD acknowledged the importance of protecting scavengers on feedgrounds for their role in removing infectious fetuses, and a suggestion was made to include wolves among the predators protected. An attendee indicated that there is inequity within the BMAP meeting process because producers alone were asked to the meetings in December and the general public arguably has a higher stake in brucellosis management. Some discussion on movements of elk captured from feedgrounds in the Gros Ventre occurred, with the WGFD reporting GPS collar data indicates Gros Ventre elk frequent the NER, and have moved to the Upper Green River, Bondurant and Dubois areas. A final suggestion recommended the current National Academy of Science's review on brucellosis in the Yellowstone area review the harsh sanctions imposed on infected livestock herds by the State and Federal government.

E. Proposed Management Actions

1. Feedground Phase-Out

The WGFD will not pursue this option in the immediate future given existing conditions. In April of 2006, the WGFD evaluated a proposal for a phase-out of elk feeding in the Gros Ventre drainage and concluded the only way a trial phase-out of feeding could be attempted is if the current population of elk wintering in the Gros Ventre is reduced by 1,000-1,500 animals, mitigation measures to prevent livestock and elk commingling are implemented by landowners in areas of highest potential for damage and commingling, and the NER agrees to accommodate any additional elk that would move from the Gros Ventre winter range to the NER. While wintering elk numbers have been reduced numbers in the Gros Ventre by about 1,000 animals, the risk of elk causing damage or commingling with cattle on private lands and the issue of more elk wintering on the NER remain as concerns in 2016. The WGFD will continue to monitor conditions in the Gros Ventre drainage and will reevaluate feeding phase-out as conditions continue to change.

2. Reduction in feeding season length

Reduced feeding season length is currently being implemented in areas where elk can find adequate early spring forage without an increased risk of commingling and inter-specific disease transmission. However, given current attempts to hold elk in the Gros Ventre by feeding longer, the feeding season has actually increased in recent years in the Gros Ventre, likely increasing intra-specific brucellosis transmission. Efforts in the future should take advantage of the low snow depths frequently found in the Gros Ventre during winter and the abundant native winter range available to end feeding as early as possible.

3. Feedground Relocation

The WGFD will not pursue relocation of any feedgrounds in the JEH in the immediate future, but will continue to investigate options as they arise in the future.

4. Elk Reduction

The WGFD manages for current, WGFC-established, elk herd unit population objectives. The current population objective for the JEH is 11,000, and a lower objective would require a public input process to discuss the issue and determine the level of support. Authority over this option ultimately lies with the WGFC. The WGFD will continue to design and implement harvest strategies to ensure elk populations are maintained at established herd unit objectives.

5. Fencing

The WGFD will encourage cattle producers in the JEH to fence areas where hay is stored (stackyards) for winter-feeding operations and continue delivery of materials for stackyard construction. As opportunities arise for additional fencing projects (e.g., winter cattle feeding exclosures), the WGFD will assess those opportunities on a case-by-case basis.

6. Elk Test and Slaughter

The WGFD implemented the pilot Test & Slaughter project in the Pinedale elk herd from 2006 through 2010. Given the financial and personnel constraints required to implement this management action at the herd unit level and the ephemeral results, the WGFD will not implement this option in the JEH in the foreseeable future.

7. Habitat Enhancement

The WGFD will continue to coordinate with private landowners, federal land managers, and livestock permittees to develop and implement habitat improvements that may reduce elk dependency on supplemental feed in the JEH. The WGFD will emphasize coordination among NER, BTNF, GTNP, and WGFD through JIHI. These projects will focus on areas designated as winter and transitional ranges, while working within the constraints of sensitive-species management and funding.

8. Acquisition/Conservation Easements

The WGFD will attempt to identify and pursue opportunities to implement this option. As projects are identified, proposals will be drafted and submitted, either through the Department's process of obtaining fee-title lands, or to various funding agencies to facilitate implementation of this option.

9. Investigate Options for Vaccination

The WGFD will continue to investigate new options for elk vaccination. Currently, the creation of an effective vaccine in elk is the limiting factor, but in early 2016, the USDA APHIS proposed to delist *B. abortus* as a "select agent or toxin" as defined by the Agricultural Bioterrorism Protection Act of 2002. Removal of the bacteria from this designation would greatly increase brucellosis vaccine research and development due to lowered costs of challenge trials.

10. Map Areas of Brucellosis Risk

This management option is currently being implemented by the WGFD's brucellosis program. The completed product will be distributed to the appropriate cattle producers, land managers and livestock health regulatory officials upon completion for use in their brucellosis risk management activities.

F. Best Management Practices

In addition to the above options and commensurate with their short and long term goals, the following best management practices should be considered for elk feedgrounds. Some may be currently employed, and should be maintained. Others may or may not be viable options for each feedground during any given winter.

Feedground Management

1. Manipulate elk distribution by supplemental feeding to reduce elk/cattle commingling and the risk of brucellosis transmission from elk to cattle.
2. Disperse feed evenly in a checkerboard pattern throughout the feedground on clean snow (low-density feeding) to reduce contacts with aborted fetuses.
3. End feeding as early in late winter/spring as possible; March-May is the peak abortion period and preventing dense aggregations during this period reduces elk-elk brucellosis transmission.
4. Where possible, implement large-scale habitat treatments at strategic locations near feedgrounds.
5. Elk feeders shall report any aborted fetus which will be collected and submitted to WSVL for testing; disinfect abortion site
6. Predators and scavengers (i.e., coyotes, foxes) shall not be killed on/near feedgrounds by WGFD employees due to their beneficial role of quickly removing aborted fetuses.

G. Additional Actions

Brucellosis Surveillance

The WGFD currently captures and tests elk for exposure to brucellosis on 7 to 15 feedgrounds every year. Around 4,500 cow elk were tested from feedgrounds during 2000-2015, with 27% of the elk showing positive reactions. This practice should continue on as many feedgrounds as possible annually to monitor prevalence of the disease. To assess efficacy of target feedground management activities (e.g., low-density feeding and early end feeding dates), the WGFD has partnered with a Ph.D. candidate out of Utah State University. The student is planning to quantitatively assess these brucellosis mitigation strategies aimed at reducing prevalence of the disease. Additionally, hunter-harvested elk brucellosis surveillance will occur annually in an effort to survey the entire state over a 4-year period.

Emergency Feeding

Periodically, winter conditions force elk off winter ranges and onto private land. Regional personnel spend a considerable amount of time working with operators and hazing elk in an effort to reduce conflicts and prevent elk from commingling with domestic livestock. Occasionally, emergency feeding operations are initiated as a means to control elk distribution and to draw animals away from commingling situations. In a effort to facilitate damage management, managers will continue to work with landowners and producers to move elk away from damage situations and may store hay in the area in the event that emergency feeding operations are required to prevent commingling of elk with domestic livestock.

Research

Reducing both the incidence of brucellosis in elk on feedgrounds and the risk of the disease's transmission from elk to cattle is facilitated by accurate and reliable data to guide management decisions. Prior to the development of the BMAPs, most research concerning brucellosis and feedgrounds focused on elk vaccination and its efficacy on reducing brucellosis prevalence at the population level. Over the last decade, the WGFD has partnered with the USGS, Montana State University, Iowa State University, and the University of Wyoming on several studies to determine spatiotemporal characteristics of brucellosis transmission, including timing of abortions and attributes of elk-to-fetus contacts. Data gathered from these endeavors has expanded our knowledge of how the disease is transmitted and led to specific management strategies to reduce incidence of the disease.

1. **Effects of management and climate on brucellosis seroprevalence of feedground elk**

Cross et al (2007) compiled 16 years of seroprevalence data from feedground elk and 54 years of feeding and climate data from feedgrounds and local weather stations throughout the Greater Yellowstone Ecosystem. They found that brucellosis seroprevalence was positively correlated to the length of the feeding season and feeding end date. However, feedground population size and density had little to no influence on seroprevalence. They suggested management strategies that reduce the length of the feeding season (e.g., early end dates) to reduce the period when a high potential for elk-fetus contacts exists should ultimately reduce prevalence of the disease among elk attending feedgrounds.

2. **Effects of management, behavior, and scavenging on risk of brucellosis transmission**

Maichak et al (2009) collected 48 culture-negative fetuses from elk associated with the test and slaughter pilot project and placed these on various locations on feedgrounds and on native winter range locations from 2005 through 2007. They found that the majority of elk-fetus contacts occurred on the feedlines on feedgrounds (<2m of haypiles), and there were no contacts off of feedgrounds. Most elk did not demonstrate a propensity to investigate fetuses, as few contacts occurred when a fetus was located ≥ 2m from the feedline. Additionally, they found that scavengers removed fetuses much faster from feedgrounds than native winter range locations, reducing the number of elk contacting fetuses. They suggested that altering hay distribution patterns could reduce elk densities on feedlines, leading to fewer elk-fetus contacts, and recommended the protection of scavengers near feedgrounds to ensure aborted fetuses are removed from the landscape as quickly as possible.

3. **Parturition ecology of feedground elk**

From 2006 through 2010, the WGFD collaborated with Iowa State University, the University of WY, Montana State University, and the USGS to deploy and recover over 300 vaginal implant transmitters (VITs) placed in elk captured from 19 feedgrounds and 3 native winter ranges as part of a multi-faceted project to document characteristics of elk parturition and abortion. Barbknecht et al. (2009) reported that VITs were an effective tool for locating elk parturition sites, and Barbknecht et al. (2011) found that most elk tended to select parturition sites with substantial horizontal and overhead cover, ranging from low elevation riparian areas to high-elevation alpine habitats. In 2015-2016, the WGFD utilized location data of over 500 VITs expelled during parturition, along with elk GPS collar location data, to update parturition range delineations for the 7 elk herd units containing feedgrounds. Land managers are already using the highly defensible data for land use planning purposes.

4**. Effects of supplemental feeding on stress levels in elk**

Forristal et. al. (2011) assessed stress levels in elk by measuring fecal glucocorticoid metabolite concentrations (fGCM) derived from numerous fresh fecal samples collected from feedgrounds and native winter ranges. Elk from feedgrounds had at least 31% higher fCGM levels than those on native ranges, suggesting higher levels of stress due to crowding. Increases in stress and glucocorticoid concentrations can reduce immune function and increase susceptibility to brucellosis, necrotic stomatitis and other diseases present on feedgrounds.

5. **Target Feedground Management: low-density feeding and early end dates**

Based on research findings of some of the projects previously mentioned, the WGFD developed and implemented management actions pertaining to the Target Feedground Management Plan (WGFD 2016). The two primary objectives are to increase dispersion of hay throughout the feedground (low-density feeding) and actively end the feeding season with a goal of ending three weeks prior to the current 10-year average. Creech et al. (2012) compared low-density (LD) to traditional feedlines via data-logging radio collars and digital video cameras and found that LD feeding reduces elk-to-fetus contacts by 66%-75% and, based on disease models, should substantially reduce seroprevalence in elk if successfully implemented over a decade or more. Active early termination of feeding is possible on some feedgrounds in light snow years, but the impacts on actual seroprevalence at the population level will require implementation of eight to 10 years (Cross et al. 2007). Since 2008, the average feeding end date has been shortened by up to 19 days at some feedgrounds, yet some feeding seasons have not changed and a few are now actually longer than prior to initiation of target feedground management (Table 1).

Table 1. WGFD-operated elk feedgrounds in western Wyoming grouped by those managed for early end dates and those with traditional end date management with mean feeding end dates (in days since November 1st) for the 10-years preceding target feedground management (1998-2007), the eight years since (2008-15), and the difference in days between those figures.

	FEEDGROUND	PRE-TFG (98-07)	POST-TFG (08-15)	DIFF
Early End Mgmt	Scab Creek	163.3	*144.6	**18.70**
	Fall Creek	151.1	132.8	**18.35**
	Bench Corral	143.2	131.4	**11.83**
	Soda Lake	150.8	**140.9	**9.95**
	Forest Park	169.1	168.6	**0.47**
	Green River Lakes	150.1	**156.9	**-6.79**
Traditional End Mgmt	Franz	177.1	166.9	**10.23**
	Black Butte	171.6	165.3	**6.35**
	Camp Creek	162.7	156.4	**6.32**
	Jewett	172.8	166.5	**6.30**
	Greys River	169.4	164.1	**5.28**
	Dog Creek	164.7	159.6	**5.07**
	Finnegan	169.6	165.4	**4.22**
	South Park	161.0	158.0	**3.00**
	Horse Creek	166.6	165.3	**1.35**
	Muddy Creek	161.5	161.3	**0.25**
	Gros Ventre	147.7	150.5	**-2.80**
	Dell Creek	172.3	175.4	**-3.07**
	McNeel	160.6	164.9	**-4.28**

**represents 2009-15*

***excludes 2010 when elk were not fed*

6. **Contacts rates of female feedground elk during brucellosis transmission season**

It has been hypothesized that the majority of disease transmission in wildlife populations can be attributed to a small number of individuals. However, using proximity data logging collars deployed on 149 elk across feedground and winter free ranging elk populations, Cross et al. (2013) found that environmental conditions associated with high contact rates is more important than a handful of efficient disease spreaders. Although, pairwise contacts were similar during and after feeding, per capita contacts were two times greater during the feeding season. Results from this study also suggest supplemental feeding may increase per capita contact rates beyond what might be expected from group size alone. This study illustrates how feedgrounds can be a driving force of disease transmission among elk in western Wyoming.

7. **Cost-benefit analysis of elk brucellosis seroprevalence reduction in the southern GYE**

Boroff (2013) compared the effectiveness and cost of 3 brucellosis management options for elk, including test & slaughter, *Brucella abortus* strain 19 vaccination and low-density feeding (based on a previous elk feeder compensation plan in which low-density feeding was incentivized) using a combination of stochastic risk and economic models. Her analysis concluded that all options had a negative net benefit (cost), and while test & slaughter was most effective at reducing seroprevalence quickly, the cost to implement this management option far exceeded that of vaccination and low-density feeding. She concluded that low-density feeding was the most cost-effective management strategy currently available to manage brucellosis. Early end date management was not included in the analyses.

8. **Effects of supplemental feeding of elk on seasonal migration**

Jones et al. (2014) utilized data from GPS collars deployed on 219 adult female elk at 18 feedgrounds and 4 adjacent native winter ranges to evaluate the effect of supplemental feeding on migration. They found that fed elk were consistently less responsive to spring green-up and more responsive to cold temperatures and precipitation events. Feedground elk had a delayed arrival to and early departure from summer range; residing on summer range 26 fewer days than unfed elk. Feedground elk carried slightly more body fat than unfed elk by March, though differences were not significant. This study indicates that feedground elk may be exploiting hay in lieu of building body reserves on summer ranges, resulting in higher program costs and increased brucellosis prevalence. Early cessation of feeding, where and when possible, would likely increase elk response to green-up and could maximize the distance between elk and cattle, as opposed to lingering on transitional ranges where commingling risk is higher. Future research could experiment with determining a "feeding threshold" on feedgrounds; the minimum amount of hay needed to trigger elk to more closely mimic migration behavior of free-ranging elk while also controlling elk movements and distributions to minimize risk of elk damage and elk-cattle commingling during winter.

9. **Timing of birth, abortion, and brucellosis transmission**

Cross et al. (2015) utilized results of elk implanted with VITs (498, 2006-2014) and data on elk abortions discovered by WGFD personnel working on feedgrounds (79, 1968-2014) to determine risk periods for birth and abortion in elk. Reviewing reproductive results from seronegative (333) and seropositive (165) elk implanted with VITs, they found that 2% and 16%, respectively, experienced reproductive failures. The study reported that the abortion risk period in feedground elk was from 5 February to 10 July, peaking in March through May. 95% of the brucellosis transmission risk period was over by 6 June. This information, in combination with elk GPS collar location data, are being utilized by the WGFD to develop models of spatiotemporal brucellosis transmission risk across the entire elk feedground system.

10. **Evaluation of the 30-year *B. abortus* strain 19 ballistic elk vaccination program**
Maichak et al. (*in press*) used feedground elk brucellosis seroprevalence data and the results of vaginal implant transmitters implanted in vaccinated and unvaccinated elk populations since 2006 to evaluate the efficacy of a *B. abortus* strain 19 elk vaccination program initiated by the WGFD in 1985. The study reported mean annual coverage of elk calves among vaccinated feedgrounds was 97%, but found no differences between: 1) seroprevalence data pre-vaccination vs. post vaccination; 2) seroprevalence of vaccinated elk populations vs. an unvaccinated population; and 3), the abortion rate of elk attending vaccinated vs. unvaccinated feedgrounds. The authors attributed the poor efficacy of the *B. abortus* strain 19 elk vaccination effort on reducing seroprevalence to the weak efficacy of the vaccine in elk itself, and the high transmission potential (R0) even a single fetus represents.

Furthermore, many aspects of feedground elk ecology, brucellosis transmission and pathology, and feedground management have not been investigated. Potential research topics that could assist in management decisions include:

1. Successes or failures of implementing the Target Feedground Management Plan (WGFD 2016). Before determining whether target feedground management is affecting brucellosis seroprevalence, it must first be determined if the two primary objectives (i.e., low-density feeding and early end dates) are being implemented properly and consistently. There are currently no adequate measures available to determine the degree to which low-density feeding is being implemented, and there appears to be considerable variation in how low density feeding is being conducted on the ground. Additionally, there are currently no measures to determine how successful managers have been in ending the feeding seasons earlier outside of subjectively comparing photo points and snow levels at feeding end times. Without an adequate measure of how successfully these two objectives have been applied, it will be difficult to attribute any potential changes in brucellosis seroprevalence to target feedground management. Research that could have significant management applications may include the following:
    a. Use elk GPS collars, GPS trackers on feed sleds and aerial cameras to develop a low density feeding index that measures the density of hay distribution at each feedground.
    b. Compare a low density feeding index to brucellosis seroprevalence data to determine relationships.
    c. Use feeding end dates and GPS collar and snow cover satellite data to predict when elk would have left feedgrounds on their own volition, compare elk movements on target feedgrounds vs. non-target feedgrounds to determine how successful managers were (in days) of encouraging elk to redistribute from feedgrounds.

   d. Evaluate effect of feed type (grass vs. alfalfa vs. pelletted hay) on end feeding date and distances elk move from feedgrounds during the latter portion of the feeding season, with respect to lbs/head fed, native habitat availability, and feedground population size.
   e. Develop a methodology for determining optimal end feeding dates in real time using remote sensing.

2. Virulence of the various *Brucella abortus* strains found in feedground elk.
3. Role of native habitat enhancement and snow water equivalent (SWE) near feedgrounds on feedground dependence of elk (i.e. distribution, dispersal, length of feeding season, brucellosis seroprevalence).
4. Disease presence (other than brucellosis) and parasite loads in elk on feedgrounds.
5. Relationship of local scavenger densities and specie assemblages vs. scavenging rates on feedgrounds.
6. Reproductive impacts of *B. abortus* infections in elk over time.
7. Genetic comparison of seropositive elk that do or do not abort.
8. Potential of aerosol transmission of brucellosis.
9. Potential for salt/mineral licks as sites of inter- and intraspecific brucellosis transmission.
10. Model population and brucellosis seroprevalence impacts of a test and vaccinate (immuno-contraceptive) pilot project.
11. Comparisons of hay quality from where elk are vs. are not fed on irrigated meadows.
12. Seroprevalence in elk that are frequently vs. infrequently captured on feedgrounds ("bottom-feeder" hypothesis).

H. Literature Cited

Barbknecht, AE, WS Fairbanks, JD Rogerson, EJ Maichak, and LL Meadows. 2009. Effectiveness of vaginal-implant transmitters for locating elk parturition sites. Journal of Wildlife Management 73:144-148.

_____, _____, _____, _____, BM Scurlock, and LL Meadows. 2011. Elk (Cervus elaphus nelson) parturition site selection at local and landscape scales in western Wyoming. Journal of Wildlife Management IN PRESS.

Boroff, KL. 2013. Cost-benefit analysis of elk brucellosis prevalence reduction in the Southern Greater Yellowstone Ecosystem. University of Wyoming.

Cook, WE. 1999. Brucellosis in elk: studies of epizootiology and control. Ph.D. Dissertation, University of Wyoming, Laramie, Wyoming, 183pp.

Cole, EK. AM Foley, JM Warren, BL Smith, SR Dewey, DG Brimeyer, WS Fairbanks, H Sawyer, and PC Cross. 2015. Changing migratory patterns in the Jackson elk herd. *The Journal of Wildlife Management*. *79*(6). pp.877-886.

Creech, TG, PC Cross, BM Scurlock, EJ Maichak, JD Rogerson, J Henningsen, and S Creel. Low-density feeding reduces elk contact rates and brucellosis transmission on feedgrounds. Journal of Wildlife Management 67:877-886.

Cross, PC, WH Edwards, BM Scurlock, EJ Maichak, and JD Rogerson. 2007. Effects of management and climate on elk brucellosis in the Greater Yellowstone Ecosystem.

Ecological Applications 17:957-964.
Cross, PC, EJ Maichak, A Brennan, BM Scurlock, J Henningsen, and G Luikart. 2013. An ecological perspective on Brucella abortus in the western United States. Revue Scientifique et Technique-Office International des Epizooties 32:79-87.
Cross, PC, EJ Maichak, JD Rogerson, KM Irvine, JD Jones, DM Heisey, WH Edwards, BM Scurlock. 2015. Estimating the phenology of elk brucellosis transmission with hierarchical models of cause-specific and baseline hazards. Journal of Wildlife Management 79:739-748.
Dorsey, L. 2005. A conservative approach to estimating forage production, availability, and elk consumption during winter on the Gros Ventre Valley Winter Range. Greater Yellowstone Coalition. 6pp. Jackson, Wyoming.
Dorsey, L, M Taylor, and T Darin. 2005. Brucellosis Solution for Elk and Cattle in Wyoming. *A proposal submitted to Governor Dave Freudenthal*. 6pp. Jackson, Wyoming
Forristal, VE, S Creel, ML Taper, BM Scurlock and PC Cross. 2012. Effects of supplemental feeding and aggregation on fecal glucocorticoid metabolite concentrations in elk. The Journal of Wildlife Management. 76: 694-702.
Herriges, JD Jr, ET Thorne, SL Anderson, and HA Dawson. 1989. Vaccination of elk in Wyoming with reduced dose strain 19 *Brucella*: Controlled studies and ballistic implant field trials. Proceedings of the U. S. Animal Health Association 93:640-655.
Jones, JD, MJ Kauffman, KL Monteith, BM Scurlock, SE Albecke, PC Cross. 2014. Supplemental feeding alters migration of a temperate ungulate. Ecological Applications 24:1769-1779.
Maichak, EJ, BM Scurlock, JD Rogerson, LL Meadows, AE Barbknecht, WH Edwards, and PC Cross. 2009. Effects of management, behavior, and scavenging on risk of brucellosis transmission in elk of western Wyoming. Journal of Wildlife Diseases 45:398-410.
Maichak, EJ, BM Scurlock, PC Cross, JD Rogerson, WH Edwards, BL Wise, SE Smith, TJ Kreeger. 2016. Assessment of the *Brucella abortus* Strain 19 ballistic vaccination program in elk on winter feedgrounds of Wyoming, USA. Wildlife Society Bulletin. In Press.
Roffe, TJ, LC Jones, K Coffin, ML Drew, SJ Sweeny, SD Hagius, PH Elzer, and D Davis. 2004. Efficacy of single calfhood vaccination of elk with *Brucella abortus* strain 19. Journal of Wildlife Management 68:830-836.
Scurlock, BM, WH Edwards, T Cornish, and LL Meadows. 2010. Using test and slaughter to reduce prevalence of brucellosis in elk attending feedgrounds in the Pinedale Herd Unit of Wyoming: results of a 5 year pilot project. WGFD, Cheyenne, Wyoming.
WGFD. 2006. Evaluation of a Proposal from the Wyoming Outdoor Council, Greater Yellowstone Coalition and Jackson Hole Conservation Alliance for a Phase Out of Elk Feeding in the Gros Ventre. 37pp. WGFD, Cheyenne, Wyoming.
_____. 2016. Annual Big Game Herd Unit Job Completion Report (2015) for the Jackson Elk Herd Unit (E102), Jackson Region. WGFD, Cheyenne, Wyoming.
_____. 2015. Target Feedground Management Plan. WGFD, Cheyenne, Wyoming.