Upper Green River Elk Herd Unit (E107)
Brucellosis Management Action Plan
April 2016

A. Introduction

This update to the Upper Green River elk herd unit (UGREH) Brucellosis Management Action Plan (BMAP) was prepared to evaluate brucellosis management recommendations developed and implemented during this plan's original development in 2007 and revision in 2011. 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 UGREH to better understand characteristics of elk to elk brucellosis transmission, refine elk parturition range delineations, and to reduce the risk of both intra- and inter-specific brucellosis transmission. This update should be considered complementary to the original UGREH BMAP and the UGREH BMAP 2011 update.

The UGREH is located on the northwest slope of the Wind River Mountain Range in northern Sublette County, Wyoming and includes elk from hunt areas (HA) 93, 95 and 96 (Figure 1). The area is bound on the northwest by Hoback Rim, the north by Union Pass, the east by the Continental Divide, the southeast by Pine Creek and Fremont Lake, and the southwest by the Green River. Total area of the UGREH is approximately 828 square miles (mi²), of which 760 mi² are considered occupied elk habitat. Approximately 502 mi² is delineated as Spring/Summer/Fall range, 104 mi² as Winter Yearlong, 48 mi² as Crucial Winter Yearlong, 56 mi² as Winter, and 48 mi² as Crucial Winter (Figure 2). A total of 202 mi² are delineated as Parturition range and overlap with various seasonal ranges. Three feedgrounds are located within the UGREH; Green River Lakes, Black Butte, and Soda Lake. The Green River Lakes feedground was established to minimize starvation losses, while the other two feedgrounds were developed primarily to reduce depredation to privately owned stored hay. The U.S. Forest Service (USFS) manages the majority of lands within the occupied elk habitat in the UGREH, with 30.7% designated as Wilderness (Bridger Wilderness). Private lands comprise 20.5 % of the herd unit with most concentrated at lower elevations associated with riparian and floodplain habitat of the Green River, New Fork, and Willow Creek drainages.

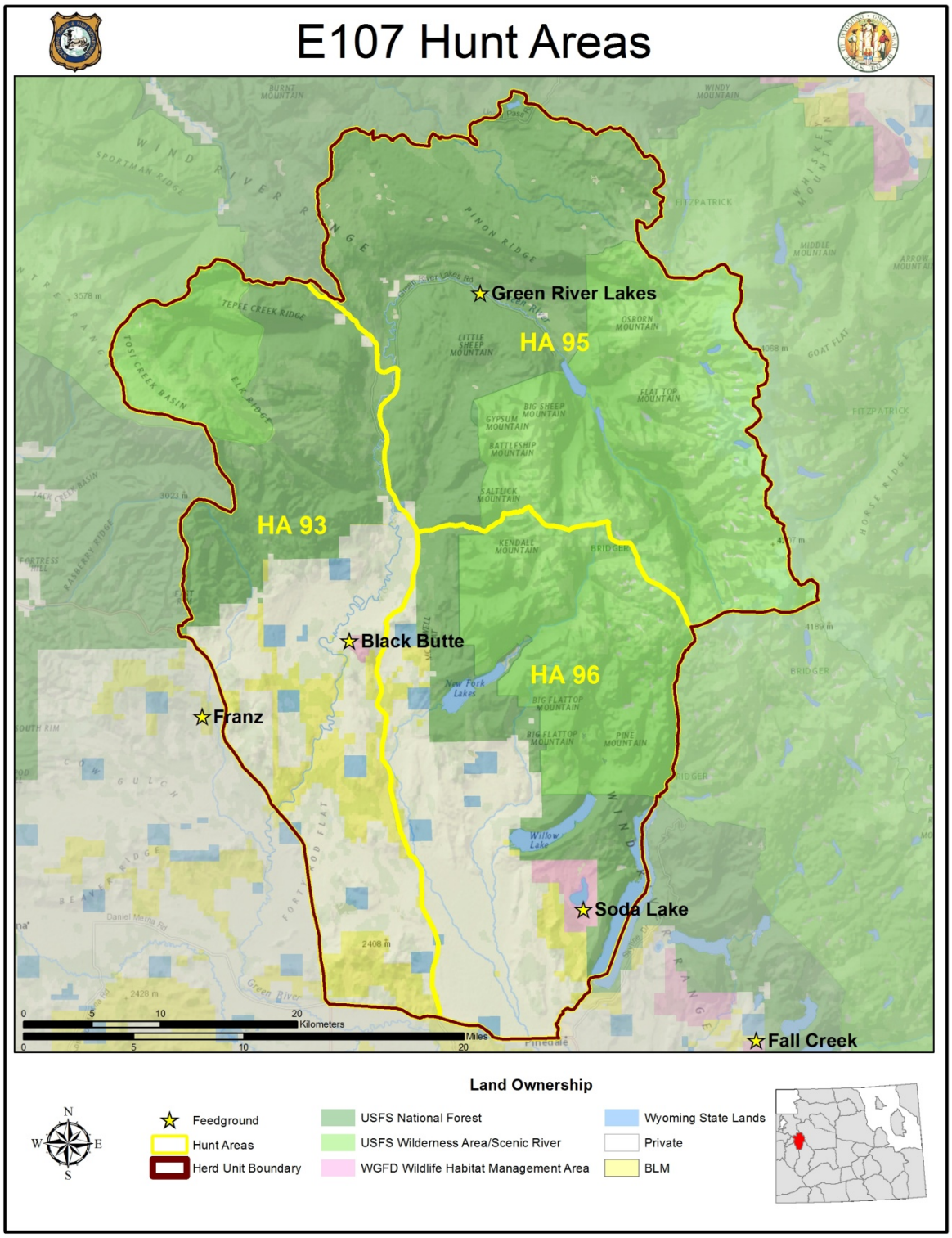

Figure 1. Land ownership, feedground locations, and hunt areas within the UGREH.

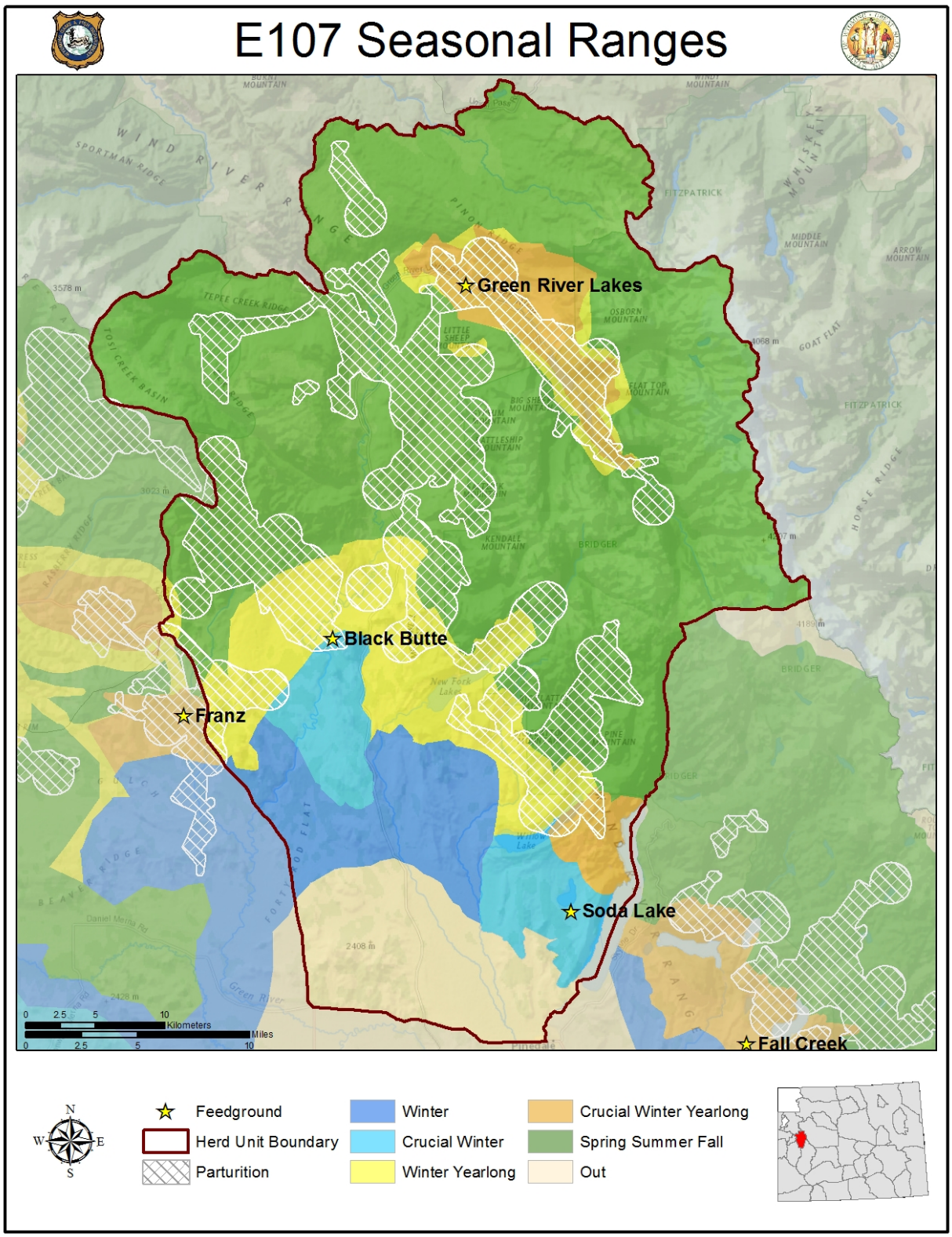

Figure 2. Seasonal elk ranges, parturition range, and elk feedgrounds within the UGREH.

B. **Brucellosis Management Options**

Listed below are potential options for managing brucellosis on the three feedgrounds in the UGREH. 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. 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

Phasing out most feedgrounds in the UGREH is probably unfeasible at this time due to the inability to maintain current population objectives without supplemental feeding. If current conditions and herd objectives change, through implementation of one or more of options 2 – 8, this option might become more realistic. Among the feedgrounds in the UGREH, population impacts and damage issues resultant from a potential feeding phase-out would be lowest for the Green River Lakes feedground, followed by Soda Lake, then Black Butte feedgrounds.

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 occur 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 over 10 years 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

Green River Lakes has a high potential for shortened feeding seasons due to low damage/commingling risk. Soda Lake feedground also has a high potential because of the 25-mile elk fence separating private from public lands, a large winter range closure area, and abundant native forage in close proximity to the feedground resulting from numerous habitat treatments over the last 20 years. Attempts to shorten the feeding seasons at Green River Lakes and Soda Lake have occurred annually since 2008 with some success (see Research section on pp17-18 for background on the Target Feedground Project). The average end of feeding date since 2008 has been shortened by 9 days at Soda Lake compared to the previous 10-year average. However, the end feeding date at Green River Lakes feedground is now 7 days later than the 10 year average prior to 2008. Difficult logistics

in reaching the feedground during spring, limited internal cooperation in executing shortened feeding seasons, and fears of political ramifications from local consumptive users have hampered efforts to truncate the feeding season at Green River Lakes feedground.

Since 2010, elk numbers at Soda Lake have approximately doubled largely due to interchange with elk from Black Butte feedground and several years of less than desired harvest. As numbers have increased, end date management at Soda Lake feedground has been less aggressive due to concerns of adequate available native forage and fear of damage/commingling issues, both real and perceived. To mitigate damage/commingling concerns, steel gates were installed in summer 2012 at 5 elk jump openings within the elk fence which are closed upon feeding end, and extensions to increase fence height were also added in one location where drifted snow may have allowed elk to pass over the fence in the past.

This option, given current conditions and herd objectives, is probably unfeasible for the Black Butte feedground, unless elk were relocated to a new site or an existing feedground where intra- and interspecific brucellosis transmission risks were lower (e.g., Soda Lake feedground). This option would probably require implementation of option 3. Options 4, 6, 7, and 8 would also facilitate successful implementation. The WGFC has the authority to make this decision.

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. 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

Black Butte is the most apparent feedground in the UGREH where relocation could improve brucellosis management. Most elk/livestock conflict within the UGREH is associated with elk that leave this feedground during the supplemental feeding season.

Moving the feedground to nearby BLM or USFS land is not a possibility at this time, and would probably not lower brucellosis transmission risks to cattle.

Alternatively, elk from Black Butte feedground could be relocated to the existing Soda Lake feedground. In recent years, numbers of elk attending the Soda Lake feedground have been above objective due to less than desired harvest and a partial consolidation of the two feedgrounds. When elk numbers were above 1,400 at Soda Lake, as in 2014 and 2015, outbreaks of necrotic stomatitis occurred resulting in above average calf mortality. Contributing factors included elk number/density, amount/frequency of snowfall, relatively warm temperatures resulting in pooled water on a large portion of the feedground, type of feed (alfalfa instead of native grass hay), mismanagement of carcasses on the feedground, and lack of adequately distributed feed across the entire available feeding area. If the proper steps are taken to avoid outbreaks of necrotic stomatitis, the consolidation of elk on the Soda Lake elk feedground would allow a greater opportunity for elk to free range, increase harvest opportunity, and lead to shortened feeding season which would lower brucellosis prevalence. While difficulties may be realized in keeping elk spatially separated from cattle or private stores of hay on their route from Black Butte to Soda Lake feedground, the development of hunter management areas and liberal private-land only hunting seasons are proven methods that would facilitate elk movements. The WGFC has the authority to make this decision.

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

Elk herd management regimes in the UGREH are designed to maintain elk numbers established by the WGFC. Current feedground quotas are as follows: Green River Lakes, 675; Black Butte, 500; and Soda Lake, 800. These quotas were last changed in 1987, when the objective for Black Butte was increased from 357 to the current quota. The current post-hunt population objective for the UGREH is 2,500 elk, with 1,975 on feedgrounds and the remaining 525 on native winter range. During winter 2006, a total of 2,217 elk were counted on Green River Lakes (675), Black Butte (750), and Soda Lake (1,017) feedgrounds, with 213 found on native winter range. This herd count is down 153 from the previous year likely due to mild winter conditions with more elk wintering out, where they are difficult to observe. Disease transmission at all feedgrounds within the UGREH would probably be affected positively with fewer elk, as densities at feedgrounds would decrease. The Soda Lake feedground may benefit most because feedground elk numbers have recently

exceeded the WGFC quota of 800.

5. Fencing

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).

Pros:

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

Cons:

- 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

Interspecific disease transmission risk in association with Black Butte feedground would decrease more than other feedgrounds in the UGREH with implementation of this option, whether implemented on public or private lands, because damage/commingling risk connected with elk from this feedground is currently higher. Where fencing stackyards is considered beneficial in preventing damage to stored crops or reducing the risk of elk-cattle commingling, the WGFD provides fencing materials and suggested schematics to landowners at no charge. Materials for over 50 stackyards have been distributed in the UGREH since the early 1990's. A drift fence erected in 1947 runs for 25 miles from north of New Fork lake south to Fremont Lake along the private-public land interface, and the WGFD will continue to maintain this fence for preventing the movement of elk onto private lands while facilitating the migration of other ungulates through the fence to the extent possible. Fencing projects around the feedgrounds at their current locations would require favorable decisions by the landowner (state and/or federal).

6. Elk Test and Slaughter

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.

Pros:

- 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

Cons:

- 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 projects have been utilized in areas adjacent to feedgrounds with some success in reducing feeding duration. Projects should be designed in areas that provide opportunity for elk to free range during the brucellosis transmission period in areas away from cattle. The decision authority is with the BLM and USFS for most areas. Affected permittee or private landowner consultation and cooperation is also necessary. This option may be best used in conjunction with options 1, 2, 3 and to achieve maximum success.

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 risk of intra- and interspecific disease transmission would likely decrease on the Green River Lakes and Soda Lake feedgrounds through decreased dependence on supplemental feed through enhanced habitat. Since 1989, there have been treatments totaling 6,250 acres at six locations near Soda Lake feedground, which has likely facilitated shortened feeding seasons there. In the Upper Green, the proposed 21,000 acre Pinyon Ridge habitat treatment has been postponed indefinitely due to litigation and other USFS priorities. There is currently low potential for a brucellosis management outcome with implementation of this option near the Black Butte feedground, though cattle grazing on the WGFD property surround this feedground has been implemented since 2009 to encourage elk to utilize areas where they can be harvested.

8. Acquisition/Conservation Easements

Disease transmission risk on feedgrounds in the UGREH 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 can be reduced. This option also secures habitat for other wildlife species. The buying or long-term leasing of land to be managed commensurate with wildlife benefits is an option that can be used to maintain stabile and healthy wildlife populations. 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

Disease transmission risk on all feedgrounds within the UGREH may decrease by managing lands adjacent to, or connected with, native elk winter ranges.

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

An effective vaccine would be beneficial to management of brucellosis at all three feedgrounds in the UGREH and would increase opportunity to implement options 1, 2, 4. The decision authority to implement a new vaccination program lies with the WGFC.

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 recovered elk GPS collars, 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

Producers and land managers throughout the UGREH may be benefited by understanding where brucellosis risk from elk is temporally/spatially located.

D. **Coordination Meetings**

1. Producer Meeting

A meeting was held December 18th, 2015 in Pinedale to discuss the ten options among livestock producers and associated land and resource management agencies within the UGREH and Pinedale elk herd. A presentation was given by the WGFD that summarized brucellosis management and research strategies and their relation to the ten options. Eighteen producers, the Assistant State Veterinarian from WLSB, and 1 BLM, 2 BTNF and 6 WGFD employees were present.

Much of the discussion revolved around implementation of test & slaughter in the Pinedale elk herd, but there was a general comment that lowering elk population objectives as a brucellosis management tool could reflect poorly on producers and that test & slaughter was a more attractive option to reduce risk and numbers. However, nearly all producers present were extremely supportive of implementing test and slaughter on feedgrounds, especially on those feedgrounds where a high risk of elk-cattle commingling exists. One producer commented that the HA96 cow/calf hunting season should be

extended to control the increasing elk population at the Soda Lake feedground to lower risk. Another commenter stated that current elk seasons and tags are complicated and should be simplified to encourage greater participation. Several producers voiced their support for feedgrounds in general, encouraging the continuation of feeding and admonishing phase out. Producers generally agreed that there was a divide in cattlemen brought about by the creation of the Designated (brucellosis) Surveillance Area in Wyoming; segregating producers has resulted in a loss of unification. Another commenter inquired whether *Brucella abortus* might be mutating genetically to become more virulent, at least partially explaining recent increases in brucellosis prevalence among winter-free ranging herds. Several producers suggested that wolves have a large impact upon elk distribution and aggregation which may be impacting brucellosis transmission dynamics.

There was much discussion on vaccines, and producers generally agreed that the best solution would be a good vaccine for cattle and a good vaccine for elk. The delivery method of the recently decommissioned *Brucella abortus* (S19*)* vaccine program in elk was very successful (97% of calves vaccinated), though the vaccine itself was not. Future research could hold promise of a better vaccine for elk. The WGFD recently cooperated with the USDA-APHIS-VS on an elk study in Colorado that is attempting to circumvent the select agent rule by invoking a 'natural challenge' in elk. Ten brucellosis seropositive, pregnant elk from Scab Creek feedground were captured and shipped to a research facility in Ft. Collins in hopes they will abort and infect naïve elk brought in from clean herds. The infection rate could then be used to establish a baseline from which to test efficacy of various vaccines. Gonacon™, another vaccination approach which prevents conception, and thus, abortion, in elk for at least 3 years could be used to fight brucellosis. One producer had concerns that Gonacon™ could reduce populations, and managers suggested that an effort to model population effects over time would be informative. Discussion continued about vaccine and vaccination strategies in cattle, particularly the anecdotal evidence suggesting the less superior efficacy of *Brucella abortus* RB51 vs. S19. The WSLB offered that S19 had issues with false positives and the initial results with RB51 showed good protection which is why the decision was made to switch vaccines; boostering with RB51 has better results in terms of protection and should be standard practice.

2. Public Meeting

A meeting was held March 24th, 2016 between the WGFD and concerned members of the public to discuss the ten options as they pertained to the Pinedale, Upper Green River, Big Piney and Hoback elk herds. Three interested publics, one producer and four WGFD personnel attended the presentation which summarized WGFD brucellosis management and research strategies and their relation to the ten options. The options of feedground phase-out, reduced feeding season length, and vaccination as well as other aspects of brucellosis were discussed throughout the presentation.

For the option of phase-out, it was noted that this should be considered as the USFS conducted a study in the 1950's indicating that feedgrounds could be closed if livestock grazing were eliminated in the foothills (native winter ranges) around Pinedale. However, a follow-up comment cautioned that closing feedgrounds could negatively impact other big game herds via competition. Regarding the option of reduced feeding season length, a producer commented that this option makes sense yet noted an apparent increase in elk near Willow Lake in spring in recent years and is concerned that elk are near cattle during the high-risk period. It was also suggested that the WGFD close gates on the Soda Lake elk

fence and notify affected landowners when managers decide to end feeding. For the option of vaccination, there was a comment cautioning the reporting of high vaccination coverage (97%) as a 'success' of the program because the biobullet is a poor drug delivery system, and questions about delivery methods of oral vaccines and effectiveness of strain RB51 in elk. Additional questions and comments touched on several aspects of brucellosis including: ecology (weather-dependent environmental persistence of *Brucella abortus*, limited population effects); management (Hunter Management Areas (HMAs) prevent elk presence on private land, need for interagency collaboration and surveillance); economics (impacts to livestock trade, profits, and compensation); funding (eliminate feedground stamp, derive funding from agricultural interests); and politics (described as a 'political football').

E. **Proposed Management Actions**

1. Feedground phase-out

The potential for phase out of the feedgrounds in the UGREH is currently low given current population objectives and low tolerance for elk damage and elk-cattle commingling. There is no proposal to eliminate any feedground in the UGREH.

2. Reduced feeding season length

WGFD will continue to manage feeding seasons for early feeding end dates at the Green River Lakes and Soda Lake feedground. This is accomplished by systematically reducing hay rations as native forage becomes accessible in the late winter/early spring to encourage elk to leave the feedground earlier. Stocking grass hay (vs. alfalfa) at these sites will facilitate efforts to encourage elk distribution away from feedgrounds while reducing the potential for outbreaks of necrotic stomatitis. Based on research, it is expected that a 2/3 reduction in brucellosis seroprevelance can be achieved through manipulating for feeding management that results in an average end feeding date of 3 weeks earlier over 10 years. There is currently no potential to implement this option at the Black Butte feedground.

3. Feedground Relocation

Based on elk counts and marked individuals, many elk that would have normally wintered at Black Butte feedground have migrated to the Soda Lake feedground in recent years. While it is unknown how long these movements have occurred, a result of fewer elk attending Black Butte feedground has reduced the intra and inter-specific disease transmission risk there by lowering elk density. Additionally, elk that switched feedgrounds also realized lower brucellosis risk through the shorter feeding season at Soda Lake feedground. The down-drainage movement of elk from Black Butte to Soda Lake will likely continue as more elk learn the migration as the southerly movement along the western slope of the Wind River Range is a commonly used migration route for other ungulates (e.g., mule deer and pronghorn). However, when the elk population at Soda Lake has climbed above 1,400 (as in 2014 and 2015), necrotic stomatitis has become a problem on the feedground, resulting in higher than average mortality. Given current population objectives and feedground quotas, and current elk conflicts on private lands between Black Butte and Soda Lake, combining Black Butte with the Soda Lake feedground is unfeasible at this time. However, through a combination of liberal private land hunting seasons and establishment of HMA's, and the potential expansion of the feeding area(s) at Soda Lake, this option may become feasible in the future.

4.Elk population reduction

Reductions beyond the current population objective would require a public input process to determine the level of support. Authority ultimately lies with the WGFC. The WGFD will continue to manage for current WGFC-established elk herd unit population objectives, but with a recently increasing population trend in the UGREH, changes have allowed hunters to possess up to 3 cow/calf tag in both HA93 and HA96. The WGFD will continue to design and implement other harvest strategies that manage the population at objective, with desirable distribution of elk between Soda Lake and Black Butte feedgrounds.

5.Fencing

There are no current plans to construct fencing for brucellosis management in the UGREH. A wing was added to the fence in the Spring Gulch area near the Soda Lake feedground to facilitate hazing of elk through a gate in the existing 25-mile elk fence. An additional wing has been identified for construction on private land in the northern portion of the fence which should facilitate hazing elk from commingling situations to Soda Lake feedground. The extension of the existing elk fence north of New Fork lake along the USFS boundary toward the Upper Green could facilitate movement of elk from Black Butte to Soda Lake. However, this would undoubtedly impact movements of other ungulates and is not considered beneficial at this time.

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

Several additional areas have been identified in the UGREH unit near feedgrounds for potential treatments. Pinyon Ridge, north and east of the current Green River Lakes feedground, includes several large south-facing slopes currently and historically used by wintering elk. These 21,000 acres are part of the 32,000-acre Moose-Gypsum Creek project proposed by the USFS that would be implemented over 10 years, but the treatment is currently postponed indefinitely due to litigation and other USFS priorities. Near the Soda Lake feedground, habitat treatments on the large southerly exposure on the ridge north of Willow Lake may be beneficial to managing brucellosis, but this treatment is not likely to be implemented due to rising concerns over the establishment of cheat grass. WGFD personnel will continue to work cooperatively to obtain funding for implementation of treatments, where possible.

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 elk vaccination options

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 high 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.

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* mutants 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. Gonacon™: model impacts to feedground elk populations and seroprevalence.

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 75:646-654.

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

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.

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. Journal of Wildlife Management. 76:694-702.

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. 2007. Big Piney Elk Herd Unit (E106) Brucellosis Management Action Plan. WGFD, Cheyenne, Wyoming.

_____. 2015. Target Feedground Management Plan. WGFD, Cheyenne, Wyoming.

_____. 2016. Annual Big Game Herd Unit Job Completion Report (2015) for the Piney Elk
Herd Unit (E106), Pinedale Region. WGFD, Cheyenne, Wyoming.