Pinedale Elk Herd Unit (E108)
Brucellosis Management Action Plan Update
April 2016

A. Introduction

This update to the Pinedale Elk Herd Unit (PEH) Brucellosis Management Action Plan (BMAP) was prepared to evaluate brucellosis management recommendations developed and implemented during this plan's original development in 2006 and the 5-year update of 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 PEH 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 PEH BMAP and the PEH BMAP 2011 update.

The PEH is located on the west slope of the Wind River Mountain Range in eastern Sublette and northern Sweetwater Counties, Wyoming and includes elk hunt areas (HA) 97 and 98 (Fig. 1). The area is bounded on the northwest by Pine Creek and Fremont Lake, the northeast by the Continental Divide, the southwest by the Green River, and the southeast by the Big Sandy River. It encompasses 2,433 square miles (mi^2), of which only 690 mi^2 are considered occupied elk habitat. Approximately 404 mi^2 is delineated as Spring/Summer/Fall range, 113 mi^2 as Winter, 99 mi^2 as Crucial Winter Yearlong, 61 mi^2 as Crucial Winter, and 13 mi^2 as Winter Year Long (Fig. 2). A total of 185 mi^2 are identified as Parturition range and overlaps with various seasonal ranges. The remaining 1,743 mi^2 are mostly lower elevation areas in lower precipitation zones, once portions of native elk winter range. Three feedgrounds are located within the PEH; Fall Creek, Scab Creek, and Muddy Creek. These feedgrounds were established primarily to reduce depredation to privately owned stored hay, minimize risk of interspecific commingling of elk and livestock, and reduce winter mortality.

The U.S. Forest Service (USFS) manages the majority of lands within the occupied elk habitat in the PEH, with over half designated as Wilderness (Bridger Wilderness). Most private lands in this herd unit are concentrated at lower elevations associated with riparian and floodplain habitat of the Big Sandy, East Fork, Boulder Creek and Pole Creek drainages. The Bureau of Land Management (BLM) manages the majority of unoccupied elk range within the PEH (Fig. 1).

.

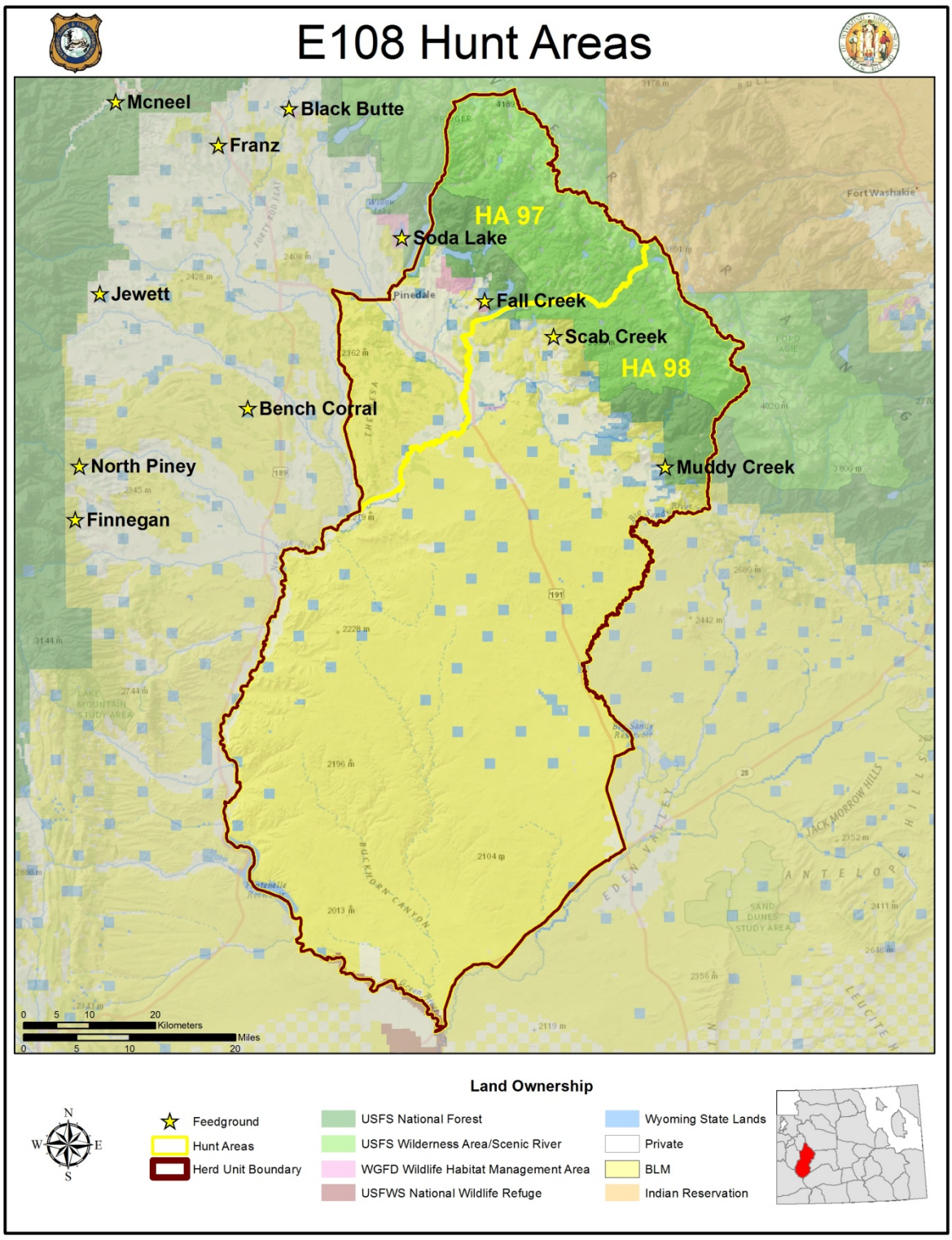

Figure 1. Land ownership, feedground locations, and hunt areas within the PEH.

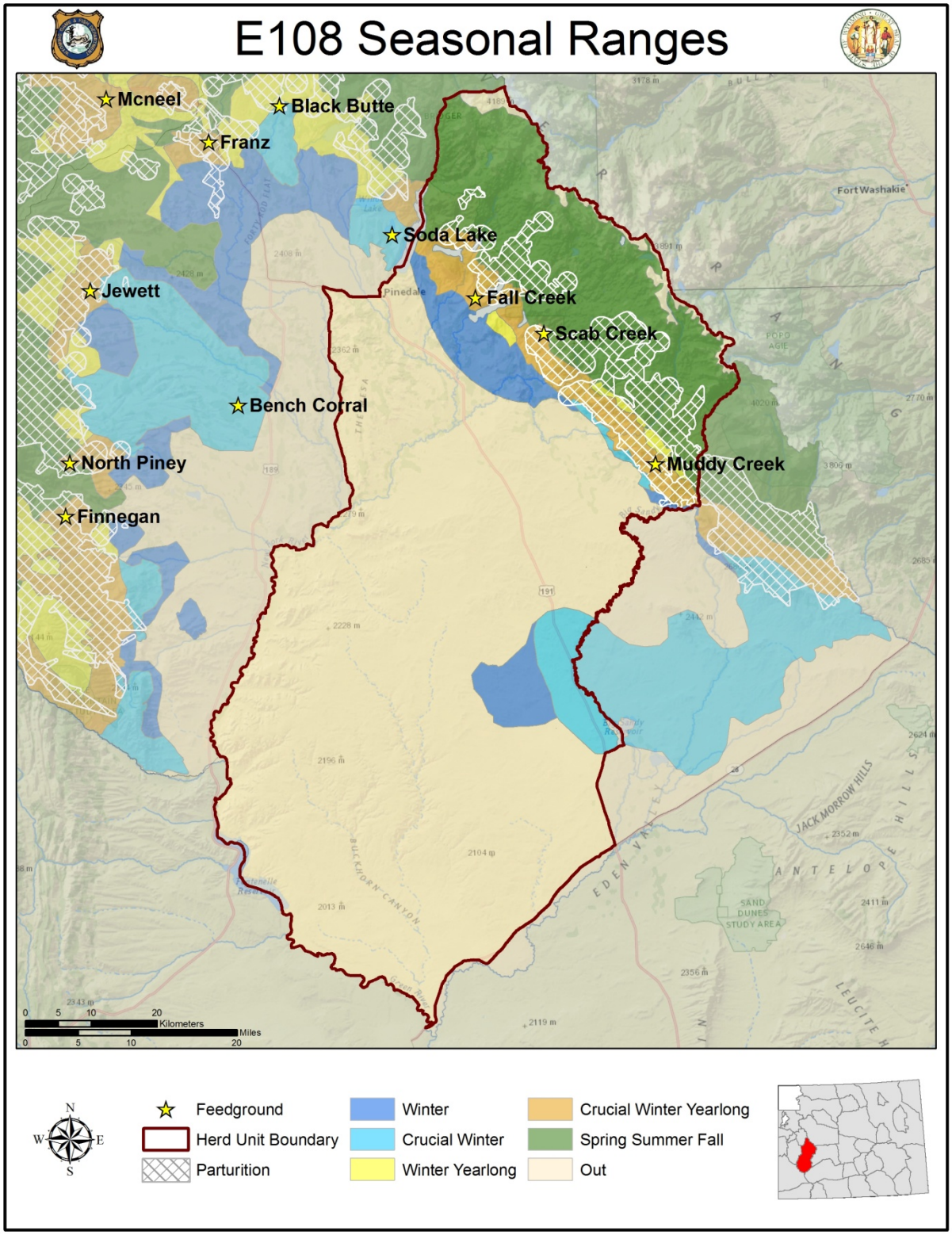

Figure 2. Seasonal elk ranges, parturition range, and elk feedgrounds within the PEH.

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 PEH is probably unfeasible at this time due to the inability to maintain current population objectives and accustomed elk distribution 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 PEH, population impacts and damage issues resultant from a potential feeding phase-out would be lowest for Muddy Creek feedground, followed by Fall Creek and Scab Creek 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 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

Fall Creek has a high potential for shortened feeding seasons due to low damage and elk-cattle commingling risk and a high opportunity for free ranging due to adjacent, abundant habitat on the Half Moon mountain WHMA in combination with fenced hay stacks on neighboring private properties. Scab Creek feedground also has a high potential due to large areas of rocky, south facing slopes that become snow free early in the spring. This option has been implemented at both of these feedgrounds since 2008, with average end feeding dates 18 and 19 days earlier at Fall Creek and Scab Creek feedgrounds, respectively, as compared to their 10-year average prior to 2008 (see Research section on pp17-18 for background on the Target Feedground Project). This option

is currently not feasible on the Muddy Creek feedground, due to high risk of commingling with neighboring cattle, but could be implemented along with 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

Muddy Creek and Scab Creek feedgrounds would benefit through implementation of this option. Moving the Muddy creek feedground would allow the ability to implement option 2, and moving both Muddy and Scab creek feedgrounds would facilitate low-density feeding which is currently not feasible at either location due to the feedground size, shape, and topography. Prior to feeding elk at the present site of the Muddy Creek feedground, the WGFD fed at three other sites. One of these sites was between Pocket Creek and the East Fork River, one at the Leckie place (SE of current site), and another near Buckskin crossing (Figure 3). Scab Creek feedground was also located at two different sites before the present location was selected. Documentation of why these sites were moved is lacking. Reduction of brucellosis transmission would not likely be realized through implementation of this option on the Fall Creek feedground.

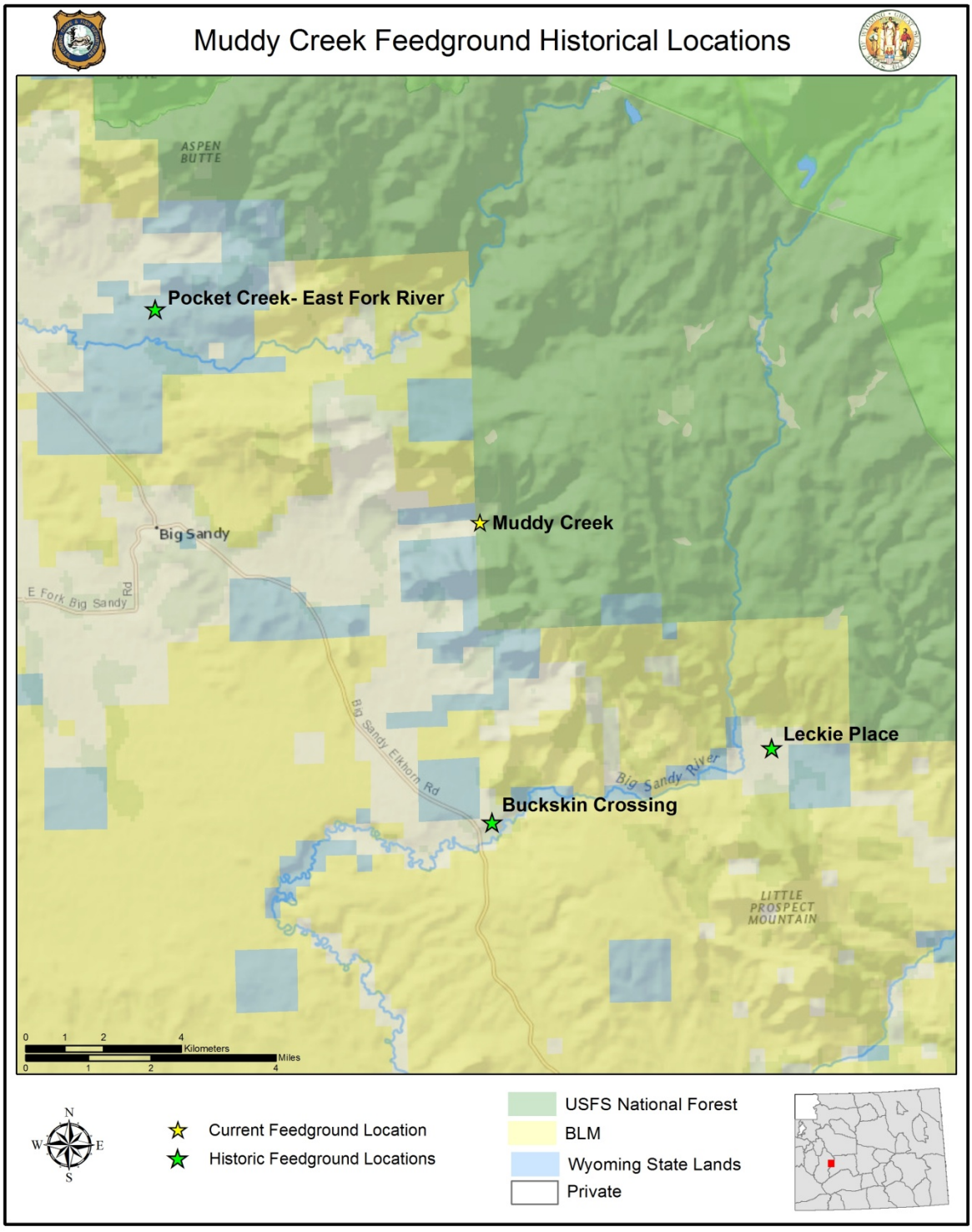

Figure 3. Current and historical locations of the Muddy Creek feedground.

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 PEH have been designed to maintain elk numbers established by the WGFC. Current feedground quotas are as follows: Fall Creek, 700; Scab Creek, 500; and Muddy Creek, 600. These quotas were last changed in 1987, when the objective for Scab Creek was increased from 233 to the current quota, and Fall and Scab Creek remained static. The current post-hunt population trend objective for the PEH is 1,900 elk wintering on and off feedgrounds. During winter 2006, 2,081 elk were counted at Fall Creek (656), Scab Creek (668), and Muddy Creek (571) feedgrounds, with 186 found on native winter range. This herd count is down 67 from the previous year likely due to mild winter conditions with more elk wintering out where they are difficult to observe. All feedgrounds within the PEH would probably be affected equally by implementation of this option. The Scab Creek feedground may benefit the most if numbers were reduced due to consistently having the highest elk attendance and smallest feeding area.

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 commingling with cattle. Fencing roadways would facilitate migration to winter ranges that 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

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 40 stackyards have been distributed in the UGREH since the early 1990's. An elk fence was erected on the border of private and state lands near the Muddy Creek feedground during the 1980's. Because of the 2006 PEH BMAP, a new ~1.5 mi elk fence was added on the western edge of the USFS boundary adjacent to the Muddy Creek feedground. GPS collar data indicate the fence is not effective at preventing down-drainage movement onto private lands during spring, but effectively holds elk on the feedground during winter. Interspecific disease transmission may decrease equally among all feedgrounds within the PEH with further implementation of this option.

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% by 2015. Test and slaughter could also reduce elk seroprevalence and 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 may decrease on all feedgrounds within the PEH with implementation of this option. Since 1996, there have been treatments on 7,200 acres at four locations associated with the Fall Creek feedground and have likely facilitated shortening of the feeding season. Nearly 1,200 acres of habitat has been treated at one location associated with the Scab Creek feedground, providing the potential for elk utilization of the area. However, the location is in close proximity to private lands, and the risk of elk damage and commingling with cattle will likely lead to the hazing of elk back to feedgrounds when present in the treatment area. Further habitat treatments in Muddy Ridge, Irish Canyon, and areas of BLM near Scab Creek may be beneficial to managing brucellosis, but prescribed burns at these locations are not likely to be implemented due to rising concerns of further establishment of cheat grass.

8. Acquisition/Conservation Easements

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

9. Investigate Options for Vaccination

The WGFD initiated the *Brucella* 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 National Elk Refuge. 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 (figure 2), and the number of abortions has not been different between vaccinated and unvaccinated elk (Maichak et al. *in press*). Other options for brucellosis vaccination on elk feedgrounds are being developed and may become available in the future. Another approach is the immune-contraceptive vaccine Gonacon$_{TM}$ which can prevent conception, thereby preventing brucellosis transmission.

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 PEH 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 and land managers can 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 PEH may be benefited by understanding where brucellosis risk from elk is temporally and 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 PEH 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 PEH. Of the three feedgrounds in the PEH, Muddy Creek feedground has the highest potential for phase-out due to the site's close proximity to native winter range and the known interchange of feedground and native winter range-utilizing elk. However, low tolerance for elk-cattle commingling, combined with the potential for elk damage to stored crops on private lands around the Muddy Creek feedground and south from the feedground in elk HA99 remain the dominant drivers in the decision to continue supplemental feeding.

Additionally, concerns have been raised about impacts to elk currently utilizing the winter ranges adjacent to Muddy Creek in HA99 if 300-400 feedground elk were to be moved south. Native winter-range elk in HA99 have been observed foraging in the HW191 right of way extensively during winters with average snowpack. This foraging behavior likely indicates that the quality of the winter range is poor, or that there is low

abundance/availability of forage in HA99. Some wildlife managers have also voiced concerns over increased competition with mule deer and pronghorn, which share some of the winter ranges in HA99, should more elk be expected to winter on these ranges.

Thus, in order to phase-out the Muddy Creek feedground and move those elk to native ranges to the south during winter, elk numbers would likely need to be reduced. Habitat enhancement projects and modifications to current land use practices would need to be conducted to increase forage production on the HA99 winter ranges, and the large numbers of feral equines that use HA99 would need to be removed. Additionally, private landowners and cattle producers in the Muddy Creek area and south would need to modify their operations to reduce the potential for elk damage and elk-cattle commingling. Without these actions, the potential for elimination or phase of the Muddy Creek feedground is low.

2.Reduced feeding season length

The WGFD will continue to manage for early feeding end dates at the Fall Creek and Scab Creek feedgrounds. This is accomplished by systematically reducing hay rations as native forage becomes accessible in the late winter/early spring, in effort to cause elk to leave the feedground earlier than they would have left on their own volition. 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 Muddy Creek feedground due to the close proximity of susceptible cattle in spring.

3. Feedground Relocation

There is currently low potential for moving the Scab and Fall Creek feedgrounds due to current elk numbers, land ownership patterns, and the presence of cattle operations in the vicinity of these feedgrounds. It may be more possible for Muddy Creek feedground as several possible options may be available. Any potential impacts to the producer and public land allotment permittee(s) nearest the new proposed location would need to be evaluated. Discussion of continuation of test and slaughter at Muddy Creek should be partnered with a discussion of feedground-relocation to aid in maintaining lower seroprevalence once it is achieved. WGFD will use elk GPS data to identify potential sites for re-location.

4. Elk population reduction

The PEH is currently within the desired population objective range, and the WGFD will continue to manage for current WGFC-established elk herd unit population objectives. Reductions beyond the current population objective would require a public input process to determine the level of support and WGFC approval.

5. Fencing

An elk-proof fence was erected in 2005 along the USFS boundary and on private land adjacent to the Muddy Creek feedground to prevent elk from funneling into cattle calving areas near the feedground in March/April. GPS collar data and observation by WGFD personnel in the field indicate that elk maneuver the fence when leaving the feeding in the spring, yet typically avoid cattle calving areas. The WGFD encourages cattle

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

6. Elk Test and Slaughter

The WGFD implemented the pilot test and slaughter project in the PEH from 2006 through 2010. The WGFD will retain test and slaughter as a tool for brucellosis management, and discussions of re-instituting test and slaughter at Muddy Creek will be partnered with a discussion of feedground relocation to aid in maintaining lower seroprevalence once it is achieved.

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 PEH. 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 less than 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 land management and livestock health regulatory agencies 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. Model population and brucellosis seroprevalence impacts of a test and vaccinate (immuno-contraceptive) pilot project.

4. 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.