Big Piney Elk Herd Unit (E106)
Brucellosis Management Action Plan Update
April 2016

A. Introduction and herd unit overview

This update to the Piney 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 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 substantial progress in the PEH to better understand characteristics of elk-to-elk brucellosis transmission, refine elk parturition delineations, and to reduce the risk of both intra- and inter-specific brucellosis transmission. This update should be considered complementary to the 2006 PEH BMAP and 2011 PEH BMAP updates

The PEH is located on the east slope of the Wyoming Range in western Sublette and eastern Lincoln Counties, WY and includes elk Hunt Areas (HA) 92 and 94 (Fig. 1). The area is bound on the north by the Hoback Rim, on the northeast by Highway 189, on the east and southeast by the Green River, on the southwest by LaBarge Creek, and on the west by the hydrographic divide between the Green River and Grey's River drainages. The Bureau of Land Management (BLM) is responsible for management of 607 mi^2 (38%) of the surface area in this herd unit. The U. S. Forest Service (USFS) manages 380 mi^2 (24%) of the area. Private and state lands account for the remaining 587 mi^2 (38%) of the area along: North and South Horse Creek; North and South Cottonwood Creek; North, Middle, and South Piney Creek; and LaBarge Creek. Currently, four feeding sites and one staging area (hereafter termed "feedgrounds") are located within the PEH: Franz, Jewett, Bench Corral, Finnegan, and North Piney (staging area). All feedgrounds in this herd unit (excluding Bench Corral) are located along the border of BLM or private lands and USFS lands and were established "uphill" from livestock operations primarily to prevent damage to stored hay (and later, prevent commingling).

The total area of the PEH is approximately 1,575 mi^2, of which 1,122 mi^2 (71%) have been delineated by the WGFD as occupied elk habitat. Approximately 351 mi^2 (31%) are delineated as Spring/Summer/Fall range, 183 mi^2 (16%) as Crucial Winter Yearlong range, 239 mi^2 (21%) as Crucial Winter range, 197 mi^2 (18%) as Winter range, and 151 mi^2 (13%) as Winter Yearlong range. About 441 mi^2 are designated as Parturition range (Fig. 2).

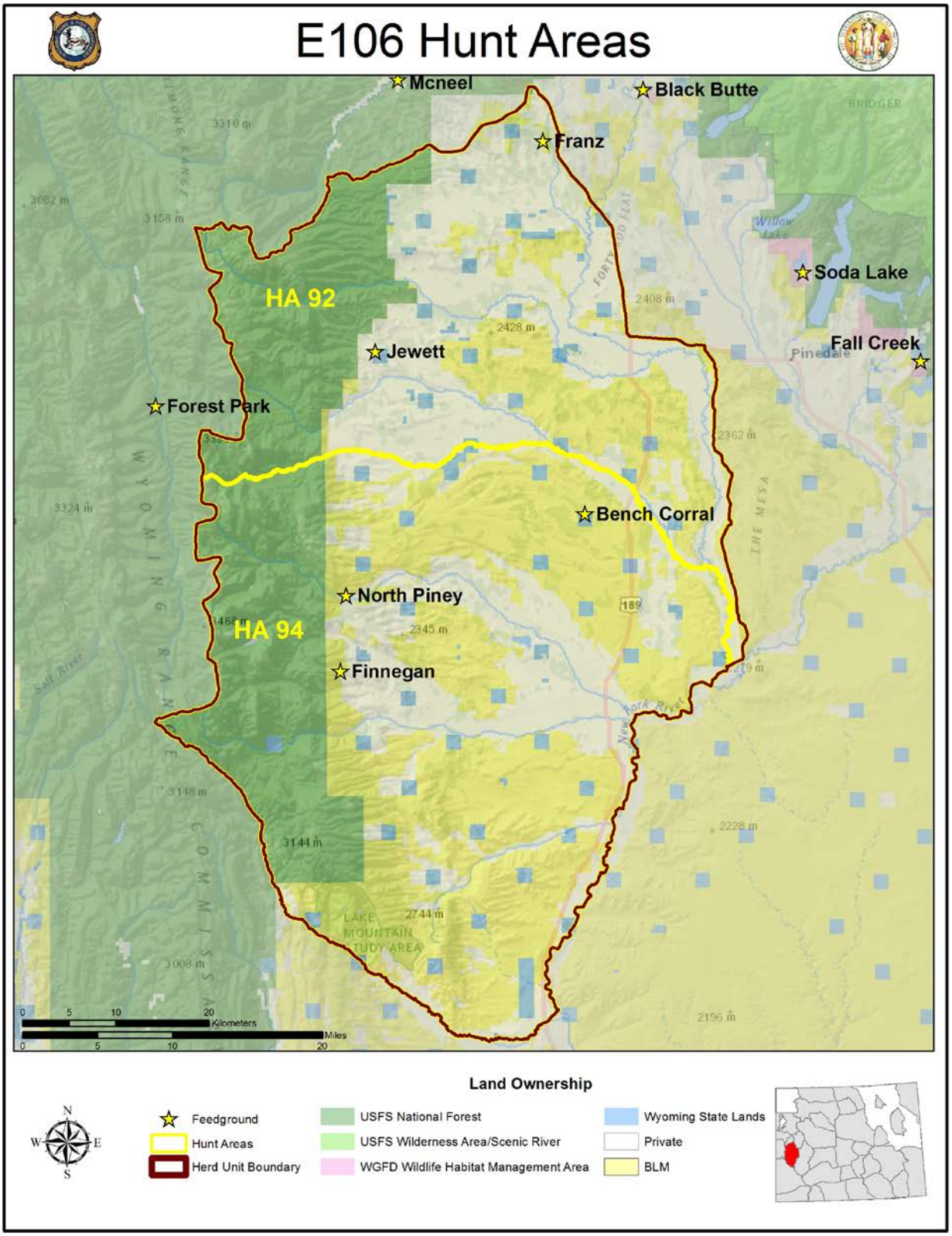

Figure 1. Land ownership, feedground locations, and hunt areas within the PEH.

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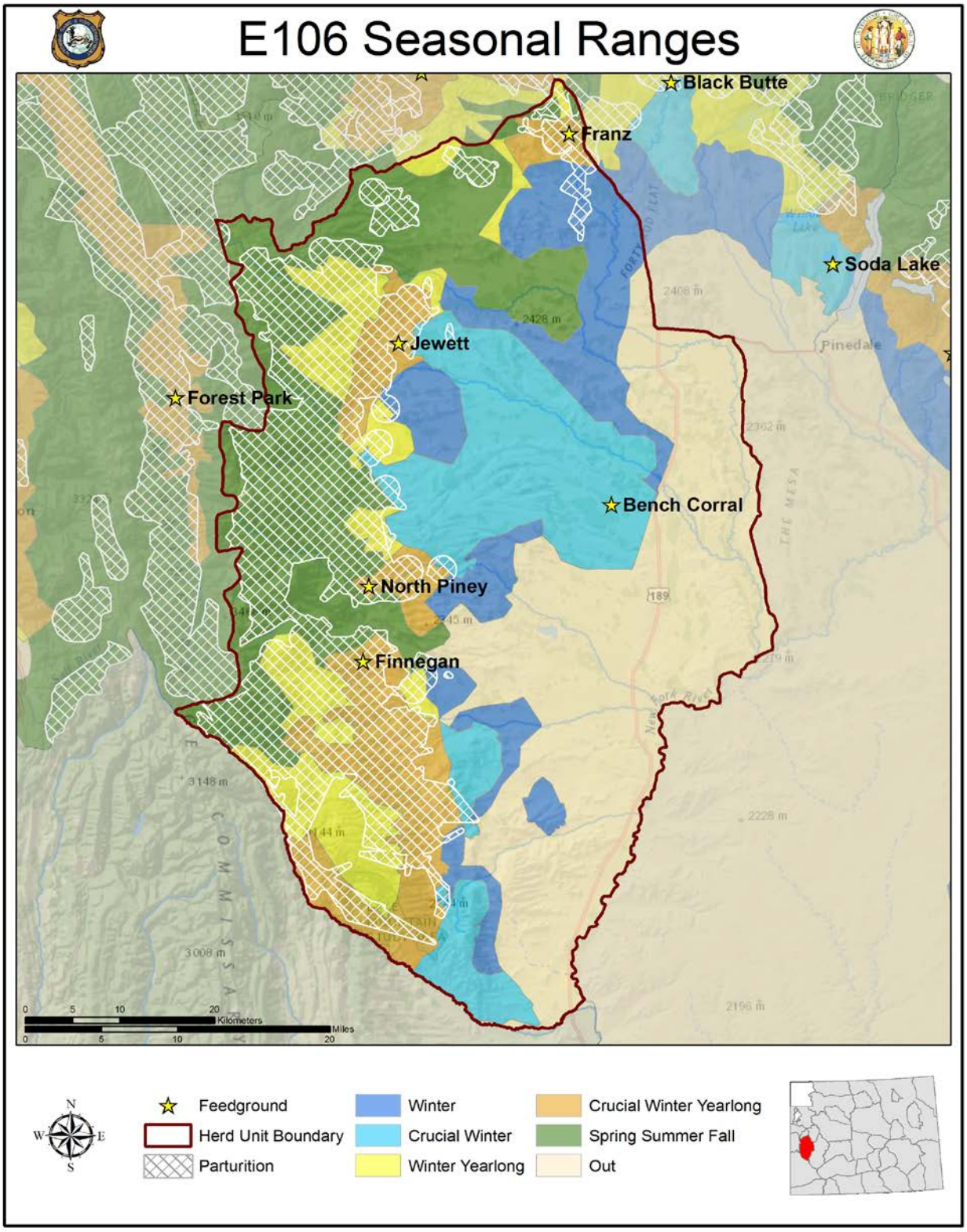

Figure 2. Seasonal elk ranges, elk feedgrounds, and hunt areas within the PEH.

B. Brucellosis Management Options

Listed below are potential options for managing brucellosis on the five feedgrounds in the PEH. 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 or 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 Wyoming Game and Fish Commission (WGFC) will require support from various constituencies (agriculture, land management agencies, sportspersons, etc.) prior to pursuing these options, and several options will require decisions from entities other than the WGFC.

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

C. Discussion of Options

1. Feedground Phase-Out

Phasing out a feedground would require much planning, effort and coordination. If conducted successfully, the dense aggregations of elk associated with feeding during the brucellosis transmission period would cease, reducing brucellosis transmission and seroprevalence. However, serology from winter-free ranging elk in Northwest Wyoming and other portions of the GYE suggest that the disease can persist without feedgrounds, so phasing out a feedground would not eliminate brucellosis in the GYE.

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. If current conditions and herd objectives change, through implementation of one or more of options 2 – 8, this option might become more realistic for some feedgrounds. However, phase-out is currently feasible for the North Piney Staging area. To reduce transmission of brucellosis among elk attending North Piney feedground, where the feeding season lasted an average 146 days (1989-1999), the elk were baited down-drainage to Bench Corral feedground (feeding duration averaged 84 days for 1989-1999) during winter 1995-96. Despite efforts to hold elk at North Piney, elk continued to migrate from North Piney to Bench Corral around late January. During the 1990's, there were concerns that these elk may cause damage to stored crops or co-mingle with wintering livestock, yet these concerns have not materialized, and the expansion of the Big Piney Hunter Management Area in 2007 has greatly reduced or eliminated elk-cattle conflicts in the area. In 2011, feeding ceased at the North Piney staging area when the feeder could no longer drive a truck into the site or January 1st, whichever came first. However, no elk have attended the North Piney feedground in recent years. There have been no increases in elk damage to stored crops or instances of elk-cattle commingling in the area since 2011, and no damage to range conditions or reductions to livestock grazing on BLM lands adjacent to Bench Corral has resulted. Additionally, elk populations have remained at or above WGFC objectives. The North Piney feedground has operationally been phased-out and elk that once attended North Piney are now fed at Bench Corral feedground.

2. Shortened Feeding Seasons

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

Pros:

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

Cons:

- Increases the risk of elk damage and elk-cattle brucellosis transmission and associated damage control costs
- Increased elk winter mortality, especially of juveniles

- Increased potential for vehicle-elk collisions
- Success or failure is highly dependent upon weather

As part of WGFD's Target Feedground Project (WGFD 2015), managers have sought to end feeding as early as possible at the Bench Corral feedground since 2008. Comparing the average end-feeding date of 1998-2007 vs. 2008-2016, managers have been able to truncate the feeding season by an average of 12 days during the brucellosis transmission period with no increase in elk-cattle commingling or damage to stored crops (Table 1). Minor reductions to end date of feeding have occurred at remaining feedgrounds in the PEH since 2008; Franz has ended an average 10 days earlier, Jewett 6 and Finnegan 4 days. Implementation of one or more options 3-8 would make this option more effective. The WGFC has the authority to make this decision.

3. Feedground Relocation

This option would initially require a suitable area lower in elevation, in a lower precipitation zone, with no winter cattle operations in the vicinity. Current habitat conditions should be evaluated to determine production, health of vegetation, and approximate potential of the 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, BLM, and the WGFC.

Pros:

- may contribute to lower brucellosis prevalence
- elk would have increased area to disperse
- feeders could feed in larger area and on clean snow
- elk numbers could be maintained at or near current levels
- may decrease damage and co-mingling situations
- reduced browsing on local native woody vegetation

Cons:

- brucellosis prevalence may persist
- requires funds for erection of new structures, fences, roads, etc.
- potential difficulty relocating and/or habituating elk to the new site
- may increase localized grazing of native herbaceous and woody vegetation
- may increase dietary competition of elk with other wildlife

Prior to feeding elk at the current sites of the five feedgrounds in the PEH, the WGFD fed on at least two other sites, Reardon Canyon (1950-1958) and Deer Hills (1952-1958, Fig. 3). The Reardon Canyon site is located approximately two miles outside the southeast edge of the PEH in the Pinedale elk herd unit. It was commissioned to entice elk to move from the PEH along an historic migration route onto native winter ranges in the Little Colorado Desert, thereby preventing damage to stored hay along the Green River, but was decommissioned as elk became increasingly difficult to move across the river. The Deer Hills site is located approximately eight miles east of the current Finnegan location and was decommissioned in 1959 as elk continued to cause damage to stored hay on nearby private lands. Subsequently, establishing feedgrounds further up-slope was chosen as the solution, and Finnegan and North Piney feedgrounds were commissioned in 1960. Locations of Franz (1952-current) and Jewett (1956-current) have likely shifted up-slope over the years, but

records are anecdotal. Feedground relocation options are possible in the PEH and would be facilitated by one or more of options 4-8 and 10. Relocating Finnegan, Jewett, and Franz downslope from current locations to private lands with larger, flat areas to feed on could reduce risk of elk-elk transmission with little to no increased risk of transmission to livestock given current management practices.

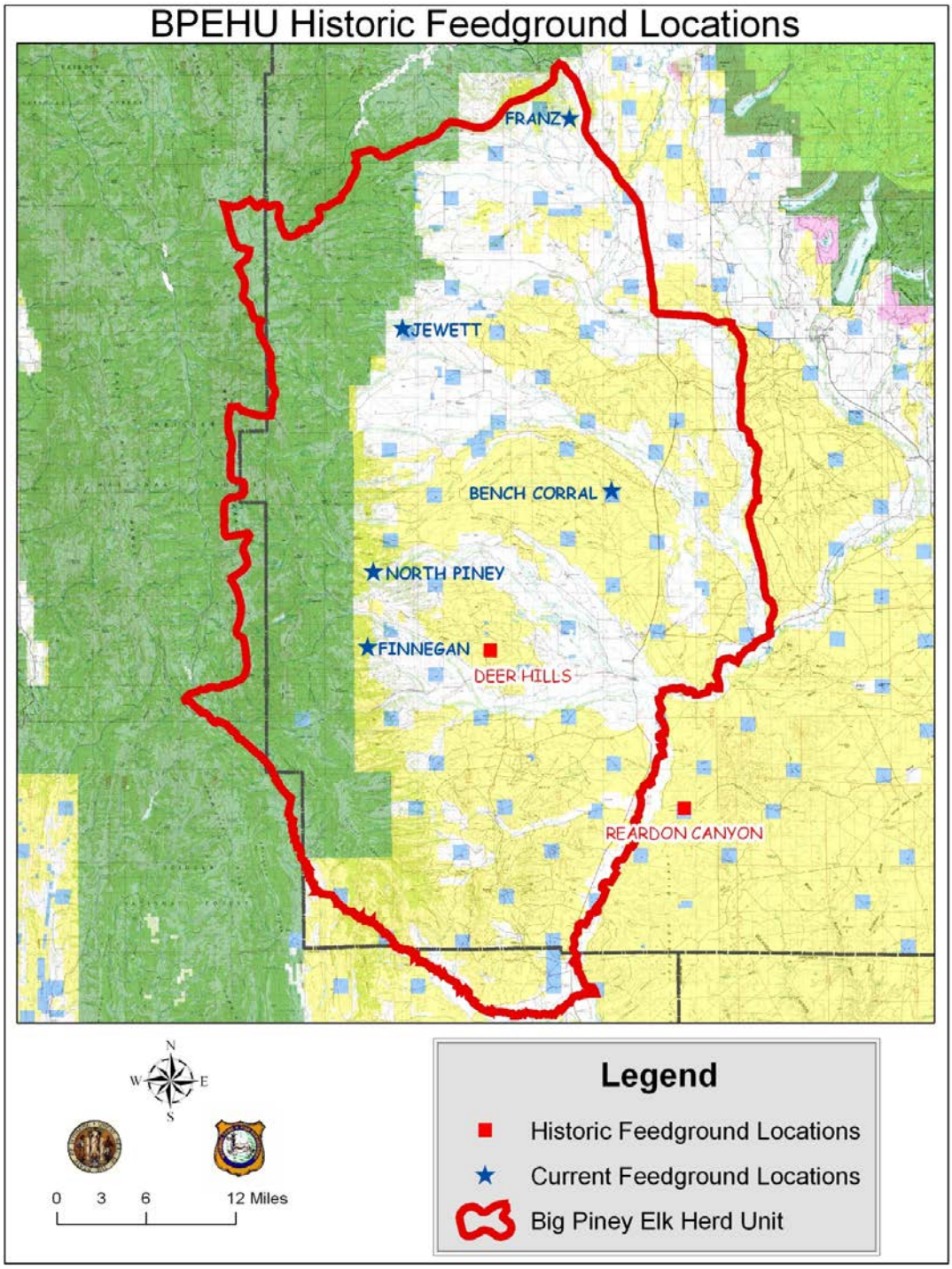

Figure 3. Locations of current and historic (decommissioned) feedgrounds in the PEH.

4. Elk Population Reduction

Reducing elk numbers on feedgrounds in the PEH through liberalized hunting seasons could allow more flexibility to pursue options 1-3 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

The 2015 post-hunt population of elk in the PEH was estimated at 3,100 elk (WGFD 2016), with a WGFC population objective of 2,400 (± 20%, or 480) elk. From 2008-2015, hunting seasons were designed to reduce elk numbers throughout the PEH to the population objective by providing up to 1,050 limited quota cow/calf licenses with liberal seasons. In 2016, these licenses were reduced to 700 to keep the herd within the population objective.

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.

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

Elk-proof fencing around private stackyards in the PEH reduces “attractiveness” of stored hay and likelihood for damage by elk (WGFD 2007). Where fencing stackyards is considered beneficial (e.g., prevent damage to stored crop), the WGFD provides fencing materials and suggested schematics to landowners. Fencing projects around feedgrounds would require favorable decisions by the landowner (private, state, or federal). Currently, no permanent elk-

proof fences exist in the PEH for any purpose other than fencing of stackyards. Wide-scale fencing across a large geographic range in any part of the PEH is likely not possible because of conflicts with seasonal migration routes of other wildlife species (e.g., deer, moose, pronghorn) and high costs. Complete enclosure of elk feedgrounds would likely reduce risk of interspecific disease transmission but likely increase risk of intraspecific disease transmission. Fencing of cattle winter feeding pastures on private lands could eliminate most elk-cattle disease transmission risk, but would need cooperation from willing landowners, would be costly, would restrict movement of other wildlife species, and could considerably complicate cattle management.

6. Elk Test and Slaughter

This option was conducted on the Muddy, Fall and Scab Creek feedgrounds in the Pinedale elk herd 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 compared to populations at Greys River and Dell Creek feedgrounds, brucellosis prevalence was reduced most significantly. However, prevalence at Muddy Creek rebounded from 5% in 2010 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 PEH 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. 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 8 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

Opportunities for habitat enhancements aimed at reducing elk dependency on feedgrounds in the PEH are located primarily around Bench Corral feedground. Other areas in the PEH exist (e.g, aspen ecotones), but may have less of an effect at reducing length of feeding season because of variable snow conditions. Since 1990, about 13,000 acres of sagebrush and aspen have been treated with various methods (fire, mechanical, Spike herbicide) within the PEH. Increased quantity/quality of native forage in spring resulting from treatment of aspen and/or sagebrush may entice elk off of feedgrounds, reducing risk of intraspecific brucellosis transmission.

8. Acquisition/Conservation Easements

With adequate intact, healthy, and accessible elk winter habitat available, elk feeding may 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 stability and health of all wildlife populations. The decision authority is between the seller and buyer.

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 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 biobullets 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

Elk populations attending all feedgrounds in the PEH are appropriate to test a new vaccine, should a promising candidate arise. Considering Gonacon, appropriate feedground populations to test this vaccine would be Bench Corral (over WGFC quota, below average seroprevalence), Jewett (excellent past vaccination coverage, typically over WGFC quota, average seroprevalence), and possibly Franz (excellent past vaccination coverage, typically over WGFC quota, above average seroprevalence). However, abundant public lands in the PEH allow hunter harvest as the primary tool for managing populations.

10. Map Areas of Brucellosis Risk

Since 2006, as part of the Wyoming Governor's Brucellosis Coordination Team's recommendation for elk brucellosis research, the WGFD has collected elk distribution data from 475 GPS-collared elk and reproductive data using VITs from 562 elk captured on or near feedgrounds in 7 elk herd units. Areas where elk are located during the brucellosis transmission period of February 5-June 15 can be considered brucellosis risk areas within the elk herd unit, and maps can be developed identifying these areas. These risk areas can be refined by selecting elk locations during March-May when data from VITs indicate that most brucellosis-induced abortions occur. 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

Livestock producers and land managers in the PEH would benefit from refined maps of brucellosis risk from elk.

D. Coordination Meetings

1. Producer & Interagency Meeting

A meeting was held December 15th, 2015 in Daniel to discuss the ten options among livestock producers and associated land and resource management agencies within the PEH and Hoback elk herd. Twenty-six producers, one USFS employee, three BLM personnel, eight WGFD personnel, two USDA-APHIS VS personnel, and one representative from the WLSB attended the meeting. A presentation was given by the WGFD that summarized management and research regarding brucellosis and elk in relation to the ten options. Questions, comments and suggestions (oral and written), and refreshments were provided throughout the meeting.

About 10% of attendees had heard of low-density feeding and were supportive. Specific to the BMAP options, there were no comments regarding elk population reduction, habitat enhancements, acquisition/easements, vaccination research, or mapping risk areas. There was no support to phase-out all feedgrounds, yet it was suggested that WGFD consider trapping-relocating elk to Rock Springs to re-establish migration routes. Reduced feeding seasons was supported with continued flexibility in dates based on weather, but also cautioned that it can't be done in places with deep snow. Although there was no support to relocate any feedground in the PEH, and the BLM has flexibility to permit feedgrounds via their RMP process, the WGFD was encouraged to investigate relocating feedgrounds from USFS to private land to reduce cost of litigation. Fencing of haystacks was fully supported, but not fencing in livestock winter feeding operations because of disease concerns (e.g., scours). Most discussion revolved around test & slaughter with many questions and answers, and it was suggested that test & slaughter be incorporated on high risk feedgrounds (i.e., high prevalence and in close proximity to cattle). Additional ideas/suggestions included WGFD manage wolves to prevent spread of brucellosis, encourage ranchers to booster-vaccinate cattle with strain RB51 and blood test prior to shipping, and compare seroprevalence of elk commonly captured vs. elk that are very difficult to capture.

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 an option 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 he 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 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 WGFD will continue to not feed elk at North Piney feedground as elk no longer attend the site, there have been no increases in elk-cattle/human conflicts, and there have been no affects on elk mortality of population size. The WGFD will not phase-out remaining feedgrounds in the PEH at present time given existing elk brucellosis seroprevalence, inability or low opportunity to implement one or more of options 2-8, and the utility of elk feedgrounds at manipulating winter distributions of elk and maintaining current elk population objectives.

2. Shortened Feeding Seasons

The WGFD will continue to implement this option on Bench Corral feedground as part of the Target Feedground project. The WGFD will pursue shortened feeding seasons on remaining feedgrounds in the PEH depending on availability of native forage, depth of snowpack, favorable long-term forecast, and risk of commingling to livestock.

3. Feedground Relocation

The WGFD will continue to investigate the potential to move the Finnegan, Jewett, and Franz feedgrounds to adjacent private lands downhill from each feedground. The WGFD will not seek to move Bench Corral feedground at this time.

4. Elk Population Reduction

The WGFD manages for the current, WGFC established elk herd unit population objective of 2,400 elk in the PEH, and tag allocations and season structures will continue to manage for the objective.

5. Fencing

The WGFD will encourage cattle producers in the PEH to fence areas where hay is stored (stackyards) for winter feeding operations and continue delivery of materials for stackyard construction. The WGFD will continue to coordinate with The Wyoming Department of Transportation regarding funding and construction of highway right-of-way game proof fencing and underpasses between Big Piney and LaBarge. As opportunities arise for additional fencing projects (e.g., winter cattle feeding exclosures), the WGFD will assess those situations on a case-by-case basis.

6. Elk Test & Removal

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 PEH in the foreseeable future.

7. Habitat Enhancement

WGFD will continue to coordinate with private landowners, federal land managers, livestock permittees, and NGO's (e.g., RMEF) to develop and implement habitat improvements that may reduce elk dependency on supplemental feed in the PEH.

8. Acquisition/Conservation Easements

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

9. Investigate Options for Vaccination

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

10. Map Areas of Brucellosis Risk

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

F. Best Management Practices

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

Feedground Management

1. Manipulate elk distribution by supplemental feeding to reduce elk/cattle commingling and the risk of brucellosis transmission from elk to cattle.
2. Disperse feed evenly in a checkerboard pattern throughout the feedground on clean snow (low-density feeding) to reduce contacts with aborted fetuses.
3. End feeding as early in late winter/spring as possible; March-May is the peak abortion period and preventing dense aggregations during this period reduces elk-elk brucellosis transmission.
4. Where possible, implement large-scale habitat treatments at strategic locations near

feedgrounds.

5. Elk feeders shall report any aborted fetus which will be collected and submitted to WSVL for testing; disinfect abortion site
6. Predators and scavengers (i.e., coyotes, foxes) shall not be killed on/near feedgrounds by WGFD employees due to their beneficial role of quickly removing aborted fetuses.

G. Additional Actions

Brucellosis Surveillance

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

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. (2012) 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^{TM}: model impacts to feedground elk populations and seroprevalence.
11. Comparison of hay quality from where elk are vs. are not fed on irrigated meadows.
12. Seroprevalence in elk that are frequently vs. infrequently captured on feedgrounds ("bottom-feeder" hypothesis).

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