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U.S. Department of the Interior
Bureau of Land Management

Draft Environmental Assessment
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Swasey HMA
Wild Horse Gather Plan

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Bureau of Land Management
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1.0 Purpose of and Need for the Proposed Action

1.1 Introduction

This Environmental Assessment (EA) has been prepared to analyze the Bureau of Land Management (BLM) Fillmore Field Office (FFO) proposal to conduct a wild horse gather plan for the Swasey Herd Management Area (HMA). The wild horse gather plan would allow for an initial gather and follow-up maintenance gathers to be conducted over the next 10 years from the date of the initial gather operation to achieve and maintain appropriate management levels (AML). The proposed gather would remove excess wild horses from inside and outside the Swasey HMA.

This EA is a site-specific analysis of the potential impacts that could result with the implementation of the Proposed Action or alternatives to the Proposed Action. Preparation of an EA assists the BLM authorized officer to determine whether to prepare an Environmental Impact Statement (EIS) if significant impacts could result, or a Finding of No Significant Impact (FONSI) if no significant impacts are expected.

This document is tiered to:

- ❒ House Range Resource Area Final Environmental Impact Statement and Proposed Resource Management Plan (EIS/RMP), 1986.
- ❒ Population Control Research Wild Horse Gather for the Conger and Frisco Herd Management Areas (DOI-BLM-UT-W020-2015-0017-EA).

Should a determination be made that the implementation of the proposed or alternative actions would not result in “significant environmental impacts” or “significant environmental impacts beyond those already addressed in the RMP/EIS’s” a FONSI will be prepared to document that determination, and a Decision Record issued providing the rational for approving the chosen alternative.

1.2 Background

Swasey HMA

The Swasey HMA comprises of about 120,113 acres of public and state lands. The HMA is located in Juab and Millard Counties, about 50 miles west from Delta, Utah. See Map (Appendix G).

The AML for wild horses within the HMA is 60-100. The AML was established in the October/1987 House Range Resource Area RMP/ROD following an in-depth analysis of habitat suitability and resource monitoring and population inventory data, with public involvement. The AML upper limit is the maximum number of wild horses that can graze in a thriving natural ecological balance and multiple use relationship on the public lands in the area. Establishing AML as a population range allows for the periodic removal of excess animals (toward the low end) and subsequent population growth (toward the high end) between removals.

The current estimated population of wild horses is approximately 721. This number is based on an aerial survey population inventory using the Simultaneous Double Count Method conducted in March of 2018, historical knowledge of the area, and a 20% population increase for the year 2018 and a 20% increase for 2019. The current population is about 12 times over the AML lower limit and approximately 7 times over the AML upper limit. A gather may occur during the year 2020 at which time the estimated population could be approximately 865 wild horses; 805 over the low AML if the gather occurs after the 2020 foaling season. For every foaling season that a gather does not occur an additional 20% will be added to account for the population increase. The HMA was last gathered in February 2013. At that time, 257 wild horses were gathered and 159 removed from the HMA. 98 wild horses were returned to the HMA and 44 of those were treated with Porcine Zona Pellucida vaccine pellets (PZP-22). Approximately 191 horses remained in the HMA after the gather.

Based upon all information available at this time, the BLM has determined that excess wild horses exist within and outside the HMA and need to be removed. This assessment is based on the following factors including, but not limited to:

- ❒ A population inventory flight conducted in March 2018 estimated 501 wild horses inside and outside the HMA (see Appendix A). The current population is approximately 721 wild horses (based on a 20% population increase for 2018 and 20% for 2019). An additional 20% will be added to account for the 2020 population increase making approximately 865 wild horses by the end of the 2020 foaling season if a gather doesn't occur prior to the foaling season.
- ❒ Current use by wild horses is exceeding the available forage allocated by approximately 6 times based on allocations established for wild horse use in the October/1987 House Range Resource Area RMP/ROD.
- ❒ Utilization monitoring completed in years 2011 through 2017 documents increased utilization by wild horses on key forage species across the HMA.
- ❒ Wild horse numbers are increasing into areas outside the HMA not normally used.
- ❒ Rangeland Health Assessments completed in August, 2000 and May, 2002 in the Antelope and Swasey Knoll Allotments indicated that all standards were met at that time. Trend data indicates a static trend (see section 3.2.2).

1.3 Purpose of and Need for the Action

The purpose of the Action is to remove excess wild horses within the Swasey HMA to achieve low AML and maintain the population within AML. Any wild horses located outside the HMA (in areas not designated for their use) would be removed.

This action is needed in order to achieve a population size within the established AML, protect rangeland resources from further deterioration associated with the current excess population, and restore a thriving natural ecological balance and multiple use relationship on public lands in the area consistent with the provisions of Section 3(b)(2) of the Wild Free-Roaming Horses and Burros Act of 1971 (WFRHBA) 1.

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1 The Interior Board of Land Appeals (IBLA) defined the goal for managing wild horse (or burro) populations in a thriving natural ecological balance as follows: "As the court stated in Dahl vs. Clark, supra at 594, the 'benchmark test' for determining the suitable number of wild horses on the public range is 'thriving natural ecological balance.' In the words of the conference committee which adopted this standard: 'The goal of WH&B management should be to maintain a thriving ecological balance (TNEB) between WH&B populations, wildlife, livestock and

1.4 Land Use Plan Conformance

The Action Alternatives are in conformance with the:

- ❒ House Range Resource Area Resource Management Plan/Record of Decision Rangeland Program Summary (RMP/ROD), 1987, Chapter 2, p 47.

1.5 Relationship to Laws, Regulations, and Other Plans

Statutes and Regulations

The Action Alternatives are in conformance with the Wild Free-Roaming Horses and Burros Act (WFRHBA) (as amended), applicable regulations at 43 CFR § 4700 and BLM policies. Included are:

❒ **43 CFR 4710.3-1 Herd management areas.**
Herd management areas shall be established for the maintenance of wild horse and burro herds. In delineating each herd management area, the authorized officer shall consider the appropriate management level for the herd, the habitat requirements of the animals, the relationships with other uses of the public and adjacent private lands, and the constraints contained in 4710.4. The authorized officer shall prepare a herd management area plan, which may cover one or more herd management areas.

❒ **43 CFR 4710.4 Constraints on management.**
Management of wild horses and burros shall be undertaken with limiting the animals' distribution to herd areas. Management shall be at the minimum feasible level necessary to attain the objectives identified in approved land use plans and herd management area plans.

❒ **43 CFR 4720.1 Removal of excess animals from public lands.**
Upon examination of current information and a determination by the authorized officer that an excess of wild horses or burros exists, the authorized officer shall remove the excess animals immediately.

❒ **43 CFR 4740.1 Use of motor vehicles or aircraft.**
(a) Motor vehicles and aircraft may be used by the authorized officer in all phases of the administration of the Act, except that no motor vehicle or aircraft, other than helicopters, shall be used for the purpose of herding or chasing wild horses or burros for capture or destruction. All such use shall be conducted in a humane manner.
(b) Before using helicopters or motor vehicles in the management of wild horses or burros, the authorized officer shall conduct a public hearing in the area where such use is to be made.

❒ All supplemental authorizations contained in of the National NEPA Handbook 1790-1.

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vegetation, and to protect the range from the deterioration associated with overpopulation of wild horses and burros.'"

1.6 Decision to be Made

The authorized officer would determine whether to implement the proposed population control measures in order to achieve and maintain the established low AML and protect the range from deterioration resulting from the current excess wild horse population. The authorized officer's decision is limited to the need to remove excess wild horses and implement some fertility control measures. It would not set or adjust AML nor would it adjust livestock use, as these were set through previous decisions.

The No Action Alternative would not achieve the identified Purpose and Need. However, it is analyzed in this EA to provide a basis for comparison with the other action alternatives, and to assess the effects of not conducting a gather at this time. The No Action Alternative is in violation of the requirement under the WFRHBA that the Secretary remove excess horses, and in also not in conformance with regulatory provisions for management of wild horses and burros as set forth at 43 CFR § 4700.

1.7 Scoping and Identification of Issues

Consultation and coordination with BLM, State Historic Preservation Office (SHPO), the Utah Division of Wildlife Resources (UDWR), US Fish & Wildlife Service (USFWS), Native American Indian tribes, Utah School and Institutional Trust Lands Administration (SITLA), Millard/Juab Counties, and routine business contacts with livestock operators and others, has underscored the need for the BLM to maintain wild horse and burro populations within the AML.

The following issues were identified as a result of consultation/coordination and internal scoping relative to the BLM's management of wild horses in the planning area:

1. Impacts to individual wild horses and the herd. Measurement indicators for this issue include:

   - Expected impacts to individual wild horses from handling stress
   - Expected impacts to herd social structure
   - Potential effects to genetic diversity
   - Potential impacts to animal health and condition

2. A need to implement population control methods in order to maintain population size within AML over the long-term. Measurement indicators for the issue include:

   - Projected population size and annual growth rate (WinEquus population modeling)
   - Projected gather frequency
   - Projected number of excess animals to be removed and placed in the adoption, sale, and short and long-term holding pipelines over the next 10 years

3. Impacts to vegetation/soils, riparian/wetland, and cultural resources (*as applicable*). Measurement indicators for this issue include:

- Expected forage utilization
- Potential impacts to vegetation/soils and riparian/wetland resources

4. Impacts to wildlife, migratory birds, and threatened, endangered, and special status species and their habitat (*as applicable*).

2.0 Proposed Action and Alternatives

2.1 Introduction

This section of the EA describes the Proposed Action and alternatives, including any that were considered but eliminated from detailed analysis. Three alternatives are considered in detail:

- **Alternative A:** Selective Removal of Excess Wild Horses to within AML range, and Population Growth Control using fertility control treatments PZP-22 or most current formulations.
- **Alternative B:** Selective Removal of Excess Wild Horses to within AML range, and Population Growth Control using fertility control treatments GonaCon™.
- **Alternative C:** Gather and Remove Excess Wild Horses to Achieve Low AML with follow-up gathers to maintain AML.
- **Alternative D:** Gather and removal of excess wild horses to low AML and population growth control by establishing a non-reproducing component.
- **Alternative E:** No Action – Continuation of Existing Management.

Alternative A-D were developed to respond to the identified resource issues and the Purpose and Need. The four action alternatives describe the population control measures that may be used for 10 years following the initial gather. Approximately 661 horses would be proposed to be removed from the HMA to return wild horse population size to low AML on the Swasey HMA. If gather operations do not occur until after the 2020 foaling season the mentioned population estimate and removal number will increase. Tracking collars and tags may be used as part of monitoring efforts for alternatives A-D. Tracking collars would not be used on stallions. These collars and tags are currently being used in the nearby Conger and Frisco HMAs and were analyzed in the EA *Population Control Research Wild Horse Gather for the Conger and Frisco Herd Management Areas* (DOI-BLM-UT-W020-2015-0017-EA).

Alternative E would not achieve the identified Purpose and Need. However, it is analyzed in this EA to provide a basis for comparison with the other action alternatives, and to assess the effects of not conducting a gather at this time. The No Action Alternative is in violation of the WFRHBA which requires the BLM to immediately remove excess wild horses.

2.2 Description of Alternatives Considered in Detail

2.2.1 Alternative A: Selective Removal of Excess Wild Horses to within AML range, and Population Growth Control using fertility control treatments PZP-22 or most current formulations.

This action would gather approximately 95% of the existing wild horses (approximately 690 animals—includes 2019 population growth—likely over multiple gathers) and return periodically to gather excess wild horses to maintain AML and administer or booster population control measures to the other gathered horses over a period of ten years from the date of the initial gather operation. After achieving low AML, the target removal number would be adjusted accordingly based off population inventories for the HMA and the resulting projection of excess animals over AML. The principal management goal for the HMA would be to retain a population of 60 wild horses, which is the low end of AML. All mares released back to the HMA would be treated with a form of porcine zona pellucida (PZP) fertility control vaccine (i.e., PZP-22 or most current formula). The combination of these actions should lower the population growth rate within the HMA.

Under this action a sufficient number of wild horses would be gathered primarily from heavily concentrated areas within the project area to reduce resource impacts in the most impacted areas and all wild horses residing in areas adjacent to the HMA (outside established boundaries) would be gathered and removed during the gather operations.

Selective removal procedures would prioritize removal of younger excess wild horses after achieving AML within the HMA, and allow older less adoptable wild horses to be released back to the HMA.

If gather efficiencies during the initial gather do not allow for the attainment of the Action during the initial gather (i.e., not enough horses are successfully captured to reach low AML), BLM would return to the Swasey HMA to remove excess horses above low AML and would conduct follow-up gathers over a 10 year period to remove any additional wild horses necessary to achieve and maintain the low range of AML as well as to allow BLM to gather a sufficient number of wild horses so as to implement the population control component of the proposed action (PZP or most current formula) for wild horses remaining in the HMA.

If gather efficiencies of the initial gather exceed the target removal number of horses necessary to bring the population within the AML range of 60-100 wild horses during the initial gather, this would allow the BLM to begin implementing the population control components (PZP or most current formula) of this alternative with the initial gather. Population inventories and routine resource/habitat monitoring would be completed between gather cycles to document current population levels, growth rates, and areas of continued resource concern (horses concentrations, riparian impacts, over-utilization, etc.) prior to any follow-up gather. The subsequent maintenance gather activities would be conducted in a manner consistent with those described for the initial gather and could be conducted during the period of November through February which is identified as the period of maximum effectiveness for fertility control application. Funding limitations and competing priorities might impact the timing of maintenance gather and population control components of the Action.

The procedures to be followed for implementing fertility control are detailed in Appendix B. At the AML level established for the HMA and based on known seasonal movements of the horses within the HMA, sufficient genetic exchange should occur to maintain the genetic health of the population. All horses identified to remain in the HMA population would be selected to maintain a diverse age structure, herd characteristics and body type (conformation).

BLM's Use of Contraception in Wild Horse Management
Expanding the use of population growth suppression (PGS) to slow population growth rates and reducing the number of animals removed from the range and sent to off-range pastures (ORPs) is a BLM priority. The WFRHBA of 1971 specifically provides sterilization (section 3.b.1). No finding of excess determination is required for BLM to pursue contraception in wild horses or wild burros only. Contraception has been shown to be a cost-effective and humane treatment to slow increases in wild horse populations or, when used with other techniques, to reduce horse population size (Bartholow 2004, de Seve and Boyles-Griffin 2013). All fertility control methods in wild animals are associated with potential risks and benefits, including effects of handling, frequency of handling, physiological effects, behavioral effects, and reduced population growth rates (Hampton et al. 2015). Contraception by itself does not remove excess horses from an HMA's population, so if a wild horse population is in excess of AML, then contraception alone would result in some continuing environmental effects of horse overpopulation. Successful contraception reduces future reproduction. Limiting future population increases of horses could limit increases in environmental damage from higher densities of horses than currently exist. Horses are long-lived, potentially reaching 20 years of age or more in the wild and, if the population is above AML, treated horses returned to the HMA may continue exerting negative environmental effects, as described above, throughout their life span. In contrast, if horses above AML are removed when horses are gathered, that leads to an immediate decrease in the severity of ongoing detrimental environmental effects.

Successful contraception would be expected to reduce the effects of frequent horse gather activities on the environment, as well as wild horse management costs to taxpayers. Bartholow (2007) concluded that the application of 2 or 3-year contraceptives to wild mares could reduce operational costs in a project area by 12-20%, or up to 30% in carefully planned population management programs. He also concluded that contraceptive treatment would likely reduce the number of horses that must be removed in total, with associated cost reductions in the number of adoptions and total holding costs. If applying contraception to horses requires capturing and handling horses, the risks and costs associated with capture and handling of horses may be comparable to those of gathering for removal, but adoption and long-term holding costs would be lower. Selectively applying contraception to older animals and returning them to the HMA could reduce long-term holding costs for such horses, which are difficult to adopt, and could reduce the compensatory reproduction that often follows removals (Kirkpatrick and Turner 1991). On the other hand, selectively applying contraception to younger animals can slow the rate of genetic diversity loss – a process that tends to be slow in a long-lived animal with high levels of genetic diversity – and could reduce growth rates further by delaying the age of first parturition (Gross 2000). Although contraceptive treatments are associated with a number of potential physiological, behavioral, demographic, and genetic effects, detailed in Section 4, Environmental Effects, those concerns do not generally outweigh the potential benefits of using contraceptive treatments in situations where it is a management goal to reduce population growth rates (Garrott and Oli 2013). This action reflects proposed management strategies that are consistent with the the WFRHBA, which allows for sterilization as a means of population control as well as recommendations from the National Academy of Science.

2.2.2 Alternative B: Selective Removal of Excess Wild Horses to within AML range, and Population Growth Control using fertility control treatments GonaCon™

Under Alternative B management actions would be similar to Alternative A with the exception that all the released mares would be treated with the population growth suppression vaccine GonaCon™ instead of a PZP vaccine. Treated animals would need to be held for a minimum of thirty days after first treatment to administer a booster shot to increase efficacy and treatment longevity. As with PZP, the long-term goal of GonaCon-Equine use is to reduce or eliminate the need for gathers and removals (NRC 2013). GonaCon-Equine vaccine is an EPA-approved pesticide (EPA, 2009a) that is relatively inexpensive, meets BLM requirements for safety to mares and the environment, and has been produced in a USDA-APHIS laboratory. Its categorization as a pesticide is consistent with regulatory framework for controlling overpopulated vertebrate animals, and in no way is meant to convey that the vaccine is lethal; the intended effect of the vaccine is as a contraceptive.

Considerations on BLM's use of contraception in wild horse management were noted above, under Alternative A. Whether to use or not use any particular method to reduce population growth rates in wild horses is a decision that must be made considering known effects as well as the potential effects of inaction, such as continued overpopulation and rangeland health degradation.

Under this alternative, the BLM would return to the HMA as needed to re-apply GonaCon-Equine and initiate new treatments in order to maintain contraceptive effectiveness in controlling population growth rates. GonaCon-Equine can safely be reapplied as necessary to control the population growth rate. Even with one booster treatment of GonaCon-Equine, it is expected that most, if not all, mares would return to fertility at some point, although the average duration of effect after booster doses has not yet been quantified. It is unknown what would be the expected rate for the return to fertility rate in mares boosted more than once with GonaCon-Equine. Once the herd size in the project area is at AML and population growth seems to be stabilized, BLM could make a determination as to the required frequency of new mare treatments and mare re-treatments with GonaCon, to maintain the number of horses within AML.

Reference in this text to any specific commercial product, process, or service, or the use of any trade, firm or corporation name is for the information and convenience of the public, and does not constitute endorsement, recommendation, or favoring by the Department of the Interior.

Additional Management Actions Proposed for Alternatives A and B

The BLM also proposes to apply fertility control to select mares through the use of a single dose inoculation and the delivery system using dart guns. This may be done on the Swasey HMA for the ten years following the initial gather (or as long as it can be reasonably concluded that no new information and no new circumstances have substantially changed in the area of analysis) in order to help maintain adult wild horses within the AML range of 60-100 wild horses. If it is determined that a mare or mares cannot be approached within darting range on foot, then water/bait trapping may be used to capture the mares. The wild horses would be released after the treatment in given. Baiting would be with water, salt, mineral, or weed free hay in areas that horses utilize in their normal movements throughout the HMA.

The literature review is intended to summarize what is known and what is not known about potential effects of treating mares with porcine zona pellucida (PZP) vaccine and GonaCon (GnRH). As noted below, some negative consequences of vaccination are possible. Fertility vaccines are administered only to females.

Whether to use, or not use, any particular method to reduce population growth rates in wild horses is a decision that must be made considering known effects as well as the potential effects of inaction, such as continued overpopulation and rangeland health degradation.

Alternatives A and B incorporate the following actions and management requirements:

- Fertility control treatment would be conducted in accordance with the approved standard operating and post-treatment monitoring procedures. Breeding age mares selected for release back to the range would be treated with approved fertility control vaccines, which would slow reproduction of the treated mares for one to three breeding seasons.
- Any new fertility controls could be used as directed through the most recent direction of the National Wild Horse and Burro Program. The use of any new fertility controls would use the most current best management practices and humane procedures available for the implementation of the new controls.
- PZP mixing procedures would follow those listed in Appendix C. The PZP protocol would be examined annually, in line with any new instructions provided by SCC. The field use of GnRH does not require mixing of the adjuvant.
- Horse Immunocontraception Data Sheets would be prepared and updated as presented in Appendix D. An individual mare's previous records would be reviewed prior to any darting activity.
- Mares would be individually marked and/or be individually recognizable without error. No mares would be treated unless she has been identified for treatment.
- Fertility control would be administered once AML is reached and go through the life of the plan. If monitoring shows successful applications, no negative reactions and reduction in foaling rates, the fertility control treatments would continue beyond the life of the plan as long as it can be reasonably concluded that no new information and no new circumstances arise that need to be considered and those that are analyzed within this document have not substantially changed within the HMA. Fertility control applications would also depend on annual funding and the presence of qualified applicators.
- Ideal time to booster previously treated mares would be between February through April of each year. However, if a previously treated mare is missed, a booster shot could be administered at any time of the year. Each mare would have an identification sheet with pictures, describing any markings, brands, scars, or other distinguishing marks. At the beginning of each year, a list of mares identified for treatment would be created. That information would be loaded into a format that is easy to use in the field (book or electronic device).

- New mares (over the age of 18 months) coming into treatment would be given the primer dose between November and January of each year. New mares would receive their booster between February and April. Age would be based on when the horses are observed being new herd foals. For older previously treated horses, it would come from the treatments data sheets. Aging older untreated horses would be based off of photographs or similar documentation provided by volunteers knowledgeable of the herd/bands. For an age of a mare that cannot be established that mare would be allowed to raise a foal to one year of age then begin treatment.
- Primer inoculations would be administered to mares that are at least 18 months old. Mares that are 2-4 years old would be treated. The 5 year old mares would be taken off the treatment schedule until they have produced at least one foal that lives to be one year old. After a mare produces one foal that survives for a year, she would be put back on fertility control treatments.
- Flexibility in determining which mares are selected for treatment is vital to the success of the fertility control program. Adjustments would be made if it is found that there is a severe reaction by an individual mare, that mare can contribute more to genetic diversity or a mare that might have a negative effect to the genetic diversity of the herd. This information would be documented on the Data Sheet.
- If timing or funding constraints arise, a treatment priority would consider the band or herd composition and priority would be given based on age class.
  Priorities would be established as follows:
  1) 2-4 year old mares,
  2) mares just coming back into treatment , and
  3) older mares that have received several treatments since producing a live foal.
- The annual treatment schedule, database and Data Sheets would be reviewed/approved by the authorized officer with the FFO wild horse specialist and/or darting specialist. An annual monitoring report would be prepared for the authorized officer and filed with the HMA records. This monitoring report would show PZP/GnRH orders placed/ costs, planned treatment schedule/actual treatments (number/dates of mares treated), lost darts, negative reactions/BLM action taken for that mare, number of new/current year foals counted/observed, unique circumstances, off road vehicular use, general rangeland condition/water availability, volunteer efforts, correspondence between/among SLFO and the Science and Conservation Center (SCC) and National Wild Horse and Burro Program (WH&B) Office and other pertinent information.

The field darting treatment protocol would take approximately two to three years after initiation to fully implement. Field darting would be conducted in an opportunistic manner while the specialist is conducting routine monitoring activities as part of normal duties in the field. Ordinarily, field darting activities would be conducted on foot. Access throughout the HMA would be achieved by use of 4X4 vehicles, other off-highway vehicles (OHVs), or horseback. Vehicles would be utilized on existing roads and trails in the HMA. On a case by case basis, the use of OHVs off existing roads and trails may be allowed for administrative purposes; however such use shall be made only with the approval of the authorized officer.

Personnel authorized for PZP field darting of the Swasey horses must be trained for this task and certified by the SCC at Zoo Montana in Billings Montana. Additionally, all work would be conducted in accordance with the SOPs (Appendix B) and mixing procedures (Appendix C).

The FFO would work with the National WH&B Office in Reno, Nevada, and the SCC at Zoo Montana to order the PZP vaccine. The SCC then prepares and ships the order to the FFO. Each dose would consist of 100 micrograms of PZP in 0.5cc buffer (a phosphate buffered saline solution). The vaccine must be kept frozen until use. Mixing the vaccine would be accomplished as described in the Wild Horse Contraceptive Training Manuel (mixing procedures in Appendix C). Remote application would be by means of 1.0cc Pneu-dart darts, with either 1.25 or 1.5 inch barbless needles, delivered by either Dan-inject or Pneu-dart CO2 powered or cartridge fired guns.

The FFO would work with the National WH&B Office in Reno, Nevada and the USDA to order the GnRH vaccine. The USDA would then prepare and ship the order to the FFO. Each dose of GonaCon (GnRH) would consist of 2 ml of liquid GonaCon, including 0.032% of mammalian GnRH. No mixing of the vaccine is required. The vaccine must be kept refrigerated. Remote application would be by means of 'Slo-inject' TM Pneu-Dart darts, equipped with 3.81 cm 14 gage Tri-Port needles and a gel collar (McCann et al. 2017), delivered by either Dan-inject or Pneu-dart CO2 powered or cartridge fired guns. An attempt would be made to recover all darts (normally about a 98% recovery is expected).

FFO would be applying adaptive management principles. If policies change or the vaccine effects or effectiveness proves undesirable, then the application of the fertility control measures would be stopped, or reconsidered based on new scientific information. If a specific vaccine formulation is dropped from BLM use and is replaced by another drug or immunization for fertility control purposes, that method would be applied by the FFO in future treatments.

Horse Identification

The treated mares would be individually marked and/or be individually recognizable without error. During past treatments, mares have been freeze branded on the hip and the neck. These brands would help in the identification of the horses. During any future gathers, new brands would be put on mares released back to the HMA. Color, leg and face markings, and any other unique markings or scars would identify any mares without a brand. Once each horse is positively identified, their information would be compiled into a database along with photographs. Individual identification information (photographs and unique characteristics) would be compiled into books or put onto an electronic device that can be taken to the field. Individual numbers are assigned to each herd/band member based on these unique characteristics. Unique numbers would be assigned to all mares and documented on the Data Sheets. A filly under 18 months would be tracked on her mother's Data Sheet. A filly over 18 months of age would receive her own number and Data Sheet. Maternal kinship would be tracked or followed through Data Sheet notes.

Record Keeping

All darting, foaling, and health data would be recorded as per the Data Sheet (Appendix D). Data Sheets would be prepared and maintained in the FFO. Initially, copies of the data sheets would be sent to the National WH&B Program Office and – under Alternative A with PZP use – to the SCC. Thereafter, only treatment updates or new mare Data Sheets would be sent annually.

Regulatory Authorization
The liquid PZP vaccine known as ZonaStat-H is federally approved by the EPA registration number 86833–1. Training is required by the SCC to receive and/or administer PZP to wild horses.

The liquid GonaCon (GnRH) vaccine, known as GonaCon-Equine, is federally approved by the EPA registration number 56228-41. No specific training is required to administer GonaCon to wild horses, though a certified pesticide handler does need to receive shipments of the drug.

Use of Intra-Uterine Devices (IUDs)

Up through the present time (October 2019), BLM has not used IUDs to control fertility as a wild horse and burro fertility control method on the range. The BLM has supported and continues to support research into the development and testing of effective and safe IUDs for use in wild horse mares (Baldrighi et al. 2017). However, existing literature on the use of IUDs in horses allows for inferences about expected effects of any management alternatives that might include use of IUDs.

IUDs may be implanted into mares in conjunction with the fertility control drug or by itself. The use of them simultaneously may provide for more effective fertility control. Any mare that receives an IUD will be documented and photos taken for field identification. The mares would be observed on occasion to see if/when the mare has another foal. It is expected that the IUD will eventually fall out.

2.2.3 Alternative C: Gather and Remove Excess Animals to Achieve Low AML.

This action would gather and remove excess wild horses from within and outside the Swasey Herd Management Area (HMA) to achieve low AML. Multiple gathers would be needed to achieve low AML. Fertility control would not be applied and no changes to the herds' sex ratios would be made. One or more gather strategies may be used. A gate cut removal would be implemented with the option to hold some horses to be returned if needed in order maintain the variety colors and conformation associated with the herd. Once low AML is achieved follow-up gathers would occur every 3 to 4 years to maintain AML. Approximately 40 wild horses would be removed in each follow-up gather. This would continue for 10 years following the date of the initial gather.

Every effort would be made to put trap sites in previously used sites or disturbed sites. Should a trap need to be located on an undisturbed site; the site would be surveyed for cultural resources by authorized BLM employees. The site would not be used if cultural resources were found.

2.2.4 Alternative D: Gather and removal of excess wild horses to low AML and population growth control by establishing a non-reproducing component.

Under Alternative D management actions would be similar to the Alternative A with the exception that some fraction of the mares returning to the HMA would be sterilized. The Swasey HMA would continue to have reproducing horses and it would continue to receive occasional genetic influence from horses crossing over from nearby HMAs. Hair samples would be pulled for genetic testing. If monitoring efforts show a need BLM FFO would augment the genetics of the herd by introducing fertile mares from other HMAs. Methods for sterilizing mares could include the following:

Laparoscopic Ovariectomy
This procedure is performed using standing sedation with a horse restrained in a stocks or squeeze chute. Ovaries are removed using a fiber optic laparoscope and three small incisions in the body wall. This method allows direct visualization of ovaries, and is more of a "high tech" approach and generally has a lower complication rate. The surgery takes about an hour per horse. Horses have three to six external incisions that can get infected unless they are confined and stay calm, which is not easy to guarantee in wild horses. The surgery requires a specialized skill set and equipment beyond that of the typical practicing veterinarian. The equipment is delicate and unlikely to withstand the rigors of use with wild horses in a corral setting. The horses must stand very still throughout the procedure, which could be difficult if not impossible for wild horses. It is unclear how reliably the surgery can be done in pregnant mares at various pregnancy stages.

Surgical Spaying – Ventral midline, oblique, or flank laparotomy
A ventral midline or oblique laparotomy is performed under general anesthesia, the horse is anesthetized and placed in dorsal recumbence. Flank laparotomy is typically performed under standing sedation, but can be done under general anesthesia. The abdomen is opened, the ovaries are surgically removed, and the incision is stitched close. This maximizes safety for the surgeon and allows for direct visualization of the ovaries. This is not a technique routinely used in practice. Abdominal incisions are prone to swelling and if they become infected this would be very difficult if not impossible to manage post operatively in a wild horse. The surgery takes about 45 minutes or more per horse including induction and recovery. The surgery is not appropriate for pregnant mares after early gestation.

Ovariectomy via Colpotomy
This procedure is performed using standing sedation with a horse restrained in a stocks or squeeze chute. The surgeon accesses the ovaries through an incision in the vagina. The ovaries are anesthetized, then removed. The incision shrinks and heals quickly, with minimal risk of infection. The method has been in use for 100+ years, and is well-established. Surgery time is about 15 minutes total, from injecting sedation to the horse walking away. The method was used in a large-scale USFWS project on the Sheldon National Wildlife Refuge, with less than 2% mortality rate. The surgeon must be skilled at handling internal organs without seeing them. There is some risk to the surgeon because the horse may kick out or sit down while the surgeon's arm is in the animal.

Laparoscopic-Assisted Colpotomy for Ovariectomy
This alternative proposes the use of a laparoscope to assist with visualization of the ovaries during an ovariectomy via colpotomy. This procedure does allow the surgeon to visualize the ovaries prior to removal, which has potential to reduce risks associated with transection of the ovary and associated bleeding at that location. However, the inclusion of laparoscopy requires an increased duration (at least 20–30 minutes for bilateral ovariectomy as per Tate et al. 2012). In the transcript of Bowen (2015, p. 17) it was discussed that a laparoscope could be used to train

veterinarians in ovariectomy via colpotomy, but it would not likely be preferred for field conditions and wild horses. See chapter 4 and Appendix H for more information on these spaying techniques.

Oviduct Blockage

This non-surgical procedure causes a long-term blockage of the oviduct, so that fertile eggs cannot go from the ovaries to the uterus. One form of this procedure infuses medical cyanoacrylate glue into the oviduct to cause long-term blockage (Bigolin et al. 2009). Treated mares would need to be screened to ensure they are not pregnant. The procedure is transcervical, so the treated mare cannot have a fetus in the uterus at the time of treatment. The mare would be sterile, although she would continue to have estrus cycles.

Cervical Resection

This brief surgical procedure involves an incision across the circular muscles that contract to close the cervix. As seen through a speculum, the cervix is grasped with forceps, and cut with a surgical tool. The result of having an incompetent cervix is that embryos are lost from the uterus before implantation. After cervical resection, mares should not be able to keep future pregnancies. However, existing fetuses that are already implanted in the uterine wall should continue developing through to normal foaling.

Pharmacological or Immunocontraceptive Sterilization

At the time of this EA preparation, BLM has not yet identified a pharmacological or immunocontraceptive method to sterilize mares that would be suitable for wild mares. However, there is the possibility that future development and testing of new methods could make an injectable sterilant available for wild horse mares. BLM cannot analyze some aspects of the specific method that may be used in the future, but analyses of the effects of having sterile mares as a part of the Swasey HMA herd, such as due to surgical sterilization, would likely be applicable to non-surgical methods as well.

If this alternative is selected one of the above sterilization procedures would be conducted. Most, if not all, mares selected to return to the HMA would be sterilized. The number of mares to be sterilized would depend on the success of gathering additional mares beyond the low end of AML. Approximately 20 mares could be sterilized. Only mares that are old enough to have had the opportunity to pass on their genetic traits would be selected for sterilization. Treated mares would be freeze marked for identification purposes. The procedure would take place at a veterinarian's facility thus giving the horses the best possible care and post operation observation and recovery. As the surgery would be conducted at a private facility, public observation of the surgical procedure would not be allowed, however; BLM FFO would be willing to consider observation by an unaffiliated, licensed veterinarian if the contracted veterinarian consents.

2.2.5 Alternative E: No Action – Continuation of Existing Management.

Under the No Action Alternative, no gather would occur and no additional management actions would be undertaken to control the size of the wild horse population at this time. The No Action Alternative does not comply with the WFRHBA of 1971, regulations, Approved House Range

RMP (1986) and does not meet the purpose and need for action in this EA, however, it is included as a basis for comparison with the Proposed Action.

2.3 Management Actions for Alternatives A-D

Helicopter

If the local conditions require a helicopter drive-trap operation, the BLM would use a contractor or in-house gather team to perform the gather activities in cooperation with BLM and other appropriate staff. The contractor would be required to conduct all helicopter operations in a safe manner and in compliance with Federal Aviation Administration (FAA) regulations 14 CFR § 91.119 and BLM IM No. 2010-164.

Helicopter drive trapping involves use of a helicopter to herd wild horses into a temporary trap. The Comprehensive Animal Welfare Program for Wild Horse and Burro Gathers (CAWP) would be implemented to ensure that the gather is conducted in a safe and humane manner, and to minimize potential impacts or injury to the wild horses. Traps would be set in an area with high probability of access by horses using the topography, if possible, to assist with capturing excess wild horses residing within the area. Traps consist of a large catch pen with several connected holding corrals, jute-covered wings and a loading chute. The jute-covered wings are made of material, not wire, to avoid injury to the horses. The wings form an alley way used to guide the horses into the trap. Trap locations are changed during the gather to reduce the distance that the animals must travel. A helicopter is used to locate and herd wild horses to the trap location. The pilot uses a pressure and release system while guiding them to the trap site, allowing them to travel at their own pace. As the herd approaches the trap the pilot applies pressure and a prada horse is released guiding the wild horses into the trap. Once horses are gathered they are removed from the trap and transported to a temporary holding facility where they are sorted.

If helicopter drive-trapping operations are needed to capture the targeted animals, BLM would assure that an Animal and Plant Health Inspection Service (APHIS) veterinarian or contracted licensed veterinarian is on-site during the gather to examine animals and make recommendations to BLM for care and treatment of wild horses. BLM staff would be present on the gather at all times to observe animal condition, ensure humane treatment of wild horses, and ensure contract requirements are met.

Bait/Water Trapping

Bait and/or water trapping may be used if circumstances require it or best fits the management action to be taken. Bait and/or water trapping generally require a longer window of time for success than helicopter drive trapping. Although the trap would be set in a high probability area for capturing excess wild horses residing within the area, and at the most effective time periods, time is required for the horses to acclimate to the trap and/or decide to access the water/bait.

Trapping involves setting up portable panels around an existing water source or in an active wild horse area, or around a pre-set water or bait source. The portable panels would be set up to allow wild horses to go freely in and out of the corral until they have adjusted to it. When the wild horses fully adapt to the corral, it is fitted with a gate system. The acclimation of the horses creates a low stress trapping method. During this acclimation period the horses would experience some stress due to the panels being setup and perceived access restriction to the water/bait source.

When actively trapping wild horses, the trap would be staffed or checked on a daily basis by either BLM personnel or authorized contractor staff. Horses would be either removed immediately or fed and watered for up to several days prior to transport to a holding facility. Existing roads would be used to access the trap sites.

Gathering excess horses using bait/water trapping could occur at any time of the year and traps would remain in place until the target number of animals are removed. Generally, bait/water trapping is most effective when a specific resource is limited, such as water during the summer months. For example, in some areas, a group of wild horses may congregate at a given watering site during the summer because few perennial water resources are available nearby. Under those circumstances, water trapping could be a useful means of reducing the number of horses at a given location, which can also relieve the resource pressure caused by too many horses. As the proposed bait and/or water trapping in this area is a low stress approach to gathering wild horses, such trapping can continue into the foaling season without harming the mares or foals.

Gather Related Temporary Holding Facilities (Corrals)

Wild horses that are gathered would be transported from the gather sites to a temporary holding corral in goose-neck trailers. At the temporary holding corral, wild horses would be sorted into different pens based on sex. The horses would be aged and provided good quality hay and water. Mares and their un-weaned foals would be kept in pens together. At the temporary holding facility, a veterinarian, when present, would provide recommendations to the BLM regarding care and treatment of the recently captured wild horses. Any animals affected by a chronic or incurable disease, injury, lameness or serious physical defect (such as severe tooth loss or wear, club foot, and other severe congenital abnormalities) would be humanely euthanized using methods acceptable to the American Veterinary Medical Association (AVMA).

Transport, Off-range Corrals, and Adoption Preparation

All gathered wild horses would be removed and transported to BLM holding facilities where they would be inspected by facility staff and if needed a contract veterinarian to observe health and ensure the animals are being humanely cared for.

Those wild horses that are removed from the range and are identified to not return to the range would be transported to the receiving off-range corrals (ORC, formerly short-term holding facility) in a goose-neck stock trailer or straight-deck semi-tractor trailers. Trucks and trailers used to haul the wild horses would be inspected prior to use to ensure wild horses can be safely transported. Wild horses would be segregated by age and sex when possible and loaded into separate compartments. Mares and their un-weaned foals may be shipped together. Transportation of recently captured wild horses is limited to a maximum of 12 hours.

Upon arrival, recently captured wild horses are off-loaded by compartment and placed in holding pens where they are provided good quality hay and water. Most wild horses begin to eat and drink immediately and adjust rapidly to their new situation. At the off-range corral, a veterinarian provides recommendations to the BLM regarding care, treatment, and if necessary, euthanasia of the recently captured wild horses. Wild horses in very thin condition or animals with injuries are sorted and placed in hospital pens, fed separately and/or treated for their injuries.
After recently captured wild horses have transitioned to their new environment, they are prepared for adoption, sale, or transport to Off-Range pastures. Preparation involves freeze-marking the animals with a unique identification number, vaccination against common diseases, castration, and de-worming. At ORC facilities, a minimum of 700 square feet of space is provided per animal.

Adoption

Adoption applicants are required to have at least a 400 square foot corral with panels that are at least six feet tall. Applicants are required to provide adequate shelter, feed, and water. The BLM retains title to the horse for one year and inspects the horse and facilities during this period. After one year, the applicant may take title to the horse, at which point the horse becomes the property of the applicant. Adoptions are conducted in accordance with 43 CFR Subpart 4750.

Sale with Limitations

Buyers must fill out an application and be pre-approved before they may buy a wild horse. A sale-eligible wild horse is any animal that is more than 10 years old or has been offered unsuccessfully for adoption at least three times. The application also specifies that buyers cannot sell the horse to slaughter buyers or anyone who would sell the animals to a commercial processing plant. Sales of wild horses are conducted in accordance with the 1971 WFRHBA and congressional limitations.

Off-Range Pastures

When shipping wild horses for adoption, sale, or Off-Range Pastures (ORPs) the animals may be transported for up to a maximum of 24 hours. Immediately prior to transportation, and after every 24 hours of transportation, animals are offloaded and provided a minimum of 8 hours on-the-ground rest. During the rest period, each animal is provided access to unlimited amounts of clean water and two pounds of good quality hay per 100 pounds of body weight with adequate space to allow all animals to eat at one time.

Mares and sterilized stallions (geldings) are segregated into separate pastures, except at one facility where geldings and mares coexist. Although the animals are placed in ORP, they remain available for adoption or sale to qualified individuals; and foals born to pregnant mares in ORP are gathered and weaned when they reach about 8-12 months of age and are also made available for adoption. The ORP contracts specify the care that wild horses must receive to ensure they remain healthy and well-cared for. Handling by humans is minimized to the extent possible although regular on-the-ground observation by the ORP contractor and periodic counts of the wild horses to ascertain their well-being and safety are conducted by BLM personnel and/or veterinarians.

Euthanasia or Sale without Limitations

Under the WFRHBA, healthy excess wild horses can be euthanized or sold without limitation if there is no adoption demand for the animals. However, while euthanasia and sale without limitation are allowed under the statute, these activities have not been permitted under current Congressional appropriations for over a decade and are consequently inconsistent with BLM policy. If Congress were to lift the current appropriations restrictions, then it is possible that excess horses removed from the HMA over the next 10 years could potentially be euthanized or sold without limitation consistent with the provisions of the WFRHBA.

Any old, sick or lame horses unable to maintain an acceptable body condition (greater than or equal to a Henneke BCS of 3) or with serious physical defects would be humanely euthanized either before gather activities begin or during the gather operations. Decisions to humanely euthanize animals in field situations would be made in conformance with BLM policy (Washington Office Instruction Memorandum (WO IM) 2015-070 or most current edition). Conditions requiring humane euthanasia occur infrequently and are described in more detail in Washington Office Instruction Memorandum 2009-041.

Public Viewing Opportunities

Opportunities for public observation of the gather activities on public lands would be provided, when and where feasible, and would be consistent with WO IM No. 2013-058 and the Visitation Protocol and Ground Rules for Helicopter WH&B Gathers. This protocol is intended to establish observation locations that reduce safety risks to the public during helicopter gathers (see Appendix E). Due to the nature of bait and water trapping operations, public viewing opportunities may only be provided at holding corrals.

2.4 Alternatives Considered but Dismissed from Detailed Analysis

2.4.1 Remove or Reduce Livestock within the HMA

This alternative was not considered in detail because it is contrary to previous decisions which allocated forage for livestock use. Such an action would not be in conformance with the existing land use plan, would be contrary to the BLM's multiple-use mission as outlined in the 1976 Federal Land Policy and Management Act (FLPMA), and would also be inconsistent with the WFRHBA, which directs the Secretary to immediately remove excess wild horses. Livestock grazing can only be reduced or eliminated following the process outlined in the regulations found at 43 CFR Part 4100. Such changes do not meet the need for the proposed action and are beyond the scope of the decision to be made. Furthermore, these changes cannot be made through a wild horse gather decision.

2.4.2 Gather the HMA to the AML Upper Limit

This alternative was dismissed from detailed study because AML would be exceeded the foaling season following the initial gather. This would result in the need for a follow up gather within one year, increased stress to individual wild horses and the herd and continued resource damage due to excess wild horses in the interim. Nor would this alternative be consistent with the WFRHBA, which upon determination excess wild horses are present, requires their immediate removal.

2.4.3 Fertility Control Treatment Only (No Removal)

Population modeling was completed to analyze the potential impacts associated with conducting gathers about every 3 years over the next 10 year period to treat captured mares with fertility control. Under this alternative, no excess wild horses would be removed. While the average population growth would be reduced, AML would not be achieved and the damage to the range associated with excess wild horses would continue. This alternative would not meet the Purpose and Need for the Action, and would be contrary to the WFRHBA, and was dismissed from further study.

2.4.4 Tubal Ligation or Laser Ablation of the Oviduct Papilla

These procedures can be performed under standing sedation, usually by flank laparoscopy as described above. Oviducts would be tied, cut or clipped to prevent passage of an egg into the uterus. A very different variation on the technique uses a flexible endoscope passed through the vagina into the uterus and uses surgical adhesive to glue the oviduct closed is under informal investigation at this time. These procedures do not require removal of the ovaries and have less risk of bleeding. Mares would continue to cycle, and be bred by stallions. It is unclear to what extent this could be done in pregnant mares. The oviduct sealing method can only be done on open mares. Currently there is no established procedure for this treatment in domestic or wild horses. This option is still experimental (oviduct sealing with surgical glue) or has not yet been tested (tubal ligation). It is possible that the oviduct sealing could be tested in wild horses; it might be considered “non-destructive” and, hence, there *might be* a potential for using the DOI CX authority for research with that method.

The BLM is aware of only one published study that tested tubal ligation in domestic mares (McCue et al. 2000) and no studies of laser ablation in mares. The safety and effectiveness of these procedures is largely unknown for domestic or wild horses. The BLM received a proposal to study these techniques in 2015, and in 2016 considered conducting research at the Oregon Wild Horse and Burro Corral Facility that would have included novel studies of mare sterilization via tubal ligation and via laser ablation of the oviduct papilla (BLM 2016). The estimated cost of treatment per animals was $150–$250 and $75–$125, respectively. The EA that analyzed that research made clear that the purpose and need of that study was to “…conduct research on three methods of permanent mare sterilization….” Tubal ligation and laser ablation were promising in principle, but had not been tested. Neither method has been proven elsewhere to be effective in wild or feral mares. Partners withdrew from the BLM-funded study that would have examined the safety and efficacy of those procedures in Oregon, and the study proposed to have taken place in 2016 did not take place. Expected outcomes of these techniques remain speculative because they have not been tested on wild horse mares. In addition, there have been no proposals submitted to BLM to test these techniques since the withdrawal of the 2016 study.

BLM FFO was unable to find sufficient information to analyze this alternative in detail at this time.

2.4.5 Male Based Population Growth Suppression using Vasectomy or Gelding

Vasectomy is a method of fertility control that could be effective in reducing wild horse and burro reproductive rates in some circumstances. In principle, this method could be used as a part of herd management by itself or in conjunction with other fertility control methods. The use of vasectomy in wild or feral horses has been addressed in peer-reviewed scientific papers (e.g., Asa 1999, Scully et al. 2015, Collins and Kasbohm 2016). Previous work has shown that sterilizing feral stallions contributed to some degree of reduction in female fertility (Collins and Kasbohm 2016). However, a general concern with male-based fertility control for wild horses is the expectation that female fertility rates will not decline in direct proportion to the fraction of males treated (Garrott and Siniff 1992). Although sterilization of dominant males may be an effective treatment to reduce foaling in a small sample of bands selected from a population, this treatment might not limit population growth (Eagle et al. 1993). That is to say, mares in bands with a vasectomized or gelded stallion can mate with multiple stallions and still get pregnant. A gelding on-range behavioral outcomes study where a portion of the stallions were gelded is currently being conducted in Utah (BLM Utah 2016).

2.4.6 Control of Wild Horse Numbers by Natural Means

This alternative would use natural means, such as natural predation and weather, to control the wild horse population. This alternative was eliminated from further consideration because it would be contrary to the WFRHBA which requires the BLM to protect the range from deterioration associated with an overpopulation of wild horses. The alternative of using natural controls to achieve a desirable AML has not been shown to be feasible in the past. Wild horse populations in the Swasey HMA are not substantially regulated by predators, as evidenced by the 20% average annual increase in the wild horse population. In addition, wild horses are a long-lived species with documented foal survival rates exceeding 95% and are not a self-regulating species. This alternative would allow for a steady increase in the wild horse populations which would continue to exceed the carrying capacity of the range and would cause increasing damage to the rangelands until severe range degradation or natural conditions that occur periodically – such as blizzards or extreme drought – cause a catastrophic mortality of wild horses in the HMA.

2.4.7 Raising the Appropriate Management Levels for Wild Horses

This alternative was not brought forward for detailed analysis because it would be outside of the scope of the analysis, and would be inconsistent with the WFRHBA which directs the Secretary to immediately remove excess wild horses and to manage for a thriving natural ecological balance and for multiple uses. Available data shows that excess wild horses are present on the range, and that excess horses need to be removed. Given the resource degradation occurring with the current overpopulation of wild horses, it is necessary to bring the population back to AML first so the agency can collect data that would help inform whether the range could support additional horses above AML while still ensuring a thriving natural ecological balance. Given the absence of data that would support a modification to the AML, this gather decision is not an appropriate mechanism for adjusting AML.

2.4.8 Designation of the HMA to be Managed Principally for Wild Horses

Designation of all HMAs, as "Wild Horse and Burro Ranges" was proposed through public comments conducted during the development of multiple NEPA documents pertaining to gathering of wild horses across the country. This action under 43 CFR 4710.3-2 would require amendment of the land use plan, which would be outside the scope of this EA. Only the BLM Director or Assistant Director (as per BLM Manual 1203: Delegation of Authority), may establish a Wild Horse and Burro Range after a full assessment of the impact on other resources through the land-use planning process. Wild Horse and Burro Range is not an "exclusive" designation. Designation would not necessarily exclude livestock use; therefore, levels of livestock grazing permitted could remain the same.

2.4.9 Use of Alternative Capture Techniques Instead of Helicopter Capture

An alternative using capture methods other than helicopters to gather excess wild horses has been suggested by some members of the public. As no specific alternative methods were suggested, the BLM identified chemical immobilization, net gunning, and wrangler/horseback drive trapping as potential methods for gathering wild horses. Net gunning techniques normally used to capture big game animals also rely on helicopters. Chemical immobilization is a very specialized technique and strictly regulated. Currently the BLM does not have sufficient expertise to implement either of these methods and it would be impractical to use given the size of the project area, access limitations, and difficulties in approachability of the wild horses. Use of wrangler on horseback drive-trapping to remove excess wild horses can be fairly effective on a small scale. However, given the number of excess wild horses to be removed from the Swasey HMA, access limitations, and difficulties in approaching the wild horses this technique would be ineffective and impractical. Horseback drive-trapping is also very labor intensive and can be very dangerous to the domestic horses and the wranglers used to herd the wild horses. Domestic horses can easily be injured while covering rough terrain and the wrangler could be injured if he/she falls off. For these reasons, this alternative was eliminated from further consideration.

2.4.10 Make Individualized Excess Wild Horse Determinations Prior to Removal

An alternative whereby BLM would make on-the-ground and individualized excess wild horse determinations prior to removal of wild horses from any HMA has been advocated by some members of the public. Under the view set forth in some comments during public commenting for wild horse gathers nationwide, a tiered or phased removal of wild horses from the range is mandated by the WFRHBA. [2]. Specifically, this alternative would involve a tiered gather approach, whereby BLM would first identify and remove old, sick or lame animals in order to euthanize those animals on the range prior to gather. Second, BLM would identify and remove

[2] The view that the WFRHBA requires a tiered removal process has been litigated and rejected by Federal courts. See *In Defense of Animals v. Salazar*, 675 F. Supp. 2d 89, 97-98 (D.D.C. 2009); *In Defense of Animals v. United States DOI*, 909 F. Supp. 2d 1178, 1190-1191 (E.D. Cal. 2012), aff'd 751 F.3d 1054, 1064-1065 (9th Cir. 2014).

wild horses for which adoption demand exists, e.g., younger wild horses or wild horses with unusual and interesting markings. Under the WFRHBA(1333(b)(2)(iv)(C)), BLM would then sell or destroy any additional excess wild horses for which adoption demand does not exist in the most humane and cost effective manner possible, although euthanasia and sale without limitations are currently limited by Congressional appropriations.

This proposed alternative could be viable in situations where the project area is contained, the area is readily accessible and wild horses are clearly visible, and where the number of wild horses to be removed is so small that a targeted approach to removal can be implemented. However, under the conditions present within the gather area and the significant number of excess wild horses both inside and outside of the HMA, this proposed alternative is impractical, if not impossible, as well as less humane for a variety of reasons.

First, BLM does euthanize old, sick or lame animals on the range when such animals have been identified. This occurs on an on-going basis and is not limited to wild horse gathers. During a gather, if old, sick or lame animals are found and it is clear that an animal's condition requires the animal to be put down, that animal is separated from the rest of the group that is being herded so that it can be euthanized on the range. However, wild horses that meet the criteria for humane destruction because they are old, sick or lame usually cannot be identified as such until they have been gathered and examined up close, e.g., so as to determine whether the wild horses have lost all their teeth or are club footed. Old, sick and lame wild horses meeting the criteria for humane euthanasia are also only a small fraction of the total number of wild horses to be gathered.

Due to the size of the gather area, access limitations associated with topographic and terrain features and the challenges of approaching wild horses close enough to make an individualized determination of whether a wild horse is old, sick or lame, it would be virtually impossible to conduct a phased culling of such wild horses on the range without actually gathering and examining the wild horses. Similarly, rounding up and removing wild horses for which an adoption demand exists, before gathering any other excess wild horses, would be both impractical and much more disruptive and traumatic for the animals. Recent gathers have had success in adopting out approximately 30% of excess wild horses removed from the range on an annual basis. The size of the gather area, terrain challenges, difficulties of approaching the wild horses close enough to determine age and whether they have characteristics (such as color or markings) that make them more adoptable, the impracticalities inherent in attempting to separate the small number of adoptable wild horses from the rest of the herd, and the impacts to the wild horses from the closer contact necessary, makes such phased removal a much less desirable method for gathering excess wild horses. This approach would create a significantly higher level of disruption for the wild horses on the range and would also make it much more difficult to gather the remaining excess wild horses.

Making a determination of excess as to a specific wild horse under this alternative, and then successfully gathering that individual wild horse would be impractical to implement (if not impossible) due to the size of the gather area, terrain challenges and difficulties approaching the wild horses close enough to make an individualized determination. This tiered approach would also be extremely disruptive to the wild horses due to repeated culling and gather activities over a short period of time. Gathering excess wild horses under this alternative would greatly increase the potential stress placed on the animals due to repeated attempts to capture specific animals and not others in the band. This in turn would increase the potential for injury, separation of mare/foal pairs, and possible mortality.

This alternative would be impractical to implement (if not impossible), would be cost-prohibitive, and would be unlikely to result in the successful removal of excess wild horses. This approach would also be less humane and more disruptive and traumatic for the wild horses. This alternative was therefore eliminated from any further consideration.

3.0 Affected Environment

This section of the EA briefly discusses the relevant components of the human environment which would be either affected or potentially affected by the Action Alternative or No Action (refer to Table 1). Direct impacts are those that result from the management actions while indirect impacts are those that exist once the management action has occurred.

3.1 General Description of the Affected Environment

Swasey HMA

The Swasey HMA encompasses 120,113 acres of public and private land, within Juab and Millard Counties, Utah, (Map). The HMA includes the Swasey Mountain of the House Range, Whirlwind and Tule Valleys as topographic features. This range is made up of long, narrow and steep ridges with large flats areas in Whirlwind Valley. Elevation varies from 9600 feet to 4500 feet. Precipitation averages 4-6 inches at lower elevations to 6-8 inches at the highest elevations. Temperatures also vary, from 0 and -10 degrees Fahrenheit in winter to between 100 and 105 degrees Fahrenheit in summer.

Vegetation in the area is made up of three main vegetative types. Saltbush-grass type, black sage-grass type, and rabbit brush-grass type. There are a few juniper trees that occur on the tops of the low mountain ridges. Key species include indian ricegrass (*Oryzopsis hymenoides*), bottlebrush squirreltail (*Sitanion hystrix*), galletta (*Hilaria jamesii*), needleandthread (*Stipa comata*), sand dropseed (*Sporobolus cryptandrus*) and winterfat (*Ceratoides lanata*). Other forage species include:

Grasses	Forbs	Shrubs
Basin wildrye (*Elymus cinereus*)	Scarlet globemallow (*Sphaeralcea coccinea*)	Black sagebrush (*Artemisia nova*)
Muttongrass (*Poa fendleriana*)	Buckwheat (*Eriogonum*)	Shadscale (*Atriplex confertifolia*)
Western wheatgrass (*Agropyron smithii*)		Ephedra (Ephedra nevadensis)
Mountain brome (*Bromus carinatus*)		Big sagebrush (*Artemisia tridentata*)
Bluebunch wheatgrass (*Agropyron spicatum*)		Budsage (*Artemisia spinescens)*
Prairie junegrass (*Koeleria macrantha*)		

Permanent waters are located on the east side of the HMA below Swasey Peak. Several of these waters have been developed and are piped to various portions of the HMA to distribute availability. Horses also water at Coyote Springs which is located on the west side of the HMA in Tule Valley. Water is also available occasionally at several springs on the north end and catchment ponds throughout the HMA after large storm events.

3.2 Description of Affected Resources/Issues

Table 1 lists the elements of the human environment subject to requirements in statute, regulation, or executive order which must be considered.

Table 1: Supplemental Authorities (Critical Elements of the Human Environment)

Supplemental Authorities	Present	Affected	Rationale
ACECs	**NO**	**NO**	Not Present
Air Quality	**YES**	**NO**	The planning area is outside a non-attainment area. Implementation of the Proposed Action would result in small and temporary areas of disturbance and associated dust emissions.
Cultural Resources	**YES**	**NO**	To prevent any impacts to cultural resources, trap sites and temporary holding facilities would be located in previously disturbed areas. Cultural resource inventory and clearance would be required prior to using trap sites or holding facilities outside existing areas of disturbance. (Refer to SHPO Project No. U-10-BL-0259b required item 12)
Environmental Justice	**YES**	**NO**	Implementation of the proposed action would not have a noticeable impact on environmental justice in Millard and Juab Counties.
Fish Habitat	**NO**	**NO**	Not present.
Floodplains	**NO**	**NO**	There are no floodplains that may be adversely impacted and the proposed action is in compliance with Executive Order 11988 on Floodplain Management
Forest and Rangelands	**YES**	**YES**	No impact to Forestry. Rangelands and Rangeland Health discussed below.
Migratory Birds	**YES**	**NO**	Given the low magnitude and short duration of the proposed action, no impacts to migratory birds are anticipated. Migratory birds may benefit from the reduction of herd numbers.
Native American Religious Concerns	**NO**	**NO**	There are no known Native American religious concerns or Traditional Cultural Properties that will be impacted within the project area.
Noxious Weeds	**YES**	**NO**	To prevent the risk for spread, any noxious weeds or non-native invasive weeds would be avoided when establishing and accessing trap sites and holding facilities.
Prime or Unique Farmlands	**NO**	**NO**	Not present.

Riparian-Wetland Zones	**YES**	**NO**	Reduction of the numbers of wild horses by implementation of the proposed action would result in reduced use of riparian vegetation by wild horses. Direct disturbance of riparian areas is not anticipated.
T&E Species	**NO**	**NO**	There are no known federally listed fish or wildlife species within the proposed wild horse gather operation.
Water Quality	**YES**	**NO**	There would be no impacts to water resources/quality.
Waste (Hazardous or Solid)	**NO**	**NO**	Not present.
Wild and Scenic Rivers	**NO**	**NO**	There are no Wild and Scenic Rivers within the proposed project location per PL111.11.
Wilderness and Wilderness Study Area	**YES**	**NO**	No direct disturbance in WSAs or Wilderness areas. Gather operations in Wilderness Study Areas (WSAs) would be conducted by herding animals by helicopter to the temporary gather sites located outside WSA boundaries.

Critical elements of the human environment identified as present and potentially affected by the Action Alternatives and/or the No Action Alternative include: Rangelands and Rangeland Health. In addition to the critical elements listed in Table 2, the following resources may be affected by the Action Alternative and/or the No Action Alternative: Wild Horses and Livestock Grazing. The existing situation (affected environment) relative to these resources is described below.

3.2.1 Livestock

The Antelope, Sand Pass, Swasey Knoll, and Tatow Allotments are within the Swasey HMA. There are a total of 7 livestock operators who are currently authorized to graze livestock in these allotments annually. The operators are authorized to use 13,954 Animal Unit Months (AUMs) of forage each year. An AUM is the amount of forage needed to sustain one cow, five sheep, or five goats for a month. The season of use may vary by 1-2 weeks annually based upon forage availability, drought conditions, and other management criteria.

The BLM allocated forage for livestock use through the House Range Resource Area RMP/ROD, 1987. AML was established as a population range 60 -100 in the House Range Resource Area Final EIS/RMP, 1986. Adjustments in permitted use have been made through Allotment Management Plans as conditions have changed such as drought and class of livestock changes.

Table 2 summarizes the livestock use information for the allotments in the HMA(s).

Table 2: Livestock Use Information

Allotment	Total Allotment Acres	% of Allotment in HMA	Permittee	Livestock	Authorized Season of Use	Authorized Livestock AUMs (Preference Entire Allotment)	Suspended AUMs or AUMs in (Nonuse Entire Allotment)
Antelope	79,707	43%	1 2	2642 Sheep 19 Cattle	11/01 – 04/30 05/01 – 09/30	3181 96	
Sand Pass	36,539	44%	1	1609 Sheep	11/01 – 04/30	1915	200
Swasey Knoll	56,040	35%	1	4092 Sheep	11/01 – 04/30	4562	
Tatow	67,122	95%	1 2 3	3777 Sheep 43 Cattle 11 Cattle	11/01 – 04/30 05/01 – 09/30 05/01 – 09/30	4076 165 55	 30 21

3.2.2 Rangeland Health Standards

The Standards for Rangeland Health indicate that the potential for soil erosion would be reduced (*Standard 1. Upland soils exhibit permeability and infiltration rates that sustain or improve site productivity, considering the soil type, climate, and landform*) and riparian areas would receive less grazing pressure, which in turn would reduce the impacts to these riparian areas (*Standard 2. Riparian and wetland areas are in properly functioning condition. Stream channel morphology and functions are appropriate to soil type, climate and landform*) and would contribute to the maintenance of desired species (*Standard 3. Desired species, including native, threatened, endangered and special-status species, are maintained at a level appropriate for the site and species involved*). Therefore, the potential for maintenance of rangeland health would be increased by removing the wild horses to keep their numbers on the HMA within the appropriate management level. If no action is taken, rangeland health will deteriorate in areas where wild horses spend most of their time. Riparian vegetation would be affected and soil erosion would increase as desired vegetation is removed from the range. Rangeland health assessments completed in August, 2000 and May, 2002 in the Antelope and Swasey Knoll Allotments indicated that all standards were met at that time. Trend data shows some fluctuations over past years, but it indicates that there is an overall static trend in the condition of the rangeland. However, in recent years drought has affected the HMA. According to the US Drought Monitor the 2013, 2014, 2015, 2016, and 2018 springs all experienced moderate to extreme drought conditions during the critical growing season in Millard and Juab Counties; which includes the Swasey HMA. Drought and moderate to high utilization has effected the forage species (see Table 3). The photos below were taken in June of 2018 on the east side of Swasey Mtn. along an ATV trail that runs north and south within the Swasey HMA. These photos show a lack of forage plants such as grasses and forbs. The photos are a good representation of conditions on the east side of the HMA during the 2018 season.

Photo1: Taken June 21, 2018 about 1 mile south of Swasey Spring's Middle Pond.

Photo 2: Taken June 21, 2018 approximately 2 miles south of Swasey Spring's Middle Pond.

Table 3: Swasey HMA Average % Utilization from Years 2014-2017

	2014*	2015*	2016*	2017*
Indian ricegrass	41	12	36	51
Galleta	30	7		51
POA	50			
Winter Fat	28	6	18	29
Globemallow	41			
Budsage	16	10		13
Black sage	38	18		4

***** Utilization was done in May each year.

3.2.3 Wild Horses

The Swasey HMA was formally designated as a Herd Management Area (HMA) through the House Range Resource Area RMP/ROD, 1987. AML was established through site vegetation inventory monitoring and data collection as a population range 60 -100 in the House Range Resource Area Final EIS/RMP, 1986.

Table 4 summarizes the AML, current population, and estimated removal numbers for the HMA under the Proposed Action.

Table 4: Summary of Wild Horse Population Information

HMA	Acres	AML Range	Estimated Pop. After 2019 Pop. Increase	Proposed Target Remove	Est'd Post Gather Pop. Size
Swasey	120,113	60 - 100	721*	661*	60

* 20% will be added to the above population number to account for population increase if the gather doesn't happen prior to Mar. 1, 2020 and for every year thereafter that the gather is delayed.

The current estimated population of wild horses in the Swasey HMA of 721 is based on the double observer aerial population survey completed in March, 2018 with 20% added to account for the 2018 population increase and 20% for 2019. Analysis of data indicates an average annual growth rate of approximately 21% since the last gather. Table 4 summarizes the projected numbers that may be present if a gather occurs prior to March 1, 2020. The last removal of excess wild horses from the Swasey HMA was completed in February, 2013 when 159 horses were removed, 98 were released back to the HMA, and 44 mares were treated with PZP-22.

Utilization levels on the rangelands within the HMA have shown increases as the wild horse population has increased (see Table 3). Potential for loss of key forage species has increased as the amount of sustainable forage is depleted through higher levels of use. 2018 had drought conditions during the critical growing season for plant species. Drought events over the past ten years have shown the effects of limited resources for wild horses through body condition and range condition. Areas outside the HMA are experiencing increased un-allotted use on forage species and resources by wild horses which have expanded outside the HMA. These wild horses above AML need to be removed in order to protect the resources outside the HMA and those resources within the HMA to allow for proper rangeland health and herd sustainability.

Wild horses within the Swasey HMA are currently in thin to moderate body class conditions or a body condition score (BCS) class 3 – 5 on the Henneke BCS chart with a few very thin or BCS 2. Increased utilization levels have been observed within key areas, which adversely impacts range health and inhibits recovery of the native vegetative communities in these key areas (see Table 3). Monitoring also indicates that wild horses have moved and are residing outside the Swasey HMA boundaries.

Hair samples will be collected for the Swasey HMA to establish baseline genetic diversity for the HMA and to determine any changes in variation over time.

Table 5: Wild Horse Gather History

HMA	Fiscal Year	Removed
Swasey	1978	161
Swasey	1984	40
Swasey	1990	39
Swasey	1993	76
Swasey	1996	53
Swasey	1999	130
Swasey	2003	87

Swasey	2007	162
Swasey	2013	159

Table 5 above shows the gather history of the HMA since 1978 and the number of removed wild horses. The table also indicates that removing wild horses from the Swasey HMA has not negatively impacted their population growth and that the herd continues to thrive.

3.2.4 Public Safety

In recent gathers, members of the public have increasingly traveled to the public lands to observe BLM's gather operations. Members of the public can inadvertently wander into areas that put them in the path of wild horses that are being herded or handled during the gather operations, creating the potential for injury to the wild horses or burros and to the BLM employees and contractors conducting the gather and/or handling the horses as well as to the public themselves. Because these horses are wild animals, there is always the potential for injury when individuals get too close or inadvertently get in the way of gather activities.

The helicopter work is done at various heights above the ground, from as little as 10-15 feet (when herding the animals the last short distance to the gather corral) to several hundred feet (when doing a recon of the area). While helicopters are highly maneuverable and the pilots are very skilled in their operation, unknown and unexpected obstacles in their path can impact their ability to react in time to avoid members of the public in their path. These same unknown and unexpected obstacles can impact the wild horses or burros being herded by the helicopter in that they may not be able to react and can be potentially harmed or caused to flee which can lead to injury and additional stress. When the helicopter is working close to the ground, the rotor wash of the helicopter is a safety concern by potentially causing loose vegetation, dirt, and other objects to fly through the air which can strike or land on anyone in close proximity as well as cause decreased vision.

During the herding process, wild horses or burros will try to flee if they perceive that something or someone suddenly blocks or crosses their path. Fleeing horses can go through wire fences, traverse unstable terrain, and go through areas that they normally don't travel in order to get away, all of which can lead them to injure people by striking or trampling them if they are in the animal's path.

Disturbances in and around the gather and holding corral have the potential to injure the government and contractor staff who are trying to sort, move and care for the horses and burros by causing them to be kicked, struck, and possibly trampled by the animals trying to flee. Such disturbances also have the potential for similar harm to the public themselves.

Public observation of the gather activities on public lands will be allowed and would be consistent with BLM IM No. 2010-164 and in compliance with visitation protocols for scheduled and nonscheduled visitation found in Appendix E.

4.0 Environmental Consequences

4.1 Introduction

This section of the EA documents the potential environmental impacts which would be expected with implementation of the Proposed Action, and the No Action Alternative. These include the direct impacts (those that result from the management actions) and indirect impacts (those that exist once the management action has occurred).

4.2 Predicted Effects of Alternatives

The direct and indirect impacts to these resources which would be expected to result with implementation of the Action Alternative or No Action Alternative are discussed in detail below.

4.2.1 Livestock

Impacts of Alternatives A, B, C, and D

Livestock are permitted to graze within the Swasey HMA and gather activities could result in direct short-term impacts by disturbing and dispersing the livestock present. Reduced competition between livestock and wild horses for the available forage and water would also result. Indirect impacts would include an increase in the quality and quantity of the available forage in the short-term. Over the longer-term, improved vegetation resources would lead to a thriving natural ecological condition.

Impacts of Alternative E (No Action)

Utilization by authorized livestock has been directly impacted due to the current overpopulation of wild horses, both within and outside the Swasey HMA. Livestock operators have had to move cattle off from allotments within the Swasey HMA to allotments outside of the Swasey HMA for short periods of time to help compensate for the high utilization that is occurring. The current wild horse population is 7 times above their forage allocation and will continue to increase each foaling season that passes without a gather. Moderate to heavy utilization will continue to occur. The indirect impacts of the No Action (Defer Gather and Removal) alternative would potentially cause continued damage to the resources. These resources are potentially impacted due to continued competition between livestock, wild horses and wildlife for the available forage and water, reduced quantity and quality of forage and water, and undue hardship on the livestock operators who would continue to be unable to fully use the forage they are authorized to use.

4.2.2 Rangeland Health Standards

Impacts of Alternatives A, B, C, and D

Rangeland Health Standards are directly impacted by the levels of use experienced upon upland soils, riparian and wetland areas, desired plant species including native, threatened, endangered and special status species. A reduction in the number and maintaining of wild horses to the appropriate management levels within the HMA would allow increased maintenance of rangeland health. Over time, as population levels are managed at AML, rangeland health would continue to improve allowing for the thriving ecological condition of all uses present.

Impacts of Alternative E (No Action)

Deterioration of rangeland health would continue to increase as population levels increase with no action. Those areas where wild horses spend a majority of their time would suffer from the loss of riparian vegetation, increased soil erosion with compaction, and the desired plant species are removed from the range. Indirect impacts from no action would occur in areas not suitable for wild horses. These areas outside the HMAs would experience increased levels of use and may not be resilient enough to recover. Wild horses exist within the HMAs because their basic needs of water, desirable vegetation, cover and space are met. Areas outside the HMAs lack some if not all of these needs and would suffer from increased use.

4.2.3 Wild Horses

Results of Win Equus Population Modeling

The Alternatives were modeled using Version 1.40 of the Win Equus population model (Jenkins, 2002). The purpose of the modeling was to analyze and compare the effects of the Alternatives on population size, average population growth rate, and average removal number. See Appendix F for additional detail.

To summarize the results obtained by simulating the range of alternatives for the Swasey HMA Wild Horse Gather, the original questions can be addressed.

Do any of the Alternatives "crash" the population?

None of the alternatives indicate that a "crash" is likely to occur to the population. Minimum population levels and growth rates are all within reasonable levels, and adverse impacts to the population are not likely. The lowest minimum population size for each alternative is above the level that genetic testing has indicated that important genetic variability in the herd could be lost (< 50 animals).

What effect does fertility control have on population growth rate?

The use of fertility control is not an alternative that was analyzed in detail in this EA, but was used in the population modeling for comparison reasons. The use of fertility control reflects a slightly lower population growth rate than without the use of fertility control. However, the use of fertility control would not reduce the population to AML without removal of wild horses from the range.

What effect do the different alternatives have on the average population size?

The level to which the population is gathered appears to be more of an influence to average population size than fertility control. As expected, alternatives without removal of wild horses result in the highest average population.

What effects do the different alternatives have on the genetic health of the herd?

The minimum population levels and growth rates are all within reasonable levels for each alternative; therefore, adverse impacts to the population are not likely to occur. Moreover, if genetic diversity monitoring reveals that there are causes for concern about the levels of observed heterozygosity in the herd, BLM can introduce additional wild horses from a different HMA, to augment genetic diversity within the Swasey HMA.

The use of tracking collars and tags was analyzed in the Wild Horse section of Chapter 4 of the EA *Population Control Research Wild Horse Gather for the Conger and Frisco Herd Management Areas* (DOI-BLM-UT-W020-2015-0017-EA). Tracking collars and tags are currently being used in horses in the Conger and Frisco HMAs.

Impacts of Alternative A: Selective Removal of Excess Wild Horses to within AML range, and Population Growth Control using fertility control treatments PZP-22 or most current formulations.

Over the past 35 years, various impacts to wild horses as a result of gather activities have been observed. Under this action, potential impacts to wild horses would be both direct and indirect, occurring to both individual horses and the population as a whole.

The BLM has been conducting wild horse gathers since the mid-1970s. During this time, methods and procedures have been identified and refined to minimize stress and impacts to wild horses during gather implementation. The CAWP would be implemented to ensure a safe and humane gather occurs and would minimize potential stress and injury to wild horses.

In any given gather, gather-related mortality averages only about one-half of one percent (0.5%), which is very low when handling wild animals. Approximately, another six-tenths of one percent (0.6%) of the captured animals, on average, are humanely euthanized due to pre-existing conditions and in accordance with BLM policy (GAO-09-77). These data affirm that the use of helicopters and motorized vehicles has proven to be a safe, humane, effective, and practical means for the gather and removal of excess wild horses (and burros) from the public lands. The BLM also avoids gathering wild horses by helicopter during the 6 weeks prior to and following the expected peak of the foaling season (i.e., from March 1 through June 30).

Individual, direct impacts to wild horses include the handling stress associated with the roundup, capture, sorting, handling, and transportation of the animals. The intensity of these impacts varies by individual, and is indicated by behaviors ranging from nervous agitation to physical distress. When being herded to trap site corrals by the helicopter, injuries sustained by wild horses may include bruises, scrapes, or cuts to feet, legs, face, or body from rocks, brush or tree limbs. Rarely, wild horses will encounter barbed wire fences and will receive wire cuts. These injuries are very rarely fatal and are treated on-site until a veterinarian can examine the animal and determine if additional treatment is indicated.

Other injuries may occur after a horse has been captured and is either within the trap site corral, the temporary holding corral, during transport between facilities, or during sorting and handling. Occasionally, horses may sustain a spinal injury or a fractured limb but based on prior gather statistics, serious injuries requiring humane euthanasia occur in less than 1 horse per every 100 captured. Similar injuries could be sustained if wild horses were captured through bait and/or water trapping, as the animals still need to be sorted, aged, transported, and otherwise handled following their capture. These injuries can result from kicks and bites, or from collisions with corral panels or gates.

To minimize the potential for injuries from fighting, the animals are transported from the trap site to the temporary (or short-term) holding facility where they are sorted as quickly and safely as possible, then moved into large holding pens where they are provided with hay and water. On many gathers, no wild horses are injured or die. On some gathers, due to the temperament of the horses, they are not as calm and injures are more frequent. Overall, direct gather-related mortality averages less than 1%.

Indirect individual impacts are those which occur to individual wild horses after the initial event. These may include miscarriages in mares, increased social displacement, and conflict in studs. These impacts, like direct individual impacts, are known to occur intermittently during wild horse gather operations. An example of an indirect individual impact would be the brief 1-2 minute skirmish between older studs which ends when one stud retreats. Injuries typically involve a bite or kick with bruises which do not break the skin. Like direct individual impacts, the frequency of these impacts varies with the population and the individual. Observations following capture indicate the rate of miscarriage varies, but can occur in about 1 to 5% of the captured mares, particularly if the mares are in very thin body condition or in poor health.

A few foals may be orphaned during a gather. This can occur if the mare rejects the foal, the foal becomes separated from its mother and cannot be matched up following sorting, the mare dies or must be humanely euthanized during the gather, the foal is ill or weak and needs immediate care that requires removal from the mother, or the mother does not produce enough milk to support the foal. On occasion, foals are gathered that were previously orphaned on the range (prior to the gather) because the mother rejected it or died. These foals are usually in poor condition. Every effort is made to provide appropriate care to orphan foals. Veterinarians may administer electrolyte solutions or orphan foals may be fed milk replacer as needed to support their nutritional needs. Orphan foals may be placed in a foster home in order to receive additional care. Despite these efforts, some orphan foals may die or be humanely euthanized as an act of mercy if the prognosis for survival is very poor.

Through the capture and sorting process, wild horses are examined for health, injury and other defects. Decisions to humanely euthanize animals in field situations would be made in conformance with BLM policy. BLM Euthanasia Policy IM-2009-041 is used as a guide to determine if animals meet the criteria and should be euthanized. Animals that are euthanized for non-gather related reasons include those with old injuries (broken or deformed limbs) that cause lameness or prevent the animal from being able to maintain an acceptable body condition (greater than or equal to BCS 3); old animals that have serious dental abnormalities or severely worn teeth and are not expected to maintain an acceptable body condition, and wild horses that have serious physical defects such as club feet, severe limb deformities, or sway back. Some of these conditions have a causal genetic component such that the animals should not be returned to the range; this prevents suffering and avoids amplifying the incidence of the deleterious gene in the wild population.

Wild horses not captured may be temporarily disturbed and moved into another area during the gather operation. With the exception of changes to herd demographics from removals, direct population impacts have proven to be temporary in nature with most, if not all, impacts disappearing within hours to several days of release. No observable effects associated with these impacts would be expected within one month of release, except for a heightened awareness of human presence.

It is not expected that genetic health would be affected by the Action Alternatives. Available indications are that these populations contain high levels of genetic diversity at this time. More information about the genetic diversity in the population will become available as a result of the Action Alternatives. The AML range of 60 – 100 should provide for acceptable genetic diversity, especially since some movement of horses between the Confusion, Conger, and Swasey HMAs does occur. If at any time in the future the genetic diversity (as measured by observed heterozygosity) in the HMA is determined to be below a critical threshold, then a large number of other HMAs could be used as sources for fertile wild horses that could be transported into the HMA of concern.

By maintaining wild horse population size within the AML, there would be a lower density of wild horses across the HMA, reducing competition for resources and allowing the wild horses that remain to use their preferred habitat. Maintaining population size near the established AML would be expected to improve forage quantity and quality and promote healthy, self-sustaining populations of wild horses in a thriving natural ecological balance and multiple use relationship on the public lands in the area. Deterioration of the range associated with wild horse overpopulation would be reduced. Managing wild horse populations in balance with the available habitat and other multiple uses would lessen the potential for individual animals or the herd to be affected by drought, and would avoid or minimize the need for emergency gathers. All this would reduce stress to the animals and increase the success of these herds over the long-term.

Transport, Short Term Holding, and Adoption (or Sale) Preparation

Wild horses removed from the range will be transported to the receiving short-term holding facility in straight deck semi-trailers or goose-neck stock trailers. Vehicles will be inspected prior to use to ensure wild horses can be safely transported and that the interior of the vehicle is in a sanitary condition. Wild horses are segregated by age and sex and loaded into separate compartments. A small number of mares may be shipped with foals. Transportation of recently captured wild horses is limited to a maximum of 8 hours. During transport, potential impacts to individual horses can include stress, as well as slipping, falling, kicking, biting, or being stepped on by another animal. Unless wild horses are in extremely poor condition, it is rare for an animal to be seriously injured or die during transport.

Upon arrival at the short-term holding facility, recently captured wild horses are off-loaded by compartment and placed in holding pens where they are fed good quality hay and water. Most wild horses begin to eat and drink immediately and adjust rapidly to their new situation. At the short-term holding facility, a veterinarian examines each load of horses and provides recommendations to the BLM regarding care, treatment, and if necessary, euthanasia of the recently captured wild horses. Any animals affected by a chronic or incurable disease, injury, lameness or serious physical defect (such as severe tooth loss or wear, clubfeet, and other severe congenital abnormalities) would be humanely euthanized using methods acceptable to the American Veterinary Medical Association (AVMA). Wild horses in very thin condition or animals with injuries are sorted and placed in hospital pens, fed separately and/or treated for their injuries as indicated. Recently captured wild horses, generally mares, in very thin condition may have difficulty transitioning to feed. Some of these animals are in such poor condition that it is unlikely they would have survived if left on the range. Similarly, some mares may lose their pregnancies. Every effort is taken to help the mare make a quiet, low stress transition to captivity and domestic feed to minimize the risk of miscarriage or death.

After recently captured wild horses have transitioned to their new environment, they are prepared for adoption or sale. Preparation involves freeze marking the animals with a unique identification number, drawing a blood sample to test for equine infections anemia, vaccination against common diseases, castration, and de-worming. During the preparation process, potential impacts to wild horses are similar to those that can occur during handling and transportation. Serious injuries and deaths from injuries during the preparation process are rare, but can occur.

At short-term corral facilities, a minimum of 700 square feet is provided per animal. Mortality at short-term holding facilities averages approximately 5% per year (GAO-09-77, Page 51), and includes animals euthanized due to a pre-existing condition; animals in extremely poor condition; animals that are injured and would not recover; animals which are unable to transition to feed; and animals which are seriously injured or accidentally die during sorting, handling, or preparation.

Adoption or Sale with Limitations, and Long Term Holding

Adoption applicants are required to have at least a 400 square foot corral with panels that are at least six feet tall for horses over 18 months of age. Applicants are required to provide adequate shelter, feed, and water. The BLM retains title to the horse for one year and the horse and the facilities are inspected to assure the adopter is complying with the BLM’s requirements. After one year, the adopter may take title to the horse, at which point the horse becomes the property of the adopter. Adoptions are conducted in accordance with 43 CFR 4750.

Potential buyers must fill out an application and be pre-approved before they may buy a wild horse. A sale-eligible wild horse is any animal that is more than 10 years old; or has been offered unsuccessfully for adoption three times. The application also specifies that all buyers are not to re-sell the animal to slaughter buyers or anyone who would sell the animal to a commercial processing plant. Sales of wild horses are conducted in accordance with Bureau policy.

Table 6 shows the adoption numbers nationwide from 2012 to 2018 and Table 7 shows the sale with limitation numbers from 2012 to 2018 to qualified individuals.

Fiscal Year	Horses	Burros	Total
2018	2,459	699	3,158
2017	2,905	612	3,517
2016	2,440	472	2,912
2015	2,331	300	2,631
2014	1,789	346	2,135
2013	2,033	278	2,311
2012	2,232	351	2,583

Table 6: Horses and Burros Adopted from years 2012 to 2018.

Fiscal Year	Horses	Burros	Total
2018	1,201	250	1,451
2017	518	64	582
2016	179	32	211
2015	88	180	268
2014	23	64	87
2013	22	43	65
2012	320	82	402

Table 7: Horses and Burros Sold to Good Homes from years 2012 to 2018.

Animals 5 years of age and older are transported to long-term holding (LTH) grassland pastures. The BLM has maintained LTH pastures in the Midwest for over 20 years.

Potential impacts to wild horses from transport to adoption, sale or LTH are similar to those previously described. One difference is that when shipping wild horses for adoption, sale or LTH, animals may be transported for a maximum of 24 hours. Immediately prior to transportation, and after every 18-24 hours of transportation, animals are offloaded and provided a minimum of 8 hours on-the-ground rest. During the rest period, each animal is provided access to unlimited amounts of clean water and 25 pounds of good quality hay per horse with adequate bunk space to allow all animals to eat at one time. Most animals are not shipped more than 18 hours before they are rested. The rest period may be waived in situations where the travel time exceeds the 24-hour limit by just a few hours and the stress of offloading and reloading is likely to be greater than the stress involved in the additional period of uninterrupted travel.

LTH pastures are designed to provide excess wild horses with humane, life-long care in a natural setting off the public rangelands. There wild horses are maintained in grassland pastures large enough to allow free-roaming behavior and with the forage, water, and shelter necessary to sustain them in good condition. About 35,700 wild horses, that are in excess of the existing adoption or sale demand (because of age or other factors), are currently located on private land pastures in the mid-west. Located in mid or tall grass prairie regions of the United States, these LTH pastures are highly productive grasslands as compared to more arid western rangelands. The majority of these animals are older in age.

Mares and sterilized stallions (geldings) are segregated into separate pastures except one facility where geldings and mares coexist. Although the animals are placed in LTH, they remain available for adoption or sale to qualified individuals. No reproduction occurs in the long-term grassland pastures, but foals born to pregnant mares are gathered and weaned when they reach about 8-10 months of age and are then shipped to short-term facilities where they are made available adoption. Handling by humans is minimized to the extent possible although regular on-the-ground observation and weekly counts of the wild horses to ascertain their numbers, well-being, and safety are conducted. A very small percentage of the animals may be humanely euthanized if they are in very thin condition and are not expected to improve to a BCS of 3 or greater due to age or other factors. Natural mortality of wild horses in LTH pastures averages approximately 8% per year, but can be higher or lower depending on the average age of the horses pastured there (GAO-09-77, Page 52). The savings to the American taxpayer which results from contracting for LTH pastures averages about $4.45 per horse per day as compared with maintaining the animals in short-term holding facilities.

Euthanasia and Sale without Limitation

While humane euthanasia and sale without limitation of healthy horses for which there is no adoption demand is authorized under the WFRHBA, Congress currently prohibits the use of appropriated funds for this purpose.

Porcine Zona Pellucida (PZP) Vaccine

Immune-contraceptive PZP vaccines have been used on dozens of horse herds by the National Park Service, US Forest Service, Bureau of Land Management, and Native American tribes and its use is approved for free-ranging wild horse herds. Taking into consideration available literature on the subject, the National Research Council concluded in their 2013 report that PZP was one of the preferable available methods for contraception in wild horses and burros (NRC 2013). PZP use can reduce or eliminate the need for gathers and removals (Turner et al. 1997). PZP vaccines meet most of the criteria that the National Research Council (2013) used to identify promising fertility control methods, in terms of delivery method, availability, efficacy, and side effects. It has been used extensively in wild horses (NRC 2013), and in feral burros on Caribbean islands (Turner et al. 1996, French et al. 2017). PZP is relatively inexpensive, meets BLM requirements for safety to mares and the environment, and is commercially produced as ZonaStat-H, an EPA-registered product (EPA 2012, SCC 2015), or as PZP-22, which is a formulation of PZP in polymer pellets that can lead to a longer immune response (Turner et al. 2002, Rutberg et al. 2017). ‘Native’ PZP proteins can be purified from pig ovaries (Liu et al. 1989). Recombinant ZP proteins may be produced with molecular techniques (Gupta and Minhas 2017, Joonè et al. 2017a). It can easily be remotely administered in the field in cases where mares are relatively approachable. Use of remotely delivered (dart-delivered) vaccine is generally limited to populations where individual animals can be accurately identified and repeatedly approached within 50 m (BLM 2010).

Under Alternative A, the BLM would return to the HMA as needed to re-apply PZP-22, ZonaStat-H, or other improved PZP vaccines that may become available in the future, and initiate new treatments in order to maintain contraceptive effectiveness in controlling population growth rates. Both currently available forms of PZP can safely be reapplied as necessary to control the population growth rate. Even with repeated booster treatments of PZP, it is expected that most, if not all, mares would return to fertility, though some mares treated repeatedly may not (see *PZP Direct Effects*, below). Once the population is at AML and population growth seems to be stabilized, BLM could use population planning software (WinEquus II, currently in development by USGS Fort Collins Science Center) to determine the required frequency of re-treating mares with PZP.

PZP Direct Effects

The historically accepted hypothesis explaining PZP vaccine effectiveness posits that when injected as an antigen in vaccines, PZP causes the mare's immune system to produce antibodies that are specific to zona pellucida proteins on the surface of that mare's eggs. The antibodies bind to the mare's eggs surface proteins (Liu et al. 1989), and effectively block sperm binding and fertilization (Zoo Montana, 2000). Because treated mares do not become pregnant but other ovarian functions remain generally unchanged, PZP can cause a mare to continue having regular estrus cycles throughout the breeding season. More recent observations support a complementary hypothesis, which posits that PZP vaccination causes reductions in ovary size and function (Mask et al. 2015, Joonè et al. 2017b).

Research has demonstrated that contraceptive efficacy of an injected PZP vaccine is approximately 90% for mares treated twice in the first year and boostered annually (Turner and Kirkpatrick 2002, Turner et al. 2008). High contraceptive rates of 90% or more can be maintained in horses that are boostered annually (Kirkpatrick et al. 1992). Approximately 60% to 85% of mares are successfully contracepted for one year when treated simultaneously with a liquid primer and PZP-22 pellets (Rutberg et al. 2017). Application of PZP for fertility control would reduce fertility in a large percentage of mares for at least one year (Ransom et al. 2011). Horses treated with PZP-22 vaccine pellets at the same time as a primer dose may experience two years of ~40% - 50% reduced foaling rates, compared to untreated animals (Rutberg et al. 2017). Other trial data, though, indicate that the pelleted vaccine may only be effective for one year (J. Turner, University of Toledo, Personal Communication).

The fraction of mares treated in a herd can have a large effect on the realized change in growth rate due to PZP contraception, with an extremely high portion of mares required to be treated to lead prevent population-level growth (e.g., Turner and Kirkpatrick 2002). Gather efficiency would likely not exceed 85% via helicopter, and may be less with bait and water trapping, so there would be a portion of the female population uncaptured that is not treated in any given year. Additionally, some mares may not respond to the fertility control vaccine, but instead would continue to foal normally.

Reversibility and Effects on Ovaries

In most cases, PZP contraception appears to be temporary and reversible (Kirkpatrick and Turner 2002, Joonè et al. 2017a). Although the rate of long-term or permanent sterility following repeated vaccinations with PZP has not been quantified, it must be acknowledged that this could be a result for some number of wild horses receiving multiple repeat PZP vaccinations.

The purposes of applying PZP treatment is to prevent mares from conceiving foals, but BLM acknowledges that long-term infertility, or permanent sterility, could be a result for some number of wild horses receiving PZP vaccinations. The rate of long-term or permanent sterility following vaccinations with PZP is hard to predict for individual horses, but that outcome appears to increase in likelihood as the number of doses increases (Kirkpatrick and Turner 2002). Permanent sterility for mares treated consecutively 5-7 years was observed by Nuñez et al. (2010, 2017). In a graduate thesis, Knight (2014) suggested that repeated treatment with as few as three to four years of PZP treatment may lead to longer-term sterility. Repeated treatment with PZP led long-term infertility in Przewalski's horses receiving as few as one PZP booster dose (Feh 2012). If some number of mares become sterile as a result of PZP treatment, that potential result would be consistent with the contraceptive purpose of applying the vaccine.

In some mares, PZP vaccination may cause direct effects on ovaries (Gray and Cameron 2010, Joonè et al. 2017b). Joonè et al. (2017a) noted reversible effects on ovaries in mares treated with one primer dose and booster dose. Bechert et al. (2013) found that ovarian function was affected by the SpayVac PZP vaccination, but that there were no effects on other organ systems. Mask et al. (2015) demonstrated that equine antibodies that resulted from SpayVac immunization could bind to oocytes, ZP proteins, follicular tissues, and ovarian tissues. It is possible that result is specific to the immune response to SpayVac, which may have lower PZP purity than ZonaStat or PZP-22 (Hall et al. 2016). However, in studies with native ZP proteins and recombinant ZP proteins, Joonè et al. (2017a) found transient effects on ovaries after PZP vaccination in some treated mares; normal estrus cycling had resumed 10 months after the last treatment. SpayVac is a patented formulation of PZP in liposomes that can lead to multiple years of infertility (Roelle et al. 2017) but which is not reliably available for BLM to use at this time. Kirkpatrick et al. (1992) noted effects on ovaries after three years of treatment with PZP. Observations at Assateague Island National Seashore indicate that the more times a mare is consecutively treated, the longer the time lag before fertility returns, but that even mares treated 7 consecutive years did eventually return to ovulation (Kirkpatrick and Turner 2002). Other studies have reported that continued applications of PZP may result in decreased estrogen levels (Kirkpatrick et al. 1992) but that decrease was not biologically significant, as ovulation remained similar between treated and untreated mares (Powell and Monfort 2001). Permanent sterility for mares treated consecutively 5-7 years was observed by Nuñez et al. (2010, 2017). In a graduate thesis, Knight (2014) suggested that repeated treatment with as few as three to four years of PZP treatment may lead to longer-term sterility, and that sterility may result from PZP treatment before puberty. Skinner et al. (1984) speculated about PZP effects on ovaries, based on their study in laboratory rabbits, as did Kaur and Prabha (2014), though neither paper was a study of PZP effects in equids.

Effects on Existing Pregnancies, Foals, and Birth Phenology

PZP vaccine application at the capture site does not appear to affect normal development of the fetus or foal, hormone health of the mare or behavioral responses to stallions, should the mare already be pregnant when vaccinated (Kirkpatrick et al. 2002).

If a mare is already pregnant, the PZP vaccine has not been shown to affect normal development of the fetus or foal, or the hormonal health of the mare with relation to pregnancy (Kirkpatrick and Turner 2003). It is possible that there may be transitory effects on foals born to mares or jennies treated with PZP. In mice, Sacco et al. (1981) found that antibodies specific to PZP can pass from mother mouse to pup via the placenta or colostrum, but that did not apparently cause any innate immune response in the offspring: the level of those antibodies were undetectable by

116 days after birth. There was no indication in that study that the fertility or ovarian function of those pups was compromised, nor is BLM aware of any such results in horses or burros. Unsubstantiated speculative connections between PZP treatment and foal stealing has not been published in a peer-reviewed study and thus cannot be verified. Similarly, although Nettles (1997) noted reported stillbirths after PZP treatments in cynomolgus monkeys, those results have not been observed in equids despite extensive use.

On-range observations from 20 years of application to wild horses indicate that PZP application in wild mares does not generally cause mares to foal out of season or late in the year (Kirkpatrick and Turner 2003). Nuñez's (2010) research showed that a small number of mares that had previously been treated with PZP foaled later than untreated mares and expressed the concern that this late foaling "may" impact foal survivorship and decrease band stability, or that higher levels of attention from stallions on PZP-treated mares might harm those mares. However, that paper provided no evidence that such impacts on foal survival or mare well-being actually occurred. Rubenstein (1981) called attention to a number of unique ecological features of horse herds on Atlantic barrier islands, which calls into question whether inferences drawn from island herds can be applied to western wild horse herds. Ransom et al. (2013), though, identified a potential shift in reproductive timing as a possible drawback to prolonged treatment with PZP, stating that treated mares foaled on average 31 days later than non-treated mares. Those results, however, showed that over 81% of the documented births in this study were between March 1 and June 21, i.e., within the normal spring season. Ransom et al. (2013) advised that managers should consider carefully before using PZP in small refugia or rare species. Wild horses and burros in Nevada do not generally occur in isolated refugia, and they are not a rare species. Moreover, an effect of shifting birth phenology was not observed uniformly: in two of three PZP-treated wild horse populations studied by Ransom et al. (2013), foaling season of treated mares extended three weeks and 3.5 months, respectively, beyond that of untreated mares. In the other population, the treated mares foaled within the same time period as the untreated mares. Furthermore, Ransom et al. (2013) found no negative impacts on foal survival even with an extended birthing season. If there are shifts in birth phenology, though, it is reasonable to assume that some negative effects on foal survival might result from particularly severe weather events.

Effects of Marking and Injection

Standard practices for PZP treatment require that treated animals be readily identifiable, either via brand marks or unique coloration (BLM 2010). BLM has instituted guidelines to reduce the sources of handling stress in captured animals (BLM 2015). Some level of transient stress is likely to result in newly captured mares that do not have markings associated with previous fertility control treatments. It is difficult to compare that level of temporary stress with long-term stress that can result from food and water limitation on the range (e.g., Creel et al. 2013). Handling may include freeze-marking, for the purpose of identifying that mare and identifying her PZP vaccine treatment history. Under past management practices, captured mares experienced increased stress levels from handling (Ashley and Holcombe 2001). Markings may also be used into the future to determine the approximate fraction of mares in a herd that have been previously treated, and could provide additional insight regarding gather efficiency.

Most mares recover from the stress of capture and handling quickly once released back to the

HMA, and none are expected to suffer serious long term effects from the fertility control injections, other than the direct consequence of becoming temporarily infertile. Injection site reactions associated with fertility control treatments are possible in treated mares (Roelle and Ransom 2009, Bechert et al. 2013, French et al. 2017), but swelling or local reactions at the injection site are expected to be minor in nature. Roelle and Ransom (2009) found that the most time-efficient method for applying PZP is by hand-delivered injection of 2-year pellets when horses are gathered. They observed only two instances of swelling from that technique. Use of remotely delivered, 1-year PZP is generally limited to populations where individual animals can be accurately identified and repeatedly approached. The dart-delivered formulation produced injection-site reactions of varying intensity, though none of the observed reactions appeared debilitating to the animals (Roelle and Ransom 2009). Joonè et al. (2017a) found that injection site reactions had healed in most mares within 3 months after the booster dose, and that they did not affect movement or cause fever. The longer term nodules observed did not appear to change any animal's range of movement or locomotor patterns and in most cases did not appear to differ in magnitude from naturally occurring injuries or scars.

Indirect Effects

One expected long-term, indirect effect on wild horses treated with fertility control would be an improvement in their overall health (Turner and Kirkpatrick 2002). Many treated mares would not experience the biological stress of reproduction, foaling and lactation as frequently as untreated mares, and their better health is expected to be reflected in higher body condition scores (Nuñez et al. 2010). After a treated mare returns to fertility, her future foals would be expected to be healthier overall, and would benefit from improved nutritional quality in the mares' milk. This is particularly to be expected if there is an improvement in rangeland forage quality at the same time, due to reduced wild horse population size. Past application of fertility control has shown that mares' overall health and body condition remains improved even after fertility resumes. PZP treatment may increase mare survival rates, leading to longer potential lifespan (Turner and Kirkpatrick 2002, Ransom et al. 2014a). To the extent that this happens, changes in lifespan and decreased foaling rates could combine to cause changes in overall age structure in a treated herd (i.e., Turner and Kirkpatrick 2002, Roelle et al. 2010), with a greater prevalence of older mares in the herd (Gross 2000). Observations of mares treated in past gathers showed that many of the treated mares were larger than, maintained higher body condition than, and had larger healthy foals than untreated mares.

Following resumption of fertility, the proportion of mares that conceive and foal could be increased due to their increased fitness; this has been called a 'rebound effect.' Elevated fertility rates have been observed after horse gathers and removals (Kirkpatrick and Turner 1991). More research is needed to document and quantify these hypothesized effects; however, it is believed that repeated contraceptive treatment may minimize the hypothesized rebound effect.

Because successful fertility control would reduce foaling rates and population growth rates, another indirect effect would be to reduce the number of wild horses that have to be removed over time to achieve and maintain the established AML. So long as the level of contraceptive treatment is adequate, the lower expected birth rates can compensate for any expected increase in the survival rate of treated mares. Also, reducing the numbers of wild horses that would have to be removed in future gathers could allow for removal of younger, more easily adoptable excess wild horses, and thereby could eliminate the need to send additional excess horses from this area to long term pastures (ORPs) or for other statutorily mandated disposition. A high level of physical health and future reproductive success of fertile mares within the herd would be sustained, as reduced population sizes would be expected to lead to more availability of water and forage resources per capita.

Reduced population growth rates and smaller population sizes could also allow for continued and increased environmental improvements to range conditions within the project area, which would have long-term benefits to wild horse habitat quality. As the population nears or is maintained at the level necessary to achieve a thriving natural ecological balance, vegetation resources would be expected to recover, improving the forage available to wild horses and wildlife throughout the HMA. With rangeland conditions more closely approaching a thriving natural ecological balance, and with a less concentrated distribution of wild horses across the HMA, there should also be less trailing and concentrated use of water sources, which would have many benefits to the wild horses still on the range. Lower population density would be expected to lead to reduced competition among wild horses using the water sources, and less fighting among horses accessing water sources. Water quality and quantity would continue to improve to the benefit of all rangeland users including wild horses. Wild horses would also have to travel less distance back and forth between water and desirable foraging areas. Should PZP booster treatment and repeated fertility control treatment continue into the future, the chronic cycle of overpopulation and large gathers and removals would no longer occur, but instead a consistent cycle of balance and stability would ensue, resulting in continued improvement of overall habitat conditions and animal health. While it is conceivable that widespread and continued treatment with PZP could reduce the birth rates of the population to such a point that birth is consistently below mortality, that outcome is not likely unless a very high fraction of the mares present are all treated in almost every year.

Behavioral Effects

The NRC report (2013) noted that all fertility suppression has effects on mare behavior, mostly as a result of the lack of pregnancy and foaling, and concluded that PZP was a good choice for use in the program. The result that PZP-treated mares may continue estrus cycles throughout the breeding season can lead to behavioral differences, when compared to mares that are fertile. Such behavioral differences should be considered as potential consequences of successful contraception.

Ransom and Cade (2009) delineate behaviors that can be used to test for quantitative differences due to treatments. Ransom et al. (2010) found no differences in how PZP-treated and untreated mares allocated their time between feeding, resting, travel, maintenance, and most social behaviors in three populations of wild horses, which is consistent with Powell's (1999) findings in another population. Likewise, body condition of PZP-treated and control mares did not differ between treatment groups in Ransom et al.'s (2010) study. Nuñez (2010) found that PZP-treated mares had higher body condition than control mares in another population, presumably because energy expenditure was reduced by the absence of pregnancy and lactation. Knight (2014) found that PZP-treated mares had better body condition, lived longer and switched harems more frequently, while mares that foaled spent more time concentrating on grazing and lactation and had lower overall body condition. Studies on Assateague Island (Kirkpatrick and Turner 2002) showed that once fillies (female foals) that were born to mares treated with PZP during pregnancy eventually breed, they produce healthy, viable foals.

In two studies involving a total of four wild horse populations, both Nuñez et al. (2009) and Ransom et al. (2010) found that PZP-treated mares were involved in reproductive interactions with stallions more often than control mares, which is not surprising given the evidence that PZP-treated females of other mammal species can regularly demonstrate estrus behavior while contracepted (Shumake and Wilhelm 1995, Heilmann et al. 1998, Curtis et al. 2001). There was no evidence, though, that mare welfare was affected by the increased level of herding by stallions noted in Ransom et al. (2010). Nuñez's later analysis (2017) noted no difference in mare reproductive behavior as a function of contraception history.

Ransom et al. (2010) found that control mares were herded by stallions more frequently than PZP- treated mares, and Nuñez et al. (2009, 2014, 2017) found that PZP-treated mares exhibited higher infidelity to their band stallion during the non-breeding season than control mares. Madosky et al. (2010) and Knight (2014) found this infidelity was also evident during the breeding season in the same population that Nuñez et al. (2009, 2010, 2014, 2017) studied; they concluded that PZP-treated mares changing bands more frequently than control mares could lead to band instability. Nuñez et al. (2009), though, cautioned against generalizing from that island population to other herds. Nuñez et al. (2014) found elevated levels of fecal cortisol, a marker of physiological stress, in mares that changed bands. The research is inconclusive as to whether all the mares' movements between bands were related to the PZP treatments themselves or the fact that the mares were not nursing a foal, and did not demonstrate any long-term negative consequence of the transiently elevated cortisol levels. The authors (Nuñez et al. 2014) concede that these effects "…may be of limited concern when population reduction is an urgent priority." In contrast to transient stresses, Creel et al (2013) highlight that variation in population density is one of the most well-established causal factors of chronic activation of the hypothalamic-pituitary-adrenal axis, which mediates stress hormones; high population densities and competition for resources can cause chronic stress. Creel also states that "…there is little consistent evidence for a negative association between elevated baseline glucocorticoids and fitness." Band fidelity is not an aspect of wild horse biology that is specifically protected by the WFRHBA of 1971. It is also notable that Ransom et al. (2014b) found higher group fidelity after a herd had been gathered and treated with a contraceptive vaccine; in that case, the researchers postulated that higher fidelity may have been facilitated by the decreased competition for forage after excess horses were removed. At the population level, available research does not provide evidence of the loss of harem structure among any herds treated with PZP. Long-term implications of these changes in social behavior are currently unknown, but no negative impacts on the overall animals or populations welfare or well-being have been noted in these studies.

The National Research Council (2013) found that harem changing was not likely to result in serious adverse effects for treated mares:

> "The studies on Shackleford Banks (Nuñez et al., 2009; Madosky et al., 2010) suggest that there is an interaction between pregnancy and social cohesion. The importance of harem stability to mare well-being is not clear, but considering the relatively large

> number of free-ranging mares that have been treated with liquid PZP in a variety of ecological settings, the likelihood of serious adverse effects seem low."

Nuñez (2010) stated that not all populations would respond similarly to PZP treatment. Differences in habitat, resource availability, and demography among conspecific populations would undoubtedly affect their physiological and behavioral responses to PZP contraception, and need to be considered. Kirkpatrick et al. (2010) concluded that: "the larger question is, even if subtle alterations in behavior may occur, this is still far better than the alternative*,"* and that the "…other victory for horses is that every mare prevented from being removed, by virtue of contraception, is a mare that would only be delaying her reproduction rather than being eliminated permanently from the range. This preserves herd genetics, while gathers and adoption do not."

The NRC report (2013) provides a comprehensive review of the literature on the behavioral effects of contraception that puts research up to that date by Nuñez's et al. (2009, 2010) into the broader context of all of the available scientific literature, and cautions, based on its extensive review of the literature that:

> ". . . in no case can the committee conclude from the published research that the behavior differences observed are due to a particular compound rather than to the fact that treated animals had no offspring during the study. That must be borne in mind particularly in interpreting long-term impacts of contraception (e.g., repeated years of reproductive "failure" due to contraception)."

Genetic Effects of PZP Vaccination

In HMAs where large numbers of wild horses have recent and / or an ongoing influx of breeding animals from other areas with wild or feral horses, contraception is not expected to cause an unacceptable loss of genetic diversity or an unacceptable increase in the inbreeding coefficient. In any diploid population, the loss of genetic diversity through inbreeding or drift can be prevented by large effective breeding population sizes (Wright 1931) or by introducing new potential breeding animals (Mills and Allendorf 1996). The NRC report (2013) recommended that single HMAs should not be considered as isolated genetic populations. Rather, managed herds of wild horses would be better viewed as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of natural and human-facilitated movements. Introducing 1-2 mares every generation (about every 10 years) is a standard management technique that can alleviated potential inbreeding concerns (BLM 2010).

In the last 10 years, there has been a high realized growth rate of wild horses in most areas administered by the BLM, such that most alleles that are present in any given mare are likely to already be well represented in her siblings, cousins, and more distant relatives. With the exception of horses in a small number of well-known HMAs that contain a relatively high fraction of alleles associated with old Spanish horse breeds (NRC 2013), the genetic composition of wild horses in lands administered by the BLM is consistent with admixtures from multiple domestic breeds. As a result, in most HMAs, applying fertility control to a subset of mares is not expected to cause irreparable loss of genetic diversity. Improved longevity and an aging population are expected results of contraceptive treatment that can provide for lengthening generation time; this result would be expected to slow the rate of genetic diversity loss (Hailer et al. 2006). Based on a population model, Gross (2000) found that a strategy to preferentially treating young animals with a contraceptive led to more genetic diversity being retained than either a strategy that preferentially treats older animals, or periodic gathers and removals.

Even if it is the case that repeated treatment with PZP may lead to prolonged infertility, or even sterility in some mares, most HMAs have only a low risk of loss of genetic diversity if logistically realistic rates of contraception are applied to mares. Wild horses in most herd management areas are descendants of a diverse range of ancestors coming from many breeds of domestic horses. As such, the existing genetic diversity in the majority of HMAs does not contain unique or historically unusual genetic markers. Past interchange between HMAs, either through natural dispersal or through assisted migration (i.e., human movement of horses) means that many HMAs are effectively indistinguishable and interchangeable in terms of their genetic composition. Roelle and Oyler-McCance (2015) used the VORTEX population model to simulate how different rates of mare sterility would influence population persistence and genetic diversity, in populations with high or low starting levels of genetic diversity, various starting population sizes, and various annual population growth rates. Their results show that the risk of the loss of genetic heterozygosity is extremely low except in case where all of the following conditions are met: starting levels of genetic diversity are low, initial population size is 100 or less, the intrinsic population growth rate is low (5% per year), and very large fractions of the female population are permanently sterilized.

It is worth noting that, although maintenance of genetic diversity at the scale of the overall population of wild horses is an intuitive management goal, there are no existing laws or policies that require BLM to maintain genetic diversity at the scale of the individual herd management area or complex. Also, there is no Bureau-wide policy that requires BLM to allow each female in a herd to reproduce before she is treated with contraceptives.

One concern that has been raised with regards to genetic diversity is that treatment with immunocontraceptives could possibly lead to an evolutionary increase in the frequency of individuals whose genetic composition fosters weak immune responses (Cooper and Larson 2006, Ransom et al. 2014a).Many factors influence the strength of a vaccinated individual's immune response, potentially including genetics, but also nutrition, body condition, and prior immune responses to pathogens or other antigens (Powers et al. 2013). This premise is based on an assumption that lack of response to PZP is a heritable trait, and that the frequency of that trait would increase over time in a population of PZP-treated animals. Cooper and Herbert (2001) reviewed the topic, in the context of concerns about the long-term effectiveness of immunocontraceptives as a control agent for exotic species in Australia. They argue that immunocontraception could be a strong selective pressure, and that selecting for reproduction in individuals with poor immune response could lead to a general decline in immune function in populations where such evolution takes place. Other authors have also speculated that differences in antibody titer responses could be partially due to genetic differences between animals (Curtis et al. 2001, Herbert and Trigg 2005). However, Magiafolou et al. (2013) clarify that if the variation in immune response is due to environmental factors (i.e., body condition, social rank) and not due to genetic factors, then there would be no expected effect of the immune phenotype on future generations. It is possible that general health, as measured by body condition, can have a causal role in determining immune response, with animals in poor condition demonstrating poor immune reactions (NRC 2013).

Correlations between physical factors and immune response would not preclude, though, that there could also be a heritable response to immunocontraception. In studies not directly related to immunocontraception, immune response has been shown to be heritable (Kean et al. 1994, Sarker et al. 1999). Unfortunately, predictions about the long-term, population-level evolutionary response to immunocontraceptive treatments are speculative at this point, with results likely to depend on several factors, including: the strength of the genetic predisposition to not respond to PZP; the heritability of that gene or genes; the initial prevalence of that gene or genes; the number of mares treated with a primer dose of PZP (which generally has a short-acting effect); the number of mares treated with multiple booster doses of PZP; and the actual size of the genetically-interacting metapopulation of horses within which the PZP treatment takes place.

BLM is not aware of any studies that have quantified the heritability of a lack of response to immunocontraception such as PZP vaccine or GonaCon-Equine in horses. At this point there are no studies available from which one could make conclusions about the long-term effects of sustained and widespread immunocontraception treatments on population-wide immune function. Although a few, generally isolated, feral horse populations have been treated with high fractions of mares receiving PZP immunocontraception for long-term population control (e.g., Assateague Island and Pryor Mountains), no studies have tested for changes in immune competence in those areas. Relative to the large number of free-roaming feral horses in the western United States, immunocontraception has not been used in the type of widespread or prolonged manner that might be required to cause a detectable evolutionary response. Although this topic may merit further study, lack of clarity should not preclude the use of immunocontraceptives to help stabilize extremely rapidly growing herds.

Impacts of Alternative B: Selective Removal of Excess Wild Horses to within AML range, and Population Growth Control using fertility control treatments GonaCon™.

Impacts from this alternative would be similar to Alternative A, however fertility control GonaCon™ would be applied. When gather efficiencies have been able to achieve horse numbers within the range of AML maintenance gathers to reapply fertility control and to remove adoptable wild horses would be conducted for the next 10 years following the date of the initial gather. All mares selected for release would be treated with GonaCon™ or a similar vaccine and released back to the range.

GonaCon™ Contraception

The literature review is intended to summarize what is known and what is not known about potential effects of treating mares with GonaCon. As noted below, some negative consequences of vaccination are possible. Anti-GnRH vaccines can be administered to either sex, but this analysis is limited to effects on females, except where inferences can be made to females, based on studies that have used the vaccine in males.

The GonaCon immunocontraceptive vaccine has been shown to provide multiple years of infertility in several wild ungulate species including horses (Killian et al., 2008; Gray et al., 2010). GonaCon utilizes a gonadotropin-releasing hormone (GnRH) which is a small neuropeptide that performs an obligatory role in mammalian reproduction. When combined with an adjuvant, the GnRH vaccine stimulates a persistent immune response resulting in prolonged antibody production against GnRH, the carrier protein, and adjuvant (Miller et al., 2008). The most compelling hypothesis on the vaccine effectiveness suggests that antibodies to GnRH likely induce transient infertility by binding to endogenous GnRH, thus preventing attachment to receptors on gonadotropes and suppression of pulsatile luteinizing hormone (LH) secretion (Molenaaret al., 2010). As anti-GnRH antibodies decline over time, concentrations of available endogenous GnRH increase and treated animals usually regain fertility (Power et al., 2011). GonaCon™-Equine has been registered with the U.S. Environmental Protection Agency (EPA) since January 2013.

GonaCon-Equine vaccine meets most of the criteria that the National Research Council of the National Academy of Sciences (NRC 2013) used to identify the most promising fertility control methods, in terms of delivery method, availability, efficacy, and side effects. GonaCon-Equine is approved for use by authorized federal, state, tribal, public and private personnel, for application to wild and feral equids in the United States (EPA 2013, 2015). Its use is appropriate for free-ranging wild horse herds. Taking into consideration available literature on the subject, the National Research Council concluded in their 2013 report that GonaCon-B (which is produced under the trade name GonaCon-Equine for use in feral horses and burros) was one of the most preferable available methods for contraception in wild horses and burros (NRC 2013). GonaCon-Equine has been used on feral horses in Theodore Roosevelt National Park and on wild horses in one BLM-administered HMA (BLM 2015). GonaCon-Equine can be remotely administered in the field in cases where mares are relatively approachable, using a customized pneumatic dart (McCann et al. 2017). Use of remotely delivered (dart-delivered) vaccine is generally limited to populations where individual animals can be accurately identified and repeatedly approached within 50 m (BLM 2010).

As with other contraceptives applied to wild horses, the long-term goal of GonaCon-Equine use is to reduce or eliminate the need for gathers and removals (NRC 2013). GonaCon-Equine vaccine is an EPA-approved pesticide (EPA, 2009a) that is relatively inexpensive, meets BLM requirements for safety to mares and the environment, and is produced in a USDA-APHIS laboratory. Its categorization as a pesticide is consistent with regulatory framework for controlling overpopulated vertebrate animals, and in no way is meant to convey that the vaccine is lethal; the intended effect of the vaccine is as a contraceptive. GonaCon is produced as a pharmaceutical-grade vaccine, including aseptic manufacturing technique to deliver a sterile vaccine product (Miller et al. 2013). If stored at 4° C, the shelf life is 6 months (Miller et al 2013).

Miller et al. (2013) reviewed the vaccine environmental safety and toxicity. When advisories on the product label (EPA 2015) are followed, the product is safe for users and the environment (EPA 2009b). EPA waived a number of tests prior to registering the vaccine, because GonaCon was deemed to pose low risks to the environment, so long as the product label is followed (Wang-Chaill et al. 2017, *in press*).

Under Alternative B, the BLM would return to the HMA as needed to re-apply GonaCon-Equine and initiate new treatments in order to maintain contraceptive effectiveness in controlling population growth rates. GonaCon-Equine can safely be reapplied as necessary to control the population growth rate; booster dose effects may lead to increased effectiveness of contraception, which is generally the intent. Even with one booster treatment of GonaCon-Equine, it is expected that most, if not all, mares would return to fertility at some point, although the average duration of effect after booster doses has not yet been quantified. It is unknown what would be the expected rate for the return to fertility rate in mares boosted more than once with GonaCon-Equine. Once the herd size in the project area is at AML and population growth seems to be stabilized, BLM could make a determination as to the required frequency of new mare treatments and mare re-treatments with GonaCon, to maintain the number of horses within AML.

GnRH Vaccine Direct Effects

GonaCon-Equine is one of several vaccines that have been engineered to create an immune response to the gonadotropin releasing hormone peptide (GnRH). GnRH is a small peptide that plays an important role in signaling the production of other hormones involved in reproduction in both sexes. GnRH is highly conserved across mammalian taxa, so some inferences about the mechanism and effects of GonaCon-Equine in horses can be made from studies that used different anti-GnRH vaccines, in horses and other taxa. Other anti-GnRH vaccines include: Improvac (Imboden et al. 2006, Botha et al. 2008, Janett et al. 2009, Schulman et al. 2013, Dalmau et al. 2015), made in South Africa; Equity (Elhay et al. 2007), made in Australia; Improvest, for use in swine (Bohrer et al. 2014); Repro-BLOC (Boedeker et al. 2011); and Bopriva, for use in cows (Balet et al. 2014). Of these, GonaCon-Equine, Improvac, and Equity are specifically intended for horses. Other anti-GnRH vaccine formulations have also been tested, but did not become trademarked products (e.g., Goodloe 1991, Dalin et al 2002, Stout et al. 2003, Donovan et al. 2013). The effectiveness and side-effects of these various anti-GnRH vaccines may not be the same as would be expected from GonaCon-Equine use in horses. Results could differ as a result of differences in the preparation of the GnRH antigen, and the choice of adjuvant used to stimulate the immune response. While GonaCon-Equine can be administered as a single dose, most other anti-GnRH vaccines require a primer dose and at least one booster dose to be effective.

GonaCon has been produced by USDA-APHIS (Fort Collins, Colorado) in several different formulations, the history of which is reviewed by Miller et al. (2013). In any vaccine, the antigen is the stimulant to which the body responds by making antigen-specific antibodies. Those antibodies then signal to the body that a foreign molecule is present, initiating an immune response that removes the molecule or cell. GonaCon vaccines present the recipient with hundreds of copies of GnRH as peptides on the surface of a linked protein that is naturally antigenic because it comes from invertebrate hemocyanin (Miller et al 2013). Early GonaCon formulations linked many copies of GnRH to a protein from the keyhole limpet (GonaCon-KHL), but more recently produced formulations where the GnRH antigen is linked to a protein from the blue mussel (GonaCon-B) proved less expensive and more effective (Miller et al. 2008). GonaCon-Equine is in the category of GonaCon-B vaccines.

Adjuvants are included in vaccines to elevate the level of immune response, inciting recruitment of lymphocytes and other immune cells which foster a long-lasting immune response that is specific to the antigen. For some formulations of anti-GnRH vaccines, a booster dose is required to elicit at contraceptive response, though GonaCon can cause short-term contraception in a fraction of treated animals from one dose (Powers et al. 2011, Gionfriddo et al. 2011a, Baker et al. 2013, Miller et al 2013). The adjuvant used in GonaCon, Adjuvac, generally leads to a milder reaction than Freunds complete adjuvant (Powers et al. 2011). Adjuvac contains a small number of killed *Mycobacterium avium* cells (Miller et al. 2008, Miller et al. 2013). The antigen and adjuvant are emulsified in mineral oil, such that they are not all presented to the immune system right after injection; it is thought that the mineral oil emulsion leads to a depot effect and longer-lasting immune response (Miller et al. 2013). Miller et al. (2008, 2013) have speculated that, in cases where memory-B leukocytes are protected in immune complexes in the lymphatic system, it can lead to years of immune response. Increased doses of vaccine may lead to stronger immune reactions, but only to a certain point; when Yoder and Miller (2010) tested varying doses of GonaCon in prairie dogs, antibody responses to the 200µg and 400µg doses were equal to each other but were both higher than in response to a 100µg dose.

The most direct result of successful GnRH vaccination is that it has the effect of decreasing the level of GnRH signaling in the body, as evidenced by a drop in leutinizing hormone levels, and a cessation of ovulation. Antibody titer measurements are proximate measures of the antibody concentration in the blood specific to a given antigen. Anti-GnRH titers generally correlate with a suppressed reproduction system (Gionfriddo et al. 2011a, Powers et al. 2011). Various studies have attempted to identify a relationship between anti-GnRH titer levels and infertility, but that relationship has not been universally predictable or consistent. The time length that titer levels stay high appears to correlate with the length of suppressed reproduction (Dalin et al. 2002, Levy et al. 2011, Donovan et al. 2013, Powers et al. 2011). For example, Goodloe (1991) noted that mares did produce elevated titers and had suppressed follicular development for 11-13 weeks after treatment, but that all treated mares ovulated after the titer levels declined. Similarly, Elhay (2007) found that high initial titers correlated with longer-lasting ovarian and behavioral anoestrus. However, Powers et al. (2011) did not identify a threshold level of titer that was consistently indicative of suppressed reproduction despite seeing a strong correlation between antibody concentration and infertility, nor did Schulman et al. (2013) find a clear relationship between titer levels and mare acyclicity.

In many cases, young animals appear to have higher immune responses, and stronger contraceptive effects of anti-GnRH vaccines than older animals (Brown et al. 1994, Curtis et al. 2001, Stout et al. 2003, Schulman et al. 2013). Vaccinating with GonaCon at too young an age, though, may prevent effectiveness; Gionfriddo et al. (2011a) observed weak effects in 3-4 month old fawns. It has not been possible to predict which individuals of a given age class would have long-lasting immune responses to the GonaCon vaccine. Gray (2010) noted that mares in poor body condition tended to have lower contraceptive efficacy in response to GonaCon-B. Miller et al. (2013) suggested that higher parasite loads might have explained a lower immune response in free-roaming horses than had been observed in a captive trial. At this time it is unclear what the most important factors affecting efficacy are.

Females that are successfully contracepted by GnRH vaccination enter a state similar to anestrus, have a lack of or incomplete follicle maturation, and no ovarian cycling (Botha et al. 2008). A leading hypothesis is that anti-GnRH antibodies bind GnRH in the hypothalamus – pituitary 'portal vessels,' preventing GnRH from binding to GnRH-specific binding sites on gonadotroph cells in the pituitary, thereby limiting the production of gonadotropin hormones, particularly luteinizing hormone (LH) and, to a lesser degree, follicle-stimulating hormone (FSH) (Powers et al. 2011, NRC 2013). This reduction in LH (and FSH), and a corresponding lack of ovulation, has been measured in response to treatment with anti-GnRH vaccines (Boedeker et al. 2011, Garza et al. 1986).

Females successfully treated with anti-GnRH vaccines have reduced progesterone levels (Garza et al 1986, Stout et al. 2003, Imboden et al. 2006, Elhay 2007, Botha et al. 2008, Killian et al. 2008, Miller et al. 2008, Janett et al. 2009, Schulman et al. 2013, Balet et al 2014, Dalmau et al. 2015) and β-17 estradiol levels (Elhay et al. 2007), but no great decrease in estrogen levels (Balet et al. 2014). Reductions in progesterone do not occur immediately after the primer dose, but can take several weeks or months to develop (Elhay et al 2007, Botha et al. 2008, Schulman et al. 2013, Dalmau et al. 2015). This indicates that ovulation is not occurring and corpora lutea, formed from post-ovulation follicular tissue, are not being established.

Changes in hormones associated with anti-GnRH vaccination lead to measurable changes in ovarian structure and function. The volume of ovaries reduced in response to treatment (Garza et al. 1986, Dalin et al. 2002, Imboden et al. 2006, Elhay et al. 2007, Botha et al. 2008, Gionfriddo 2011a, Dalmau et al. 2015). Treatment with an anti-GnRH vaccine changes follicle development (Garza et al. 1986, Stout et al. 2003, Imboden et al. 2006, Elhay et al. 2007, Donovan et al. 2013, Powers et al. 2011, Balet et al 2014), with the result that ovulation does not occur. A related result is that the ovaries can exhibit less activity and cycle with less regularity or not at all in anti-GnRH vaccine treated females (Goodloe 1991, Dalin et al. 2002, Imboden et al. 2006, Elhay et al. 2007, Janett et al. 2009, Donovan et al. 2013, Powers et al. 2011). In studies where the vaccine required a booster, hormonal and associated results were generally observed within several weeks after delivery of the booster dose.

GnRH Vaccine Contraceptive Effects

The NRC (2013) review pointed out that single doses of GonaCon-Equine do not lead to high rates of initial effectiveness, or long duration. Initial effectiveness of one dose of GonaCon-Equine vaccine appears to be lower than for a combined primer plus booster dose of the PZP vaccine Zonastat-H (Kirkpatrick et al. 2011), and the initial effect of a single GonaCon dose can be limited to as little as one breeding season. However, preliminary results on the effects of boostered doses of GonaCon-Equine indicate that it can have high efficacy and longer-lasting effects in free-roaming horses (Baker et al. 2017) than the one-year effect that is generally expected from a single booster of Zonastat-H.

GonaCon and other anti-GnRH vaccines can be injected while a female is pregnant (Miller et al. 2000, Powers et al. 2011, Baker et al. 2013) – in such a case, a successfully contracepted mare would be expected to give birth during the following foaling season, but to be infertile during the same year's breeding season. Thus, a mare injected in November of 2018 would not show the contraceptive effect (i.e., no new foal) until spring of 2020.

Too few studies have reported on the various formulations of anti-GnRH vaccines to make generalizations about differences between products, but GonaCon formulations were consistently good at causing loss of fertility in a statistically significant fraction of treated mares for at least one year (Killian et al. 2009, Gray et al. 2010, Baker et al. 2013, 2017). With few exceptions (e.g., Goodloe 1991), anti-GnRH treated mares gave birth to fewer foals in the first season when there would be an expected contraceptive effect (Botha et al. 2008, Killian et al. 2009, Gray et al. 2010, Baker et al. 2013). Goodloe (1991) used an anti-GnRH-KHL vaccine with a triple adjuvant, in some cases attempting to deliver the vaccine to horses with a hollow-tipped 'biobullet,'but concluded that the vaccine was not an effective immunocontraceptive in that study.

Not all mares should be expected to respond to the GonaCon-equine vaccine; some number should be expected to continue to become pregnant and give birth to foals. In studies where mares were exposed to stallions, the fraction of treated mares that are effectively contracepted in the year after anti-GnRH vaccination varied from study to study, ranging from ~50% (Baker et al. 2017), to 61% (Gray et al. 2010) to ~90% (Killian et al. 2006, 2008, 2009). Miller et al. (2013) noted lower effectiveness in free-ranging mares (Gray et al. 2010) than captive mares (Killian et al. 2009). Some of these rates are lower than the high rate of effectiveness typically reported for the first year after PZP vaccine treatment (Kirkpatrick et al. 2011). In the one study that tested for a difference, darts and hand-injected GonaCon doses were equally effective in terms of fertility outcome (McCann et al. 2017).

In studies where mares were not exposed to stallions, the duration of effectiveness also varied. A primer and booster dose of Equity led to anoestrus for at least 3 months (Elhay et al 2007). A primer and booster dose of Improvac also led to loss of ovarian cycling for all mares in the short term (Imboden et al. 2006). It is worth repeating that those vaccines do not have the same formulation as GonaCon.

Results from horses (Baker et al. 2017) and other species (Curtis et al. 2001) suggest that providing a booster dose of GonaCon-Equine would increase the fraction of temporarily infertile animals to higher levels than would a single vaccine dose alone.

Longer-term infertility has been observed in some mares treated with anti-GnRH vaccines, including GonaCon-Equine. In a single-dose mare captive trial with an initial year effectiveness of 94%, Killian et al. (2008) noted infertility rates of 64%, 57%, and 43% in treated mares during the following three years, while control mares in those years had infertility rates of 25%, 12% and 0% in those years. GonaCon effectiveness in free-roaming populations was lower, with infertility rates consistently near 60% for three years after a single dose in one study (Gray et al. 2010) and annual infertility rates decreasing over time from 55% to 30% to 0% in another study with one dose (Baker et al. 2017). Similarly, gradually increasing fertility rates were observed after single dose treatment with GonaCon in elk (Powers et al. 2011) and deer (Gionfriddo et al. 2011a).

Baker et al. (2017) observed a return to fertility over 4 years in mares treated once with GonaCon, but then noted extremely low fertility rates of 0% and 16% in the two years after the same mares were given a booster dose four years after the primer dose. These are extremely promising preliminary results from that study in free-roaming horses; a third year of post-booster monitoring is ongoing in summer 2017, and researchers on that project are currently determining whether the same high-effectiveness, long-term response is observed after boosting with GonaCon after 6 months, 1 year, 2 years, or 4 years after the primer dose. Four of nine mares treated with primer and booster doses of Improvac did not return to ovulation within 2 years of the primer dose (Imboden et al. 2006), though one should probably not make conclusions about the long-term effects of GonaCon-Equine based on results from Improvac.

It is difficult to predict which females would exhibit strong or long-term immune responses to anti-GnRH vaccines (Killian et al. 2006, Miller et al. 2008, Levy et al. 2011). A number of factors may influence responses to vaccination, including age, body condition, nutrition, prior immune responses, and genetics (Cooper and Herbert 2001, Curtis et al. 2001, Powers et al. 2011). One apparent trend is that animals that are treated at a younger age, especially before puberty, may have stronger and longer-lasting responses (Brown et al. 1994, Curtis et al. 2001, Stout et al. 2003, Schulman et al. 2013). It is plausible that giving ConaGon-Equine to prepubertal mares would lead to long-lasting infertility, but that has not yet been tested.

To date, short term evaluation of anti-GnRH vaccines, show contraception appears to be temporary and reversible. Killian et al. noted long-term effects of GonaCon in some captive mares (2009). However, Baker et al. (2017) observed horses treated with GonaCon-B return to fertility after they were treated with a single primer dose; after four years, the fertility rate was indistinguishable between treated and control mares. It appears that a single dose of GonaCon results in reversible infertility but it is unknown if long term treatment would result in permanent infertility.

Other anti-GnRH vaccines also have had reversible effects in mares. Elhay (2007) noted a return to ovary functioning over the course of 34 weeks for 10 of 16 mares treated with Equity. That study ended at 34 weeks, so it is not clear when the other six mares would have returned to fertility. Donovan et al. (2013) found that half of mares treated with an anti-GnRH vaccine intended for dogs had returned to fertility after 40 weeks, at which point the study ended. In a study of mares treated with a primer and booster dose of Improvac, 47 of 51 treated mares had returned to ovarian cyclicity within 2 years; younger mares appeared to have longer-lasting effects than older mares (Schulman et al. 2013). In a small study with a non-commercial anti-GnRH vaccine (Stout et al. 2003), three of seven treated mares had returned to cyclicity within 8 weeks after delivery of the primer dose, while four others were still suppressed for 12 or more weeks. In elk, Powers et al. (2011) noted that contraception after one dose of GonaCon was reversible. In white-tailed deer, single doses of GonaCon appeared to confer two years of contraception (Miller et al. 2000). Ten of 30 domestic cows treated became pregnant within 30 weeks after the first dose of Bopriva (Balet et al. 2014).

Permanent sterility as a result of single-dose or boostered GonaCon-Equine vaccine, or other anti-GnRH vaccines, has not been recorded, but that may be because no long-term studies have tested for that effect. It is conceivable that some fraction of mares could become sterile after receiving one or more booster doses of GonaCon-Equine, but the rate at which that could be expected to occur is currently unknown. If some fraction of mares treated with GonaCon-Equine were to become sterile, though, that result would consistent with text of the WFRHBA of 1971, as amended, which allows for sterilization to achieve population goals.

In summary, based on the above results related to fertility effects of GonaCon and other anti-GnRH vaccines, application of a single dose of GonaCon-Equine to gathered or remotely-darted wild horses could be expected to prevent pregnancy in perhaps 30%-60% of mares for one year. Some smaller number of wild mares should be expected to have persistent contraception for a second year, and less still for a third year. Applying one booster dose of GonaCon to previously-treated mares should lead to two or more years with relatively high rates (80+%) of additional infertility expected, with the potential that some as-yet-unknown fraction of boostered mares may be infertile for several to many years. There is no data to support speculation regarding efficacy of multiple boosters of GonaCon-Equine; however, given it is formulated as a highly immunogenic long-lasting vaccine, it is reasonable to hypothesize that additional boosters would increase the effectiveness and duration of the vaccine.

GonaCon-Equine only affects the fertility of treated animals; untreated animals would still be expected to give birth. Even under favorable circumstances for population growth suppression, gather efficiency might not exceed 85% via helicopter, and may be less with bait and water trapping. Similarly, not all animals may be approachable for darting. The uncaptured or undarted portion of the female population would still be expected to have normally high fertility rates in any given year, though those rates could go up slightly if contraception in other mares increases forage and water availability.

GnRH Vaccine Effects on Other Organ Systems

BLM requires individually identifiable marks for immunocontraceptive treatment; this may require handling and marking. Mares receiving any vaccine as part of a gather operation would experience slightly increased stress levels associated with handling while being vaccinated and freeze-marked, and potentially microchipped. Newly captured mares that do not have markings associated with previous fertility control treatments would be marked with a new freeze-mark for the purpose of identifying that mare, and identifying her vaccine treatment history. This information would also be used to determine the number of mares captured that were not previously treated, and could provide additional insight regarding gather efficiency, and the timing of treatments required into the future. Most mares recover from the stress of capture and handling quickly once released back to the HMA, and none are expected to suffer serious long term effects from the fertility control injections, other than the direct consequence of becoming temporarily infertile.

Injection site reactions associated with immunocontraceptive treatments are possible in treated mares (Roelle and Ransom 2009). Whether injection is by hand or via darting, GonaCon-Equine is associated with some degree of inflammation, swelling, and the potential for abscesses at the injection site (Baker et al. 2013). Swelling or local reactions at the injection site are generally expected to be minor in nature, but some may develop into draining abscesses. When PZP vaccine was delivered via dart it led to more severe swelling and injection site reactions (Roelle and Ransom 2009), but that was not observed with dart-delivered GonaCon (McCann et al. 2017). Mares treated with one formulation of GnRH-KHL vaccine developed pyogenic abscesses (Goodloe 1991). Miller et al. (2008) noted that the water and oil emulsion in GonaCon would often cause cysts, granulomas, or sterile abscesses at injection sites; in some cases, a sterile abscess may develop into a draining abscess. In elk treated with GonaCon, Powers et al. (2011) noted up to 35% of treated elk had an abscess form, despite the injection sites first being clipped and swabbed with alcohol. Even in studies where swelling and visible abscesses followed GonaCon immunization, the longer term nodules observed did not appear to change any animal's range of movement or locomotor patterns (Powers et al. 2013, Baker et al. 2017).

The result that other formulations of anti-GnRH vaccine may be associated with less notable injection site reactions in horses may indicate that the adjuvant formulation in GonaCon leads a single dose to cause a stronger immune reaction than the adjuvants used in other anti-GnRH vaccines. Despite that, a booster dose of GonaCon-Equine appears to be more effective than a primer dose alone (Baker et al. 2017). Horses injected in the hip with Improvac showed only transient reactions that disappeared within 6 days in one study (Botha et al. 2008), but stiffness and swelling that lasted 5 days were noted in another study where horses received Improvac in the neck (Imboden et al. 2006). Equity led to transient reactions that resolved within a week in some treated animals (Elhay et al. 2007). Donovan et al. noted no reactions to the canine anti-GnRH vaccine (2013). In cows treated with Bopriva there was a mildly elevated body temperature and mild swelling at injection sites that subsided within 2 weeks (Balet et al. 2014).

Several studies have monitored animal health after immunization against GnRH. GonaCon treated mares did not have any measurable difference in uterine edema (Killian 2006, 2008). Powers et al. (2011, 2013) noted no differences in blood chemistry except a mildly elevated fibrinogen level in some GonaCon treated elk. In that study, one sham-treated elk and one GonaCon treated elk each developed leukocytosis, suggesting that there may have been a causal link between the adjuvant and the effect. Curtis et al. (2008) found persistent granulomas at GonaCon-KHL injection sites three years after injection, and reduced ovary weights in treated females. Yoder and Miller (2010) found no difference in blood chemistry between GonaCon treated and control prairie dogs. One of 15 GonaCon treated cats died without explanation, and with no determination about cause of death possible based on necropsy or histology (Levy et al. 2011). Other anti-GnRH vaccine formulations have led to no detectable adverse effects (in elephants; Boedeker et al. 2011), though Imboden et al. (2006) speculated that young treated animals might conceivably have impaired hypothamic or pituitary function.

Kirkpatrick et al. (2011) raised concerns that anti-GnRH vaccines could lead to adverse effects in other organ systems outside the reproductive system. GnRH receptors have been identified in tissues outside of the pituitary system, including in the testes and placenta (Khodr and Siler-Khodr 1980), ovary (Hsueh and Erickson 1979), bladder (Coit et al. 2009), heart (Dong et al. 2011), and central nervous system, so it is plausible that reductions in circulating GnRH levels could inhibit physiological processes in those organ systems. Kirkpatrick et al. (2011) noted elevated cardiological risks to human patients taking GnRH agonists (such as leuprolide), but the National Academy of Sciences (2013) concluded that the mechanism and results of GnRH agonists would be expected to be different from that of anti-GnRH antibodies; the former flood GnRH receptors, while the latter deprive receptors of GnRH.

GnRH Vaccine Effects on Fetus and Foal

GonaCon had no apparent effect on pregnancies in progress, foaling success, or the health of offspring, in horses that were immunized in October (Baker et al. 2013), elk immunized 80-100 days into gestation (Powers et al. 2011, 2013), or deer immunizeed in February (Miller et al. 2000). Kirkpatrick et al. (2011) noted that anti-GnRH immunization is not expected to cause hormonal changes that would lead to abortion in the horse, but this may not be true for the first 6 weeks of pregnancy (NRC 2013). Curtis et al. (2011) noted that GonaCon-KHL treated white tailed deer had lower twinning rates than controls, but speculated that the difference could be due to poorer sperm quality late in the breeding season, when the treated does did become pregnant. Goodloe (1991) found no difference in foal production between treated and control animals.

Offspring of anti-GnRH vaccine treated mothers could exhibit an immune response to GnRH (Khodr and Siler-Khodr 1980), as antibodies from the mother could pass to the offspring through the placenta or colostrum. In the most extensive study of long-term effects of GonaCon immunization on offspring, Powers et al. (2012) monitored 15 elk fawns born to GonaCon treated cows. Of those, 5 had low titers at birth and 10 had high titer levels at birth. All 15 were of normal weight at birth, and developed normal endocrine profiles, hypothalamic GnRH content, pituitary gonadotropin content, gonad structure, and gametogenesis. All the females became pregnant in their second reproductive season, as is typical. All males showed normal development of secondary sexual characteristics. Powers et al. (2012) concluded that suppressing GnRH in the neonatal period did not alter long-term reproductive function in either male or female offspring. Miller et al. (2013) report elevated anti-GnRH antibody titers in fawns born to treated white tailed deer, but those dropped to normal levels in 11 of 12 of those fawns, which came into breeding condition; the remaining fawn was infertile for three years.

Direct effects on foal survival are equivocal in the literature. Goodloe (1991), reported lower foal survival for a small sample of foals born to anti-GnRH treated mares, but she did not assess other possible explanatory factors such as mare social status, age, body condition, or habitat in her analysis (NRC 2013). Gray et al. (2010) found no difference in foal survival in foals born to free-roaming mares treated with GonaCon.

There is little empirical information available to evaluate the effects of GnRH vaccination on foaling phenology. It is possible that immunocontracepted mares returning to fertility late in the breeding season could give birth to foals at a time that is out of the normal range (Nuñez et al. 2010, Ransom et al 2013). Curtis et al. (2001) did observe a slightly later fawning date for GonaCon treated deer in the second year after treatment, when some does regained fertility late in the breeding season. In anti-GnRH vaccine trials in free-roaming horses, there were no published differences in mean date of foal production (Goodloe 1991, Gray et al. 2010). Unpublished results from an ongoing study of GonaCon treated free-roaming mares indicate that some degree of aseasonal foaling is possible (D. Baker, Colorado State University, personal communication to Paul Griffin, BLM WH&B Research Coordinator). Because of the concern that contraception could lead to shifts in the timing of parturitions for some treated animals, Ransom et al. (2013) advised that managers should consider carefully before using PZP immunocontraception in small refugia or rare species. The same may also apply to GonaCon. It should be noted that wild horses and burros in most areas do not generally occur in isolated refugia, they are not a rare species at the regional, national, or international level, and genetically they represent descendants of domestic livestock with most populations containing few if any unique alleles (NAS 2013). Moreover, in PZP-treated horses that did have some degree of parturition date shift, Ransom et al. (2013) found no negative impacts on foal survival even with an extended birthing season. If there were to be a shift in foaling date for some treated mares, the effect on foal survival may depend on weather severity and local conditions; for example, Ransom et al. (2013) did not find consistent effects across study sites.

Indirect Effects of GnRH Vaccination

One expected long-term, indirect effect on wild horses treated with fertility control would be an improvement in their overall health. Many treated mares would not experience the biological stress of reproduction, foaling and lactation as frequently as untreated mares, and their better health is expected to be reflected in higher body condition scores. After a treated mare returns to fertility, her future foals would be expected to be healthier overall, and would benefit from improved nutritional quality in the mares' milk. This is particularly to be expected if there is an improvement in rangeland forage quality at the same time, due to reduced wild horse population size. Past application of fertility control has shown that mares' overall health and body condition can remain improved even after fertility resumes. Anecdotal, subjective observations of mares treated with a different immunocontraceptive, PZP, in past gathers showed that many of the treated mares were larger, maintained better body condition, and had larger healthy foals than untreated mares.

Body condition of anti-GnRH-treated females was equal to or better than that of control females in published studies. Ransom et al. (2014) observed no difference in mean body condition between GonaCon-B treated mares and controls. Goodloe (1991) found that GnRH-KHL treated mares had higher survival rates than untreated controls. In other species, treated cats gained more weight than controls (Levy et al. 2011), as did treated young female pigs (Bohrer et al. 2014).

Following resumption of fertility, the proportion of mares that conceive and foal could be increased due to their increased fitness; this has been called by some a 'rebound effect.' Elevated fertility rates have been observed after horse gathers and removals (Kirkpatrick and Turner 1991). More research is needed to document and quantify these hypothesized effects. If repeated contraceptive treatment leads to a prolonged contraceptive effect, then that may minimize or delay the hypothesized rebound effect.

Because successful fertility control would reduce foaling rates and population growth rates, another indirect effect would be to reduce the number of wild horses that have to be removed over time to achieve and maintain the established AML. Contraception would be expected to lead to a relative increase in the proportion of older animals in the herd. Reducing the numbers of wild horses that would have to be removed in future gathers could allow for removal of younger, more easily adoptable excess wild horses, and thereby could eliminate the need to send additional excess horses from this area to off-range holding corrals or pastures for long-term holding. Among mares in the herd that remain fertile, a high level of physical health and future reproductive success of fertile mares within the herd would be expected as reduced population sizes should lead to more availability of water and forage resources per capita.

Reduced population growth rates and smaller population sizes could also allow for continued and increased environmental improvements to range conditions within the project area, which would have long-term benefits to wild horse habitat quality. As the local horse abundance nears or is maintained at the level necessary to achieve a thriving natural ecological balance, vegetation resources would be expected to recover, improving the forage available to wild horses and wildlife throughout the HMA or HMAs. With rangeland conditions more closely approaching a thriving natural ecological balance, and with a less concentrated distribution of wild horses across the HMA, there should also be less trailing and concentrated use of water sources. Lower population density would be expected to lead to reduced competition among wild horses using the water sources, and less fighting among horses accessing water sources. Water quality and quantity would continue to improve to the benefit of all rangeland users including wild horses. Wild horses would also have to travel less distance back and forth between water and desirable foraging areas. Should GonaCon-Equine treatment, including booster doses, continue into the future, with treatments given on a schedule to maintain a lowered level of fertility in the herd, the chronic cycle of overpopulation and large gathers and removals might no longer occur, but instead a consistent abundance of wild horses could be maintained, resulting in continued improvement of overall habitat conditions and animal health. While it is conceivable that widespread and continued treatment with GonaCon-Equine could reduce the birth rates of the population to such a point that birth is consistently below mortality, that outcome is not likely unless a very high fraction of the mares present are all treated with primer and booster doses, and perhaps repeated booster doses.

<u>Behavioral Effects of GnRH Vaccination</u>

Behavioral differences should be considered as potential consequences of contraception with GonaCon. The NRC report (2013) noted that all successful fertility suppression has effects on mare behavior, mostly as a result of the lack of pregnancy and foaling, and concluded that GonaCon was a good choice for use in the program. The result that GonaCon treated mares may have suppressed estrous cycles throughout the breeding season can lead treated mares to behave in ways that are functionally similar to pregnant mares.

While successful in mares, GonaCon and other anti-GnRH vaccines are expected to induce fewer estrous cycles when compared to non-pregnant control mares. This has been observed in many studies (Garza et al. 1986, Curtis et al. 2001, Dalin et al. 2002, Killian et al. 2006, Dalmau et al. 2015). In contrast, PZP vaccine is generally expected to lead mares to have more estrous cycles per breeding season, as they continue to be receptive to mating while not pregnant. Females treated with GonaCon had less estrous cycles than control or PZP-treated mares (Killian et al. 2006) or deer (Curtis et al. 2001). Thus, concerns about PZP treated mares receiving more courting and breeding behaviors from stallions (Nuñez et al. 2009, Ransom et al. 2010) are not generally expected to be a concern for mares treated with anti-GnRH vaccines (Botha et al. 2008).

Ransom et al. (2014) found that GonaCon treated mares had similar rates of reproductive behaviors that were similar to those of pregnant mares. Among other potential causes, the reduction in progesterone levels in treated females may lead to a reduction in behaviors associated with reproduction. Despite this, some females treated with GonaCon or other anti-GnRH vaccines did continue to exhibit reproductive behaviors, albeit at irregular intervals and durations (Dalin et al. 2002, Stout et al. 2003, Imboden et al. 2006), which is a result that is similar to spayed (ovariectomized) mares (Asa et al. 1980). Gray et al. (2009) found no difference in sexual behaviors in mares treated with GonaCon and untreated mares. When progesterone levels are low, small changes in estradiol concentration can foster reproductive estrous behaviors (Imboden et al. 2006). Owners of anti-GnRH vaccine treated mares reported a reduced number of estrous-related behaviors under saddle (Donovan et al. 2013). Treated mares may refrain from reproductive behavior even after ovaries return to cyclicity (Elhay et al. 2007). Studies in elk found that GonaCon treated cows had equal levels of precopulatory behaviors as controls (Powers et al. 2011), though bull elk paid more attention to treated cows late in the breeding season, after control cows were already pregnant (Powers et al. 2011).

Stallion herding of mares, and harem switching by mares are two behaviors related to reproduction that might change as a result of contraception. Ransom et al. (2014) observed a 50% decrease in herding behavior by stallions after the free-roaming horse population at Theodore Roosevelt National Park was reduced via a gather, and mares there were treated with GonaCon-B. The increased harem tending behaviors by stallions were directed to both treated and control mores. It is difficult to separate any effect of GonaCon from changes in horse density and forage following horse removals.

Mares in untreated free-roaming populations change bands; some have raised concerns over effects of PZP vaccination on band structure (Nuñez et al. 2009), with rates of band fidelity being suggested as a measure of social stability. With respect to treatment with GonaCon or other anti-GnRH vaccines, it is probably less likely that treated mares would switch harems at higher rates than untreated animals, because treated mares are similar to pregnant mares in their behaviors (Ransom et al. 2014). Indeed, Gray et al. (2009) found no difference in band fidelity in a free-roaming population of horses with GonaCon treated mares, despite differences in foal production between treated and untreated mares. Ransom et al. (2014) actually found increased levels of band fidelity after treatment, though this may have been partially a result of changes in overall horse density and forage availability.

Even in cases where there may be changes in band fidelity, the National Research Council (2013) found that harem changing was not likely to result in serious adverse effects for treated mares:

> "The studies on Shackleford Banks (Nuñez et al., 2009; Madosky et al., 2010) suggest that there is an interaction between pregnancy and social cohesion. The importance of harem stability to mare well-being is not clear, but considering the relatively large number of free-ranging mares that have been treated with liquid PZP in a variety of ecological settings, the likelihood of serious adverse effects seem low."

Kirkpatrick et al. (2010) concluded that "the larger question is, even if subtle alterations in behavior may occur, this is still far better than the alternative."

The NRC (2013) provides a comprehensive review of the literature on the behavioral effects of contraception that puts Nuñez's (2009, 2010) research into the broader context of all of the available scientific literature, and cautions, based on its extensive review of the literature that:

> ". . . in no case can the committee conclude from the published research that the behavior

> differences observed are due to a particular compound rather than to the fact that treated animals had no offspring during the study. That must be borne in mind particularly in interpreting long-term impacts of contraception (e.g., repeated years of reproductive "failure" due to contraception)."

Gray et al. (2009) and Ransom et al. (2014) monitored non-reproductive behaviors in GonaCon treated populations of free-roaming horses. Gray et al. (2009) found no difference between treated and untreated mares in terms of activity budget, sexual behavior, proximity of mares to stallions, or aggression. Ransom et al. (2014) found only minimal differences between treated and untreated mare time budgets, but those differences were consistent with differences in the metabolic demands of pregnancy and lactation in untreated mares, as opposed to non-pregnant treated mares.

Genetic Effects of GnRH Vaccination

In HMAs where large numbers of wild horses have recent and / or an ongoing influx of breeding animals from other areas with wild or feral horses, contraception is not expected to cause an unacceptable loss of genetic diversity or an unacceptable increase in the inbreeding coefficient. In any diploid population, the loss of genetic diversity through inbreeding or drift can be prevented by large effective breeding population sizes (Wright 1931) or by introducing new potential breeding animals (Mills and Allendorf 1996). The NRC report recommended that managed herds of wild horses would be better viewed as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of both natural and human-facilitated movements. In the last 10 years, there has been a high realized growth rate of wild horses in most areas administered by the BLM, such that most alleles that are present in any given mare are likely to already be well represented in her siblings, cousins, and more distant relatives. With the exception of horses in a small number of well-known HMAs that contain a relatively high fraction of alleles associated with old Spanish horse breeds (NRC 2013), the genetic composition of wild horses in lands administered by the BLM is consistent with admixtures from domestic breeds. As a result, in most HMAs, applying fertility control to a subset of mares is not expected to cause irreparable loss of genetic diversity. Improved longevity and an aging population are expected results of contraceptive treatment that can provide for lengthening generation time; this result would be expected to slow the rate of genetic diversity loss (Hailer et al., 2006). Based on a population model, Gross (2000) found that an effective way to retain genetic diversity in a population treated with fertility control is to preferentially treat young animals, such that the older animals (which contain all the existing genetic diversity available) continue to have offspring. Conversely, Gross (2000) found that preferentially treating older animals (preferentially allowing young animals to breed) leads to a more rapid expected loss of genetic diversity over time.

Even if it is the case that booster treatment with GonaCon may lead to prolonged infertility, or even sterility in some mares, most HMAs have only a low risk of loss of genetic diversity if logistically realistic rates of contraception are applied to mares. Wild horses in most herd management areas are descendants of a diverse range of ancestors coming from many breeds of domestic horses. As such, the existing genetic diversity in the majority of HMAs does not contain genetic markers that have been identified as unique or historically unusual (NRC 2013).

Past interchange between HMAs, either through natural dispersal or through assisted migration (i.e. human movement of horses) means that many HMAs are effectively indistinguishable and interchangeable in terms of their genetic composition. Roelle and Oyler-McCance (2015) used the VORTEX population model to simulate how different rates of mare sterility would influence population persistence and genetic diversity, in populations with high or low starting levels of genetic diversity, various starting population sizes, and various annual population growth rates. Their results show that the risk of the loss of genetic heterozygosity is extremely low except in cases where all four of the following conditions are met: starting levels of genetic diversity are low, initial population size is 100 or less, intrinsic population growth rate is low (5% per year), and very large fractions of the female population are permanently sterilized.

Many factors influence the strength of a vaccinated individual's immune response, potentially including genetics, but also nutrition, body condition, and prior immune responses to pathogens or other antigens (Powers et al 2013). One concern that has been raised with regards to genetic diversity is that treatment with immunocontraceptives could possibly lead to an evolutionary increase in the frequency of individuals whose genetic composition fosters weak immune responses (Cooper and Larson 2006, Ransom et al. 2014a). This premise is based on an assumption that lack of response to PZP is a heritable trait, and that the frequency of that trait would increase over time in a population of PZP-treated animals. Cooper and Herbert (2001) reviewed the topic, in the context of concerns about the long-term effectiveness of immunocontraceptives as a control agent for exotic species in Australia. They argue that imunocontraception could be a strong selective pressure, and that selecting for reproduction in individuals with poor immune response could lead to a general decline in immune function in populations where such evolution takes place. Other authors have also speculated that differences in antibody titer responses could be partially due to genetic differences between animals (Curtis et al. 2001, Herbert and Trigg 2005).

BLM is not aware of any studies that have quantified the heritability of a lack of response to immunocontraception such as PZP vaccine or GonaCon-Equine in horses. At this point there are no studies available from which one could make conclusions about the long-term effects of sustained and widespread immunocontraception treatments on population-wide immune function. Although a few, generally isolated, feral horse populations have been treated with high fractions of mares receiving PZP immunocontraception for long-term population control (e.g., Assateague Island and Pryor Mountains), no studies have tested for changes in immune competence in those areas. Relative to the large number of free-roaming feral horses in the western United States, immunocontraception has not been used in the type of widespread or prolonged manner that might be required to cause a detectable evolutionary response at a large scale.

Magiafolou et al. (2013) clarify that if the variation in immune response is due to environmental factors (i.e., body condition, social rank) and not due to genetic factors, then there would be no expected effect of the immune phenotype on future generations. Correlations between immune response and physical factors such as age and body condition have been documented; it remains untested whether or not those factors play a larger role in determining immune response to immunocontraceptives than heritable traits. Several studies discussed above noted a relationship between the strength of individuals' immune responses after treatment with GonaCon or other anti-GnRH vaccines, and factors related to body condition. For example, age at immunization was a primary factor associated with different measures of immune response, with young animals tending to have stronger and longer-lasting responses (Stout et al. 2003, Schulman et al. 2013). It is also possible that general health, as measured by body condition, can have a causal role in determining immune response, with animals in poor condition demonstrating poor immune reactions (Gray 2009, NRC 2013). Miller et al. (2013) speculated that animals with high parasite loads also may have weaker immune reactions to GonaCon.

Correlations between such physical factors and immune response would not preclude, though, that there could also be a heritable response to immunocontraception. In studies not directly related to immunocontraception, immune response has been shown to be heritable (Kean et al. 1994, Sarker et al. 1999). Unfortunately, predictions about the long-term, population-level evolutionary response to immunocontraceptive treatments are speculative at this point, with results likely to depend on several factors, including: the strength of the genetic predisposition to not respond to GonaCon-Equine; the heritability of that gene or genes; the initial prevalence of that gene or genes; the number of mares treated with a primer dose of GonaCon-Equine (which generally has a short-acting effect, if any); the number of mares treated with a booster dose of GonaCon-Equine; and the actual size of the genetically-interacting metapopulation of horses within which the GonaCon treatment takes place.

Use of IUDs for Alternatives A and B

IUDs are considered a temporary fertility control method that does not generally cause future sterility (Daels and Hughes 1995). Use of IUDs is an effective fertility control method in women, and IUDs have historically been used in livestock management, including in domestic horses. IUDs in mares may cause physiological effects including discomfort, infection, perforation of the uterus (by a hard IUD), endometritis, uterine edema (Killian et al. 2008), and pyometra (Klabnik-Bradford et al. 2013). In women, deaths attributable to IUD use may be as low as 1.06 per million (Dales and Hughes 1995).

The exact mechanism by which IUDs prevent pregnancy is uncertain (Daels and Hughes 1995), but the presence of an IUD in the uterus may, like a pregnancy, prevent the mare from coming back into estrus (Turner et al. 2015). However, some domestic mares did exhibit repeated estrus cycles during the time when they had IUDs (Killian et al. 2008). The main cause for an IUD to not be effective at contraception is its failure to stay in the uterus (Daels and Hughes 1995). As a result, one of the major challenges to using IUDs to control fertility in mares on the range is preventing the IUD from being dislodged or otherwise ejected over the course of daily activities, which include, at times, frequent breeding.

At this time, it is thought that any IUD inserted into a pregnant mare may cause the pregnancy to terminate, which may also cause the IUD to be expelled. For that reason, it is expected that IUDs would only be inserted in non-pregnant (open) mares. Some method of testing for pregnancy status, such as palpation or ultrasound examination, could be used as a precursor to determining whether a given mare is a candidate for IUD use. If a mare has a zygote or very small, early phase embryo, it is possible that it will fail to develop further, but without causing the expulsion of the IUD.

Hard IUDs, such as metallic or glass marbles, may prevent pregnancy (Nie et al. 2003) but can pose health risks to domestic mares (Turner et al. 2015, Freeman and Lyle 2015). Marbles may break into shards (Turner et al. 2015), and uterine irritation that results from marble IUDs may cause chronic, intermittent colic (Freeman and Lyle 2015). Metallic IUDs may cause severe infection (Klabnik-Bradford et al. 2013). A researcher from the University of Massachusetts has developed a magnetic IUD (2019) which consist of three oblong, shatter-proof, magnetic beads that has been effective at preventing estrus in non-breeding domestic mares. When two sizes of those magnetic IUDs were tested in breeding domestic mares, they fell out at high rates (Holyoak et al., unpublished results), but the magnetic IUDs will be undergoing additional testing in breeding mares in the near future (Gradil 2019).

In domestic ponies, Killian et al. (2008) explored the use of three different IUD configurations, including a silastic polymer O-ring with copper clamps, and the "380 Copper T" and "GyneFix" IUDs designed for women. The longest retention time for the three IUD models was seen in the "T" device, which stayed in the uterus of several mares for 3-5 years. Reported contraception rates for IUD-treated mares were 80%, 29%, 14%, and 0% in years 1-4, respectively. They surmised that pregnancy resulted after IUD fell out of the uterus. Killian et al. (2008) reported high levels of progesterone in non-pregnant, IUD-treated ponies.

Soft IUDs may cause relatively less discomfort than hard IUDs (Daels and Hughes 1995). Daels and Hughes (1995) tested the use of a flexible O-ring IUD, made of silastic, surgical-grade polymer, measuring 40 mm in diameter; in five of six breeding domestic mares tested, the IUD was reported to have stayed in the mare for at least 10 months. In mares with IUDs, Daels and Hughes (1995) reported some level of uterine irritation, but surmised that the level of irritation was not enough to interfere with a return to fertility after IUD removal.

Several types of flexible IUDs are being tested for use in breeding mares. When researchers attempted to replicate the O-ring study (Daels and Hughes 1995) in an USGS / Oklahoma State University (OSU) study with breeding domestic mares, using various configurations of silicone O-ring IUDs, the IUDs fell out at unacceptably high rates over time scales of less than 2 months (Baldrighi et al. 2017). Subsequently, the USGS / OSU researchers have been testing a Y-shaped IUD to determine retention rates and assess effects on uterine health; results are still pending but retention rates were much higher (Holyoak et al., unpublished results). Another new form of IUD is an anchor-shaped silicone object. This IUD has been shown to be effective over 18 months in a field situation where natural breeding behavior occurs.

IUDs seem to be effective, as long as the device remains in place the mare should remain infertile. Mares should return to fertility if the device is removed or falls out. Mares would likely continue to cycle and be bred for several months each year.

Impacts of Alternative C: Gather and Remove Excess Wild Horses to Achieve Low AML with follow-up gathers to maintain AML.

Impacts from this alternative would be similar to the gathering and handling impacts under Alternative A, however there would be no horses released or fertility control administered to release horses. While wild horses would be gathered to the within the low range of AML, the

AML would be exceeded sooner than under Alternatives A and B since fertility rates would be higher.

Impacts of Alternative D: Gather and removal of excess wild horses to low AML and population growth control by establishing a non-reproducing component.

Impacts from this alternative would be similar to Alternative A, however fertility control via sterilization would be applied. The anticipated effects of the sterilization treatment are both physical and behavioral. For any method using surgery or requiring extensive animal handling, a veterinarian would ensure use of appropriate sedation, anesthesia, analgesics and antibiotics. Physical effects would be due to post-surgical healing and the possibility for complications. When gather efficiencies have been able to achieve horse numbers within the range of AML and fertility control via sterilization has been performed; maintenance gathers to apply fertility control and to remove adoptable wild horses would be conducted for the next 10 years following the date of the initial gather only if needed. The need for follow up gathers and spaying treatments will be determined based on wild horse population numbers exceeding the upper AML limit. For further detail on the following sterilization techniques see Appendix H.

Spaying via Flank Laparoscopy

Flank laparoscopy is now commonly used in domestic mares due to its minimal invasiveness and full observation of the operative field (Lee and Hendrickson 2008). Ovariectomy via flank laparoscopy was seen as the lowest risk method in terms of mortality and morbidity when discussed in Bowen (2015). Flank laparoscopy requires a far longer surgical duration than ovariectomy via colpotomy and requires that the patient remain standing still for the duration of the surgery, which may be over 45 minutes (Bowen 2015). During that time, the horse must be maintained in an anesthetic plane that prevents it from making sudden movements. If the mare is not still during surgery, there is a risk that the instruments placed inside the body cavity may damage internal organs or that the instruments may become malfunctional. The long duration and requirement that mares stand peacefully reduce the likelihood that this surgical method would be feasible for most wild horses. BLM is not aware of any studies documenting the use of ovariectomy via flank laparoscopy in wild mares.

This surgical approach costs at least $450–$500 per mare (Bowen et al. 2015), but with inflation since 2015 may be higher. The procedure involves three small incisions on each flank of the animal, through which three cannulas (tubes) allow entry of narrow devices to the body cavity: these are the insufflator, endoscope, and surgical instrument. The surgical procedure involves the use of narrow instruments introduced into the abdomen, via cannulas, for the purpose of transecting the ovarian pedicle, but the insufflation should allow the veterinarian to navigate inside the abdomen without damaging other internal organs. The insufflator blows air into the cavity to increase the operating space between organs, and the endoscope provides a video feed to visualize the operation of the surgical instrument. Flank laparoscopy may leave three small (<5 cm), visible scars on each side of the horse's flank, which would be subject to infection and dehiscence. It may be possible to access both ovaries from one side of the animal, using longer surgical tools. Because of the three or six external wounds, domestic mares recovering from surgery are typically confined alone in small pens after surgery for several days. Experience handling wild animals in relatively confined areas shows that wild horses, as compared to domestic horses, cannot and should not be restrained for long periods of time or confined in individual pens that prevent them from rolling or interacting with other horses. Restraint for long periods of time (days) would induce additional stress on a wild animal as well as added risk when the treated animals would fight the restraint. Fowler (2008) cautioned that, "Animals may become overstimulated with an epinephrine rush during restraint procedures. They may be inclined to and capable of, feats of athleticism beyond imagination"; such struggles could cause unnecessary injury. Furthermore, rolling on the ground is not conducive to external wound healing. If the patient does not roll and remove bandages to expose the wound from flank laparoscopy, it is expected that the tissues and musculature under the skin at the site of the incisions in the flank will heal quickly, leaving no long-lasting effects on horse health. However, as noted above, preventing (by restraint) wild horses from rolling is not expected to be safe for the animal.

Previous use of flank laparoscopy, or other flank approaches, for ovariectomy on ungentled mares is unknown to BLM. Therefore BLM must reach out to experts, as was done through Bowen (2015), for interpretation of the potential applicability of this technique on wild horses. The above discussions indicate to BLM that until adjustments are made to this technique showing that this method can be successfully demonstrated in conditions that are comparable to those expected for wild horse mares, spaying via flank laparoscopy may be technically infeasible for application due to the higher risk of infection at external incision sites, the time required to perform each surgery, and the post-surgical care requirements.

Surgical Spaying – Ventral midline, oblique, or flank laparotomy

The ventral midline or oblique laparotomy is performed under general anesthesia, the horse is anesthetized and placed in dorsal recumbence. Flank laparotomy is typically performed under standing sedation, but can be done under general anesthesia. In each of these approaches one to two large incisions are made and the abdomen is opened; the ovaries are surgically removed and the incision(s) is stitched closed. Dorsal recumbence maximizes safety for the surgeon while the standing sedation is cheaper and has less risk to the horse. All three approaches allow for direct visualization of the ovaries. These surgeries take about 45 minutes or more per horse including induction and recovery. Abdominal incisions are prone to swelling and if they become infected this would be very difficult if not impossible to manage post operatively in a wild horse. If bandages are needed to help prevent inflection, it is unlikely that wild horses would keep them on. Biting and kicking of incision sites creates higher risk for infection and complications and is not reasonably preventable with wild horses. Incision complications under sterile conditions with domestic horses are 5% and under field conditions may be 10-20% (Bowen 2015). Anywhere between 4 and 12 weeks recovery time is needed before full exercise and natural servicing should be allowed (Loesch and Rodgerson 2003). These surgeries are not appropriate for pregnant mares after early gestation. These approaches cost approximately $350 or more per mare. See Appendix H for more information.

Laparoscopic-Assisted Colpotomy for Ovariectomy

Laparoscopic-assisted colpotomy allows the surgeon to visualize the ovaries prior to removal, which has potential to reduce risks associated with transection of the ovary and associated bleeding at that location. However, the inclusion of laparoscopy requires an increased duration (at least 20–30 minutes for bilateral ovariectomy as per Tate et al. 2012), which adds stress to an already stressed animal; requires insufflation of the abdomen, which can cause post-laparoscopic pain due to the pneumoperitoneum created (Devick et al. 2018); and requires external (flank) incisions for insertion of the laparoscope, which necessitates post-operative restraint and increases the risk of infection (discussed above). In the transcript of Bowen (2015, p. 17) it was discussed that a laparoscope could be used to train veterinarians in ovariectomy via colpotomy, but it would not likely be preferred for field conditions and wild horses due to the reasons described above. This procedure conducted on domestic horses in a veterinary teaching hospital costs approximately $2,500 per mare (including two nights' board). To BLM's knowledge, this procedure has never been conducted on ungentled mares and, therefore, best estimates for costs in a field setting and in larger quantities of wild mares would be approximately $750 to $1,500 each.

Non-surgical, Physical Sterilization

This type of procedure would include any physical form of sterilization that does not involve surgery. This could include any form of physical procedure that leads a mare to be unable to become pregnant, or to maintain a pregnancy. For example, one form of physical, non-surgical sterilization causes a long-term blockage of the oviduct, so that fertile eggs cannot go from the ovaries to the uterus. The mare retains her ovaries. The mare would be sterile, although she would continue to have estrus cycles. Because of the retention of estrus cycles, it is expected that behavioral outcomes would be similar to those observed for PZP vaccine treated mares. The procedure is transcervical, so the treated mare cannot have a fetus in the uterus at the time of treatment. Treated mares would need to be screened to ensure they are not pregnant, because transcervical procedures can cause a pregnancy to terminate. Screening could be with transrectal palpation or ultrasonography. Those procedures require restraint and evacuation of the colon, and for a veterinarian to feel across the rectum, or hold an ultrasound probe there, but do not require sedation or analgesia.

The oviduct blockage form of physical sterilization infuses medical-grade N-butyl cyanoacrylate glue into the oviduct to cause long-term blockage (Bigolin et al. 2009). A pilot project used this approach in six domestic mares, and has shown that after three years of breeding by a fertile stallion, all six mares remained infertile (Dr. I. Liu, UC Davis Emeritus Professor, personal communication to BLM). A three person team of experts is required to manipulate and operate an endoscope monitor, insert and hold the endoscope, manipulate and position a fine-tipped catheter into the oviduct, and infuse the fluid into the oviduct. After restraint, sedation and analgesic administration, fecal material is removed from the rectum, the tail is wrapped and suspended, and the vaginal area is cleaned with betadine. An endoscope is inserted through the cervix to the uterotubal junction (which is the entrance to the oviduct). A sterile catheter is inserted into the uterotubal junction. A half mL of N-butyl cyanoacrylate is infused into each oviduct. A new catheter is used for the procedure on the second oviduct. The mares are monitored initially for 10 minutes, but no further pain management is expected to be needed. The total time required for the procedure is approximately 30-40 minutes, and costs may be approximately $500-1000.

Ovariectomy via Colpotomy

Colpotomy is a surgical technique in which there is no external incision, reducing susceptibility to infection. For this reason, ovariectomy via colpotomy has been identified as a good choice for feral or wild horses (Rowland et al. 2018). Ovariectomy via colpotomy is a relatively short surgery, with a relatively quick expected recovery time. Surgery cost is approximately $250-$300 dollars per mare.

In 1903, Williams first described a vaginal approach, or colpotomy, using an ecraseur to ovariectomize mares (Loesch and Rodgerson 2003). The ovariectomy via colpotomy procedure has been conducted for over 100 years, normally on open (non-pregnant) domestic mares. Removal of the ovaries is permanent and 100 percent effective; however, the procedure is not without risk. In its review, the NRC (2013) briefly discussed surgical ovariectomy (removal of the ovaries) as a method of female-directed fertility control, noting that although ovariectomy is commonly used in domestic species, it has been seldom applied to free-ranging species. The committee cautioned that “the possibility that ovariectomy may be followed by prolonged bleeding or infection makes it inadvisable for field application” (NRC Review 2013); however, they explained that ovariectomy via colpotomy was an alternative approach that avoids an external incision and reduces the chances of complication and infection (NRC Review 2013). This NRC Review (2013) was prior to the Collins and Kasbohm (2016) publication where 114 feral horse mares were treated with ovariectomy via colpotomy with results showing a less than two percent mortality rate associated with the procedure. Although gestational stage was not recorded, many of the mares treated were pregnant (Gail Collins, US Fish and Wildlife Service (USFWS), pers. comm.). The NRC (2013) also noted that no fertility control method existed that did not affect physiology or behavior. The committee warned that the impacts of not managing population numbers were potentially harsher than contraception, as population numbers would likely be limited by starvation (NRC Review 2013).

Anticipated Complications and Complication Rates Associated with Ovariectomy via Colpotomy

Between 2009 and 2011, the Sheldon NWR in Nevada conducted ovariectomy via colpotomy surgeries (August through October) on 114 feral mares and released them back to the range with a mixture of sterilized stallions and untreated mares and stallions (Collins and Kasbohm 2016). As stated previously, gestational stage was not recorded, but a majority of the mares were pregnant in the Sheldon NWR study. Only a small number of mares were very close to full term (Gail Collins, USFWS, pers. comm.). Those mares with late term pregnancies did not receive surgery as the veterinarian could not get good access to the ovaries due to the position of the foal (Gail Collins, USFWS, pers. comm.). After holding the mares for an average of 8 days after surgery for observation, they were returned to the range with other treated and untreated mares and stallions (Collins and Kasbohm 2016). During holding the only complications were observed within 2 days of surgery. The observed mortality rate for ovariectomized mares following the procedure was less than 2 percent (Collins and Kasbohm 2016, Pielstick pers. comm.). Similar to these findings, Prado and Schumacher (2017) reported observation of "… only two surgical complications after performing over 100 ovariectomies by colpotomy."

The proposed action does not include treatment of pregnant mares. It is unknown if the reported less than 2 percent mortality rate from the Collins and Kasbohm (2016) study was associated with pregnancy status; however, treating only open (non-pregnant) mares may reduce additional risks associated with the maintenance of a pregnancy. During the Sheldon NWR ovariectomy study, mares generally walked out of the chute and started to eat; some would raise their tail and act as if they were defecating; however, in most mares one could not notice signs of discomfort (Bowen 2015). In their discussion of ovariectomy via colpotomy, McKinnon and Vasey (2007) considered the procedure safe and efficacious in many instances, able to be performed expediently by personnel experienced with examination of the female reproductive tract, and associated with a complication rate that is similar to or less than male castration. Nevertheless, all surgery is associated with some risk. Bilateral ovariectomy through either a colpotomy or flank approach can be performed efficiently in a standing mare, but potentially serious complications can occur with these approaches; unidentified and potentially fatal hemorrhage from the mesovarium, intestinal and mesenteric trauma, peritonitis, adhesions, and death are complications associated with both approaches (Rodgerson et al. 2001). Loesch and and Rodgerson (2003) add to the potential risks with colpotomy: pain and discomfort, delayed vaginal healing, evisceration of the bowel, incisional site hematoma, intra-abdominal adhesions to the vagina, and chronic lumbar or bilateral hind limb pain. Prado and Schumacher (2017) added hemorrhage from the ovarian pedicle as a potential complication. Shock is also a possibility that could be associated with any surgery. Most horses, however, tolerate ovariectomy via colpotomy with very few complications, as reported by Prado and Schumacher (2017), including feral horses (Collins and Kasbohm 2016). In the two out of 100 horses observed to have surgical complications from ovariectomy via colpotomy, Prado and Schumacher (2017) stated one mare experienced severe hemorrhage at the ovarian pedicle and the other strained after surgery, presumably because of vaginitis induced by an unsuccessful attempt to suture the colpotomy. Both mares survived, however the mare experiencing severe hemorrhage required multiple blood transfusions. Blood transfusions are not possible when applying this procedure to wild horse mares as blood from acceptable donors would not be available. Measures are in place, described in the proposed action, to minimize the risk of hemorrhage at the ovarian pedicle. A complication of the colpotomy itself is fatal hemorrhage cause by inadvertent perforation of the vaginal artery with a scalpel blade, "but this artery is avoided if it is located by palpation before the fornix of the vagina is incised and if the incision is created at the proper location (Embertson 2009, Prado and Schumacher 2017)." Prado and Schumacher (2017) also considered evisceration a possibility, but considered it rare. Mortality due to surgery or post-surgical complications is not anticipated, but it is a possibility and therefore every effort would be made to mitigate risks.

In September 2015, the BLM solicited the USGS to convene a panel of veterinary experts to assess the relative merits and drawbacks of several surgical ovariectomy techniques that are commonly used in domestic horses for potential application in wild horses. A table summarizing the various methods was received by the BLM (Bowen 2015) and provides a concise comparison of several methods. Of these, ovariectomy via colpotomy was found to be relatively safe when practiced by an experienced surgeon and was associated with the shortest duration of potential complications after the operation. The panel discussed the potential for evisceration through the vaginal incision with this procedure. In marked contrast to a suggestion by the NRC Review (2013) who explained that domestic mares are typically cross-tied to keep them standing for 48 hours post-surgery to prevent evisceration through the unclosed incision in the anterior vagina, this panel of veterinarians (Bowen 2015) identified evisceration as not being a probable risk associated with ovariectomy via colpotomy and "none of the panel participants had had this occur nor had heard of it actually occurring."

One reason why evisceration is rarely observed could be the small, vaginal incision (1–3 cm long) enlarged by blunt dissection. "This method separates rather than transects the muscle fibers so the incision decreases in length when the vaginal muscles contract after the tranquilization wanes post-surgery. Three days post-op the incision edges are adhered, and healed after 7–10 days" (Bowen 2015).

Most spay surgeries on mares have low morbidity[3] and with the help of medications pain and discomfort can be mitigated. Pain management is an important aspect of any ovariectomy (Rowland et al. 2018); according to the surgical protocol described in the proposed action, a long-lasting direct anesthetic would be applied to the ovarian pedicle, and systemic analgesics in the form of butorphanol and flunixin meglumine would be administered. In a study of the effects of bilateral ovariectomy via colpotomy on 23 mares, Hooper and others (1993) reported that post-operative problems were minimal (1 in 23, or 4 percent). Hooper and others (1993) noted that four other mares were reported by owners as having some problems after surgery, but that evidence as to the role the surgery played in those subsequent problems was inconclusive. In contrast, Röcken and others (2011) noted a morbidity of 10.8 percent for mares that were ovariectomized via a flank laparoscopy. "Although 5 mares in our study had problems (repeated colic in 2 mares, signs of lumbar pain in 1 mare, signs of bilateral hind limb pain in 1 mare, and clinical signs of peritonitis in 1 mare) after surgery, evidence is inconclusive in each as to the role played by surgery" (Hooper et al. 1993). A recent study showed a 2.5 percent complication rate where one mare of 39 showed signs of moderate colic after laparoscopic ovariectomy (Devick et al. 2018).

The NRC (BLM 2015) who reviewed an ovariectomy via colpotomy protocol on wild horse mares believed "this procedure could be operationalized immediately to sterilize mares, with the caveat that fatalities may be higher than the 1% reported in the literature…and quoted in the protocol, which is based on domestic mares." The NRC did not explain what literature they were referencing. However, the near 1 percent reference in the protocol was referring to the, at that time, unpublished (now Collins and Kasbohm 2016) ovariectomy via colpotomy study conducted on feral horse mares at the Sheldon NWR where they documented a less than 2 percent loss.

Anticipated Effects on Mare Health and Behavior on the Range

3 Morbidity is defined as the frequency of the appearance of complications following a surgical procedure or other treatment. In contrast, mortality is defined as an outcome of death due to the procedure.

No fertility control method exists that does not affect physiology or behavior of a mare (NRC Review 2013). Any action taken to alter the reproductive capacity of an individual has the potential to affect hormone production and therefore behavioral interactions and ultimately population dynamics in unforeseen ways (Ransom et al. 2014a). The health and behavioral effects of spaying wild horse mares that live with other fertile and infertile wild horses has not been well documented, but the literature review below can be used to make reasonable inferences about their likely behaviors.

Horses are anovulatory (do not ovulate/express estrous behavior) during the short days of late fall and early winter, beginning to ovulate as days lengthen and then cycling roughly every 21 days during the warmer months, with about 5 days of estrus (Asa et al. 1979, Crowell-Davis 2007). Estrus in mares is shown by increased frequency of proceptive behaviors: approaching and following the stallion, urinating, presenting the rear end, clitoral winking, and raising the tail towards the stallion (Asa et al. 1979, Crowell-Davis 2007). In most mammal species other than primates estrous behavior is not shown during the anovulatory period, and reproductive behavior is considered extinguished following spaying (Hart and Eckstein 1997). However, mares may continue to demonstrate estrous behavior during the anovulatory period (Asa et al. 1980). Similarly, ovariectomized mares may also continue to exhibit estrous behavior (Scott and Kunze 1977, Kamm and Hendrickson 2007, Crabtree 2016), with one study finding that 30 percent of mares showed estrus signs at least once after surgery (Roessner et al. 2015) and only 60 percent of ovariectomized mares cease estrous behavior following surgery (Loesch and Rodgerson 2003). Mares continue to show reproductive behavior following ovariectomy due to non-endocrine support of estrous behavior, specifically steroids from the adrenal cortex. Continuation of this behavior during the non-breeding season has the function of maintaining social cohesion within a horse group (Asa et al. 1980, Asa et al. 1984, NRC Review 2013). This may be a unique response of the horse (Bertin et al. 2013), as spaying usually greatly reduces female sexual behavior in companion animals (Hart and Eckstein 1997). In six ponies, mean monthly plasma luteinizing hormone[4] levels in ovariectomized mares were similar to intact mares.

The likely effects of spaying on mares' social interactions and group membership can be inferred from available literature, even though wild horses have rarely been spayed and released back into the wild, resulting in few studies that have investigated their behavior in free-roaming populations. Wild horses are instinctually herd-bound and this behavior is expected to continue. However, no study has documented the rate at which spayed mares will continue to remain with the stallion and band to which the mare was most recently attached. Overall, the BLM anticipates that some spayed mares may continue to exhibit estrous behavior that could foster band cohesion. If free-ranging ovariectomized mares show estrous behavior and occasionally allow copulation, interest of the stallion may be maintained, which could foster band cohesion (NRC Review 2013). This last statement could be validated by the observations of group associations on the Sheldon NWR where feral mares were ovariectomized via colpotomy and released back onto the range with untreated horses of both sexes (Collins and Kasbohm 2016). No data were

4 Luteinizing hormone (LH) is a glycoprotein hormone produced in the pituitary gland. In females, a sharp rise of LH triggers ovulation and development of the corpus luteum. LH concentrations can be measured in blood plasma. the anestrous season and during the breeding season were similar to levels in intact mares at mid-estrus (Garcia and Ginther 1976).

collected on inter- or intra-band behavior (e.g. estrous display, increased tending by stallions, etc.). During multiple aerial surveys in years following treatment, all treated individuals appeared to maintain group associations, and there were no groups consisting only of treated males or only of treated females (Collins and Kasbohm 2016). In addition, of solitary animals documented during surveys, there were no observations of solitary treated females (Collins and Kasbohm 2016). These data help support the expectation that ovariectomized mares would not lose interest in or be cast out of the social dynamics of a wild horse herd. As noted by the NRC Review (2013), the ideal fertility control method would not eliminate sexual behavior or change social structure substantially.

A study conducted for 15 days in January 1978 (Asa et al. 1980), compared the sexual behavior in ovariectomized and seasonally anovulatory (intact) pony mares and found that there were no statistical differences between the two conditions for any measure of proceptivity or copulatory behavior, or days in estrus. This may help to explain why treated mares at Sheldon NWR continued to be accepted into harem bands, in that they may have been behaving similarly to a non-pregnant mare. Five to ten percent of pregnant mares exhibit estrous behavior (Crowell-Davis 2007). Although the physiological cause of this phenomenon is not fully understood (Crowell-Davis 2007), it is hypothesized to be a bonding mechanism that assists in the maintenance of stable social groups of horses year-round (Ransom et al. 2014b). The complexity of social behaviors among free-roaming horses is not entirely centered on reproductive receptivity, and fertility control treatments that suppress the reproductive system and reproductive behaviors may only lead to minimal changes to social behavior (Ransom et al. 2014b, Collins and Kasbohm 2016).

The BLM expects that wild horse family structures would continue to exist under the proposed action because fertile mares, stallions, and their foals would continue to be a component of the herd. It is not expected that spaying a subset of mares would significantly change the social structure or herd demographics (age and sex ratios) of fertile wild horses.

Movement, Body Condition, and Survival of Ovariectomized Mares

The free-roaming behavior of wild horses is not anticipated to be affected by this alternative as the definition of free-roaming is the ability to move without restriction by fences or other barriers within an HMA (H-4700-1, 2010), and there are no new, permanent physical barriers being proposed.

In domestic animals spaying is often associated with weight gain and associated increase in body fat (Fettman et al. 1997, Beckett et al. 2002, Jeusette et al. 2006, Belsito et al. 2009, Reichler 2009, Camara et al. 2014). Spayed cats had a decrease in fasting metabolic rate, and spayed dogs had a decreased daily energy requirement, but both had increased appetite (O'Farrell and Peachey 1990, Hart and Eckstein 1997, Fettman et al. 1997, Jeusette et al. 2004). In wild horses, contracepted mares tend to be in better body condition than mares that are pregnant or that are nursing foals (Nuñez et al. 2010); the same improvement in body condition is likely to take place in spayed mares. In horses spaying has the potential to increase risk of equine metabolic syndrome (leading to obesity and laminitis), but both blood glucose and insulin levels were similar in mares before and after ovariectomy over the short term (Bertin et al. 2013). For wild horses the quality and quantity of forage is unlikely to be sufficient to promote over-eating and obesity.

Coit and others (2009) demonstrated that spayed dogs have elevated levels of LH-receptor and GnRH-receptor mRNA in the bladder tissue, and lower contractile strength of muscles. They noted that urinary incontinence occurs at elevated levels in spayed dogs and in post-menopausal women. Thus, it is reasonable to suppose that some ovariectomized mares could also suffer from elevated levels of urinary incontinence.

Sterilization had no effect on movements and space use of feral cats or brushtail possums (Ramsey 2007, Guttilla and Stapp 2010), or greyhound racing performance (Payne 2013). Rice field rats (*Rattus argentiventer*) tend to have a smaller home range in the breeding season, as they remain close to their litters to protect and nurse them. When surgically sterilized, rice field rats had larger home ranges and moved further from their burrows than hormonally sterilized or fertile rats (Jacob et al. 2004). Spayed possums and foxes (*Vulpes vulpes*) had a similar core range area after spay surgery compared to before and were no more likely to shift their range than intact females (Saunders et al. 2002, Ramsey 2007).

The likely effects of spaying on mares' home range and habitat use can also be surmised from available literature. Bands of horses tend to have distinct home ranges, varying in size depending on the habitat and varying by season but always including a water source, forage, and places where horses can shelter from inclement weather or insects (King and Gurnell 2005). It is unlikely that spayed mares will change their spatial ecology, but being free from the energy demands of lactation may imply they could spend more time away from water sources and increase their home range size. Lactating mares need to drink every day, but during the winter when snow can fulfill water needs or when not lactating, horses can traverse a wider area (Feist and McCullough 1976, Salter 1979). During multiple aerial surveys in years following the mare ovariectomy study at the Sheldon NWR, it was documented that all treated individuals appeared to maintain group associations, no groups consisted only of treated females, and none of the solitary animals observed were treated females (Collins and Kasbohm 2016). The result that treated females in that study maintained group associations suggests that wild mare movement patterns and travel distances may not change due to spaying.

Spaying wild horses does not change their status as wild horses under the WHB Act (as amended). In terms of whether spayed mares would continue to exhibit the free-roaming behavior that defines wild horses, BLM does expect that spayed mares would continue to roam unhindered in the Swasey HMA where this action would take place. Wild horse movements may be motivated by a number of biological impulses, including the search for forage, water, and social companionship that is not of a sexual nature. As such, a spayed animal would still be expected to have a number of internally-motivated reasons for moving across a landscape and, therefore, exhibiting "free-roaming" behavior. Despite marginal uncertainty about subtle aspects of potential changes in habitat preference, there is no expectation that spaying wild horses will cause them to lose their free-roaming nature.

In this sense, a spayed wild mare would be just as much “wild” as defined by the WHB Act as any temporarily contracepted or fertile wild mare, even if her patterns of movement differ slightly. Congress specified that sterilization is an acceptable management action (16 U.S.C. 1333.b.1). Sterilization is not one of the clearly defined events that cause an animal to lose its status as a wild free-roaming horse (16 U.S.C. 1333.2.C.d). The BLM must adhere to the legal definition of what constitutes a wild free-roaming horse5, based on the WHB Act (as amended). The BLM is not obliged to base management decisions on personal opinions, which do not meet the BLM’s principle and practice to “[u]se the best available scientific knowledge relevant to the problem or decision being addressed, relying on peer reviewed literature when it exists” (Kitchell et al. 2015).

Spaying is not expected to reduce mare survival rates. Individuals receiving fertility control often have reduced mortality and increased longevity due to being released from the costs of reproduction (Kirkpatrick and Turner 2008). Similar to contraception studies, in other wildlife species a common trend has been higher survival of sterilized females (Twigg et al. 2000, Saunders et al. 2002, Ramsey 2005, Jacob et al. 2008, Seidler and Gese 2012). Observations from the Sheldon NWR provide some insight into long-term effects of ovariectomy on feral horse survival rates. The Sheldon NWR ovariectomized mares were returned to the range along with untreated mares. Between 2007 and 2014, mares were captured, a portion treated, and then recaptured. There was a minimum of 1 year between treatment and recapture; some mares were recaptured a year later and some were recaptured several years later. The long-term survival rate of treated wild mares appears to be the same as that of untreated mares (Collins and Kasbohm 2016). Recapture rates for released mares were similar for treated mares and untreated mares.

Bone Histology

The BLM knows of no scientific, peer-reviewed literature that documents bone density loss in mares following ovariectomy. A concern has been raised in an opinion article (Nock 2013) that ovary removal in mares could lead to bone density loss. That paper was not peer reviewed nor was it based on research in wild or domestic horses, so it does not meet the BLM’s standard for “best available science” on which to base decisions (Kitchell et al. 2015). Hypotheses that are forwarded in Nock (2013) appear to be based on analogies from modern humans leading sedentary lives. Post-menopausal women have a greater chance of osteoporosis (Scholz-Ahrens et al. 1996), but the BLM is not aware of any research examining bone loss in horses following ovariectomy. Bone loss in humans has been linked to reduced circulating estrogen. There have been conflicting results when researchers have attempted to test for an effect of reduced estrogen on animal bone loss rates in animal models; all experiments have been on laboratory animals, rather than free-ranging wild animals. While some studies found changes in bone cell activity after ovariectomy leading to decreased bone strength (Jerome et al. 1997, Baldock et al. 1998, Huang et al. 2002, Sigrist et al. 2007), others found that changes were moderate and transient or

5 “Wild free-roaming horses and burros” means all unbranded and unclaimed horses and burros on public lands of the United States.

minimal (Scholz-Ahrens et al. 1996, Lundon et al. 1994, Zhang et al. 2007) and even returned to normal after 4 months (Sigrist et al. 2007).

Consistent and strenuous use of bones, for instance using jaw bones by eating hard feed, or using leg bones by travelling large distances, may limit the negative effects of estrogen deficiency on micro-architecture (Mavropoulos et al. 2014). The effect of exercise on bone strength in animals has been known for many years and has been shown experimentally (Rubin et al. 2001). Dr. Simon Turner, Professor Emeritus of the Small Ruminant Comparative Orthopaedic Laboratory at Colorado State University (CSU), conducted extensive bone density studies on ovariectomized sheep, as a model for human osteoporosis. During these studies, he did observe bone density loss on ovariectomized sheep, but those sheep were confined in captive conditions, fed twice a day, had shelter from inclement weather, and had very little distance to travel to get food and water (Simon Turner, CSU Emeritus, written comm., 2015). Dr. Turner indicated that an estrogen deficiency (no ovaries) could potentially affect a horse’s bone metabolism, just as it does in sheep and human females when they lead a sedentary lifestyle, but indicated that the constant weight bearing exercise, coupled with high exposure to sunlight ensuring high vitamin D levels, is expected to prevent bone density loss (Simon Turner, CSU Emeritus, written comm., 2015).

Home range size of horses in the wild has been described as 4.2 to 30.2 square miles (Green and Green 1977) and 28.1 to 117 square miles (Miller 1983). A study of distances travelled by feral horses in “outback” Australia shows horses travelling between 5 and 17.5 miles per 24 hour period (Hampson et al. 2010a), travelling about 11 miles a day even in a very large paddock (Hampson et al. 2010b). Thus, extensive movement patterns of wild horses are expected to help prevent bone loss. The expected daily movement distance would be far greater in the context of larger pastures typical of BLM long-term holding facilities in off-range pastures. A horse would have to stay on stall rest for years after removal of the ovaries in order to develop osteoporosis (Simon Turner, CSU Emeritus, written comm. 2015), and that condition does not apply to any wild horses turned back to the range or any wild horses that go into off-range pastures.

Effects on Genetic Diversity

It is true that spayed mares are unable to contribute to the genetic diversity of a herd, but that does not lead to an expectation that the Swasey HMA would necessarily experience high levels of inbreeding because there would continue to be a core breeding population of mares present, because horses could always be introduced to augment genetic diversity if future monitoring indicates cause for that management action, and because there is an expectation of continued positive growth in the herd. Here, population growth rate expresses the annual percentage increase in the total number of animals. “Fertility control application should achieve a substantial treatment effect while maintaining some long-term population growth to mitigate the effects of environmental catastrophes” (BLM IM 2009-090). This statement applies to all population growth suppression techniques, including spaying. According to the WinEquus population model trial for population growth suppression, the health of individual animals or the herd would not be threatened. (refer to Appendix F).

In HMAs with adequate levels of genetic diversity (i.e., well above the critical value for observed heterozygosity), or which have recent and/or an ongoing influx of breeding animals from other areas with wild or feral horses, contraception is not expected to cause an unacceptable loss of genetic diversity or an unacceptable increase in the inbreeding coefficient. In any diploid population, the loss of genetic diversity through inbreeding or drift can be prevented by large effective breeding population sizes (Wright 1931) or by introducing new potential breeding animals (Mills and Allendorf 1996). The NRC Review (2013) recommended that single HMAs should not be considered as isolated genetic populations. Rather, managed herds of wild horses should be considered as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of both natural and human-facilitated movements. It is worth noting that, although maintenance of genetic diversity at the scale of the overall population of wild horses is an intuitive management goal, there are no existing laws or policies that require BLM to maintain genetic diversity at the scale of the individual HMA or complex. Also, there is no BLM-wide policy that requires BLM to allow each female in a herd to reproduce. Introducing 1–2 mares every generation (about every 10 years) is a standard management technique that can alleviate potential inbreeding concerns (BLM 2010). There would be little concern with regards to effects on genetic diversity of the herd because this action incorporates BLM's management plan for genetic monitoring and maintenance of genetic diversity.

In the last 10 years, there has been a high realized growth rate of wild horses in most areas administered by the BLM, including the Swasey HMA. As a result, most alleles that are present in any given mare are likely to already be well represented in her siblings, cousins, and more distant relatives on the HMA. As a result, in most HMAs, applying fertility control to a subset of mares is not expected to cause irreparable loss of genetic diversity. Improved longevity and an aging population are expected results of contraceptive treatment that can provide for lengthening generation time; if fertile mares also have increased longevity as a result of improved resource conditions, this result would be expected to slow the rate of genetic diversity loss (Hailer et al. 2006). Based on a population model, Gross (2000) found that a strategy to preferentially treat young animals with a contraceptive led to more genetic diversity being retained than either a strategy that preferentially treats older animals or a strategy with periodic gathers and removals.

There would be little concern for effects to genetic diversity of the Swasey HMA wild horses because the proposed action incorporates BLM's management plan for genetic monitoring and maintenance of genetic diversity. Wild horses in most HMAs are descendants of a diverse range of ancestors coming from many breeds of domestic horses. Past interchange between HMAs, either through natural dispersal or through assisted migration (i.e., human movement of horses) means that many HMAs are effectively indistinguishable and interchangeable in terms of their genetic composition. The Swasey HMA is no exception. Mares captured in 2016 from the Conger HMA were fitted with GPS collars to gain horses movement data for a gelding study; one of those mares after being released back to the Conger HMA made its way to the northeast end of the Swasey HMA (a distance of over 30 miles) where it was adopted into a band and remained there. The researchers monitored that mare for approximately one year before they had to drop off the collar; by which time the mare was well established in the Swasey herd. Roelle and Oyler-McCance (2015) used the VORTEX population model to simulate how different rates of mare sterility would influence population persistence and genetic diversity in populations with high or low starting levels of genetic diversity, various starting population sizes, and various annual population growth rates. Their results show that only in the most extreme circumstances (where all of the following conditions are met: low initial genetic diversity, low population growth rate, high proportion of mares treated, and no change in management for 50 years) would there likely be any noticeable effect on genetic diversity or a significant probability of extirpation of a herd. Monitoring and adaptive management would reduce the probability of unacceptable results even further. Roelle and Oyler-McCance (2015) conclude that nothing in their results indicates wild horse managers should steer away from permanent contraceptive techniques, as long as results are monitored and adjustments are made if necessary.

Impacts of Alternative E: No Action – Continuation of Current Management.

Under the No Action Alternative, there would be no gather at this time. In the absence of a gather, wild horse populations would continue to grow at an average rate of 20% within the Swasey HMA. Without a gather, the population could grow to over 1,000 wild horses on and around the Swasey HMA in three to four years.

Use by wild horses would continue to exceed the amount of forage allocated for their use. Competition between wildlife, livestock and wild horses for limited forage and water resources would continue. Damage to rangeland resources would continue or increase. The risks to the health of individual horses would increase, and the need for emergency removals to prevent their death from starvation or thirst would also increase. Over the long-term, the health and sustainability of the wild horse population is dependent upon achieving a thriving natural ecological balance and sustaining healthy rangelands. Allowing wild horses to die of dehydration or starvation would be inhumane and would be contrary to the WFRHBA which requires that excess wild horses be immediately removed. Allowing rangeland damage to continue to result from wild horse overpopulation would also be contrary to the WFRHBA which requires the BLM to "*protect the range from the deterioration associated with overpopulation*", "*remove excess animals from the range so as to achieve appropriate management levels*", and "*to preserve and maintain a thriving natural ecological balance and multiple-use relationship in that area*."

Public Safety

Members of the public can inadvertently wander into areas that put them in the path of wild horses that are being herded or handled during the gather operations, creating the potential for injury to the wild horses or burros and to the BLM employees and contractors conducting the gather and/or handling the horses as well as to the public themselves. Because these horses are wild animals, there is always the potential for injury when individuals get too close or inadvertently get in the way of gather activities.

While helicopters are highly maneuverable and the pilots are very skilled in their operation, unknown and unexpected obstacles in their path can impact their ability to react in time to avoid members of the public in their path. These same unknown and unexpected obstacles can impact the wild horses or burros being herded by the helicopter in that they may not be able to react and can be potentially harmed or caused to flee which can lead to injury and additional stress. When the helicopter is working close to the ground, the rotor wash of the helicopter is a safety concern by potentially causing loose vegetation, dirt, and other objects to fly through the air which can strike or land on anyone in close proximity as well as cause decreased vision.

Fleeing horses can go through wire fences, traverse unstable terrain, and go through areas that they normally don't travel in order to get away, all of which can lead them to injure people by striking or trampling them if they are in the animal's path.

Disturbances in and around the gather and holding corral have the potential to injure the government and contractor staff who are trying to sort, move and care for the horses and burros by causing them to be kicked, struck, and possibly trampled by the animals trying to flee. Such disturbances also have the potential for similar harm to the public themselves.

4.3 Cumulative Effects for All Alternatives

The NEPA regulations define cumulative impacts as impacts on the environment that result from the incremental impact of the Proposed Action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such actions (40 CFR 1508.7). Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. The cumulative impacts study area (CSA) for the purposes of evaluating cumulative impacts is the project area. According to the 1994 BLM *Guidelines for Assessing and Documenting Cumulative Impacts*, the cumulative analysis should be focused on those issues and resource values identified during scoping that are of major importance. Accordingly, the issues of major importance to be analyzed are maintaining rangeland health and maintaining appropriate management level.

Past and Present Actions

4.3.1 Wild Horses

The House Range Resource Area RMP/ROD Rangeland Program Summary, 1987 designated the Swasey HMA for the long-term management of wild horses. The HMA established in 1976 and identified in the "West Desert Wild Horse Capture Plan" (1977) is nearly identical in size and shape to the original herd areas identified in 1971. Management of wild horses within the HMA today is guided by the House Range Resource Area RMP, 1987. AML was established as a population range of 60 – 100 on the Swasey HMA in 1987 through issuance of the House Range Resource Area ROD.

Congressional appropriations over the past ten years and most recently for the 2019 budget year prohibits the destruction of healthy animals that are removed or deemed to be excess. BLM policy is consistent with these appropriations provisions such that only sick, lame, or dangerous animals can be euthanized, and destruction is no longer used as a population control method. Nor does BLM sell excess wild horses for slaughter; rather BLM makes every effort to place excess wild horses with private citizens who can provide the animals with a good home.

Public interest in the welfare and management of wild horses continues to be very high. There are many different values pertaining to wild horse management from the public's perceptions. Some view wild horses as nuisance animals, while others strongly advocate management of wild horses as living symbols of the pioneer spirit.

4.3.2 Rangeland Health and Livestock

Through previous decisions, the BLM has allocated the available forage to wild horses, wildlife and domestic livestock. Other decisions have resulted in adjustments to livestock numbers and seasons of use and for implementation of grazing systems and the associated range improvements to promote rangeland health.

While the present livestock grazing system and efforts to manage the wild horse population within AML has reduced past historic impacts, the current overpopulation of wild horses is continuing to contribute to areas of heavy vegetation utilization, trailing and trampling damage and is preventing the BLM from managing for rangeland health and a thriving natural ecological balance and multiple use relationship on the public lands in the area. Rangeland Health Assessments have been conducted within the Swasey HMA for the associated livestock grazing allotments. Portions of the HMA have been monitored over the past several years due to problems with drought, vegetation condition and the combined use of wild horses and domestic livestock. Temporary adjustments to season of use have been made on a year-to-year evaluation of rangeland health and available forage.

The Proposed Action analyzed in this EA would result in the reduction in competition between wild horses and other users (i.e. native wildlife and domestic livestock) for the limited available forage and water resources. Direct improvements in soils and riparian condition would be expected in the short term and result in fewer multiple-use conflicts within and adjacent to the Swasey HMA.

Over the long-term, improving the range would further benefit all users and the resources they depend on for forage and water.

Under the No Action (no removal) alternative, the current population of wild horses would not be reduced through the completion of a gather this year. Competition among wild horses, native wildlife and domestic livestock for limited resources would increase, and riparian conditions would continue to deteriorate. Over the long-term, the health of wild horses and native wildlife would be expected to suffer as rangeland productivity further declines.

4.4 Reasonably Foreseeable Future Actions

4.4.1 Wild Horses

Over the next 10-20 year period, reasonably foreseeable future actions include gathers about every three to five years once low AML is obtained to remove excess wild horses in order to manage population size within the established AML range. Other means of population control may be analyzed and implemented. Small selective management removals could be conducted to maintain the AML within the HMA reducing the need for large gathers thus reducing the amount of stress experienced by the wild horses. The excess animals removed would be transported to short-term corral facilities where they would be prepared for adoption, sale (with limitations), or long-term holding. A Herd Management Area Plan could also be completed which would establish short and long-term management and monitoring objectives for the herd and its habitat. Future wild horse management involving gathers, following the time frame of this EA, would be analyzed in appropriate environmental documents following site-specific planning with public involvement.

4.4.2 Rangeland Health and Livestock

Livestock grazing is expected to continue at similar stocking rates and utilization of the available vegetation (forage) would also be expected to continue at similar levels. Continuing to graze livestock in a manner consistent with grazing permit terms and conditions would be expected to achieve or make significant progress towards achieving/maintaining Rangeland Health Standards. There are not any future actions that would adversely affect vegetation within the Swasey HMA area currently being developed.

4.5 Summary of Past, Present, and Reasonably Foreseeable Future Actions

Impacts of Action Alternatives A, B, C, and D

The cumulative effects associated with the capture and removal of excess wild horses includes gather-related mortality of less than 1% of the captured animals, about 5% per year associated with transportation, short term holding, adoption or sale with limitations and about 8% per year associated with long-term holding. This compares with natural mortality on the range ranging from about 5-8% per year for foals (animals under age 1), about 5% per year for horses ages 1-15, and 5-100% for animals age 16 and older (Stephen Jenkins, 1996, Garrott and Taylor, 1990). In situations where forage and/or water are limited, mortality rates increase, with the greatest impact to young foals, nursing mares and older horses. Animals can experience lameness associated with trailing to/from water and forage, foals may be orphaned (left behind) if they cannot keep up with their mare, or animals may become too weak to travel. After suffering, often for an extended period, the animals may die. Before these conditions arise, the BLM generally removes the excess animals to prevent their suffering from dehydration or starvation.

While humane euthanasia and sale without limitation of healthy horses for which there is no adoption demand is authorized under the WFRHBA, Congress prohibited the use of appropriated funds between 1987 and 2004 and again in 2010 to present for this purpose. It is unknown if a similar limitation will be placed on the use of FY-2020 appropriated funds.

The other cumulative effects which would be expected when incrementally adding the Action Alternatives to the CSA would include continued improvement of upland vegetation conditions, which would in turn benefit permitted livestock, native wildlife, and wild horse population as forage (habitat) quality and quantity is improved over the current level. Benefits from a reduced wild horse population would include fewer animals competing for limited forage and water resources. Cumulatively, there should be more stable wild horse populations, healthier rangelands, healthier wild horses, and fewer multiple use conflicts in the area over the short and long-term. Over the next 10-20 years, continuing to manage wild horses within the established

AML range would achieve a thriving natural ecological balance and multiple use relationship on public lands in the area.

Gathering to low AML without any sex ratio adjustment to favor males or fertility control treatment on mares keeps the growth rate higher and causes the need to return to the HMA more frequently to maintain horses at the AML levels. This causes more repeated stress on the animals. Alternative C would require the need to gather and remove horses every 3 to 5 years in order to maintain AML levels.

Impacts of Alternative E (No Action)

Under the No Action Alternative, the wild horse population within the Swasey HMA area could exceed 1000 in three to four years. Movement outside the HMA would continue as greater numbers of horses search for food and water for survival, thus impacting larger areas of public lands. Heavy to excessive utilization of the available forage would be expected and the water available for use could become increasingly limited. Eventually, ecological plant communities would be damaged to the extent that they are no longer sustainable and the wild horse population would be expected to crash.

Emergency removals could be expected in order to prevent individual animals from suffering or death as a result of insufficient forage and/or water. These emergency removals could occur as early as the summer of 2019 with the current population levels and expected growth. During emergency conditions, competition for the available forage and water increases. This competition generally impacts the oldest and youngest horses as well as lactating mares first. These groups would experience substantial weight loss and diminished health, which could lead to their prolonged suffering and eventual death. If emergency actions are not taken, the overall population could be affected by severely skewed sex ratios towards stallions as they are generally the strongest and healthiest portion of the population. An altered age structure would also be expected.

Cumulative impacts would result in foregoing the opportunity to improve rangeland health and to properly manage wild horses in balance with the available forage and water and other multiple uses. Attainment of site-specific vegetation management objectives and Standards for Rangeland Health would not be achieved. AML would not be achieved and the opportunity to collect the scientific data necessary to re-evaluate AML levels, in relationship to rangeland health standards, would be foregone.

5.0 Monitoring and Mitigation Measures

The BLM Wild Horse Specialist assigned as lead for the gather would be responsible for ensuring all personnel abide by the SOPs (Appendix E). Ongoing monitoring of forage condition and utilization, water availability, aerial population surveys, and animal health would continue.

6.0 List of Preparers

The following list identifies the interdisciplinary team member's area of responsibility:

Name	Title	Area of Responsibility
Trent Staheli	Wild Horse Specialist	Project Lead/Wild Horses

Paul Griffin	Research Coordinator	WH&B Program Research Coordination
Cassie Mellon	Hydrologist	Wetlands/Riparian Zones
Wesley Willoughby	Archeologist	Cultural Resources, Native American Religious Concerns
Teresa Frampton	Recreation Specialist	Areas of Critical Environmental Concern, Recreation, Wilderness/WSA, Visual Resources, Lands with Wilderness Characteristics
Trevor Riding	Rangeland Management Specialist	Livestock Grazing, Standards for Rangeland Health
Trevor Riding	Rangeland Management Specialist	Farmlands (Prime or Unique)
RB Probert	Weed Specialist	Invasive Species/Noxious Weeds
David Whitaker	Rangeland Management Specialist	Vegetation, Special Status Species

7.0 Consultation and Coordination

An annual single state-wide public hearing is held regarding the use of helicopters and motorized vehicles to capture wild horses (or burros) within the state of Utah. During the hearing, the public is given the opportunity to present new information and to voice any concerns or opinions regarding the use of these methods to capture wild horses (or burros). A hearing was held in the Vernal BLM Office in Vernal, Utah on Dec. 11, 2018. Four individuals from the public were present at the meeting. Primary issues discussed were: (1) how helicopters are used during gathers and their effects on wild horses, (2) appropriate management levels in HMAs and how they are establish and monitored, and (3) legal ability of BLM using motorized vehicles. General questions & answers were discussed. The hearing lasted a little over an hour.

8.0 Public Involvement

Notification of the proposed action was listed in E Planning on 12/16/19.

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10.0 Appendices

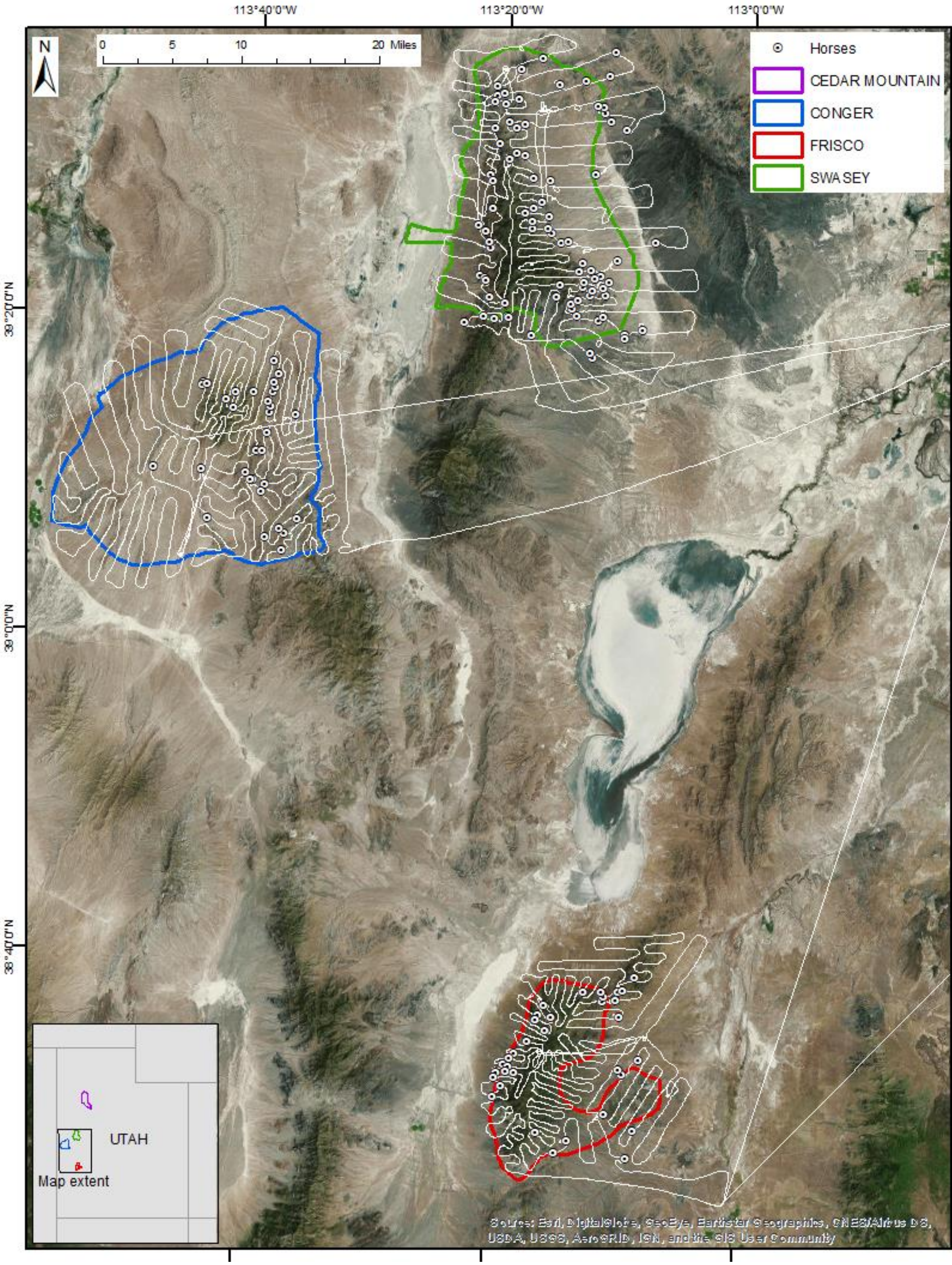
Appendix A – March 2018 Population Inventory Results
Appendix B – Standard Operating Procedures for Population-level Fertility Control Treatments
Appendix C – PZP Mixing Procedures
Appendix D – Data Sheet
Appendix E – Standard Operating Procedures for Wild Horse Gathers
Appendix F – Win Equus Population Modeling
Appendix G – Swasey HMA Map
Appendix H – Ovariectomy Procedures

Appendix A
March, 2018 Population Inventory

TABLE 1. Estimated abundance (Estimate) is for the number of horses in the surveyed areas at the time of survey. 90% confidence intervals are shown in terms of the lower limit (LCL) and upper limit (UCL). The coefficient of variation (CV) is a measure of precision; it is the standard error as a percentage of the estimated population. Number of horses seen (No. Seen) leads to the estimated percentage of horses that were present in the surveyed area, but that were not recorded by any observer (% Missed). The estimated number of horses associated with each HMA but located outside the HMA's boundaries is already included in the total estimate for that HMA.

Area	**Age Class**	**Estimate (No. Horses)**	LCL[a]	UCL	Std Err	CV	No. Horses Seen	% Missed	Estimated # of Groups	Estimated Group Size	Foals per 100 Adults	Est. No. Horses Outside HMA
Frisco HMA	Total	144[e]	130	169	12.3	8.5%	127	11.8%[c]	40	3.6	5.9	58
	Foals	8	5	13	2.9	36.8%	6					
	Adults	136	122	158	11.4	8.4%	121					
Conger HMA	Total	172[f]	157	206	14.7	8.5%	157	8.7%[d]	35	4.9	0	0
	Foals	0	0	0	0	-	0					
	Adults	172	157	206	14.7	8.5%	157					
Swasey HMA	Total	503	467	579	35.4	7.0%	450	10.5%	91	5.5	0.4	126
	Foals	2	2	3	0.3	15.8%	2					
	Adults	501	465	576	35.3	7.0%	448					
Cedar Mountain HMA	Total	681	606	752	45.2	6.6%	578	15.1%	126	5.4	1.6	180
	Foals	11	8	14	1.7	15.6%	10					
	Adults	670	596	739	44.5	6.6%	568					

[a] The lower 90% confidence limit is based on bootstrap simulation results or the number of horses seen, whichever is higher.
[b] Burros were surveyed on March 5 in Canyonlands HMA with much of the same crew on, but those data are analyzed separately.
[c] At the time of the survey, 25 horses had VHF/GPS collars in Frisco. Observers noted 19 of these collars, suggesting that observers missed 24% of animals.
[d] At the time of the survey, 36 horses had VHF/GPS collars in Conger. Observers noted 33 of these collars, suggesting that observers missed 8% of animals.
[e] Research crews on the ground, who can identify nearly all individuals in the population, estimate 151 horses (146 adults and 5 foals) in Frisco in March.
[f] Research crews on the ground, who can identify nearly all individuals in the population, estimate 154-170 horses (2 foals) in Conger in March (Dr. Sarah King, pers comm 12 June 2018). 16 horses had not been seen inside the HMA since September 2017, and we do not know if they were in the HMA at the time of the survey.



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SWASEY
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Map extent
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix B

Standard Operating Procedures for Population-level Fertility Control Treatments

The following implementation and monitoring requirements are part of the Proposed Action Alternative and Alternative B which involves the use of PZP and GonaCon™:

1. Fertility control vaccine would be administered only by trained BLM personnel or collaborating research partners.

2. The fertility control drug is administered with two separate injections: (1) a liquid dose of fertility Control is administered using an 18-gauge needle primarily by hand injection; (2) the pellets(PZP22) are preloaded into a 14-gauge needle. These are delivered using a modified syringe and jab-stick to inject the pellets into the gluteal muscles of the mares being returned to the range. The pellets are designed to release PZP over time similar to a time-release cold capsule.

3. Mares that have never been treated would receive 0.5 cc of PZP vaccine emulsified with 0.5 cc of Freund's Modified Adjuvant (FMA) and loaded into darts at the time a decision has been made to dart a specific mare. Mares identified for re-treatment receive 0.5 cc of the PZP vaccine emulsified with 0.5 cc of Freund's Incomplete Adjuvant (FIA).

4. Delivery of the vaccine would be by intramuscular injection into the gluteal muscles while the mare is restrained in a working chute. With each injection, the liquid or pellets would be injected into the left hind quarters of the mare, above the imaginary line that connects the point of the hip (hook bone) and the point of the buttocks (pin bone).

5. In the future, the vaccine may be administered remotely using an approved long range darting protocol and delivery system if or when that technology is developed.

6. All treated mares would be freeze-marked on the hip or neck HMA managers to positively identify the animals during the research project and at the time of removal during subsequent gathers.

Monitoring and Tracking of Treatments:
1. At a minimum, estimation of population growth rates using helicopter or fixed-wing surveys would be conducted before any subsequent gather. During these surveys it is not necessary to identify which foals were born to which mares; only an estimate of population growth is needed (i.e. # of foals to # of adults).

2. Population growth rates of herds selected for intensive monitoring would be estimated every year post-treatment using helicopter or fixed-wing surveys. During these surveys it is not necessary to identify which foals were born to which mares, only an estimate of population growth is needed (i.e. # of foals to # of adults). If, during routine HMA field monitoring (on-the-ground), data describing mare to foal ratios can be collected, these data should also be shared with the NPO for possible analysis by the USGS.

3. A fertility Control Application Data sheet would be used by field applicators to record all pertinent data relating to identification of the mare (including photographs if mares are not freeze-marked) and date of treatment. Each applicator would submit an Application Report and accompanying narrative and data sheets would be forwarded to the NPO (Reno, Nevada). A copy of the form and data sheets and any photos taken would be maintained at the field office.

4. A tracking system would be maintained by NPO detailing the quantity of fertility control issued, the quantity used, the number of treated mares by HMA, field office, and State along with the freeze-mark(s) applied by HMA and date.

5. When using GonaCon the horses would need to receive a booster shot at some point and may be held for 30-45 days after the initial treatment.

Appendix C

Mixing Procedures – PZP Mixing Vaccine and Adjuvant

Equipment Needed

2 5.0 cc glass syringes

1.5 inch needle

vial of adjuvant

vial of PZP

Luer-Lok connector

1.0 cc C-type or P-type Pneu-Dart dart with 1.5 inch barbless needle

Procedures

1. Place the 1.5 inch needle on a glass syringe
2. Draw out 0.5 cc of adjuvant
3. Using the same syringe, draw up the 0.5 cc of PZP
4. Holding the syringe very carefully (because the plunger can slip out), take off the needle and attach the syringe to the second syringe using the Luer-Lok connector (have the Luer-lok connector already attached to the second syringe).
5. Push the PZP-adjuvant mixture back and forth through the two syringes 100 times. The resulting emulsion will become thick and look white. **THIS PROCEDURE IS VERY IMPORTANT AND IS RELATED TO THE PRESENTATION OF THE ANTIGEN AND THE SUBSEQUENT EFFICACY OF THE VACCINE.**
6. Make sure all the emulsion is in one syringe.
7. Holding the first syringe very carefully (the one with the emulsion), remove the second syringe, leaving the Luer-Lock on the first syringe.

If you are loading a 2.0 or 3.0 mL plastic syringe for hand-delivery, attach the glass syringe to the plastic syringe and inject the PZP emulsion in to the plastic syringe. It is helpful if you move the plunger of the plastic syringe just a bit before pumping the PZP emulsion into it. After loading the plastic syringe, disconnect the glass syringe and connect an 18g. 1.5 inch needle on the plastic syringe.

Appendix D
Data Sheet

HORSE IMMUNOCONTRACEPTION DATA SHEET

HORSE MANAGEMENT AREA: Muddy Creek HMA

HORSE IDENTIFICAION NUMBER/NAME: ________________________________

HORSE COLOR: ______________________________

OTHER MARKINGS/BRANDS: ____

Inoculation Dates	PZP Dose (µg)[1]	Adjuvant	Delivery System[2]	Injection Site[3]	Vaccine Lot Number

POST-INOCULATION REPRODUCTIVE HISTORY (Diagnosed pregnancies and/or births) DESCRIBE ANY:

[1] Standard dose is 100 µg with raw vaccine

[2] Pneu-Dart unless otherwise noted

[3] Left or right hip

1. Drugs administered to this horse concurrent with study (name of drug, dose, date):

2. Post-treatment health problems (with particular reference to injection-site abscesses):

3. Additional remarks:

Appendix E

Standard Operating Procedures for Wild Horse Gathers

Gathers are conducted by utilizing contractors from the Wild Horse Gathers-Western States Contract or BLM personnel. The following standard operating procedures (SOPs) for gathering and handling wild horses apply whether a contractor or BLM personnel conduct a gather. For helicopter gathers conducted by BLM personnel, gather operations would be conducted in conformance with the Wild Horse Aviation Management Handbook (January 2009).

Prior to any gathering operation, the BLM would provide for a pre-gather evaluation of existing conditions in the gather area(s). The evaluation would include animal conditions, prevailing temperatures, drought conditions, soil conditions, road conditions, and a topographic map with Wilderness boundaries, the location of fences, other physical barriers, and acceptable gather locations in relation to animal distribution. The evaluation would determine whether the proposed activities would necessitate the presence of a veterinarian during operations. If it is determined that a large number of animals may need to be euthanized or gather operations could be facilitated by a veterinarian, these services would be arranged before the gather would proceed. The contractor would be apprised of all conditions and would be given instructions regarding the gather and handling of animals to ensure their health and welfare is protected.

Gather sites and temporary holding sites would be located to reduce the likelihood of injury and stress to the animals, and to minimize potential damage to the natural resources of the area. These sites would be located on or near existing roads whenever possible.

The primary gather methods used in the performance of gather operations include:
1. Helicopter Drive Gathering. This gather method involves utilizing a helicopter to herd wild horses into a temporary gather site.

2. Helicopter Assisted Roping. This gather method involves utilizing a helicopter to herd wild horses to ropers.

3. Bait Trapping. This gather method involves utilizing bait (e.g., water or feed) to lure wild horses into a temporary gather site.

The following procedures and stipulations would be followed to ensure the welfare, safety and humane treatment of wild horses in accordance with the provisions of 43 CFR 4700.

A. Gather Methods used in the Performance of Gather Contract Operations
The primary concern of the contractor is the safe and humane handling of all animals gathered. All gather attempts shall incorporate the following:

1. All gather sites and holding facilities locations must be approved by the Contracting Officer's Representative (COR) and/or the Project Inspector (PI) prior to construction. The Contractor may also be required to change or move gather locations as determined by the COR/PI. All gather sites and holding facilities not located on public land must have prior written approval of the landowner.

2. The rate of movement and distance the animals travel shall not exceed limitations set by the COR who would consider terrain, physical barriers, access limitations, weather, extreme temperature (high and low), condition of the animals, urgency of the operation (animals facing drought, starvation, fire rehabilitation, etc.) and other factors. In consultation with the contractor the distance the animals travel would account for the different factors listed above and concerns with each HMA.

3. All gather sites, wings, and holding facilities shall be constructed, maintained and operated to handle the animals in a safe and humane manner and be in accordance with the following:

a. Gather sites and holding facilities shall be constructed of portable panels, the top of which shall not be less than 72 inches high for horses and 60 inches high for burros, and the bottom rail of which shall not be more than 12 inches from ground level. All gather sites and holding facilities shall be oval or round in design.

b. All loading chute sides shall be a minimum of 6 feet high and shall be fully covered, plywood, metal without holes larger than 2”x4”.

c. All runways shall be a minimum of 30 feet long and a minimum of 6 feet high for horses, and 5 feet high for burros, and shall be covered with plywood, burlap, plastic snow fence or like material a minimum of 1 foot to 5 feet above ground level for burros and 1 foot to 6 feet for horses. The location of the government furnished portable fly chute to restrain, age, or provide additional care for the animals shall be placed in the runway in a manner as instructed by or in concurrence with the COR/PI.

d. All crowding pens including the gates leading to the runways shall be covered with a material which prevents the animals from seeing out (plywood, burlap, plastic snow fence, etc.) and shall be covered a minimum of 1 foot to 5 feet above ground level for burros and 2 feet to 6 feet for horses.

e. All pens and runways used for the movement and handling of animals shall be connected with hinged self-locking or sliding gates.

4. No modification of existing fences would be made without authorization from the COR/PI. The Contractor shall be responsible for restoration of any fence modification which he has made.

5. When dust conditions occur within or adjacent to the gather site or holding facility, the Contractor shall be required to wet down the ground with water.

6. Alternate pens, within the holding facility shall be furnished by the Contractor to separate mares or jennies with small foals, sick and injured animals, estrays or other animals the COR determines need to be housed in a separate pen from the other animals. Animals shall be sorted as to age, number, size, temperament, sex, and condition when in the holding facility so as to minimize, to the extent possible, injury due to fighting and trampling. Under normal conditions, the government would require that animals be restrained for the purpose of determining an animal’s age, sex, or other necessary procedures. In these instances, a portable restraining chute may be necessary and would be provided by the government.

Alternate pens shall be furnished by the Contractor to hold animals if the specific gathering requires that animals be released back into the gather area(s). In areas requiring one or more satellite gather site, and where a centralized holding facility is utilized, the contractor may be required to provide additional holding pens to segregate animals transported from remote locations so they may be returned to their traditional ranges. Either segregation or temporary marking and later segregation would be at the discretion of the COR.

7. The Contractor shall provide animals held in the gather sites and/or holding facilities with a continuous supply of fresh clean water at a minimum rate of 10 gallons per animal per day. Animals held for 10 hours or more in the gather site or holding facilities shall be provided good quality hay at the rate of not less than two pounds of hay per 100 pounds of estimated body weight per day. The contractor would supply certified weed free hay if required by State, County, and Federal regulation.

8. An animal that is held at a temporary holding facility through the night is defined as a horse/burro feed day. An animal that is held for only a portion of a day and is shipped or released does not constitute a feed day.

9. It is the responsibility of the Contractor to provide security to prevent loss, injury or death of gathered animals until delivery to final destination.

10. The Contractor shall restrain sick or injured animals if treatment is necessary. The COR/PI would determine if animals must be euthanized and provide for the destruction of such animals. The Contractor may be required to humanely euthanize animals in the field and to dispose of the carcasses as directed by the COR/PI.

11. Animals shall be transported to their final destination from temporary holding facilities as quickly as possible after gather unless prior approval is granted by the COR for unusual circumstances. Animals to be released back into the HMA following gather operations may be held up to 21 days or as directed by the COR. Animals shall not be held in gather sites and/or temporary holding facilities on days when there is no work being conducted except as specified by the COR. The Contractor shall schedule shipments of animals to arrive at final destination between 7:00 a.m. and 4:00 p.m. No shipments shall be scheduled to arrive at final destination on Sunday and Federal holidays; unless prior approval has been obtained by the COR. Animals shall not be allowed to remain standing on trucks while not in transport for a combined period of greater than three (3) hours in any 24 hour period. Animals that are to be released back into the gather area may need to be transported back to the original gather site. This determination would be at the discretion of the COR/PI or Field Office Wild Horse & Burro Specialist.

B. Gather Methods That May Be Used in the Performance of a Gather

1. Gather attempts may be accomplished by utilizing bait (feed, water, mineral licks) to lure animals into a temporary gather site. If this gather method is selected, the following applies:

a. Finger gates shall not be constructed of materials such as "T" posts, sharpened wouldows, etc., that may be injurious to animals.

b. All trigger and/or trip gate devices must be approved by the COR/PI prior to gather of animals.

c. Gather sites shall be checked a minimum of once every 10 hours.

2. Gather attempts may be accomplished by utilizing a helicopter to drive animals into a temporary gather site. If the contractor selects this method the following applies:

a. A minimum of two saddle-horses shall be immediately available at the gather site to accomplish roping if necessary. Roping shall be done as determined by the COR/PI. Under no circumstances shall animals be tied down for more than one half hour.

b. The contractor shall assure that foals shall not be left behind, and orphaned.

3. Gather attempts may be accomplished by utilizing a helicopter to drive animals to ropers. If the contractor, with the approval of the COR/PI, selects this method the following applies:

a. Under no circumstances shall animals be tied down for more than one hour.

b. The contractor shall assure that foals shall not be left behind, or orphaned.

c. The rate of movement and distance the animals travel shall not exceed limitations set by the COR/PI who would consider terrain, physical barriers, weather, condition of the animals and other factors.

C. Use of Motorized Equipment

1. All motorized equipment employed in the transportation of gathered animals shall be in compliance with appropriate State and Federal laws and regulations applicable to the humane transportation of animals. The Contractor shall provide the COR/PI, if requested, with a current safety inspection (less than one year old) for all motorized equipment and tractor-trailers used to transport animals to final destination.

2. All motorized equipment, tractor-trailers, and stock trailers shall be in good repair, of adequate rated capacity, and operated so as to ensure that gathered animals are transported without undue risk or injury.

3. Only tractor-trailers or stock trailers with a covered top shall be allowed for transporting animals from gather site(s) to temporary holding facilities, and from temporary holding facilities to final destination(s). Sides or stock racks of all trailers used for transporting animals shall be a minimum height of 6 feet 6 inches from the floor. Single deck tractor-trailers 40 feet or longer shall have at least two (2) partition gates providing at least three (3) compartments within the trailer to separate animals. Tractor-trailers less than 40 feet shall have at least one partition gate providing at least two (2) compartments within the trailer to separate the animals. Compartments in all tractor-trailers shall be of equal size plus or minus 10 percent. Each partition shall be a minimum of 6 feet high and shall have a minimum 5 foot wide swinging gate. The use of double deck tractor-trailers is unacceptable and shall not be allowed.

4. All tractor-trailers used to transport animals to final destination(s) shall be equipped with at least one (1) door at the rear end of the trailer which is capable of sliding either horizontally or vertically. The rear door(s) of tractor-trailers and stock trailers must be capable of opening the full width of the trailer. Panels facing the inside of all trailers must be free of sharp edges or holes that could cause injury to the animals. The material facing the inside of all trailers must be strong enough so that the

animals cannot push their hooves through the side. Final approval of tractor-trailers and stock trailers used to transport animals shall be held by the COR/PI.

5. Floors of tractor-trailers, stock trailers and loading chutes shall be covered and maintained with wood shavings to prevent the animals from slipping as much as possible during transport.

6. Animals to be loaded and transported in any trailer shall be as directed by the COR/PI and may include limitations on numbers according to age, size, sex, temperament and animal condition. The following minimum square feet per animal shall be allowed in all trailers:

- 11 square feet per adult horse (1.4 linear foot in an 8 foot wide trailer);

- 8 square feet per adult burro (1.0 linear foot in an 8 foot wide trailer);

- 6 square feet per horse foal (0.75 linear feet in an 8 foot wide trailer);

- 4 square feet per burro foal (0.5 linear feet in an 8 foot wide trailer).

7. The COR/PI shall consider the condition and size of the animals, weather conditions, distance to be transported, or other factors when planning for the movement of gathered animals. The COR/PI shall provide for any brand and/or inspection services required for the gathered animals.

8. If the COR/PI determines that dust conditions are such that the animals could be endangered during transportation, the Contractor would be instructed to adjust speed.

D. Safety and Communications

1. The Contractor shall have the means to communicate with the COR/PI and all contractor personnel engaged in the gather of wild horses utilizing a VHF/FM Transceiver or VHF/FM portable Two-Way radio. If communications are ineffective the government would take steps necessary to protect the welfare of the animals.

2. The proper operation, service and maintenance of all contractor furnished property is the responsibility of the Contractor. The BLM reserves the right to remove from service any contractor personnel or contractor furnished equipment which, in the opinion of the contracting officer or COR/PI violate contract rules, are unsafe or otherwise unsatisfactory. In this event, the Contractor would be notified in writing to furnish replacement personnel or equipment within 48 hours of notification. All such replacements must be approved in advance of operation by the Contracting Officer or his/her representative.

3. The Contractor shall obtain the necessary FCC licenses for the radio system.

4. All accidents occurring during the performance of any task order shall be immediately reported to the COR/PI.

5. Should the contractor choose to utilize a helicopter the following would apply:

a. The Contractor must operate in compliance with Federal Aviation Regulations, Part 91. Pilots provided by the Contractor shall comply with the Contractor's Federal Aviation Certificates, applicable regulations of the State in which the gather is located.

b. Fueling operations shall not take place within 1,000 feet of animals.

E. Site Clearances

1. No personnel working at gather sites may excavate, remove, damage, or otherwise alter or deface or attempt to excavate, remove, damage or otherwise alter or deface any archaeological resource located on public lands or Indian lands.

2. Prior to setting up a gather site or temporary holding facility, BLM would conduct all necessary clearances (archaeological, T&E, etc.). All proposed site(s) must be inspected by a government archaeologist. Once archaeological clearance has been obtained, the gather site or temporary holding facility may be set up. Said clearance shall be arranged for by the COR, PI, or other BLM employees.

3. Gather sites and temporary holding facilities would not be constructed on wetlands or riparian zones.

F. Animal Characteristics and Behavior

Releases of wild horses would be near available water when possible. If the area is new to them, a short-term adjustment period may be required while the wild horses become familiar with the new area.

G. Public Participation

Opportunities for public viewing (i.e. media, interested public) of gather operations would be made available to the extent possible; however, the primary considerations would be to protect the health, safety and welfare of the animals being gathered and the personnel involved. The public must adhere to guidance from the on-site BLM representative. It is BLM policy that the public would not be allowed to come into direct contact with wild horses being held in BLM facilities. Only authorized BLM personnel or contractors may enter the corrals or directly handle the animals. The general public may not enter the corrals or directly handle the animals at any time or for any reason during BLM operations.

H. Responsibility and Lines of Communication

- Contracting Officer's Representative/Project Inspector:

- Contracting Officer's Representative/Project Inspector:

The Contracting Officer's Representatives (CORs) and the project inspectors (PIs) have the direct responsibility to ensure the Contractor's compliance with the contract stipulations. The Field Managers for the Humboldt River and Tuscarora Field Offices would take an active role to ensure the appropriate lines of communication are established between the field, Field Office, District

Office, State Office, National Program Office, and BLM Holding Facility offices. All employees involved in the gathering operations would keep the best interests of the animals at the forefront at all times.

All publicity, formal public contact and inquiries would be handled through the Field Manager and District Public Affairs Officer. These individuals would be the primary contact and would coordinate with the COR/PI on any inquiries.

The COR would coordinate with the contractor and the BLM Corrals to ensure animals are being transported from the gather site in a safe and humane manner and are arriving in good condition. The contract specifications require humane treatment and care of the animals during removal operations. These specifications are designed to minimize the risk of injury and death during and after gather of the animals. The specifications would be vigorously enforced. Should the Contractor show negligence and/or not perform according to contract stipulations, he would be issued written instructions, stop work orders, or defaulted.

Appendix F
Win Equus Population Modeling
Swasey HMA 2019 Population Modeling

To complete the population modeling for the Confusion HMA 2018, version 1.40 of the WinEquus program, created January 30, 2019, was utilized.

Objectives of Population Modeling

Review of the data output for each of the simulations provided many use full comparisons of the possible outcomes for each alternative. Some of the questions that need to be answered through the modeling include:

- Do any of the Alternatives "crash" the population?
- What effect does Population growth suppression have on population growth rate?
- What effects do the different alternatives have on the average population size?
- What effects do the different alternatives have on the genetic health of the herd?

Population Data, Criteria, and Parameters utilized for Population Modeling
All simulations used the survival probabilities, foaling rates, and sex ratio at birth that was supplied with the Winn Equus population for the Garfield HMA.

Sex ratio at Birth:
42% Females
58% Males

The following percent effectiveness of Population growth suppression was utilized in the population modeling for Alternative I: Year 1: 90%

The following table displays the contraception parameters utilized in the population model for Proposed Alternative:

Contraception Criteria

Age	Percentages for Fertility Treatment
1	100%
2	100%
3	100%

Age	Percentages for Fertility Treatment
4	100%
5	100%
6	100%
7	100%
8	100%
9	100%
10-14	100%
15-19	100%
20+	100%

Population Modeling Criteria

The following summarizes the population modeling criteria that are common to the Proposed Action and all alternatives:

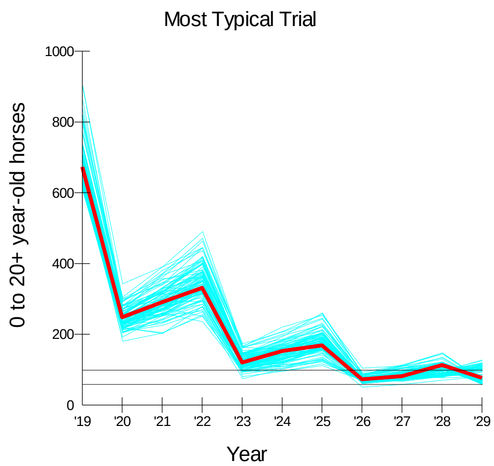
- Starting year: 2019
- Initial Gather Year: 2019
- Gather interval: regular interval of three years
- Gather for fertility treatment regardless of population size: Yes
- Continue to gather after reduction to treat females: Yes
- Sex ratio at birth: 58% males
- Percent of the population that can be gathered: 70%
- Minimum age for long term holding facility horses: Not Applicable (Gate Cut)
- Foals are included in the AML
- Simulations were run for 10 years with 100 trials each

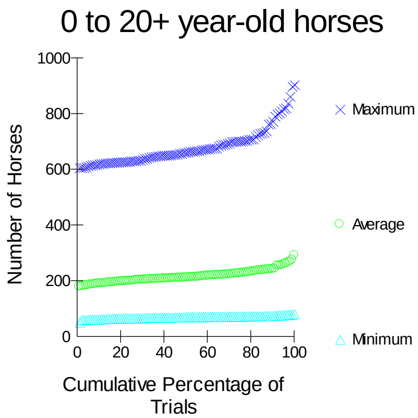
The following table displays the population modeling parameters utilized in the model:

Population Modeling Parameters Modeling Parameter	Gather and Removal of Excess Wild Horses and Application of Population Growth Suppression	Gather and Removal of Excess Wild Horses without Population Growth Suppression.	No Action – Continue Existing Management. No Gather and Removal
Management by removal only	No	Yes	No
Threshold Population Size Following Gathers	60	60	N/A
Target Population Size Following gather	60	60	N/A
Gather for Population Growth Suppression regardless of population size	Yes	No	N/A
Gather continue after removals to treat additional females	Yes	Yes	N/A
Effectiveness of Population Growth Suppression: Year 1	90%	N/A	N/A

Results - Gather and Removal of Excess Wild Horses and Application of Population Growth Suppression.

Population Size



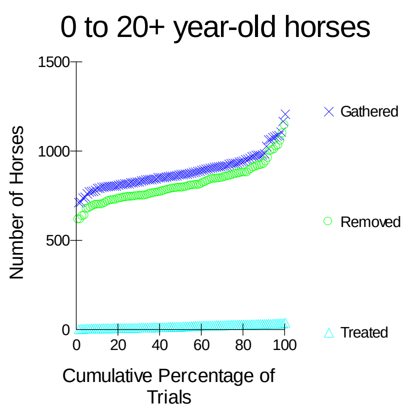


Population Sizes in 11 Years*

	Minimum	Average	Maximum
Lowest Trial	52	179	606
10th Percentile	62	191	621
25th Percentile	66	200	631
Median Trial	71	212	662
75th Percentile	73	228	702
90th Percentile	76	243	782
Highest Trial	82	291	904

* 0 to 20+ year-old horses

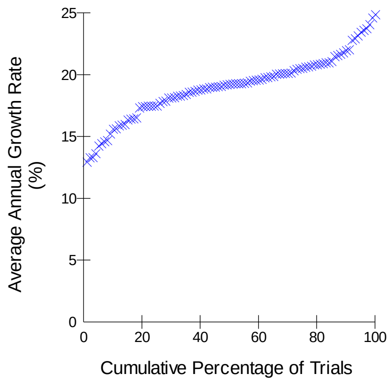
In 11 years and 100 trials, the lowest number 0 to 20+ year-old horses ever obtained was 52 and the highest was 904. In half the trials, the minimum population size in 11 years was less than 71 and the maximum was less than 662. The average population size across 11 years ranged from 179 to 291.



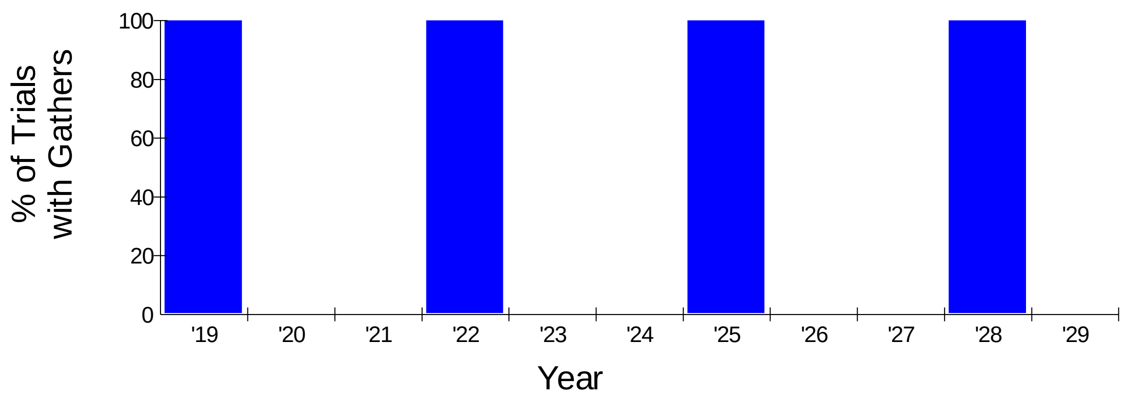
Totals in 11 Years*

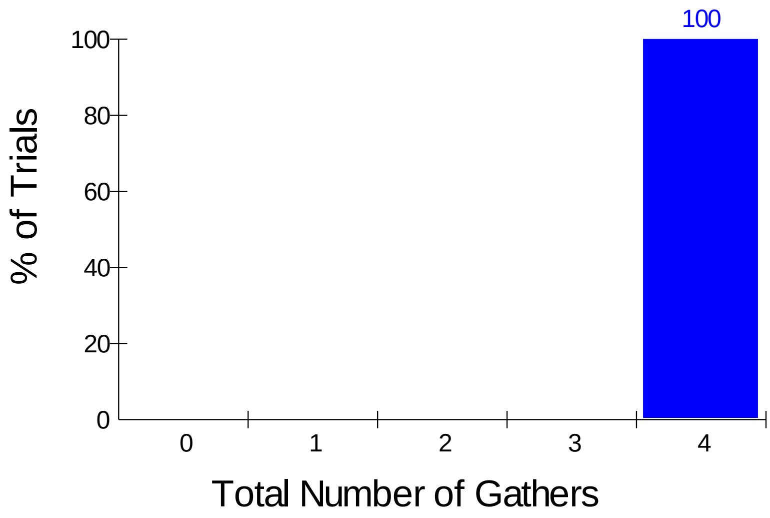
	Gathered	Removed	Treated
Lowest Trial	715	617	4
10th Percentile	794	700	9
25th Percentile	823	743	12
Median Trial	872	794	19
75th Percentile	934	868	30
90th Percentile	1009	934	34
Highest Trial	1210	1144	42

* 0 to 20+ year-old horses



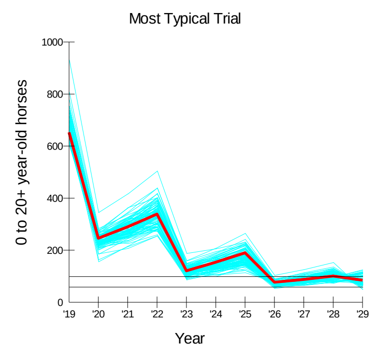
Average Growth Rate in 10 Years	
Lowest Trial	13.0
10th Percentile	15.6
25th Percentile	17.6
Median Trial	19.3
75th Percentile	20.6
90th Percentile	22.0
Highest Trial	24.9

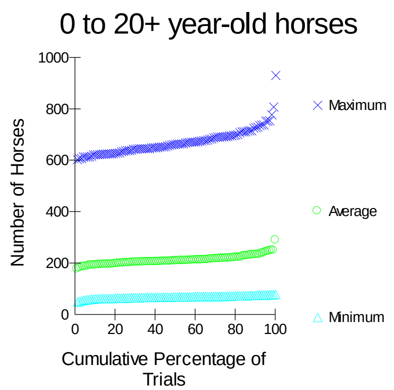




Results - Gather and Removal of Excess Wild Horses without Population Growth Suppression

Population Size



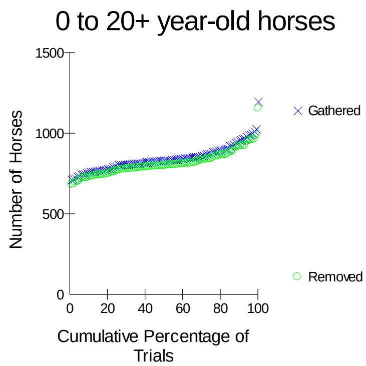


Population Sizes in 11 Years*

	Minimum	Average	Maximum
Lowest Trial	50	177	604
10th Percentile	63	193	624
25th Percentile	66	201	640
Median Trial	70	209	664
75th Percentile	73	220	694
90th Percentile	76	234	730
Highest Trial	80	290	932

* 0 to 20+ year-old horses

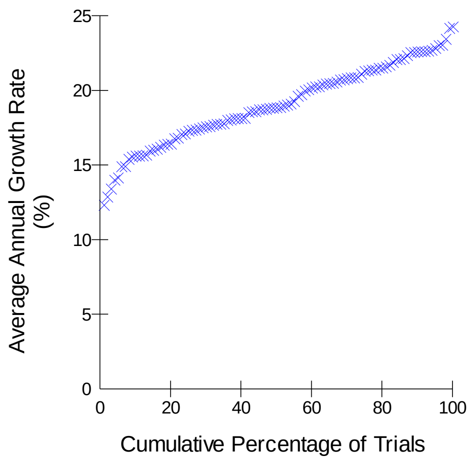
In 11 years and 100 trials, the lowest number 0 to 20+ year-old horses ever obtained was 50 and the highest was 932. In half the trials, the minimum population size in 11 years was less than 70 and the maximum was less than 664. The average population size across 11 years ranged from 177 to 290.



Totals in 11 Years*

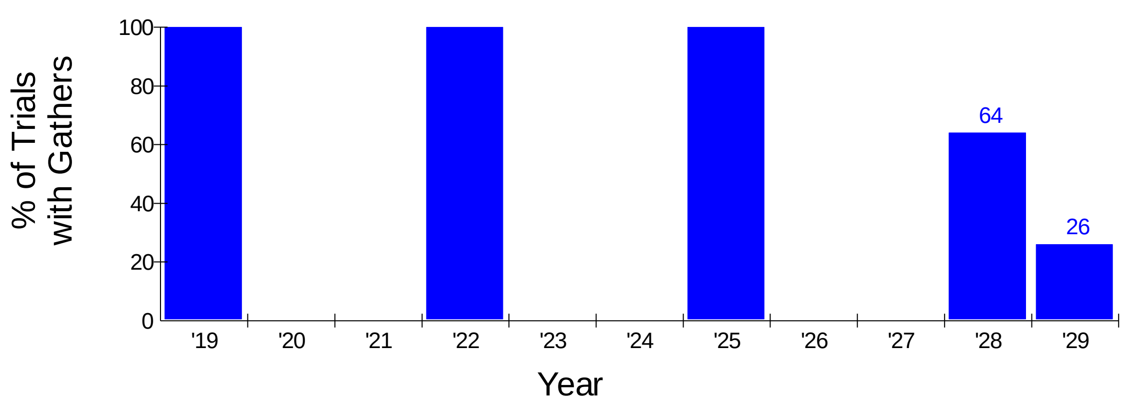
	Gathered	Removed
Lowest Trial	712	683
10th Percentile	760	730
25th Percentile	800	770
Median Trial	832	800
75th Percentile	880	846
90th Percentile	957	921
Highest Trial	1197	1155

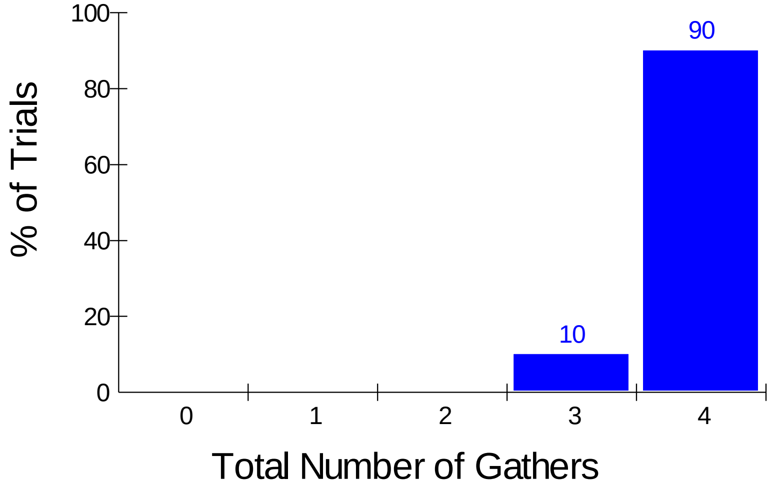
* 0 to 20+ year-old horses



Average Growth Rate in 10 Years

Lowest Trial	12.3
10th Percentile	15.6
25th Percentile	17.3
Median Trial	18.9
75th Percentile	21.3
90th Percentile	22.6
Highest Trial	24.3

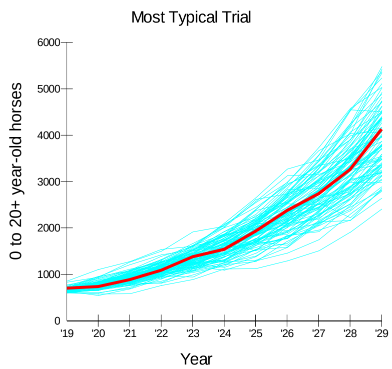




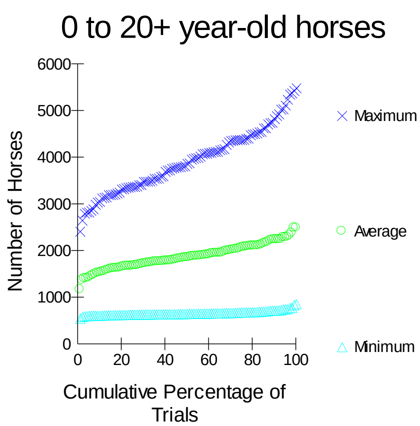
Results - No Action – No Gather, Removal or use of Population Growth Suppression

Results - No Action

Population Size



Population Sizes in 11 Years*

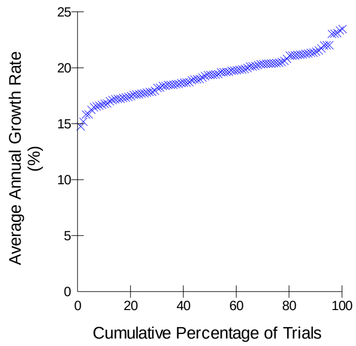


Population Sizes in 11 Years*

	Minimum	Average	Maximum
Lowest Trial	551	1168	2416
10th Percentile	614	1540	3092
25th Percentile	632	1681	3375
Median Trial	653	1857	3877
75th Percentile	682	2057	4381
90th Percentile	722	2241	4860
Highest Trial	863	2492	5489

* 0 to 20+ year-old horses

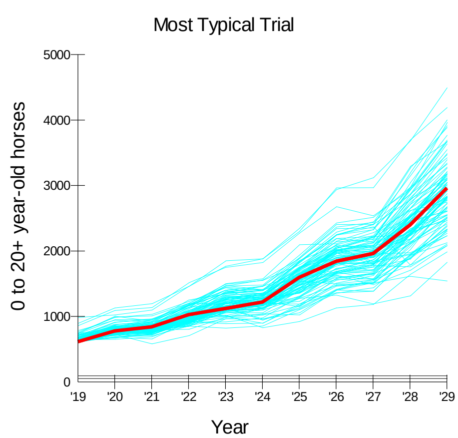
In 11 years and 100 trials, the lowest number 0 to 20+ year-old horses ever obtained was 551 and the highest was 5489. In half the trials, the minimum population size in 11 years was less than 653 and the maximum was less than 3877. The average population size across 11 years ranged from 1168 to 2492.



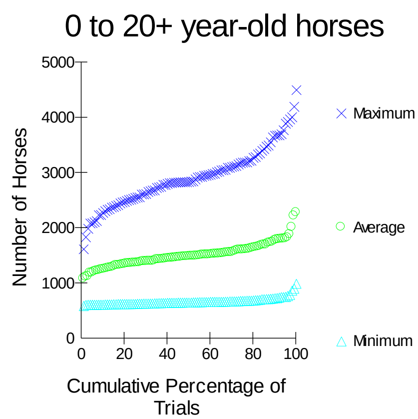
Average Growth Rate in 10 Years	
Lowest Trial	14.8
10th Percentile	16.8
25th Percentile	17.8
Median Trial	19.4
75th Percentile	20.5
90th Percentile	21.5
Highest Trial	21.8

Results - Alternative Considered but Not Analyzed: Population Growth Suppression Only.

Population Size



Population Sizes in 11 Years*

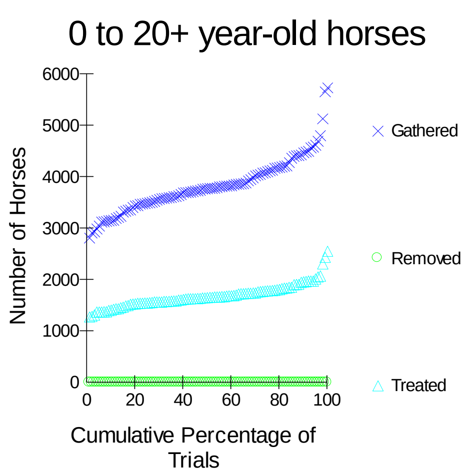


Population Sizes in 11 Years*

	Minimum	Average	Maximum
Lowest Trial	591	1081	1621
10th Percentile	616	1256	2294
25th Percentile	630	1370	2555
Median Trial	655	1490	2842
75th Percentile	684	1607	3192
90th Percentile	732	1781	3680
Highest Trial	993	2280	4503

* 0 to 20+ year-old horses

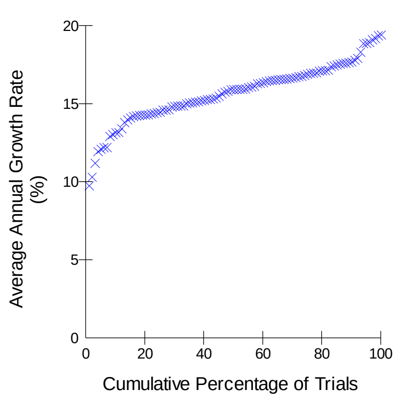
In 11 years and 100 trials, the lowest number 0 to 20+ year-old horses ever obtained was 591 and the highest was 4503. In half the trials, the minimum population size in 11 years was less than 655 and the maximum was less than 2842. The average population size across 11 years ranged from 1081 to 2280.



Totals in 11 Years*

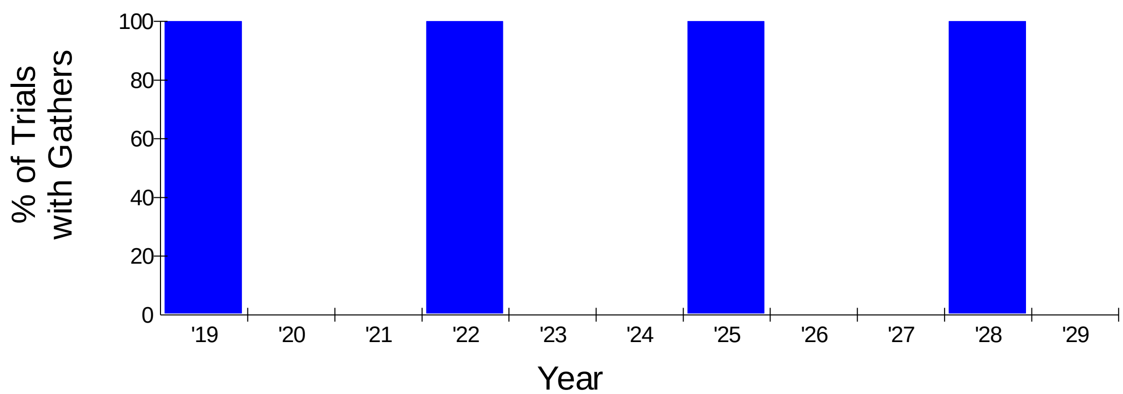
	Gathered	Removed	Treated
Lowest Trial	2816	0	1280
10th Percentile	3162	0	1420
25th Percentile	3500	0	1554
Median Trial	3779	0	1658
75th Percentile	4115	0	1789
90th Percentile	4483	0	1964
Highest Trial	5738	0	2559

* 0 to 20+ year-old horses

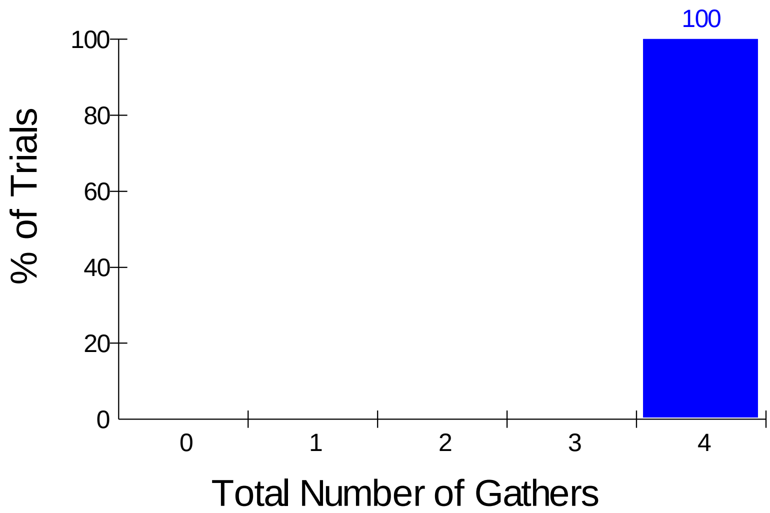


Average Growth Rate in 10 Years

Lowest Trial	9.8
10th Percentile	13.2
25th Percentile	14.6
Median Trial	15.9
75th Percentile	17.0
90th Percentile	17.8
Highest Trial	19.4



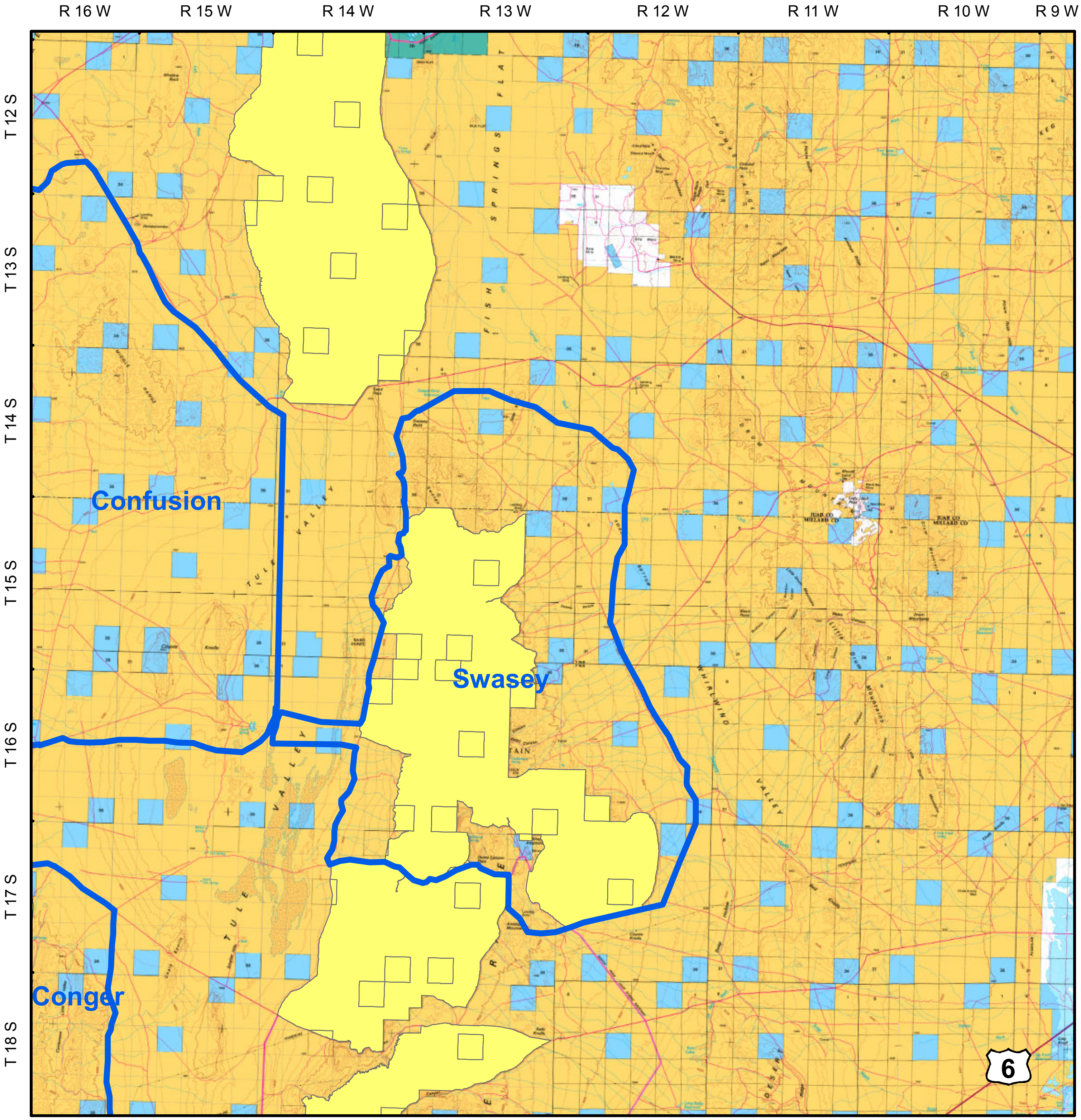
% of Trials
with Gathers
100
80
60
40
20
0
'19
'20
'21
'22
'23
'24
'25
'26
'27
'28
'29
Year



100
% of Trials
100
80
60
40
20
0
0
1
2
3
4
Total Number of Gathers

BUREAU OF LAND MANAGEMENT
FILLMORE FIELD OFFICE

Appendix G - Swasey HMA Map



Wild Horse & Burro Herd Management Areas

Wilderness Study Areas
and Lands Managed as Wilderness Study Areas

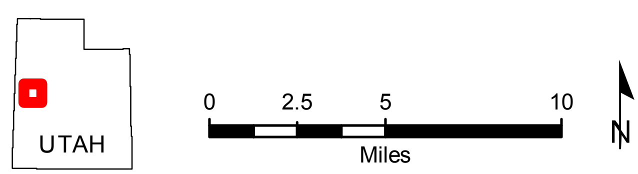
Land Status

Bureau of Land Management (BLM)

Private

State

US Fish & Wildlife (USFW) National Wildlife Refuge



December 16, 2019

No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data.

Document Path: T:\UT\GisData\ut\fm\projects\WildHorseBurro\HMA\arcprojects\Swasey_HMA_121619.mxd

Appendix H
Ovariectomy Procedures

U.S. Geological Survey
Fort Collins Science Center
2150 Centre Avenue, Building C
Fort Collins, Colorado 80526-8118

November 24, 2015

Dean Bolstad
Acting Division Chief,
Wild Horse and Burro Program
Bureau of Land Management, WO-260
20 M Street,
Washington, DC 20003

Dear Mr. Bolstad,

Attached please find a summary table and notes resulting from expert panel discussions on September 24, 2015, exploring several alternative methods for wild horse spaying. In addition to veterinary and equine experts, several USGS, BLM, USDA-APHIS, and Colorado State University staff also observed and contributed to discussions.

The materials reflect professional opinions about the current state of understanding of four spay methods currently used on domestic horses, as represented and discussed by panel members during and after the day-long meeting. These materials do not provide BLM with a recommendation, but hopefully provide useful information for BLM to consider.

Sincerely,

24 Nov 15

Zack Bowen
Branch Chief, Ecosystem Dynamics

Attachments.

Colorado State University

Sarah R.B. King, Ph.D.
Research Scientist
Coordinator of the Equid Red List Authority, IUCN

Department of Ecosystem Science & Sustainability
A242 NESB - Campus Delivery 1476
Colorado State University, Fort Collins, CO 80523
Phone: (720) 587-9890; Fax: (970) 491-1965
Email: sarah.king@colostate.edu

November 24, 2014

Dean Bolstad
Acting Division Chief
Wild Horse and Burro Program
Bureau of Land Management, WO-260
20 M Street
Washington, DC 20003

Dear Mr. Bolstad,

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These materials do not provide BLM with recommendations, but provide information for BLM to consider. The materials reflect the professional opinions on the current state of understanding about the pros and cons of four spay methods currently used on domestic horses, as represented and discussed by panel members during and after the day-long meeting.

Sincerely,

Sarah R. B. King
Research Scientist, CSU

Attachments.

Assessment of spay techniques for mares in field conditions

Panel meeting held at USGS Fort Collins Science Center

September 24, 2015

Summary of panel expert responses on four potential spay methods

	Colpotomy	Ventral midline	Flank incision	Flank laparoscopy
Facilities needed	Squeeze chute with a kick panel and access to the perineum.	Squeeze chute, table fitted on a forklift.	Squeeze chute (may require access to both sides).	Squeeze chute (may require access to both sides), sling.
Equipment needed	Ecraseur, scalpel or bistury, blunt scissors, gauze sponges tied with umbilical tape.	Complete surgical pack, surgical drapes, gauze sponges.	Complete surgical pack, surgical drapes, gauze sponges.	Laparoscope, CO_2 for insufflation, surgical pack, surgical drapes, gauze sponges.
Equipment preparation	Ecraseur autoclaved or cold-sterilized in ortho-phthalaldehyde (OPA/28) >10 minutes then rinsed in sterile water, or use chlorhexidine for sterilization.	Autoclave or cold-sterilize instruments.	Autoclave or cold-sterilize instruments.	Prepare laparoscopic equipment – cleaned and cold-sterilized.
Sedation	IV injection to the jugular of xylazine + butorphanol + detomadine.	Horses are placed in dorsal recumbency following an induction dose of xylazine/ butophenol/diazepam and ketamine.	Local lidocaine infiltration of flank and IV butorphanol.	IV jugular catheter continuous sedation drip - 20 mg detomidine in 1 liter fluid for standing sedation.
Anesthetic /analgesic protocol	Horses remain standing under tranquilization: butorphanol + xylazine or detomidine . Add low dose ketamine as needed.	Anesthesia may be maintained by IV administration of triple drip (IV-ketamine, xylazine and guaifenesin 5%) or using inhalant anesthesia.	Horses remain standing under tranquilization: butorphanol + xylazine or detomidine. Injection of lidocaine in line or L-block (~100-200 ml) at incision site.	Horses remain standing under tranquilization: butorphanol + xylazine or detomidine. Epidural for analgesia of the reproductive tract, local anesthesia at portal sites.
Procedure	Administer antibiotic (Excede - ceftiofur) that lasts for 4	Administer antibiotic (Excede - ceftiofur) that lasts for 4	Administer antibiotic (Excede - ceftiofur) that lasts for 4	Administer antibiotic (Excede - ceftiofur) that lasts for 4

	Colpotomy	Ventral midline	Flank incision	Flank laparoscopy
	days. Wrap tail and tie up. Evacuate rectum/bowel, prep perineum. Make 1 cm incision in vaginal fornix. Expand incision via blunt dissection. Locate ovaries. Sterile 4x4 gauze soaked with 30 ml 2% lidocaine compressed over ovarian pedicle 3-5 minutes or lidocaine injected into pedicle. Remove ovaries via ecraseur. Repeat for other ovary through same incision.	days (or given 40 ml procaine penicillin and 10 ml flunixin meglumine post surgery). Surgical area is clipped and prepped with chlorhexidine scrub followed by chlorhexidine solution swabs. Incision into peritoneum made on ventral midline. Ovaries exteriorized through ventral midline incision. An emasculator is applied to the ovarian pedicle. #6 MSA used to ligate the ovarian stump proximal to the emasculator. The emasculator is removed and the ligated stump allowed to retract into the abdomen. Closure is accomplished in three layers, the outermost being a subcuticular layer using #6 MSA absorbable.	days. Surgical area is clipped and prepped with chlorhexidine scrub followed by chlorhexidine solution swabs. Line or L-block injections are administered. Wait until block has effect, then single incision in left flank through skin and fascia followed by blunt dissection into the peritoneum. 9-inch burdizzo (or emasculator) for removal of ovaries. Closure of the underlying layers of muscle and fascia such that only the skin requires suturing. Very bottom of the skin suture line is left open to prevent seroma formation.	days. Approach both flanks: surgical area is clipped and prepped with chlorhexidine scrub followed by chlorhexidine solution swabs. Make incision at flank. Insert cannula for instruments. Insufflate with CO_2. Lidocaine injected to ovary and pedicle. Ovary is removed through incision; incision may have to be enlarged to remove ovary. Suture incision. Repeat on other side.
Incision	5 cm in anterior vagina.	9-15 cm incision made just cranial to the udder.	10-15 cm in flank (on one or both sides).	One 1 cm incision and one 6-10 cm incision in the left flank, and three 1 cm incisions on the right side.
Standing or recumbent surgery?	Standing	Recumbent	Standing	Standing
Surgery time per	15-20 minutes	20-30 minutes	45 minutes	40-60 minutes

	Colpotomy	Ventral midline	Flank incision	Flank laparoscopy
horse				
Complications	1-2% seen within 2 days.	Infection of open wound; potential for evisceration; potential for injury upon recovering from anesthesia.	5% incisional complications under sterile conditions (more likely 10-20% under field conditions).	1-2% incisional complications (in sterile environment), 10% subcutaneous edema; puncturing a bowel; dropping ovaries in abdomen.
Recovery time (before release)	3 days	2-3 weeks	2-4 weeks	1-2 weeks
Contra-indications	Uterine infection/pyometra. Enlarged (>6 cm) ovary; pelvic or ovarian abnormalities. Heavy late gestation may prevent access to ovaries. Surgery may not be possible if the mare cannot be sufficiently sedated.	Very dirty animal; old/multiparous; any animal that is contraindicated for general anesthesia. Contraindicated in later term gestation due to risk of initiating labor and abdominal wall rupture during parturition. Pregnant mares in surgery have a 3x greater risk of pregnancy loss with general anesthesia.	Very dirty animal; any animal that is contraindicated for general anesthesia. Pregnant mares in surgery have a 3x greater risk of pregnancy loss with general anesthesia.	Dependent on technology; abnormal ovary.
Effect on pregnant/lactating mares	Late gestation may challenge access to ovaries. Pregnancy no issue following first ±70 days. No foal abandonment issues. No issues with lactation.	Late gestation may be challenging. May affect nursing (pain when the foal tries to nurse).	Unknown. May affect nursing (pain when the foal tries to nurse).	Unknown, but likely easily done.
Effect of breeding post-surgery	Vaginal incision usually healed by 7-10 days post-	Breeding may cause injury prior to recovery.	Breeding may cause injury to the incision line.	Breeding may cause injury to the incision line.

	Colpotomy	Ventral midline	Flank incision	Flank laparoscopy
	surgery. If open or <100 days pregnant administer long acting progesterone which should suppress receptivity/save pregnancy.			
Operator safety	Strapping the back of the mare helps prevent kicking, kickboard and tail tied dorsally aids operator safety. Short time with scalpel.	Animal fully anesthetized.	Operator protected due to small window of access on side of animal. Longer time with scalpel.	Operator protected when coming from the flank, but injuries can occur due to equipment and two people in a restricted space.
Cost per horse	$250-$300[1] Long-acting progesterone ($7/mare)	$350[2] includes all drugs and supplies. Plus long-acting progesterone ($7/mare).	$350[2] Includes all drugs and supplies. Plus long-acting progesterone ($7/mare).	$450-$500[3] Long-acting progesterone ($7/mare).
Pro of method	Fast healing and recovery, quick surgery, can be done on pregnant mares.	Low risk to operator, common surgery for companion animals.	Low risk to operator, common surgery.	Direct visualization, low morbidity, good public opinion.
Con of method[4]	Higher risk to operator, need for trained surgeons.	Risk of evisceration, risk of incision infection.	Risk of incision infection and pain.	Most expensive and time-consuming approach.

Notes:

[1] Colpotomy cost per mare: $100-1500 initial equipment cost (chain ecraseur Jorgensen J-37E $450 buy 2 or 3, replacement chain MidWest 350.01254.2 J37ED1 $95). Then $80-100/mare: OPA/28 4 gal $99.56 (estimate 50-80 mares: $2/mare), suture 2-0 monocryl 36/box $205 ($6/mare), #10 or #21 scalpel blade 100/$25.52 ($3/mare), Lidocaine 100ml $8 ($4/mare), Xylazine $1/100 mg ($4/mare), Butorphanol 10mg/ml 50 ml $250 ($5/mare), Detomadine $16/mare, Ceftiofur - excede 15 ml $30/mare. Once the ecraseur and scalpels have been purchased, the expense via colpotomy for each mare is the drugs, the lidocaine and gauze for the pedicles, and the sterilizing of the ecraseur.

[2] Ventral midline and flank incision – there will be a cost of drapes, gowns, sutures, etc., as for all abdominal surgeries, and a cost for the surgical equipment. Drug and other equipment cost will be as in [1].

[3] Laparoscopy equipment costs: $25,000 for camera, light core, light source, monitor, Thorston telepack, $5,000 – insufflator, $3,000 – microscope, $750 x 6 for hand instruments (need two sets): $40,000 total new, or could buy used. Likely need to replace 5 hand instruments per 100 mares. Drug and other equipment cost will be as in [1].

[4] It should be noted that all surgeries are associated with a risk of death. There are no published data available to assess the mortality risk of any spay surgery in wild horses, although preliminary data on domestic and wild equids were discussed by the panel.

Assessment of spay techniques for mares in field conditions

Panel meeting held at USGS Fort Collins Science Center
September 24, 2015

Transcript of Comments

Questions or topics are in **bold**.
The speaker is in *italics*. If the person introducing the topic made the comment it is indented with a bullet. If the speaker is not known the comment is indented with a hyphen. All attendees and invitees have been given the opportunity to edit this document. As these are notes taken from a discussion, what is written here may not capture the exact intended meaning of a given statement.

Attendees
In person: Zach Bowen (USGS), Jason Bruemmer (CSU), Doug Eckery (USDA/APHIS), Paul Griffin (BLM), Al Kane (USDA/APHIS), Sarah King (CSU), Joanna Ruffino (USGS), Kate Schoenecker (USGS).
By WebEx/Phone: Cheryl Asa (St. Louis Zoo), Gail Collins (NPS), Robert Cope, Jay D'Ewart (BLM), Bryan Fuell (BLM), Dean Hendrickson (CSU), Katrin Hinrichs (Texas A&M), Sue McDonnell (U. Penn.), Leon Pielstick (DVM), Patricia Sertich (U. Penn.), Mark Stetter (CSU), Regina Turner (U. Penn.), Julie Weikel (DVM).
Information provided after the panel: Paul Zancanella (DVM)

Introduction
Paul Griffin

- Purpose of the meeting is to discuss different procedures for spaying wild horse mares.
- We will discuss pros and cons of the various methods that could potentially be used for spaying wild horse mares.
- This is not a definitive decision making meeting for BLM, but to get the opinions of experts.

Background of study to be conducted by USGS/CSU
Sarah King

- Aim of the study is to look at the short-term impact of spaying on health and behavior of individual mares, specifically any effects on band fidelity, spatial ecology and population demography.
- Location: White Mountain HMA, Wyoming.
- We have proposed to spay 60% of adult mares (adult mares are 3 years old and older), which will probably be 36-48 mares, depending on the age structure, leaving 24-32 untreated controls plus juveniles and foals.

- We will collect 1 year of pre-treatment data, and then 3 years of post-treatment data.

Facilities at Rock Springs BLM Adoption Facility

Al Kane:

- It's a typical BLM facility.
- Two hydraulic squeeze chutes. Most facilities do not have a split tailgate. At Rock Springs, the door would need to be re-fitted to have a split tailgate that would allow access to perform a colpotomy. It's an open question about whether BLM would have the funding to get a new tailgate (that is split).
- Squeeze chutes give access to the left side and hindquarters of the animal. They are -padded and compress the animal front to back and side to side.
- For recumbent surgery the mare can be rolled out of the chute onto the ground; no access to a table.
- No hospital and no indoor facility.
- Transportation to and from the HMA: gooseneck, stock type trailer, or semi-trailers.

Zack Bowen:

- We will compile notes and comments and put them in a briefing paper. This will not be published. It will be a statement to BLM compiling information, not making a recommendation.
- Information will be compiled based on considerations that will be asked of each technique.

Kane: Today we will discuss some considerations for what technique may be most appropriate for this study, but another technique may be more appropriate in the future for spaying on a wider scale across HMAs. But it may be the same.
King: The method chosen by the BLM for this study should be the same as what is used in the future elsewhere, as this will have been the method we gathered data on.

Discussion of Colpotomy - *Leon Pielstick*

History:

- Leon is a veterinarian who has worked with the BLM since 1975, and has also been involved with the management of horses at Sheldon-Hart. At Sheldon he spayed horses which had been placed on a private pasture for the trial.
- Spayed mares in the field successfully: Out of 34 mares spayed, 31 were open, 3 were pregnant and successfully foaled. At Sheldon they used spaying as a management tool – they vasectomized males and spayed females that were considered unadoptable, then turned them back out to the range. The majority of such spayed mares were pregnant.
- He has spayed 188 mares by colpotomy, including 16 spayed at a wild horse sanctuary in California, 16 spayed as part of a PZP safety study in Oregon.

- Out of the 188 mares there were 2 fatalities: one bled to death internally due to a clotting abnormality, and one got sick, aborted her foal and died (anecdotal evidence indicated that she had a peritoneal infection). We can expect a 1-2% complication rate with colpotomy. For any given choice of spay method, the BLM must be prepared to accept some level of loss.
- 70-75% of mares are likely to be pregnant in late summer. Pregnant mares can still be sterilized by colpotomy because of the way the foal drops in the uterus: the ovaries are still at the top of the uterus so can be reached. At 7-8 months pregnant it gets harder to move the intestines to reach the ovaries, so it is more difficult to keep the intestine out of the ecraseur tool. The only mare that had an abortion was the mare that died.
- To do the surgery, give heavy sedation/analgesia (butorphenol + xylazine or detomidine + Dormosedan) and heavy analgesics (banamine + butorphenol); the surgery is performed with the mares standing. Banamine was added to eliminate mild post surgical colic which had occurred in a few of the mares the first year in which the procedures were done.
- Mares held off feed for 24 hours before surgery seemed to have good recovery after. Holding off feed means that fecal balls are reduced, which can resemble ovaries on palpation and thus take time to sort out, and reduces abdominal fill. Depending on the horse there was a little colic within the first few hours post surgery until Banamine was added to the procedure. Mares generally walked out of the chute and started to eat, some would raise their tail and act as if they were defecating, however in most you could not notice signs of discomfort.
- There was no squeeze chute at Sheldon, but the mares could be held at the back of the chute where there was an access window. Some mares needed additional sedation as they could not be squeezed. It should be possible to make any facility functional for this surgery.

Facilities:

- Needs a kick panel and an access window, so that there is access to the perineal area. Use a strap above the rump, to help prevent jumping and kicking. Most facilities can be made functional. At the BLM Burns facility, for example, there is enough room to slide in a 3 foot tall plywood kick panel.

Behavior:

- In the first group of 33 spayed mares with 10 intact mares and 2 stallions (on private land) – the group all stayed together as a herd.
- In another situation two groups of 8 spayed mares formed their own bachelorette band. They were new to the facility.
- In Sheldon it is assumed that they returned to their band.

Recovery time:

- The only complications were seen within two days of surgery. After 2 days there were no visual problems so they could be released to the range.

- It is typically recommended in domestic mares that they not be ridden for a month, but they seem okay after 2 days.
- The incision in the anterior vagina is not sutured; this heals rapidly (within days, cannot be identified easily on speculum examination). Evisceration through the vaginal incision is often brought up as a possible complication of colpotomy, but none of the panel participants had had this occur nor had heard of it actually occurring. In addition, being held off feed would reduce the chance of evisceration.
- Being held off of feed before-hand is important according to Pielstick, although others said it was less necessary.

Gail Collins - At Sheldon they had the opportunity to recapture spayed mares that were released (3yr, 5yr, 6yr later) to monitor progress.

- They were given a dose of antibiotic (Excede -- ceftiofur) that lasts for 4 days within the mare (single injection).

Procedure:

- Cold sterilize ecraseur. Give antibiotic.
- Wrap tail and tie up for procedure.
- Evacuate bowel, surgically scrub peritoneum and flush out vagina. Clean vagina with iodine. Others perform procedure without vaginal flush (vagina should be essentially sterile).
- Put on sterile sleeves, introduced hand into vagina, and make the incision in the anterior vagina.
- Mares have no nerve receptors in that area, so they only feel pressure/stretching. They show no outward sign of discomfort. Mares feel the pull on and compression of the ovarian pedicle, but lidocaine administered to the pedicle to minimizes this. This analgesic lasts a couple / few hours. The pain afterwards is similar to that of castration.
- Timeline: 15 minutes for the whole procedure. Speed is often necessary due to volume of horses. Can do 30-35 horses a day as it is not physically taxing.
- Controlling the level of dust is very important, but otherwise it is possible to keep the area ‘field sterile’.
- Can make a portable chute for this procedure out of a hydraulic cattle chute; this would have an adequate tail gate.
- Mares walk out of the surgery.

Comments:

Julie Weikel served as an observer for Leon’s procedure at Sheldon; wrote a review:

- Some mares would walk out from surgery and immediately want to eat (hunger pain worse than spay pain due to keeping them off food).
- Some (a few individuals) showed minor signs of colic for about a half hour, such as getting up and down repeatedly. These were collected so that they could be watched more closely for up to an hour, then turned out to join a bigger group with feed and

water. For these horses they did not use lidocaine, which might alleviate the colic symptoms. Leon now uses liodocaine in every spay.

Katrin Hinrichs: **Did you give any antibiotics before the procedure?**

- Antibiotics are given after sedation, so not as long before surgery as ideal. There isn't a large opportunity to give it long before surgery due to the circumstances of these being wild horses.

How is the Lidocaine injected in to the pedicle?

- Via needle, an assistant pumps the drug, but the surgeon guides the needle.
- Dr. Pielstick is trying to modify the ecraseur to also hold a needle, thereby reducing the overall risk of contamination (and needle stick); having the needle on the ecraseur would mean one less trip in and out of the abdomen.

Are the mares in pain after the drugs wear off? Are they observed at night?

Hinrichs: has seen mares in pain at night after the surgery; she now gives butorphanol for 24 h after surgery, or morphine + detomidine epidural at the time of surgery.

Pielstick: They are observed for several hours after. They seem fairly comfortable. Pain is at an acceptable level; the banamine helps.

- Domestic mares are given banamine and sent home.
- They seem more comfortable than castrated stallions.

Weikel: I walked pens every morning and evening at the gather observing behavior. Mares were mostly involved in social status behaviors.

Pielstick: Finished surgery at 4pm on a good day, so not a lot of light for observations after surgeries.

Regina Turner: **What is the effect of operator experience?**

- This is a practical technique. Leon taught 9 vets in Arizona when spaying 5 donkeys. Any vet who generally works with equine reproduction can pick it up, however there is a learning curve. On one donkey they had trouble getting the left ovary out, after they finally succeeded the donkey bled to death. They did a flank incision on two donkeys and this seemed better on that species.

Are there enough trained people?

- Plenty of vets would be interested in learning the technique. If there is a complication it can be used as a learning experience to avoid future complications. There were complications with the donkeys as multiple people were learning how to do it. The chance of complications increases with the number of times you go in and out of the animal.

Cheryl Asa: **Could we have more follow up on the AZ procedures?**

- Concerns about the Arizona project include the fact that one died, one lost a 50-70 day old fetus, and others had post-operative infections.

Pielstick: The burro that died had a left ovary with a membrane around it; there was no post mortem exam to discern exact cause of death. If a female has an unusual ovary it would be best to abort surgery and not proceed.

It seems as though the training contributed significantly to the mortality there?

- If there are unusual situations then generally complications arise, and this is used as a learning curve to create a better procedure.
- It is also worth noting that the number of learning surgeons entering the body cavity of those burros could have contributed to the one in five mortality rate for those burros. Dr. Asa noted that one of the major complications could have been the training itself.

Kane: **What are the contra-indications of this technique? Does the condition of the horse affect the procedure?**

- Generally body condition will affect the choice made to do the procedure. Best to pass on very old mares or mares in poor condition.
- Late gestation will increase the complication rate, but pregnancy will not be an issue in the first or second trimester.
- Surgeons should also pass on mares with pelvic abnormalities.
- 1-2% of mares could not be sedated heavily enough to do the procedure. 1cc of ketamine would help. If a mare fails to sedate the issue is that she moves, so the procedure is not done.

Of the big group of mares that you spayed, what percentage were pregnant? Which were checked before-hand?

- Of the first 33 mares that had the procedure, 3 were pregnant (about 60-70 days). All 3 foaled.
- The 16 spayed in CA were all open.
- At Sheldon 70-80% were pregnant - up to 7 or 8½ months gestation. Ovaries were easy to reach, but it was generally a little harder with the foal in the uterus.

Did it affect pregnant or lactating mares to keep them off feed?

Pielstick: They were only held off feed for 24 hours, and were given water. Mares were released with their foals. There were no abandonment issues.

Hinrichs: does not hold off of food and has not had an issue.

Pielstick: feels holding off food is important; the less abdominal fill, the better.

Hinrichs: **How long do you take to close the ecraseur?**

Pielstick: A few seconds.

Griffin: **Could we release into the wild and worry about potential breeding?**

Hinrichs: The result of ecraseur is a very clean pedicle, as she has had the opportunity to observe via flank incision during removal of ovaries with the ecraseur. Additionally, after 2 or 3 days you can barely see the incision in the vagina, but if she is mated at that time it could open up the incision.

- There is a chance they could be in heat, but if the procedure is in fall many will be pregnant.

- There is a concern that, if they are bred shortly after the procedure, the vaginal incision could be opened by the stallion's penis. This could result in peritonitis and death of the mare.

Patricia Sertich: Not necessary to hold off feed. Instead rely on careful palpation of the uterus and ovary. 32 years experience doing ovariectomy by colpotomy. The initial incision (<1cm) is made in the vaginal fornix with a no.10 scalpel and the incision is enlarged by blunt dissection. This method separates rather than transects the muscle fibers so the incision decreases in length when the vaginal muscles contract after the tranquilization wanes post-surgery. Three days post-op the incision edges are adhered, and healed after 7-10 days. If the mare is not pregnant or less than 60-80 days pregnant she will likely tolerate copulation by a stallion in 3-7 days due to the decrease in ovarian progesterone.
Hinrichs: They could be given an injection of a long-lasting progesterone (e.g. Altrenogest) to stop the mare tolerating stallion advances.
Asa: Estrus behavior is seen in pregnant mares, but in our study they did not not allow copulation.
Pielstick: could do a study to monitor how often mares show heat after spaying.
Sue McDonnell: Spayed mares can be receptive all year round. Typically can not even put them with geldings as they would be mounted. If given the opportunity a spayed mare would tolerate the sexual advance of an amorous gelding. If over 100 days pregnant at the time of ovariectomy, and don't immediately lose the pregnancy, the feto-placental unit has taken over from the ovary for progesterone to support the pregnancy, and without the ovary will likely suppress attractivity and receptivity.
Kane: **What are the long-term complications of spaying? What is the incidence of pyometras in spayed mares?**
Gail Collins: At Sheldon 85% of mares that had been spayed and released (plus 30 mares not spayed) were recaptured. The survival rate of spayed and non-spayed mares was not different.
Hinrichs: Breeding is not a problem if the incision is elsewhere than the vagina.
- There may be a long-term risk of vaginitis and pyometra in spayed mares if bred repeatedly after spaying. There is risk of penetration into the abdomen and peritonitis if mares are allowed to breed before the vaginal incision has healed.

Hinrichs: This is unlikely as the cervix will be open due to lack of progesterone (no ovaries).
Griffin: **How long should we keep mares in captivity?**
Collins: At Sheldon they kept them in for 7-8 days before release.
Hinrichs: Has just visited a lab that does a lumbosacral epidural on mares for oocyte recovery. This would eliminate the need for lidocaine and make sure the mare does not move during the procedure. May not be feasible in wild mares. The lumbosacral was given while the perineum was being prepared; done at the level of the tuber coxae. Lab she visited has used this on client mares over 300 times successfully.
Pielstick: It may be faster to just block the ovarian pedicle.

Discussion of ventral midline and flank incision approach - *Julie Weikel*

History

- Julie has spayed about 100,000 cows by either flank or vaginal approach. The vast majority of these were spayed by the vaginal approach, however several hundred were spayed through the flank at all stages of pregnancy. These experiences are the ones that inform our discussion about spaying mares as there are many similarities in the issues faced and potential consequences. The adult cattle spays were all performed as part of federal Brucellosis eradication efforts. Under the Brucellosis control program neither sexually intact nor pregnant animals could leave a quarantined premises, hence the need for both spays and C-sections, frequently in the same individual animals. Rarely were the conditions under which these surgeries occurred ideal in any way; cleanliness, weather, adequate manpower, etc. In other words, true field conditions. While Julie always tried to obtain follow-up information about complications and survival, she did not always get that feedback. Some of the problems in cattle might inform the discussion.
- In cows you cannot reach the ovary through the vagina when they are pregnant, so had to go through the flank.
- All the mares (domestic) Julie spayed were via a single flank approach, probably less than a dozen. They were all decades ago and were for either granulosa cell tumor removal or attempts to control "nymphomania." All were done in horses used to being handled and in a clinical environment.
- Entry for flank spays utilized a skin and fascia incision followed by blunt dissection that results in a "closure" of the underlying layers of muscle and fascia such that only the skin requires suturing. Only the very bottom of that skin suture line is left open. Julie came to this procedure as a result of dealing with seromas as a not uncommon sequence in fully closed suture lines. Seromas are not a serious post surgical complication, but in field situations where any secondary handling poses additional risk to the animal, they should be avoided if possible.
- In mares always used a 9 inch burdizzo rather than an ecraseur when doing flank incisions. Has never had a hemorrhage issue with castration using the burdizzo.
- P. 869 in Loesch and Rodgerson (2003) article is very thorough in regards to complications from any non-colpotomy approach in a horse.
- Always better to do surgery with a horse standing if possible – want to avoid lying horses down. Surgical vasectomies are done recumbent.
- Surgical recovery in a wild horse is already an extraordinary event (i.e., presenting unusual circumstances).

Conditions:

- Dust control is crucial (not completely sterile by any means).
- Heifer corrals mirror field conditions.
- Any surgery poses an issue for infection at the incision site.

Training:

- Julie has taught numerous vets to spay heifers. Only a small percentage are still spaying. All found it to be quite difficult. Adopting colpotomy for wild mares means that we need to find people who have gone through the steep learning curve. Some people can develop a good feel to correctly assess what tissue you have hold of, but it takes experience to learn.
- In the west, many dude ranches do not like cycling mares. Julie works with a veterinarian who spays these mares. Other vets with this experience are a potential for pool of people to choose from for the colpotomy method.
- While Julie has usually required 100 heifers to "train" a veterinarian to spay heifers, 100 mares may not be necessary to train an already accomplished equine surgeon to perform colpotomies. Training will vary with the individuals involved and hopefully could be accomplished with many fewer animals, maybe 5-10, with time to rest between surgeries for reflection during training.

Comments:

Hinrichs: Feels there is not such a problem with training veterinarians for equine ovariectomies via colpotomy. Did ovariectomies by colpotomy for PhD work – everyone wanted to learn the technique. Reproduction vets are best because they can tell if the ovary is covered by omentum, and recognize the anatomy better via palpation than surgeons. They are more familiar with the feel of it. Katrin has trained many veterinarians on ovariectomy via colpotomy, and they have been successful. They have conducted colpotomy on 22-30 year old mares with no complications. Reproductive specialists are used to palpating mares, so the colpotomy method is not difficult to teach.

Weikel: The biggest mistake is that trainees are too eager to jump right in and because the initial entrance into the abdomen is extremely important this causes an issue. During autopsies of spayed heifers the vaginal wall penetration site was difficult to find. This was observed in heifers only because she has never lost a mare.

Griffin: **Is there a minimum number of mares to use to teach people how to do the procedure?**

Hinrichs: 3-5 colpotomies should be done under supervision.

Weikel: People who were good had it after 1-2 animals. There are others who still wouldn't get it after 100. You need people with experience or competence.

- Dust control is critical – spray pens down every day, and re-spray during the day. In her opinion, field conditions make colpotomy an attractive option.

Kane: **Is there one incision or both flanks?**

- Single incision (left flank) and does the left ovary first. Dr. Weickel uses the burdizzo to access the second ovary, carrying the tool though the abdomen.

Chemical immobilization?

- Lidocaine and adequate sedation (butorphenol). Some mares respond differently – can't settle even when sedated. These are generally released without surgery.
- Sedation is an important variable.

Issues with flank incisions?

- It's an open wound. An external wound can become an abscess.

Recovery time? Or effects on pregnant mare?

- Cannot speak first hand on the flank approach in pregnant mares.
- In heifers Weikel would attempt vaginally or go in via flank. She would C-section (after 120 days pregnancy) therefore could see the ovary and proceed.

Turner: It will be harder to find people who are good at colpotomies. Some people prefer flank incisions, and more people are trained to do it. However flank incisions can take longer to heal and be more painful.

Weickel concurred that colpotomy appears less painful.

Kane: **Can anyone comment on the access to the ovaries on pregnant mares via flank incisions?**

[No response from the panel]

Kane: **Recovery time on flank incision?**

Weikel: There is a prolonged recovery time (2-3 weeks) due to the risk of abscesses developing after surgery.

Asa: Following up with data from the burro project: 2 were spayed via flank incision. These got infected and opened up within a week. They took a month to heal. These animals were closely monitored.

Turner: You will likely be able to find more veterinarians who are trained in and comfortable with flank incisions for ovariectomy. However, there are many complications in flank incisions even under sterile conditions. Most of these are related to healing of the incision line and discomfort. On the other hand, it will be hard to find people who are good at colpotomy. When untrained people perform colpotomies there is in an increased risk that things will go wrong and sometimes things can go very wrong.

Weikel: We need to be conscious of trained personnel who are good at colpotomy to teach others to do this procedure so they can take over if there are complications.

Hinrichs: has not had issues training people, however, she is very detailed in her training methods. She goes through every complication she has experienced with each new trainee. Reiterated that she prefers reproductive vets over surgeons.

Kane: **Safety of the people involved during the surgery?**

- Colpotomy – strapping the back of the mare helped stopped the mare from kicking, plus there is a kickboard and the tail is tied up.
- Flank incision – operator can be more protected. Small window of access. Weikel does not believe that this outweighs the consideration of the colpotomy.
- Hinrichs noted that the time with the scalpel in colpotomy is only a couple of seconds. This time is longer for flank incision, which means more opportunity for fractiousness and infection.

Ventral midline incision approach: ***Jay D'Ewart***

Procedure

- 8 mares were spayed using the ventral midline approach at Rock Springs, WY. All survived. It was not a blind procedure. Done under anesthetic with the surgery similar to a dog or cat. Given three-layer sutures. After surgery the mare got up and wandered to the recovery pen. The mares were watched for 2-3 weeks at Rock Springs and then sent to long-term holding facilities.

Comments:

Kane: **Were the mares pregnant? How long after were they turned out?**

- Unsure if any mares were pregnant, but it is unlikely as they had been in holding for some time prior to surgery.
- These mares were never released to the range (they are in long-term holding somewhere).

Griffin: **How would this affect pregnant mares?**

Hinrichs: It would be difficult to access ovaries via ventral midline in a pregnant mare.

Kane: **How would this affect lactating mares?**

D'Ewart: Might be able to select mares that are close to weaning.

Weikel: It is likely to be more of a problem if the mare is still sore. In heifers there is soreness due to the calf poking around to nurse. The relationship between dam and foal could be compromised. Edema could affect lactation. Flank incision might also make some mares resistant to nursing.

Griffin: **With the ventral midline procedure is there a potential for evisceration?**

Weickel: Yes, definitely. This is a primary possible complication of this procedure, and it is an awful outcome.

Hinrichs: what is the incision size?

D'Ewart: 5 inches

[Referred to Loesch and Rodgerson (2003): 25-35 cm]

Weikel: depends on the size of the ovary and size of the operator's hand.

Doug Eckery: close to the mammary gland, so may affect nursing.

- Evisceration is a horrific consequence so we want to be careful of a method in which evisceration is a complication, as in ventral midline.

Hinrichs: Although evisceration is said to be a risk of colpotomy, she has not known of any evisceration post-colpotomy.

[Neither had people at U. Penn.]

Sertich: Domestic horses that have had a ventral midline incision are usually restricted to stall rest for one month, and then only hand walked for the second month. These horses are kept with very limited activity. No data on mares that had free access to exercise.

D'Ewart: Had a successful experience in Wyoming. After anesthesia the horses are turned out in a holding pen where they don't get a lot of exercise. No eviscerations. The vet thinks it is a very teachable procedure.

King: We will be sending the briefing statement to Paul Zancanella who conducts and advocates for the ventral midline approach. He can add comments.

Ventral midline procedure - Paul Zancanella (written comment submitted after the panel)

- Mares are restrained in a padded chute and administered an induction dose of xylazine and ketamine. Upon induction an indwelling catheter was installed in the jugular vein. Anesthesia was maintained using intravenous administration of triple drip (IV-ketamine, zylazine and Guiafensin 5%) to effect. Horses are placed in dorsal recumbency. Surgical area is clipped, pre-surgical preparation was done with chlorhex scrub followed by chorhex solution swabs. Seven-inch incisions were made just cranial to the udder. Ovaries are exteriorized through the incision. A serra emasculator is applied to the ovarian stump. Number 6 MSA is used to ligate the ovarian stump proximal to the emasculator. The emasculator is removed and the ligated stump allowed to retract into the abdomen.
- Closure is accomplished in three layers. The outermost being a subcuticular layer using #6 MSA absorbable. The surgical time, induction to completion, is twenty to thirty minutes.
- Mares all received 40 ml procaine penicillin and 10 ml flunixin meglumine post surgery.
- Mares are standing within thirty minutes of surgery and eating within two hours of surgery.
- In conclusion, a ventral midline ovariectomy is a viable field surgical procedure for fertility control in mares. The surgery is accomplished relatively easily with less risk and expense than other fertility control methods.
- The ventral midline can be performed with little or no modifications to the existing facilities.
- Postoperative pain is much less than colpotomy and is easily managed with intraoperative IV flunixin meglumine.
- Operator and assistants safety is much better than standing procedures.
- Some concerns expressed for mares being anesthetized is exaggerated or naïve. Equine practitioners anesthetize thousands of horses with minimal problems.
- Ventral midline surgeries are accomplished routinely on horses without complications.
- Having performed both the colpotomy and ventral midline I much prefer the ventral midline approach.

Kane: We need sedation and anesthetic protocols for the three incision approaches.
Griffin: **Is there something additional about lying horses down that is an issue?**
Weikel: There is a lot of weight on the tissues if on its back, pressure on the aorta (cardiovascular effects), and recovery issues; these are mentioned in the review article [Loesch and Rodgerson (2003)]. When a domestic horse that trusts you is recovering you can keep them calm and help them. With wild horses this is not an option. The goal is to get away from them (and get them

away from people) as soon as possible. They can sometimes run and buck/get acrobatic; level ground is a must for recovery.

[*Hinrichs* and *Turner* agree with not laying horses down for surgery if at all possible.]

Hinrichs: We always do ovariectomy surgery standing. Injectable sedation for ventral midline seems risky, as compared to gas anesthesia. People are moving away from abdominal incisions in humans; for example in women they are doing hysterectomy etc. via colpotomy and this is associated with less pain and much faster recovery.

Weikel: There is potential for adhesions to the ovary, for example due to a history of inflammation. Those are problematic. Leon will not take such ovaries out of mares. Individuals with these inflammations are high risk - heifers walked around with the hump in their back even if they lived. Would be skeptical if there are adhesions.

King: **Is this similar to cryptorchid stallions?**

- If a mare has an ovary left she will still cycle, even if one ovary is infertile. Generally in cryptorchids they do not have adhesions, so not really comparable.

Kane: **What are contra-indications for flank or midline methods?**

Weickel: No external surgical incisions should be done on any mare that is very dirty. Any mare that is especially dirty we need to ask why is she laying down and rolling a lot. Will she be doing this post-surgical procedure? How dirty are the field conditions? At Sheldon, the corral where the surgeries took place was clean, and not used at all for many months per year.

Sertich: Would avoid ventral midline incisions in late gestation in mares (in last month before parturition) as they may go into labor. Some mares have delivered foals after midline surgery for colic, but they were watched carefully. The concern is that there may be a breakdown of the abdominal wall during delivery.

Kane: **Is there an age effect for these approaches?**

Sertich: No specific numbers, but as mares get older they are more at risk for abdominal wall rupture.

Turner: Older/multiparous mares have an increased risk under general anesthesia because they may be at increased risk for catastrophic fracture during the recovery process. Also, many physical conditions would preclude the use of general anesthesia and subsequent recovery (e.g. neurologic horses, horses with heart conditions, etc.) Any of these conditions would be contraindications for general anesthesia and therefore the ventral midline approach. Mares would need to have a full physical examination prior to anesthesia, which is unlikely in the field.

Sertich: Mares that lactate year round every year probably have lower bone density, so are more at risk of catastrophic fractures during recovery from general anesthesia. These risks are inherent to the recovery process following general anesthesia (not the method of surgery chosen). But since the ventral midline approach can only be done under general anesthesia, these potential complications would be unavoidable with ventral midline (vs. other procedures that could be done standing).

Weikel: The Sheldon mares (colpotomy) spayed were skewed towards older mares. The recovery was the same as the mares that did not have the procedure, but all of these mares were done standing and did not have general anesthesia.
Hinrichs: 8 mares 21-30 years old were given ovariectomies by (standing) colpotomy without complication.
Kate Schoenecker: **How does an ovariectomy affect the fetus?**
Hinrichs: [will be sending the research paper cited to Joanna] Mares ovariectomized earlier than 50 days – all lost their fetus. At 50-70 days about half lost their pregnancy. >140 days none lost their foal. In her own research, took ovariectomized mares off progesterone after 100 days of gestation and then had no problem.
Sertich: When mares get abdominal surgery of any kind they are also administered progesterone/progestin before and for a few weeks after surgery to prevent pregnancy loss. There is less risk of losing a foal with a colpotomy. General anesthesia for a ventral midline incision requires that the horse is off its feed, which means more muscle trauma and more stress.
Turner: Pregnant mares in surgery have a 3x greater risk of pregnancy loss with general anesthesia.
Griffin: **Due to colpotomy sometimes early stage pregnancy can be lost. Can we give them long term progesterone injection to save the pregnancy?**
Hinrichs: It could be possible to keep ovariectomized mares pregnant by injecting progesterone. At <50 days of gestation won't find evidence of fetal loss. Pregnancies of 50-70 days might be helped by a long-lasting progesterone shot. Pregnancies over 70 days are likely to be maintained even without exogenous progesterone.
Kane: **What product would you recommend?**
Hinrichs: Not sure on commercial availability of certain products. BET had a long-lasting progesterone and long-acting altrenogest that was available. (Checked subsequent to the panel: 30-day altrenogest injection still available).
Kane: **Potential for a feed through on mares that die due to this procedure in the wild?**
Hinrichs: Main issue is if an animal were to eat the area of the mare where the progesterone is injected, but progesterone is a natural hormone and the consumer would just receive an oral dose. (Note added later: Altrenogest does have the potential for feed-through).
Kane: If gestational stage is <50 days, we should consider accepting fetal loss. If stage is 50-70 days, one could consider injecting a drug to maintain the pregnancy.
Hinrichs: **Does anyone know what time in gestation an abortion is visible?**
Kane: It is very difficult to find aborted fetuses, even in a stall. Most that are found are close to term (size of a beagle). There are behavioral signs preceding abortion. We want to avoid abortions to the extent possible.

- Beagle size is 150 or more days (5-6 months) gestation.

Collins: We rarely found aborted fetuses in corrals. Only a few times did we find beagle size fetuses.

How often is the fetus reabsorbed?

Sertich: It is thought to be expelled/passed out through the cervix and not found, rather than resorbed.
Weikel: When it's hormonal abortion we are less likely to see discharge from the mare. When it is infection one sees a messier discharge.
Kane: Horses are corralled for testing purposes and held for 30-90 days. We vary rarely see secondary complications in mares that abort a fetus. The complications with abortion of foals are minimal. The mares do not show signs of illness, pyometra, or founder. The mares are generally farther along when we see complications, if any.
Hinrichs: In Argentina the polo industry is aborting hundreds of male foals, then within a few weeks transferring another embryo to the same mare with no ill effects.

Discussion of Laparoscopy: *Dean Hendrickson*

Procedure:

- Done a lot in horses at CSU. Performed in domestic horses with standing sedation. Typically approach both flanks. Can do it through one flank but this takes more time. Typically it takes 40 mins to remove both ovaries (doesn't include time for preparing/sterilizing horses for surgery, which brings the total to 50-60 minutes per animal).
- Equipment needed is a laparoscopic tower, light source and monitor, camera box, CO_2 canister, insufflator, and one standard surgery pack per animal (scalpel, blades, clamps, etc.).

Recovery time:

- Some are sent home the same day or some stay over night. There is minimal postoperative care.
- Has done the surgery in a field setting (laparoscopic vasectomy of elephants in Africa). Can keep the animals/instruments clean and sterile enough with cold sterilization.
- Standing sedation may not be possible in a wild horse for this surgery.
- The effect on the fetus if the hormones are not maintained (at less than 50 days gestation) is that the mares will generally abort. It is most likely that there is the same level of risk as for other procedures.

Comments:

Hinrichs: **What is the sterilization time for the instruments?**

- About 20 minutes to sterilize between animals (would work better with 2 sets of instruments to avoid wasting time).

Jason Bruemmer: **If you were to do it from only one side does it affect your time of completion?**

- Yes, it can take up to an hour standing sedated in a squeeze chute if surgery is from one side.

Sertich: When we do ovariectomies by laparoscopy they allow 1 to 1.5 hours, which includes scrubbing the flanks. They make incisions from both sides to get both ovaries.

Collins: **How is sedation maintained?**

- IV jugular catheter, continuous sedation drip. More consistent than with a bolus.
- Have done epidural (caudal) which also works well, but not sure this will work for wild mares.
- With this procedure in elephants they are under general anesthetic and hung in a sling from a crane so there is access to the flanks. Not sure if this is possible for horses.

What is the size of the incision?

- Ovaries are removed through the flank. Incision size is dependent on the size of the ovary (just enough to pop the ovary through), normally 4-10 cm.
- In 2% of cases there is incisional drainage, and in 10% there is subcutaneous emphysema from the CO_2 insufflation.

How are they managed post operatively?

- 1 dose of antibiotics pre-op and 3-5 days of NSAID post-op.
- Kept in a pen for 1 week, and then normal work after 2 weeks. But would not have a problem waking the mares up and sending them off.

Is it possible to use the laparoscope vaginally?

- Yes, there have been two reports using it to aid in colpotomy.

King: **Have you ever carried out this procedure on a pregnant mare?**

- No.

Hinrichs: **What type of epidural do you use?**

- Caudal epidural as it reduces movement. But there is no flexibility in that method of sedation as if you put in too much it's hard to keep them standing, and too little means they aren't sufficiently sedated.
- 40 µg/kg detomidine is used. Lidocaine would require too much volume to be used as an epidural.

Do you use lidocaine on the ovary?

- Yes – injected into the ovarian pedicle (15 ml local anesthetic injected to the pedicle).Give an epidural for analgesia of the reproductive tract, rather than the flank.

Kane: **Can you comment on the ventral approach?**

- It makes laparoscopy more difficult. When dorsal it is harder to get to the ovaries and find them. Ovaries present better when standing from the flank.
- In the small animal world they put the animal head down tail up and tip them from side to side. It might be possible to roll horses one side to the other to get to the ovaries.

Kane: **What are the general equipment costs?**

- $25,000 for camera, light core, light source, monitor, Thorston telepacs (sp.?)
- $5,000 - insufflator
- $3,000 - microscope

- $750 x 6 for hand instruments
- $40,000 total new, or could buy used.
- You would need two sets of instruments to be efficient, so that one set could be cold sterilizing while the other was in use.

Kane: **Contra-indications for this method?**

- You are very dependent upon technology – if something breaks and you don't have a duplicate then you need to stop. It takes time to get used to the approach and do it.
- Worst-case complications would be puncturing a bowel. Withholding feed tends to reduce this risk.
- It is possible to drop ovaries in the abdomen. There is no proof that this is an issue but could be.

Durability of equipment?

- Not a huge worry – machinery is not that delicate. The monitor is most delicate - if kicked it could break the screen.

What do you recommend for pre-op?

- 12 hours off feed but not critical. The more comfortable you are with the tech the less you need to worry about feed – 3 hours would be fine. Time off food possibly upsets them. Elephants were never held off feed and they have similar digestive tracts.

Hinrichs: **How long does it take to learn the procedure?**

- With 3 days and 5 or 6 mares you can get someone up to speed. Doing it regularly helps. Has learned how to teach it well. Ovaries in a standing mare are easy to access. It is not difficult to do an ovariectomy.

Kane: **Can you guess what would happen in a pregnant mare?**

- Pregnant mares present ovaries well if standing. It could be easily done.

Do you have any ideas about slinging them under anesthesia in a chute?

- Can use the same concept as hoisting horses up and out of ditches. You can use this to keep them into position.
- You could potentially have two teams working on either side of the abdomen and cut your time shorter.

Hinrichs: **What is the infection rate?**

- It's about 1/10 less when the instruments go in and out of the body cavity through a cannula, rather than flank laparotomy where they go repeatedly in and out through an incision. Instead of 5 in 100 you'll get 1 in 100.
- We don't see them commonly in open flank procedure.

Kane: **How safe is this procedure for the operator?**

- Coming from the flank you can avoid the feet, but he has still ended up with bruises and a broken toe.
- The difficulty is the amount of equipment and two people puts you a little more at risk than standing flank ecraseur, but slightly safer than a colpotomy.

How do you feel about training on a large scale?

- He feels good about training people fully. Colpotomy is rough because you cannot see what you are doing. One could use the laparoscope to train colpotomy.
- Won't walk away from someone until comfortable that they could do it.

Hinrichs: When training students on colpotomy, the student will find the ovary and place it in the loop of the ecraseur, then she will put her hand in and make sure it's an ovary before anything is cut.

Griffin: **Can you comment on the approximate cost the procedure will be per animal?**

- CSU charge is $1400 to do mare ovariectomy at the hospital (including technician time).
- Could do it in the field for $250/ horse for procedure alone (not including salaries).
- Did ovariectomies on dude ranch mares in Durango – 11 horses in 3 days. The real cost was $450-$500 per horse.

What is the cost per colpotomy and ventral midline?

Collins: Colpotomy was $250-$300 per horse at Sheldon NWR.

- Ventral midline is approximately $350/horse at Rock Springs, WY.

Fragility of the equipment? Is the jostling of the wild mares going to be an issue for the equipment?

- Wise choice is per 100 mares look to replace 5 instruments (this is the rate with people who are not fiscally responsible for the equipment).
- More likely to break hand instruments than the scope.
- Laparoscopy is the most expensive approach, but there is direct visualization, low morbidity, and better public opinion.

Schoenecker: **Do you cold sterilize?**

- Yes. Clean with soap and then water, rinse with sterile water.

What happens with dust?

- Blowing dust is less of a problem as the instruments are solid. Has been able to brush dust off during elephant procedures.

Sertich: **Infection issues or seromas?**

- One does get some seromas but no big problems with them. 1-2% incisional complications, but those rates are for mares in a clean and controlled environment. Opening and draining generally fixes this.
- No long-term negative or infection rates. In a field setting there may be a 2-3 x higher risk, but this is still small and corrects on its own.

D' Ewart: **Is there a difference in laparoscopy vs just through the flank?**

- You can see what you are doing with lap.
- You can ligate the pedicle with two ($10) ligatures to cut sharply, rather than putting the ecraseur through with a flank incision.
- Two ligating loops is faster than the radiofrequency "Ligasure".

- There is a radio frequency device for cauterizing the ligated tissue, but it is expensive and finicky, and is just one more piece of equipment to worry about that may halt surgeries.

Bruemmer: **Can you use umbilical clamps?**

- Seems like you could. Thicker pedicle in the horse than cattle.

D'Ewart: **What is the infection rate difference in flank than scope?**

- 5% incisional infection for flank.
- 2% with laparoscopy.

Hinrichs: **Is the opening for the ovary a straight incision? How is it closed?**

- Incision of 5-10 cm modified grid. Close fascia and skin in continuous pattern.

D'Ewart: **How do you manage pain?**

- A lot of the pain comes from the flank incision. It is helpful to anesthetize the pedicle (with carbocaine).
- Since laparoscopy incision is smaller than with the flank laparotomy method, it is mildly less painful but not a huge difference.

Behavioral estrus post spaying: *Cheryl Asa*

History

- 10 ovariectomized mares and 10 anovulatory mares were put with stallions and monitored for 15 days in January. The study was published in 1980.
- Of the 20 mares all showed at least one day of weak estrus. One mare showed full estrus all 15 days. Most had at least some mounting and were accepting of a stallion to full copulation.
- Most notable is that there was nothing cyclic (it was on and off day to day).
- Considering our various studies, only when a mare had elevated progesterone (e.g., diestrus, pregnancy) was there an absence of estrus and copulation. The adrenal cortex produces sex steroids. Estrus was not shown in mares with adrenal cortical hormone production was blocked with dexamethasone, suggesting that it is adrenal sex steroids that support estrus in mares that are ovariectomized and during the non-breeding season.
- It would be interesting to know whether this represents what mares would do in a naturalistic circumstance.

Comments:

Weikel: **What was the relationship between stallion and exposure? And relationship to spay?**

- Mares and stallions were kept separate and introduced (several mares and a stallion in a paddock) and allowed to interact freely.

Weikel: The increase in breeding activity may have been because the mares were new to the stallion. In Asa's study, the stallions were not with the mares except during the study.

Collins: Didn't monitor for sexual behavior at Sheldon but did analyze band association. Spayed mares maintained their band associations, and were in mixed groups. They were not found in bachelorette bands, or as solitary animals.

Is there a more natural setting?

Asa: Horses stay together year round (unlike most animals), so behavioral estrus may be a mechanism for the band to stay together outside of the breeding season.
Collins: Mares that were not coming into estrus were not driven off or kicked out the band.
Hinrichs: **In an intact band full of intact mares what portion of those mares would not be pregnant?**
Collins: 45-50% recruitment in Sheldon.
Asa: Reviewed horse literature for the NAS report. It looked like there was a trend where mares on BLM range were reproducing about every other year.
Kane: varies from HMA to HMA. 60-75% of mares are coming up pregnant based on fecal testing or foaling. There is 75-80% pregnancy rate based on fecal testing or foaling, observed at Teddy Roosevelt NP.
Collins: Most foal deaths were within the first 2 months of life.
Griffin: If a foal survives to fall, then typically BLM would consider it part of the population. "Recruitment" is survival to nearly a year old.
King: **Any other observations of behavioral differences in mares post ovariectomy?**
Sertich: Teaser mares (stimulus mares for semen collection) are ovarectomized. They are sexually receptive to stallion advances every day for the rest of their lives. Sometimes ovariectomized mares are administered estrogen to encourage proceptivity, but most of the time they are not. Ovariectomy to prepare a stimulus mare is common in the horse breeding industry for semen collection to be used for artificial insemination.
Griffin: The main reason we are asking USGS to conduct this study is because this behavior is not well known, so part of the purpose of this study is to discover that.
Griffin: **An injection of progesterone would create more time for the mare to heal by making her less receptive to being bred?**
Hinrichs: Yes. A long-acting progesterone given at a concentration of 1-2 ng/ml could suffice. They should reject the stallion for about 7-10 days.
Kane: **Any concern about exogenous progesterone affecting post-operative uterine infection rates?**
Hinrichs- There could be concern, but because the cervix may open shortly thereafter, when the progesterone level falls, this should be self-limiting. Some contamination could occur during the procedure, but because of antibiotics the likelihood of infection would be low.
Collins: **If you are doing the surgery when is the injection being administered?**
Collins: At Sheldon we held animals for a week, and restricted the number of times they handled the animals.

Hinrichs: If you give injection at the time of ovariectomy it should last 7-10 days, which would be OK if the mares are released in 2-3 days. Otherwise would need to be given later for a later release, and it would be better not to handle the horses again.

Were the stallions held?

Collins: Depended on the studs (they were doing vasectomies). Some were turned out sooner than the mares, but not always.

Did the mares get back to the same harem group?

Collins: They were not released all at once and this was not monitored as some were adopted.

Griffin: **Is a week enough to heal?**

Weikel: Yes, the healing rate is very quick with colpotomy.

Hinrichs: To be safe maybe one should allow 2 weeks before the mare is repeatedly bred in the wild in order to avoid catastrophe. A stallion can rupture even an intact vagina. It takes a surgical incision 7-10 days to fully heal.

Risk is running through chute once or keeping them in captivity?

Weickel: Checking the BET website, there is a 30 day progestin injection, Altrenogest, that could also be given. Could it promote uterine infection?

Hinrichs: if the uterus was contaminated at surgery, but as noted before, this is unlikely.

King: **Could progesterone injections also be given to control animals** (to reduce any confounding effects of progesterone injection on comparisons of observed animal behavior)?

Hinrichs: This drug has been thoroughly tested in pregnant mares and shown not to be detrimental to the mare or foal.

Mare menopause approach: *Doug Eckery*

- The aim is to develop a vaccine. GonaCon and PZP are currently available and both have been shown to be effective, but for a limited time. PZP prevents fertilization; GonaCon prevents ovulation. A vaccine is only good as long as antibodies can be maintained. PZP, in particular, requires many booster shots. Follicles are constantly replenishing, so mares need a booster throughout their lifetime.
- The idea is to target something earlier in ovarian function. Successful reproduction in female mammals depends on an adequate supply of eggs that are found in primordial follicles. However, there is only a finite supply of eggs in the ovaries, that if destroyed would cause permanent sterilization. Every day a certain number of primordial follicles begins to grow, and only a very few ever reach the final stages of maturation and go to ovulation. The initiation of growth is a committed step and controlled largely by local growth factors. Oocyte-specific growth factors are involved in the early stages of follicular growth. A research team in New Zealand found that a certain group of infertile sheep had a mutation causing infertility. The research goal is to come up with a vaccine to mimic this mutation but for horses. If the primordial follicles do not mature then the animal is sterile. For sterility you need to deplete the ovaries of eggs by directly killing the eggs/primordial follicles or by

causing a mass activation of the primordial follicles (once growth is started it cannot be stopped).

- We are going to test vaccines against oocyte specific growth factors in horses. This will prevent follicular growth and ovulation in the short term, but hopefully will eventually deplete eggs leading to mare menopause, but this is a hypothesis.

Timeline:

- Start research in November by vaccinating mares against the growth factors. After 1 year will conduct a unilateral ovariectomy and look at the ovaries under the microscope. Throughout the year will conduct hormone testing. AMH levels will be measured, as this can be one index of follicular reserve. The project will run for 2 years. Also will track ovarian function through ultrasound and behavior through teasing.

Comments:

Kane: **When would you expect them to be sterile? Are you planning a fertility challenge?**

- We do not expect animals to continue to cycle. The follicles will not produce any steroids so behavior will be changed. Eventually we will conduct fertility testing. It is unknown how long it will take to deplete the ovaries. This is a test to see if the mechanism will work.
- Vaccine and booster will be 6 weeks apart. Next step is to develop a vaccine.

Kane: single shot vaccination is a lofty goal.

Schoenecker: **What happens if given to a pregnant mare and depletes her eggs?**

- The vaccine should have no effect on an existing pregnancy as it is not affecting the corpus luteum.
- The time frame of egg depletion would take longer than the term of a pregnancy, so therefore no effect on the pregnancy.

Kane: **What about the effect on the fetus?**

- Antibodies would probably not pass through the placenta to affect the foal, and probably not in the colostrum long enough to affect the foal's antibodies. But it is unknown whether there would be a long-term effect on the offspring.

A Review of Equine Standing Laparoscopic Ovariectomy

Monika Lee and Dean A. Hendrickson, DVM, MS

INTRODUCTION

Equine ovariectomies are performed for various reasons. The most common indications are to prepare a mount mare for semen collection, eliminate estrus behavior and colic signs associated with estrus,[1,2] sterilize the mare for registration purposes, and to prepare recipient mares for embryo transfer.[2] Other reasons are associated with removing pathologically abnormal ovaries in the form of granulosa–theca cell tumors.[2] Regardless of the reasons for performing the surgery, it has developed into a regularly requested procedure.

Different surgical approaches and amputation techniques have been developed to remove equine ovaries. Horses can be operated on while in a standing or dorsally recumbent position. The standing technique can be performed using sedation and local anesthesia,[3] whereas dorsally recumbent procedures require administration of general anesthesia.[2] General anesthesia has been shown to cause hypoxemia and hypoventilation that may necessitate a ventilator.[1] The surgery can be done as a ventral midline celiotomy, flank laparotomy, or colpotomy.[1,2] Colpotomy complications include unidentified and potentially fatal hemorrhage of the mesovarium caused by poor hemostasis, intestinal and mesenteric trauma, peritonitis, adhesions, and possibly death.[2] The flank approach is favorable because visibility is improved, but it is still difficult to exteriorize the ovary without making large incisions.[2] Consequently, standing laparoscopic ovariectomy has become a more common technique to remove ovaries in mares.

Advantages of laparoscopic techniques include the reduction of complications through full observation of the operative field, minimal invasiveness, a shortened convalescent time with fewer postsurgical complications,[1,2] and improved cosmetics after surgery.[1] It also allows for tension-free ligation of vessels in the mesovarium.[2] Concerns and limitations associated with laparoscopic techniques include the necessity and cost of specialized equipment, technical difficulty of the procedures and required training to conduct them, and the fact that a lack of familiarity with procedures can dramatically increase operating time.[2,3]

Performing laparoscopy in standing horses adds the advantage of avoiding the risk and expense of general anesthesia while providing easier access to the ovaries because of the location of the reproductive anatomy.[3] Limitations of standing procedures include horses with unsuitable temperaments for standing sedation surgery, the size of the horse, and the availability of appropriate facilities for restraint.[3]

MATERIALS AND METHODS

Patient Preparation

Feed but not water is withheld from the horses for 18 to 24 hours to reduce bulk in the peritoneal cavity and improve the working space. The use of prophylactic antibiotics is left to the surgeon's discretion; however, at most only perioperative antibiotics should be used. Preoperative nonsteroidal anti-inflammatory drugs should be given to reduce pain and inflammation associated with surgery. The horses are sedated, a catheter is placed, and surgical sedation can be obtained with intravenous boluses of detomidine, epidural detomidine (40 μg/kg brought to a total volume of 10–12 mL with sterile saline), or titrated to effect intravenous infusion of detomidine (20 mg/L liter saline or polyionic replacement fluids). Both flanks for bilateral ovariectomy, and the ipsilateral flank for unilateral ovariectomy, should be clipped and aseptically prepared for surgery. The surgical sites can be anesthetized with local anesthesia in either an inverted "L" block, a line block, or, as the authors prefer, individual portal blocks (Fig. 1). The first portal is placed at the level of the base of the tuber coxae, midway between the tuber coxae and the last rib. A 10- to 12-mm-diameter, 15- to 20-cm-long cannula with a blunt trocar is advanced through a 12-mm incision in the skin and external abdominal oblique fascia and the rest of the abdominal musculature into the peritoneal space. The trocar is then replaced by a laparoscope connected to a 300-watt xenon light source and laparoscopic camera, which is used to confirm penetration through the parietal peritoneum. Abdominal insufflation with carbon dioxide is to an intra-abdominal pressure of 8 to 12 mmHg initially. The second portal is made just cranial and 10 cm proximal to the first cannula, and the third portal is made 10 cm ventral to the first cannula[3] (Fig. 2).

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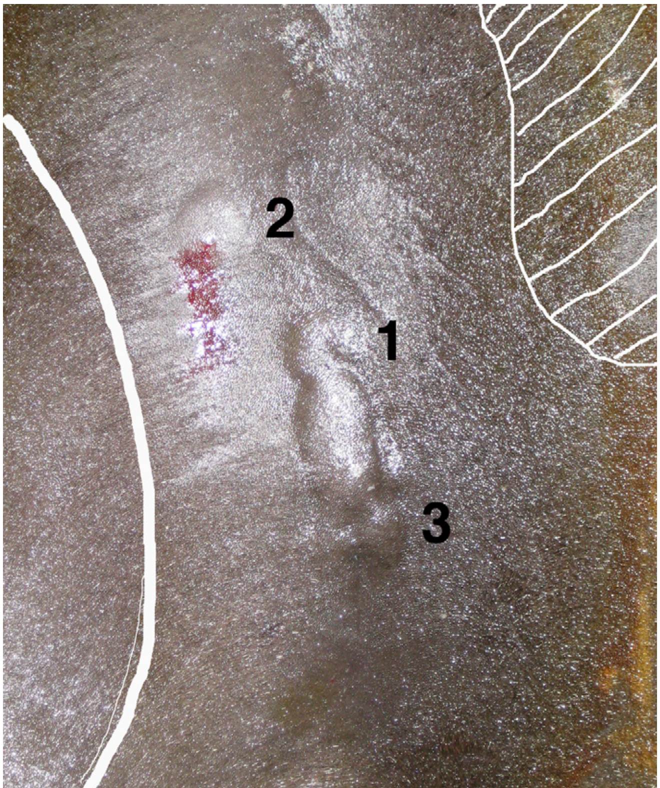

Figure 1. Photograph of left flank showing portal sites: 1, first portal; 2, second portal; 3, third portal. Note the local anesthetic between portals 1 and 3 to facilitate enlargement of portals for ovary removal. White line on left corresponds to last rib. White line with crosshatches on right corresponds to tuber coxae.

Throughout the procedure, all laparoscopic instruments are inserted through the instrument portals as required. The mesovarium should be infiltrated with 10 to 15 mL 2% lidocaine before resection.[4] If a single ovary is removed, the ventral incision is enlarged for removal of the ovary. For bilateral ovariectomy, both are resected; the right ovary is passed under the descending colon to the left side of the abdomen and removal is via the left flank. Only the skin is closed in the small incisions using size 2−0 nylon in a cruciate or simple interrupted pattern. The external abdominal oblique muscle and fascia are closed in the single enlarged incision using size 0 polyglyconate (Maxon, Covidien) in a simple continuous pattern and size 2−0 nylon in the skin in a simple continuous pattern. The horses are generally kept in a stall for 1 week and a stall/run for 1 week, and then they are returned to work.

Various techniques have been used to amputate the ovary in standing laparoscopic ovariectomy. The main variations are the methods with which hemostasis is achieved. Reported methods include hand-tied ligating loops, pre-

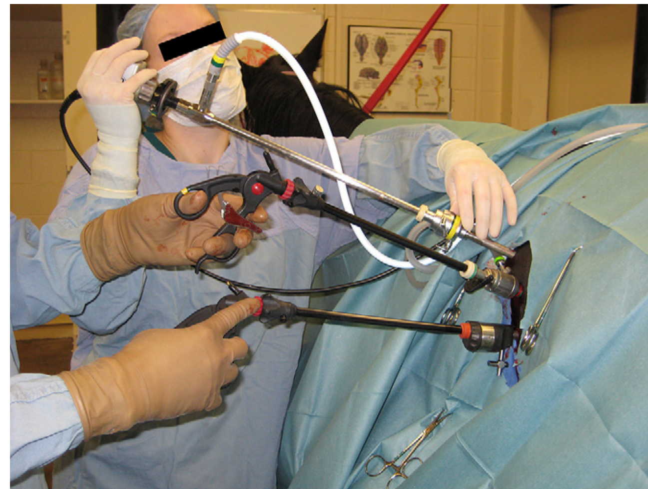

Figure 2. Portal placement in left flank.

tied ligating loops, bipolar and monopolar electrosurgical forceps, ultrasonic cutting/coagulating devices, radiofrequency devices, surgical staples, and lasers. The ultimate objective in ovariectomy experiments is to find a method that facilitates the ovarian resection and removal with minimal hemorrhage and ovarian manipulation.[5]

Ligating Loops

Intracorporeal suturing in laparoscopic surgery requires extensive skill and practice. Consequently, other suture techniques have been developed to provide a simpler ligation technique using loop sutures. The most common suture combinations are size 2 or 3 polyglactin 910 (Vicryl, Ethicon) in a modified Roeder knot,[1] size 1 polyglyconate (Maxon, Covidien) using a 4-S modified Roeder knot,[3,6] or the pre-tied Endoloop (size 0 polyglactin 910 or polydioxinone, Ethicon Endosurgery). All of these knots are designed to slip while advancing but to lock into place when tightened. In the study by Shettko et al,[6] the combination of the 4-S modified Roeder knot, and size 1 Maxon was significantly stronger than all other suture and knot combinations tested.

The caudal pole of the ovary is sharply dissected to reduce the pedicle size (Fig. 3), and two ligating loops are placed on the ovarian pedicle (Fig. 4). The ovary is grasped with forceps through the ligature loop and then manipulated to tease the loop around the newly created ovarian pedicle. It is generally effective to twist the ovary through the loop. Once the pedicle is snared, the loop is tightened by advancing the knot pusher while pulling the tail end of the ligature. The knot pusher is then exchanged for scissors, and the tail of the ligature is cut and removed; this is repeated. The ovarian pedicle is then carefully transected with laparoscopic scissors between the ovary and ligature and checked for bleeding (Fig. 5). Specific equipment for this technique

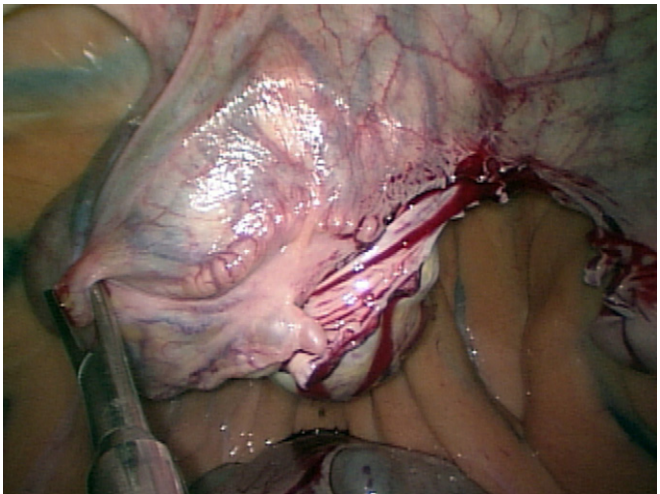

Figure 3. Photo showing dissection of the caudal pole of the left ovary.

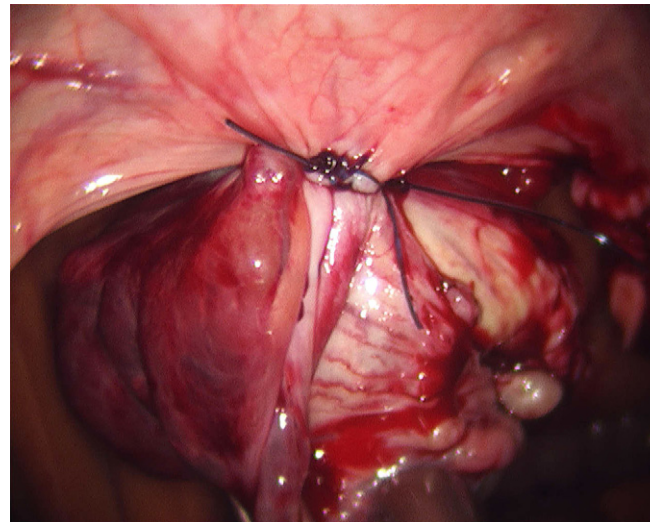

Figure 4. Photo showing two ligating loops on the left ovarian pedicle.

includes a knot pusher, a 5-mm reducer, a suture scissors, and a tissue scissors.

No major complications have been associated with this technique. In a few circumstances, incomplete hemostasis occurs, which is very easily resolved with an additional ligature or by placement of a ligating clip. Hemostasis also can be achieved without ovarian pedicle dissection, but it often results in reduced ligature security. Limits to this technique occur when the ovaries are larger than 15 to 18 cm in diameter, because it is difficult to control such a large loop in the abdomen.

Polyamide Tie-Rap

Another technique used to perform mesovarian ligation is through the use of a white-colored, commercially available polyamide tie-rap, more commonly known as a zip-tie.[7] The tie used is 500 mm long, 4.8 mm wide, and 1.2 mm thick. Sterilization of the tie-rap can be done using gas plasma sterilization, steam, ethylene oxide (which minimizes elongation of the material), and autoclave techniques. The tie is manually marked every 20 mm before initiation of the surgery to ensure that the tie-rap tightens adequately during surgery. The polyamide tie-rap is prepared by creating a loop and connecting it to a hooked metal bar. The metal bar tie-rap unit is inserted in the metal tube, and cervical forceps are inserted to grasp the ovary and provide tension on the mesovarium. Curved Metzenbaum scissors are inserted through the second portal and are used to slightly transect the mesovarium, on the caudal and cranial ends. The scissors are then removed, replaced by tie-rap unit, and the loop is set horizontally and under the ovary. The loop typically slides quite easily over the ovary due to the stiffness of the polyamide tie. With the traction from the cervical forceps on the ovary, the loop

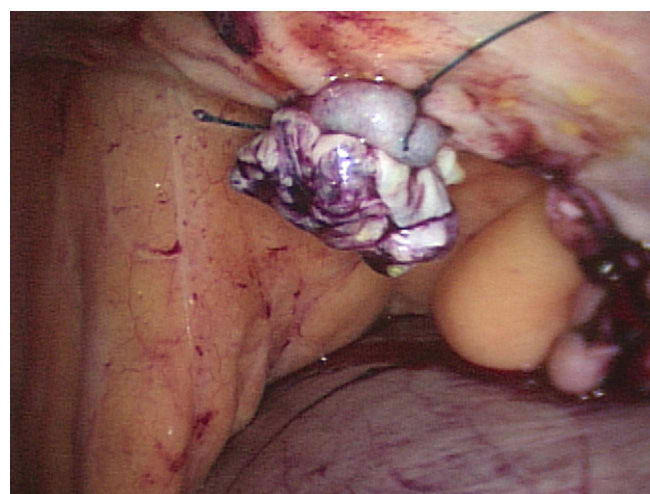

Figure 5. Photo showing transected stump after amputation of left ovary.

is positioned as high as possible on the pedicle and then tightened by pushing up on the buckle of the tie rap with the metal tube while pulling on the end of the tie-rap with the hooked metal bar. The tie-rap is tightened until the surgeon sees the buckle rest between marks 3 and 4. The metal bar is then removed and replaced by tissue forceps, which is used to completely tighten the loop. The cutter–sleeve unit is inserted to cut off the end of the tie rap, and the ovary is then completely transected from the mesovarium with laparoscopic scissors.

Few complications were noted in this report. Mesovarial hemorrhage can occur if the vessels are not entirely occluded, which is easily fixed with the application of a second tie-rap proximal to the first. Two weeks after surgery, the tie-rap and mesovarial stump is partially encapsulated with yellowish fibrovascular tissue, at 4 weeks encapsulation is complete, and at 12 weeks, the stump is entirely encapsulated with organized fibrous tissue.

The polyamide tie is inexpensive and widely available at any hardware store. Because the polyamide polymer is a nylon monofilament material, it is biologically inert and noncapillary. Its melting point is 250°C, which is important to remember when sterilizing. The suture material is nonabsorbable and can elicit an inflammatory reaction but typically does not cause problems. The major advantage of using the polyamide tie-rap is that the loop to be placed around the ovary is rigid and is therefore easier to apply in comparison with a ligature. The 14-cm-diameter loop can be a limitation when it is insufficient to allow passage of a large ovary. Larger tie-raps are available, however, which minimize this problem.

Electrocoagulation

Bipolar cautery can be used to provide hemostasis of the ovarian pedicle.[2] This procedure involves the use of basic laparoscopic tools and bipolar forceps to provide hemostasis of the mesovarium. Bipolar cautery provides a safer environment than monopolar cautery, because there is a reduced likelihood of collateral damage from aberrant currents.

Laparoscopic grasping forceps are inserted through one instrument portal to provide traction on the ovary. The bipolar electrosurgical instrument is inserted through either the most cranial or the most dorsal instrument portal. Pedicle dissection is initiated when the electrosurgical forceps are placed across the cranial aspect of the mesovarium approximately 1 cm proximal to the ovary. The cranial mesovarium is coagulated until blanching and shrinkage are observed. The laparoscopic scissors then replace the atraumatic grasping forceps, and coagulation and transaction is repeated caudally until the ovary is only suspended by the tubal membrane, oviduct, and proper ligament of the ovary. The electrosurgical instrument is replaced with grasping forceps to grab the ovary. Laparoscopic scissors are used to transect the remaining mesovarium, which now lacks any major blood vessels. Once the ovary is transected, the mesovarium is observed for bleeding before laparoscope removal.

The advantages of electrosurgery are that it is less technically demanding than ligature placement; however, it does require more equipment to purchase and maintain. It can generally provide adequate hemostasis of the mesovarium and consequently a dry surgical field. However, it is generally limited to coagulating vessels of 3 mm in diameter or less. Thermal injury to bowel from stray currents can lead to perforation and subsequent life-threatening postoperative peritonitis. This can occur because of insulation failure in the active electrode, direct coupling, or capacitive coupling. These complications can be reduced by avoiding the use of high-power settings, energizing the active electrode only when it is in contact with the target tissue, keeping the active electrode in the field of view, not inserting metal cannulas through plastic devices, avoiding touching the active electrode to other metal instruments, and avoiding long activation of the active electrode. The standing position helps minimize injury because the ovary and mesovarium are located dorsal to abdominal viscera; however, distention of the bowel can cause problems, which emphasizes the importance of withholding feed before surgery.

Ultrasonic Cutting and Coagulating Devices

Ultrasonic energy is delivered to the ovarian pedicle to coagulate vessels and cut the tissue of the pedicle.[8,9] Standard laparoscopic instrumentation along with a device for providing the ultrasonic energy are required for this procedure. Two main devices are available, the Harmonic Scalpel (Ethicon Endosurgery) and the Autosonix (US Surgical, Covidien). The units consist of a generator, a foot pedal, and hand piece with a connecting cable, and a blade system. A transducer in the hand piece converts electrical energy from the generator into ultrasonic vibration, 55,000 Hz, which is transmitted along an extending rod to the active blade tip. This energy is sufficient to cause protein disorganization and denaturation, resulting in a sticky protein coagulum capable of sealing vessels up to 3 to 5 mm in diameter. The devices use multiple power settings to empower a blade system that allows a surgeon to control the balance between cutting and coagulation by varying power settings, changing blade configurations, and varying the grip force.

The ovary is stabilized by grasping the infundibulum with laparoscopic claw forceps while the shears are inserted. When using the Harmonic Scalpel (Ethicon Endosurgery), the coagulating shears transect the mesosalpinx, uterine tube, and proper ligament with a sharp blade and the number 5 setting while simultaneously coagulating blood vessels. The vertical part of the ovarian pedicle is transected using the blunt blade and number 3 setting, and the first cuts are made on the most cranial part. The shears are exchanged for laparoscopic scissors, and the remainder of the ovarian pedicle is separated into medial and lateral components by blunt dissection. The laparosonic coagulating shears are reintroduced into the craniodorsal portal, and the lateral aspect of ovarian pedicle is transected followed by the medial aspect.[8] A similar technique is performed using the Autosonix (US Surgical, Covidien) except that a single pair of shears is used[9] (Fig. 6).

The advantages of using an ultrasonic device are that it is simple to use and it is capable of grasping, coagulating, and cutting tissue simultaneously. It minimizes the number of

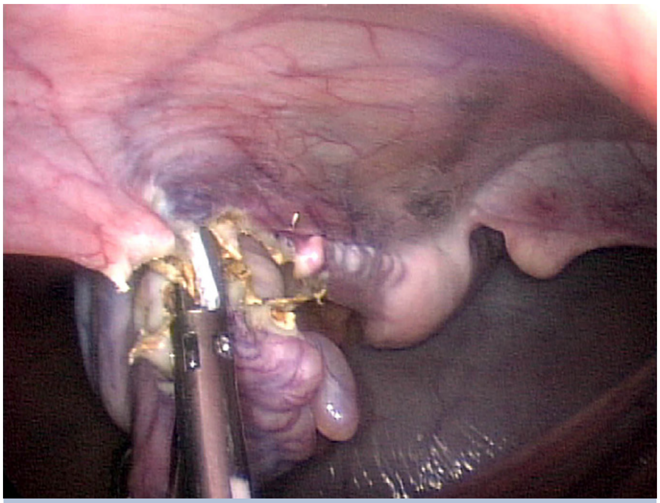

Figure 6. Intra-abdominal view of cauterization and amputation of the left ovary using the ultrasonic cutting/coagulating shears (Autosonix, US Surgical, Covidien).

Figure 7. Intraabdominal view of cauterization and amputation of the left ovary using a radiofrequency wand (LigaSure, Covidien).

instrument exchanges needed to complete the procedure, and the surgeon can control the balance of coagulation and cutting by varying the power setting, blade configuration, and tissue pressure. The shears are easy to use and achieve reasonable hemostasis of the ovarian pedicles. In the report by Alldredge and Hendrickson,[9] many of the pedicles required further treatment in the form of ligating clips for hemostasis. The shears can be used to offer further hemostasis. The equipment can be expensive, and the shears are designed to be single use.

Radiofrequency

Radiofrequency can be used to cauterize the ovarian pedicle.[10] The LigaSure (Covidien) device is a feedback-controlled bipolar vessel sealing device used to establish hemostasis. The feedback-controlled electrothermal scaler applies the precise amount of energy to produce a seal of the vessel walls in the form of partially denatured protein. The integrity of the seal is independent of a proximal thrombus and resists dislodgment because the seal is inside the vessel wall structure. Unlike electrocoagulation device, the LigaSure minimizes thermal spread to adjacent tissue and reduces sticking or charring at the seal sites.

The use of the LigaSure does not require the dissection of the mesovarium to create a smaller ovarian pedicle. The instrument is inserted through the appropriate portal and is positioned to begin from either the caudal or the cranial pole of the ovary. The Atlas wand incorporates a cutting blade so that the tissue can be coagulated and cut sequentially without changing instruments. This process is repeated until the ovary is removed, which takes approximately five to seven applications of the LigaSure (Fig. 7).

A technical problem of spark emittance has been reported with mechanical operation of the device when discharging it across tissue. This could be attributable in part to too much tissue forced into the instrument's jaws, or sterilizing and re-using a device designed for single use. The LigaSure is advantageous to use because it does not require dissection of the mesovarium, there is no likelihood of ligature slippage, and no foreign-body reaction occurs because of the suture material. The instrument is effective for vessels up to 7 mm in diameter, and the translucent appearance of the seal indicates a complete lack of blood flow to the cut edge of the pedicle. Although designed to be a single-use instrument, the wand can be sterilized for cost-effectiveness in a hydrogen peroxide/plasma sterilizer.

Endoscopic Stapling

Stapling devices have been part of equine surgery since the 1970s. Recently they have been adapted for endoscopic procedures. The endoscopic stapling devices generally require a 12- or 15-mm-diameter cannula. The Endo-GIA II (US Surgical, Covidien) stapling device is designed to seal ovarian vessels and transect the mesovarium all in a single application. It also is possible to use a disposable specimen pouch for removal of the ovaries from the abdomen.[5]

The mesovarium is dissected to isolate ovarian vessels, creating a pedicle capable of containment within the stapling device. The ovary is manipulated with grasping forceps to incorporate the entire pedicle into both arms of the stapler. The distal aspect of the stapler is typically the most common site of incomplete occlusion, which is important to consider when performing this procedure. Once the pedicle is completely encased in both arms of the stapler, the blade within the stapler is advanced, causing release of the staples and subsequent severing of the pedicle. Any residual attachment of the pedicle that is not incised is transected using laparoscopic tissue scissors. It is critical that the transected pedicle be evaluated for bleeding before removal of the ovary. The detached ovary can then be placed in the EndoCatch II (US Surgical, Covidien) disposable specimen pouch, previously inserted into abdomen through the dorsal instrument portal. In the report reviewed, the right ovary was placed into the bag and then the left ovary directed toward the caudal aspect of the right abdomen by passing it between the bladder and the body of the uterus. To perform this step more carefully, the camera is moved to the left flank for better visualization and then moved to the right flank for removal. Once both ovaries are in the pouch, it is closed with a drawstring and pulled tightly against the flank. The right abdominal incision is then enlarged to pull the bag through the body wall, and all incisions are closed.

Bleeding from the pedicle can occur when the initial dissection is too close to the ovary. The advantages of using this technique are the simultaneous hemostasis of the ovarian vessels and transection of the ovary. The disadvantage is the cost of the staple cartridge and bag if used. The main advantages of using a laparoscopic stapling device technique compared with a suture are the shorter surgical time, that the ovary is resected from the mesovarium immediately without the need for transaction after individually ligating vessels, and that there is no risk of inadvertently cutting the suture or displacing the knot during amputation. The primary advantage of using the EndoCatch II device is the avoidance of losing the ovary during transfer to another grasping instrument, given there is sufficient space in the bag for both ovaries. The disadvantage associated with this technique is the increased surgical time needed to control bleeding when ovarian vessels are inadvertently transected, which can be corrected with electrocautery or laparoscopic clips.

CONCLUSIONS

The primary advantages of standing laparoscopic surgeries are excellent intraoperative visibility, secure hemostasis, reduced surgical and postoperative morbidity, decreased postoperative discomfort, rapid and uncomplicated healing, reduced quantity of medication needed, shorter postoperative management, and less expense than for ovariectomies performed under general anesthesia.[3]

There have been few reported significant complications associated with standing laparoscopic ovariectomy. Choosing the appropriate animals to undergo standing surgery under sedation is the most important first step. If the mare is not amenable to a standing surgical procedure performed in the stocks, it should be anesthetized. Bleeding from the pedicle can be managed immediately because the procedure allows direct visualization of the surgical site. It is possible to drop the ovary into the abdomen after amputation; it is generally considered important to find the ovary and remove it from the abdomen. In most cases, this can be done using laparoscopic instruments. In some cases, it requires an enlarged incision and identifying the ovary manually for removal.[2] Sometimes ovaries with large follicles are difficult to exteriorize and are incised and drained in the abdomen to decrease ovarian size and avoid slippage during removal.[7] Most mares are clinically normal immediately after surgery. The tension-free amputation is believed to be less painful than traditional techniques. There are reports of mares that have a slight decrease in appetite and increase in temperature for the first 12 hours postoperatively or that experience mild incisional edema and subcutaneous emphysema, which often resolves in 3 to 5 days.[1] Mares often show mild signs of colic and are given a single dose of flunixin meglumine, which has been shown to be useful.[2]

All of the reported techniques are useful in equine ovariectomy. Of the techniques discussed in this review, the ligating loop is the least expensive but requires the most skill. The LigaSure device requires the least skill and is similar in cost to the other techniques. The authors recommend using the ligating loops for normal-sized ovaries and the LigaSure device for ovaries larger than 15 to 18 cm. In a recent retrospective study evaluating the clients' perspective on standing laparoscopic ovariectomy, behavioral improvement was seen in 83% (19/23) of mares treated for behavior-related problems, aggression problems improved in 86% (12/14) of cases, general disagreeable demeanor improved in 81% (17/21), and excitability improved in 75% (12/16) of cases where these behaviors had been previously observed. Kicking and biting improved in 73% (8/11), problems in training improved in 72% (13/18), and frequent urination and problems with other horses improved in 64% (7/11 and 9/14, respectively) of cases.[11]

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Surgical Approaches to Ovariectomy in Mares

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KEY FACTS

- When performing ovariectomy by a colpotomy (vaginal) approach, proper positioning of the vaginal incision is necessary to prevent fatal complications.
- A colpotomy approach should not be used to remove ovaries larger than 8 to 10 cm in diameter; ovaries up to 15 cm in diameter can be removed safely through a flank approach; and larger ovaries should be removed through a celiotomy incision.
- Laparoscopic ovariectomy techniques allow optimal visualization and tension-free ligation to maximize hemostatic security.
- A wide variety of complications of differing severity (from mild to fatal) can follow any ovariectomy technique.

ABSTRACT: The preoperative considerations, surgical techniques, postoperative care, and complications associated with the surgical techniques available to perform unilateral or bilateral ovariectomy in horses are described. Standing techniques described include the colpotomy (vaginal), flank laparotomy, and laparoscopic approaches. Procedures that require general anesthesia, including flank laparotomy, ventral midline celiotomy, paramedian celiotomy, diagonal (oblique) paramedian celiotomy, and laparoscopic approaches, are also discussed. Complications following surgery can range from mild incisional swelling and pain to fatal intraabdominal hemorrhage or eventration. Careful consideration of the advantages and disadvantages of each procedure allow equine surgeons to select the most appropriate approach for each patient.

Equine ovariectomy is a commonly performed elective surgical procedure. Various surgical approaches are used for unilateral or bilateral ovariectomy. The surgical approaches described include vaginal or colpotomy, flank, diagonal or oblique paramedian, ventral midline, caudal paramedian, and numerous laparoscopic techniques. The decision as to which approach to use for a particular case depends on the following factors:

- Specific indications for ovariectomy
- Size of the affected ovary
- Surgeon's preference
- Financial constraints imposed by the client
- Temperament of the mare
- Equipment available
- Client expectations

An understanding of the benefits and disadvantages of all approaches can aid the clinician in selecting the appropriate surgical approach for each patient. This article reviews the surgical approaches used to perform unilateral and bilateral ovariectomy in mares.

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PREOPERATIVE CONSIDERATIONS

Special preoperative preparation of the mare should be instituted before performing ovariectomy. Food should be withheld for 12 to 24 hours before surgery to help decrease the amount of ingesta and gas within the gastrointestinal tract, thereby making it easier to exteriorize the ovary and suture the abdominal wall incision. Depending on patient positioning, laparoscopic techniques require that food be withheld for 12 to 48 hours prior to surgery[1,2] to improve visualization of intraabdominal structures and to decrease the likelihood of penetrating a viscus when the laparoscopic instruments are introduced into the abdomen.[3–7]

Abdominal palpation per rectum (with or without ultrasonographic evaluation) is useful in detecting abnormalities associated with the reproductive tract and should be performed in all mares presenting for ovariectomy regardless of the reason. Results of this evaluation may help dictate the necessary surgical approach based on the palpable size of the ovary to be removed. In addition, identifying pathology, such as adhesions or abscessation associated with the reproductive tract, may provide valuable information regarding the optimal surgical approach.

The rationale for and use of antibiotics to treat horses undergoing ovariectomy vary among surgeons. If antibiotics are used, they should be administered preoperatively to ensure that adequate systemic concentrations are present at the time of surgery. Administration of broad-spectrum antibiotics should be continued postoperatively if a break in aseptic technique occurred during the procedure. Tetanus prophylaxis should be administered routinely when performing ovariectomy.

SURGICAL PROCEDURES

Vaginal Approach (Colpotomy)

In 1903, Williams first described a vaginal approach, or colpotomy, using an ecraseur to ovariectomize mares.[8] The vaginal approach is now commonly used to perform a bilateral ovariectomy in normal mares, but unilateral removal of a suspected granulosa–theca cell tumor less than 8 to 10 cm in diameter can also be performed using this approach.[9,10] There are several advantages to the colpotomy technique, including the fact that it is performed as a standing procedure, minimal instrumentation is required, the procedure can be performed quickly, excellent cosmetic results can be expected, and the convalescent period following surgery is relatively short.

Ideally, mares should be in diestrus or anestrus because ovarian vasculature is believed to be minimized at these times.[11] Mares are restrained in standing stocks and sedated. Sedation is most commonly accomplished with an α_2-agonist and butorphanol to provide analgesia as well as profound sedation. Acepromazine can be administered for tranquilization as well. Administration of caudal epidural anesthesia is unnecessary but is recommended by some surgeons to help prevent the mare from straining during the procedure.[12,13] The tail is wrapped and secured away from the perineal region, and all manure should be evacuated from the rectum to prevent contamination of the external genitalia. Routine aseptic preparation of the external genitalia and perineal region is performed, and the vagina is lavaged with sterile saline or dilute povidone–iodine solution. In some mares, catheterization of a large urinary bladder may facilitate the procedure and may help reduce the risk of inadvertent injury during the procedure.[14–16]

The location of the initial incision in the cranial fornix of the vagina is very important. The incision must be placed in either a craniodorsal (at the 2- or 10-o'clock) or a cranioventral (at the 4- or 8-o'clock) position. Potential complications of a misplaced incision include entering the rectum if the incision is placed too dorsal, injuring the urethra or bladder if placed too ventral, and incising the caudal uterine branch of the urogenital artery if too medial or lateral (at the 3- or 9-o'clock position).[11,17,18] The incision should be started 3 to 5 cm caudal to the os cervix to avoid disruption of the cervical musculature.[12,14,16] Using a scalpel blade, scissors, or mosquito hemostat, a small 1- to 3-cm vaginal incision is sharply/bluntly created. This initial incision should penetrate the full thickness of the vagina and peritoneum to prevent the peritoneum from lifting away from the underlying tissues during blunt dissection. The incision is then bluntly enlarged digitally, and the peritoneum is perforated to allow the surgeon's hand to enter the abdomen. The ovary and associated mesovarium are isolated by direct manual palpation. Anesthesia of the mesovarium can be attempted using gauze sponges soaked with local anesthetic, which are held around the mesovarium for 30 seconds to 2 minutes. To prevent loss of the sponges within the abdomen, a long suture or strand of umbilical tape should be secured to the sponges.[13,16,19]

To transect the ovary from the mesovarium, a chain ecraseur is used to slowly crush and cut the mesovarium. The chain ecraseur should be carefully placed around the mesovarium, ensuring that bowel, intestinal mesentery, or a portion of the uterine horn is not encircled by the chain.[12,17,18] Once the chain is properly positioned, it is tightened slowly (over 1 to 4 minutes) using the ratchet system of the ecraseur. Hemostasis of the mesovarium depends on crushing the vascular structures and the resulting vasospasm. While the ecraseur is being tightened around the ovary, the ovary should be held within the surgeon's hand to prevent losing it within the abdomen. The contralateral ovary may be removed via the same vaginal incision if a bilateral procedure is to be performed. The vaginal incision is left open to heal by second intention. Optionally, an episioplasty (Caslick's procedure) may be performed to complete the surgery in an effort to decrease the risk of ascending infection.[11]

Tie stall restriction for 2 to 7 days postoperatively has been advocated to prevent recumbency and reduce the risk of evisceration.[13,19,20] However, some authors suggest that this is unnecessary and report no adverse effects with routine stall confinement.[11,17] Exercise restriction is employed for 1 to 3 weeks following surgery, depending on the rate of healing of the vaginal incision. During this time, limited hand walking or small paddock turnout is important to reduce the potential formation of adhesions to the ovarian stump.[11,15,18] Light riding and a slow return to normal work are allowed after this time.

The primary disadvantage to the colpotomy approach is the lack of visualization.[21] By palpation alone, the ovary must be differentiated and isolated from the omentum, local mesentery, loops of intestine, and fecal balls within the small colon.[12,22] Hemorrhage from the mesovarium may be difficult to determine and control due to the lack of visualization with this approach.[13,21] Postoperative administration of broad-spectrum antibiotics may be indicated in mares undergoing a vaginal approach because it is difficult to adequately prepare the vagina for aseptic surgery. This approach is not recommended in mares that pool urine or in mares with vaginal, cervical, or uterine infections.[14,18,22] Ecraseur transection of large ovaries (larger than 8 to 10 cm in diameter) should not be attempted due to the size of vaginal incision needed to remove the ovary, the possibility of dropping the ovary within the abdomen, and the enlarged vascular supply associated with larger ovaries.[10,11,13,18,23] Even with adequate restraint and heavy sedation, this approach poses a risk to the surgeon due to positioning behind the mare.[12,22] Thus only tractable mares are good candidates for this procedure.

Flank Approach

The flank ovariectomy approach can be performed with the mare in the standing or recumbent position. To perform a standing flank laparotomy, the mare's temperament must be amenable to standing surgery. When performing a standing flank laparotomy, the mare is sedated, restrained in standing stocks, and the tail is wrapped and secured away from the surgical site (as described for the colpotomy procedure). For the recumbent technique, mares are placed in lateral recumbency so that the ovary to be removed is uppermost. The recumbent flank technique requires general anesthesia, resulting in a slightly greater cost to the client and potentially increased risk to the mare. The recumbent flank technique is generally only used for unilateral ovariectomy, as it offers easy access to only one ovary.[14]

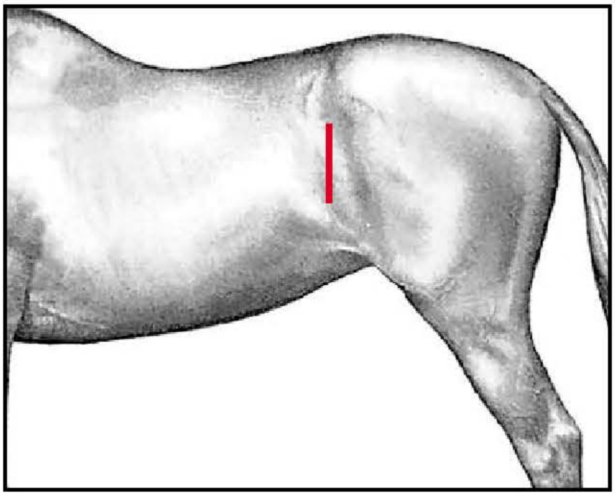

Figure 1—Position of paralumbar flank incision for ovariectomy between the 18th rib and tuber coxae. This incision position can be used in both standing and recumbent horses.

Compared with the colpotomy approach, both the standing and recumbent flank laparotomy approaches enable the surgeon to remove larger ovaries and give better exposure of the mesovarium, thus potentially providing superior hemostasis.[13,19,22] The ovary is normally situated beneath the paralumbar fossa. In horses, the limited size of the paralumbar fossa (compared with bovines) and the thickness of the body wall in the flank region may limit the ability to easily exteriorize large ovaries.[10,11,24] Ovaries up to 15 cm in diameter can be removed easily through a flank approach.[9,18,23] Bilateral ovariectomy typically requires a second incision through the opposite paralumbar fossa to remove the contralateral ovary. In the standing mare, bilateral ovariectomy can be achieved through a single flank incision, but the contralateral ovary must be excised blindly within the abdomen using a chain ecraseur.[12,14,19]

Regardless of positioning, the paralumbar fossa is clipped, aseptically prepared, and draped. Regional anesthesia in the form of an inverted L-block or local infiltration of the proposed incision site is required in standing mares.[11,12,24] The incision is started 5 cm ventral to the lumbar transverse processes between the 18th rib and the tuber coxae and is extended ventrally 10 to 15 cm as needed, depending on the size of the ovary to be

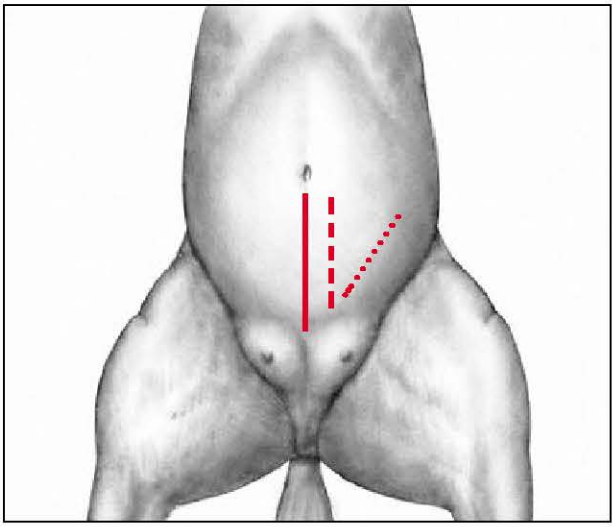

Figure 2—Position of traditional celiotomy incisions performed under general anesthesia with the horse in dorsal recumbency. *Solid red line* = ventral midline approach; *dashed line* = paramedian approach; *dotted line* = diagonal (oblique) paramedian approach.

removed (Figure 1). Following incision of the skin and subcutaneous tissues, a grid or modified grid approach may be used to incise the abdominal musculature. The grid approach creates a slightly smaller opening into the abdomen and should only be used for ovaries less than 10 cm in diameter; larger ovaries will necessitate use of the modified grid technique.[13,14,19] A grid approach involves separating the external abdominal oblique muscle along the direction of its fibers, whereas a modified grid technique involves incising this muscle along the line of the skin incision.[14] For both techniques, the internal abdominal oblique and transversus abdominis muscles are bluntly separated along the direction of their fibers or incised to expose the peritoneum. The peritoneum may be incised or bluntly perforated to allow access to the abdomen. The ovary is then identified and isolated. In standing mares, the mesovarium is anesthetized by topical administration of anesthetic, similar to that described for the colpotomy procedure, or by direct injection of anesthetic into the mesovarium, if visualization permits. The ovary may be transected within the abdomen or after exteriorization. Aspiration of cystic cavities within the ovary may reduce the overall ovarian size and facilitate exteriorization.[9,10,18] The means to achieve hemostasis and transection of the mesovarium depend on the ability to exteriorize or visualize the mesovarium through the flank incision. Possible choices include the use of a chain ecraseur, emasculator, surgical stapling device, or transfixing ligatures.[11,14,16,19,24] Following removal of the ovary, the mesovarium is observed for hemorrhage and oversewn if desired, when adequate visualization permits. Oversewing the mesovarium with 2-0 absorbable suture material may reduce possible intraabdominal adhesions of a segment of bowel to the transected mesovarium.[14,18] Closure of the laparotomy incision is routine.

Postoperative pain and discomfort may be observed in association with the flank incision. Incisional swelling and discharge may be noted 24 to 72 hours after surgery.[24,25] Incisions created in a more ventral position on the flank tend to develop more swelling and cause increased postoperative pain and discomfort.[24] Incisions in the flank have been associated with incisional discharge and partial dehiscence.[13,14,22] Occasionally, this approach results in a poor cosmetic outcome if scarring of the incision site occurs.[10-12] Exercise should be restricted to hand walking or turnout in a small paddock for 4 to 6 weeks following surgery, after which light riding and a slow return to normal work may be allowed, provided the incision has healed without complications.

Diagonal (Oblique) Paramedian Approach

The diagonal (oblique) paramedian approach has been reported to be superior to other approaches for ovariectomy, especially for the removal of ovaries up to 20 to 25 cm in diameter.[26,27] Because the incision is created so close to the intraabdominal position of the ovary, exteriorization through a diagonal paramedian incision generally results in less traction being placed on the mesovarium. In addition, the body wall is thinner at this location, as compared with other approaches, which allows greater flexibility in retracting the wound edges. Improved visualization of the ovary and mesovarium can often be achieved with this approach. Bilateral ovariectomy can be performed; however, two incisions are generally required. General anesthesia is necessary to perform an ovariectomy with this approach; therefore, the cost and risks associated with recumbency are also associated with this technique.

Perioperative preparation and care is similar to that for the previously described approaches. Following induction of general anesthesia, the mare is placed in dorsal recumbency. Slightly tilting the mare toward the side opposite the affected ovary helps minimize the tendency for bowel to protrude from the incision. Following routine aseptic preparation of the ventral abdomen, an incision is started approximately 5 to 10 cm cranial to the ipsilateral mammary gland and extended approximately 20 cm (or as needed, depending on the size of the affected ovary) cranially and laterally toward the fold of the flank[11,15,16] (Figure 2). The incision is extended through the underlying external rectus sheath, parallel to the initial skin incision. The rectus abdominis, internal rectus sheath, and peritoneum are bluntly divided in the direction of their fibers or incised (depending on surgeon preference) to allow access to the abdomen.[13,18,26] The ovary is located and exteriorized. Local anesthesia of the mesovarium, either by topical application of anesthetic-soaked gauze sponges or direct injection of local anesthetic, may be used to diminish the pain response secondary to traction on the ovary.[16,28] Fluid within cystic cavities may be aspirated to reduce the size of the ovary and facilitate its removal from the abdomen.[16,23,27] Large suture material placed as stay sutures within the ovary and retraction on the incision edges may aid the surgeon in exteriorizing large ovaries. Overlapping transfixation ligatures of No. 2 absorbable suture material or application of a TA-90 stapler (US Surgical) may be used for hemostasis prior to transection of the mesovarium.[15,18,26,29] Ligatures should be tightened and staples should be applied to the mesovarium in a relaxed position; application under tension may result in failure to provide adequate hemostasis.[13,19,28] Following complete transection of the mesovarium, closure of the abdominal incision is routine. Due to the location of the incision on the ventrum, a good cosmetic outcome usually follows ovariectomy by the diagonal paramedian approach.[11]

Exercise restriction during the early postoperative period should consist of stall confinement with hand walking for the first 2 to 4 weeks following surgery.[11,27] After this time, small paddock turnout may be allowed for an additional 2 to 4 weeks of confinement,[11] the actual length of restriction depending on the individual patient's wound-healing progress. Return to a full exercise schedule and/or the allowance of natural service should not be allowed for at least 8 to 12 weeks postoperatively.[27] Mares may be bred by artificial insemination when the estrous cycle occurs following surgery.[15]

Ventral Midline Celiotomy Approach

A ventral midline celiotomy approach offers good exposure of the ovaries in the majority of mares.[14,15,28] The ventral midline incision can easily be extended as necessary, depending on the individual case, making it the technique of choice for removal of extremely large, tumorous ovaries.[13,19] The ventral midline approach is generally used to remove very large granulosa–theca cell tumors but can also be used to perform a bilateral ovariectomy.[11,15,16,23,25] A good cosmetic outcome is expected with this approach, provided no complications with incisional healing occur.

Perioperative preparation and care are similar to previously described approaches. For a ventral midline technique, general anesthesia is required and the mare is placed in dorsal recumbency. A caudal ventral midline linea incision is created, beginning at the mammary gland and extending cranially 25 to 35 cm as needed for adequate exposure[13,14,29] (Figure 2). The ovary is located by manual palpation and exteriorized. Local anesthesia of the mesovarium can be used if desired. Topical application of anesthetic-soaked gauze sponges or direct injection of the mesovarium with local anesthetic may decrease the pain response related to traction on the mesovarium.[16,28] Intraoperative hypotension believed to cause myopathies and neuropathies has been associated with excessive traction on the mesovarium, and these complications may be reduced by the application of local anesthetic.[28] Hemostasis and transection of the mesovarium are similar to what was described for the flank and diagonal paramedian approaches. Closure of the ventral midline incision is routine.

Postoperatively, care is similar to the other ovariectomy approaches. Stall confinement with hand walking should be enforced for the first 2 to 4 postoperative weeks, at which time sutures or staples used to close the ventral incision should be removed.[19] Small paddock turnout may be allowed after this, for an additional 2 to 4 weeks of confinement, after which light riding or pasture turnout may be allowed.[14] Full exercise should not be allowed for a minimum of 8 to 12 weeks after surgery, depending on the progress of incisional healing.[13,14]

Paramedian Approach

The paramedian approach can be used to remove large pathologic ovaries or to perform bilateral ovariectomy through one (contralateral ovary must be transected blindly) or two incisions.[18,19,23,25,28,30,31] The paramedian approach is similar to the ventral midline approach except for the location of the incision. The incision is made 4 to 8 cm lateral to midline and extends cranially from the level of the mammary gland for 25 to 35 cm or as needed for adequate exposure[16,19] (Figure 2). Methods to exteriorize the ovary and provide hemostasis of the mesovarium are similar to those described for other approaches. Postoperative care following a paramedian celiotomy is similar to the ventral midline and diagonal paramedian approaches.

Laparoscopic Techniques

In the past 10 years, laparoscopic ovariectomy techniques have been described for mares in the standing[3,4,32–34] and dorsally recumbent[2,4,5,21,34,35] positions. Laparoscopic techniques can greatly improve visualization of the ovary and mesovarium, potentially decrease postsurgical complications, and allow tension-free ligation of the vessels within the mesovarium.[2,3,21,32,33] How-

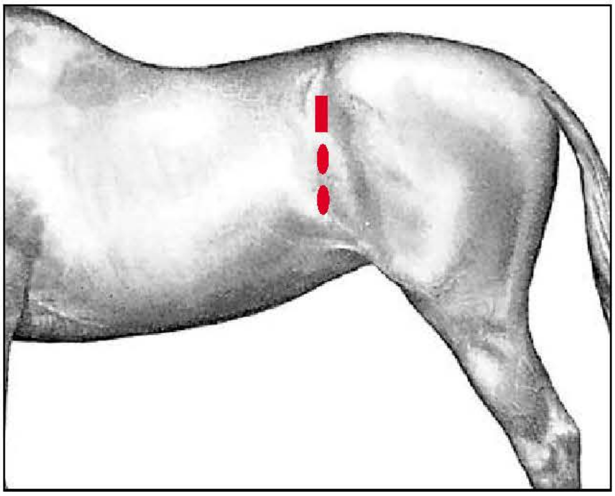

Figure 3—Position of the laparoscope *(rectangle)* and instrument portals *(ovals)* for laparoscopic ovariectomy in the standing horse. The laparoscope portal is positioned between the 18th rib and the tuber coxae, just dorsal to the crus of the internal abdominal oblique muscle. Instrument portals are created 4 to 8 cm ventral to the laparoscope portal.

ever, important considerations when performing equine laparoscopic ovariectomy include the requirement of specialized equipment, the technical difficulty of certain procedures, and the potential for anesthetic complications in horses placed in the Trendelenberg position.[4,21,33] Additionally, the use of laparoscopic equipment may be cost prohibitive in certain situations.[3,21]

Laparoscopic Ovariectomy in the Standing Mare

Laparoscopic ovariectomy in the standing mare avoids the need for general anesthesia, eliminates the cardiovascular derangements associated with the Trendelenberg position, and shortens the required preoperative fasting time (12 hours instead of 24 to 48 hours).[1,3,32] Mares are sedated using either xylazine hydrochloride or detomidine hydrochloride in combination with butorphanol tartrate. For bilateral ovariectomy, both paralumbar fossae are prepared for aseptic surgery and draped. The paralumbar fossa is desensitized using regional anesthesia or by direct infiltration of the proposed laparoscope and instrument portal sites.[4,5,36] The abdominal cavity can be insufflated with carbon dioxide through either a Verres-type needle inserted dorsally in the paralumbar fossa or a teat cannula inserted ventrally, as if performing abdominocentesis.[7,37] As an alternative (to avoid the potential complication of inadvertently insufflating the retroperitoneal space), the trocar–cannula can be inserted through the paralumbar fossa prior to insufflation of the abdominal cavity.[6,32,33,38]

A 15-mm skin incision is made at the dorsal border of the internal abdominal oblique muscle, and the sharp laparoscopic trocar–cannula is introduced into the abdominal cavity perpendicular to the paralumbar fossa[1,3,4,39] (Figure 3). The trocar is replaced by the laparoscope, and the caudal portion of the abdomen is examined to identify the ovary. The first instrument portal is made 4 to 8 cm ventral to the laparoscope portal, and a second instrument portal is made 4 to 8 cm ventral to the first[4] (Figure 3). Trocar–cannula units are passed through each instrument portal perpendicular to the flank musculature. Using a long spinal needle inserted separately through the flank musculature or a laparoscopic injection needle placed through a cannula, the mesovarium can be infiltrated with local anesthetic.[5,31,38] Hemostasis of the mesovarium can be achieved using suture ligatures, staples, laser energy, electrosurgical instrumentation, a vessel-sealing device, or a harmonic scalpel.[1,3,32,33,36,38–41] The ovary is transected using laparoscopic scissors distal to the site of ligation or coagulation. The ovary is removed by enlarging one of the instrument portals or by connecting the two instrument portals.[5,36] After removing the ovary, the abdomen is deflated through a laparoscopic cannula. The superficial abdominal fascia and skin at the portals are closed separately. The same procedure is then performed through the opposite paralumbar fossa to remove the contralateral ovary in bilateral procedures.

A hand-assisted laparoscopic ovariectomy technique in standing mares can be used to remove granulosa–theca cell tumors as well.[42] A standard flank approach is used, but the process of injecting local anesthetic into the mesovarium, application of a surgical stapling device, and transection of the mesovarium is performed intraabdominally with digital manipulation while using laparoscopic observation of the procedure.[42] After transecting the ovary from its mesovarium, the ovary is placed within a sterile plastic bag and sharply transected. Placing the ovary within the bag facilitates removal through a smaller incision and prevents abdominal and body wall contamination from the ovarian cystic fluid.[35,42] The standing, hand-assisted, laparoscopic ovariectomy technique is technically easy to perform, can be used for large pathologic ovaries (up to 30 cm in diameter), allows accurate placement of the staple line, and eliminates the potential risks and costs associated with general anesthesia.[42]

Laparoscopic Ovariectomy in the Anesthetized Mare

To perform unilateral or bilateral ovariectomy in an anesthetized mare using laparoscopy, the horse is anesthetized and positioned in dorsal recumbency, and the

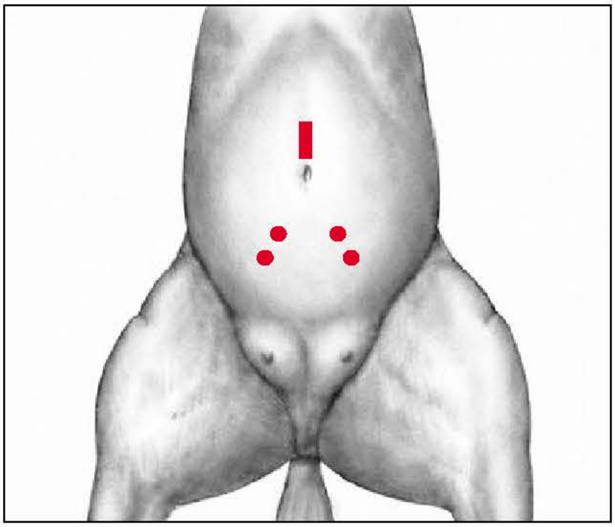

Figure 4—Position of the laparoscope and instrument portals for ovariectomy in the dorsally recumbent horse under general anesthesia. The laparoscope portal *(rectangle)* can be positioned just cranial to the umbilicus or just lateral to the umbilicus. Instrument portals *(dots)* are created between the laparoscope portal and the ipsilateral mammary gland.

tail is secured to the surgery table. The caudal abdomen is aseptically prepared and draped. To improve visualization of the caudal abdomen, a urinary catheter can be passed to decompress the urinary bladder.[35,43] A 10-mm skin incision is made just cranial or lateral to the umbilicus (Figure 4). The abdomen is insufflated with carbon dioxide through a teat cannula to a pressure of approximately 15 to 20 mm Hg.[2,4,39] A laparoscopic trocar–cannula unit is introduced into the abdomen, and the trocar is replaced with the laparoscope. In the recumbent technique, patient positioning becomes important for adequate visualization of the caudal abdomen. In routine dorsal recumbency, the female reproductive tract is obscured by intestinal viscera, so the surgical table must be elevated in such a way that the mare's head is lower than the hindquarters. For removing ovaries, an angle of inclination of approximately 30° from horizontal (Trendelenberg position) is generally required.[4,21] Two instrument portals (cranial and caudal) are created on both the left and right ventral abdomen (Figure 4). The cranial instrument portals are located midway between the ipsilateral mammary gland and the umbilicus. The caudal instrument portals are placed midway between the ipsilateral mammary gland and the cranial instrument portal.[35] After creating the four instrument portals, the ipsilateral uterine horn is elevated using a Chambers catheter (Jorgensen Laboratories) inserted through the contralateral caudal instrument portal. A knot push rod equipped with a modified Roeder knot or a commercial suture loop is inserted through the ipsilateral caudal instrument portal (left caudal instrument portal for removing a left ovary).[2] Sharp-toothed laparoscopic grasping forceps are passed through the cranial instrument portal on the same side as the suture loop. The jaws of the forceps are passed through the suture loop and used to grasp the ovary. The suture loop is passed over the ovary and tightened around the mesovarium. The mesovarium is then transected distal to the suture ligature.[21] The transected ovary is maintained in the jaws of the grasping forceps while the same series of steps are reversed to allow removal of the opposite ovary. The abdomen is deflated and the ovaries are removed by enlarging one of the cranial instrument portals. For the enlarged incision, the external fascia of the rectus abdominis, subcutaneous tissue, and skin are closed separately.[21] All remaining incisions are closed by simply apposing the skin.

Because most laparoscopic ovariectomy techniques can be accomplished through small incisions, the mare can be returned to exercise shortly after the procedure is performed. Postoperatively, mares should be confined to a stall for the first 24 hours followed by stall or small paddock confinement for 2 to 3 weeks before they are returned to unrestricted exercise.[33,35,38]

Laparoscopy can be used to remove large ovarian granulosa–theca cell tumors. One report described two mares that had a granulosa–theca cell tumor removed using a recumbent laparoscopic ovariectomy technique.[2] The mares were placed in Trendelenberg position, and the maximum diameter of the ovaries was estimated to be 20 cm in diameter.[2]

Complications that may occur following laparoscopic ovariectomy are similar to those seen with other approaches. Hemorrhage from the mesovarium has been reported following ligature slippage.[1,21] Subcutaneous emphysema may be observed postoperatively if the abdomen is not decompressed adequately prior to closure of the incisions.[32,43]

COMPLICATIONS

Although great advances have been made in the routine use of general anesthesia and surgical technique in horses, ovariectomy remains a procedure in which potential complications may occur, regardless of the approach used. In general, ovariectomy has been associated with greater postoperative morbidity and mortality than for other elective procedures.[10,13,15,22,25] Postoperative hemorrhage from the mesovarium can occur if hemostasis of the mesovarium fails.[3,22,23,44,45] Intraabdominal hemorrhage from branches of the ovarian artery is a serious and possibly fatal complication that may go undetected at the time of surgery. Therefore, mares should be confined to a stall for the first 24 hours after surgery. Clinical signs associated with blood loss include tachycardia, pale mucous membranes, weakness or ataxia, weak thready pulse, and poor jugular distention.[13,18,22] Hemorrhage must be controlled, and initial medical therapy should be aimed at replacing the lost blood volume by intravenous administration of fluids and whole blood.

The vaginal approach also has the potential risk of inadvertently incising the caudal uterine branch of the urogenital artery when making the incision into the abdomen.[11,15] Care to avoid the 3- and 9-o'clock positions will help prevent this potentially fatal complication. Other potential complications reported when performing a vaginal approach include pain and discomfort; injuries to the cervix, bladder, or a segment of bowel; delayed vaginal healing; eventration of bowel, incisional site hematoma, or abscess; intraabdominal adhesions to the vagina; and chronic lumbar or bilateral hindlimb pain.[14,17,19,45]

Reported complications with the other celiotomy approaches vary depending on position. Intraoperative hypotension, myopathies, and neuropathies have been associated with traditional ovariectomy approaches performed under general anesthesia to remove granulosa–theca cell tumors.[13,22,25,45] Tension placed on the mesovarium during the process of exteriorizing an ovary is speculated to cause a decrease in arterial blood pressure and potentially lead to inadequate peripheral circulation.[25]

Cardiopulmonary derangements have been observed during laparoscopic procedures with horses placed in the Trendelenberg position.[21,32,39,46] This positioning exaggerates the force of abdominal insufflation and the weight of abdominal viscera on the diaphragm, decreasing the horse's ability to adequately ventilate without mechanical assistance and potentially compromising venous return to the heart.[21,32] Metabolic acid–base disturbances may also occur following prolonged abdominal insufflation with carbon dioxide, which diffuses easily into the systemic circulation.[39,46] As with traditional surgical approaches, myopathies and neuropathies can be a consequence of prolonged dorsal recumbency.[21] Therefore, proper anesthetic patient monitoring is required when performing laparoscopic ovariectomy with the mare in the dorsal recumbent position.

Regardless of whether the surgery is performed with the mare standing or recumbent, postoperative pain, anorexia, depression, incisional swelling, incisional infections, incisional dehiscence, eventration, peritonitis, intraabdominal adhesions, and death have been reported following ovariectomy in mares.[10,11,13,17,22,25,44,45]

Incisional complications have been associated with ovariectomy techniques to remove granulosa–theca cell tumors.[25] A higher incidence of incisional complications have been observed with approaches through the paralumbar fossa.[14,24,47] This may be associated with the increased amount of dead space and possible muscle necrosis that may occur with the paralumbar approach.[47]

Proper aseptic techniques must be employed when performing ovariectomy procedures, or postoperative septic peritonitis may result.[12,24,25,44] This potential complication can be prevented by adhering to proper aseptic technique throughout the procedure and by the administration of perioperative antibiotics. Intraabdominal adhesions can develop after any abdominal procedure; however, the use of proper aseptic technique and ensuring minimal trauma to gastrointestinal serosal surfaces can help prevent formation of adhesions.[14,28]

Ovariectomized mares may continue to display signs of estrus after ovariectomy. It has been reported that 60% of ovariectomized mares will cease estrous behavior following surgery.[19] If previous hormonal therapy has been successful in altering the mare's behavior and/or performance favorably, then bilateral ovariectomy is likely to be successful at meeting the client's expectations. Prospective "jump" mares to be used for stallion collection should stand well during estrus as an intact mare; otherwise, the individual is not likely to be a good candidate for ovariectomy for this purpose.[48]

CONCLUSION

The equine surgeon presented with a mare requiring ovariectomy has numerous approaches available. The specific approach to be used should be chosen carefully to minimize traction on the pedicle yet allow adequate exposure and visualization of the ovarian pedicle for secure hemostasis. Standing techniques include colpotomy (vaginal), flank laparotomy, and laparoscopy. Traditional techniques that require general anesthesia are flank, paramedian, diagonal (oblique) paramedian, and ventral midline celiotomy approaches as well as laparoscopic procedures. Laparoscopic techniques are superior in providing visualization of the ovaries and tension-free ligation for maximal hemostatic security. However, laparoscopy requires specialized instrumentation and surgical knowledge, which may increase operative time, at least initially, until experience is gained. Each technique for equine ovariectomy has associated advantages and disadvantages, and as such, there is no single "proper" technique to be used for every case. When deciding which approach to use, clinicians should be intent on completing the procedure in the most efficient way, while at the same time minimizing patient discomfort and postoperative complications.

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ARTICLE #5 CE TEST

The article you have read qualifies for 1.5 contact hours of Continuing Education Credit from the Auburn University College of Veterinary Medicine. *Choose the best answer* to each of the following questions; then mark your answers on the postage-paid envelope inserted in *Compendium.*

1. Mares undergoing ovariectomy by colpotomy should be in what stage of the estrous cycle?
   a. immediately after ovulation
   b. diestrus or anestrus
   c. actively cycling
   d. pregnant
   e. seasonal transition

2. The initial vaginal incision for the colpotomy approach to ovariectomy should be in which position?
   a. directly dorsal
   b. on the medial wall
   c. on the lateral wall
   d. cranioventral or craniodorsal
   e. directly ventral

3. Oversewing the mesovarium following transection is recommended for which of the following reasons?
   a. decrease adhesion formation
   b. prevent eventration
   c. provide analgesia
   d. ensure adequate hemostasis
   e. complete sterilization

4. Which of the following is considered the main advantage to the ventral midline celiotomy approach to ovariectomy?
   a. little interference from abdominal viscera
   b. ease of performing a bilateral procedure
   c. optimal visualization of ovaries on short pedicles
   d. most tension-free ligation
   e. the ability to extend the incision as needed

5. Which of the following is generally not used for hemostasis when performing laparoscopic ovariectomy?
   a. suture ligatures
   b. staples
   c. chain ecraseur
   d. laser energy
   e. electrosurgical instrumentation

6. What is the main theory for why intraoperative hypotension is associated with traditional ovariectomy procedures performed under general anesthesia?
   a. Tension on the mesovarium decreases arterial blood pressure.
   b. Blood loss from the surgical incision causes hypovolemia.
   c. Hypoventilation causes decreased arterial oxygen content.
   d. Anesthetic agents cause decreased systemic blood pressure.
   e. Abdominal viscera interfere with venous return to the heart.

7. Which incision location has been associated with a higher incidence of complications?
   a. ventral midline
   b. paramedian
   c. laparoscopic
   d. flank
   e. diagonal paramedian

8. What percentage of mares stop showing estrous behavior following bilateral ovariectomy?
   a. 100%
   b. 60%
   c. 75%
   d. 50%
   e. 30%

9. Which of the following are advantages to laparoscopic ovariectomy approaches compared with the traditional celiotomy approaches?
   a. smaller incisions for access to the abdomen
   b. visualization of the ovary and mesovarium
   c. tension-free ligation of the mesovarium
   d. shorter, less complicated postoperative recovery
   e. all of the above

10. Which of the following is not a reported complication following equine ovariectomy?
    a. septic peritonitis
    b. eventration
    c. neurologic deficits
    d. hemorrhage
    e. hindlimb pain

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Original Article

How to perform ovariectomy through a colpotomy

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Keywords: horse; ovariectomy; colpotomy

Summary

Bilateral ovariectomy of mares is performed most commonly to eliminate or diminish unwanted behaviour, create a teaser mare, sterilise a mare so that it can be registered in its breed association, or produce a recipient mare for embryo transfer. A practical technique of bilateral ovariectomy that can be easily performed without the mare sedated and without a surgical facility is ovariectomy through a colpotomy. Ovariectomy through a colpotomy is less expensive than ovariectomy using other approaches because it is performed with the mare standing, can be performed quickly and the only specialised instrument required is a chain écraseur. Complications of ovariectomy performed through a colpotomy are uncommon when the mare is correctly prepared for the procedure and when proper precautions are taken during and after the procedure.

Both ovaries are sometimes removed from mares to eliminate the regular oestrous cycle, create a teaser mare, or produce a recipient mare for embryo transfer (Hooper *et al.* 1993). Surgical approaches described for bilateral ovariectomy of mares include celiotomy through one or both flanks, or through the vagina (Hooper *et al.* 1993; Palmer 1993; Pader *et al.* 2011). A practical technique of bilateral ovariectomy that can be performed easily without anaesthetising the mare and without a surgical facility is ovariectomy through a colpotomy, with the use of an écraseur. Ovariectomy performed with an écraseur through a colpotomy, although once performed commonly (Nichols 1988; Embertson 2009), is now performed rarely because of perceived dangers associated with the procedure and the increasingly widespread use of laparoscopy to remove ovaries. Ovariectomy through a colpotomy is relatively inexpensive because it is performed with the mare standing, can be performed quickly and the only specialised instrument required is an écraseur. Removing one or both ovaries through a colpotomy avoids scarring, which is common when ovariectomy is performed using other approaches.

Ovariectomy through a colpotomy is usually performed to spay mares because most neoplastic ovaries are too large to be removed through a vaginal celiotomy. A neoplastic ovary is usually removed using a ventral midline, or oblique paramedian celiotomy (Moll *et al.* 1987; Westermann *et al.* 2003). Neoplastic ovaries less than about 10 cm in diameter, however, can be removed through a colpotomy (Colbern 1993; Moll and Slone 1998). Complications of ovariectomy performed through a colpotomy are uncommon when the mare is prepared properly for the procedure and when the correct precautions are taken during and after the procedure (Nichols 1988; Moll and Slone 1998; Embertson 2009; Pader *et al.* 2011).

Preparation of the mare for the surgery

Feed should be withheld for 24 h if the surgeon is inexperienced to reduce the number of faecal balls in the small colon, in order that a faecal ball is not confused with an ovary during the procedure. Administering 4 L of liquid paraffin 12–24 h in advance of surgery decreases the likelihood of faecal balls being present in the small colon. The mare is restrained in an equine stock and sedated with detomidine HCl (0.002–0.022 mg/kg bwt i.v.) and butorphanol (0.002–0.022 mg/kg bwt i.v.) (Pleasant and McGrath 1998). Administration of detomidine HCl should precede administration of butorphanol to avoid opioid-induced excitement. Sedation can be maintained by administering sedatives i.v. by constant rate infusion. Drugs commonly administered by constant rate infusion include detomidine alone (0.02 mg/kg bwt/h, i.v.), or in combination with butorphanol (0.012 mg/kg bwt/h, i.v.), or morphine (0.05 mg/kg bwt/h, i.v.) (Doherty and Valverde 2006). To avoid inducing excitement when using butorphanol in combination with detomidine, a loading dose of detomidine (0.008 mg/kg bwt i.v.) should be administered initially before a loading dose of butorphanol (0.022 mg/kg bwt i.v.) is administered (Doherty and Valverde 2006).

The mare is administered antimicrobial therapy and an anti-inflammatory, analgesic drug such as phenylbutazone (2.2 mg/kg bwt i.v.) and the perineum, vestibule and vagina desensitised by infusing 2% mepivacaine HCL (1.8 mg/kg bwt) alone, or in combination with, 2 or 10% xylazine HCl (0.18 mg/kg bwt), into the epidural space. A mare can be ovariectomised safely through a colpotomy without receiving epidural anaesthesia (authors' observation), but epidural anaesthesia, in addition to desensitising the vestibule and at least a portion of the vagina, prevents the mare from defaecating during surgery.

The tail is bandaged with rolled gauze, elevated and secured to the overhead cross-bar of the stock. The faeces are removed manually and the mare's ovaries and uterus evaluated by palpation per rectum. Hair surrounding the perineum is clipped and the perineum scrubbed with an antiseptic soap. Irrigating the vagina with 1 L isotonic saline solution not only cleans the vagina and vestibule, it also induces pneumovagina, easing the introduction of a hand and arm into the vagina.

Preparation of the surgeon

Although the procedure can be performed with the surgeon and assistant wearing only sterile obstetrical sleeves, we prefer to wear sterile surgical gowns, the arms of which are covered with a sterile obstetrical sleeve to decrease friction between the arm and vagina. Sterile surgical gloves are donned over the hands of the obstetrical sleeves. The glove and sleeve on the surgeon's dominant arm are lubricated with sterile KY jelly to ease introducing the hand and arm into the vagina and into the abdomen after colpotomy.

Surgical procedure

A small pack of sterile gauze swabs, tethered to a sterile suture (e.g. umbilical tape) and saturated with local anaesthetic solution, such as mepivacaine HCl or lidocaine HCl, is introduced into the vagina with the surgeon's dominant arm (**Fig 1**). Pressing the pack to the fornix of the vagina for several minutes ensures that the mucosa at the fornix is desensitised. A stab incision is made with a No.10 or 15 scalpel blade, tethered to sterile strand of suture (e.g. umbilical tape), at the dorsolateral aspect of the fornix of the vagina, at the 10.30 or 13.30 h position, about 2 cm dorsolateral to the base of the cervix. This incision is cranial and dorsal to the vaginal branch of the internal pudendal artery (i.e. the vaginal artery) (Embertson 2009), which can usually be easily palpated when the vagina is distended with air (**Figs 2** and **3**). A right-handed surgeon can perform bilateral ovariectomy more easily through a colpotomy created on the right aspect of the vaginal fornix (i.e. the 13.30 h position), whereas a left-handed surgeon can perform bilateral ovariectomy more easily through a colpotomy created on the left aspect of the vaginal fornix (i.e. the 10.30 h position).

The blade is inserted through vaginal mucosa and submucosa and the stab incision is spread, first with the jaws of a haemostat and then with fingers, until an opening in the mucosa and submucosa is created that can accommodate the entire hand into the retroperitoneal space. Fascia and peritoneum are torn with a finger to create a hole into the abdominal cavity large enough to accommodate the hand and forearm of the surgeon. Trying to thrust a finger through the peritoneum, rather than tearing the peritoneum with a finger, is ineffective because this manoeuvre pushes the peritoneum away from the abdominal wall.

***Fig 1:** A pack of sterile gauze, tethered to a sterile suture and saturated with local anaesthetic solution, is introduced into the vagina.*

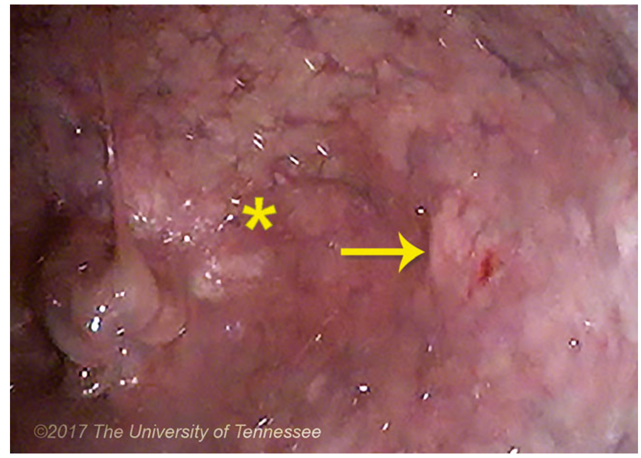

***Fig 2:** A stab incision is made with a No. 10 or 15 scalpel blade at the dorsolateral aspect of the fornix of the vagina, at the 10.30 or 13.30 h position, about 2 cm away from the base of the cervix and cranial and dorsal to the vaginal branch of the internal pudendal artery. *, site of incision; arrow, points to the vaginal branch of the internal pudendal artery.*

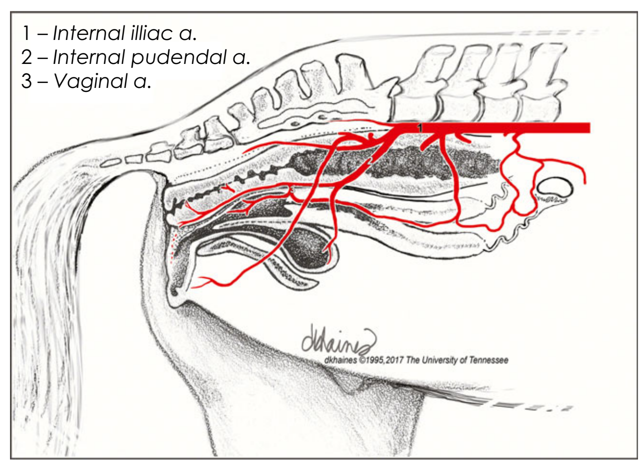

***Fig 3:** Schematic diagram showing the vaginal branch of the internal pudendal artery. 1, internal iliac artery; 2, internal pudendal artery; 3, vaginal artery.*

The ovaries are identified and the pedicle of each ovary desensitised by pressing sterile gauze swabs, saturated with local anaesthetic solution, to each ovarian pedicle for several minutes (**Fig 4**). The gauze is tethered to a long, sterile suture (e.g. umbilical tape) to ensure that the gauze can be retrieved from the abdomen, if the gauze swabs are accidently dropped. The chain of the écraseur is secured over the dominant hand of the surgeon by placing four fingers through the loop of the chain of the écraseur and inserting the hand, the chain and the end of the écraseur through the colpotomy into the abdomen. The chain of the écraseur is positioned, with tension, against the surgeon's proximal row of phalanges as the end of the écraseur is introduced into the abdomen. The écraseur preferred by the authors is the Chassaignac écraseur[1] (**Fig 5**).

The left ovary should be removed first, if the colpotomy was created on the right side of the vagina, so that when

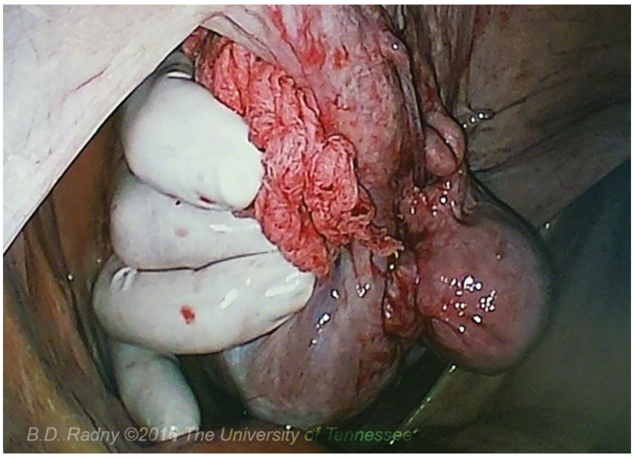

***Fig 4:** Ovaries are identified and the pedicle of each ovary is desensitised by pressing sterile gauze, saturated with local anaesthetic solution, to each ovarian pedicle.*

***Fig 5:** The écraseur preferred by the authors is the Chassaignac écraseur[1].*

the right ovary is removed, the pedicle of the left ovary is not disturbed by the arm of the surgeon. When removing the ovary on the side contralateral to the colpotomy, the surgeon should ensure that his, or her, hand and the écraseur have passed beneath the small colon to access the ovary, so that the ovary is not grasped through the mesocolon. Removing an ovary encased by mesocolon risks severing a colonic vein and artery and creates a hole in the mesocolon through which intestine can become entrapped.

With the chain of the écraseur secured against the proximal row of the surgeon's phalanges, the ovary is grasped and the chain is slipped over the hand to encircle the ovarian pedicle (**Fig 6**). The chain is tightened around the pedicle, being careful that the chain encircles no other structure, such as a loop of intestine. The surgeon, or preferably an assistant surgeon, slowly tightens the chain by using the ratchet on the end of the écraseur while the surgeon holds the ovary and ensures that the ovarian pedicle is not stretched during this part of the procedure. The chain is tightened, using the ratchet, until the pedicle is severed (**Fig 7**). Stretching the pedicle while the chain is tightened may cause the pedicle to recoil when the pedicle is severed, which, in turn, may result in excessive haemorrhage from the ovarian artery. The ovary is extracted through the colpotomy and the contralateral ovary is removed in a similar manner.

The palm of a hand is held beneath each pedicle at the end of the procedure to feel for bleeding from the pedicle (**Fig 8**). If, on rare occasion, the amount of blood emanating from a pedicle is alarming, a long forceps, such as a Knowles cervical forceps, can be inserted vaginally, through the

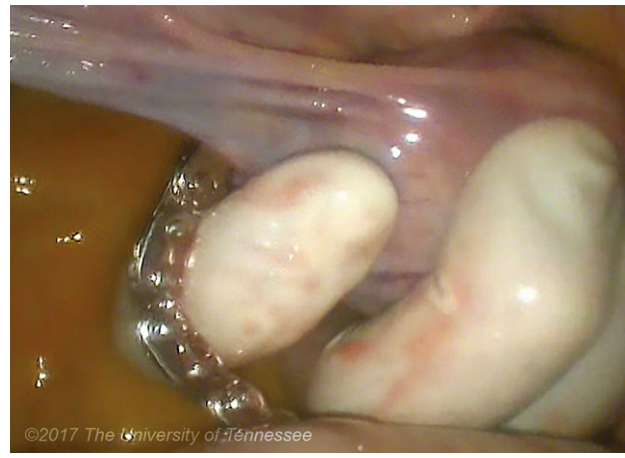

***Fig 6:** The chain of the écraseur is secured against the proximal row of the surgeon's phalanges, the ovary grasped, and the chain slipped over the hand to encircle the ovarian pedicle. This photograph was obtained through a laparoscope introduced into the abdominal cavity at the mare's flank, for the purpose of demonstrating ovariectomy through a colpotomy.*

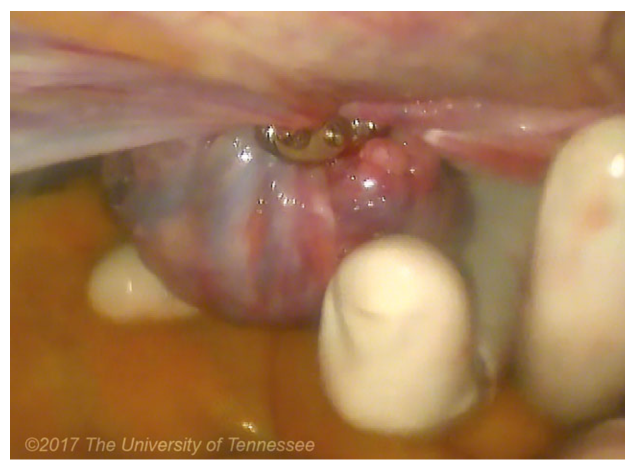

***Fig 7:** The chain is tightened, using the ratchet, until the pedicle is severed. This photograph was obtained through a laparoscope introduced into the abdominal cavity at the mare's flank, for the purpose of demonstrating ovariectomy through a colpotomy.*

colpotomy, applied to the pedicle and left in situ for 1 h or more to induce haemostasis. The colpotomy is usually left unsutured to heal by second intention because suturing the colpotomy is difficult and may induce vaginitis, causing the mare to strain.

The mare should receive a Caslick's vulvoplasty if its perineal conformation is poor, to prevent pneumovagina and subsequent contamination of the vestibule, vagina and abdomen. Antimicrobial and analgesic therapy is continued for 3–5 days after surgery. The mare should be cross-tied for 2–3 days to prevent it from becoming recumbent because rising from recumbency increases abdominal pressure which, in turn, increases the likelihood of evisceration (Embertson 2009). Within about 3 days, the colpotomy contracts to a diameter that accommodates only one finger (**Fig 9**). The hole is usually completely sealed from the abdomen within

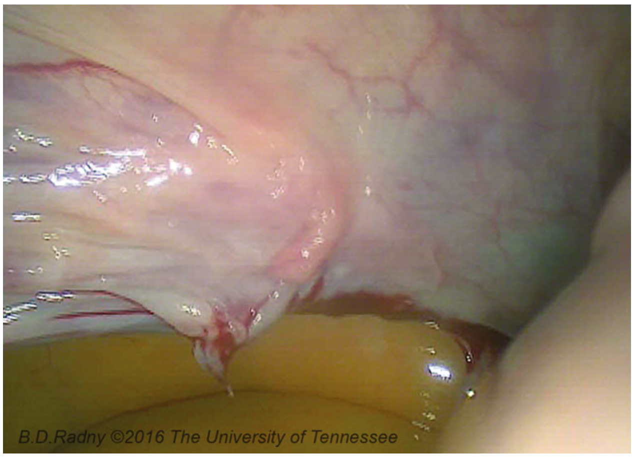

Fig 8: The palm of a hand is held beneath each pedicle at the end of the procedure to detect bleeding from the pedicle. This photograph was obtained through a laparoscope introduced into the abdominal cavity at the mare's flank, for the purpose of demonstrating ovariectomy through a colpotomy.

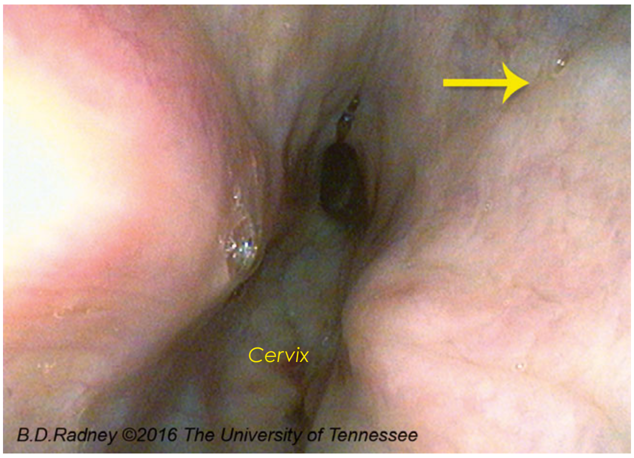

Fig 9: Endoscopic view of the fornix of the vagina 3 days after colpotomy. The colpotomy has contracted to a diameter smaller than that of one finger. The bulge in the vaginal wall (arrow) is the vaginal artery.

3 weeks (Moll and Slone 1998). The mare can be allowed unrestricted exercise after about 5 days (Nichols 1988; Colbern 1993; Moll and Slone 1998; Embertson 2009; Pader *et al.* 2011).

Discussion

The primary disadvantage of ovariectomy by colpotomy is that the ovarian pedicle is crushed and transected blindly, making detection of excessive intra-abdominal haemorrhage difficult. Because of this difficulty, the mare's haematocrit and serumal total protein should be determined before surgery and periodically after surgery to ensure that haemorrhage from the severed ovarian pedicles is not severe. Determining the magnitude of blood loss by monitoring the horse's haematocrit and total serumal solids during the first 6–24 h after ovariectomy, however, is difficult, because with severe blood loss, a decrease in total serumal protein is often not evident for 6 h and a decrease in haematocrit may not be evident for 12–24 h (Getman 2009).

Clinical signs associated with substantial blood loss include tachycardia, tachypnoea, a weak pulse, pale mucous membranes, prolonged capillary refill, cold extremities and weakness (Mudge 2014). If severe haemorrhage is suspected, the horse should receive fluid therapy and transfusion of blood from an acceptable donor should be considered. A complication of colpotomy itself is fatal haemorrhage caused by inadvertent perforation of the vaginal artery with a scalpel blade, but this artery is avoided if it is located by palpation before the fornix of the vagina is incised and if the incision is created at the proper location (Embertson 2009).

One of the authors (J.S.) has observed only two surgical complications after performing over 100 ovariectomies by colpotomy. One mare experienced severe haemorrhage, requiring multiple blood transfusions, but survived. The cause of severe haemorrhage was thought to result from transecting the ovarian pedicle while the pedicle was under tension. Another mare strained after surgery, presumably because of vaginitis induced by an unsuccessful attempt to suture the colpotomy. Straining gradually diminished over several days.

Persistence of unwanted behaviour is a complication of bilateral ovariectomy performed to eliminate or ameliorate that behaviour (Hooper *et al.* 1993; Kamm and Hendrickson 2007; Crabtree 2016). Success of ovariectomy in eliminating or ameliorating unwanted behaviour is likely if that behaviour occurs primarily during oestrus and if hormonal therapy has been shown to improve the mare's behaviour (Kamm and Hendrickson 2007). Ovariectomy is unlikely to resolve unwanted behaviour, if that behaviour is sexual behaviour that occurs during oestrus, because ovariectomy commonly results in continued display of sexual receptiveness with loss of normal cyclic activity (Hedberg *et al.* 2007).

Bilateral ovariectomy eliminates the production of oestrogen by eliminating the theca and granulosa cells of the ovarian follicles (Christensen 2011). Continued signs of oestrus displayed by ovariectomised mares is most likely due to absence of the corpora lutea, the primary source of progesterone, because progesterone is responsible for inhibiting the behavioural signs of oestrus (Watson and Hinrichs 1989).

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

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Authorship

The manuscript was written by both authors who also obtained the photographs.

Manufacturer's address

[1]Jorgensen Laboratories, Loveland, Colorado, USA.

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Journal Title : The Journal of equine medicine and surgery Journal Vol: 1 Journal Issue: 1 Journal Year: 1977 Article Title: OVARIECTOMY IN MARE - PRESURGICAL, SURGICAL AND POSTSURGICAL CONSIDERATIONS Article Author: SCOTT, Article Pages: 5-12

Thanks a lot!

Ovariectomy in the Mare: Presurgical, Surgical and Postsurgical Considerations

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Ovariectomy in the mare is frequently indicated for removal of a pathological ovary. Presurgical considerations are: (1) nature of ovarian abnormality, (2) size of ovary to be removed, (3) temperament and tractability, (4) economical considerations, and (5) physical condition of the mare. Surgical planning should include a consideration of: (1) experience of surgeon, (2) anesthesia, anesthesia equipment, and surgical facilities available, (3) availability of selected surgical instruments, (4) preparation of mare for surgery, (5) laparotomy approach, and (6) technique of ovariectomy. Postsurgical care may include by necessity the treatment of the following: (1) hemorrhage, (2) shock, (3) abdominal pain (colic), (4) hematoma, abscess, granuloma development with adhesions, (5) peritonitis, (6) dehiscence of laparotomy incision with occasional herniation or evisceration, and (7) behavioral change of operated mare.

Removal of 1 or both ovaries in the mare (to ovariectomize or spay) has been employed for surgical correction of various ovarian conditions. The most frequent indication for removal of a pathological ovary is granulosa cell tumor.[3,4,14,15] Additional ovarian tumors reported in the mare include melanoma, epithelioma, cystadenoma, adenocarcinoma, and teratoma.[15] Less common indications for ovariectomy are: (1) ovarian abscess and hematoma, (2) ovarian cysts, (3) nymphomania, and (4) prevention of estrus.[4,14,15,16,17]

In the majority of tumor cases, ovariectomy is performed unilaterally for removal of the neoplastic mass, and the tumor is usually granulosa cell type.[3,4,8,14,15,17,18,19,21,22] In this paper the discussion centers around the surgical correction of ovarian tumors, except where otherwise indicated.

Granulosa cell tumors are functional androgen producers, and clinical alterations seen are related to changes in estrus, colic, infertility, lameness, abnormal muscular development, changes in external genitalia, and personality.[3,4,8,9,17,18,19,23,24] This tumor predominantly affects 1 ovary, rarely if ever metastasizes in the mare, and occurs primarily in the young mare.[12,15,16,19] A consistent physical examination finding of granulosa cell tumors is a slow but progressive increase in size. Tumorous ovaries, exceeding 20 kg in weight, have been successfully removed in certain cases.[16] Once a presumptive diagnosis of ovarian tumor is made, ovariectomy is the preferred surgical approach.[21]

Ovarian abscesses and hematomas may accompany neoplastic involvement or occur as primary entities. Rough handling of ovaries by rectal palpation and drainage of ovarian cysts by percutaneous or vaginal centesis are probable causes.[15] Hematomas, abscesses, and cysts may fluctuate considerably in size due to seasonal variation and iatrogenic factors. Ovariectomy is an elective procedure for this group of abnormalities in virtually all instances.

Spaying a mare for correction of nymphomania has had variable and inconsistent results.[3,14,17] Based on clinical observations of nymphomaniac tendencies only during estrus and "normal" ovarian size, bilateral ovariectomy has been reported as a satisfactory means of surgical correction. Conversely, the nymphomaniac mare with marked abnormal behavior that is chronic and constant in nature has not generally been responsive to bilateral ovariectomy.[14,17] This type of mare should be considered extremely dangerous and hazardous to the surgeon, handlers, and animals that come in contact with her. Humane destruction is frequently the end result of this case and the advisability of surgical intervention (ovariectomy) should be questioned for economical as well as therapeutic reasons.[17]

Although the physical attitude, personality, and various other clinical manifestations of ovarian tumor may be altered by ovariectomy, sterility may persist for the life of the mare.[2,3]

Presurgical Considerations

Nature of Ovarian Abnormality — A history of infertility, abortion, alterations of estrus, nymphomania, "mounting" of other mares, personality changes, lameness, masculinity, overdevelopment of external genitalia, and ovarian enlargement contains clinical signs and physical findings consistent with ovarian tumors.

Rectal examination of such a mare may reveal an enlarged ovary, with the opposite ovary normal. Palpation of small, firm, and atrophied ovaries is a consistent finding in the classical form of nymphomania. If the history includes a previous attempt to "tap" an ovarian cyst, careful palpation per rectum may reveal adhesions, abscessation, or fluid-filled structures.

Radioimmunoassays can be performed on blood samples for analysis of hormone concentrations. Results of such analyses from mares with tumorous ovaries may correlate with clinical findings and responses to surgical removal. Function of a remaining ovary may be assessed by comparing hormone concentrations in blood samples collected pre- and postsurgical with those that are recognized to be normal. This type of test may aid the clinician in formulating hormonal treatment and predicting the prognosis of fertility for unilateral ovariectomize(mares.[13,19,20,21]

Size of Ovary to be Removed — Accurate assess ment of ovarian dimensions by rectal palpation is no always possible. If the ovary is very large or the mar(difficult to palpate, an estimation may be necessary Since this parameter is important in selecting the surgica approach, sedative agents or epidural anesthesia shoul(be employed in the intractable mare. Inaccurate assess ment of ovarian size contributes to the following surgica errors: (1) inadequate surgical exposure (wron; laparotomy approach), (2) unnecessary tissue traum; promoting abscesses, hematomas, and seromas, (3) mis diagnosis of problem, and (4) inability to correct prob lem(s).

Temperament and Tractability of Mare — Thi parameter influences not only the method of anesthesi: and surgical approach used, but is a trait that hopefull; will be altered by surgery in certain cases.

With ovariectomy performed in the standing mar((flank approach or via colpotomy) under appropriat(anesthesia, it is imperative that the mare's disposition b(conducive to surgical incision and manipulation. Such a! operation performed on a vicious or intractable mare wil consistently lead to disastrous results. Therefore, stand ing ovariectomies should be reserved for surgical case that are more than adequately manageable under thes(circumstances.

Economical Considerations — Cost of surgery an(anesthesia will not be a deciding factor in all cases When economic circumstances influence and com promise the surgical, anesthetic, and postsurgical phase of ovariectomy, the anticipated standard results will nc be achieved. The most inexpensive way to spay a mare i via colpotomy. Special instrumentation and a coopera tive mare are prerequisites for this procedure to be suc cessful. Conversely, the greatest cost of a similar opera tion would be ovariectomy through a midline laparotom; under general anesthesia of an inhalation type. Co: should be a factor that is always considered but shoul(never assume priority over the appropriate anestheti agent or surgical approach for a given case.

Physical Condition of the Mare — In a few ir stances, physical condition of a mare may influence th surgeon's choice of anesthesia or laparotomy approach t(be used. Generally, intravenous anesthesia will be dis carded in favor of a standing approach for the debilitate(or crippled case. The presence of uterine, cervical, c vaginal infection eliminates the vaginal approach fror available laparotomy choices. Excessively fat an(short-coupled mares may have inadequate room for su! gical exposure through a paralumbar incision. Chroni

TABLE 1

Anesthesia Chart for Selecting Type Compatible with Laparotomy Approach Chosen

Laparotomy Approach	Primary Anesthetic	Complementary Anesthetic
Vaginal	Caudal epidural 1-1.5 ml 2% lidocaine [a] per 100 # (45.6 kg) body weight	Topical application of gauze soaked in lidocaine applied to ovarian pedicle
Flank (local anesthesia)	Line infiltration Inverted L block (Local infiltration of lidocaine with syringe and needle)	Topical application as with vaginal approach
Flank (general anesthesia)	1. Glyceryl guaiacolate (GG) [b] with 5% dextrose and barbiturate [c] added. Used both as inducing agent and maintenance solution. 2. Short acting barbiturate (thiamylal sodium) [c] as inducing agent and 1% solution as a slow intravenous drip for maintenance. 3. Combinations of chloral hydrate-magnesium sulfate [d] with or without pentobarbital [e] for induction and maintenance. 4. Inhalation anesthesia (halothane [f] or methoxyflurane [g]) induction and intubation.	
Midline or paramedian	[1 through 4 under general anesthesia]	
Brand Name	**Generic Name**	**Company**
[a] Xylocaine	Lidocaine U.S.P.	Astra Pharmaceutical Products, Inc. Worcester, MA 01606 USA
[b] Gecolate Sterile Pwd.	Glyceryl guaiacolate	Summit Hill Laboratories Avalon, NJ 08202 USA
Guaifenesin, N.F. XIV	Glyceryl guaiacolate	Gane's Chemical Works, Inc. Industrial Park Road Pennsville, NJ 08070 USA
[c] Surital	Thiamylal sodium	Parke, Davis & Company Detroit, MI 48232 USA
[d] Mag-Chloral	Chloral hydrate Magnesium sulfate Chlorobutanol	Haver-Lockhart Laboratories Division of Bayvet Corporation Shawnee, KS 66201 USA
[e] Equi-Thesin	Chloral hydrate Pentobarbital Magnesium sulfate	Jensen-Salsbery Laboratories Division of Richardson-Merrell, Inc. Kansas City, MO 64141 USA
[f] Fluothane	Halothane	Ayerst Laboratories, Inc. Veterinary Med. Division New York, NY 10017 USA
[g] Metofane	Methoxyflurane	Pitman-Moore, Inc. Washington Crossing, NJ 08560 USA
[h] Betadine Surgical Scrub	Povidone-iodine	The Purdue Frederick Company Norwalk, CT 06856 USA
[i] Nolvasan Solution	Chlorhexidine	Fort Dodge Laboratories, Inc. Fort Dodge, IA 50501 USA

alveolar emphysema, if present, is a deterrent to general anesthesia if an alternate method will suffice.

If any doubt exists in the mind of the surgeon as to the status of organ function (liver, pancreas, lungs, heart, kidney, etc.), then appropriate laboratory tests should be performed. In all cases scheduled for surgery, a complete physical examination may provide the most rewarding and fruitful information obtainable.

Surgical Considerations

Experience of Surgeon — Previous experience tends to be a major factor in planning an operative procedure. However, a lack of experience or experience in abundance should not prevent one from integrating personal knowledge, knowledge of literature written on the subject, and the expertise of colleagues in formulating a surgical plan. This plan by necessity must vary with individual cases. No single approach will suffice for all ovariectomy procedures.

Anesthetic, Anesthetic Equipment, and Surgical Facilities — Surgical facilities and a recovery area with inhalation anesthesia are optimal. A standing flank or vaginal approach is facilitated by a stock or chute to confine the operative case. This affords some safety to the operator with mares that become unruly for a period of time. Various acceptable methods of anesthesia for selected laparotomy approaches are listed in Table 1. For a better understanding of specific anesthetic agents and anesthesia procedures, the reader is referred to selected writings.[6,7]

Special Instruments — A chain ecraseur (Fig 1) is a valuable surgical instrument in selected approaches to ovariectomy. It is essential for ovariectomy through the vagina and can also be used with other laparotomy approaches. This instrument is not available commercially, and, unless one is presently owned, the instrument can not be procured.

Preparation of Mare for Surgery — In all operative cases, starving the animal 24 hours prior to surgery is recommended. In vaginal ovariectomies this is absolutely essential to avoid penetration of viscera during colpotomy incisions. Fasting will also increase exposure in the ovarian area and enhance manipulative procedures.

Surgical areas of the external abdominal wall are clipped and scrubbed with appropriate antiseptic preparations.[a] Preparation of the mare for vaginal ovariectomy involves removal of feces manually from the rectum, wrapping of tail, and surgical scrub of perineal area. The vagina is douched with an antiseptic solution[b] and the mare's bladder emptied by catheterization. A small area

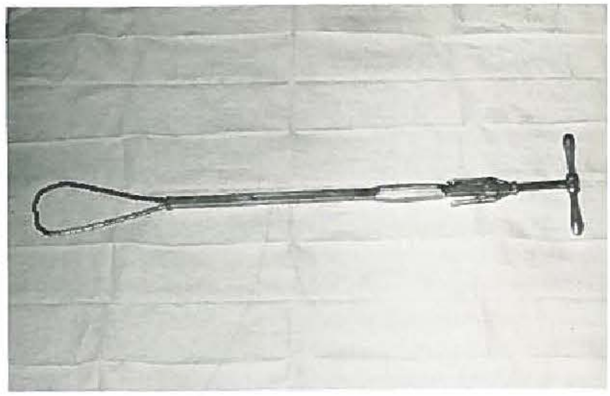

Fig 1— Example of a chain ecraseur that is commonly used f(ovariectomy via colpotomy.

over the tailhead is clipped and scrubbed in preparatio for anesthesia.

Laparotomy Approaches — For concise descriptio of various surgical approaches to the abdominal wal readers are referred to the following writings.[10,22,23] I this discussion, 3 procedures will be discussed: (1) flan approach (paralumbar fossa), (2) midline or paramediar and (3) vaginal (via colpotomy).

Flank (paralumbar fossa) approach — This is a ve satile approach that can be performed standing (loc anesthesia) or in lateral recumbency (general anesthesia) For ovaries that are small (less than 8–10 cm) a gri approach (muscles separated in direction of fiber rathe than incised) may suffice. For greater exposure and re moval of larger ovaries (up to 15–16 cm in diameter) th muscle layers can be transected in a parallel manner t the skin incision. Use of a chain ecraseur is applicable i this procedure, particularly when a bilateral ovariectom is performed. In this case the preferred method would b transfixation ligation of the pathological ovary through laparotomy performed on the same side and chain ec raseur removal of the opposite through the same incisior Removal of both ovaries utilizing the chain ecraseur ca also be performed through a grid incision, if the ovarie are small.

An example of a through and through flank incisio is shown in Fig 2, and the left ovary is indicated by th arrow. Shown in Fig 3 is the correct placement of a chai ecraseur over the hand of the operator. The correc placement of chain loop over the ovary, is shown in Fi 4, and the size of left ovary after removal is illustrated i Fig 5. This ovary could have safely been remove through a grid or vaginal approach also.

Primary advantages of this method are: (1) it can b

a,b See footnotes h and i, Table 1.

Fig 2— Paralumbar fossa laparotomy, left flank approach, with left ovary visualized at the end of the arrow.

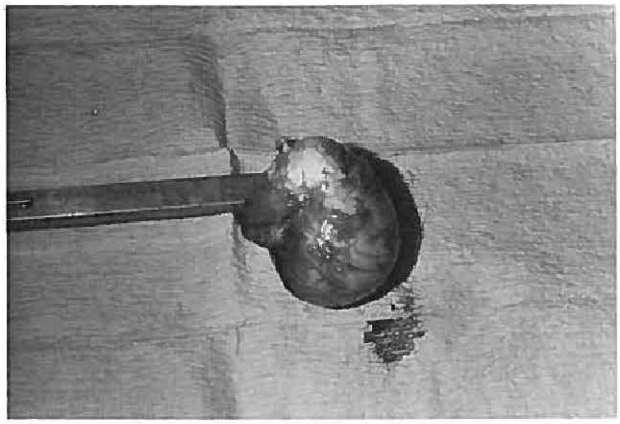

Fig 5— Left ovary after removal, with chain ecraseur also shown.

Fig 3— Hand of operator placed through chain loop of ecraseur.

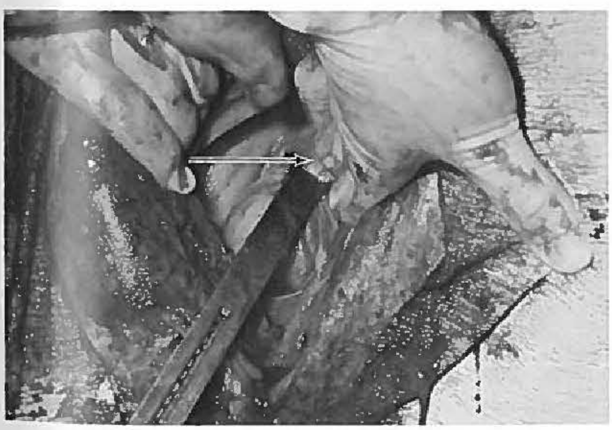

Fig 4— Chain ecraseur has been carried into abdomen (via approach in Fig 2) and properly placed for removal of the left ovary. Mesovarium is at end of pointer.

performed in the standing mare under local infiltration of anesthesia, and (2) it minimizes the problem of postsurgical dehiscence, herniation, and evisceration that are more commonly seen with ventral approaches.

Midline or paramedian — The most versatile approach is one that has inherent allowances for errors committed by the surgeon. This approach is the preferred method of exposure for: (1) large tumorous ovaries, (2) bilateral ovariectomies in vicious mares where an ecraseur is not available, and (3) ovaries for which an accurate assessment of size was not obtained. This laparotomy gives adequate exposure for even unusually large ovaries (Fig 6), and transfixation ligation of the ovarian pedicle with #1-2 medium chromic gut (Fig 7).

Its major disadvantages are: (1) requirement for general anesthesia, (2) surgical time necessary for approach, ovariectomy, and closure, and (3) tendency toward incision problems (dehiscence, etc.). The incision should be located just anterior to the mammary glands and extended forward as necessary.

Vaginal approach via colpotomy[1,23] — A contraindication to this procedure is the presence of vaginal, cervical, or uterine infection. As previously mentioned, the maximal size of ovary (diameter) that can safely be removed via colpotomy is smaller than the other laparotomies discussed and should not exceed 8–9 cm (baseball size). After careful surgical preparation of the perineal and vaginal area, the mare is placed in stocks with her tail wrapped. Epidural anesthesia is used if deemed necessary. A fully gloved hand and arm (obstetric length) is wetted and inserted into the vagina, carrying along a solid scalpel or scissors. Moving the arm back and forth will allow air to enter and distend the vaginal wall. An incision is made in the anterior fornix of the vagina, off the midline and dorsolateral to the exter-

Fig 6— Midline laparotomy with large neoplastic ovary visualized through the incision.

Fig 7— Ovarian pedicle is ligated with transfixation ligature of #1-2 medium chromic gut (arrow). Ovary seen in this figure weighed over 45 pounds (20 kg).

nal os of the cervix. If the right ovary is to be removed, the left hand is gloved and incision of the vaginal wall located at about a 2 o'clock position. Both ovaries can be removed through 1 incision, and the location of the incision in this case is not important. Incising the vaginal wall with a scalpel is effected with a controlled depth incision. The solid scalpel is guarded with the blade properly positioned between the thumb and forefinger with the blade projecting approximately 3 cm. A thrust is made with scalpel in the proper area of vaginal fornix. Directing the knife forward and slightly ventral will prevent accidental laceration of the rectum, bladder, and major vessels in the area. An alternative to sharp incision with a scalpel is perforation of the same area with a pair of scissors. Entry into the peritoneal cavity is through a reflection of pelvic peritoneum, the rectogenital pouch (Fig 8, arrow). If the complete thickness of vaginal wall (mucosa-muscularis-peritoneum) is not incised, the scal-

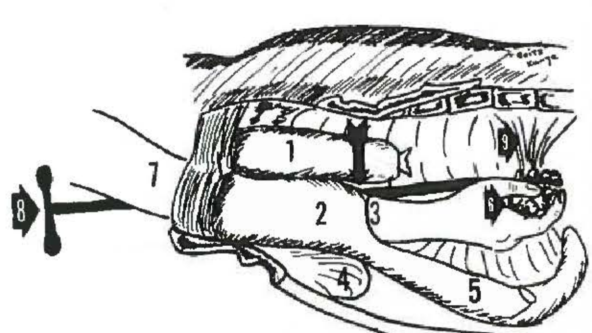

Fig 8— Vaginal approach to ovariectomy via colpotomy—lateral view and important anatomical areas are identified. Rectum (1); vagina (2); colpotomy incision (3); bladder (4); uterine horn (5); ovary (6); operator's arm (7); ecraseur (8); mesovarium (9); rectogenital pouch (arrow).

pel or scissors are withdrawn and the remaining layers perforated with a sharp thrust of a pointed finger. Once the abdomen is entered, enlargement of the incision is accomplished with 2 fingers followed by 3 and then a coned hand. Tracing a uterine horn will aid in locating the proper ovary. If mesovarian anesthesia is desired, a gauze sponge soaked in a local anesthetic preparation is secured to a long piece of suture (umbilical tape) and placed around the ovarian pedicle. This should be held in place for 2–3 minutes and can be retrieved safely if inadvertently dropped.

Passing an ecraseur along the area, the chain is looped over the hand within the abdomen, in a manner similar to that demonstrated in Fig 3. Alternatively, the hand may be withdrawn and reentry made with the ecraseur. The ovary is grasped and the chain loop passed over the ovary which is elevated upward, away from the viscera. The chain loop is closed slowly by an assistant with the surgeon checking the loop repeatedly to insure that no loops of intestine or the tip of a uterine horn have been included (Fig 8). Additional tension is placed on the chain loop until considerable resistance or crushing of mesovarium is palpable. This action should be slowly advanced over a period of 5–8 minutes. A separated ovary may be dropped into the vagina or held until completion of the operation, at which time both the ovary and ecraseur are removed. Once the chain loop has been closed to the point of lying withing the ecraseur handle, the ovarian pedicle is crushed and divided, and the operation virtually completed. Hemorrhage, if it occurs, is palpable by the surgeon. Removal of a secondary ovary may be similarly accomplished if desired.

A Caslick operation completes the surgical procedure and is performed with local or existing epidural anesthesia. This prevents vaginal aerophagia if straining should occur, thus enhancing healing and minimizing herniation or evisceration.

Postsurgical Care

In general, antimicrobial therapy is systemically administered for 3–7 days in ovariectomy cases and longer in selected cases. In uncomplicated cases, a broad spectrum antibiotic should suffice. In cases complicated by sepsis or infection, antimicrobial agents should be chosen on the basis of culture and susceptibility testing results. Tetanus toxoid or antitoxin is administered according to the vaccination status.

Feeding is restored slowly to the ovariectomy case since bowel distention and excessive peristalsis may produce pain. Bulk is slowly added to the diet using bran or pelleted feed. Grain is given in handsful initially and progressively increased over 7–10 days.

Controlled exercise is encouraged to alleviate edema of limbs and surgical site and stimulate bowel movements. This should be controlled as excessive exercise may disrupt incisions and ligatures and produce episodes of severe abdominal pain.

A mare operated through the vagina (unilateral or bilateral ovariectomy) is placed in a stall and cross-tied after surgery. This cross-tied and standing position is continued for 36–48 hours to reduce the possibility of herniation or evisceration.

Hemorrhage — Hemorrhage usually occurs at the time of ovariectomy and should be managed at this point. The mare spayed through the vagina that hemorrhages after ovariectomy with an ecraseur can be ecraseured a second time. A long suture of #2-3 medium chromic gut may be carried into the abdomen through the vaginal incision, passed around the ecraseur positioned snugly on the bleeding pedicle, exteriorized, and knots placed on the outside. This knot is carried in and repeatedly tied until secure. Long ends are cut off with scissors carried into the abdomen while some slight tension is maintained on the suture. Hemorrhage postsurgically occurs when a ligated pedicle is disturbed by movement of ligatures or when an unligated pedicle is disturbed by massage of adhesions. Thrashing during recovery and blood disorders may be contributing causes. Transfixation of ligatures placed in the ovarian stump (Fig 7) and individual ligation of large vessels is the most effective way to control hemorrhage.

Shock — Acute blood loss, hypovolemia, severe abdominal pain, and adverse responses to use of the ecraseur in the standing unanesthetized mare are probable causes of shock. Blood or fluid volume replacement, effective anesthesia (particularly of ovarian pedicle in vaginal approach), and control of postsurgical pain may circumvent this problem. The first few hours after surgery are critical and a surgical case should be carefully watched during this period.

Abdominal Pain — Ovariectomy is attended by various degrees of pain in all cases. Judicious use of analgesics during the first 24–48 hours after surgery will enhance postsurgical recovery. It should be noted that sedatives or tranquilizers are potentially hypotensive and should be used with caution. Severe intractable abdominal pain is suggestive of a more severe state. Rectal palpation, physical examination, and laparotomy results may reveal the cause.

Hematoma, Abscess, Granuloma, and Adhesions – Rectal palpation should be routinely performed 2-3 days after surgery, or immediately in the case that differs from the usual and expected response. Formation of adhesions occurs early in most cases and can be gently broken down by manual massage. Any enlargement of the ovarian pedicle or unmanageable adhesions should be noted. Very large hematomas of the right ovary or ovarian pedicle may place extramural pressure on the terminal ileum or proximal jejunum. This interrupts the flow of ingesta and may produce signs of colic. Subsequent rectal examinations will reveal the progress of these conditions.

Unless the hematoma, abscess, or granuloma becomes excessively large or painful, interrupts digestive function, or is complicated by unmanageable adhesions, surgical intervention is elective.

Peritonitis — A degree of localized peritonitis with adhesions is not uncommon as sequelae to ovariectomy. If they are confined to the ovarian pedicle and abdominal wall, minimal problems will be seen. Severe peritonitis is accompanied by more extensive adhesions and, if the animal recovers, will manifest variable degrees of recurrent abdominal pain (colic). Peritonitis in the acute phase is a medicinal problem. Abdominal paracentesis and culture and susceptibility testing are guides to appropriate antimicrobial therapy. A broad spectrum antibiotic should be administered while culture and susceptibility results are forthcoming. If peritonitis is responsive to antimicrobial therapy, surgical intervention for the correction of adhesions is elective.

Dehiscence, Herniation, and Evisceration — Sepsis at the surgical site, unnecessary trauma, hematomas, seromas, and improper laparotomy closure are factors that promote this category of problems. Herniation occurs when the primary confining layers of the abdominal wall are disrupted. If the intact skin and subcutaneous layers prevent evisceration, adhesions may form between a herniated organ and the abdominal wall. Clincial signs of colic, sepsis of incision area, enlargement of incision site, anorexia, depression, and fever are common. Evisceration may occur through any abdominal approach but is more likely to occur with a vaginal approach since the incision is not sutured. If herniated and eviscerated organs are identified before gross injury or contamination has occurred, the organs may be replaced and appropriate reconstruction performed on the laparotomy incision. Herniation may be acceptable, depending on the organ herniated and site of hernia. Herniation following a vaginal approach may be managed by manual reduction per rectum.

Behavioral Changes and Fertility — As mentioned previously, the vicious chronic nymphomaniac mare will probably not be altered by surgical removal of ovaries. An unfavorable prognosis for behavioral changes following surgery is therefore justified. Other mares less severely influenced show varying degrees of response, and some improvement is usually seen. Prognosis for fertility is guarded for the mare that has 1 ovary removed. Radioimmunoassays of blood withdrawn from operated cases before and after surgery may be helpful in suggesting medicinal (hormone) treatment and evaluating progress of mares that continue to be infertile.

Conclusions

This paper is an attempt to relate the various factor involved in the successful approach to ovariectomy in th mare. Of prime importance is the choice of anesthesi used and laparotomy approach employed. Failure t select a combination that is complementary for each cas will complicate all aspects of the procedure and promot unfavorable results.

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