Stop Horsing Around:

A comparative economic analysis of wild horse conservation programs to reduce overpopulation in Western America

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- **Introduction**

The objective for this essay is to identify and determine current and future impacts of the overpopulation of wild horses and burros within Western United States, the relevant policy of wild horse conservation, and to examine available data to define whether the decisions made by the Bureau of Land Management (BLM) can be adjusted to obtain an economically and environmentally sustainable outcome.

When the Wild Free-Roaming Horses and Burros Act of 1971 (WFRHB) was passed, the purpose was to guard one of the most sacred and iconic species of America—the wild horse. To protect the mustangs from abuse, slaughter, harm, and exploitation, the congressionally-passed mandate looked to sustain the horses, and has attempted to do so for the past four decades. However, the act may have sustained horses too well; public rangelands are now overpopulated, holding facilities are stockpiled, and authorities face the tough task of dealing with the plummeting welfare of horses and the rising costs to humans.

In the United States, wild horse herds and burros have expanded, nearly doubling, and excessively surpassed their Appropriate Management Level (AML) benchmark size set by the BLM; a benchmark to "manage wild free-roaming horses and burros… that is designed to achieve and maintain a thriving natural ecological balance on the public lands"[1]. The estimated population of free-roaming wild horses and burros under the authority of the BLM was almost 50,000 in March 2014, which exceeds the legislatively allowed level by more than 22,500.[2] Likewise, for March 2016, the BLM reported further expansion of wild horse herd size greater than 67,000, now exceeding AML by over 40,000. [3] Left without intercession, the BLM states that the wild horse population would soar to 145,000 by 2020.

With the WFRHB, the Federal Government and BLM face the difficult task of caring for these 67,000 wild horses. The task for the BLM has been one of the most divisive environmental subjects within the U.S. agricultural and rangeland sector. On one side, ranchers stand to protect their livelihoods as overpopulation

has degraded the environment and depleted resources insomuch that cattle/beef sustainability has plummeted. On the other side, animal rights and horse advocates looking to protect the animals and keep the free-running mustangs uninhibited. In the middle, the Bureau of Land Management (BLM) continues to search for an overdue dynamic solution

[1] Ray G. Huffaker et al (2015).
[2] U.S. Department of Interior, Bureau of Land Management. (2015)
[3] Herd Area and Herd Management Area Statistics (2016)

where rangeland is preserved, wild horses are protected, and the livestock industry unharmed.

The Government and BLM see the importance of sustaining an ecological balance to curtail the surplus of horses, and avoid future problems for the species health, environment, and economic sustainability. However, this is easier said than done as overpopulation has had an impact upon the environment and economy that is difficult to reverse. And thus, to tackle the negative effects of wild horse overpopulation, the BLM, along with many non-profit agencies and the Federal Government, has funded processes to decrease horse surplus through trying to increase adoption rates, create low-cost fertility programs, and develop efficient policies. It has been the objective of the WFRHB and the BLM to increase the welfare of all species involved: horse and humans together.

The paper will be discussed as follows. Section II gives an overview on the causes and consequences of overpopulation, as well as relevant current policy solutions. Section III works through a model demonstrating the impact of an updated adoption program for the BLM to tackle the overpopulation of wild horses. Section IV examines the different future techniques to reduce overpopulation, and the need for a hybrid system. Section V concludes the paper.

- **Background**

Impacts

The BLM looks to provide protection, management, and controls for the 32 million acres of public rangeland within the United States. With this responsibility, the BLM faces the challenge of attaining a cost-effective policy approach to management via a sustainable benchmark (set by the AML within the Western States of America to that of 26,500[4]). The agency's mechanisms, within the process of removal of horses from public ranges, has impacted not just the horses and the environment, but, as we will see, the economy also.

At first glance, the wild horse is a beautiful, adept, and capable species, so the thought of having "too many horses" as a negative is rather disappointing. As if to compare to an excess of dynamic and vibrant flowers, how could that be harmfully impactful? Take a deeper look, and one will note that

[4] Elizondo et al (2000)

overpopulation within an ecosystem, no matter what it may be, can pilot consequences that disrupt the ecological and healthy flow of the natural cycle.

In the 1970's, a population count by the BLM indicated that the wild horse population had increased resulting in overgrazing of public rangeland. Following a stated benchmark, or an "optimal number of wild horses, which results in a thriving natural ecological balance and avoids deterioration of the range"[5], an AML, or Appropriate Management Level, of horses was defined. Therefore, anything more than the AML is not ecologically sustainable, nor balanced.

With an unfettered ability to graze public rangelands, with no viable predation, the number of horses rise, and so do their impacts on the environment. As wild horse populations roam across 31.6 million acres of land, the survival of their species, and others, is at risk. The trampling of their feet across the barren lands and biotic crusts (a key composition material of grasslands) of the West, leads to, sometimes irreversible, damage; erosion, degraded, barren rock replaces the fertile environment.

As global temperatures change, hotter weather and droughts occur more often; water sources deplete

and the competition for remaining water is difficult. Dehydration and death ensue for the incapable numbers of wild horses and burros that look to obtain enough to drink. Likewise, wild horses face the difficult task of finding limited food sources (forage quality and availability are inadequate) considering droughts and overgrazing by the species. Consequently, starvation of wild horses and burros can lead to death, as well as weakened immune systems to the degree that wild horses are more prone to disease and infection.

Wild horses not only compete with themselves for food and water, they compete with other wildlife. The Ecological Society of America stipulated that "feral horse grazing at the utilization levels…can affect the ecological function of semi-arid rangelands and may degrade the habitat value of these communities for associated wildlife."[6] The depleted resources consumed by wild horses makes it a challenge for wildlife to survive sustainably. Likewise, the dominant behavior and size of horses, along with their interaction with other wildlife, may lead certain native species to avoid areas in which they originally

5Animal Protection Institute of America, 109 IBLA 112, 119 (1989)
[6]Davies et al (2014)

occupied. In addition, the grazing actions of wild horses reduce the quality and quantity of vegetation available for wildlife to live in and find habitat, often leading to desertification.[7]

Economically, the effects of wild horse population are large and encompassing. For US citizens, the BLM records that taxpayers have fronted more than $290 million for wild horse and burro management in its lifetime, with $50 million in 2016 alone going to the care and maintenance of horses in off-range holding facilities. The study conducted by Chris T. Bastian finds that foregone wild horses upon public rangelands is at levels beyond that of $1,900 per horse.[8]

Take the economic impacts of wild horses on the American farmer and rancher, who uses the public

rangelands offered by the BLM and Federal Government, and you will see that the effects are deep. The BLM used to issue 18 million animal unit monthly's (AUM's) back in the 1950's; however, in light of wild horse overpopulation, the BLM currently provides only 8.6 million AUM's.[9] These AUM's allow a rancher to graze their cattle on public lands, which they have the right to do. With the decrease in AUM's, the tide has turned for ranchers who utilize Federal land reserves for cattle grazing. Overpopulation of wild horses has reduced forage rates and yield so much so that the BLM must reduce the ranchers' ability to use public lands.

With the lower dispersal of AUM's, cattle feeding, and care is significantly more challenging: reducing the health and the size of cattle. Lower forage rates, from the overgrazing of feral horses and lack of forage nutrients, leads to lower weights of cattle, and lower market value of beef sales for ranchers. Economically, this is a huge challenge as federal property land reserves are meant for this exact task, to stimulate the cattle industry and maintain lands. After the implementation of the Wild Free-Roaming Horses and Burros Act in 1971, wild horse and burro numbers increased, and rangelands deteriorated to the point where cattle and other animals were dying of starvation. In an article, the American Horse Crisis, it was stated that the land of Western United States is depleted; so much so that there is not enough food and water left to feed cattle, let alone wild horses[10].

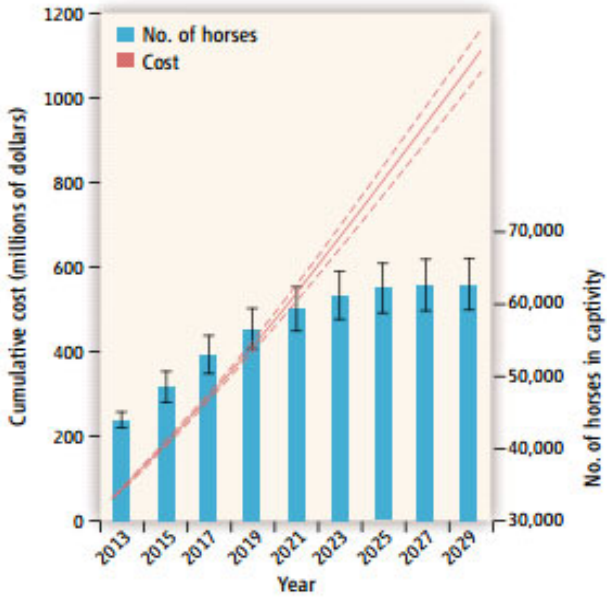
The BLM has taken steps forward in the past years to attain an approach that mitigates and lessens the negative impacts of wild horses in the Western United States. The BLM has developed an auction process,

[7] Chris T. Bastian (1999)
[8] Chris T. Bastian (1999)
[9] U.S. Department of Interior, Bureau of Land Management (2016)
[10] The American Horse Crisis - Impact (2015)

introduced in 1973 as the Adopt-A-Horse initiative, which keeps wild horses from slaughter and misuse. The early achievement of this program has kept it alive today, being the main catalyst for removal of wild horses from public ranges. Since 1971, the BLM has adopted out more than 235,000 wild horses and burros

nationwide and the BLM has sold more than 5,900 horses and burros since 2005. [11] Likewise, the BLM consistently funds the development of tools and methods to control wild horses and population growth, conducting socio-economic and bio-economic research that diminishes the costs of wild horse overpopulation.

For the BLM, the success and accomplishments do not outshine the rising costs and ineffective policies that have stolen the spotlight in recent years. The $165 in taxes to capture a horse, and $2.25/day to sustain the horses in captivity, costs $50 million annually to American taxpayers as of 2016; a cost which will rise if not curtailed.[12] The program's direct costs for holding wild horses has increased from $7 million in 2000 (46 percent) to $21 million in 2007 (67 percent) to $50 million in 2015 (66 percent).[13] As seen in the graph below, if these costs associated with the wild horse and burrows continue to increase at their current rate, as between the years of 2000 and 2013; the nominal costs of the program would reach $250 million midway through 2020.[14]



Projections of U.S. captive wild horses and costs (with 95% confidence intervals). (see SM for more details).

[11]U.S. Department of Interior, Bureau of Land Management (2015)
[12]Elizondo et al (2000)
[13]General Accountability Office (2008)

[14]Elizondo et al (2000)

On top of this, the number of horses removed by the BLM does not equate to number of horses being sold or adopted, consequently, limiting its ability to sequester overpopulation. From 2001 to 2008, per the United States Accountability Office, 74,000 horses have been removed from public range lands and only 46,000 have been adopted or sold. The remaining horses are funneled into the BLM short-term and long-term holding facilities where they await their death or possible adoption, leaving a huge cost to the welfare of horses.

The long-term sustainability of the BLM is at question, as rising costs and insufficient policy dominate the program. For the agency to continue, the costs of the holding facilities must be controlled and the adoption program must find options to deal with the non-adopted horses.

Without the implementation of a low-cost and effective way to remove and hold wild horses, the ecological and economical sustainability of the horses, and BLM respectively, will be compromised.

Current Solutions and Policies

Ever since the emergence of the wild horse and burro populations on BLM and federal forest ranges, legislators have looked for solutions to the environmental and economic challenges that have flourished. The first attempt to rein in and control the widespread capture of wild horses by Mustangers and those alike was in 1959 with the prohibition of motorized vehicles for capturing or killing wild horses on public lands.

Shortly after, and with the help of wild horse advocates and enthusiasts, Congress passed the Wild Free-Roaming Horses and Burros Act in 1971 (WFRHBA). Under this act, protectionism of wild horses found its place within legislation and became clear in enforcing and maintaining a “thriving natural ecological balance” of wild horses on the public rangelands. The allotment of Herd Management Areas (HMAs) and AML have arisen in consideration of the WFRHBA.

Problems have followed from the increased protectionism of horses. Overpopulation, overgrazing, starvation, and rampant disease have taken the wild horse populations by storm. The BLM faced the task of

mitigating, turning toward the removal of horses from on-range to off-range sites, as well as instituting a nationwide adoption program for private parties. Benchmark numbers, or Appropriate Management Levels (AML), were then set and used to determine the adequate wild horse and burro populations. To meet these benchmark numbers, removal of horses is outsourced to private companies.

The BLM then selects certain horses to be placed in selection, based on sex, age, adoptability. And are taken to short-term holdings. There "they receive vaccinations and other treatments prior to either being adopted, sold, or sent to long-term holding facilities.[15] From there, the horses move to adoption.

Adoption:

After being removed, the wild horses are placed for adoption in private care. For the BLM, more than 235,000 wild horses have been adopted since 1971 via their Adopt-a-Horse-or-Burro Program.[16] The BLM sets a $125 fee for adoption or sale, and, as of 2015, the adoption process costs $6.3 million.[17] The adoption process primarily aims to remove horses from the BLM holding facilities through the transfer of horses to private care on private lands. The program allows private individuals to adopt as many horses as seen fit by the BLM, who considers adopters ability to care and provide for the horses. The intent of adopters are closely monitored to make sure horses are kept from slaughter and remain in healthy environments.

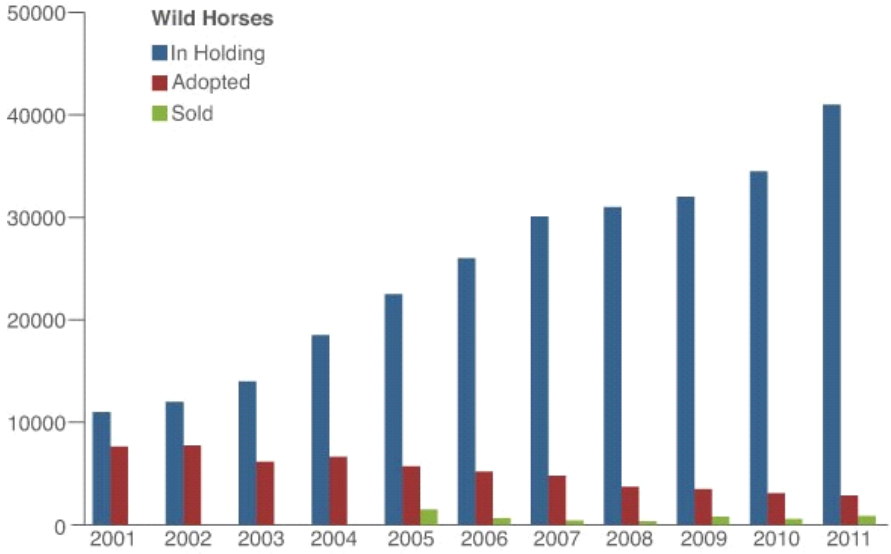
Along with the adoption process, training of wild horses has been conducted by the BLM to increase the attractiveness of the horses to potential adopters. Many of the more recently gathered animals have prospects for being adopted, especially if trained; estimates by JARE show that although 18% would be adopted under current adoption rules without training, nearly all would attract bids of $125 with training. The current training policy can be adapted to determine the most cost efficient and effective allocation of training, as to be discussed within Section III.

Along with wild horses and adoption, in 2016, 101 of the 2,331 wild horses adopted through the Bureau of Land Management's Wild Horse and Burro Adoption Program were relinquished back to the agency. In previous years, when adoption numbers were higher, it was typical for 300 to 500 wild horses to be

returned by adopters, who were "in over their heads."[18] This shines the light on the BLM's struggle to house excess wild horses, as represented in the graph below. Consequently, when adoption demand is not sufficient to uptake all the horses that have been removed, then short-term and long-term holding facilities are opened to house them.

15 General Accountability Office, (2008)

[16]U.S. Department of Interior, Bureau of Land Management (2015)
[17]U.S. Department of Interior, Bureau of Land Management (2015)
[18] Nicole Rivard (2016)



Holdings (Short and Long Term):

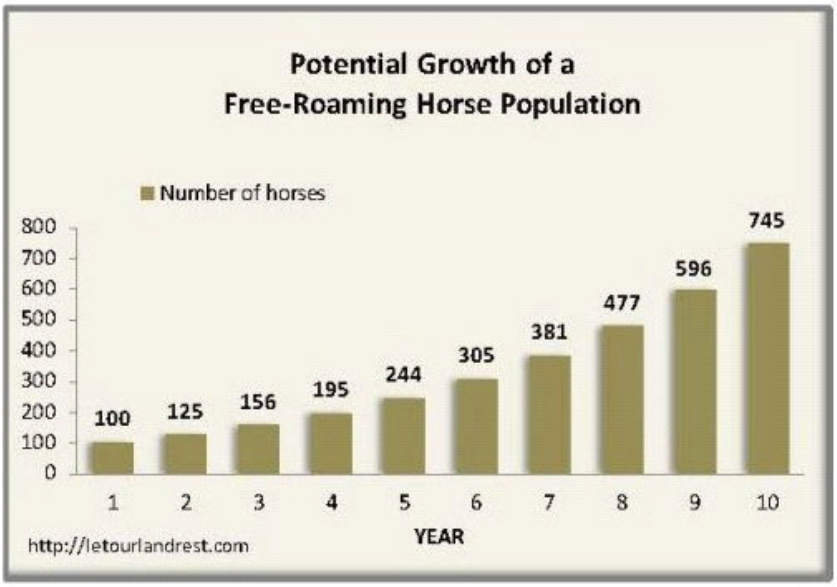
If horses are not adopted or sold, they are moved to short-term or long-term holding facilities supplied by the BLM. Operating under a moratorium to not destroy excess wild horses, brought about by wild horse activists, the BLM has opened these holding facilities. However, the costs, as discussed above, have skyrocketed, leaving more than 34,000 horses in corrals and pastures that must be kept running with taxpayer dollars.[19] In an unlimited manner, stipulated under the WFRHBA to attain the AML, the BLM can remove the remaining horses from the facilities, by means of lowest cost and sell them without limitation (usually

referring to the sale of wild horses to slaughter houses); the exercising of such actions has been curtailed under the moratorium, consequently leading to an excess of horses in facilities. These facilities are located through Western and mid-Western United States, where the BLM pays private contractors a fee per horse per day for the horses to occupy their lands—all to keep them off the deteriorating public ranges. In 2015, the BLM stated that off-range holding costs accounted for 66 percent of fiscal year budget, or $50 million dollars.

Associated with holding facilities, there are indirect costs to the horses themselves. As horses are corralled and placed in facilities, the changing of environment can be traumatizing to the horses. Many activists believe the treatment and the conditions the wild horses face are detrimental to the future and current welfare of the horses. The change of environment, from wild and free, to secluded and captured, would make any species afraid and terrified, leaving a lasting impression upon the horses.

[19] U.S. Department of Interior, Bureau of Land Management (2010)

Fertility Control:



The population of free-roaming horses can double in size every four years and triple every six years. Thus, the importance to find a solution in slowing the rate of fertility is imperative and crucial. The immunocontraceptive (a

contraceptive called porcine zona pellucida (PZP)) has been used by the BLM to work at reducing the fertility of mares (female horses) within the public range system. For the agency, the control has shown an effectiveness of 90% in preventing pregnancies and continues to be used to reduce foaling.[20] The NRC notes that while the control program can work to attain the AML, it cannot obtain the optimal level prescribed alone.

The cost considerations of fertility control management are an initial one time cost of approximately $300 per horse and further requiring population monitoring to make sure the contraceptive is successful.[21] The cost, as Bartholow finds, of fertility control monitoring is approximately $7,000 per HMA per year. Likewise, Garrott and Oli (2013) found that if the PZP was more generously and widely used, it could help to curtail wild horse fecundity, and possibly lead to birth rates being reduced to half.
Interestingly, Garrott and Oli (2013) estimate $16,110 per prevention of each additional birth could be saved regarding long-term holding.

20 Bartholow (2007)
21 Bartholow (2007)

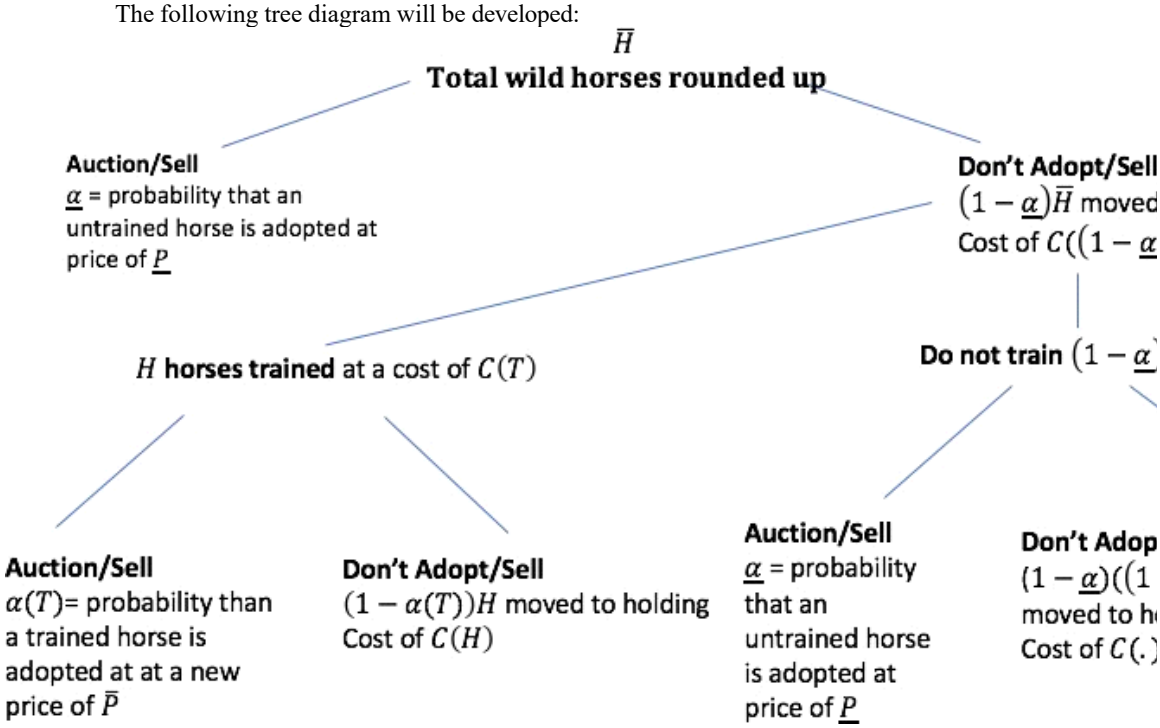
- **Model**

The single-period model will look at the effects of one policy on reducing the stock of wild horses on public rangeland, while reducing the costs to the BLM. Ultimately, the reduction policy aims at adapting the current adoption program of the BLM to decrease the cost of ownership for wild horses, specifically by increasing training efforts of wild horses. The model looks at the comparative effects of the policies on the costs associated with offering trained wild horses for adopters, which will decrease the costs of adoption. As

well, the impact of less holding days for the BLM are noted to decrease the carry costs.

Ultimately, by increasing adoption rates and clearing holding areas faster, the BLM can economically enforce the regulated ALM level of wild horses by moving more horses through their program, leading to a reduction on wild horse and burro populations.

The following tree diagram will be developed:



In this one-period model, the BLM starts by rounding up a total of H wild horses from the public range lands. These selected horses are either adopted, or they are not, and every horse is untrained. With a probability of $\underline{\alpha}$ the untrained wild horse, within the H population, will be adopted. We assume that $\underline{\alpha} > 0$, and that every untrained horse adopted is sold at a transfer price of $\underline{P}$. Therefore, the BLM auctions horses:

$\underline{\alpha}H$ sold at a price of $\underline{P}$.

With a probability of $(1-\underline{\alpha})$ the wild horses will not be adopted. Thus,

$1-$ moved to holding facilities.

Within these holding facilities, the BLM has a cost function of:

$$C(\ 1-\alpha\ \ H)$$

From here, the principles of the policy come into play as training upon the horses by the BLM is now applied to the horses to increase horse attractiveness and adoptability.[22] For instance, from the $1-$ population that did not sell initially, H horses are selected and trained at a cost of $C\ \ T$, where T is the level of training applied to one wild horse. We assume here, that the cost function of training is increasing in the amount of training applied, so that

$$\frac{\partial C}{\partial T} > 0$$

Therefore, the wild horses that are not selected for training equal $1 - \quad - H$. These horses can go through the adoption program again and be adopted at a probability of $\underline{\alpha}$ so that:

$$\underline{\alpha}(\ 1 - \qquad - H) \text{ sold at a price of } \underline{P}$$

Again, the horses that do not sell,

$$(1 - \underline{\alpha})(\ 1 - \qquad - H) \text{ moved to holding facilities.}$$

Within these holding facilities, the BLM has a cost function of:

$$\left(\left(C(\ 1 - \quad 1 - \qquad - H\ \right)\right.$$

From the H horses that have been trained by the BLM, there is a probability of $\alpha(T)$ that the trained horse will be sold at a new price of P, where $P \gg \underline{P}$. Thus, we assume that the probability of selling a trained horse is:

$$\frac{\partial \alpha}{\partial T} > 0$$

$$\frac{\partial^0 \alpha}{\partial T^0} > 0$$

So that probability of selling is increased with training at an increased rate. Therefore,

$$\alpha(T)\ H \text{ trained horses sold at price of } P$$

22 Assuming trained wild horses are more greatly valued and desired by potential adopters.

From the H horses selected for training, $1 - \alpha(T)$ of the horses are not adopted. We have:

$$1 - \alpha(T)\ H \text{ moved to holding facilities}$$

$$C\ H \quad \text{cost of holding}$$

To summarize:

H = Total wild horses rounded up

H = Horses selected for training

$\underline{P}$ = Transfer price of untrained horse

P = Transfer price for trained horse

$\underline{\alpha}$ = Probability that an untrained horse is adopted

$1 -$ = Probability that an untrained horse is not adopted

T = Level of training

$\alpha\ T$ = Probability a trained horse will be adopted

$1 - \alpha(T)$ = Probability a trained horse will not be adopted

$C(.)$ = Cost function for training and holding wild horses

Therefore, with the payoff and cost structures in mind, the BLM's decision problem is to maximize the payoff of π by maximizing sales revenue and minimizing holding and training costs.

$$E\ \pi_{456789:;<5=9=} = \alpha\ T\ PH - C\ T\ H - 1 - \alpha\ T^{))}C(H)$$

On the RHS, the first term is the expected sales revenue for trained horses, the second is the cost of training horses, and the third term is holding costs for the non-adopted horses. Likewise, for the untrained horses:

$$E\ \pi_{?8456789:;<5=9=}$$

$= \underline{\alpha P}[\ 1 -$

$-H] - \ 1 -$

$C(\ 1 -$

$- H)$

On the RHS, the first term is the expected sales revenue for untrained horses and the second term is holding costs for the non-adopted horses. The final decision problem for the BLM is to sum these two expected return equations to form:

$$E\ \pi_{4<46B} = E\ \pi_{456789:;<5=9=} + E\ \pi_{?8456789:;<5=9=} =$$

$$))_{\alpha\ T\ PH - C\ T\ H - 1 - \alpha\ T\ C\ H + \underline{\alpha P}[\ 1 -}$$

$-H] - \ 1 -$

$C(\ 1 -$

$- H)$

Therefore, $E \ \ \pi_{4<46\mathrm{B}}$

represents the total expected payoff for the BLM and provides an optimality decision

structure with first order conditions to find the level of training T^* and number of horses selected for training H^*.

$$\max_{\mathrm{H,I}} E\ \pi_{4<46\mathrm{B}} =$$

$$\alpha\ T$$

$- \ C \ T)]H - \ 1 - \alpha \ T \ C \ H \ + \ \underline{\alpha P}[\ 1 -$

$- H] - \ 1 -$

$C(\ 1 -$

$- H)$

$$)\,)\frac{\partial E\ \pi_{4<46\mathrm{B}}}{\partial T} = \alpha_{)} PH - \partial C\ H - (-\alpha_{)}) C(H) = 0$$

∂T

$*$ J ∂C

$\alpha^{\downarrow} C(H)$

T : α P =

$\partial T^{-} \quad H$

$$T^{*}: \alpha^{J}[P + \frac{C\ H}{H}] = \frac{\partial C}{\partial T}$$

Thus, on the LHS of the T^{*} equation is the expected marginal benefits of training horses:

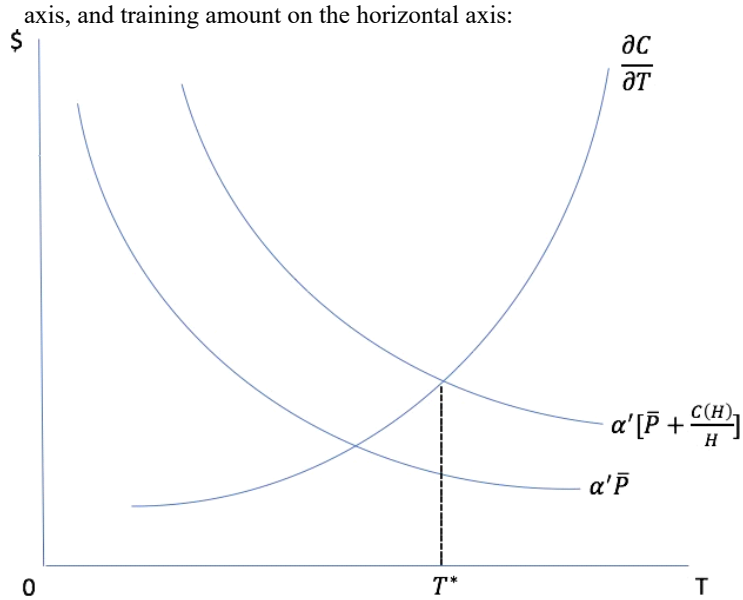
$$\alpha^{J}[P + \frac{C\ H}{H}] = E[MB_{I}]$$

and where the $^{O\ H}$

^{H}

is the external benefit of training, as the BLM has less unsold horses in holding.

On the RHS is the marginal cost of training a horse, minus the expected reduction in average holding costs of "sold" trained horses $\frac{PO}{PI}$. Associated with the assumptions outlined above, of increasing and decreasing functions, the decision problem to choose T^* can be represented as follows, with dollars on the vertical axis, and training amount on the horizontal axis:



Further, for finding optimal H^*:

$$\frac{\partial E\ \pi_{4<46B}}{\partial H} = \alpha\ T$$

$$- C\ T)] - \ 1 - \alpha\ T$$

$$+ \alpha P[\ -1\ ] - (1-\alpha)\frac{\partial C}{\partial H}(-1) = 0$$

H^*:

$\alpha \quad T \quad -$

$$[()]_{=} \; C \; T \; + \qquad 1 - \alpha \; T \qquad - \; 1 -$$

$$-(\alpha\ T\ -\ \alpha)\ \frac{\partial C}{\partial H}$$

Thus, on the LHS of the H^* equation is the expected marginal benefit of picking a horse for training:

$$\alpha\ T$$

$$- \underline{\alpha P} = E[MB_{\mathrm{H}}]$$

which is the expected price differential between a trained horse and an untrained horse. On the RHS, the first term is the incremental cost of training one horse, the second term is the marginal holding cost for non-adopted horses, and the third term is the increase in the expected probability of a sale with training. To simplify further:

H^{*}: α T $-$

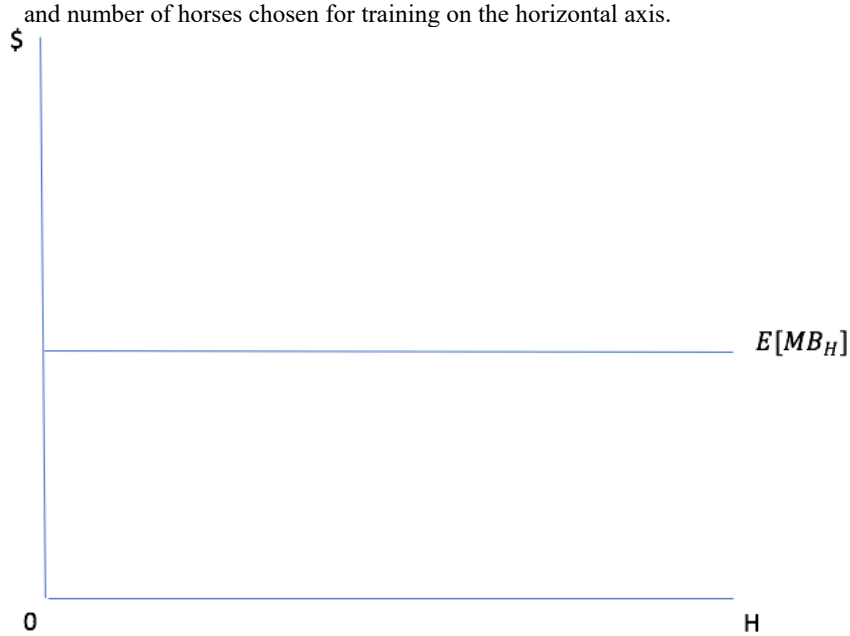
$$[()]_{=\ C\ T\ -\qquad \alpha\ T\ -}$$

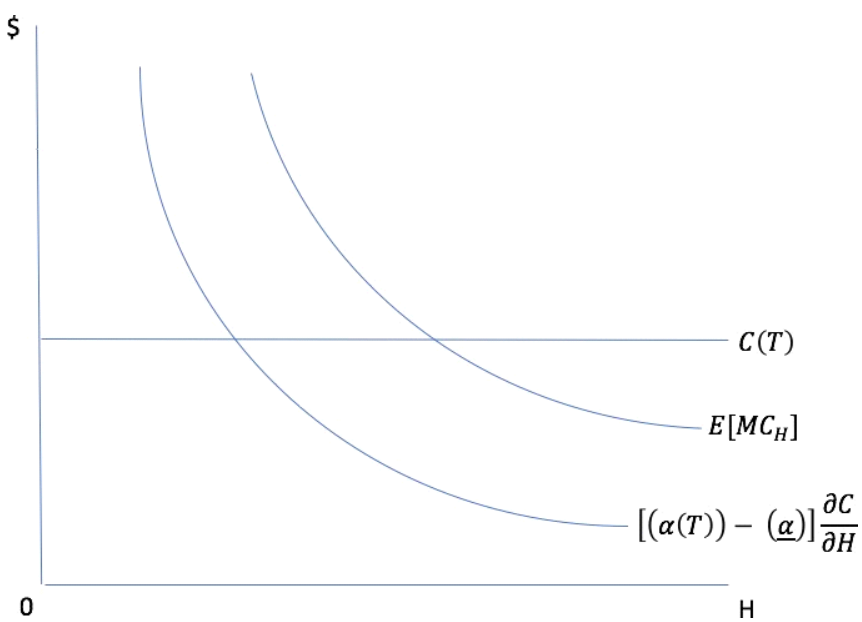
Thus, on the RHS of the H^* equation is the expected marginal cost of picking a horse for training:

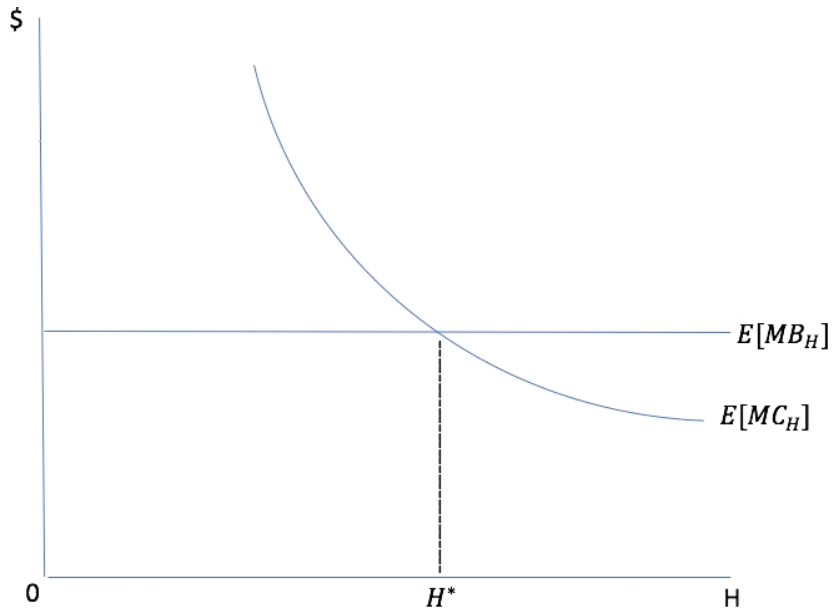
$$[()]_{C\ T\ -\qquad \alpha\ T\qquad -}$$

$= E[MC_{\mathrm{H}}]$

Looking at the construction of the marginal benefit and marginal cost curves, we see the optimal number of horses chosen to be trained at the intersection point of the curves, noted as H^*, with dollars on the vertical axis, and number of horses chosen for training on the horizontal axis.







For the BLM, the decision set is obtained through equating the estimated marginal benefit and cost of training, as well as equating the marginal benefit and cost of horse selection, (T^*, H^*). This optimality allows the BLM to choose a specified level of training and horse selection that will maximize expected total returns via maximization of revenues and minimization of costs associated with holdings and training levels.

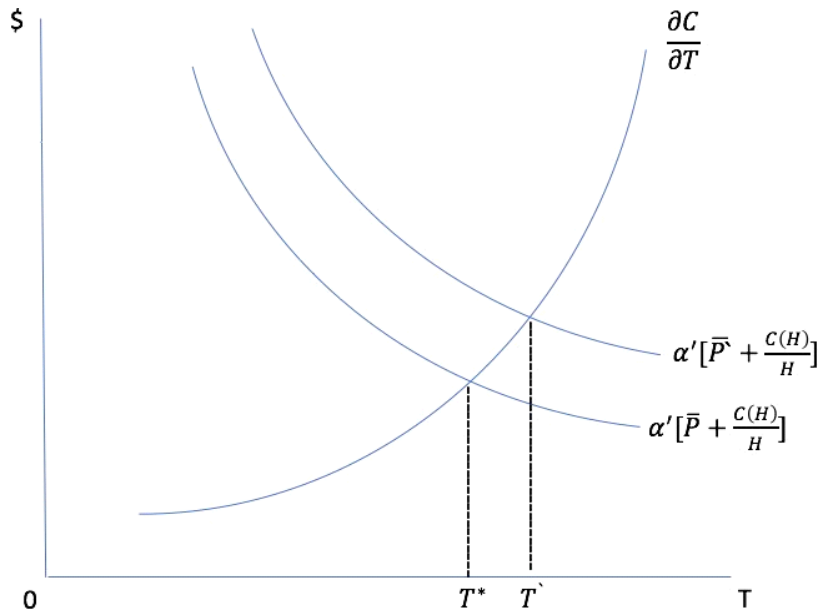
For comparative exercises, and to see the effects on the selection set of (T^*, H^*), the model can be

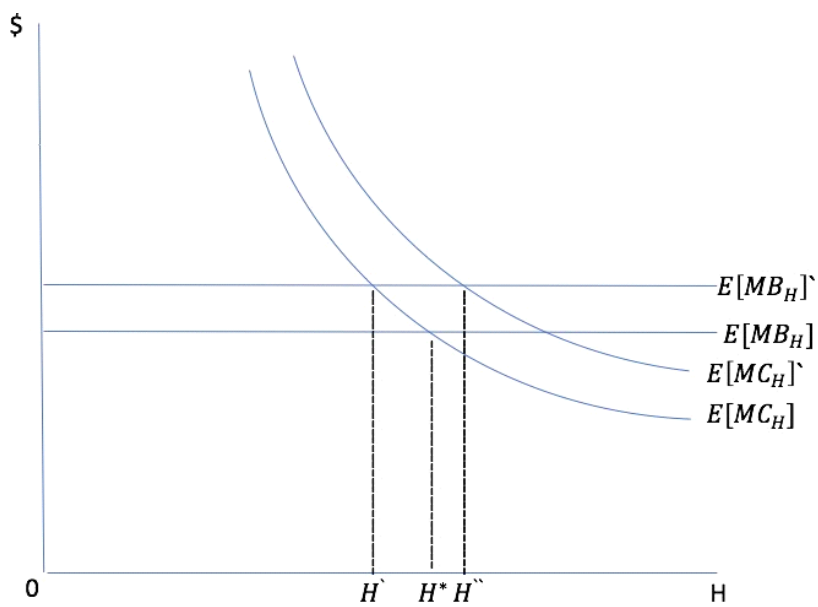
manipulated. Changing the exogenous variables of the above equations to meet real world dynamics of normative levels, the model will show that specific endogenous (T^*, H^*) allocations can be determined. If

the exogenous variables of H, $\underline{P}$, P, $\underline{\alpha}$ are manipulated, the given functions of α T and $C(.)$ will be influenced to transform and transition the expected benefit and costs, under training and horse selection, accordingly. Likewise, to meet the real-world dynamics, the benefit and cost-curve functions can be controlled to include factors that are not mentioned, such as horse type, adoption fee levels, etcetera; to be developed in further studies.

To provide a comparative statics example, the model is changed to account for a rise in the exogenous price variable of P: the transfer price for a trained horse. Within the benefit and costs function of determining T^*, the increase in price will increase the expected marginal benefit of training horses, as revenues rise with a higher price. This will, in turn, shift up the $E[MB_{\mathrm{I}}]$ curve and the new $T^{`}$ will rise and be determined at the curve intersection equilibrium.

Likewise, for determining H^*, there will be the given rise in P, but also the consequent rise in training level chosen from the new $T^{`}$. Here, the model assumes the substitution effect is greater than the income effect. The rise in price level will increase the expected marginal benefit of picking a horse for training, shifting up the $E[MB_{\mathrm{H}}]$ curve and facing lower $H^{`}$. Also, the rise in training will increase the costs for the BLM, shifting up the $E[MC_{\mathrm{H}}]$. The rise in chosen transfer price for a trained horse will lead to an increase in the number of horses selected for training to $H^{``}$.





The model that has been defined makes many key assumptions not yet mentioned. Firstly, the stock and flow of horses is limited to that of the BLM's selection process for wild horses for round-up. This eliminates the basis of supply from outside sources, such as relinquishment, commercial breeders, or private horses. Secondly, the model assumes that the price received for a trained horse will be greater than the price

received for an untrained horse; this assumption creates the incentive for the BLM to train wild horses. Thirdly, horse welfare is assumed away, allowing the model to define a fully internalized decision process for the BLM. Fourthly, the probability of horse adoption with training is assumed to be greater than the probability of adoption without training. This eliminates the likelihood that trained horses will be adopted at a lower rate than untrained.

It is important to note that the model developed focuses on the optimality decision, by the BLM, to choose a specific level of training for the horses without much restriction. As such, it is limited in its ability to fully examine the policies' impacts upon the decision process and costs. While the model defines cost sensitive allocations, playing a big role in adoption success and decreasing the wild horse population, it does not fully account for real-world dynamics. A more integrated approach may be developed to account for these dynamics in a later paper.

For training horses alone, a requirement of initial payments and investments of public funds will need to supplied to the BLM. With the assumption that the probability of horse adoption with training is greater than the probability of adoption without training, then there will be an incentive to invest in

training. However, as Hyde (1978) suggests, the issue of wild horse overpopulation can be expressed in an economic framework to help determine the allocation of government and public resources, used by the BLM, for wild horses. The paper uses a framework that is broader and not specific to training but comparing wild horse management costs with benefits is similar in determining expenditures. What could be integrated into this model requires us to define the Hyde (1978) level of government funding and optimize government funding over this restriction.[23] This definition, however, is beyond the scope of this model.

- **Where to Go Now?**

This section addresses the broader scope and methods in which wild horse and burro overpopulation can be reduced. In the developed model, the other methods of population growth control are not discussed. Thus, the possibility of a lower costed method, other than training, to reduce the number of horses in the wild could be developed. The following methods are taken in turn, then presented as a collective hybrid system that may provide the most cost-effective and efficient solution to wild horse overpopulation.

Firstly, and as discussed in Section I, the lack of natural predators for the wild horses and burros is a main driving force in exponential population growth. The large animals graze rangeland without a significant threat of predators; the natural causes of death are limited to disease, dehydration, age, and starvation. A method for population control that could be encouraged is the introduction of a natural predator species back to the public rangeland, such as wild wolves. The success of this process is for the development of wolf populations; thus, the enforcement of hunting restrictions must be imposed by the government and the BLM.

It is important to note that the introduction of wolves is a "reintroduction" of the species to the ranges. At the hands of ranchers and hunters during the late 1800's and early 1900's, the wolves were culled to curtail the impact on livestock deaths; consequently, leading to their extinction. Similarly, this extinction is what is being faced by the wild horses and burros in Western United States as horses impose a negative externality to ranchers who look to remove horses from the lands in place of

[23] Hyde (1978)

their own livestock interests. It is imperative that, like horses, wolves become protected from political interests and ranchers so they can sustain healthy numbers.

Like the horses, the optimal level of wolves must be controlled and monitored to avoid wolf overpopulation, and this could be done through the release of hunting permits or fertility control. In addition, the BLM must be able to demonstrate that the wolves are successful at decreasing horse populations, without

significant population effects on other species. The process of introducing a native predator to horses is an indirect way of tackling overpopulation as the native species may take to "lesser" animals in the range, instead of the horses.

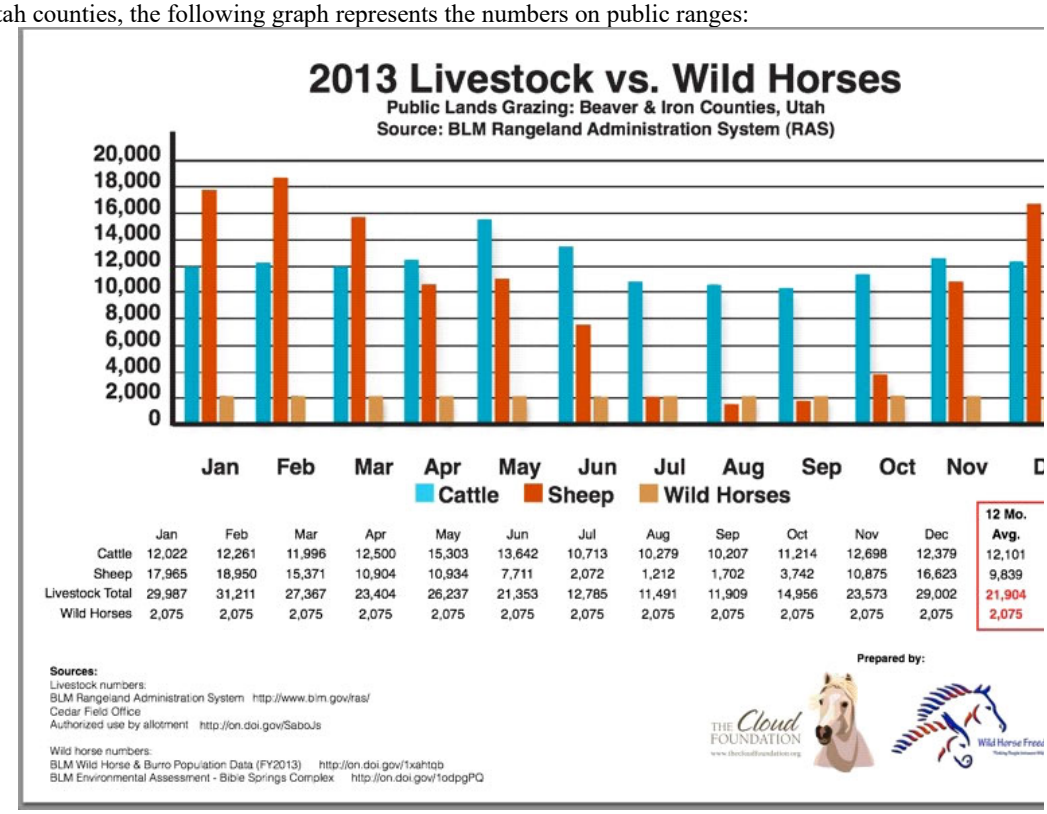
Secondly, an additional method to reducing the overpopulation of horses would be to set a price for the distributed grazing permits. Presently, the public ranges are common property and grazing numbers are restricted to the allotted HMU's, as discussed in Section I. Thus, the negative externality of cattle grazing on public lands is not internalized and does not meet social optimality. The internalization of costs associated with excess cattle grazing would be reflective in pricing the public land grazing permits.

Likewise, looking at policy analysis, the BLM could implement a tradeable permit level for stock, so BLM could exchange grazing permits with horse activists and ranchers, this would allow wild horses to effectively replace some of the livestock on BLM lands. Implementing this option, as well as increasing the price of grazing permits, would involve fundamental changes in the structure and provisions of Federal grazing leases and would require the resolution of myriad complex issues. The tradeable permit level and increased price for grazing permits could allow the attainment of a more socially-economic allocation of horses and cattle to public lands as prices would be bided up.

Ultimately, the internalization of costs for the ranchers is to mitigate, as much as possible, the Tragedy of the Commons. The excess number of horses upon public ranges are significant and to be sequestered, yet the number of ranchers' livestock upon the lands far exceeded those of horses, so much so that livestock use has degraded the rangeland as well. In this way, the tradeable permit and priced AUM's charge the ranchers, responsible for a large portion of overgrazing and environmental degradation on public lands, to pay for the costs associated. With the AUM's tilted towards the interest of political and economic interests, as seen with the excess of cattle upon public ranges, should lead to further study and

investigation. To graphically understand the use differences, from those of cattle, sheep and wild horses

within Utah counties, the following graph represents the numbers on public ranges:



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	12 Mo. Avg.
Cattle	12,022	12,261	11,996	12,500	15,303	13,642	10,713	10,279	10,207	11,214	12,698	12,379	12,101
Sheep	17,965	18,950	15,371	10,904	10,934	7,711	2,072	1,212	1,702	3,742	10,875	16,623	9,839
Livestock Total	29,987	31,211	27,367	23,404	26,237	21,353	12,785	11,491	11,909	14,956	23,573	29,002	21,904
Wild Horses	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075	2,075

Thirdly, fertility control techniques are limited with costliness and lack of immediate results.

Bartholow (2007) finds that the current 2-year contraceptives being used could be combined with experimental 3-year contraceptives and a modified herd-sex ratio to reduce the number of horses in long-term holding by 17% over a 20-year period. Therefore, the need for a more effective approach to fertility control could be found. However, as Bartholow (2007) notes, the decrease in long-term holding numbers, and costs, can be significant and the need for contraceptives is required early on if cost benefits are to be noticed. In other words, there is short-term expenditure for long-term sustainability of horse populations and control regarding fertility.

With the developed model, and the noted methods of reducing wild horse and burro populations, it is rather clear that the specified policies alone may not reduce the overpopulation of BLM wild horses significantly enough to curtail overpopulation and the costs associated with. Therefore, a dynamic model

could be worked out to develop the lowest cost management system for wild horses as to include all features: training, adoption, native predator introduction, policy and permits. With a hybrid model, the respective strengths and weaknesses from each specific management option could be co-aligned and formed into a preferred single management alternative. This management alternative would allow for an increase in adoption rates, plus a

decrease in carrying costs for the BLM, as well as an efficiency gain in associated policy. With this, wild horse populations could be maintained at a desirable level, possibly allowing for a reduction in management intensity, further decreasing costs, and providing an ecological balance for the public rangelands

- **Conclusion**

In the developed model, and the attempt to reduce wild horse overpopulation, it is important and necessary to consider the diverse dynamics that come into play. There is no "one size fits all" approach to successfully reducing herd size to an optimal level as the players involved are all connected to the outcome. A single policy — such as increased training — will only address one aspect of the plethora of undercurrents surrounding wild horses. Even if training reduces the stock of horses within holding facilities, it may not adequately reduce the number of horses in public ranges, making it unable to fully impact the overpopulation. As a result, it is highly imperative to consider a dynamic solution that considers all the incentives and costs of players involved. A more dynamic solution will be harder to monitor and control, but overall effectiveness will supplant the costs associated.

With the study of wild horse and burro overpopulation, many methods for its reduction have been studied and addressed, providing a range of low-cost solutions. However, the ability for these solutions to be implemented successfully requires the foundations of adequate funding and resources, consistent monitoring, and steady efforts on all fronts from that of farmers/ranchers, advocates, and the BLM. The application of

policies and solutions are costly, but the effects of reducing the overpopulation of horses are only positive and required to preserve the health of the horses, their environment, and the economy. The costs are not unnecessary, but rather imperative, to tackle the challenge in the most positive and effective way possible.

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