Understanding the Economic Impact of Wild Horse Management on Local Communities

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INTRODUCTION

The question of how to effectively and equitably management public lands held by the federal government has been a contentious issue for years. This problem draws the attention of local communities, extractive industry users, ranchers, environmental and wildlife interest groups, and federal and state agencies. For local communities, these discussions are framed as matters of economic necessity as the public lands represent an important source of economic activity and revenue. For environmental groups, the discussion is framed in ecological terms that focus on the preservation of wild places and the ability of native species to roam free. For government agencies, balancing these competing interests has been a difficult task.

These discussions have permeated nearly every aspect of public land management, and they raise important issues that often prove intractable. One area of policy management facing considerable discussion is the management of wild horses and burros. This debate highlights competing claims over what the aim of wild horse management should be and the effects of current management policies.

Wild horses have long been associated with popular culture's romantic view of the West. When thinking about public lands, many conjure an image of wild horses running free along the ridgeline at sunset. Wild horses hold a majestic place in the iconography of the West, but the debate over their management has been far less romantic. The effects of wild horse management, both on the horses and the communities in which they are co-located, is one of the more contentious public land issues in need of further study.

In this paper, we examine one aspect of the debate to better understand the implications of wild horse management decisions and their impact on the communities where Herd Management Areas (HMAs) are established.

To explore these policy implications, we begin with a core question: Are counties where HMAs are present economically different from non-HMA counties? As we explore this question, we use a cross sectional time series-regression to examine how HMAs may impact the economic conditions of a county. We then present an illustrative case study from Beaver County, Utah, to more clearly examine how an HMA and its attendant management approach may impact the communities with which they are co-located. We find, in general, the presence of an HMA in a county is associated with lower overall economic activity.

BACKGROUND

Native wild horses roamed North America during the prehistoric period, but they have long been extinct (Pitt, 1984-1985). European explorers (mostly from Spain) re-introduced horses when they arrived on the continent in the late 15th and early 16th centuries. Columbus brought horses to Hispaniola on his second journey to the Americas, and the island soon became a source of horses for Peru and Central and North America. As explorers moved north from Mexico, they brought horses with them; missions founded in the late 16th century were likely the source of the lost and stolen animals that became America's first wild horses (McKnight, 1959).

The wild horse population has fluctuated in the United States. During the westward expansion, more fences limited the open range and increased opportunities for horses to break free from captivity. When ranchers had too many horses, they often turned them loose into the wild. At its peak, some estimates suggest the wild horse population may have reached 5-7 million in the United States (McKnight, 1959).

In the 20th century, wild horses faced increased fencing and competition from domestic livestock. Horses were hunted for commercial pet food and by ranchers trying to alleviate competition for grazing. As a result, the wild horse population declined to about 25,000 by the early 1950s (Pitt, 1984-1985; Huffaker, Wilen, & Gardner, 1990).

During this time, wild horses were gathered for slaughter by using aircraft to frighten and herd the horses, exhaust them, and tightly pack them into trucks for transport. Wild horse advocates, including Velma Johnston, believed the roundup process was inhumane, and that without protection, the wild horses in America would soon die off (Johnston, 1971-1972).

As Johnston and other advocates raised awareness, the hunting of wild horses gained national attention. In 1959, Congress passed the Hunting Wild Horses and Burros on Public Lands Act to prevent the use of motorized vehicles to hunt wild horses and burros on public lands (Danvir, 2018). However, the law was not well-enforced, and it did not protect horses from roundups on private land or non-motorized roundups on public land. The Bureau of Land Management (BLM) estimated that the wild horse population consequently fell to about 9,500 by 1971 (Pitt, 1984-1985).

In response, Congress passed the Wild Free-Roaming Horses and Burros Act of 1971, which protected wild horses on public lands. The law protects wild-roaming horses and burros from being captured, branded, harassed, or killed. In addition, horses are treated as elements of the public lands and managed by the BLM and Forest Service. Thus, the government can maintain and designate particular ranges on public lands as places for protection and preservation (U.S. Department of the Interior [U.S. DOI], 2018b).

At the time of the Act's passage, scientists estimated the range could sustain about 27,000 wild horses and burros (Frey & Thacker, 2018). The population has since grown substantially. With no natural predators and the ability to live in a variety of habitats, wild horses have exceeded the capacity of the range; as of March 2019, approximately 88,090 wild horses and burros live on the range (U.S. DOI, 2019; Frey & Thacker, 2018). To control the population, the BLM provides fertility control for mares and periodically removes excess animals from the range. These animals are then kept in off-range holding facilities or adopted and sold into private care. Despite these measures, the population has continued to grow. Birth control has limited efficacy and is difficult

to distribute, while horses removed from the range are more likely to remain at an off-range holding facility than be adopted (U.S. DOI, 2018b).

Effects of Wild Horse Population Growth

Ecologists have studied the ecological consequences of wild horse population growth, but there has been limited research on the economic impacts of wild horses. Researchers have looked at the biological effects of fertility control (Garrott, 1991; Garrott, Siniff, Tester, Eagle, & Plotka 1992; Gross, 2000) and the impact of wild horses on range plant life (Boyd, Davies, & Collins, 2017; Beever & Brussard, 2000; Beever, 2003; Loydi & Zalba, 2008; de Villalobos, Zalba, & Peláez, 2011). Other studies show that wild horses have diet overlap with domestic livestock and native ungulates (Scasta, Beck, & Angwin, 2016; Hansen, Clark, & Lawhorn, 1977; Hanley & Hanley, 1982; Krysl, Hubbert, Sowell, Plumb, Jewett, Smith, & Waggoner, 1984); compete for water with native ungulates (Hall, Larsen, Knight, & McMillan, 2018; Miller, 1983; Perry, Morey, & San Miguel, 2015); and impact the presence of smaller animals on the range (Beever & Brussard, 2004; Beever & Aldrige, 2011).

One study infused ecology with economics to develop a bioeconomic livestock/wild horse tradeoff mechanism for conserving vegetation (Huffaker, Wilen, & Gardener, 1990). The mechanism uses a theoretical permit to grant perpetual grazing rights to permit holders. This provides an incentive for permit holders to maintain the range for their own future use. It also requires the public rangeland manager to set target sustained vegetation levels. The mechanism does not attempt to use or find the socially optimal level of vegetation. Rather, the goal is to determine the optimal combination of wild horse removal rates and grazing fees that encourage permit holders to choose the ideal cattle stocking density to preserve the vegetation at target levels.

In a case study at the Whiskey Peak Allotment Complex in Wyoming, Bastian, researchers estimated the opportunity costs associated with the grazing competition between wild horses, wildlife, and domestic livestock (Van Tassell, Cotton, & Smith, 1999). According to their analysis, a population of horses at or below the median appropriate management level (AML) of 184 horses has an opportunity cost less than $500. However, beyond the median AML, opportunity costs quickly rose to $1,900 and beyond. This suggests effective removals that maintain horse levels at minimum or median AMLs would be less costly in terms of wildlife and livestock grazing than current circumstances. However, the authors note this result should not be confused with socially optimal horse levels.

Another study sought to address the question of a socially optimal solution to the overpopulation of wild horses (Hyde, 1978). The author asserts that wild horses are a public resource that must be managed, and efficient management must yield at least as much benefit as it costs. The following equations are suggested to aid this calculation:

> **benefits** = 1) value of recreational viewing of the horses, plus 2) the vicarious values (i.e. knowledge of their existence)
>
> **costs** = 1) the opportunity value for domestic livestock and wildlife forgone, plus 2) the separable cost of managing wild horses, minus 3) the value of wild horses to their foster parents, plus 4) the cost of public scrutiny of foster homes, plus 5) the cost of negative externalities created by horses. (p. 76)

The author recommends quantifying these benefits and costs on a case-by-case basis to achieve the optimal solutions to specific wild horse problems. While many of the benefits and costs are difficult to quantify, it is better to have a poor estimate than a completely uninformed guess (Hyde, 1978).

Attempts to Limit Wild Horse Populations

While large scale studies of the overall economic impacts of wild horse management are scarce in the extant literature, a wider set of studies have examined the BLM's attempts to manage the

herds. These studies have focused primarily on three management strategies: fertility control, removal, and adoption. Consistent with the wider ecological literature, these strategies are focused on bringing populations down to approved AMLs to mitigate the negative impacts on range conditions and animal health while considering the overall budgetary costs of horse management.

Fertility Control. Studies found that fertility control alone is not an effective population management strategy because it does not eliminate the need to remove wild horses from the range to achieve AMLs. However, fertility control might be able to lower program costs in some cases.

A study analyzing four HMAs [Challis HMA (ID); McCullough Peaks HMA (WY); Pryor Mountain Wild Horse Range (WY, MT); and Little Book Cliffs HMA (CO)] found fertility control would be most effective at lowering program costs in three of four herds studied if 2-3 year contraceptives were used in combination with either more efficient horse removals (McCullough Peaks and Little Book Cliffs) or removals aimed at increasing the proportion of males to above 50% (Challis) (Bartholow, 2007).

Another study in Nevada and Oregon compared the effects of fertility control with two-year effectiveness alone, removal alone, and a hybrid approach (Fonner & Bohara, 2017). Two-year fertility control treatment was insufficient on its own because it was slow to produce results and nearly impossible to treat every mare. Optimal 50-year removal and hybrid scenarios would begin with intensive removals to reduce the populations to AMLs relatively quickly. From there, removals alone or removals combined with fertility control would be used to maintain AMLs. The authors predict that removal only management would be more cost effective in Nevada while hybrid management would create greater savings in Oregon due to a larger proportion of Oregon horses being adopted after removal. Both cases would result in higher costs initially but overall cost savings across 50 years.

Adoption. A second area of exploration has surrounded the programs that attempt to remove excess horses by providing them for adoption. One study argues that a major source of the BLM's management problems are related to the fact that the quantity of wild horses supplied for adoption at a price floor of $125, as stipulated by the BLM's Adopt-a-Horse program, exceeds the quantity demanded (Elizondo, Fitzgerald, & Rucker, 2016). A potential solution to this problem is to increase demand. This could be achieved by training more horeses before adoption; all trained horses in the data set, 1007-2010, were adopted. However, the authors acknowledge that they lacked comprehensive cost data and recommend further analysis.

Researchers have examined where training makes wild horses more desirable. In a study from November 2012 to March 2013, halter training was shown to increase the likelihood that someone would bid on a horse for adoption with a positive demand elasticity of 66.86%, while saddle training decreased the likelihood of bids with a negative demand elasticity of 90.98% (Adekunle, Saghaian, Stowe, & Markus, 2013).

Another option to increase demand would be to remove some of the restrictions on selling wild horses for commercial use (e.g., slaughter) (Elizondo, Fitzgerald, & Rucker, 2016). However, considering outrage over commercial use fueled the protective legislation, this solution seems politically unlikely.

Reducing supply could be accomplished through fertility control or allowing horse advocates to buy grazing permits from livestock producers. However, permits for wild horse advocates would only create a short-run solution because the additional horses allowed by the permits would contribute to population growth in the long-run and exacerbate the problem.

A more obvious solution would be to lower or remove the price floor. Researchers found that if the adoption fee was cut in half ($75), about 85% of horses that went unadopted from 1997-2010 would have been adopted. They estimate this would have created net savings of about $383 million (2009 Dollars) coming mainly from forgone long-term holding

costs. With no adoption fee ($0), greater than 99% of unadopted horses would have been adopted, resulting in net savings of about $452 million (Elizondo, Fitzgerald, & Rucker, 2016).

On the other hand, a study looking at increasing the adoption fee suggests the demand for wild horses is relatively inelastic (Godfrey & Lawson, 1986). From this result, the authors infer that the BLM could increase revenue by increasing adoption fees because the demand for wild horses is more likely to be influenced by other facts such as consumer preferences and the prices of domesticated horses.

Examining the BLM's internet auctions for wild horses from November 2012 through March 2013, researchers used a hedonic pricing model to determine which traits were most desirable and the related demand elasticities (Adekunle, Saghaian, Stowe, & Markus, 2013). They found that horses that are colored, mare, stallion, or captured outside the holding facility have demand elasticity higher than 70% and are more likely to attract bids and sell for a higher price. Moreover, potential wild horse buyers are generally interested in the novelty of owning a piece of history and protecting the horses from extinction. Because potential buyers are interested in the novelty, they prefer horses born outside of the holding facilities. Therefore, the BLM could increase the proportion of horses adopted by sterilizing the horses in their facilities. Another major factor in wild horse auctions is proximity of the bidder to where the horse is being held. Bidders are more likely to place a higher bid on horses near them. With this study in mind, the BLM could have a better idea of which traits to emphasize in the promotion of their adoption program and what locations to target for specific horses. Maximizing adoptions is another way the BLM could cut their costs.

While these studies have made some interesting observations about potential changes to the BLM's management of horse populations, no approach has identified a clear and effective way to return horse numbers to AMLs. Further, most have suggested that significant issues exist in both the institutional structure and the management of reduction programs that make large-scale reduction difficult and unlikely. These realities suggest that wild horse management will continue to produce population numbers that substantially exceed AMLs unless steps are taken toward institutional change.

Rural Economies

Rural economies that co-exist with federally protected lands in the United States, especially in the American West, illustrate how government protection can have an economic impact on surrounding communities. The economies of places like Utah's Beaver County have traditionally relied on agriculture, especially grazing-related industries. Attempts to diversify their economic systems into other areas such as renewable energy production and outdoor recreation have been largely reliant on the public lands. These local trends mirror national level trends. For example, outdoor recreation has become a larger economic sector than mining (Highfill, Franks, & Georgi, 2018). As a result, various studies have attempted to link proximity to federally protected land, which may provide opportunities for outdoor recreation, to this economic transformation. In spite of this potential change in use, what remains clear is that the impact of these public lands is likely to remain even as the use of them evolves. For places like Beaver County, Utah, this transformation remains a possibility rather than a reality.

While most of the literature agrees that proximity to federally protected lands has an economic impact on rural communities, whether this impact is positive or negative is subject to debate. For example, one study found that close proximity to federally protected lands was correlated with population, income, and employment growth (Lorah & Southwick, 2003). For their analysis, the authors considered wilderness, national parks, national monuments, and roadless areas to be federally protected lands and measured proximity by calculating the amount of federally protected lands within 50 miles of the center of each county in 11 western states (MT, CO, UT, WY, ID, NV, AZ, NM, CA, WA, and OR). They found that nonmetropolitan protected lands counties had higher population, employment, and income growth than nonmetropolitan counties without protected lands. The authors conclude that there is evidence to support the idea that proximity to

federally protected lands does not harm local economies and is likely beneficial.

Another study found evidence that the presence of federally protected land is economically beneficial to certain types of counties (Rasker, 2006). This study considered national parks, national conservation areas, national monuments, wilderness, national recreation areas, national wild and scenic rivers, national wildlife refuges, waterfowl production areas, and wildlife management areas to be protected lands and accounted for federally protected land within and adjacent to each county. The study classified all counties of 11 western states (MT, CO, UT, WY, ID, NV, AZ, NM, CA, WA, and OR) as "[m]etropolitan or within a metropolitan 'commuter shed', nonmetropolitan with an airport or within an airport 'commuter shed', nonmetropolitan without an airport and not within an airport 'commuter shed.'" The author found that public lands (protected or otherwise) and unprotected/industrial public lands are both positively correlated with personal income growth for all types of counties studied.

Unprotected public lands adjacent to protected lands were most strongly positively correlated with growth; federally protected lands were strongly correlated with growth in nonmetropolitan counties; and employment in extractive industries had a strong negative correlation with growth across all types of counties (Rasker, 2006). The author generally concludes that public lands are not economically detrimental to local economies. However, the presence of protected land, while it can be beneficial, is not enough to stimulate economic growth on its own, and an educated workforce and access to markets are more important factors overall. Additionally, while the study found no evidence that federally protected lands harm local economies, only certain types of counties benefitted from the presence of federally protected land.

A contrasting study found that a federal wilderness designation generally has a negative economic impact on local communities (Yonk, Steed, Simmons, & Martin, 2016). The researchers defined "wilderness" as any lands designated by the Wilderness Act of 1964 and managed by the U.S. Forest Service, the U.S. Fish and Wildlife Service (FWS), the U.S. National Park Service (NPS), and the Bureau of Land Management (BLM). In their analysis, the authors considered all U.S. counties (rather than just the West) and classified a county as wilderness if it contained any amount of federally designated wilderness. This analysis found "an economically significant negative relationship between the presence of wilderness and median household income and total payroll" (Yonk, Steed, Simmons, & Martin, 2016, p. 3). Specifically, median household income and total nonfarm payroll was lower in wilderness counties compared to non-wilderness counties. While wilderness may not be economically beneficial, that does not necessarily make it bad. The authors note the importance of recognizing the tradeoffs between the emotional, ecological, and cultural values of wilderness and the impact on local economies.

Two consistent findings appear throughout the literature on the effect of public lands on rural economies. First, public lands and their management are an important part of these areas' economic reality. Second, the type and management approach to those lands has a substantial impact on the economic effect.

THEORY

We take our theory from this relative agreement about the effect and importance of both land type and management approach, as well as the disagreement over the impact of that management. These lands and their management are important, and decisions about them are likely to impact the communities they are co-located with in non-trivial ways.

While there is much debate over what to do in wild horse population management, there is no dispute about the effects of wild horses on rangelands. BLM range scientists have found that in the Great Basin, "areas with wild horses had less shrub cover, plant cover, species richness, native plant cover, and overall plant biomass, and more unpalatable and invasive plant species…" (U.S. DOI, 2018a, p. 9). Aside from these effects on plant life, they also displace native ungulates including pronghorn antelope, deer, and elk (U.S. DOI, 2018a). These ungulates include game species that inevitably impact the ability for recreational hunting. Likewise, seeing

sickly or malnourished wild horses (as vivid photographs portray) does not provide an appealing experience for onlookers. This reality diminishes the outdoor recreation draw for counties containing HMAs. Wild horse population also hurts local vegetation, local animal species, and the horses themselves. We attempt to explore the effect of horse management, and ultimately overpopulation as a result of that management, on the economic systems of the areas they inhabit.

There is scant evidence on the economic effects of wild horse grazing on Federal Lands. Huffaker, Wilen, and Gardener (1990) proposed a bioeconomic livestock-wild horse trade-off mechanism for the purpose of conserving vegetation. They sought to find an appropriate balance between combinations of rate of wild horse removal and grazing fees to balance cattle and wild horse populations to keep the vegetation at target levels. This approach, though very conscious of vegetation levels, did not address the issue of economic impact. Bastian, Van Tassell, Cotton, and Smith (1999) approached the issue to calculate the opportunity costs associated with wild horses, wildlife, and domestic livestock. They make it clear that they are not trying to find a socially optimal horse level. Though previous studies have applied economic concepts in their analysis, this paper uses a cross sectional time-series regression to evaluate the economic effects of HMAs on counties, if there are any at all.

The direct costs of wild horse management are relatively clear, as BLM budgets can illustrate. In 2017, the BLM spent nearly $48 million in off-range holding facilities, accounting for nearly 60% of the total budget (U.S. DOI, 2018a, p. 6). The high cost reduces the BLM's ability to properly manage excess horses and burros, further exasperating the on-range wild horse and burro population.

To address these problems and gaps in the literature, we develop a framework from which to base our empirical tests. Growing wild horse populations have a variety of negative effects on local ungulates: impacted plant life, diet overlap with domestic livestock, and competition for water sources. These negative effects not only affect the local vegetation and native ungulates, but also cattle. It is realistic to suspect that overpopulation is impacting the cattle industry, which plays an important role in the economies of arid areas. Beaver County, Utah, for example, has over 27,000 cattle and calves where 92% of sales by type are Livestock, poultry, and products (2017 Census of Agriculture, 2017). There is a clear economic link that is important to further study. Thus, we predict that HMAs will be associated with lower economic activity in a given county, measured in total nonfarm payroll and total tax receipts.

Testing the Economic Effects

Almost no empirical work has been conducted on the economic effects of wild horse herds and their management on the rural counties in which they are co-located. A few assessments have attempted to provide a snapshot of the correlative relationship between wild horse herds and economic development. However, this approach fails to capture and model the relationship between the horse herds, their management, impact on rangelands, and economic outcomes. It is our belief that a cross-sectional time series model is the appropriate approach to understand the potential relationship between wild horse herds and local economic conditions.

Further, most questions surrounding federal management decisions, including the management of wild horse populations, have focused on the direct costs of management rather than the impacts those management decisions might have on the larger economic systems. Additionally, most studies that have investigated the questions of public land management are interested in the broad effects of generic policy decisions rather than the impacts on counties directly.

Our approach allows us to test whether the presence of an HMA impacts the economic outcomes of counties with HMAs as compared to counties where HMAs are not present. As is always the case in the real world, once an event has occurred, it is impossible to know what would have happened had it not occurred. In an attempt to isolate the economic impact of the HMA, we compare the counties where a wild horse or burro management area has been established with the remainder of U.S. counties.

Using this methodological approach, we perform two regressions using two dependent variables, each of which attempt to capture the economic condition. We run our panel from 1980 just after the establishment of most HMAs and the beginning of more active wild horse and burro management. We run our panel in five year waves that end in 2005 just prior to the most recent recession. We exclude 2010 and 2015 as their inclusion is likely to overestimate negative effects in rural areas.

Our first measure of economic development is the total payroll expended in a county by nonfarm establishments. We use this to proxy for economic condition as it represents economic activity occurring within the county boundaries and has the distinct advantage of not being a direct function of the institutional arrangements that exist; it instead measures the economic activity that surround those institutions. (That is not to say it is not an indirect function of those institutions.)

We further use this variable because it is a measure that speaks directly to the economic situation of individuals and to capture a measure of business activity. We use payroll over total receipts or total business activity on the assumption that payroll is more likely to remain within the county and have a direct impact on the geographic area than are the gross receipts of corporations. This measure is not a perfect proxy and does not capture the capital investment, out of county workers, or retirees that do not receive payroll.

Our second dependent variable is the total tax receipts of a particular county. We use this variable as a proxy for economic development and to identify the impact on local governments directly. The tax receipts captured by this variable include sales, property, and franchise and other taxes received by the counties. Using this dependent variable has a number of advantages. The data is largely complete, and local governments are typically required by state and federal statute to correctly report tax receipts. This reality provides some confidence in the data that self-reporting or estimations of economic activity do not provide. This dependent variable faces some problems as there are significant institutional differences across states, regions, and often counties themselves about how, when, and why taxes may be collected. Indeed, the total tax receipts collected might be a function of underlying economic activity or of the institutional decisions that are also likely to be important predictors of tax receipts and will exist in our model as omitted variables.

While neither of our dependent variables are ideal proxies for economic development, taken together they paint a relatively complete picture of the economic situation. The expectation is that the presence of a HMA would affect them in nearly the same way and the direction of effect should be the same if these variables are measuring the same underlying economic activity.

The results of the presence of an HMA on the local economic conditions has largely remained an open question. Neither local elected officials nor proponents of the HMAs have been able to quantify the impact of wild horses on local counties.

To better isolate the effect of the HMA, we include controls for other possible economic drivers. Our first set of control variables are primarily demographic in nature and include measures of race, sex, age, birth rate, educational attainment, population, and population density—all of which are likely to be directly associated with economic development; their inclusion in the analysis is necessary to better isolate the independent effect of HMAs.

Our second set of controls addresses the public lands nature of the counties. Controlling for the type of land control is essential to isolate the effects HMAs because all of the counties where HMAs are located have substantial public land holdings that impact the economic makeup and productivity of the land. A robust literature has demonstrated that the presence of public lands has an impact (although the literature is divided on the direction) on the economic condition of counties where they are present. Including variables for these public lands and the management regime that governs their use is essential in any attempt to isolate the effect of HMAs on local economic conditions. We include variables that measure the percent of land managed by each of the major federal land management entities and include a dummy

variable for the most restrictive use category, Wilderness, in the analysis.

Table 1 and Table 2 report the results of these regressions using both fixed effects and robust standard errors. We fix the effects consistent with the results of a Hausman test for endogeneity among the regressors. While we report the results of the fixed effects model here, the direction and significance of the key independent variable, HMA Presence, is consistent in both specifications.

ANALYSIS

The results presented in Table 1 and Table 1 show that the presence of an HMA in a county is related to lower total payroll and lower total tax receipts when compared to counties without an HMA in their boundaries. The presence of an HMA is associated with a large negative effect on both total nonfarm payroll and total tax receipts that is statistically significant to the 95% confidence level. We find sufficient evidence to reject the null hypothesis of there being no effect for the presence of wild horse management areas on both total nonfarm payroll and on the total tax receipts of counties, and evidence for our hypothesis of negative impacts.

Table 1 shows a negative coefficient on the presence of an HMA that is statistically significant at the 95% confidence level. This indicates that HMA counties see lower total nonfarm payrolls than their non-HMA counterparts. We also see a negative effect on the presence of wilderness in a county, as shown by the wilderness dummy variable that is statistically significant at the 99% confidence level. This is consistent with other examinations of the effect of the presence of wilderness in a county that finds it is generally related to lower economic activity when compared to non-wilderness counties.

Table 1 shows other demographic trends and their effects on counties. As the median age rises, total nonfarm payroll has a downward trend. The impacts of primary vs. secondary education have differing effects on total nonfarm payroll. Whereas a higher percentage of high school graduates is associated with lower total nonfarm payroll, a higher percentage of college graduates is associated with a positive effect, although not statistically significant, on total nonfarm payroll. Similarly, more population, more land area, and a higher population density all show a positive effect on total nonfarm payroll.

Land management by two federal agencies had a statistically significant effect on total nonfarm payroll: the Bureau of Reclamation and the Department of Defense. The Bureau of Reclamation is statistically significant at the 95% confidence interval with a positive effect on total nonfarm payroll. The Department of Defense has a negative effect on total nonfarm payroll that is statistically significant to the 95% confidence level.

Table 2 shows that total tax receipts are also lower in counties where an HMA is present when compared with counties without a management area. This result is statistically significant at the 95% confidence level. This means that counties where HMAs are active have lower tax revenues when compared to non-HMA counties. Further, when we include Bureau of Land Management increases and the interactive effect between BLM and the presence of HMA, the coefficient is positive and significant. Consistent with our finding in Table 1, the presence of wilderness in a county is statically significant and related to lower total tax receipts as well.

Similar to our findings in Table 1, median age and the percent of high school graduates both have a statistically significant effect on total tax receipts. Both are associated with lower tax receipts. As the population, land area, and population density increase, they are all associated with increased total tax receipts and are statistically significant.

In Table 1, many variables involving land owned by federal entities had no effect on total nonfarm payroll. In contrast, total tax receipts in Table 2 showed more statistically significant findings. For example, we found additional impacts of various federally managed lands that were also statistically significant.

Table 1: Total NonFarm Payroll, Cross Sectional Time Series with fixed effects

	Model 1 Total Non Farm Payroll
Observations	18,798
R-SQ Overall	.7550
Variables	Total Non Farm Payroll
HMA Presence	-334023** (121145)
Percent Bureau of Land Management Managed Land in County	6557.99 (4152.43)
HMA Presence*Percent BLM Land	4361.45 (2619)
Wilderness Dummy	-116560.3*** (17066.21)
Percent White	2883.3 (1904.91)
Percent Female	-4585.99 (3016.06)
Median Age	-3.46** (1.37)
Percent High School Grad	-26097.16*** (3675.54)
Percent College Grad	47071.65*** (7614.12)
Birth Rate	-12,077.96 (23713.66)
Population	13.27*** (1.544)
Land Area	3.61* (1.69)
Population Density	513.23** (172.46)
Percent Federal Owned Land	-1043.25 (3545)
Percent Bureau of Reclamation Managed Land in county	47764.08** (477765.08)
Percent Department of Defense Managed Land in County	-19256.44** (6713.78)
Percent Forest Service Managed Land in County	3599.95 (3441.77)
Percent Fish and Wildlife Service Managed Land In County	3753.14 (5576.72)
Percent National Park Service Managed Land in County	-10522.53 (5689.81)
Percent Bureau of Indian Affairs Managed Land in County	5519.75 (4878.22)
Percent Other Federal Managed Land in County	-6621.90 (5929.81)

*Robust Standard Errors in Parentheses (*P = .10 **P = .05 ***P = .01)*

Table 2: Total Tax Receipts, Cross Sectional Time Series with fixed effects

	Model 1 Total Tax Receipts
Observations	18,798
R-SQ Overall	.5573
Variables	Total Tax Receipts
HMA Presence	-37279.48** (14909.22)
Percent Bureau of Land Management Managed Land in County	1450.32*** (332.48)
HMA Presence*Percent BLM Land	24.68 (265.82)
Wilderness Dummy	-18597.48*** (1028.75)
Percent White	24.59 (79.59)
Percent Female	-16.45 (131.94)
Median Age	-.50** (.10)
Percent High School Grad	-903.85** (312.12)
Percent College Grad	44.38 (754.89
Birth Rate	-710.98 (1693.14)
Population	1.26*** (.14)
Land Area	.27* (.25)
Population Density	30.37*** (8.22)
Percent Federal Owned Land	-748.60** (291.26)
Percent Bureau of Reclamation Managed Land in county	5541.40*** (1356.79)
Percent Department of Defense Managed Land in County	-1116.32* (481.33)
Percent Forest Service Managed Land in County	1036.03** (290.55)
Percent Fish and Wildlife Service Managed Land In County	1171.33** (469.92)
Percent National Park Service Managed Land in County	-1401.67 (5689.81)
Percent Bureau of Indian Affairs Managed Land in County	900.49* (382.14)
Percent Other Federal Managed Land in County	1017.97* (497.53)

*Robust Standard Errors in Parentheses (*P = .10 **P = .05 ***P = .01)*

Our empirical tests found consistent negative and statistically significant effects of HMA Presence on our measures of economic activity, after controlling for other potential influences. Further, we included other federal management agencies to better isolate this effect, and we find the HMA effect after controlling for these other land management agencies and approaches. Our analysis finds mixed direction and mixed statistical significance across the federal agencies—a result that is consistent with the variety of land type, management approach, and the goals of the various agencies.

These results provide significant evidence that counties where HMAs are present tend to have lower total economic activity and, at least partially as result of these effects, lower tax revenues. With these broader results, we now turn to a more direct look at a particular HMA county, Beaver County, Utah, to better understand the mechanism and relationship between the county and the public lands that surround it.

BEAVER COUNTY, UTAH

Overview

Beaver County, Utah, has an estimated population of 6,500 (2018) and makes up 2,590 square miles (U.S. Census Bureau, n.d. b). It is a largely rural county with significant portions of land being federally managed. Only 157,030 acres – less than one-tenth of the total land area in the county – is private farmland (2017 Census of Agriculture, 2017). The BLM is responsible for 1,137,227 acres (68.7% of the total land area of Beaver County), and the U.S. Forest Service manages another 138,967 acres (8.4%). The state of Utah manages 167,288 acres (10.1%). Of that, 155,152 acres (9.4%) is State Trust Land; 11,925 acres (0.7% of the state land) is State Wildlife Reserve; and a tiny portion is State Parks and Recreation land at 212 acres (0.01% of state land) (Crispin, Downen, Perlich, & Wood, 2008). Overall, out of the 1,654,381 acres in the county, 1,275,936 acres (77%) of Beaver County is federally owned, 169,994 acres (10%) is state owned, and only 20,8451 acres (13%) is privately owned (Strambo, Downen, Hogue, Pace, Jakus, & Grijalva 2014).

This unique land ownership and the management approaches that emerge from it position Beaver County among those most likely to be impacted by agency management decisions. We would expect that given the small private holdings in Beaver County, the economic conditions of the county would be directly and substantially tied to the decisions those agencies make. Understanding these decisions, including those that surround wild horse management, are key to Beaver County's economic reality.

Beaver County is home to several HMAs. The largest covers 265,675 acres, or 16% of the total land area of the county. Current estimates (2016) for this HMA put the population of wild horses at 957 animals, or 707 above the maximum AML amounts of 250. The BLM conducted a NEPA analysis that yielded a preferable alternative that would attempt to lower the total number by conducting up to four roundups over a 6-10 year period. The BLM further suggests that an annual growth rate of 20% is necessary to account for additions to the population, suggesting there could be as many as 1,982 horses if the roundups were not conducted by May 2020. This exponential growth rate further illustrates the potential impact the management decisions surrounding HMAs can have (U.S. DOI, 2016).

Agricultural Production

Though not the largest county in the state of Utah, Beaver County had the greatest total value in agricultural cash receipts in 2014 (Ward & Salisbury, 2014), with a total market value of agricultural products sold at over $288 million in 2012. At only 28% of the total agricultural land, cropland is a significantly smaller portion compared to pastureland at 62&; woodland comprising 1% of private farm land. The data indicates that this is consistent with the sales by type of agricultural product. A majority of sales consist of livestock and poultry production (92% of total sales) with the rest (8%) being crop. While most of the livestock production is by hog and pig farmers, and primarily a single producer, those operations represent a relatively small total land use. Cattle and sheep production, however, are closely tied to public land use and represent a smaller but important part of the economic activity in the county as

they are tied to a diversity of producers (2017 Census of Agriculture, 2017).

The total amount of cropland in Beaver County has fluctuated from 2007 to 2017, with the total land in farms rising by 20% from 2007 to 2012 (from 158,323 acres to 189,995 acres) (2012 Census of Agriculture, 2012), and falling by 17% from 2012 to 2017 to the previously indicated 157,030 acres (2017 Census of Agriculture, 2017).

Beaver County is considered a county in the Southern Production Region, where ranchers run cattle for four months on federal BLM land and three months on national forest land. A wide majority of BLM land in the state is available for permitted grazing, highlighting the importance of management decisions on economic activity (Strambo et al., 2014).

The total grazing AUMs (the amount of forage needed to sustain one cow for one month) on BLM land in Beaver County was 675,000 AUMs in 2009. This value has shrunk significantly from the once 2,749,000 AUMs (Beaver County Resource Management Plan, 2017). The root causes of those reductions are an open question in the wider literature, but the management decisions of agencies have clearly impacted the total AUMs available.

In Beaver County, most operators of cattle and sheep farms hold permits to graze on federal land. Though the data does not go as far down as the county level, in the Beaver/Juab/Millard county area, there were 160 permittees for cattle farms to graze on federal land, as opposed to 30 non-permittees (Godfrey, 2008, p. 24). For ewes (female sheep), the number of permits and non-permittees were 30 and 6, respectively. In addition, non-permittees in this region get approximately 13% of their feed from federal land, as compared to 52% for permittees (Godfrey, 2008, p. 32-33). Thus, there are disproportionality more operations with permits to graze on federal land than without, demonstrating the importance of federally managed, especially BLM, land for grazing in Beaver County and the economic activity it provides.

Energy/Mineral Land Use

Beaver County has limited energy production. One of the types of energy production in the county is geothermal. Beaver County made up a majority of the geothermal energy produced in the state in 2018 (U.S. DOI, 2018.). There are two plants in the county that produce geothermal energy. One site covers 2,000 acres of private and BLM federal land, 800 acres of Utah State School and Institutional Trust Lands Administration land, and 400 acres of privately-owned land near Milford, Utah (PacifiCorp, 2011). The other plant spans over 6,750 acres and comprises slightly more than 450 acres of state land, 2,070 acres of federal BLM land, and just over 4,200 acres of private land (U.S. Department of Energy, 2018).

There are also a couple of solar power plants in Beaver County (Cassell, 2014; SunEdison, 2015). One of the solar projects, which has several locations throughout the county, takes up a total of 1,900 acres (Cassell, 2014). The other project is much smaller, taking up between 150 and 200 acres, based on calculations of the MW and total land use requirements by MW (Ong, Campbell, Denholm, Margolis, & Heath 2013; SunEdison, 2015). In addition, there is one wind power production area that covers a small portion of the county (U.S. DOI, 2008).

The total land use for energy production, while relatively small, occurs almost exclusively on publicly managed land, and the management decisions surrounding those lands impact the limited energy sector that exists.

Recreational Land Use

There is nearly no exclusively recreational land use in Beaver county. The small portion that exists makes up 212 acres, or 0.01%, and is managed by State Parks and Recreation. There is no federal recreation land (e.g., national parks) in the state (Crispin et al., 2008). While only a negligible amount of land is managed exclusively for recreation, the multiple use mandate of federal agencies requires that recreation be part of management considerations. Decisions about other uses, including wild horse management, are likely to impact how recreation occurs on multiple use lands in the county.

Conclusion

The economic profile of Beaver County reveals an economic system that is deeply and substantially tied to the public lands within its boundaries. Management decisions about these lands are likely to impact key economic sectors including agriculture, energy development, and tourism. As a result, it is clear that the impact of those management decisions will be felt in larger economic outcomes and, ultimately, in the tax revenues of the county.

IMPLICATIONS

An analysis of the wider data indicates that counties where HMAs are located have lower total tax receipts and lower overall economic activity in the form of total non-farm payroll. A more detailed examination of the economic profile of Beaver County, Utah, as it relates to those lands suggests that management decisions, such as those stemming from having an HMA that covers a substantial portion of the county, are likely having negative economic effects on those counties.

Our analysis suggests that the economic systems of counties like Beaver County, Utah, and other rural, public lands counties find their economies and their tax revenues inextricably tied with the decisions of land management areas.

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REFERENCES

2012 Census of Agriculture County Profile - Beaver County, Utah. (2012).

2017 Census of Agriculture County Profile - Beaver County, Utah. (2017).

Adekunle, O. O., Markus, L., Stowe, C. J., & Saghaian, S. H. (2013). A Hedonic Price Analysis of Internet Auctions for the BLM's Wild Horses and Burros. *Southern Agricultural Economics Association 2014 Annual Meeting, Feb 1-4, Dallas, Texas*. doi: 10.22004/ag.econ.162469

Bartholow, J. (2007). Economic Benefit of Fertility Control in Wild Horse Populations. *The Journal of Wildlife Management*, *71*(8), 2811–2819. doi: 10.2193/2007-064

Bastian, C. T., Van Tassell, L. W., Cotton, A. C., & Smith, M. A. (1999). Opportunity costs related to feral horses: a Wyoming case study. *Journal of Range Management*, *52*(2), 104–112.

Beaver County Resource Management Plan. (2017).

Beever, E. A. (2003). Management Implications of the Ecology of Free-Roaming Horses in Semi-Arid Ecosystems of the Western United States. *Wildlife Society Bulletin*, *31*(3), 887–895.

Beever, E. A., & Aldridge, C. L. (2011). Influences of Free-Roaming Equids on Sagebrush Ecosystems, with a Focus on Greater Sage-Grouse. *Greater Sage-Grouse: Ecology and Conservation of a Landscape Species and Its Habitats* (pp. 273–290). University of California Press.

Beever, E. A., & Brussard, P. F. (2004). Community- and landscape-level responses of reptiles and small mammals to feral-horse grazing in the Great Basin. *Journal of Arid Environments*, *59*(2), 271–297.

Beever, E. A., & Brussard, P. F. (2000). Examining ecological consequences of feral horse grazing using exclosures . *Western North American Naturalist*, *60*(3).

Boyd, C. S., Davies, K. W., & Collins, G. H. (2017). Impacts of Feral Horse Use on Herbaceous Riparian Vegetation Within a Sagebrush Steppe Ecosystem. *Rangeland Ecology & Management*, *70*(4), 411–417.

Cassell, B. (2014). PacifiCorp approved for 320 MW of new solar in Utah.

Crispin, J. E., Downen, J. C., Perlich, P. S., & Wood, J. A. (2008). An Analysis of Long-Term Economic Growth in Southwestern Utah: Past and Future Conditions.

Danvir, R. E. (2018). Multiple-use management of western U.S. rangelands: wild horses, wildlife, and livestock. *Human-Wildlife Interactions*, *12*(1), 5–17.

de Villalobos, A. E., Zalba, S. M., & Peláez, D. C. (2011). Pinus halepensis invasion in mountain pampean grassland: Effects of feral horses grazing on seedling establishment. *Environmental Research*, *111*(7), 953–959.

Elizondo, V., Fitzgerald, T., & Rucker, R. R. (2016). You Can't Drag Them Away: An Economic Analysis of the Wild Horse and Burro Program. *Journal of Agricultural and Resource Economics*, *41*(1), 1–24.

Fonner, R., & Bohara, A. K. (2016). Optimal Control of Wild Horse Populations with Nonlethal Methods. *Land Economics*, *93*(3), 390–412. doi: 10.22004/ag.econ.236215

Frey, S. N. & Thacker, E. (2018). Wild Horses and Burros: An Overview. *All Current Publications*.

Garrott, R. A. (1991). Feral Horse Fertility Control: Potential and Limitations. *Wildlife Society Bulletin*, *19*(1), 52–58.

Garrott, R. A., Siniff, D. B., Tester, J. R., Eagle, T. C., & Plotka, E. D. (1992). A Comparison of Contraceptive Technologies for Feral Horse Management. *Wildlife Society Bulletin*, *20*(3), 318–326.

Godfrey, E. B. (2008). Livestock Grazing in Utah: History and Status. Report for the Utah Governor's Public Lands Policy Coordination Office (December). Utah State University, Logan, Utah, USA.

Godfrey, E. B. & Lawson, P. (1986). Wild Horse Management: An Economic Perspective. *Journal of Equine Veterinary Science*, *6*(5), 266–272. doi:10.1016/s0737-0806(86)80054-5.

Gross, J. E. (2000). A dynamic simulation model for evaluating effects of removal and contraception on genetic variation and demography of Pryor Mountain wild horses. *Biological Conservation*, *96*(3), 319–330.

Hall, L. K., Larsen, R. T., Knight, R. N., & McMillan, B. R. (2018). Feral horses influence both spatial and temporal patterns of water use by native ungulates in a semi-arid environment. *Ecosphere*, *9*(1).

Hanley, T. A., & Hanley, K. A. (1982). Food Resource Partitioning by Sympatric Ungulates on Great Basin Rangeland. *Journal of Range Management*, *35*(2), 152–158.

Hansen, R. M., Clark, R. C., & Lawhorn, W. (1977). Foods of Wild Horses, Deer, and Cattle in the Douglas Mountain Area, Colorado. *Journal of Range Management*, *30*(2), 116–118.

Highfill, T., Franks, C., & Georgi, P. S. (2018). Outdoor Recreation Satellite Account: Updated Statistics. *The Journal of the U.S. Bureau of Economic Analysis*, *98*(9).

Huffaker, R. G., Wilen, J. E., & Gardner, B. D. (1990). A Bioeconomic Livestock/Wild Horse Trade-off Mechanism for Conserving Public Rangeland Vegetation. *Western Journal of Agricultural Economics*, *15*(1), 73–82. doi: 10.22004/ag.econ.32493

Hyde, W. K. (1978). The Wild Horse and Allocation of Public Resources. *Rangeman's Journal*, *5*(3), 75–78.

Johnston, V. B. (1971-1972). The Fight To Save A Memory. *Texas Law Review*, *50*, 1055–1063.

Krysl, L. J., Hubbert, M. E., Sowell, B. F., Plumb, G. E., Jewett, T. K., Smith, M. A., & Waggoner, J. W. (1984). Horses and Cattle Grazing in the Wyoming Red Desert, I. Food Habits and Dietary Overlap. *Journal of Range Management*, *37*(1), 72–76.

Lorah, P., & Southwick, R. (2003). Environmental Protection, Population Change, and Economic Development in the Rural Western United States. *Population and Environment*, *24*(3), 255–272.

Loydi, A., & Zalba, S. M. (2008). Feral horses dung piles as potential invasion windows for alien plant species in natural grasslands. *Plant Ecology*, *201*(2).

McKnight, T. L. (1959). The Feral Horse in Anglo-America. *Geographical Review*, *49*(4), 506–525.

Miller, R. (1983). Habitat Use of Feral Horses and Cattle in Wyoming's Red Desert. *Journal of Range Management*, *36*(2), 195–198.

Ong, S., Campbell, C., Denholm, P., Margolis, R., & Heath, G. (2013). Land-Use Requirements for Solar Power Plants in the United States.

PacifiCorp. (2011). Blundell Plant. Retrieved from https://www.yumpu.com/en/document/read/29330539/blundell-plant-fact-sheet-pacificorp

Perry, N. D., Morey, P., & Miguel, G. S. (2015). Dominance of a Natural Water Source by Feral Horses. *The Southwestern Naturalist*, *60*(4), 390–393.

Pitt, K. P. (1984-1985). The Wild Free-Roaming Horses and Burros Act:* A Western Melodrama. *Environmental Law*, *15*, 503–533.

Rasker, R. (2006). An Exploration Into the Economic Impact of Industrial Development Versus Conservation on Western Public Lands. *Society and Natural Resources*, *19*(3), 191–207. doi: 10.1080/08941920500460583

Scasta, J. D., Beck, J. L., & Angwin, C. J. (2016). Meta-Analysis of Diet Composition and Potential Conflict of Wild Horses with Livestock and Wild Ungulates on Western Rangelands of North America. *Rangeland Ecology & Management*, *69*(4), 310–318.

Strambo, J. E., Downen, J. C., Hogue, M. T., Pace, L., Jakus, P. M., & Grijalva, T. C. (2014). An Analysis of a Transfer of Federal Lands to the State of Utah.

SunEdison, Inc. (2015). SunEdison Breaks Ground On 22.6 MW Seven Sisters Solar Power Plants In Utah.

U. S. Census Bureau. (n.d. a). Retrieved from https://web.archive.org/web/20111123100037/http://www.census.gov/geo/www/gazetteer/files/Gaz_counties_49.txt

U.S. Census Bureau. (n.d. b). QuickFacts: Beaver County, Utah; United States.

U.S. Department of Energy. (2018). *Draft Environmental Assessment for Frontier Observatory for Research into Geothermal Energy (Forge), Milford, Utah*.

U.S. Department of the Interior. (2008). Milford Wind Corridor Project Millard and Beaver Counties, Utah.

U.S. Department of the Interior, Bureau of Land Management. (2018a). Report to Congress, Management Options for a Sustainable Wild Horse and Burro Program (SuDoc: I 53.11/3-2:H 78/5).

U.S. Department of the Interior, Bureau of Land Management. (2018b). About the Program.

U.S. Department of the Interior, Bureau of Land Management. (2019). Program Data.

U.S. Department of the Interior. (n.d.). Utah: Natural Resources Revenue Data.

Ward, R. A., & Salisbury, K. (2014). *The Economic Contribution of Agriculture to the Utah Economy in 2014*.

Yonk, R. M., Steed, B. C., Simmons, R. T., & Martin, R. C. (2016). Boon or Bust: Wilderness Designation and Local Economies. *The Journal of Private Enterprise*, *31*(3), 1–19.