CONSERVATION

A Critical Crossroad for BLM's Wild Horse Program

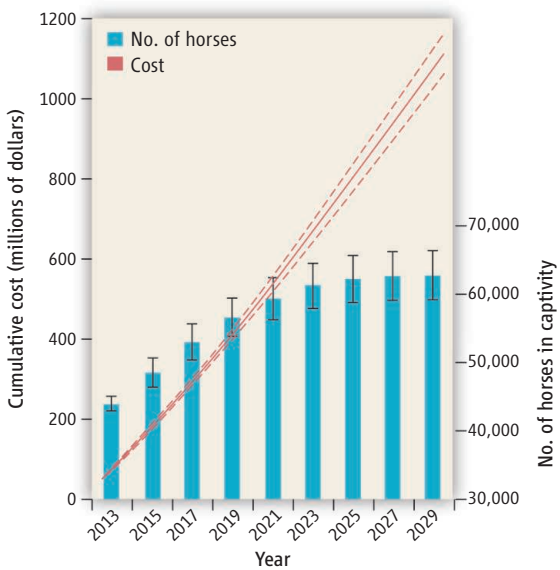
Captive wild horses will cost the United States over $1 billion by 2030 unless management approaches change

Robert A. Garrott,[1]* and Madan K. Oli[2]

Although horses evolved in North America, they went extinct 10 to 12 thousand years ago. Spanish conquistadors returned domestic horses to the continent in the mid-1500s, and since then, domestic horses have escaped captivity and also were purposefully released onto western rangelands where they thrive today. Most free-roaming horse populations are managed primarily by the Bureau of Land Management (BLM) of the U.S. Department of the Interior (*1*).

In 1971, the Wild Free-Roaming Horses and Burros Act (*2*) was passed, which establishes public ownership of free-roaming horses and instructs federal agencies to "protect and manage" horses as "an integral part of the natural system of the public lands." The act mandates that BLM and other federal agencies monitor horse numbers, determine appropriate population levels, and remove excess horses from public lands "to preserve and maintain a thriving natural ecological balance." However, at present, tens of thousands of horses are not living the life of "wild mustangs" as Congress intended in passing the Wild and Free-Roaming Horses and Burros Act; instead, they have reverted back to the status of captive, domestic livestock, and the cost of the captive horse program is increasingly unsustainable.

The BLM currently reports ~33,000 free-roaming horses in the western United States. The National Wild Horses and Burros (WHB) Program has 179 designated Herd Management Areas, with population objectives for each, and an aggregate maximum goal of 23,622 horses (*3*). Since its inception, the WHB Program has been embroiled in controversy over appropriate population goals, management activities, and the accuracy of its estimates of population size and growth rates (*4*–*7*). The BLM monitors numbers using aerial surveys and captures and removes horses from rangelands when horse numbers exceed target population size. As of 2012, BLM has removed >195,000 horses from public lands under this program (*3*). The act requires BLM to place removed horses into "private maintenance and care for which … an adoption demand exists," with unadoptable, old, and excess animals, beyond the adoption demand, either sold or "destroyed in the most humane manner possible" (*2*). The number of horses BLM removes from public lands routinely exceeds adoption demand (*8*). However, because of pressure from horse advocates, administrative directives and congressional appropriation bills prohibit killing healthy horses (*9*); therefore, BLM is left with large numbers of captive horses that must be maintained indefinitely.



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

These policies have led to a complex and costly system for maintaining captive horses. Horses removed from public lands are processed in short-term holding facilities similar to cattle feed lots and held for several months or more. Many mature females are pregnant when captured and foal in the facilities, which adds to the captive population. Most adult males are castrated. Horses can be adopted from the short-term holding facilities, and some are removed through deaths, sales, or release back onto public lands. Excess animals are eventually transferred to private pastures, primarily in the Midwest, that are contracted as long-term holding facilities. Although small numbers are sold, horses typically remain in these facilities until they die of natural causes. Currently, the ~45,000 horses in captivity exceeds the estimated 33,000 free-ranging horses on public rangelands (*3*).

In a recently released National Research Council (NRC) report (*7*), a committee of 14 scientists concluded that, left unmanaged, horse numbers on public lands would triple every 6 to 8 years until food and water became limited. Under these conditions, horses would be in poor health, reproduction would be suppressed, and deaths from starvation and dehydration would become common, with mass mortality events possible during periods of drought. High horse populations and limited resources would also degrade rangelands, which would affect all native species and public uses of these lands. Thus, although the NRC committee concluded that BLM must actively manage wild horse populations, it asserts that continuing "business as usual" will impede effective management of wild horses on public lands and recommends management changes to put the WHB Program on a more sustainable course (*7*).

Although the NRC report focused on scientific issues, a major impetus for changing the WHB Program is the escalating costs of maintaining increasing numbers of horses in captivity. The WHB Program budget grew from $19.8 million in 2000 (*10*) to $74.9 million in 2012 (*3*). More than 60% of the 2012 budget was used to maintain captive horses, 11% expended to capture and remove animals from public lands, and 10% for adoption programs (*3*). To inform the policy debate, we extend the implications of the NRC report to provide a projection of the captive horse population and associated costs if current policies and management approaches continue.

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The Consequences of Business as Usual

We used records of the sex and age of 165,459 horses removed from public lands and placed in captive facilities between 1990 and 2011 to develop demographic projections and associated costs (see the chart) [see supplementary materials (SM) for details]. We made two basic assumptions. First, we projected the life span of 33,946 unadoptable horses currently in long-term holding facilities. Under this scenario, BLM will accrue 366,846 horse-years of maintenance costs over a 30-year period before all animals currently in captivity die. Given that $45.9 million was budgeted to maintain 42,835 horses in captivity during 2011 (*10*), annual per-horse maintenance costs would be ~$1074. Thus, the 30-year cost of maintaining horses currently in long-term holding facilities would be ~$394 million ($449 million with 2% annual inflation).

Second, we assumed the current management program would continue, with a mean of 9412 horses in short-term holding facilities and 3803 horses transferred annually to long-term holding facilities. Expenses would be ~$1.1 billion between 2013 and 2030, and annual costs thereafter would be $67 million. Although some citizens may support such expenditures, these projections reinforce assertions (*7*, *8*) that BLM's current approach to managing horse numbers is not sustainable.

A Way Forward

More than 30 years of research on contraceptive agents for feral horses have resulted in the development of effective vaccines that prevent pregnancy in both captive and free-ranging mares for 1 to 3 years (*7*). Experimental application of these vaccines has contributed to the control of a small horse population on an Atlantic Coast barrier island, and limited experiments on western horse herds have also produced encouraging results. The Environmental Protection Agency recently sanctioned two contraceptive vaccines, which enables their routine use for horse population management on western rangelands (*7*). The average life-expectancy of horses entering long-term holding facilities is about 15 years (see SM). Therefore, every horse that does not enter long-term holding facilities would save, because of contraceptive application, $16,110 in maintenance cost (or savings of $1 million for every 62 horses), not considering the modest costs of contraceptive application.

Uncertainties exist when attempting to deliver vaccines to large numbers of horses. Although concerns have been raised regarding behavioral, physiological, and demographic consequences of contraceptive vaccines, none of these concerns preclude their use for managing rapidly increasing populations (*7*). The level of reduction in population growth that can be realistically attained for western horse herds through application of contraceptive vaccines remains unclear. Large-scale management experiments, perhaps within an adaptive management framework, would help address some of this uncertainty (*11*).

We estimate that the typical 15 to 20% annual population increase of western horse herds (*7*) could be halved by means of contraceptive vaccines. If a gather-and-removal effort reduced the western horse population to the BLM's goal of 23,622 horses and aggressive contraception treatment was initiated, then BLM need only remove 2000 to 3000 horses annually to maintain its goal. The number of horses annually removed would then more closely match adoption demand and that would minimize or eliminate the need for long-term maintenance of unadopted animals.

Although broad-scale use of contraceptives can help reduce the number of horses that BLM must remove to control populations, it is not a panacea. Current contraceptive vaccines are most effective when hand-injected, and remote delivery of vaccines via dart is impractical for most free-ranging horse populations (*7*). Accordingly, vaccine delivery will require continuing, and perhaps increasing, the frequency of horse captures. It may also take a decade of experiment and refinement of treatment regimens and contraceptive methods to scale-up management to include the entire population of horses on western rangelands. Furthermore, most populations already exceed management objectives, and population modeling efforts indicate that current contraceptives can only reduce, not stabilize or reverse, population growth. Thus, even with the changes suggested by the NRC report, BLM must continue removing horses from public lands for the foreseeable future.

It is up to society to decide how they want their government to manage wild horses, how many wild horses should be accommodated on public lands, what should be done with excess horses, and how much they are willing to spend. The debate has gone on for many decades; however, we are at a critical juncture. BLM recently announced that because of funding constraints and lack of additional capacity for maintaining captive animals, it will substantially reduce scheduled removals of horses from public lands this year. This decision has been made despite worsening drought conditions that are causing severe shortages of forage and water for horses, wildlife, and livestock (*12*). Terminating or reducing active management will lead to a rapid increase in the number of horses, further exacerbating resource limitations.

The current situation in Australia provides a sobering view of what might be in store for western rangelands in the United States if the current management dilemma is not resolved. The wild horse population in Australia is estimated to exceed 400,000 animals (*13*), and severe drought conditions in central Australia have reportedly forced government agencies to propose shooting 10,000 horses from helicopters to reduce animal suffering and environmental degradation (*14*). One can only hope that there is the political will to change current policy and place BLM's WHB Program on a more sustainable trajectory.

References and Notes

1. BLM, www.blm.gov/wo/st/en/prog/whbprogram/herd_management/HMA_and_HA_Maps.html.
2. Pub. L. No. 92-195, 85 Stat. 649 (1971) (codified as amended at 16 U.S.C. §§ 1331–1340).
3. BLM, www.blm.gov/wo/st/en/prog/whbprogram/history_and_facts/quick_facts.html.
4. NRC, *Wild and Free-Roaming Horses and Burros: Current Knowledge and Recommended Research* (National Academies Press, Washington, DC, 1980).
5. NRC, *Wild and Free-Roaming Horses and Burros: Final Report* (National Academies Press, Washington, DC, 1982).
6. NRC, *Wild Horse Populations: Field Studies in Genetics and Fertility* (National Academies Press, Washington, DC, 1991).
7. NRC, *Using Science to Improve the BLM Wild Horse and Burro Program: A Way Forward* (National Academies Press, Washington, DC, 2013).
8. U.S. General Accounting Office, *Effective Long-Term Options Needed to Manage Unadoptable Wild Horses* (GAO-09-77, GAO, Washington, DC, 2008).
9. GAO, *Rangeland Management: Improvements Needed in Federal Wild Horse Program* (RECD-90-110, GAO, Washington, DC, 1990).
10. BLM, *Caring for America's Wild Horses and Burros: Fundamental Reforms—An Overview* (BLM, Washington, DC, 2011); www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate/public_affairs/news_release_attachments.Par.4000.File.dat/WHB_Fundamental_022411.pdf.
11. C. Walters, *Adaptive Management of Renewable Resources* (MacMillan, New York, 1986).
12. BLM, announcement; www.blm.gov/wo/st/en/info/newsroom/2013/july/nr_07_19_2013.html.
13. S. Csurhes, G. Paroz, A. Markula, *Pest Animal Risk Assessment: Feral Horse* Equus caballus (Queensland Primary Industries and Fisheries, Queensland, Australia, 2009); www.daff.qld.gov.au/__data/assets/pdf_file/0004/51961/IPA-Feral-Horses-Risk-Assessment.pdf.
14. Australian Associated Press, *The Australian*, 22 May 2013; www.theaustralian.com.au/news/breaking-news/wild-horses-to-be-culled-in-nt/story-fn3dxiwe-1226648548218.

Supplementary Materials

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Supplementary Materials for

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Materials and Methods

Estimation of Age- and Sex-Specific Survival Rates

We obtained the following data from the Bureau of Land management (BLM):

(1) Sex and age of 165,459 horses that were removed from the wild during 1990–2011 and placed into short-term holding facilities (SHTF);

(2) Sex and age of 45,155 horses that were transferred from STHF to long-term holding facilities (LTHF) during 2001–2011;

(3) Sex and age at death of 10,400 horses that died in the LTHF during 2001–2011.

These data allowed us to estimate the sex and age composition of horses held annually in the LTHF for the years 2001 through 2011, providing 217,521 animal-years of survival data for horses maintained in the LTHF. We estimated age- and sex-specific annual survival rates as the proportion of animals of a given age and sex surviving from one year to the next. Our analyses revealed that survival rates improved over time, perhaps because of improved care. Thus, we used the last five (2007–2011) years of data to estimate age- and sex-specific survival rates, and from these rates, we developed sex-specific survivorship functions that were subsequently smoothed to avoid inconsistent survival rates for older age classes owing to small sample sizes.

Estimating Cost of Caring for Horses in Captive Facilities

In 2011, BLM spent $45.9 million to maintain 42,835 horses in captivity (both LTHF and STHF). From these figures, we estimated that annual maintenance cost per horse was $1074. We estimated annual cost of caring for horses in captivity by multiplying the projected number of horses by the estimated per horse cost ($1074). The cumulative cost was then calculated as the sum of annual costs from 2013 onward. If one assumes that the cost of caring for captive horses remains unchanged, the cumulative cost of caring for captive horses would reach $1.1 billion by 2030, with an annual cost of $67 million thereafter (Fig. S1). If one assumes a modest 2% annual increase in cost, cumulative cost would reach $1 billion by 2027, and $2 billion by 2037 (Fig. S2).

We also performed an alternative cost projection using cost estimates from a U.S. General Accounting Office (GAO) document (*10*) that reported BLM paid an average of

$5.08 per horse maintained in STHF (or $1854 per horse per year) and $1.27 per horse maintained in LTHF (or $464 per horse per year). In 2011 there were 12,275 horses in STHF and 30,570 horses in LTHF (LTHF). From cost estimates provided by GAO, the total cost of caring for horses in captive facilities would be $36,931,029 (12,275 horses × $1854 = $22,760,305 for horses in STHF plus 30,570 horses × $464 = $14,170,724 for horses in LTHF). However, BLM reported that $45.9 million was spent in 2011 to care for horses in captive facilities, which suggests administrative expenses of $9 million annually. Under this costing scenario, the cumulative cost of caring for captive horses would reach $1billion by 2037, with an annual cost of $52 million thereafter (Fig. S3). If one assumes a modest 2% annual increase in cost, the cumulative cost would reach $1 billion by 2030 and $2 billion by 2043 (Fig. S4).

Projection of Horse Numbers and Cost of Caring for Horses in Captive Facilities

We used the sex-specific survivorship functions to compile a sex-specific, age-structured population projection matrix **A** using the post-breeding census method (*15*). Because the number of births in LTHF are negligible (males are castrated before they are transferred to the LTHF, and females are not allowed to associate with intact males), the population projection matrices only included age-specific survival rates; age-specific fertility rates were assumed to be zero. There were 30,570 horses in the LTHF in 2011. These horses were distributed according to age structure of horses in the LTHF during 2007–2011. The resulting age-specific number of males and females were used as the starting population vectors for population projections.

We simulated two scenarios. First, we assumed that no additional horses were added to the LTHF after 2011. We then projected the population vector as: $\boldsymbol{N}(t + 1) = \mathbf{A}\boldsymbol{N}(t)$, where $\boldsymbol{N}(t)$ and $\boldsymbol{N}(t + 1)$ are population vectors for year t and t +1, respectively, and **A** is the population projection matrix (*15*). The population vectors for both males and females were projected forward until all horses had died. The total number of horses in each successive year was multiplied by annual per capita cost of maintaining horses in captivity ($1074 per horse per year) to obtain annual cost of maintaining horses in the LTHF.

Second, in addition to the horses that are currently in the LTHF, we also considered the estimated number of horses that are transferred from STHF to LTHF. We compiled data on the number of horses by sex and age that were transferred from STHF to LTHF during 2001–2011. We assumed that these numbers on average are representative of the number of horses that will be transferred from STHF to LTHF in the foreseeable future. We then calculated bootstrapped mean number of horses by sex and age and added it to projected sex-specific population vectors during each year of simulation. The annual cost of caring for horses in LTHF was estimated by multiplying the projected number of horses by annual per capita cost ($1074; see above). We repeated this process 50,000 times and used that calculation to estimate the mean number of males and females by age, projected cost, and percentile-based 95% confidence intervals, for both horse numbers and projected cost (*16*).

Unlike LTHF, we lacked sex- and age-specific data for the STHF. Thus, we compiled data on the total number of horses in the STHF each year from 2001 through 2011 and assumed that these annual totals represent the distribution of the average number of horses in these facilities for the foreseeable future. To estimate the number of horses in the STHF during each year of simulation, we calculated the bootstrapped mean number of horses in the STHF and estimated the cost of caring for these horses as described previously. We repeated this process 50,000 times and calculated mean and percentile-based 95% confidence intervals for both the number of horses in the STHF and estimated cost of caring for these horses, as described previously. The total number (mean and 95% confidence interval) of horses in captivity during each year of the simulation was the sum of horses in the STHF and LTHF, likewise, the cost of caring for horses was a sum obtained the same way.

Life Expectancy of Horses Entering the LTHF

We constructed sex-specific population projection matrices as described previously. Because our population projection matrices included survival probabilities but not fertility rates, population projection matrix $\mathbf{A} = \mathbf{T}$, where $\mathbf{T}$ is the matrix of transition probabilities (*15*). We calculated the fundamental matrix as $\mathbf{N} = (\mathbf{I} - \mathbf{T})^{-1}$, where $\mathbf{I}$ is the identity matrix. Age-specific life-expectancies were then estimated as the sum of each

column of the fundamental matrix (*15*). The average age of horses entering the LTHF is ~7 years; our results show that these horses are expected to live for 15 more years. Thus, the average lifetime cost of caring for each horse entering the LTHF would be $1,074 × 15 = $16,110, or about $1 million for every 62 horses.

Fig. S1. Estimated cost of caring for horses in captive facilities, if one assumes a fixed annual cost of $1074 per horse. Estimated annual (**A**) and cumulative cost (**B**). Solid lines represent means and dotted lines 95% confidence intervals.

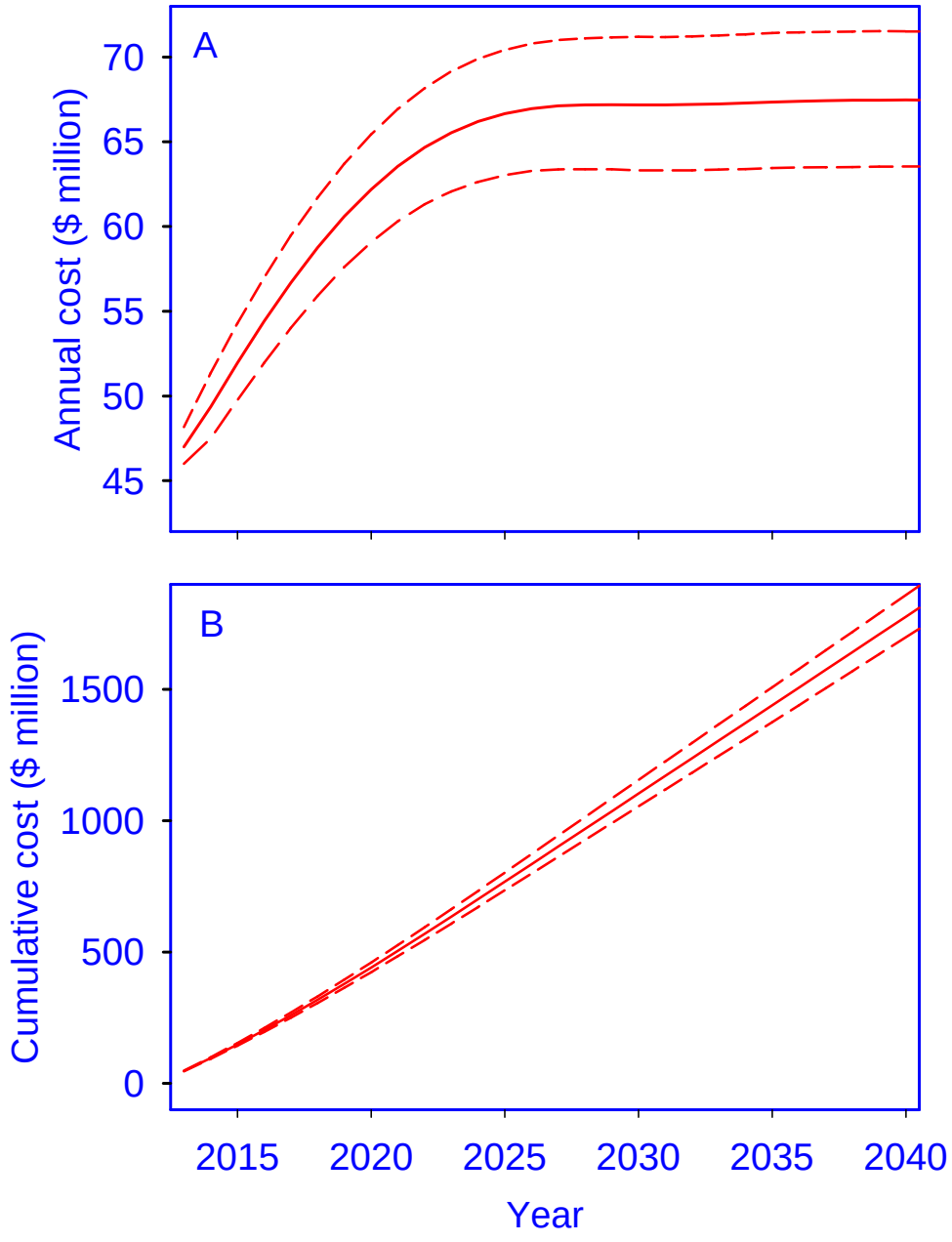


Fig. S2. Estimated cost of caring for horses in captive facilities, if one assumes an annual cost of $1074 per horse in 2013, and 2% annual increase in cost thereafter. Estimated annual (**A**) and cumulative cost (**B**). Solid lines represent means and dotted lines 95% confidence intervals.

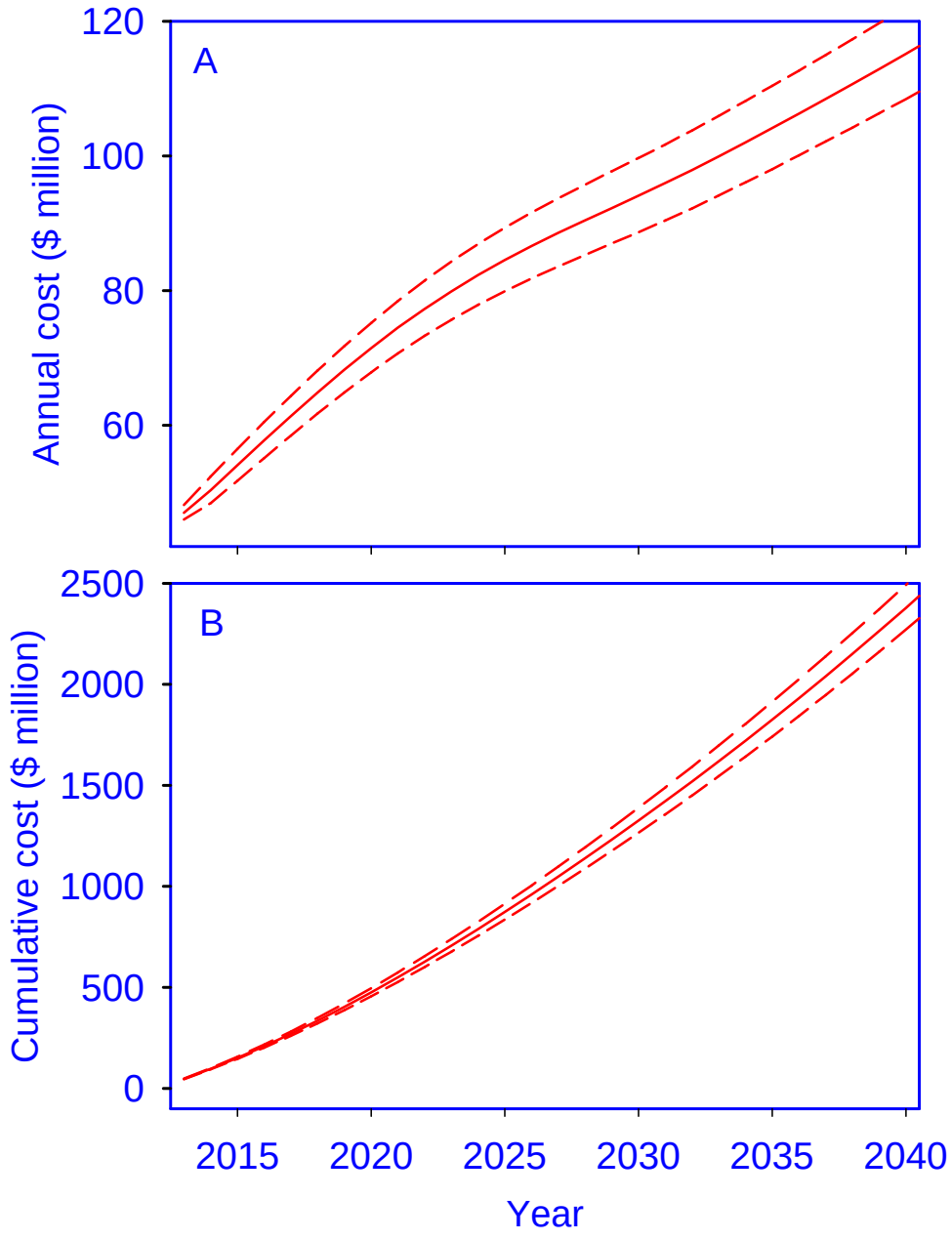


Fig. S3. Estimated cumulative cost of caring for horses in captive facilities, if one assumes a fixed annual cost of $1854 and $464 per horse for horses in STHF and LTHF, respectively. Estimated annual (**A**) and cumulative cost (**B**). A fixed overhead ($9 million) was added to annual cost. Solid lines represent means and dotted lines 95% confidence intervals.

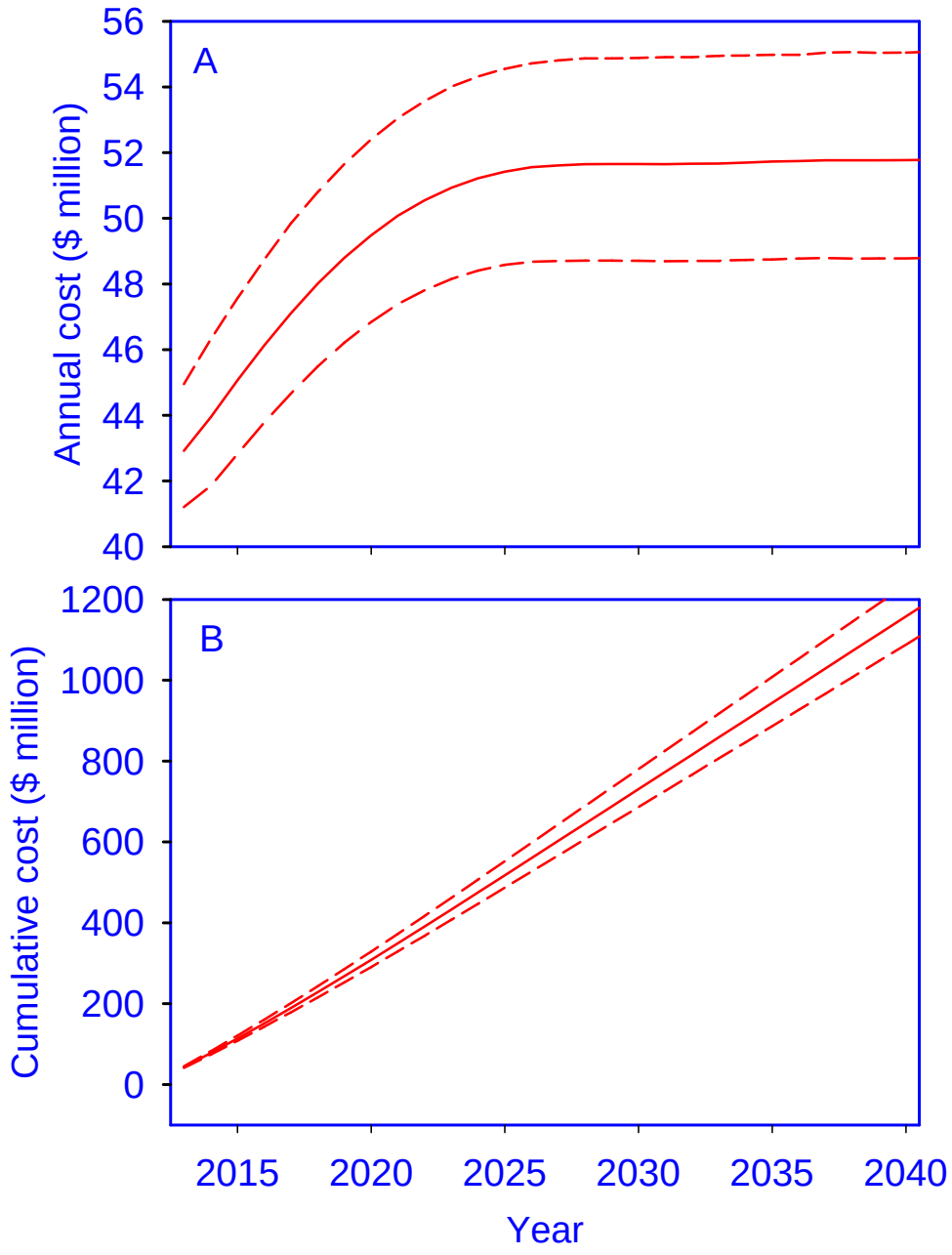


Fig. S4. Estimated cost of caring for horses in captive facilities, if one assumes an annual cost of $1854 and $464 per horse for horses in STHF and LTHF,

respectively, in 2013 and 2%annual increase in cost thereafter. Estimated annual (**A**) and cumulative cost (**B**). A fixed overhead ($9 million) was added to the annual cost. Solid lines represent means and dotted lines 95% confidence intervals.

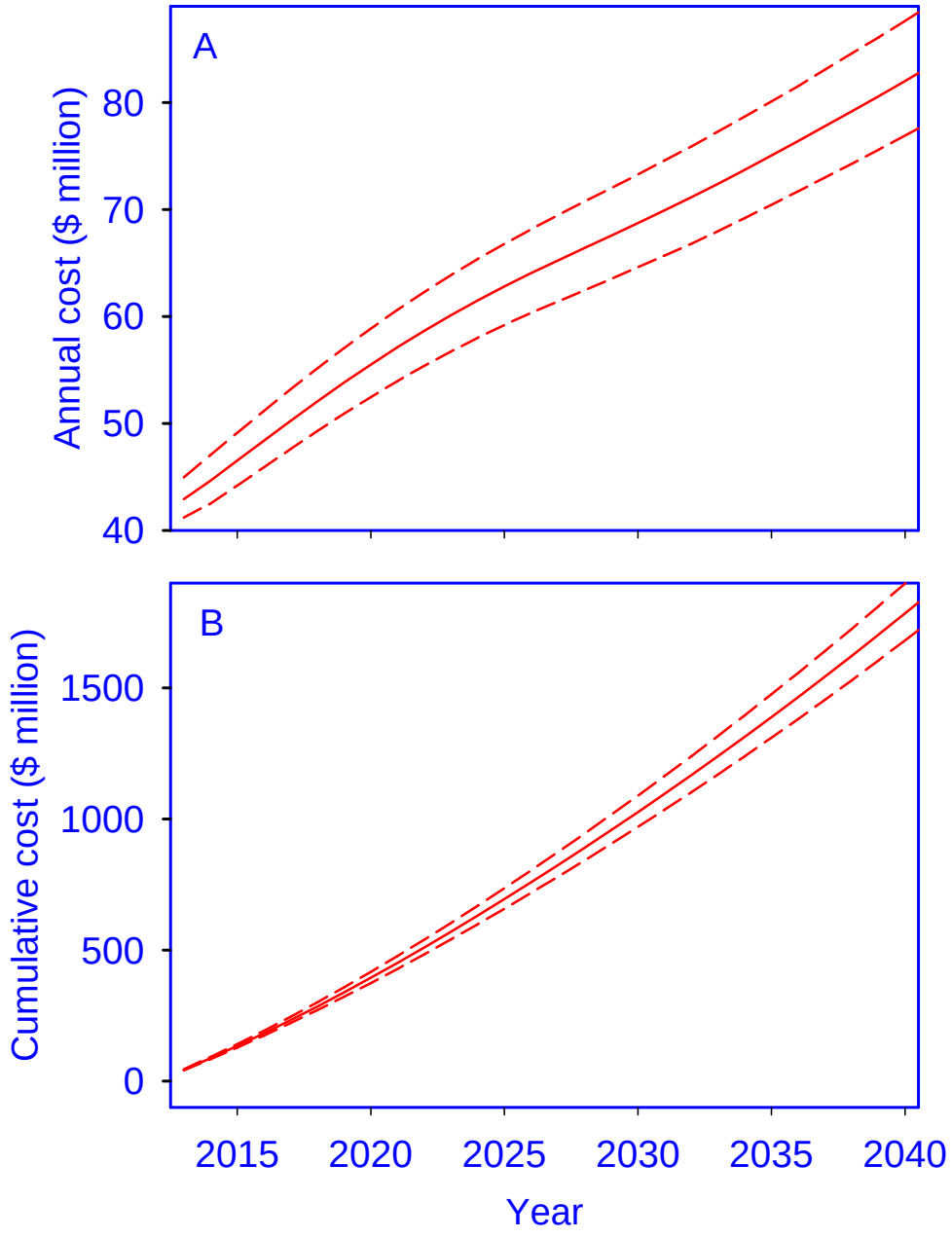
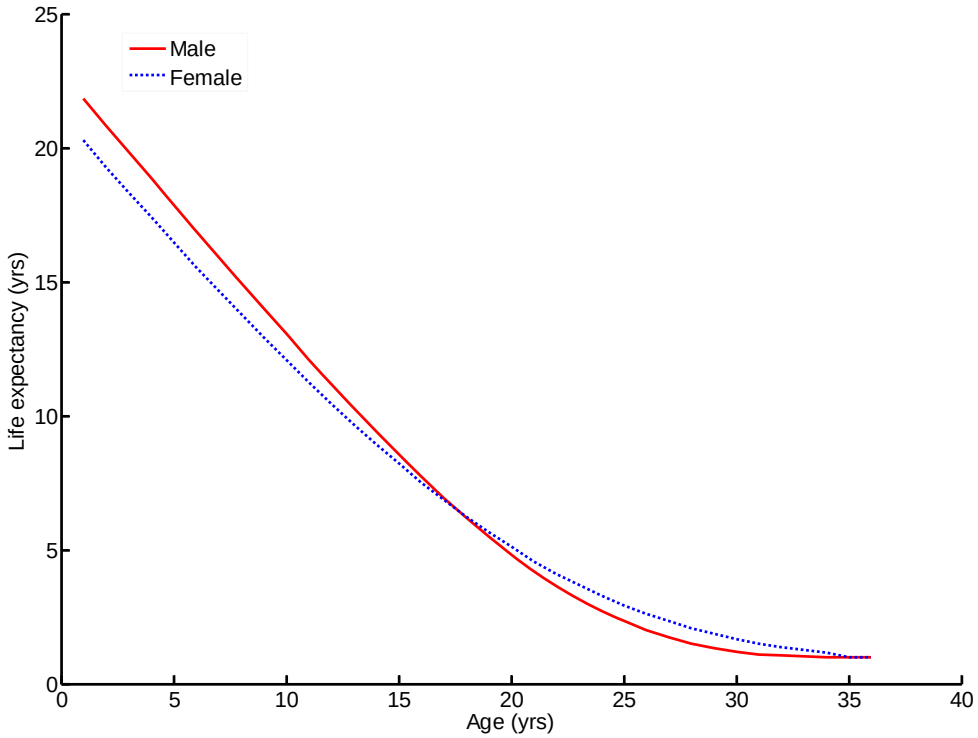


Fig. S5. Age-specific life expectacy of horses in the LTHF.



References and Notes

1. BLM, www.blm.gov/wo/st/en/prog/whbprogram/herd_management/HMA_and_HA_Maps.html.
2. Pub. L. No. 92-195, 85 Stat. 649 (1971) (codified as amended at 16 U.S.C. §§ 1331–1340).
3. BLM, www.blm.gov/wo/st/en/prog/whbprogram/history_and_facts/quick_facts.html.
4. NRC, *Wild and Free-Roaming Horses and Burros: Current Knowledge and Recommended Research* (National Academies Press, Washington, DC, 1980).
5. NRC, *Wild and Free-Roaming Horses and Burros: Final Report* (National Academies Press, Washington, DC, 1982).
6. NRC, *Wild Horse Populations: Field Studies in Genetics and Fertility* (National Academies Press, Washington, DC, 1991).
7. NRC, *Using Science to Improve the BLM Wild Horse and Burro Program: A Way Forward* (National Academies Press, Washington, DC, 2013).
8. U.S. General Accounting Office, *Effective Long-Term Options Needed to Manage Unadoptable Wild Horses* (GAO-09-77, GAO, Washington, DC, 2008).
9. GAO, *Rangeland Management: Improvements Needed in Federal Wild Horse Program* (RECD-90-110, GAO, Washington, DC, 1990).
10. BLM, *Caring for America's Wild Horses and Burros: Fundamental Reforms—An Overview* (BLM, Washington, DC, 2011); www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate/public_affairs/news_release_attachments.Par.4000.File.dat/WHB_Fundamental_022411.pdf.
11. C. Walters, *Adaptive Management of Renewable Resources* (MacMillan, New York, 1986).
12. BLM, announcement; www.blm.gov/wo/st/en/info/newsroom/2013/july/nr_07_19_2013.html.
13. S. Csurhes, G. Paroz, A. Markula, *Pest Animal Risk Assessment: Feral Horse* Equus caballus (Queensland Primary Industries and Fisheries, Queensland, Australia, 2009); www.daff.qld.gov.au/__data/assets/pdf_file/0004/51961/IPA-Feral-Horses-Risk-Assessment.pdf.
14. Australian Associated Press, *The Australian*, 22 May 2013; www.theaustralian.com.au/news/breaking-news/wild-horses-to-be-culled-in-nt/story-fn3dxiwe-1226648548218.
15. H. Caswell, *Matrix Population Models* (Sinauer Associates, Inc., Sunderland, MA, 2006).
16. B. Efron, R. Tibshirani, *An Introduction to the Bootstrap* (Chapman & Hall/CRC, Boca Raton, FL, 1993).

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